Kasetsart University
มหาวิทยาลัยเกษตรศาสตร์

IRD
Institut de recherche pour le développement

Chulalongkorn University

KYOTO UNIVERSITY FOUNDED 1897

Proceedings of the International Conference:

The Chao Phraya Delta :

Historical Development, Dynamics and Challenges of Thailand's Rice Bowl

Volume 1

12-13-14-15 December 2000, Kasetsart University, Bangkok

Proceedings of the International Conference:

The Chao Phraya Delta :

Historical Development, Dynamics and Challenges of Thailand's Rice Bowl

12-13-14-15 December 2000, Kasetsart University, Bangkok

Kasetsart University
IRD (Institut de Recherche pour le Développement)
Chulalongkorn University, CUSRI
Kyoto University, CSEAS

Front cover: all snapshots from the Chao Phraya Delta by François Molle

Rice fields in Tha Maka project, Mae Klong	Weir in the Mae Klong Irrigation Project	Mobile pump set used for plot irrigation	Rice fields near a garbage dump	Dredging canals: an unending task
Raising geese	Transmitting culture and wisdom: old woman and her grandson	Lowlift axial pumps used to pump water from the main canal	Fields of taro being irrigated	Motorised spraying of rice fields
Canal in Damnoen Saduak area	Mechanisation of the harvesting of sugar cane	Raised beds for vegetable production	Post harvest work at home	Raised beds in Damnoen Saduak area

Kasetsart University
IRD (Institut de Recherche pour le Développement)
Chulalongkorn University, CUSRI
Koto University, CSEAS

Proceedings of the International Conference:

The Chao Phraya Delta :

Historical Development, Dynamics and Challenges of Thailand's Rice Bowl

Volume 1

Volume 2

Scientific Committee of the Conference

Srisak Wallipodom	**Panel 1**
Atsushi Kitahara (Nagoya Univ.)	**Panel 1**
Aphiphan Pookpakdi (Kasetsart University)	**Panel 2**
Booriboon Samrid(IRRI/DOA)	**Panel 2**
Mingsarn Kaosa-ard (Chiang Mai University)	**Panel 3**
Apichart Anukularmphai (A & R)	**Panel 3**
Chatthip Nartsupha (Chulalongkorn University)	**Panel 4**
Akin Rabibhadana	**Panel 4**
Amara Pongsapich (Chulalongkorn University)	**Panel 5**
Ammar Siamwalla (TDRI)	**Panel 5**
Charnvit Kasetsiri (Thammasat University)	**Panel 6**
Yoshihiro Kaida (Kyoto University)	**Panel 6**

Rapporteurs

Naruemon Hinshiranan (Chula)	**Panel 1**
Banthinee Soothsukon (Kasetsart University)	**Panel 2**
François Molle (Institut de Recherche pour le Développement)	**Panel 3**
Somporn Isvilanonda (Kasetsart University)	**Panel 4**
Porphant Ouyyanont (Sukhothai Thammatirat Univ.)	**Panel 5**
Thanawat Jarupongsakul (Chulalongkorn University)	**Panel 6**

Organising Committee of the Conference

Supot Faungfupong
Vice-President for Research and Academic Service, KU

Napavarn Noparatnaraporn
Dir. of Kasetsart University Research and Development Institute

Phacharavadee Paerattakul
International Affairs Division, Kasetsart University

Mailings, registration, information
Amphawan Guadkhan (DORAS, Kasetsart University)

Rooms, catering, reception, transports, social events, field trips
KURDI staff and International affairs Division staff

Conference Secretariat

- François Molle, Institut de Recherche pour le Développement
- Thippawal Srijantr, Faculty of Agriculture, Kasetsart University
- Amara Pongsapich, CUSRI, Chulalongkorn University
- Yoshihiro Kaida, CSEA, Kyoto University
- Bordin Rassameethes , KURDI, Kasetsart University

Contents

Keynote address

Panel 2

Land use: constraints, competition and opportunities

Panel 3

Water resources management and environmental issues

Posters

The Chao Phraya Society : Development and Change

Prof. Srisak Wallipodom

สังคมลุ่มแม่น้ำเจ้าพระยา : พัฒนาการและการเปลี่ยนแปลง

ศรีศักร วัลลิโภดม

พัฒนาการทางประวัติศาสตร์วัฒนธรรมของสยามประเทศก็คือ การเปลี่ยนแปลงสภาพทางภูมิศาสตร์ของดินดอนสามเหลี่ยมเจ้าพระยา จากเดลต้าเก่าสู่เดลต้าใหม่ที่ควบคู่ไปกับการเข้ามาตั้งหลักแหล่งของกลุ่มชนที่หลากหลายทางชาติพันธุ์จากภายนอก ทำให้เกิดสังคมลุ่มแม่น้ำขึ้น ลักษณะสำคัญของสังคมลุ่มแม่น้ำก็คือ การเป็นทั้งสังคมเกษตรกรรมทำสวนทำนา และทำการค้าขายกับภายนอกทางทะเล โดยมีแม่น้ำลำคลองเป็นเส้นชีวิต คือเป็นทั้งเส้นทางคมนาคมทั้งกับภายนอกและภายใน แหล่งน้ำเพื่อการกินอยู่และการเกษตร กับการเป็นแหล่งของการตั้งถิ่นฐานที่อยู่อาศัยเป็นบ้านเป็นเมืองและเป็นรัฐ การเปลี่ยนแปลงทางเศรษฐกิจสังคมที่มีผลกระทบอย่างรุนแรงกับชีวิตวัฒนธรรมของผู้คนในลุ่มแม่น้ำ เกิดเมื่อมีการพัฒนาประเทศให้เป็นสังคมอุตสาหกรรมที่เริ่มมาแต่ครั้งรัฐบาลจอมพลสฤษดิ์ ธนะรัชต์

ความนำ

ดินดอนสามเหลี่ยมเจ้าพระยา (Chao Phraya Delta) ที่รู้จักกันทั่วไปว่าลุ่มน้ำเจ้าพระยานั้น ก็คงเหมือนกับพื้นที่ลุ่มแม่น้ำในที่อื่นๆ ของโลก ที่เป็นแหล่งเกิดของบ้านเมืองและรัฐที่ใหญ่โตในสมัยโบราณ ไม่ว่าจะเป็นลุ่มแม่น้ำไนล์ของอียิปต์ ลุ่มแม่น้ำสินธุของอินเดีย ลุ่มแม่น้ำโขงในประเทศเวียดนามและกัมพูชา และลุ่มแม่น้ำอิรวดีของพม่า ต่างก็มีพัฒนาการของบ้านเมืองที่คล้ายคลึงกัน นั่นก็คือเมืองใหญ่เมืองสำคัญทางการเมืองและเศรษฐกิจ มักตั้งอยู่บนฝั่งของแม่น้ำที่ติดต่อกับภายนอกทางทะเลและภายในทั้งทางน้ำและทางบก เหตุที่มีพัฒนาการของสังคมมนุษย์จนเป็นบ้านเป็นเมืองที่สำคัญเกิดขึ้นนั้นเนื่องมาจากสภาพทางภูมิศาสตร์เป็นปัจจัยสำคัญ ดินดอนสามเหลี่ยมหรือเดลต้า คือพื้นที่ราบลุ่มที่เกิดจากการทับถมของโคลนตะกอนที่แม่น้ำและลำน้ำพัดพาลงมาจากภูเขาและพื้นที่สูง จึงเป็นดินที่อุดมสมบูรณ์ด้วยปุ๋ยธรรมชาติ เหมาะกับการเพาะปลูกพืชพันธุ์ธัญญาหารที่เลี้ยงคนได้เป็นจำนวนมาก และการมีลำน้ำและแม่น้ำที่ไหลลงสู่ทะเลได้ ทำให้มีการเคลื่อนไหวของผู้คนทั้งจากภายนอกและภายในเข้ามาตั้งหลักแหล่งที่อยู่อาศัยอย่างถาวร (sedentary settlements) และพัฒนาขึ้นเป็นบ้านเมืองทางเกษตรกรรมและการค้าขาย (port polity) เกิดขึ้น

ถ้าพิจารณาจากลักษณะการตั้งถิ่นฐานที่อยู่อาศัยและสภาพแวดล้อม สังคมมนุษย์ที่เกิดขึ้นบนดินดอนรูปสามเหลี่ยมแล้วก็อาจเรียกได้ว่าเป็นสังคมลุ่มแม่น้ำ (riverine society) เพราะการตั้งหลักแหล่งจะเกิดขึ้นตามริมฝั่งแม่น้ำลำคลองที่เป็นเส้นทางคมนาคมทั้งสิ้น เหตุที่เป็นเช่นนี้ เพราะบริเวณริมฝั่งแม่น้ำมักเป็นพื้นที่สูงที่เกิดจากการทับถมของโคลนตะกอน (levee) ในยามที่น้ำล้นฝั่งในฤดูน้ำ เป็นที่เหมาะกับการสร้างบ้านเรือนและเรือกสวนเป็นแหล่งชุมชน ตั้งแต่ระดับหมู่บ้าน (Villages) เมือง (towns) และนคร (cities) เรียงรายอยู่ตามริมฝั่งแม่น้ำลำคลอง รูปแบบของการตั้งถิ่นฐานเป็นแบบแนวยาวไปตามลำน้ำ (linear pattern) ด้านหน้าของบ้านเรือนที่อยู่อาศัยรวมทั้งวัดวาอารามที่เป็นศาสนสถาน ต่างก็หันหน้าลงแม่น้ำลำคลองที่เป็นเส้นทางคมนาคมทั้งสิ้น ส่วนด้านหลังของชุมชนก็มักเป็นทุ่งโล่ง เป็นไร่นาสาโทอันเป็นแหล่งที่ทำการเพาะปลูกพืชผลทางเกษตรกรรม ความสำคัญที่โดดเด่นของสังคมลุ่มแม่น้ำก็คือเป็นสังคมที่มีการเคลื่อนไหวเปลี่ยนแปลงอยู่ตลอดเวลา อันเนื่องมาจากการที่คนหลายเผ่าพันธุ์ หลายวัฒนธรรมทั้งที่เข้ามาจากภายนอกทางทะเล และเคลื่อนย้ายจากพื้นที่ภายใน (hinter land) มาผสมปนเปกันอย่างต่อเนื่อง จนทำให้เกิดบูรณาการทางวัฒนธรรมและการเมืองขึ้นเป็นสังคมที่เป็นรัฐและอาณาจักรในที่สุด

นอกจากนี้สภาพและลักษณะทางภูมิศาสตร์ของดินดอนรูปสามเหลี่ยม ก็เป็นปัจจัยที่สำคัญอีกอย่างหนึ่งที่ทำให้สังคมลุ่มแม่น้ำมีพัฒนาการและเปลี่ยนแปลงอยู่ตลอดเวลา ทั้งนี้เนื่องมาจากการงอกและการเกิดเป็นที่ดอนของพื้นดิน และการเปลี่ยนเส้นทางเดินของแม่น้ำลำน้ำที่เป็นเส้นทางคมนาคม ปัจจุบันหลักฐานทางด้านโบราณคดีและประวัติศาสตร์เท่าที่ศึกษากันในขณะนี้ ได้สะท้อนให้เห็นถึงพัฒนาการของบ้านเมืองและสังคมมนุษย์ที่สัมพันธ์กับการเปลี่ยนแปลงทางภูมิศาสตร์ของดินดอนรูปสามเหลี่ยมเจ้าพระยาอย่างน้อย ๓ สมัยเวลาด้วยกัน คือสมัยโลหะตอนปลาย สมัยทวารวดี – ลพบุรี และสมัยอยุธยา – กรุงเทพฯ แต่การเติบโตของสังคมลุ่มแม่น้ำที่ชัดเจนและสืบเนื่องมาจนถึงปัจจุบันนั้นแลเห็นในช่วงเวลาที่กรุงศรีอยุธยาและกรุงเทพฯ เป็นราชธานีและศูนย์กลางของประเทศ

โครงสร้างทางกายภาพของดินดอนสามเหลี่ยมเจ้าพระยากับการตั้งหลักแหล่งบ้านเมือง

นักวิชาการด้านธรณีสัณฐานที่ให้ภาพโครงสร้างทางกายภาพของดินดอนสามเหลี่ยมเจ้าพระยาอย่างเป็นที่เข้าใจแก่ข้าพเจ้าเป็นอย่างดี ก็คือ ศาสตราจารย์ โยชิกาสุ ทากาย่า แห่งมหาวิทยาลัยเกียวโต ประเทศญี่ปุ่น เป็นสิ่งที่ทำให้ข้าพเจ้านำไปเชื่อมโยงกับพัฒนาการของสังคมมนุษย์ที่เป็นบ้านเป็นเมืองได้อย่างเป็นรูปธรรม ทากาย่าได้แบ่งพื้นที่ภาคเหนือและภาคกลางของประเทศไทยออกเป็นสามตอน ตอนบน (upper reach) คือประมาณตั้งแต่จังหวัดเชียงใหม่ลงมาจนถึงอุตรดิตถ์ ลักษณะภูมิประเทศเป็นเขตภูเขา (mountains) และพื้นที่ราบลุ่มระหว่างเขา (intermountain basins) ตอนกลาง (middle reach) ตั้งแต่อุตรดิตถ์ลงมาจนถึงนครสวรรค์และชัยนาทเป็นพื้นที่ภูเขา (mountains) พื้นที่ลาดและที่ราบรูปพัด (Fan–terrace Complex) และพื้นที่น้ำท่วมถึง (flood plain) และพื้นที่ตอนล่าง (lower reach) ตั้งแต่จังหวัดชัยนาทลงมาจนจดอ่าวไทย บริเวณตอนล่างนี้นับเนื่องเป็นบริเวณดินดอนสามเหลี่ยมเจ้าพระยา ที่ประกอบด้วยพื้นที่ภูเขา (mountains) และพื้นที่ลาดและที่ราบรูปพัด (Fan–terrace

Complex) ทางด้านตะวันตกและตะวันออก ในขณะที่บริเวณตอนกลางเป็นดินดอนสามเหลี่ยมเก่า (Old delta) และดินดอนสามเหลี่ยมใหม่ (young delta) บริเวณที่เป็นเดลต้าเก่าเริ่มแต่ชัยนาทมาถึงอยุธยา บริเวณที่มีพื้นที่น้ำท่วมถึง (flood plain) รวมอยู่ด้วยทางด้านตะวันออก ส่วนพื้นที่เดลต้าใหม่นั้นกินบริเวณที่มีระดับต่ำกว่า ๒.๕ เมตร จากระดับน้ำทะเล ตั้งแต่จังหวัดอยุธยาลงมาจนถึงกรุงเทพฯ และอ่าวไทย[๑]

เมื่อนำโครงสร้างทางกายภาพทางภูมิศาสตร์ดังกล่าวนี้ มาเชื่อมโยงกับหลักฐานทางโบราณคดีที่เกี่ยวกับพัฒนาการของสังคมที่เป็นบ้านเป็นเมือง ก็พบว่าพัฒนาการของบ้านเมืองในระยะแรกเริ่มพบในบริเวณตอนล่าง (lower reach) ที่เป็นบริเวณดินดอนสามเหลี่ยม โดยอาจแบ่งออกเป็น ๓ ช่วงเวลาตามที่กล่าวมาแล้วในตอนต้น สมัยแรกเริ่มแต่ยุคโลหะตอนปลายที่มีอายุประมาณ ๑๕๐๐ ปีก่อนคริสตกาลจนถึงคริสต์ศตวรรษที่ ๔-๕ การตั้งถิ่นฐานอย่างถาวรของมนุษย์ (sedentary settlements) ขึ้นเป็นบ้านและเมืองเกิดขึ้นในบริเวณที่ลาด และที่ราบรูปพัด (Fan-terrace Complex) ที่อยู่ทางด้านตะวันตกและตะวันออกของดินดอนสามเหลี่ยม บริเวณเหล่านี้จะมีลำน้ำจากภูเขาและที่สูงซึ่งปัจจุบันเป็นต้นน้ำและลำน้ำเก่าของลำน้ำแม่กลอง ลำน้ำท่าจีน ลำน้ำลพบุรี ลำน้ำป่าสัก และลำน้ำปราจีนบุรี และบางปะกงหล่อเลี้ยง กลุ่มชนที่เข้ามาตั้งหลักแหล่งส่วนหนึ่งมาจากภายนอกทั้งทางบกและทางทะเล อีกทั้งมีความรู้ทางโลหะวิทยาแล้ว พอประมาณ ๕๐๐ ปีก่อนคริสตกาลลงมาก็มีการติดต่อกับอินเดียและจีน ทำให้เกิดการค้าขายทางทะเลขึ้น พบร่องรอยของชุมชนที่เป็นท่าเรือในบริเวณใกล้ทะเล ซึ่งปัจจุบันเคยเป็นพื้นที่ป่าชายเลนและชุมชนที่อยู่ภายในใกล้ลำน้ำใหญ่หลายแห่ง ตั้งแต่คริสต์ศตวรรษที่ ๔-๕ ลงมา ชุมชนบ้านเมืองเหล่านี้ก็ขยายตัวลงมายังพื้นที่ดินดอนสามเหลี่ยมเก่าและบริเวณใกล้เคียง เรียนรู้และรับอารยธรรมอินเดีย ตลอดจนมีการค้าขายกับโพ้นทะเลอย่างกว้างขวาง เกิดเมืองสำคัญที่เป็นทั้งเมืองท่าและศูนย์กลางของรัฐขึ้นมาตามลำน้ำสำคัญหลายแห่ง เช่นเมืองอู่ทอง เมืองคูบัว เมืองนครชัยศรีในลุ่มน้ำแม่กลอง-ท่าจีน เมืองละโว้ในลุ่มน้ำลพบุรี เมืองศรีมโหสถ เมืองพระรถในลุ่มน้ำบางปะกง เป็นต้น บ้านเมืองเหล่านี้ต่างเติบโตและขยายลงสู่ลุ่มน้ำต่างๆ ในพื้นที่ดินดอนสามเหลี่ยมเก่าจนถึงสมัยลพบุรีในคริสต์ศตวรรษที่ ๑๓ ปัจจุบัน ยังเห็นร่องรอยของชุมชนบ้านเมืองตามลำน้ำเก่าสายต่างๆ เป็นจำนวนมากที่แสดงให้เห็นว่าสังคมบ้านเมืองในสมัยทวารวดี-ลพบุรีนั้นคือสังคมลุ่มแม่น้ำ ที่การตั้งถิ่นฐานตามฝั่งแม่น้ำลำคลองที่เป็นเส้นทางคมนาคม การเติบโตของบ้านเมืองในบริเวณดินดอนสามเหลี่ยมใหม่ ที่มีอายุราวคริสต์ศตวรรษที่ ๑๔ ลงมา โดยมีเมืองอยุธยาเป็นศูนย์กลางนั้น ก็คือการสืบเนื่องของสังคมลุ่มแม่น้ำเก่าที่มีมาตั้งแต่สมัยทวารวดี-ลพบุรี นั่นเอง

การเกิดขึ้นของชุมชนบ้านเมืองในดินดอนสามเหลี่ยมใหม่นั้น สะท้อนให้แลเห็นการเปลี่ยนแปลงทางภูมิศาสตร์และสภาพแวดล้อมของดินดอนสามเหลี่ยมเจ้าพระยาอย่างแท้จริง นั่นก็คือทางน้ำและลำน้ำเก่าที่เคยเป็นเส้นทางคมนาคมในบริเวณดินดอนสามเหลี่ยมเก่า เปลี่ยนทางเดินไป ในขณะที่หลายๆ แห่งเกิดการตื้นเขิน ทำให้ชุมชนบ้านเมืองต้องโยกย้ายไปอยู่ที่อื่น โดยเฉพาะตามลำน้ำสายใหม่ที่เป็นเส้นทางคมนาคม ในขณะเดียวกันพื้นที่ซึ่งเคยต่ำในบริเวณดินดอนสามเหลี่ยมใหม่ก็ดอนขึ้น พอที่จะตั้งหลักแหล่งของบ้านเมืองได้ สิ่งที่น่าสังเกตก็คือในช่วงเวลานี้เริ่มแลเห็นความสำคัญของลำน้ำเจ้าพระยาอย่างชัดเจน เพราะก่อนหน้านี้จะไม่พบร่องรอยของบ้านเมืองที่อยู่ริมฝั่งแม่น้ำเจ้าพระยา ไม่

ว่าจะในพื้นที่ของดินดอนสามเหลี่ยมเก่าและใหม่ ในพื้นที่ดินดอนสามเหลี่ยมเก่าลำน้ำเจ้าพระยาที่ไหลลงมาจากเขตจังหวัดชัยนาทนั้น สองฝั่งของลำน้ำเป็นพื้นที่ลุ่มต่ำน้ำท่วมถึง (flood plain) ที่ไม่ต่างอะไรกันกับระดับของบริเวณดินดอนสามเหลี่ยมใหม่ แต่นับแต่การเกิดเมืองพระนครศรีอยุธยาขึ้นตรงรอยต่อของบริเวณดินดอนสามเหลี่ยมเก่าและใหม่ ก็เกิดมีการตั้งถิ่นฐานบ้านเมืองกันริมสองฝั่งน้ำเจ้าพระยาขึ้น และแม่น้ำนี้ก็กลายมาเป็นเส้นทางคมนาคมที่สำคัญที่ทำให้อยุธยาเป็นทั้งเมืองท่าติดต่อกับต่างประเทศทางทะเล และเป็นชุมทางของเส้นทางคมนาคมทางน้ำจากหัวเมืองต่างๆ ที่อยู่ภายใน ในช่วงเวลาที่เกิดเมืองอยุธยาขึ้นที่แม่น้ำเจ้าพระยานั้น ก็มีการเกิดของเมืองรุ่นใกล้เคียงกันตามลำน้ำสายอื่นๆ ที่เป็นเส้นทางคมนาคมยุคใหม่ของบริเวณดินดอนสามเหลี่ยมเจ้าพระยา เช่นเมืองสุพรรณภูมิ หรือสุพรรณบุรีบนฝั่งแม่น้ำท่าจีน เมืองแพรกศรีราชาบนฝั่งลำน้ำน้อย เมืองราชบุรีบนฝั่งน้ำแม่กลองและเมืองเพชรบุรีบนฝั่งน้ำเพชรบุรี เป็นต้น

ควบคู่กันไปกับการเกิดเมืองสำคัญตามลำแม่น้ำที่อยู่ภายใน ก็มีการเคลื่อนไหวของการตั้งถิ่นฐานและบ้านเมืองแถวบริเวณปากแม่น้ำและชายทะเลในพื้นที่ ซึ่งเป็นป่าชายเลนและทะเลตมในรูปของบางต่างๆ ที่มีชื่อสัมพันธ์กับลักษณะพื้นที่ภูมิประเทศ พืชพันธุ์ ต้นไม้ และสัตว์ที่อยู่ในท้องถิ่น ในสมัยหลังลงมา บรรดาบางหรือท้องถิ่นเหล่านี้ หลายแห่งก็กลายเป็นเมือง เช่นเมืองสมุทรสงคราม เมืองสาครบุรี เมืองธนบุรี เมืองนนทบุรี

วรรณคดีชิ้นสำคัญของกรุงศรีอยุธยาที่เรียกชื่อว่า กำศรวลสมุทร *(ที่ทางราชการเรียกว่ากำศรวลศรีปราชญ์ และเข้าใจว่าแต่งขึ้นในรัชกาลของสมเด็จพระนารายณ์ฯ ในคริสต์ศตวรรษที่ ๑๗)* แต่งขึ้นประมาณรัชกาลของสมเด็จพระรามาธิบดีที่ ๒ ในคริสต์ศตวรรษที่ ๑๕ นั้น คือหลักฐานทางประวัติศาสตร์ที่สำคัญที่แสดงให้เห็นถึงบรรดาท้องถิ่นที่อยู่อาศัยของผู้คนตามสองฝั่งแม่น้ำเจ้าพระยา ตั้งแต่พระนครศรีอยุธยาลงมาจนถึงปากแม่น้ำและชายฝั่งทะเลที่เป็นป่าชายเลนและทะเลตม

แม้ว่าวรรณคดีฉบับนี้จะไม่กล่าวถึงเมืองบางกอก ธนบุรี และนนทบุรีแต่อย่างใด แต่ก็กล่าวถึงชื่อย่านและบางต่างๆ ที่สืบมาจนทุกวันนี้ เช่น บางตระนาว เกาะราชคราม เชียงราก เทียนถวาย สำโรงบางบำหรุ ทุ่งบางเขน บางระมาด บางผึ้ง เป็นต้น

สิ่งที่น่าสังเกตก็คือตามสองฝั่งลำน้ำเจ้าพระยาจากอยุธยาถึงชายทะเลในวรรณคดีเรื่องนี้ ไม่กล่าวถึงคลองที่มีการขุดขึ้นแต่อย่างใด การเดินทางคงไปตามลำน้ำธรรมชาติที่มีลักษณะคดเคี้ยวเป็นคุ้งเป็นตอนที่ดูเสียเวลามากกว่าจะออกทะเล

การกล่าวถึงการขุดลอกคลอง มีปรากฏในพระราชพงศาวดารอยุธยา ที่ว่าในรัชกาลของสมเด็จพระรามาธิบดีที่ ๒ โปรดเกล้าฯ ให้ขุดลอกคลองสำโรงที่มีมาก่อน จากแม่น้ำเจ้าพระยาผ่านบริเวณป่าชายเลน ไปออกทะเลแถวอ่าวบางปะกง

สมัยรัชกาลของสมเด็จพระชัยราชาธิราชในตอนปลายของคริสต์ศตวรรษที่ ๑๕ ได้มีการขุดคลองลัดที่ตำบลบางกอก แล้วต่อมาก็สถาปนาเมืองธนบุรีศรีมหาสมุทรขึ้นในบริเวณนั้น ซึ่งก็อาจกล่าวได้ว่า การขุดคลองลัดทำให้บริเวณนั้นเกิดเป็นเมืองขึ้น

เรื่องนี้ก็ดูเข้ากันได้กับการขุดคลองลัดแม่น้ำอ้อมจากปากคลองบางใหญ่บริเวณเหนือวัดเฉลิมพระเกียรติมายังปากคลองบางกรวยที่หน้าวัดเขมาภิรตารามในรัชกาลของสมเด็จพระเจ้าปราสาททองในคริสต์ศตวรรษที่ ๑๖ ทำให้เกิดเมืองตลาดแก้ว ตลาดขวัญ ที่ต่อมาเป็นเมืองนนทบุรี

ในขณะที่ผลของการขุดคลองลัดแม่น้ำอ้อมที่เชียงราก ที่เรียกว่าคลองลัดเกร็ดใหญ่ ในรัชกาลของสมเด็จพระเจ้าทรงธรรมนั้น ต่อมาในรัชกาลของสมเด็จพระนารายณ์ โปรดฯ ให้พวกมอญอพยพมาพึ่งพระบรมโพธิสมภารไปตั้งถิ่นฐานอยู่อาศัย ได้เกิดเป็นเมืองสามโคกขึ้นมา แล้วมาเปลี่ยนเป็นเมืองปทุมธานีในรัชกาลที่ ๒ แห่งกรุงรัตนโกสินทร์

สิ่งที่น่าสังเกตเป็นพิเศษในเรื่องการตั้งถิ่นฐานบ้านเมืองแต่สมัยอยุธยาลงมาก็คือ แหล่งที่เป็นชุมชนใหญ่ที่เป็นเมืองนั้น มักเกิดขึ้นในบริเวณที่เป็นแม่น้ำอ้อม ซึ่งมักมีบริเวณที่ดอนเกิดขึ้นเนื่องจากการทับถมของโคลนตะกอน ดังเห็นได้จากบริเวณเมืองพระนครศรีอยุธยา เมืองบางกอกหรือเมืองธนบุรี เมืองนนทบุรี เมืองสามโคก และบริเวณอำเภอปากเกร็ดในปัจจุบัน

ในขณะเดียวกันก็มีการขุดคลองลัดและคลองเชื่อมลำน้ำธรรมชาติเพื่อความสะดวกในการคมนาคม และในเวลาเดียวกันก็มีการขยายตัวของชุมชนหมู่บ้านและเมืองขนาดเล็กไปตามลำน้ำลำคลองเหล่านั้น ลักษณะเช่นนี้แลเห็นได้จากบรรดาคลองขุดรอบๆ ตัวเมืองอยุธยา โดยเฉพาะทางเหนือและทางใต้ จนทำให้เห็นได้ว่าเมืองอยุธยานั้นไม่เพียงแต่เป็นเกาะที่มีแม่น้ำล้อมรอบเท่านั้น หากยังมีเครือข่ายของแม่น้ำลำน้ำ และลำคลองอยู่โดยรอบ การขุดคลองเชื่อมระหว่างลำน้ำอ้อมบางกอกน้อยที่ผ่านวัดชัยพฤกษ์มาลาไปยังลำน้ำอ้อมบางกรวยที่วัดรวก ในรัชกาลของสมเด็จพระมหาจักรพรรดิ์ก็เป็นอีกตัวอย่างหนึ่งที่ทำให้เกิดการเติบโต และการขยายตัวของชุมชนในบริเวณดินดอนสามเหลี่ยมใหม่ที่ต่ำจากอยุธยาลงมา ครั้นถึงสมัยกรุงเทพฯ ก็มีการขุดคลองซอยออกจากสองฝั่งแม่น้ำเจ้าพระยาไปทั้งทางตะวันตก และตะวันออกมากมาย โดยเริ่มแต่เขตเมืองสามโคกลงมา คลองเหล่านี้ล้วนมีชื่อเสียงเรียงนาม และมักปรากฏกล่าวถึงในวรรณคดีที่เรียกว่านิราศ เช่น นิราศภูเขาทองของสุนทรภู่ เป็นต้น บ้านเรือนผู้คนก็จะขยายตัวตามลำคลองนี้ออกไปสู่บริเวณท้องทุ่ง บริเวณใดที่เป็นเมืองก็มักจะมีคลองขุดแยกออกจากแม่น้ำออกไปทั้งสองฝั่ง ตรงใดที่เป็นปากคลองก็มักพบวัดสำคัญและย่านตลาด สิ่งที่น่าสังเกตก็คือ มีการขุดคลองเชื่อมต่อกันระหว่างแม่น้ำสำคัญ ไม่ว่าจะเป็นกับแม่น้ำบางปะกงที่อยู่ทางด้านตะวันออก กับแม่น้ำท่าจีนและแม่น้ำแม่กลองทางด้านตะวันตก แต่ความสำคัญดูเหมือนจะหนักไปทางด้านตะวันตกกับทางแม่น้ำท่าจีนและแม่กลองมากกว่า ทำให้แลเห็นการตั้งถิ่นฐานที่เติบโตและต่อเนื่องของพื้นที่ในลุ่มน้ำเจ้าพระยาทางด้านตะวันตกกับแม่น้ำท่าจีนและแม่กลอง พื้นที่ทั้งสามลุ่มน้ำนี้คือ พื้นที่รองรับประชากรส่วนใหญ่ในดินดอนสามเหลี่ยมใหม่ในสมัยกรุงเทพฯ ตอนต้น

พอมาถึงสมัยรัชกาลที่ ๕ การเติบโตของบ้านเมืองในลุ่มแม่น้ำก็ถึงขีดสุด เพราะมีการขุดคลองกันอย่างมากมายในท้องทุ่งสองฝั่งแม่น้ำเจ้าพระยา แต่คลองส่วนใหญ่ที่ขุดนั้นไม่ได้มุ่งหวังเพื่อการคมนาคมอย่างแต่ก่อนเพียงอย่างเดียว หากมุ่งเพื่อขยายพื้นที่การเกษตรในการปลูกข้าว ซึ่งเป็นสินค้าที่สำคัญของประเทศ ผลที่ตามมาของการขุดคลองก็คือ การกระจายตัวของชุมชนในระดับหมู่บ้านที่เข้าไปในท้องทุ่งทั้งด้านตะวันตกและตะวันออก โดยเฉพาะทุ่งรังสิตนั้นกินพื้นที่ไกลออกไปจนถึงเขตจังหวัดนครนายก

พัฒนาการทางสังคมและวัฒนธรรม

ตามที่กล่าวมาแล้วก็คือ การเสนอให้เห็นถึงการเปลี่ยนแปลงทางสภาพแวดล้อมและลักษณะทางภูมิศาสตร์ของดินดอนสามเหลี่ยมเจ้าพระยา ที่สัมพันธ์กับการตั้งถิ่นฐานบ้านเมืองของมนุษย์ในพื้นที่ลุ่มแม่น้ำในช่วงเวลาต่างๆ ซึ่งถ้าหยุดอยู่เพียงแค่นี้ก็เท่ากับเป็นการยอมรับอิทธิพลของสภาพทางภูมิศาสตร์ในการกำหนดการตั้งถิ่นฐานและการเกิดขึ้นของบ้านเมืองอย่างสิ้นเชิง (geographical determinism) แต่ถ้ามองในทำนองตรงข้าม ผู้ที่กำหนดการตั้งถิ่นฐานและรูปแบบทั้งในด้านโครงสร้างทางกายภาพและโครงสร้างทางสังคม-วัฒนธรรมที่แท้จริงแล้ว ก็คือมนุษย์นั่นเอง

การที่มนุษย์ต้องอยู่รวมกันเป็นสังคมนั้น ทำให้เกิดการตั้งถิ่นฐานร่วมกันเป็นชุมชนขึ้น ในขณะเดียวกันศักยภาพของมนุษย์ในด้านการเรียนรู้ได้ทำให้มนุษย์คิดอะไรร่วมกันในด้านการดำรงชีวิต ไม่ว่ากระบวนการปรับตัวเองเข้ากับสภาพแวดล้อมทางธรรมชาติ การสร้างระบบทางสังคมเศรษฐกิจ การเมืองและระบบความเชื่อ จนเกิดเป็นระบบทางวัฒนธรรมที่มีรูปแบบเฉพาะของแต่ละกลุ่มแต่ละสังคมขึ้นมา รูปแบบดังกล่าวนี้ก็มักเปลี่ยนแปลงไปตามยุคสมัยแห่งกาลเวลา อันเนื่องมาจากความไม่หยุดนิ่งทางสังคมและความคิดที่เกิดจากกระบวนการเรียนรู้ของมนุษย์นั่นเอง

ความไม่หยุดนิ่งทางสังคมของมนุษย์นั้นคือ การเกิดและการตายตามธรรมชาติที่ทำให้เกิดคนรุ่นเก่าและรุ่นใหม่อยู่ตลอดเวลา ในขณะเดียวกันก็มีการย้ายเข้าและย้ายออกที่ทำให้จำนวนคนอาจเพิ่มขึ้นหรือน้อยลงกว่าเดิมได้ พัฒนาการทางสังคมของผู้คนในบริเวณดินดอนสามเหลี่ยมเจ้าพระยานั้น หาได้เกิดขึ้นจากการเติบโตของกลุ่มชนใดกลุ่มชนหนึ่งจากอัตราการเกิด หรือการเจริญพันธุ์ไม่ หากเกิดขึ้นจากการเคลื่อนย้ายของชนกลุ่มต่างๆ จากภายนอกเข้ามาตั้งถิ่นฐานในช่วงเวลาต่างๆ ทางประวัติศาสตร์เป็นสำคัญ

จากหลักฐานทางด้านโบราณคดีเท่าที่พบและศึกษากันในขณะนี้ สะท้อนให้เห็นว่าบริเวณดินดอนสามเหลี่ยมเจ้าพระยามีพัฒนาการทางสังคมที่แลเห็นได้ชัดเจนจากการตั้งถิ่นฐานและรูปแบบทางวัฒนธรรมเป็นบ้านเป็นเมืองมาประมาณ ๓,๕๐๐ ปีที่ผ่านมาเป็นอย่างมาก อีกทั้งเป็นพัฒนาการที่เกิดจากการเคลื่อนย้ายเข้ามาของกลุ่มชนต่างๆ จากภายนอก วัฒนธรรมที่เกิดขึ้นในช่วงเวลาดังกล่าวนี้ พอเรียกได้ว่าเป็นยุคโลหะ เพราะคนในยุคนี้มีความรู้ในการถลุงโลหะธาตุ และนำโลหะมาทำเครื่องมือเครื่องใช้และเครื่องประดับกันแล้ว ซึ่งก็แสดงให้เห็นว่าเป็นสังคมที่มีความก้าวหน้าทางเทคโนโลยีเป็นอย่างมาก ความรู้ในด้านนี้คงมากับกลุ่มชนจากภายนอกที่เคลื่อนย้ายเข้ามา ยิ่งกว่านั้นกลุ่มคนเหล่านี้ยังมีการนำเอาเปลือกหอยทะเลชนิดต่างๆ จากทะเลลึก มาทำเป็นเครื่องประดับที่มีราคาและใช้เป็นเงินตราในการแลกเปลี่ยนสินค้าอีกด้วย

ตัวอย่างเช่น ทางด้านตะวันออกของลุ่มน้ำเจ้าพระยาพบแหล่งฝังศพของคนก่อนประวัติศาสตร์ในลุ่มน้ำลพบุรี-ป่าสัก ที่มีการใช้หอยเบี้ย (cowry) ปูพื้นรองรับศพคนตาย และมีการใช้หอยสังข์และหอยมือเสือทำเครื่องประดับ เช่น กำไลและต่างหู เป็นต้น ในขณะเดียวกันก็พบว่าบรรดาชุมชนโบราณเหล่านั้นหลายแห่งสัมพันธ์กับการถลุงทองแดงและเหล็ก อาจตีความได้ว่าโลหะธาตุคือสิ่งสำคัญ ที่ดึงดูดให้มีกลุ่มชนจากภายนอกที่มีความก้าวหน้าทางเทคโนโลยีเคลื่อนย้ายเข้ามาตั้งถิ่นฐาน ส่วนทางด้านตะวันตกของลุ่มน้ำเจ้าพระยาก็พบชุมชนในยุคโลหะที่สะท้อนให้เห็นถึง การติดต่อกับภายนอกทางทะเล

อย่างต่อเนื่อง เช่น บริเวณโคกพลับ ตำบลโพธิ์หัก อำเภอบางแพ จังหวัดราชบุรี พบแหล่งฝังศพของกลุ่มชนโบราณที่ตั้งอยู่บนที่ราบลุ่มใกล้ทะเล พบเครื่องประดับเป็นต่างหู และหวีที่เป็นศิลปะของเวียดนามเหนือและจีน เป็นชุมชนที่มีอายุไม่ต่ำกว่า ๒๘๐๐ ปีที่ผ่านมา แต่ที่สำคัญก็คือในพื้นที่ลุ่มน้ำท่าจีน-แม่กลองที่อยู่ในเขตจังหวัดสุพรรณบุรี ราชบุรี และกาญจนบุรีนั้น มีแหล่งชุมชนโบราณที่พบโบราณวัตถุทั้งที่เป็นของนำเข้ามาจากภายนอก และที่แสดงให้เห็นว่าเป็นของกลุ่มชนที่เคลื่อนย้ายจากภายนอกเข้ามา เช่น พวกลูกปัดหลายสี (etched beads) และภาพจารบนภาชนะสำริดที่เป็นวัฒนธรรมอินเดีย ต่างหู จี้ห้อยคอแบบ-ลิง-ลิง-โอ และกลองมโหระทึกที่มาจากเวียดนามและจีนใต้ ชุมชนทางซีกตะวันตกของลุ่มน้ำเจ้าพระยาดังกล่าวนี้ นับเนื่องเป็นชุมชนทางการค้าที่ติดต่อกับภายนอกทางทะเลและติดต่อกับผู้คนที่อยู่ตามป่าเขาที่เป็นเครือข่าย เพราะพบแหล่งโบราณคดีตามถ้ำและป่าเขาในเทือกเขาตะนาวศรี และถนนธงชัยหลายแห่ง ที่มีโบราณวัตถุที่ได้มาจากการแลกเปลี่ยนสินค้าของป่าและแร่ธาตุ ยกตัวอย่างเช่น กลองสำริด ลูกปัด และเครื่องมือเครื่องใช้ที่ทำด้วยสำริดและเหล็ก

บริเวณที่มีความเคลื่อนไหวในด้านการค้าขายและติดต่อกับภายนอกทางทะเล และติดต่อกับภายในทั้งทางบกและทางน้ำ มากว่าแห่งใดๆ ในลุ่มน้ำเจ้าพระยา ก็คือบริเวณลุ่มน้ำจระเข้สามพันซึ่งเป็นลำน้ำสาขาของแม่น้ำท่าจีน มีต้นน้ำมาจากที่สูงทางตะวันตกและทางเหนือในเขตอำเภอพนมทวน และอำเภอบ่อพลอย จังหวัดกาญจนบุรี ลำน้ำนี้ไหลลงสู่ที่ลุ่มต่ำของแม่น้ำท่าจีนในเขตอำเภอสองพี่น้อง จังหวัดสุพรรณบุรี พื้นที่ซึ่งลำน้ำจระเข้สามพันไหลผ่านนี้พบร่องรอยของชุมชนโบราณที่มีอายุแต่ราว ๒,๕๐๐ ปีลงมามากมาย อีกทั้งมีการอยู่สืบเนื่องมาจนถึงสมัยยุคต้นประวัติศาสตร์โดยมีเมืองอู่ทองพัฒนาขึ้นเป็นเมืองท่าที่มีการติดต่อกับภายนอกทางทะเลที่มีอายุเก่ากว่า และร่วมสมัยเดียวกันกับเมืองออกแอวซึ่งเป็นเมืองท่าของแควันฟูนันที่อยู่ใกล้กับปากน้ำโขงในประเทศเวียดนาม บริเวณนี้พบโบราณวัตถุมากมายที่มาจากภายนอก เช่น จากกรีก โรมัน จีนและอินเดีย ความแตกต่างกันระหว่างเมืองอู่ทองกับเมืองออกแอวก็คือเมืองออกแอวอยู่ในพื้นที่ลุ่มต่ำน้ำท่วมถึง ลักษณะเหมือนกับพื้นที่ป่าชายเลน ส่วนเมืองอู่ทองอยู่บนตระพักที่สูงที่ลาดลงจากภูเขามาจดกับพื้นที่ลุ่มต่ำที่มีลำน้ำใหญ่ผ่าน ทำให้แลเห็นตัวเมืองและความเป็นเมืองโดดเดี่ยวกว่า แต่ทั้งนี้ทั้งนั้นไม่ได้หมายความว่าบรรดาชุมชนอื่นๆ ใกล้เคียงที่ร่วมสมัยเดียวกันกับเมืองอู่ทองจะตั้งอยู่บนที่สูงที่ดอนเช่นเมืองอู่ทอง ทำนองตรงข้ามกลับพบร่องรอยของชุมชนขนาดเล็กอีกมากมายที่กระจายกันอยู่ตามพื้นที่ริมลำน้ำและที่ดอนในบริเวณที่ลุ่มต่ำของแม่น้ำท่าจีน ทั้งในเขตอำเภอสองพี่น้องและบริเวณใกล้เคียง

แม้ว่าเมืองอู่ทองจะสืบเนื่องมาจนถึงคริสต์ศตวรรษที่ ๗-๘ ที่นับเนื่องเป็นสมัยทวารวดีที่มีพัฒนาการของรัฐที่ได้รับอารยธรรมจากอินเดียแล้ว แต่ความสำคัญในฐานะเป็นเมืองท่าก็ลดน้อยลง อันเนื่องมาจากการเกิดเมืองสำคัญขึ้นตามลำน้ำที่สะดวกในการคมนาคมกว่า ได้แก่เมืองนครชัยศรีที่ลำน้ำบางแก้วในเขตจังหวัดนครปฐม และเมืองคูบัว ที่ลำแม่น้ำอ้อมในเขตจังหวัดราชบุรี เมืองนครชัยศรีสัมพันธ์กับลำน้ำท่าจีนในขณะที่เมืองคูบัวเกี่ยวข้องกับลำน้ำแม่กลอง ทั้งสองเมืองต่างก็เป็นเมืองท่าที่ใหญ่และสำคัญทางซีกตะวันตกของแม่น้ำเจ้าพระยา อีกทั้งเป็นศูนย์กลางทางพุทธศาสนาและศิลปวัฒนธรรมของสมัยทวารวดี ความเจริญทางการค้าและวัฒนธรรมเป็นสิ่งที่แพร่หลายจากเมืองสำคัญที่เป็นเมืองท่าทั้งสองแห่งนี้ไปทางตอนเหนือและตะวันออกเฉียงเหนือของดินดอนสามเหลี่ยมเจ้าพระยา ไป

ตามแม่น้ำลำคลอง เป็นผลให้เกิดบ้านเมืองภายในที่เป็นดินดอนสามเหลี่ยมเก่า ตั้งแต่สิงห์บุรี ลพบุรี ชัยนาท ไปจนถึงนครสวรรค์ ปัจจุบันจะพบร่องรอยของเมืองโบราณที่มีคูน้ำคันดินล้อมตามลำน้ำต่างๆ ในเขตดินดอนสามเหลี่ยมเก่ามากมาย เมืองเหล่านี้ไม่อาจนับเป็นเมืองท่าที่ติดต่อกับโพ้นทะเลได้ เช่น นครชัยศรีและคูบัว เพราะไม่พบหลักฐานทางโบราณคดีที่เป็นของมาจากภายนอกเหมือนเช่นทางอู่ทอง นครชัยศรีและคูบัว ดูเหมือนเมืองท่าที่ติดต่อทางทะเล ทางซีกตะวันออกของลุ่มน้ำเจ้าพระยา จะพบเฉพาะในลุ่มน้ำบางปะกงซึ่งได้แก่เมืองศรีมโหสถ ในเขตอำเภอโคกปีป จังหวัดปราจีนบุรี และเมืองพระรถในเขตอำเภอพนัสนิคม จังหวัดชลบุรี เท่านั้น

หากมองภาพรวมจากการเชื่อมโยงบรรดาร่องรอยเมืองโบราณและชุมชนโบราณที่พัฒนาขึ้นในสมัยทวารวดีเข้ากับสภาพภูมิศาสตร์ของดินดอนสามเหลี่ยมเจ้าพระยาแล้ว ก็อาจกล่าวได้ว่าสังคมมนุษย์ที่อยู่ในบริเวณนี้ คือ สังคมในลุ่มแม่น้ำลำคลอง เพราะส่วนใหญ่เกิดขึ้นในที่ราบลุ่ม ตามแม่น้ำและลำน้ำที่เป็นเส้นทางคมนาคม จากหลักฐานทางโบราณคดีและเส้นทางคมนาคมโบราณ พออนุมานได้ว่าผู้คนที่เข้ามาตั้งหลักแหล่งนั้น มีทั้งการขยายตัวของกลุ่มชนเดิมของท้องถิ่นที่มีมาแต่สมัยโลหะตอนปลาย กลุ่มชนที่เคลื่อนย้ายลงมาจากที่ราบสูงในภาคตะวันออกเฉียงเหนือ และกลุ่มชนที่เข้ามาทางทะเล การขยายตัวของกลุ่มคนในพื้นที่แต่เดิมในยุคโลหะลงสู่ลุ่มแม่น้ำนั้น เห็นได้จากการพบแหล่งโบราณคดีแบบก่อนประวัติศาสตร์ในพื้นที่ลุ่มแม่น้ำ ปะปนและผสมผสานกันกับแหล่งชุมชนในวัฒนธรรมพุทธศาสนาแบบทวารวดี ส่วนร่องรอยของการเคลื่อนย้ายของกลุ่มชนสมัยก่อนประวัติศาสตร์จากภาคตะวันออกเฉียงเหนือลงสู่พื้นที่ลุ่มแม่น้ำในภาคกลางนั้น เห็นได้จากรูปแบบของชุมชนหลายแห่งในพื้นที่ลุ่มน้ำเจ้าพระยาตอนบน คล้ายคลึงกับที่พบในภาคตะวันออกเฉียงเหนือ เช่น ผังเมืองศรีเทพ จังหวัดเพชรบูรณ์ เมืองบน เมืองบึงคอกช้างและเมืองดงแม่นางเมือง ในจังหวัดนครสวรรค์ เป็นต้น ยิ่งกว่านั้นยังพบโบราณวัตถุบางอย่างที่แสดงความสัมพันธ์ทางสังคมและวัฒนธรรมกับผู้คนในภาคตะวันออกเฉียงเหนือ เช่น ประเพณีการปักหินตั้งหรือเสมาแสดงเขตศักดิ์สิทธิ์ของศาสนสถาน ที่ตามชุมชนทวารวดีในภาคกลางหลายแห่ง เช่น ที่เมืองศรีเทพ เมืองบน เมืองทัพชุมพล และดงแม่นางเมืองในเขตจังหวัดนครสวรรค์ สำหรับความสัมพันธ์ระหว่างชุมชนบ้านเมืองในลุ่มน้ำเจ้าพระยากับกลุ่มชนในภาคตะวันออกเฉียงเหนือนี้ ยังยืนยันให้เห็นจากร่องรอยของอิทธิพลศาสนา และวัฒนธรรมยุคทวารวดีจากภาคกลาง ที่ผ่านเมืองศรีเทพเข้าสู่ลุ่มน้ำมูล-ชี อีกด้วย ยิ่งเมื่อย้อนหลังขึ้นไปในยุคโลหะก็ยิ่งแลเห็นร่องรอยของการเคลื่อนย้ายของผู้คนจากภายนอกทางชายทะเลในเขตประเทศเวียดนาม ผ่านเข้ามายังภาคตะวันออกเฉียงเหนือ จนทำให้ภูมิภาคนี้มีประชากรที่หนาแน่นกว่าบริเวณอื่นๆ ในประเทศไทยและประเทศใกล้เคียง เช่นลาวและเขมร

แต่กลุ่มคนที่สำคัญที่ทำให้เกิดการเคลื่อนไหว และเปลี่ยนแปลงทางเศรษฐกิจและวัฒนธรรมอย่างมากนั้น น่าจะเป็นกลุ่มที่อยู่ในพื้นที่ใกล้ทะเล ร่องรอยของการเข้ามาตั้งถิ่นฐานของผู้คนเหล่านี้ นักวิชาการส่วนใหญ่โดยเฉพาะนักโบราณคดีให้ความสนใจน้อย เพราะมักจะคิดเห็นว่าบริเวณพื้นที่ใกล้ทะเลเป็นที่ลุ่มต่ำเป็นป่าชายเลนและทะเลตม ไม่เหมาะแก่การตั้งถิ่นฐานของคนส่วนใหญ่ที่มีอาชีพทางเกษตรกรรม จนเมื่อไม่นานมานี้ได้มีการพบแหล่งโบราณคดีในพื้นที่เหล่านี้ขึ้น เช่นที่โคกพนมดี และบริเวณใกล้เคียงที่แสดงให้เห็นว่ามีกลุ่มชนที่อาศัยอยู่ในพื้นที่นี้มาช้านาน หากินอยู่กับการรวบรวม

อาหารทะเล เช่น หอย ปู ปลา ในพื้นที่ทะเลตมและป่าชายเลนมาดำรงชีวิต รวมทั้งนำอาหารเหล่านี้ไปแลกเปลี่ยนกับกลุ่มชนภายในที่เป็นกสิกร สิ่งที่น่าสังเกตและน่าสนใจก็คือ บรรดาแหล่งโบราณคดีของคนเหล่านี้มักอยู่บนที่ดอนคล้ายๆ กับเกาะอยู่ท่ามกลางที่ลุ่มน้ำท่วมถึง ทำให้เข้าใจได้ว่าบรรดาพื้นที่ลุ่มต่ำตามริมลำน้ำในแถบป่าชายเลนใกล้ทะเล ก็มีพื้นที่ดอนที่ตั้งหลักแหล่งชุมชนได้เหมือนกัน หลายๆ แห่งของชุมชนเหล่านี้ได้กลายเป็นแหล่งท่าเรือ หรือที่พักสินค้าของพวกพ่อค้าหรือผู้ที่เข้ามาทางทะเลได้เข้ามาตั้งหลักแหล่งผสมผสาน จนเกิดเป็นชุมชนที่กระจายกันอยู่ตามที่ต่างๆ แต่น่าเสียดายที่ไม่ใคร่มีผู้สนใจทำการสำรวจค้นคว้ากัน หลายๆ แห่งก็ถูกทำลายหมดไป คงเหลือแหล่งที่พอให้ศึกษาได้ไม่กี่แห่ง เช่น หนองโนในเขตจังหวัดชลบุรี ในพื้นที่ซีกตะวันออกของดินดอนสามเหลี่ยมเจ้าพระยา ที่อาจนับเนื่องเป็นชุมชนบริวารของเมืองพระรถในเขตอำเภอพนัสนิคม อันเป็นเมืองท่าสมัยทวารวดีที่พัฒนาขึ้นในระยะเวลาต่อมา ในขณะที่ทางซีกตะวันตกในเขตลุ่มน้ำท่าจีนก็เห็นตัวอย่างได้ที่โคกพลับ ตำบลโพธิ์หัก อำเภอบางแพและบริเวณอื่นๆ ในแถบลุ่มน้ำท่าจีนที่มีส่วนสัมพันธ์กับการเกิดเมืองนครชัยศรีอันเป็นเมืองสำคัญของสมัยทวารวดี

บริเวณที่พบแหล่งชุมชนโบราณของกลุ่มชนใกล้ทะเลที่แสดงให้เห็นถึงการสืบเนื่องแต่สมัยทวารวดีมาจนสมัยลพบุรีและอยุธยา ก็คือบริเวณปากน้ำแม่กลองและอ่าวบางตะบูนที่สัมพันธ์กับปากแม่น้ำเพชรบุรี แต่เดิมเคยเป็นชายหาดเก่า เมื่อมีการทับถมของโคลนตะกอนเพิ่มขึ้นก็เกิดพื้นที่ป่าชายเลนและทะเลตมยื่นล้ำออกไป ทำให้บริเวณชายหาดแต่เดิมกลายเป็นที่ดอน เป็นที่ตั้งของชุมชนโบราณในสมัยทวารวดีที่มีเมืองคูบัวเป็นเมืองสำคัญ และมีชุมชนบริวารกระจายไปตามแนวชายหาดเดิมจนถึงเพชรบุรี เมืองคูบัวเป็นเมืองท่าที่มีลำน้ำใหญ่จากทะเลเข้าไปถึง คือ ลำแม่น้ำอ้อมที่แยกจากลำน้ำแม่กลอง ที่อำเภออัมพวาไหลวกไปทางอำเภอวัดเพลง แล้วมาบรรจบกับแม่น้ำแม่กลองอีกทีหนึ่งตรงบริเวณหน้าเมืองราชบุรี สองฝั่งแม่น้ำอ้อมเป็นป่าชายเลนที่มีทั้งที่ดอนและที่ลุ่ม พบการตั้งถิ่นฐานของผู้คนที่มีมาแต่สมัยก่อนประวัติศาสตร์ตอนปลายจนถึงสมัยทวารวดี เช่นที่โคกพริก และที่สืบเนื่องมาจนสมัยอยุธยา สิ่งที่แสดงให้เห็นร่องรอยการอยู่อาศัยที่สืบเนื่องก็คือ บรรดาเปลือกหอยโดยเฉพาะหอยแครงที่คนนำมาบริโภคและเศษภาชนะดินเผาหลายยุคหลายสมัย โดยเฉพาะเศษภาชนะดินเผาเคลือบของจีนนั้นมีแต่สมัยห้าราชวงศ์ สมัยราชวงศ์ซุ้ง ราชวงศ์หยวน มาจนถึงสมัยราชวงศ์หมิง ตรงท้องน้ำที่ลำแม่น้ำอ้อมมาบรรจบกับแม่น้ำแม่กลองที่หน้าเมืองราชบุรีนั้นมีผู้งมภาชนะดินเผานานาชนิดที่เป็นของมาจากภายนอก โดยเฉพาะภาชนะในยุคราชวงศ์หยวนนั้นมากเป็นพิเศษ รวมทั้งเหรียญอีแปะจีนหลายยุคหลายสมัยแต่ราชวงศ์ซุ้งเป็นต้นมา แต่ที่สำคัญพบแผ่นอิฐสมัยราชวงศ์ซุ้ง ที่มีผู้นำเข้ามาเพื่อสร้างศาสนสถานของคนจีนที่เข้ามาตั้งถิ่นฐาน ซึ่งก็อาจกล่าวได้ว่าหลักฐานทางโบราณคดีที่พบดังกล่าวนี้ พอชี้ให้เห็นว่ามีการเคลื่อนย้ายของคนจีนแต่สมัยราชวงศ์ซุ้งเข้ามาตั้งถิ่นฐานแถวปากแม่น้ำแม่กลอง เข้ามาตามลำแม่น้ำอ้อมจนถึงหน้าเมืองราชบุรี

เมืองราชบุรีมีหลักฐานทางโบราณคดี เช่น พระบรมธาตุที่เป็นพระปรางค์และกำแพงศิลาแลงล้อมวัดที่มีอายุแต่คริสต์ศตวรรษที่ ๑๓-๑๔ ลงมานั้น ตั้งอยู่ห่างจากเมืองคูบัวที่เป็นเมืองสำคัญในสมัยทวารวดีเพียง ๕ กิโลเมตร ทั้งระยะทางที่ห่างกันและช่วงเวลาที่สืบเนื่องกันนั้นแสดงให้เห็นว่าเมืองทั้งสองคือ เมืองเดียวกันแต่คนละสมัย การเปลี่ยนตำแหน่งเมืองก็เนื่องมาจากการย้ายตำแหน่งเมืองมาอยู่

ใกล้ทางน้ำที่เป็นเส้นทางคมนาคมใหม่ ประการหนึ่ง และอีกประการหนึ่งก็คือ เกิดชุมชนใหม่ขึ้นอันเนื่องมาจากมีคนจากภายนอกที่เป็นพวกพ่อค้าวานิชเข้ามาตั้งถิ่นฐานนั่นเอง การเกิดเมืองราชบุรีขึ้นในคริสต์ศตวรรษที่ ๑๓ นั้น นับเนื่องเป็นสมัยลพบุรี เพราะศิลปกรรมที่เห็นได้จากศาสนสถานที่เป็นแหล่งพิธีกรรมของชุมชนได้รับอิทธิพลวัฒนธรรมขอมที่มีอายุแต่คริสต์ศตวรรษที่ ๑๓ ลงมา แต่ในช่วงเวลานี้ก็หามีเมืองราชบุรีแต่เพียงแห่งเดียวไม่ หากเกิดเมืองร่วมสมัยอีกมากมาย อันแสดงให้เห็นถึงยุคของการเกิดบ้านเมืองใหม่อย่างชัดเจน โดยเฉพาะที่สัมพันธ์กับเมืองราชบุรี ก็คือเมืองเพชรบุรีเป็นเมืองที่ตั้งอยู่ริมลำน้ำเพชรบุรีที่ไหลมาออกอ่าวบางตะบูนบริเวณที่ตั้งของเมือง โดยเฉพาะในเขตวัดพริบพรีเคยเป็นชุมชนโบราณสมัยทวารวดีมาก่อน ชุมชนโบราณแห่งนี้มีอายุร่วมสมัยกับเมืองคูบัว และตั้งอยู่บนแนวหาดทรายเดิมที่ขนานไปกับแนวชายฝั่งทะเลปัจจุบันที่ยาวต่อเนื่องไปจนถึงเขตอำเภอชะอำ จังหวัดประจวบคีรีขันธ์

ความแตกต่างกันระหว่างเมืองราชบุรีและเมืองเพชรบุรีซึ่งร่วมสมัยเดียวกันก็คือ เมืองราชบุรีเป็นเมืองท่าที่สมบูรณ์ เพราะนอกจากสืบต่อมาจากเมืองคูบัวแต่สมัยทวารวดีแล้ว ยังเป็นเมืองที่ตั้งอยู่ริมแม่น้ำแม่กลองที่เรือเดินทะเลขนาดใหญ่สามารถแล่นเข้ามาได้ถึงบริเวณตัวเมือง ในขณะที่เมืองเพชรบุรีตั้งอยู่ริมลำน้ำเพชรบุรีที่แคบเรือเดินทะเลหรือเรือขนาดใหญ่ ไม่อาจแล่นเข้าไปถึงบริเวณตัวเมืองได้ แต่เมืองเพชรบุรีกลับมีหลักฐานทางด้านเอกสาร เช่นจดหมายเหตุจีนในคริสต์ศตวรรษที่ ๑๒-๑๓ ระบุให้เห็นว่าน่าจะเป็นเมืองท่า เช่น กล่าวว่าในปี ค.ศ.๑๒๙๔ ได้มีทูตของเสียมหรือสยามจากเมืองพริบพรีไปยังเมืองจีน เป็นต้น ซึ่งในช่วงเวลานี้ บริเวณดินดอนสามเหลี่ยมเจ้าพระยามีแคว้นหรือรัฐอยู่ ๒ รัฐ คือ เสียมหรือสยามกับหลอฮกหรือละโว้ เพราะในศตวรรษเดียวกันนั้น ทางหลอฮกหรือละโว้ก็มีการส่งทูตไปเมืองจีนด้วย

การที่หลักฐานด้านเอกสารระบุว่าเมืองเพชรบุรีเป็นเมืองท่านั้น ในชั้นแรกก็ดูขัดแย้งกับการที่เมืองเพชรบุรีตั้งอยู่ริมลำน้ำที่แคบมาก แต่ต่อมาในชั้นหลังเมื่อมีการพบหลักฐานทางโบราณคดีเพิ่มขึ้นก็ทำให้พอเข้าใจได้ นั่นก็คือความเป็นเมืองท่าของเพชรบุรีหาได้อยู่ที่ต้องมีลำน้ำใหญ่ที่เรือเดินทะเลจะเข้ามาจอดหน้าตัวเมืองได้อย่างเมืองราชบุรีไม่ หากอยู่ที่การมีท่าเรือจอด (entrepot)[*] หลายแห่งตามชายฝั่งทะเลตั้งแต่อ่าวบางตะบูนเรื่อยขึ้นไปจนเขตอำเภอชะอำ แหล่งโบราณคดีเหล่านี้มักอยู่ในพื้นที่ป่าชายเลนที่มีทางน้ำออกไปทะเลได้สะดวก ซึ่งปัจจุบันนี้ทางน้ำเหล่านั้นตื้นเขิน หรือแคบลงอีกทั้งมีการเปลี่ยนทางเดินบ่อยๆ จากรูปแบบของเศษภาชนะดินเผาเคลือบที่เป็นสินค้ามาจากเมืองจีน พอกำหนดได้ว่าแหล่งท่าเรือจอดเหล่านี้มีอายุแต่สมัยราชวงศ์ซุ้ง- หยวน และราชวงศ์หมิงลงมา ในบรรดาเศษภาชนะเหล่านี้ก็พบเศษภาชนะสังคโลกของสุโขทัยรวมอยู่ด้วย

ดังนั้นเรือสินค้าจึงไม่จำเป็นที่จะต้องแล่นเข้ามาถึงตัวเมืองเพชรบุรี และการขนส่งสินค้าก็ทำด้วยการใช้เรือเล็กจากบรรดาท่าเรือตามชายฝั่งเข้ามายังตัวเมือง ลักษณะความสัมพันธ์ระหว่างท่าเรือจอดหรือสถานที่ขนส่งสินค้ากับเมืองท่าริมฝั่งลำน้ำเพชรบุรีก็เคยมีมาก่อนในแถบอ่าวไทย เช่นระหว่างท่าเรือจอดที่แหลมโพธิ์ ตำบลพุมเรียงกับเมืองไชยาที่สุราษฎร์ธานี ที่มีอายุในคริสต์ศตวรรษที่ ๘-๑๐

แหล่งท่าเรือจอดที่มีการขุดค้นทางโบราณคดีในอ่าวไทยที่สัมพันธ์กับการตั้งถิ่นฐานของผู้คนในดินดอนสามเหลี่ยมเจ้าพระยา ก็คือบริเวณเขายี่สารในเขตตำบลยี่สาร อำเภออัมพวา จังหวัด

สมุทรสงคราม โดยตำแหน่งทางภูมิศาสตร์บริเวณนี้อยู่ในเขตอ่าวบางตะบูนที่สัมพันธ์กับปากน้ำเพชรบุรี อาจนับเนื่องเป็นท่าเรือของเมืองเพชรบุรีแห่งหนึ่งได้ หลักฐานจากการขุดค้นชั้นดินทางโบราณคดีพบว่าเป็นชุมชนที่มีอายุย้อนไปถึงคริสต์ศตวรรษที่ ๑๓ ที่มีการอยู่สืบเนื่องมาจนถึงปัจจุบัน ชาวบ้านเคยพบโครงกระดูกมนุษย์ห่อด้วนฟากไม้ไผ่ที่แสดงให้เห็นว่ามีผู้คนที่มาจากภายนอกเข้ามา เพราะในช่วงเวลาเช่นนี้คนในท้องถิ่นมีประเพณีเผาศพกันตามความเชื่อทางพุทธศาสนากันหมดแล้ว แต่ทั้งนี้ก็หาได้หมายความว่าผู้ที่เข้ามาตั้งถิ่นฐานในที่นี้จะเป็นมาจากภายนอกทั้งหมด การพบเศษภาชนะดินเผาแกร่งที่เป็นตุ่ม หม้อ ไห ที่มาจากเตาแม่น้ำสุพรรณจากเมืองสุพรรณบุรี รวมทั้งพระพุทธรูปหินทรายแดงและเสมาของโบสถ์ ก็ทำให้แลเห็นการมีวัดและการมีคนท้องถิ่นผสมผสานอยู่ด้วย แต่ที่สำคัญก็คือในบรรดาภาชนะดินเผาแกร่งเหล่านั้นมีตุ่มไหขนาดใหญ่รวมอยู่ด้วย มีที่ยังอยู่อย่างสมบูรณ์ก็มีเป็นโบราณวัตถุที่ทางวัดยังคงรักษาไว้ ตุ่มไหขนาดใหญ่ดังกล่าวนี้เคยมีผู้เข้าใจผิดและเชื่อว่าเป็นของที่ผลิตจากเตาที่เมืองสุโขทัย จึงมักเรียกกันว่าตุ่มสุโขทัย ทั้งๆ ที่ความเป็นจริงนั้นยังไม่พบเตาขนาดใหญ่ใดที่สุโขทัยพอเผาตุ่มไหเหล่านี้ได้ ยิ่งกว่านั้นบรรดาตุ่มเหล่านี้มักพบมากตามบริเวณลุ่มน้ำท่าจีน แม่กลองและเพชรบุรี โดยเฉพาะแต่บริเวณปากแม่น้ำเข้ามาภายใน ปัจจุบันนี้ยังพบอยู่ตามวัดต่างๆ ก็มี

ตุ่มไหขนาดใหญ่นี้มีความสัมพันธ์กับสภาพแวดล้อมที่เป็นพื้นที่น้ำกร่อยของป่าชายเลนบริเวณปากแม่น้ำเป็นอย่างมาก นั่นก็คือผู้ที่จะเข้ามาตั้งถิ่นฐานอยู่อาศัยเป็นชุมชนในพื้นที่นี้ได้ ก็จะต้องควบคุมภาวะการมีน้ำจืดเพื่อการบริโภคอุปโภคให้ได้ ซึ่งปัจจุบันนี้ก็สะท้อนให้เห็นได้จากบรรดาชาวบ้านแถวป่าชายเลนของอ่าวบางตะบูน ต่างก็หาทางกักน้ำฝนไว้กินและนำน้ำจืดจากแม่น้ำเพชรบุรีใส่เรือมาขายและแจกจ่ายระหว่างกัน สิ่งที่เก็บน้ำจืดไว้ได้ก็คือโอ่งน้ำขนาดใหญ่ ที่แต่ละบ้านเรือนจะมีอยู่ไม่ต่ำกว่า ๑๐ หรือ ๑๕ ใบขึ้นไปทีเดียว โอ่งเหล่านี้คือโอ่งซีเมนต์ในปัจจุบันที่มีการผลิตขายกันในท้องถิ่น แต่สมัยโบราณการมีตุ่มไหขนาดใหญ่นี้ก็คือสิ่งที่ควบคุมภาวะการขาดแคลนน้ำจืดนั่นเอง ซึ่งก็เป็นสิ่งที่คนในท้องถิ่นไม่มีความรู้ทางเทคโนโลยีที่จะผลิตขึ้นมาได้ น่าจะเป็นเรื่องของการนำเข้ามาของคนจากภายนอกที่เข้ามาตั้งถิ่นฐานมากกว่า จึงทำให้พอตีความได้ว่าบรรดาตุ่มไหเหล่านี้น่าจะมีความสัมพันธ์กับการเข้ามาตั้งถิ่นฐานในบริเวณพื้นที่น้ำกร่อยตามปากแม่น้ำและป่าชายเลนของดินดอนสามเหลี่ยมเจ้าพระยาเป็นอย่างมาก ดังนั้น จึงเกิดคำถามขึ้นว่า คนจากภายนอกที่เข้ามานั้นเป็นใคร คำตอบเบื้องแรกก็คือ ตุ่มไหเหล่านั้นผลิตจากที่ใด และใครเป็นผู้นำเข้ามา หลายๆ คนคิดว่าตุ่มไหนี้น่าจะมีเตาผลิตในดินแดนตอนใต้ของประเทศจีน และพ่อค้าที่มาจากประเทศจีนตอนใต้ เช่น กวางตุ้ง กวางสี นำเข้ามา ข้อคิด ข้อสันนิษฐานนี้มีหลักฐานอื่นที่แวดล้อมสนับสนุน เช่นชื่อของชุมชนที่อยู่ปากแม่น้ำท่าจีนที่เรียกว่า หลังเกียฉ ซึ่งแปลว่า ท่าจีน และการเกิดสวนผลไม้ที่มีการยกร่องขึ้นตามริมฝั่งแม่น้ำแม่กลอง และแม่น้ำเจ้าพระยาตอนล่าง โดยเฉพาะการมีสวนแบบยกร่องขึ้นนั้นเป็นการแสดงให้เห็นถึงวิธีการของคนในบริเวณตอนใต้ของประเทศจีนอย่างชัดเจน

สวนผลไม้ที่รู้จักกันมาแต่โบราณก็คือ บริเวณสองฝั่งแม่น้ำแม่กลองตั้งแต่เขตอำเภอเมือง และอำเภออัมพวา จังหวัดสมุทรสงครามขึ้นไปจนจดเขตอำเภอเมือง จังหวัดราชบุรี คนทั่วไปเรียกว่าสวนนอก กับบริเวณริมฝั่งแม่น้ำเจ้าพระยาฝั่งตะวันตก จากธนบุรีไปจนถึงนนทบุรี เรียกว่าสวนใน เป็นของคู่กันกับสวนนอก ปัจจุบันยังไม่ทราบแน่ชัดว่าการทำสวนผลไม้นี้เกิดขึ้นเมื่อใด แต่สมัยอยุธยาครั้งรัชกาล

สมเด็จพระนารายณ์มีจดหมายเหตุฝรั่ง โดยเฉพาะเดอ ลา ลูแบร์ ได้กล่าวถึงสวนริมฝั่งแม่น้ำเจ้าพระยาจากบางกอกไปถึงตลาดแก้วตลาดขวัญ ซึ่งต่อมาคือเมืองนนทบุรีแล้ว[๓] แต่ถ้าย้อนหลังขึ้นไปถึงสมัยรัชกาลของสมเด็จพระบรมไตรโลกนาถ กำศรวลสมุทรซึ่งเป็นวรรณคดีในยุคนั้น ได้กล่าวถึงการมีผู้คนและถิ่นฐานบ้านสวนอยู่แล้ว

"[๓]เยียมาพิเศศพี้	*บางพลู*
ถนัดเหมือนพลูทาๆเสวอย	*พี่ดิ้น*
รยมรักษเมื่อไขดู	*กระหนยก นางนา*
รศรำเพอยต้องมลิ้น	*ล่นนใจ ลานใจ*
"[๔]เรือมาจยรจยดใกล้	*ฉมงงราย*
ฉมงงนอกฉมงงใน	*อกช้ำ*
ชาวขุนสรมุทรหลาย	*เหลือย่าน*
อวนหย่อนยงงท่าน้ำ	*ถูกปลา ฯ*
"[๔]กล้วยอ้อยเหลืออ่านอ้าง	*ผักนาง*
จรหลาดเลขคนหนา	*ฝั่งงเฝ้า*
เยียมาลุดลบาง	*รมาต*
ถนัดรมาตเต้นเต้า	*ไถ่ฉนยร*
"[๙]มุ่งเหนดยรดาษสร้อย	*แสนส่วน*
แมนม่วงขนุนไรรยง	*รุ่นสร้อย*
กทึงทองรำดวรโดร	*รศอ่อน พี่แม่*
ปรางประเหล่แก้มช้อย	*ซาบฟนน*
[๖๑]ด้าวหันนอเนขซื้อ	*ขนํขาย*
วอนว่อนเลวงคิด	*ค่าพร้าว*
หมากสรุกซระลายปลง	*ปลิดไหม่*
มือแม่ค้าล้าวล้าว	*แล่นชิงโซรมชิง*[๔]

พื้นถิ่นและชุมชนที่กล่าวถึงในบทโคลงที่ยกมากล่าวนี้ ส่วนใหญ่คือบริเวณสองฝั่งลำน้ำเจ้าพระยาเก่าตามลำคลองบางกอกน้อยไปจนถึงบางระมาดและย่านใกล้เคียง ทำให้แลเห็นกลุ่มคนที่เรียกว่า ชาวขุนสมุทร มีการจับปลาและมีย่านที่เป็นสวนมะม่วง ขนุน มะปราง หมาก มะพร้าว กล้วยอ้อย ผักต่างๆ รวมทั้งต้นไม้ดอก เช่น กระทิงและลำดวน เป็นย่านที่มีการซื้อขายและกล่าวถึงแม่ค้าที่เป็นพวกลาว ทั้งหมดนี้สะท้อนให้เห็นสังคมชาวสวนที่พัฒนาขึ้นตามฝั่งแม่น้ำลำคลอง เป็นสังคมที่แตกต่างไปโดยสิ้นเชิงจากสังคมชาวนาที่ปลูกข้าวและที่ทำไร่ อย่างไรก็ตามคงไม่อาจทราบได้ว่าบรรดาสวนที่เกิดขึ้นในตอนนั้น เป็นสวนที่มีการยกร่องที่เป็นอิทธิพลมาจากจีนตอนใต้หรือเปล่า แต่สิ่งที่ต้องสังเกตก็

คือ การเกิดสวนผลไม้ขึ้นในบริเวณนี้ เป็นการปรับตัวของกลุ่มชนที่ต้องมีความรู้ความเข้าใจทางธรรมชาติและเทคโนโลยีไม่ใช่น้อย เพราะพื้นบริเวณที่ชาวขุนสมุทรอยู่ก็คือ บริเวณน้ำกร่อยที่เคยเป็นป่าชายเลนนั่นเอง ปัจจุบันชาวสวนจะเรียกว่าเป็นที่ดินลักจืดลักเค็ม ถือว่าเป็นดินที่อุดมสมบูรณ์เหมาะแก่การทำสวนผลไม้ และภาพของสวนในที่นี้ก็คือ การเลือกเฟ้นพันธุ์ไม้ผล ไม้ดอกและพืชพันธุ์ต่างๆ ที่มีประโยชน์ต่อการดำรงชีวิตของมนุษย์มาเพาะปลูกขึ้น ผลผลิตของสวนก็เพื่อการค้าขายเป็นสำคัญ และผู้ที่ทำหน้าที่สำคัญในการซื้อขายก็เป็นพวกผู้หญิงที่ในบทโคลงระบุว่า *"แม่ค้าล้าวล้าว"* การเติบโตของสังคมชาวสวนใหญ่ในช่วงเวลาต่อมาก็คือมีการนำเข้าของต้นผลไม้จากที่อื่น ซึ่งมีทั้งมาจากภายนอกโพ้นทะเลเข้ามาปลูก เช่น ทุเรียน ลิ้นจี่ มังคุด ลำใย เงาะ เป็นต้น

ตามที่กล่าวมาแล้วก็คือ สิ่งที่แสดงให้เห็นว่าสังคมชาวสวน คือผลผลิตของการตั้งถิ่นฐานและปรับตัวเข้ากับสภาพแวดล้อมในพื้นที่ใกล้ปากแม่น้ำที่เคยเป็นป่าชายเลนมาก่อน อาจนับเนื่องเป็นสังคมที่เป็นเนื้อแท้ของดินดอนสามเหลี่ยมใหม่อย่างแท้จริง เป็นการปรับตัวของคนหลายเผ่าพันธุ์ที่มีทั้งมาจากภายนอกและภายใน ในสมัยรัชกาลสมเด็จพระชัยราชาธิราชการเติบโตของสังคมชาวสวน ทำให้เกิดเมืองบางกอกขึ้นมา มีการขุดคลองลัดแม่น้ำอ้อมตั้งแต่ปากคลองบางกอกน้อยมายังปากคลองบางหลวง ทำให้สองฝั่งของคลองลัดที่กลายเป็นลำน้ำใหญ่นั้นเกิดเป็นเมืองธนบุรีศรีมหาสมุทรเป็นเมืองอกแตกที่มีแม่น้ำผ่ากลางขึ้นมา มีวัดเกิดขึ้นหลายแห่ง แต่ที่สำคัญก็คือ วัดระฆังโฆสิตารามหรือวัดบางหว้าใหญ่ เป็นวัดที่มีพระปรางค์สมัยอยุธยาตอนต้นๆ เป็นหลักฐานให้เห็น ซึ่งในสมัยรัชกาลที่ ๑ แห่งกรุงรัตนโกสินทร์ได้มีการบูรณะพระปรางค์องค์นี้ เลยทำให้มีผู้เข้าใจผิดไปว่าเป็นของที่สร้างขึ้นครั้งรัชกาลนี้ไป ปัจจุบันยังมีวัดและพระปรางค์สมัยอยุธยาตอนต้นเหลืออยู่ริมคลองบางกรวยที่เคยเป็นลำแม่น้ำอ้อมเช่นเดียวกับคลองบางกอกน้อย คือวัดปรางค์หลวง พระปรางค์ของวัดนี้ยังอยู่ในสภาพที่เป็นของเดิมที่แสดงให้เห็นถึงการมีตัวตนและการเติบโตของสังคมชาวสวนในย่านบางกอกและบางกรวยเป็นอย่างดี นอกจากนี้ยังมีแหล่งที่เป็นวัดเก่าที่มีความเชื่อและตำนานสนับสนุนอีกหลายแห่ง เช่นวัดบางขนุน เป็นต้น ที่มีซากวิหารเก่าและพระพุทธรูปหินทรายที่มีอยู่ในสมัยอยุธยา และในนิราศพระประธมของสุนทรภู่กล่าวถึงว่า

บางขนุนขุนกองมีคลองกว้าง
ว่าเดิมบางชื่อถนนเขาขนของ
*เป็นเรื่องหลังครั้งคราว**ท้าวอู่ทอง***
แต่คนร้องเรียกเพื่อนไม่เหมือนเดิม[๕]

ตำนานท้าวอู่ทองกับการเคลื่อนไหวของคนกลุ่มใหม่ในเดลต้า

การกล่าวถึงท้าวอู่ทองที่วัดบางขนุนริมฝั่งคลองบางกรวยที่เป็นลำน้ำเก่าของแม่น้ำเจ้าพระยาในนิราศพระประธมของสุนทรภู่ในสมัยกรุงเทพฯ ตอนต้นนี้ มีความสำคัญมาก เพราะเป็นสิ่งชี้เงื่อนงำในเรื่องกลุ่มชนและการตั้งถิ่นฐานในบริเวณเดลต้าใหม่ แต่สมัยแรกเริ่มของพระนครศรีอยุธยาลงมา ทั้งวัดเก่าและตำนานต่างก็เป็นหลักฐานให้เห็นว่า ลำน้ำเจ้าพระยาเก่าที่ปัจจุบันเรียกคลองบางกรวยนั้น เป็น

ทั้งเส้นทางคมนาคมในสมัยอยุธยาตอนต้น อีกทั้งเป็นบริเวณที่มีการตั้งถิ่นฐานบ้านเรือนของผู้คนที่เป็นชาวสวนด้วย โดยเฉพาะชื่อท้าวอู่ทองนั้นมีลักษณะเป็นนามของผู้นำทางวัฒนธรรม (culture hero) มากกว่าที่จะเป็นพระนามของพระมหากษัตริย์ที่มีตัวตนในประวัติศาสตร์ ที่แล้วมาการเขียนประวัติศาสตร์อยุธยาได้ใช้ท้าวอู่ทองเป็นสิ่งเชื่อมโยงให้แลเห็นพัฒนาการของบ้านเมืองและรัฐขึ้น อย่างเช่นสมเด็จกรมพระยาดำรงราชานุภาพและนักปราชญ์รุ่นก่อนๆมีความเห็นว่าสมเด็จพระรามาธิบดีที่๑ ผู้สถาปนาพระนครศรีอยุธยาเมื่อ ค.ศ.๑๓๕๐ นั้น คือพระมหากษัตริย์ในราชวงศ์เชียงรายที่สืบมาจากกษัตริย์ไทยทางภาคเหนือ ซึ่งเท่ากับเป็นการชี้นำและสนับสนุนความคิดที่ว่าคนไทยที่เข้ามาตั้งถิ่นฐานในดินแดนประเทศไทยนั้น คือพวกที่อพยพมาจากบ้านเมืองที่เคยรุ่งเรืองอยู่แล้วทางตอนใต้ของประเทศจีน โดยเส้นทางบกผ่านเชียงแสน เชียงราย สุโขทัยและกำแพงเพชรลงมายังลุ่มน้ำเจ้าพระยา ภายหลังได้มีนักประวัติศาสตร์บางท่านตีความใหม่โดยใช้เรื่องราวจากตำนานที่ฟอนฟลีต ชาวฮอลันดาในสมัยอยุธยาบันทึกไว้มาเสนอว่า พระเจ้าอู่ทองเป็นเชื้อสายคนจีนและเป็นกษัตริย์ที่เมืองเพชรบุรีก่อนเข้ามาสร้างพระนครศรีอยุธยา[๖]

การแลเห็นของนักประวัติศาสตร์ที่ว่า พระเจ้าอู่ทองมาจากทางเพชรบุรีและมีเชื้อสายคนจีนตามตำนานที่ฝรั่งบันทึกไว้นั้นมีความหมายมากกว่าความคิดเห็นของปราชญ์รุ่นเก่า ที่เชื่อว่าเป็นเป็นเชื้อสายที่สืบเนื่องมาจากทางเชียงราย เพราะแลเห็นความสัมพันธ์ของเมืองร่วมสมัยไม่ว่าอยุธยา เพชรบุรี ราชบุรี และสุพรรณบุรีในดินดอนสามเหลี่ยมเจ้าพระยาเป็นอย่างดี แต่จุดอ่อนนั้นก็คือยากที่จะกำหนดพระเจ้าอู่ทองเป็นบุคคลในประวัติศาสตร์ได้ เพราะบุคคลในตำนานนั้นอยู่ในมิติทางเวลาที่ไม่เป็นจริงในทางประวัติศาสตร์ เรื่องนี้เห็นได้ชัดเจนจากการนำไปเปรียบเทียบกับตำนานและความเชื่อในท้องถิ่น เช่น ตำนานเมืองนครศรีธรรมราช และชื่อของสถานที่ตามท้องถิ่นในเขตจังหวัดเพชรบุรี ราชบุรีและที่อื่นๆ จากเรื่องราวในตำนานการมีตัวตนของท้าวอู่ทอง ไม่อาจกำหนดระยะเวลาที่ชัดเจนได้ เพราะกล่าวว่าท้าวอู่ทองเป็นกษัตริย์จากเมืองเพชรบุรียกกองทัพไปรุกรานเขตแดนภาคใต้ของเมืองนครศรีธรรมราชที่มีพระยาศรีธรรมาโศกราชปกครองอยู่ มีการรบพุ่งและทำไมตรีแบ่งเขตแดนกัน ในขณะที่จดหมายเหตุของฟอนฟลีตที่เป็นตำนานกล่าวว่าพระเจ้าอู่ทองเป็นลูกของกษัตริย์จีนถูกเนรเทศเข้ามาโดยทางเรือ ไปมีความสัมพันธ์กับบรรดาเมืองสำคัญชายทะเลในเขตอ่าวไทยก่อนคือเมืองปัตตานีและนครศรีธรรมราช ต่อมาก็เคลื่อนย้ายมาตั้งถิ่นฐานที่เมืองกุยบุรีและเพชรบุรีตามลำดับ ในท้องถิ่นบนเส้นทางคมนาคมโบราณจากเมืองเพชรบุรีไปยังราชบุรีและสุพรรณบุรีนั้น มีบริเวณถนนที่เรียกว่าถนนท้าวอู่ทอง บางแห่งมีชื่อของสถานที่ที่กองเกวียนขนส่งสินค้าของท้าวอู่ทองมาจอดพัก บางแห่งก็เป็นสถานที่พักและมีสระน้ำเป็นต้น นอกนั้นก็มีตำนานของการเอาเจ้าอู่ทองซึ่งเป็นเชื้อสายคนจีนมายกขึ้นเป็นกษัตริย์ เป็นต้น

ตำนาน (myth) และความเชื่อที่สัมพันธ์กับชื่อสถานที่ตามท้องถิ่นดังกล่าวนี้ หาได้เป็นเรื่องพิเศษแปลกใหม่อะไรไม่ หากเป็นความเชื่อในเรื่องอดีต ความเป็นมาของเผ่าพันธุ์และหมู่เหล่าของมนุษย์โดยทั่วไป ที่สะท้อนให้เห็นการเคลื่อนไหวของกลุ่มชนที่มีผู้นำทางวัฒนธรรม (culture hero) เป็นสัญลักษณ์ ผู้นำทางวัฒนธรรมนี้อาจมีตัวตนจริงก็ได้ แต่ไม่อาจกำหนดช่วงเวลาและพิสูจน์ให้เห็นจริง ดังนั้นการตีความ จำเป็นต้องเชื่อมโยงกับหลักฐานแวดล้อมในด้านภูมิศาสตร์ วัฒนธรรม ประวัติศาสตร์โบราณคดีอีกมากมาย ในกรณีตำนานและความเชื่อเรื่องท้าวอู่ทองนี้ จัดอยู่ในเรื่องการสร้างบ้านแปง

เมือง เช่นเดียวกันกับเรื่องขุนเจือง ขุนบรม พระร่วง และพระยาศรีธรรมาโศกราช ที่ไม่อาจกำหนดได้ว่าผู้นำทางวัฒนธรรมเหล่านั้นมีตัวตนในประวัติศาสตร์ในช่วงเวลาใดได้แน่นอน แต่อาจสะท้อนให้แลเห็นความเคลื่อนไหวของกลุ่มชนที่สัมพันธ์กับสถานที่และบ้านเมืองได้ จากตำนานครั้งกรุงศรีอยุธยาที่ฝรั่งจดบันทึกไว้ก็ดี และที่นำมารวบรวมเป็นตำนานเมืองต่างๆ ในสมัยกรุงรัตนโกสินทร์ก็ดี เมื่อนำมาเชื่อมโยงกับหลักฐานทางโบราณคดี แล้วสะท้อนให้เห็นว่าในคริสต์ศตวรรษที่ ๑๓ มีการเคลื่อนไหวของผู้คนที่เข้ามาในประเทศไทยทางทะเลอย่างมากมาย ตำนานส่วนใหญ่มักกล่าวถึงการค้าทางสำเภากับคนจีน การแต่งงานของคนจีนกับคนในท้องถิ่น และการเข้ามาตั้งถิ่นฐานตามบ้านเมืองต่างๆ ตัวอย่างเช่นเรื่องมหาเภตราของเมืองเพชรบุรี ที่บอกถึงสำเภาเข้ามาชนภูเขา ทำให้คนจากสำเภาเข้ามาตั้งถิ่นฐานที่เมืองเพชรบุรี เรื่องตาม่องล่ายและนางยมโดย ที่กล่าวถึงความขัดแย้งทางสังคมในเรื่องการแต่งงานระหว่างคนจีนที่เข้ามากับคนพื้นเมือง และเรื่องทำนองนี้ก็เกิดขึ้นในหลายๆ ท้องถิ่นในภาคกลาง เช่นที่ลพบุรี แต่ที่มีการบันทึกไว้ในตำนาน เช่น พงศาวดารเหนือ ก็คือเรื่องพระนางสร้อยดอกหมากกับพระเจ้าสายน้ำผึ้ง

แต่ความโดดเด่นและแลเห็นทิศทางในการเคลื่อนไหวก็คือสิ่งที่ฟอนฟลีตบันทึกไว้เกี่ยวกับเรื่องเจ้าอู่ โอรสกษัตริย์จีนซึ่งถูกบิดาเนรเทศ และเดินทางเข้ามายังอ่าวไทยทางเรือสำเภา ไปมีความสัมพันธ์กับเมืองปัตตานี เมืองนครศรีธรรมราช เมืองกุยบุรี และเมืองเพชรบุรีตามลำดับ บรรดาเมืองต่างๆ ที่กล่าวมานี้ล้วนเป็นเมืองท่าทั้งสิ้น จากหลักฐานทางโบราณคดี เมืองเหล่านี้ ไม่ว่าเป็นปัตตานี นครศรีธรรมราช และเพชรบุรี มีบริเวณที่เป็นเมืองเก่าและเมืองใหม่ซ้อนกันอยู่ ยกเว้นเมืองกุยบุรีเท่านั้นที่ไม่มีร่องรอย ทำให้แลเห็นได้ว่าน่าจะเกิดเมืองท่าใหม่ที่สัมพันธ์กับการเข้ามาตั้งถิ่นฐานของคนจากภายนอก โดยเฉพาะที่เมืองเพชรบุรีนั้นอาจกล่าวได้ว่ามีตำนานซ้อนตำนานเกิดขึ้นทีเดียว นั่นก็คือตำนานจากการบันทึกของเดอ ลาลูแบร์ ราชทูตฝรั่งเศสในรัชกาลสมเด็จพระนารายณ์มหาราชเรื่องหนึ่งกับตำนานที่ฟอนฟลีตบันทึกไว้ตามที่กล่าวมาแล้วอีกเรื่องหนึ่ง[๗]

ตำนานที่เดอ ลาลูแบร์บันทึกไว้กล่าวว่า ต้นวงศ์กษัตริย์ของพระนครศรีอยุธยานั้นเสด็จมาจากเมืองนครไทยทางทิศเหนือขึ้นไป ซึ่งปัจจุบันอยู่ในเขตจังหวัดพิษณุโลก ได้อพยพผู้คนมาอยู่ที่เมืองเพชรบุรีก่อน จุดซ้อนกันของตำนานทั้งสองเรื่องที่เมืองเพชรบุรีก็คือ ในตำนานเจ้าอู่ของฟอนฟลีตนั้นระบุว่า เมื่อมาตั้งถิ่นฐานที่เมืองเพชรบุรีนั้นได้มีเมืองมาก่อนแล้ว ดังนั้น การตีความในที่นี้จึงพุ่งประเด็นไปที่ว่ามีคนกลุ่มใหม่ที่มาจากภายนอก ที่เรียกว่าคนจีน เข้ามาตั้งถิ่นฐานในพื้นที่ซึ่งเป็นเมืองและมีผู้คนอยู่แล้ว การเข้ามาตั้งถิ่นฐานและการผสมผสานนี้ทำให้เกิดเมืองใหม่ขึ้นมา ซึ่งก็ตั้งอยู่ในตำแหน่งที่เป็นศูนย์กลางทางการคมนาคมและเศรษฐกิจที่เหมาะสมกับสภาวะแวดล้อมและกาลเวลาในสมัยนั้น

ถ้าหากพิจารณาจากการตีความเรื่องราวการเคลื่อนไหวของผู้คนจากภายนอกเข้ามาผสมผสานกับคนภายใน ที่ทำให้เกิดบ้านเมืองใหม่ที่กล่าวมาแล้ว ก็พอจะแลเห็นภาพของผู้คนยุคใหม่ในลุ่มน้ำเจ้าพระยาที่มีท้าวอู่ทองเป็นผู้นำทางวัฒนธรรมได้โดยไม่ยาก อีกทั้งถ้าหากตัดประเด็นเรื่องการมีตัวตนในทางประวัติศาสตร์ของท้าวอู่ทองได้แล้ว ก็จะแลเห็นว่าท้าวอู่ทองมีความหมายเชิงสัญลักษณ์ของการเป็นผู้นำของคนรุ่นใหม่และกษัตริย์ที่มีอาณาบริเวณอยู่ในพื้นที่ลุ่มน้ำเจ้าพระยาอย่างชัดเจน

ความชัดเจนนี้แลเห็นได้จากการเปรียบเทียบกับผู้นำทางวัฒนธรรมในอาณาบริเวณอื่น เช่น พระยาศรีธรรมาโศกราชของทางภาคใต้ และพระร่วงของทางภาคกลางตอนบนหรือภาคเหนือตอนล่าง

พระนามของท้าวอู่ทองและตำนานที่สัมพันธ์กับสถานที่ ไม่ว่าจะเป็นเรื่องที่เกี่ยวกับวัด ชุมชน ถนน สระน้ำ และลักษณะทางภูมิศาสตร์อื่นๆ มีการแพร่กระจายตั้งแต่เมืองเพชรบุรีเข้ามาพื้นที่ภายในต่างๆ ของดินดอนสามเหลี่ยมเจ้าพระยา

การเคลื่อนไหวของผู้คน และการสร้างบ้านแปงเมืองในยุคใหม่นี้ ถ้าหากนำมาเชื่อมโยงกับหลักฐานทางโบราณคดีและหลักฐานทางประวัติศาสตร์แล้ว ก็จะเห็นได้ชัดว่าอยู่ในช่วงคริสต์ศตวรรษที่ ๑๓ ลงมา

ในด้านหลักฐานทางโบราณคดีนั้นได้กล่าวมามากแล้ว แต่หลักฐานทางประวัติศาสตร์นั้นก็มีสนับสนุนค่อนข้างชัดเจน คือจดหมายเหตุจีนในช่วงคริสต์ศตวรรษที่ ๑๓ ที่กล่าวถึงความสัมพันธ์ทางการค้าและการทูตระหว่างบ้านเมืองในลุ่มน้ำเจ้าพระยากับจีน เช่น มีการส่งทูตจากละโว้และเสียมไปเมืองจีนตามที่กล่าวมาแล้วในตอนต้น แต่ยังมีอีกแห่งหนึ่งที่มีชื่อว่าเจนลีฟู ซึ่งน่าจะเป็นรัฐและเมืองภายในของลุ่มน้ำเจ้าพระยา ได้มีการติดต่อกับจีนเช่นเดียวกัน

ศาสตราจารย์โวลเตอร์ แห่งมหาวิทยาลัยคอร์แนล ซึ่งทำการค้นคว้าเกี่ยวกับเจนลีฟูได้ระบุว่าเจนลีฟูมีการส่งทูตไปเมืองจีนหลายครั้ง ทั้งยังระบุว่ามีพ่อค้าจากเจนลีฟูไปตายที่เมืองจีนด้วย ซึ่งก็แน่นอนว่าเมืองท่าของจีนที่ติดต่อค้าขายกันนั้น คือจีนตอนใต้ที่กวางตุ้งและกวางสี[๙]

เพราะฉะนั้นคำว่าคนจีนที่เข้ามาในช่วงคริสต์ศตวรรษที่ ๑๓ นั้น คงหมายถึงจีนในตอนใต้ที่มีความหลากหลายทางชาติพันธุ์ ถ้าหากจะให้ตีความแบบเข้าข้างตัวเอง ก็อาจจะสันนิษฐานได้ว่าท่ามกลางความหลากหลายของชาติพันธุ์ในจีนตอนใต้นั้น อาจมีกลุ่มชนชาติไทอยู่รวมอยู่ด้วยก็ว่าได้ ซึ่งสิ่งเหล่านี้น่าจะนำไปสัมพันธ์กับการมีคนไทยและภาษาไทยในดินแดนประเทศไทยในยุคที่เกิดเมืองสุโขทัยและกรุงศรีอยุธยาขึ้น ถ้าหากเป็นเช่นนี้จริง การเคลื่อนย้ายของคนไทเข้ามาในดินแดนประเทศไทยนั้น คงหาได้มาตามเส้นทางเดินบกเข้ามาที่เชียงแสนเชียงรายและสุโขทัยอย่างที่เคยเชื่อกันแต่เพียงทางเดียวไม่ หากต้องคำนึงถึงทั้งเส้นทางเดินบกที่ผ่านเวียดนามและลาวเข้ามา รวมทั้งการเข้ามาตามเส้นทางการค้าทางทะเลด้วย อีกทั้งน่าจะมีการเคลื่อนไหวอย่างสืบเนื่องอยู่ตลอดเวลา

การสถาปนาพระนครศรีอยุธยาเป็นราชธานีในคริสต์ศตวรรษที่ ๑๔ ก็คือผลผลิตของการเคลื่อนไหวของกลุ่มชนรุ่นใหม่ ที่มีการผสมผสานระหว่างคนจากภายนอกและภายใน ทำให้เกิดบ้านเมืองใหม่ตามชายทะเล ปากแม่น้ำ และบริเวณเดลต้าใหม่ รวมไปถึงบริเวณภายในอื่นๆ ที่ใกล้เคียงด้วย

สังคมของคนยุคใหม่เกิดขึ้นพร้อมทั้งวัฒนธรรมรุ่นใหม่ที่มีพุทธศาสนาเถรวาท ที่เรียกว่าลังกาวงศ์ เป็นแก่นสาร การเติบโตของอาณาจักรอยุธยาเป็นสิ่งที่ควบคู่ไปกับการค้าทางทะเล ที่นอกจากจะทำให้เศรษฐกิจรุ่งเรืองแล้ว ยังมีคนภายนอกหลั่งไหลเข้ามาตั้งสถานีการค้าและถิ่นฐานบ้านเรือน

ยิ่งกว่านั้น การทำสงครามกับประเทศพม่าและบ้านเมืองใกล้เคียง ก็ทำให้มีการกวาดต้อนผู้คนที่มีทั้งออกไปและเข้ามา ผลตามมาก็คือลุ่มน้ำเจ้าพระยาได้กลายเป็นบริเวณที่มีผู้คนที่หลากหลายทางชาติพันธุ์ เข้ามาตั้งถิ่นฐานผสมผสานกัน ทั้งในสังคมเมืองและสังคมชนบท ในสังคมเมืองคนจากภายนอกที่เผอิญมีความรู้ความสามารถทางด้านวิชาการและเทคโนโลยีที่เป็นประโยชน์กับบ้านเมือง ก็อาจ

ได้รับการยอมรับให้เข้ามาเป็นขุนนาง ข้าราชการ เป็นผู้มีศักดิ์มีตระกูลก็มากมาย จนกล่าวได้ว่าตั้งแต่รัชกาลของสมเด็จพระนารายณ์ลงมานั้น มีชาวต่างชาติเข้ามารับราชการเป็นขุนนางในตำแหน่งต่างๆ ทั้งฝ่ายทหารและพลเรือนเป็นอันมาก ลูกหลานและเชื้อสายของคนเหล่านี้ต่างสืบสายตระกูลอยู่อย่างสืบเนื่องมาจนสมัยกรุงเทพฯ ส่วนในสังคมชนบทนั้นกลุ่มชาติพันธ์หลายกลุ่มก็ได้รับพระราชทานที่ดินจากพระมหากษัตริย์ให้ตั้งบ้านที่อยู่อาศัยตามท้องถิ่นต่างๆ เป็นชุมชนในระหว่างพวกเดียวกัน บางกลุ่มก็ได้รับมอบหมายหน้าที่ให้ประกอบอาชีพเฉพาะ เช่น คนมอญที่เข้ามาตั้งหลักแหล่งในเขตเมืองสามโคกก็มีอาชีพทำเครื่องปั้นดินเผาเพื่อประโยชน์ใช้สอยของคนทั่วไป ในขณะพวกมอญที่เข้าไปตั้งหลักแหล่งริมลำน้ำแม่กลองในเขตอำเภออัมพวาก็กลายเป็นพวกชาวสวน ผสมผสานชีวิตความเป็นอยู่ไปกับพวกคนจีนและคนไทย ในขณะที่คนลาวมีกระจายอยู่ทั่วไปตามริมฝั่งแม่น้ำเจ้าพระยา แม่น้ำป่าสักและลพบุรี ดูเหมือนการกระจายตัวและความหนาแน่นของประชากรในบริเวณเดลต้าใหม่นั้น จะอยู่ในบริเวณตั้งแต่ฝั่งแม่น้ำเจ้าพระยาไปทางตะวันตกไปยังสุพรรณบุรี ราชบุรี เพชรบุรี มากกว่าทางด้านตะวันออกซึ่งนับเป็นที่ว่างเปล่าเป็นทุ่งเป็นป่าและเขาที่มีบ้านและเมืองอยู่ห่างกัน ความหนาแน่นของชุมชนและบ้านเมืองจากฝั่งแม่น้ำเจ้าพระยาไปทางตะวันตกนี้ สอดคล้องกับบันทึกของโยสต์ เคาเต็น ผู้จัดการบริษัทการค้าของฮอลันดาใน ค.ศ.๑๖๓๖ ที่ว่าแม่น้ำนั้นแตกออกเป็น ๓ สายไหลลงอ่าวสยาม เป็นพื้นที่อุดมสมบูรณ์เหมาะแก่การปลูกข้าว ทั้งชะล้างสิ่งโสโครกต่างๆ ซึ่งอาจจะทำให้เกิดโรคติดต่อไปหมด[๙] ลำน้ำ ๓ สายนี้ก็คงเป็นลำน้ำแม่กลอง ท่าจีนและเจ้าพระยาอย่างไม่ต้องสงสัย โดยเฉพาะสายตะวันออกซึ่งก็คงหมายถึงแม่น้ำเจ้าพระยานั้นกว้างใหญ่ บริเวณปากแม่น้ำ มักมีเรือกำปั่นและสำเภาเข้าออกเสมอ

การเปลี่ยนแปลงทางสังคมและวัฒนธรรม

พัฒนาการของบ้านเมืองในบริเวณเดลต้าใหม่ ที่เริ่มแต่การสถาปนาพระนครศรีอยุธยาตั้งแต่คริสต์ศตวรรษที่ ๑๔ ลงมานั้น นอกจากแลเห็นจากการเคลื่อนไหวของกลุ่มชนจากภายนอกเข้ามาตั้งถิ่นฐานผสมผสานกับคนภายในตามที่กล่าวมาแล้ว ยังเห็นได้จากสิ่งใหม่ๆ ที่มีความหลากหลายเพิ่มขึ้นทั้งในด้านเศรษฐกิจ สังคม และวัฒนธรรมที่อาจขมวดให้เห็นภาพกว้างๆ ในเรื่องการทำสวนและการทำนา การเกิดการทำสวนผลไม้ไม่ว่าจะเป็นสวนนอกที่แม่น้ำแม่กลองและสวนในที่แม่น้ำเจ้าพระยา ก็นับเป็นส่วนหนึ่งที่แลเห็นได้ชัด การเกิดสวนผลไม้ขึ้น คือการนำเอาวิธีการและเทคโนโลยีใหม่ๆ ของการเพาะปลูกมาจัดการกับสภาพแวดล้อมที่เคยเป็นป่าชายเลนมาก่อน รวมทั้งการนำพันธุ์ไม้ผล ไม้ดอกต่างๆ ทั้งที่เป็นของพื้นเมืองและจากภายนอกเข้ามา ซึ่งความรู้เกี่ยวกับชนิดของพันธุ์ไม้ผล และไม้ดอกเหล่านี้จะปรากฏรายชื่อให้เห็นจากวรรณคดีที่มีมาแต่สมัยอยุธยาจนถึงกรุงเทพฯ ในด้านการทำนาก็นับว่ามีการเติบโตและขยายตัวมากกว่าแต่ก่อนอย่างมากมาย แม้ว่าจะไม่เห็นการเปลี่ยนแปลงทางในเรื่องวิธีการทำนาและการใช้เทคโนโลยีใหม่เท่าใด แต่ก็แลเห็นพัฒนาการของพันธุ์ข้าว (Agronomy) อย่างชัดเจน สมัยก่อนกรุงศรีอยุธยาแต่คริสต์ศตวรรษที่ ๑๓ ขึ้นไป พันธุ์ข้าวปลูกในลุ่มน้ำเจ้าพระยาและบริเวณใกล้เคียงแต่สมัยเหล็กลงมาจนถึงสมัยทวารวดีและลพบุรีนั้น มักเป็นข้าวเมล็ดอ้วนสั้นคล้ายกับเมล็ดข้าวเหนียว ตัวอย่างและหลักฐานของพันธุ์ข้าวแบบนี้พบจากการขุดค้นทางโบราณคดีและจากแกลบข้าวที่

ผสมอยู่ในแผ่นอิฐที่ใช้ก่อสร้างศาสนสถาน โดยเฉพาะการพบแกลบข้าวจากแผ่นอิฐนั้นสะท้อนให้เห็นถึงการปลูกข้าวเป็นอาหารหลักและน่าจะเป็นอาชีพหลักของผู้คนในยุคที่มีเมืองมีรัฐเกิดขึ้น

แต่ตั้งแต่สมัยอยุธยาเป็นต้นมา บรรดาแกลบที่ผสมอยู่ตามแผ่นอิฐได้เปลี่ยนมาเป็นเมล็ดรียาวเหมือนกับเมล็ดพันธุ์ข้าวเจ้าโดยทั่วไป ซึ่งก็แสดงให้เห็นถึงการเปลี่ยนแปลงและเลือกเฟ้นพันธุ์ข้าวที่เหมาะกับพื้นที่ในที่ลุ่มต่ำเติบโตในระดับน้ำที่สูงกว่าแต่ก่อน พันธุ์ข้าวดังกล่าวนี้น่าจะเป็นของที่นำเข้ามาจากภายนอกที่พวกพ่อค้าหรือกลุ่มชาติพันธุ์บางกลุ่มนำเข้ามา เป็นสิ่งที่ผลักดันให้เกิดการปลูกข้าวและเกิดแหล่งชุมชนในที่ลุ่มแม่น้ำลำคลองอย่างแท้จริง ยิ่งในสมัยหลังลงมาที่อยุธยาส่งข้าวไปขายนอกประเทศ พันธุ์ข้าวเจ้าเหล่านี้อาจเป็นสินค้าที่ผู้คนจากภายนอกต้องการอีกด้วย ภาพของสังคมลุ่มแม่น้ำที่เกิดขึ้นนี้สะท้อนให้เห็นจากการบันทึกของโยสต์สเคาเต็นที่พูดถึงบ้านเมืองและตลาดที่ดูสอดคล้องกับสิ่งที่เล่าไว้ในคำให้การของขุนหลวงประดู่ทรงธรรม ความเป็นเมืองของพระนครศรีอยุธยา แลเห็นได้จากบริเวณตัวเมืองที่มีกำแพงและแม่น้ำล้อม และบริเวณโดยรอบของเมืองที่นอกจากมีแม่น้ำหลายสายแยกแยะกันออกไปแล้ว ยังมีคลองที่ขุดลัดและเชื่อมแม่น้ำลำน้ำต่างๆ มากมาย เป็นโครงสร้างพื้นฐาน (hydraulic infrastructure) ที่สัมพันธ์กับการเกิดย่านที่อยู่อาศัยที่เป็นตลาด แหล่งหัตถกรรม แหล่งอุตสาหกรรม และแหล่งปลูกข้าวทำนาอีกมากมาย ภาพพจน์ของสังคมลุ่มแม่น้ำที่แลเห็นก็คือสองฝั่งแม่น้ำในเขตเมือง จะมีบ้านเรือนเรียงรายเป็นแถวๆ ไปไม่ต่ำกว่า ๒-๓ แถว จากริมตลิ่งยื่นล้ำลงไปในพื้นน้ำ บ้านเรือนเหล่านั้นล้วนตั้งอยู่บนเสาสูงพ้นระดับน้ำท่วมถึงในฤดูน้ำ แถวหน้าของบ้านเรือนก็คือ เรือนแพที่ขึ้นลงได้ตามระดับน้ำในฤดูน้ำและฤดูแล้ง เรือแพส่วนใหญ่เป็นร้านค้าที่อาจเคลื่อนย้ายได้ ในจดหมายเหตุชาวต่างประเทศบางคนบอกว่า ผู้ที่อยู่บนเรือนแพเหล่านี้คือคนจีน การที่สร้างบ้านเรือนอยู่ตามชายฝั่งแม่น้ำน้ำก็คือการได้อาศัยกระแสน้ำพัดพาสิ่งสกปรกให้หมดไปนั่นเอง

ดูเหมือนสังคมลุ่มแม่น้ำที่มีมาแต่สมัยอยุธยานั้น การสร้างบ้านเรือนบนตลิ่งคงทำกันน้อยมาก มักปล่อยให้พื้นที่ริมฝั่งน้ำเป็นที่ของเรือกสวน และพื้นที่สำหรับสัตว์เลี้ยง รวมทั้งเป็นที่ตั้งของวัดอันเป็นศูนย์กลางของชุมชน ทั้งวัดและบ้านเรือนต่างก็หันหน้าลงสู่แม่น้ำ เรื่องนี้เป็นคติประเพณีที่เกิดขึ้นแต่สมัยอยุธยาโดยแท้ เพราะก่อนหน้านั้นบรรดาวัดวาอารามจะหันหน้าไปทางทิศตะวันออก ชุมชนในระดับหมู่บ้านที่มีวัดเป็นศูนย์กลางดังกล่าวนี้จะเรียงรายไปตามชายฝั่งน้ำ ในเขตเมืองใหญ่ๆ จะมีหลายหมู่บ้านเรียงรายอยู่ในพื้นที่อันเป็นท้องถิ่นเดียวกัน และมักจะมีวัดสำคัญในระดับท้องถิ่นเป็นศูนย์กลางในการประกอบประเพณีพิธีกรรม วัดดังกล่าวนี้มักมีขนาดใหญ่ มีวิหารและพระสถูปเจดีย์เป็นประธาน มักแตกต่างจากวัดในระดับหมู่บ้านธรรมดาที่ให้ความสำคัญแก่โบสถ์อันเป็นที่ทำสังฆกรรมของพระสงฆ์ ในยามปกติวัดสำคัญของท้องถิ่นก็อาจเป็นวัดประจำชุมชนหมู่บ้านใดหมู่บ้านหนึ่งได้ แต่ในเวลาที่เป็นนักขัตรฤกษ์วัดดังกล่าวนี้จะเป็นศูนย์กลางในงานประเพณีพิธีกรรม เช่นในพิธีเดือนสิบเอ็ด มีพิธีทอดกฐินและการแข่งเรือ จะมีเรือที่วัดของบรรดาหมู่บ้านที่อยู่ในท้องถิ่นเดียวกันส่งมาร่วมในการแข่งขัน เพื่อเชื่อมความสัมพันธ์ระหว่างกัน วัดประจำท้องถิ่นเช่นนี้ก็คือวัดที่มักจะมีพระมหากษัตริย์ เจ้านาย ขุนนาง หรือคหบดีพากันมาสร้างหรือไม่ก็มีส่วนร่วมในการสร้าง ทำให้นอกจากเป็นศูนย์กลางในด้านพิธีกรรมแล้วยังเป็นศูนย์กลางทางศิลปวัฒนธรรมของท้องถิ่นด้วย ลักษณะอีกอย่างหนึ่งของสังคมลุ่มแม่น้ำก็คือ

ในฤดูที่มีประเพณีพิธีกรรมนั้น พื้นที่ในท้องน้ำจะกลายเป็นพื้นที่ทางพิธีกรรมโดยอัตโนมัติ มีความเคลื่อนไหวและแออัดของผู้คนที่สัญจรไปมาโดยทางเรือ

ในที่ใดที่เป็นปากแม่น้ำหรือลำคลอง อันเป็นที่สบกันของลำน้ำตั้งแต่สองสายขึ้นไป มักจะเป็นที่ตั้งของชุมชนที่ขนาดใหญ่กว่าชุมชนในระดับหมู่บ้าน เพราะเป็นบริเวณที่มีย่านตลาดเกิดขึ้น เป็นที่คนต่างชาติพันธุ์ที่เป็นทั้งพ่อค้า ชาวนา หรือชาวสวนตั้งถิ่นฐานในบริเวณเดียวกัน โดยเฉพาะคนจีนที่อาจอยู่ได้ทั้งแพและเรือนบ้าน มีการสร้างศาลเจ้า ศาลผีในการประกอบประเพณีพิธีกรรม แต่ที่สำคัญก็คือการอาศัยท้องน้ำที่สบกันระหว่างลำน้ำและลำคลองเป็นที่ลอยเรือค้าขายแลกเปลี่ยนสินค้าของสดของคาวกันในชีวิตความเป็นอยู่ประจำวัน การดำรงอยู่ของชุมชนในสังคมลุ่มแม่น้ำดังกล่าวนี้สืบเนื่องแต่สมัยอยุธยาลงมาจนถึงสมัยกรุงเทพฯ ความแตกต่างกันดูเหมือนจะอยู่ที่ในสมัยกรุงรัตนโกสินทร์หรือกรุงเทพฯนั้น การตั้งถิ่นฐานตามแม่น้ำลำคลองที่มีกลุ่มชนที่หลากหลายทางชาติพันธุ์มีมากกว่าสมัยอยุธยา บริเวณที่เป็นเมืองแต่ละแห่งจะมีการขุดคลองแยกออกจากสองฝั่งแม่น้ำไปในพื้นที่ทำสวนและทำนามากมาย แต่ที่สำคัญก็คือมีการขุดคลองใหญ่ๆ ที่เชื่อมระหว่างแม่น้ำเจ้าพระยา แม่น้ำท่าจีน และแม่น้ำแม่กลองเพิ่มขึ้น พร้อมๆ กันนั้นก็มีการขยายตัวของชุมชนหมู่บ้านเมืองและย่านตลาดการค้าไปตามลำคลองเหล่านั้น ชีวิตความเป็นอยู่ของผู้คนตามแม่น้ำลำคลองเหล่านี้ปรากฏให้เห็นชัดเจนจากจดหมายเหตุของต่างประเทศ และวรรณคดีนิราศที่กวีสำคัญได้แต่งไว้ เช่นของสุนทรภู่และผู้ที่เป็นลูกศิษย์เป็นต้น สมัยรัชกาลที่ห้าแห่งกรุงรัตนโกสินทร์นั้นดูเหมือนเป็นยุคที่สังคมลุ่มแม่น้ำเติบโตอย่างเต็มที่ อันเนื่องมาจากการขุดคลองชลประทาน เพื่อใช้น้ำในการเกษตรกรรมในพื้นที่ว่างเปล่าที่เป็นท้องทุ่งทั้งฝั่งตะวันตกและฝั่งตะวันออกของแม่น้ำเจ้าพระยา โดยเฉพาะฝั่งตะวันออกที่แต่ก่อนเคยเป็นที่ว่างเปล่าประโยชน์นั้น ได้มีการขยายตัวอย่างกว้างขวางในพื้นที่จึงสัมพันธ์กับจังหวัดสระบุรี นครนายก และฉะเชิงเทรา การขยายตัวของพื้นที่ทางชลประทานนี้ควบคู่ไปกับการใช้เทคโนโลยีแบบใหม่ คือเรือขุดที่มีบริษัทชาวต่างชาติมาดำเนินการ เกิดการตั้งถิ่นฐานเป็นกลุ่มบ้านเรือนเล็กๆ ที่เรียกว่า บ้านห่าง (homestead) ขึ้นมากมาย เป็นรูปแบบของชุมชนชาวนาที่ปลูกข้าวที่เกิดขึ้นในช่วงเวลานี้ ที่สัมพันธ์กับการขยายตัวของการปลูกข้าวเป็นพืชเศรษฐกิจ และการมีกรรมสิทธิ์ที่ดินของผู้คนพลเมือง

การดำรงอยู่ของสังคมชาวสวนและชาวนาของลุ่มแม่น้ำเจ้าพระยาที่ใช้แม่น้ำลำคลองเป็นทั้งเส้นทางคมนาคมและการตั้งแหล่งชุมชนที่อยู่อาศัย เริ่มมีการเปลี่ยนแปลงแต่สมัยรัชกาลที่สี่ในคริสต์ศตวรรษที่ ๑๙ อันเนื่องมาจากมีเรือยนต์และเรือกลไฟอันเป็นผลผลิตทางเทคโนโลยีจากตะวันตกเข้ามาแล่นในแม่น้ำลำคลอง ทำให้เกิดคลื่นกระทบเรือนแพที่อยู่ชายท้องน้ำ เกิดความเสียหาย บรรดาเรือนแพก็ค่อยๆ หมดไป บ้านเรือนที่อยู่ชายตลิ่งต่างก็ถอยขึ้นไปปลูกสร้างบนตลิ่งและฝั่งน้ำ หรืออีกนัยหนึ่งก็คือถอยขึ้นบกนั่นเอง ครั้นถึงสมัยรัชกาลที่ห้าก็มีการสร้างทางรถไฟและถนนหนทางบนบกขึ้น ทำให้เกิดสถานที่ราชการที่เป็นศูนย์กลางการปกครองของท้องถิ่น เช่น ที่ทำการตำบล อำเภอ และจังหวัดขึ้น ซึ่งก็เป็นเรื่องควบคู่กันไปกับการเกิดย่านตลาดขึ้นตามสถานที่รถไฟ หรือตามถนนสายต่างๆ เป็นเหตุให้มีการขยายตัวของชุมชนไปตั้งถิ่นฐานเรียงรายกันไปตามทางรถไฟและทางถนนแทน รวมทั้งการคมนาคมก็เริ่มเปลี่ยนมาใช้เส้นทางบกแทนทางน้ำ บรรดาชุมชนที่เคยอาศัยอยู่ตามแม่น้ำลำคลองก็ค่อยๆ ร่วงโรยไป ผู้คนทิ้งถิ่นฐานและถิ่นฐานที่อยู่เดิมก็กลายเป็นที่ล้าหลังและห่างไกลความเจริญไป ความเปลี่ยน

แปลงดังกล่าวนี้แลเห็นได้ชัดในกรณีกรุงเทพฯและธนบุรี แต่เดิมบริเวณฝั่งธนบุรีคือแหล่งชุมชนเมืองที่เจริญมาก่อน คนเมืองทุกหมู่เหล่า ตั้งแต่เจ้านาย ขุนนาง ข้าราชการ พ่อค้า คหบดี และชาวสวน ต่างก็มีนิวาศสถานอยู่ทางฝั่งตะวันตกนี้ของแม่น้ำเจ้าพระยาทั้งนั้น ปล่อยให้ฝั่งกรุงเทพฯ เป็นสถานที่ราชการและย่านการค้าธุรกิจ ตลอดจนที่อยู่อาศัยของชาวต่างประเทศ พื้นที่ห่างออกไปเป็นที่โล่ง เป็นท้องทุ่งท้องนา ครั้นสมัยรัชกาลที่ห้าเป็นต้นมา การเติบโตแบบสมัยใหม่เกิดขึ้นทางฝั่งกรุงเทพฯ แทน การเกิดถนนหนทางทำให้เกิดย่านที่อยู่อาศัยแบบใหม่ ตึกรามบ้านช่องขยายตัวไปอย่างรวดเร็วและต่อเนื่อง ซึ่งนอกจากบริเวณเขตเมืองกรุงเทพฯ แล้ว บรรดาเส้นทางรถไฟและถนนหลวงล้วนอยู่ทางฝั่งตะวันออกของแม่น้ำเจ้าพระยาทั้งสิ้น ดูเหมือนการเติบโตของบ้านเมืองที่ก้าวหน้าทันสมัยแต่ครั้งรัชกาลที่ห้าลงมาก็เกิดทางฝั่งกรุงเทพฯ หรือพระนครเช่นเดียวกัน ทำให้เกิดความแตกต่างระหว่างฝั่งธนบุรี และฝั่งพระนครขึ้น โดยที่ทางฝั่งธนบุรีสภาพบ้านเมืองยังคงคล้ายกับเมืองชนบทที่มีถนนแคบ มีตรอกและซอกมากมาย คนไปไหนมาไหนด้วยการเดินและรถเมล์ขนาดเล็ก ยิ่งที่อยู่ตามลำน้ำลำคลองในสวนด้วยแล้วยังคงลักษณะที่เรียกว่า บ้านนอกอย่างชัดเจน ในขณะที่ทางฝั่งพระนครคือ สังคมเมืองที่มีถนนหนทาง มีรถเมล์ รถรางวิ่งรวมทั้งมีตึกรามบ้านช่องและสถานที่ราชการและสถานธุรกิจการค้าเป็นแบบอย่างตะวันตก การเปลี่ยนแปลงทางเศรษฐกิจและสังคมของทางฝั่งธนบุรีเริ่มฉายแสงให้เห็นในยุคต้นๆ ของรัฐบาลจอมพลสฤษดิ์ ธนะรัชต์ เมื่อเกิดมีเรือหางยาววิ่งกันตามแม่น้ำลำคลอง แทนบรรดาเรือแจวเรือจ้าง และเรือแท็กซี่ที่เคลื่อนไหวเชื่องช้า เป็นเหตุให้การเดินทางติดต่อกันระหว่างฝั่งพระนครกับพื้นที่เรือกสวนตามลำน้ำลำคลองต่างๆ เป็นไปอย่างสะดวก ผู้คนจากที่อื่นเริ่มเคลื่อนย้ายเข้าไปอยู่ในพื้นที่เพิ่มขึ้น ความเป็นบ้านนอกเมืองสวนของธนบุรีได้เปลี่ยนแปลงไปอย่างรวดเร็วในเวลาต่อมาก็คือ เมื่อเกิดการสร้างสะพานข้ามแม่น้ำเจ้าพระยาเพิ่มขึ้นจากการมีสะพานพระพุทธยอดฟ้าและสะพานพระรามหก เช่น สะพานกรุงธนฯ และต่อมาคือสะพานพระปิ่นเกล้า เกิดการสร้างถนนใหญ่น้อยมากมายไปตามที่ต่างๆ สวนเริ่มหมดไปและคนเข้าไปสร้างบ้าน สร้างเรือน สร้างซอยที่มีการติดต่อคมนาคมด้วยถนนและทางบกแทนทางน้ำอย่างแต่เดิม โดยเฉพาะบรรดาบ้านเรือนและชุมชนที่อยู่ริมแม่น้ำลำคลอง ซึ่งแต่ก่อนหันหน้าลงลำน้ำนั้น ต่างก็หันหลังลงน้ำและหันหน้าเข้าถนน เกิดการทิ้งของเสียและขยะลงแม่น้ำลำคลองกัน เป็นเหตุให้เกิดความสกปรกกันไปทั่ว

แต่สิ่งที่ทำให้เกิดการเปลี่ยนแปลงที่สำคัญในเดลต้าเจ้าพระยา อันเป็นสังคมชาวสวน ชาวนาที่อยู่ตามแม่น้ำลำคลองก็คือ การที่รัฐบาลสมัยจอมพลสฤษดิ์ ธนะรัชต์ ดำเนินการพัฒนาประเทศให้มีความเป็นอุตสาหกรรม เริ่มด้วยการสร้างโครงสร้างพื้นฐาน เช่น ถนน และเขื่อน พลังงานไฟฟ้า จึงเป็นเหตุให้เกิดการเปลี่ยนแปลงสภาพแวดล้อมทั้งด้านธรรมชาติและวัฒนธรรมเรื่อยมา การสร้างเขื่อนในบริเวณลุ่มน้ำเจ้าพระยา โดยเฉพาะเขื่อนเจ้าพระยาและเขื่อนภูมิพลที่อยู่ตอนบนขึ้นไปได้ก่อให้เกิดการเปลี่ยนแปลงธรรมชาติที่เกี่ยวกับฤดูน้ำมากและน้ำน้อยอย่างมากมาย แต่ก่อนฤดูน้ำมากคือฤดูกาลที่ผู้คนในสังคมลุ่มแม่น้ำมีความคึกคักรื่นเริงและมีความสุข น้ำที่ท่วมท้นตลิ่งและล้นทุ่งนาที่ลุ่มหนองบึงนั้นนำความหลากหลายของสัตว์น้ำและพันธุ์พืชธรรมชาติในน้ำให้อุดมสมบูรณ์ขึ้น การสัญจรไปมาทางน้ำสะดวกสบายแทบทุกแห่งหน ในขณะที่ฤดูน้ำลดที่บางแห่งแห้งคอดคลอง ที่มีแต่น้ำสีขุ่นมัว ทำให้เกิดความหดหู่ไม่ชื่นบาน รวมทั้งการไปมาติดต่อกับที่อื่นๆ ไม่สะดวกสบาย ต้องเดินทางบากเช่นถนนที่เต็ม

ไปด้วยหรือทางเกวียนทุกขลุกขลักทุรกันดาร ภายหลังการสร้างเขื่อนความหลากหลายทางชีวภาพลดน้อยลง แทบไม่มีฤดูน้ำมากและน้ำลด เส้นทางคมนาคมทางน้ำหมดไปเป็นส่วนมาก เกิดความสัญจรไปมาทางถนนที่เพิ่มพูน มลภาวะทั้งในด้านเสียง อากาศและสภาพแวดล้อมด้านอื่นๆ และที่สำคัญก็คือการสิ้นสุดของสังคมลุ่มแม่น้ำอย่างที่เคยมีมาแล้วกว่าพันปีอย่างสิ้นเชิง

ทุกวันนี้แม่น้ำสายใหญ่ๆ ของลุ่มน้ำเจ้าพระยาไม่ว่าจะเป็นเจ้าพระยา ท่าจีน แม่กลอง เพชรบุรี และบางปะกง ต่างก็เป็นลำน้ำที่ไร้วิญญาณ ที่เป็นผลมาจากการสร้างเขื่อน สร้างถนน โดยเฉพาะพื้นที่ระหว่างแม่น้ำทั้งสามคือ เจ้าพระยา ท่าจีน และแม่กลองที่เป็นบ้านเป็นเมืองของคนในสังคมชาวสวนและชาวนานั้น ดูย่อยยับมากกว่าที่อื่นๆ เกิดโรงงานอุตสาหกรรมหลายพันแห่ง ที่นอกจากจะทำให้พื้นที่ทางเกษตรกรรมที่เป็นสวนและไร่นาสาโทที่ดีที่สุดของประเทศหมดไปแล้ว ยังระบายน้ำเสียและสิ่งปฏิกูลลงมาตามแม่น้ำลำคลองให้เกิดเน่าเสียอีกด้วย ไม่ต้องดูอะไรอื่น เพียงแต่บริเวณปากคลองบางหลวงและคลองบางกอกน้อยที่อยู่ทางฝั่งธนบุรีที่บรรจบกับลำน้ำเจ้าพระยาที่ไหลผ่านกรุงเทพมหานครนั้น ก็เป็นบริเวณที่เรียกได้ว่าแม่น้ำสองสี คือสีน้ำตาลธรรมชาติ และสีโคลนดำที่ขุ่นมัวเน่าเสีย ที่บรรดาโรงงานทั้งหลายผลักดันและระบายลงคลองด่าน คลองภาษีเจริญ และคลองต่างๆ มาออกแม่น้ำเจ้าพระยา พื้นที่ซึ่งเคยเป็นสวนในในเขตฝั่งธนบุรีทั้งหมดถูกทำลาย และกำลังคืบคลานต่อไปยังเขตบางกรวย บางใหญ่ ในเขตจังหวัดนนทบุรี ในขณะที่พื้นที่ทางเกษตรกรรมในการปลูกข้าวตามท้องทุ่งทั้งหลายในเขตจังหวัดอยุธยาและปทุมธานี เกิดโรงงานอุตสาหกรรมและย่านอุตสาหกรรมขึ้นเป็นดอกเห็ด ทำให้แหล่งปลูกข้าวที่ดีต้องหมดไปเป็นจำนวนมาก ในฤดูฝนและฤดูน้ำหลาก น้ำท่วมทุ่งก็เปิดโอกาสให้บรรดาน้ำเสียและของเสียจากโรงงานอุตสาหกรรมต่างๆ ได้ระบายผ่านมาลงลำน้ำสำคัญ เช่นแม่น้ำลพบุรี แม่น้ำป่าสัก แม่น้ำน้อย และในที่สุดก็ลงมาสู่แม่น้ำเจ้าพระยาที่ไหลผ่านกรุงเทพฯ ลงสู่อ่าวไทย สิ่งที่น่าวิตกในขณะนี้ก็คือ บรรดาสิ่งที่เป็นมลภาวะทั้งหลายที่มากับลำน้ำเจ้าพระยานั้น มีส่วนที่จะไหลผ่านเข้าคลองประปาที่แยกออกจากแม่น้ำเจ้าพระยาในเขตจังหวัดปทุมธานี แล้วทำให้เป็นอันตรายแก่สุขภาพและชีวิตของคนกรุงเทพฯ ได้อย่างไม่มีใครรู้ตัว อีกนัยหนึ่งก็คือทำให้เกิดการตายผ่อนส่งขึ้นแก่ผู้คนในส่วนรวมนั่นเอง

สรุป

ดินดอนสามเหลี่ยมเจ้าพระยาคือบริเวณที่มีความสมบูรณ์ในตัวเอง ที่ทำให้เกิดพัฒนาการทางเศรษฐกิจ และสังคมของมนุษย์ขึ้นเป็นรัฐและประเทศ ปัจจัยที่ทำให้เกิดพัฒนาการดังกล่าวนี้ก็คือ ประการแรกเป็นพื้นที่ราบลุ่มที่อุดมสมบูรณ์ ที่เหมาะกับเกษตรกรรมที่เลี้ยงชีวิตมนุษย์ได้เป็นจำนวนมาก มีแม่น้ำและลำน้ำมากมายหล่อเลี้ยงพื้นดินและทำหน้าที่เป็นเส้นทางคมนาคมที่ทำให้การติดต่อระหว่างกันของบรรดาชุมชนมนุษย์ที่เข้ามาตั้งถิ่นฐานในบริเวณต่างๆ เป็นไปอย่างสะดวกสบายส่งผลให้เกิดความสัมพันธ์ทางเศรษฐกิจสังคมและวัฒนธรรม ที่ง่ายต่อกระบวนบูรณาการทางวัฒนธรรมและการเมืองขึ้นเป็นรัฐและอาณาจักร ปัจจัยประการที่สองก็คือ ตำแหน่งทางภูมิศาสตร์ของดินดอนสามเหลี่ยมอยู่ในบริเวณอ่าวไทยที่ติดต่อกับโลกภายนอกทางทะเลได้ ทำให้คนจากภายนอกที่หลากหลายทางชาติพันธุ์เข้ามาแสวงทรัพยากรธรรมชาติที่มาจากความหลากหลายทางชีวภาพและแร่ธาตุที่มี

อยู่อย่างอุดมสมบูรณ์ในพื้นที่ต่างๆ ของประเทศ ตั้งแต่สมัยก่อนประวัติศาสตร์ในยุคโลหะลงมา ผู้คนเหล่านี้บางกลุ่มก็มีความก้าวหน้าทางเทคโนโลยีได้เข้ามาตั้งถิ่นฐานอยู่อย่างถาวร ทำให้เกิดพัฒนาการของบ้านเมืองที่เป็นรัฐและอาณาจักรขึ้นหลายยุคหลายสมัย ตามสภาวะการเปลี่ยนแปลงทางภูมิศาสตร์และสภาพแวดล้อมและความสัมพันธ์ทางเศรษฐกิจและสังคมกับภายนอก ที่นำผู้คนแต่ยุคแต่ละสมัยเข้ามา

การเคลื่อนไหวของผู้คนและการเกิดบ้านเมืองและรัฐขึ้นในดินดอนสามเหลี่ยมเจ้าพระยา ที่สัมพันธ์กับการเปลี่ยนแปลงทางภูมิศาสตร์นั้น อาจแบ่งออกได้เป็น ๒ ช่วงเวลาคือ สมัยทวารวดี-ลพบุรี และสมัยอยุธยา-กรุงเทพฯ การเกิดบ้านเมืองและรัฐในช่วงเวลาแรกนั้นสัมพันธ์กับพื้นที่ ซึ่งเรียกว่าเดลต้าเก่า ที่อยู่เหนือจังหวัดพระนครศรีอยุธยาขึ้นไป รวมกับพื้นที่บริเวณชายขอบของทางด้านตะวันตกและตะวันออก เมืองสำคัญๆ ที่เกิดขึ้นในยุคนี้ล้วนตั้งอยู่ใกล้กับลำน้ำที่สามารถออกทะเลได้ จึงเป็นทั้งเมืองท่าและเมืองที่เป็นศูนย์กลางทางเศรษฐกิจ การเมืองและวัฒนธรรมในเวลาเดียวกัน จากหลักฐานทางโบราณคดีมีพัฒนาการของกลุ่มบ้านเมืองเหล่านี้ย้อนหลังไปถึงสมัยสุพรรณภูมิ ที่มีการติดต่อกับอินเดียประมาณ ๓๐๐-๔๐๐ ปีก่อนคริสตกาล ส่วนพัฒนาการของบ้านเมืองในยุคหลังที่เรียกว่า สมัยอยุธยา-กรุงเทพฯ นั้น เกิดขึ้นในบริเวณที่เรียกว่า เดลต้าใหม่ คือบริเวณตั้งแต่จังหวัดพระนครศรีอยุธยาลงมาจนถึงอ่าวไทย เมืองต่างๆ ที่เกิดขึ้นที่สำคัญอยู่ตามฝั่งน้ำของแม่น้ำสำคัญๆ ที่เป็นเส้นทางคมนาคมติดต่อได้กับทั้งภายนอกทางทะเลและบ้านเมืองที่อยู่ภายในโดยทางลำน้ำ เมืองเหล่านี้ได้แก่อยุธยา สุพรรณบุรี ราชบุรี เพชรบุรี สมุทรสงคราม สมุทรสาคร ธนบุรี และอื่นๆ การเกิดบ้านเมืองขึ้นใหม่ในยุคนี้มีความเกี่ยวข้องกับการเคลื่อนย้ายของผู้คนหลายเผ่าพันธุ์ที่มาจากประเทศจีนตอนใต้ และบริเวณใกล้เคียงเป็นอย่างมาก ความเคลื่อนไหวของกลุ่มชนที่เป็นพ่อค้าวานิชจากภายนอกเข้ามาสร้างบ้านแปงเมืองนั้นเห็นได้จากตำนานและนิทานเรื่องท้าวอู่ที่ทำให้เกิดชื่อของท้องถิ่นและสถานที่จากชายฝั่งทะเลเข้าไปยังพื้นที่ภายในของเดลต้า บ้านเมืองและรัฐที่เกิดขึ้นในบริเวณเดลต้าใหม่นี้ เป็นที่รู้จักกันของคนภายนอกในนามว่า สยามประเทศ

ลักษณะทางสังคมและสภาพทางภูมิศาสตร์ของสยามประเทศก็คือ เป็นสังคมลุ่มแม่น้ำ ที่บรรดาแม่น้ำลำคลองคือเส้นชีวิตของชุมชน นับแต่การได้อาศัยเป็นเส้นทางคมนาคม แหล่งน้ำเพื่อการอยู่อาศัยและการเกษตรแล้ว ยังเป็นที่ตั้งของแหล่งที่อยู่อาศัยของชุมชนในระดับต่างๆ ตั้งแต่บ้าน เมือง จนถึงนคร การสิ้นสุดของพระนครศรีอยุธยาในฐานะเมืองราชธานีของสยามประเทศนั้น หาได้ทำให้สังคมลุ่มแม่น้ำต้องมีอันเป็นไปในลักษณะล่มสลายไม่ หากเกิดความงอกงามและแผ่กว้างเป็นแหล่งที่ตั้งถิ่นฐานของผู้คนทั้งจากภายนอกและภายใน ที่มีกรุงเทพมหานครเป็นศูนย์กลาง ทั้งการเป็นเมืองท่าการค้าขายกับภายนอก และศูนย์กลางทางการเมืองการปกครองและศิลปวัฒนธรรม ในที่สุดความเป็นสังคมลุ่มแม่น้ำของสยามประเทศที่เคยเป็น ก็พบกับการเปลี่ยนแปลงในยุคแค่สมัยจอมพลสฤษดิ์ ธนะรัชต์ เป็นนายกรัฐมนตรี เป็นต้นมา เพราะมีการพัฒนาประเทศในทางเศรษฐกิจและการเมืองที่จะทำให้สังคมลุ่มแม่น้ำที่เป็นเกษตรกรรมมีทั้งการทำสวนทำนา เป็นพื้นฐานสำคัญ กลายเป็นสังคมอุตสาหกรรม รวมทั้งการสร้างถนนหนทางและการขยายการค้าของเมืองและโรงงานอุตสาหกรรม ที่ทำกันมาอย่างสืบเนื่อง

เป็นเวลารวม ๙๐ ปีนั้น ได้ทำให้ความสำคัญของแม่น้ำลำคลองที่เป็นฐานทางเศรษฐกิจและสังคมของสังคมลุ่มแม่น้ำที่เป็นไปในขณะนี้

---

[๑] Takaya, Yoshikazu. **Argricultural Development of a Tropical Delta : A Study of the Chao Phraya Delta,** *chapter3 : A Schematic view of the Chao Phraya Delta*, [University of Hawaii Press, Honolulu, 1987] p.115-116

[๒] ในที่นี้ entrepot หมายถึงชุมชนขนาดเล็กซึ่งเป็นจุดจอดเรือพักสินค้า

[๓] La Loubere, Simon de. **The Kingdom of Siam,** [Oxford University Press, Kuala Lumper], p.1

[๔] ศิลปากร, กรม. **วรรณกรรมสมัยอยุธยา เล่ม ๒** [กรุงเทพฯ, ๒๕๓๐] หน้า. ๕๒๖-๕๒๘

[๕] สุนทรภู่. **นิราศสุนทรภู่**, [องค์การค้าของคุรุสภา, กรุงเทพฯ, ๒๕๒๐] หน้า. ๔๑๒

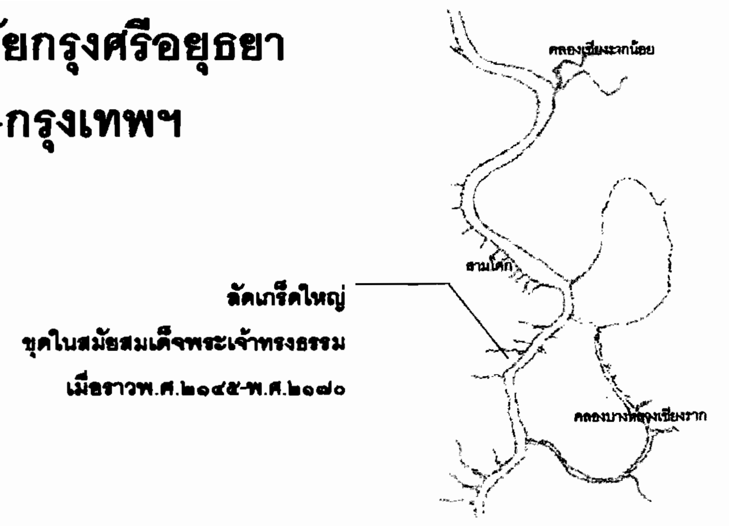
[๖] Charnvit Kasertsiri. *Origin of a capita and seaport : The early settlement of Ayutthaya and its East Asian trade*, **From Japanese to Arabia : Ayutthaya' s maritime relation with Asia**, [Bangkok,1999] p.66

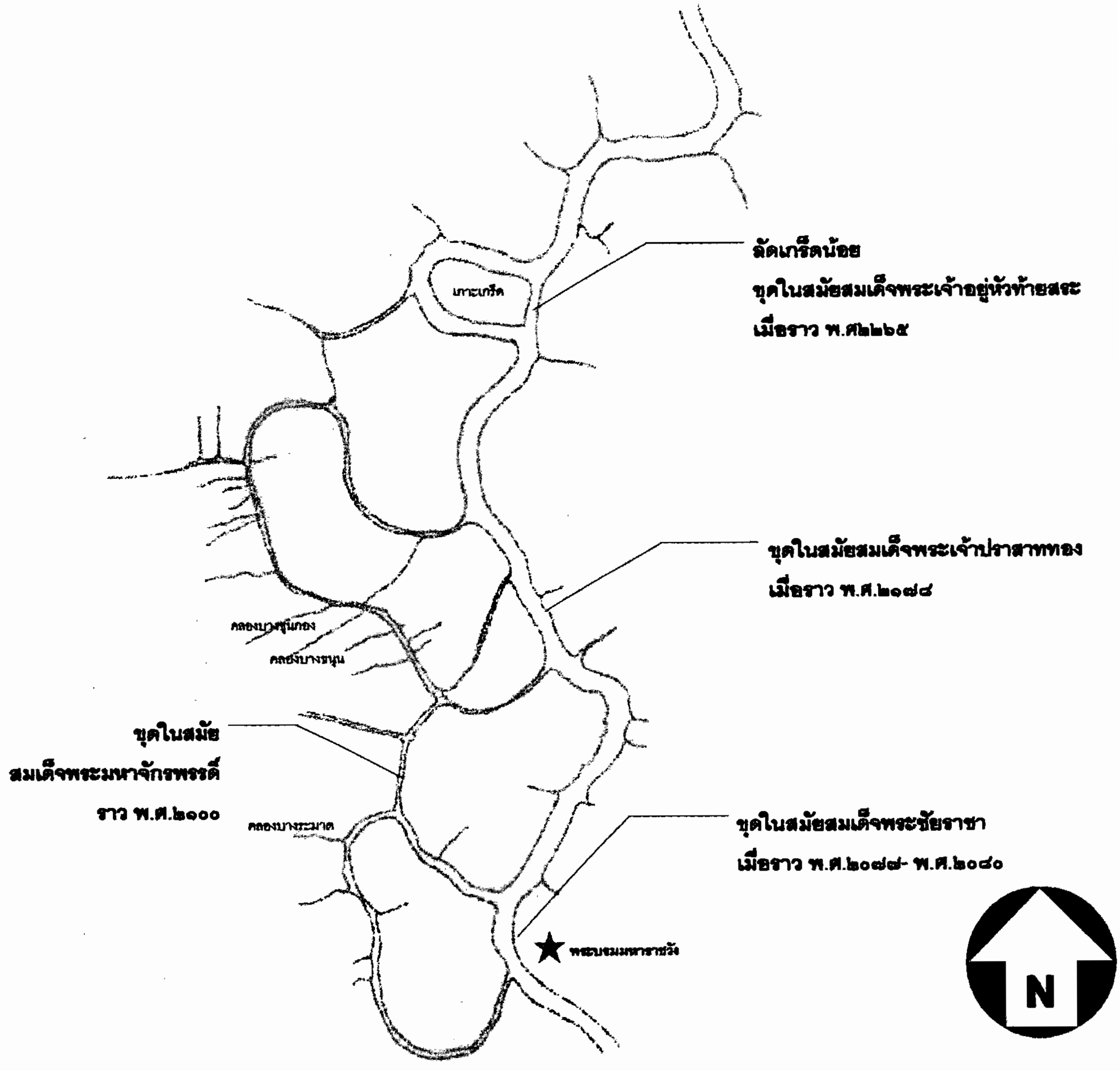
[๗] La Loubere, Simon de. **The Kingdom of Siam,** [Oxford University Press, Kuala Lumper], p.8 และ เดวิด เค. วัยอาจ บรรณาธิการ. **พงศาวดารกรุงศรีอยุธยาฉบับวัน วลิต พ.ศ.๒๑๘๒**, [ภาควิชาประวัติศาสตร์ มหาวิทยาลัยศรีนครินทรวิโรต ประสานมิตร, กรุงเทพฯ, ๒๕๒๓] หน้า. ๒๐-๒๗

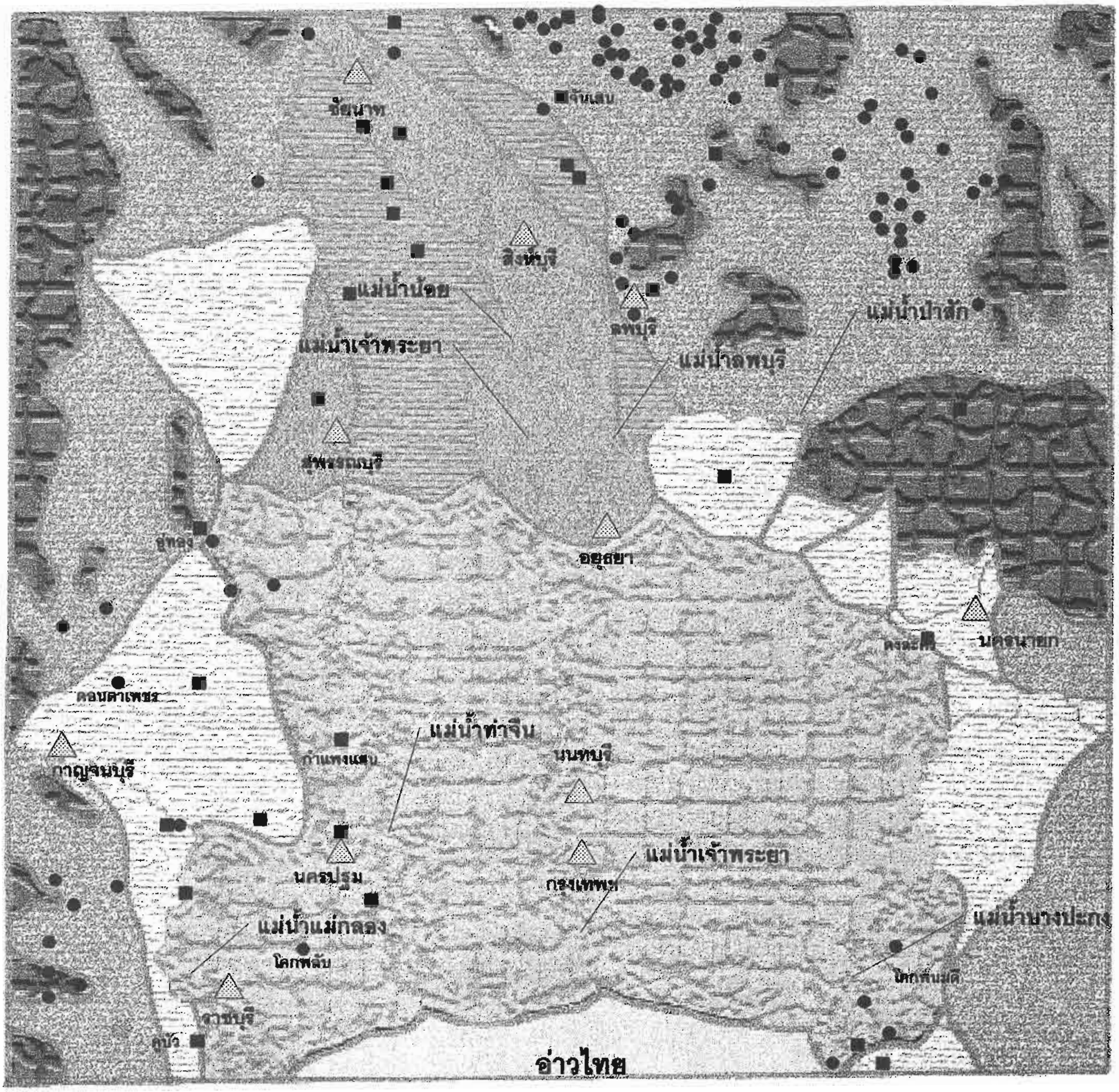
[๘] Wolter, O.W. *Tambralinga.* **Bullentin of the Oriental and African Studies, V.XXI, part 3,** [University of London,1958]

[๙] คณะกรรมการอำนวยการจัดงานฉลองสิริราชสมบัติครบ ๕๐ ปี. **จดหมายเหตุของโยสต์ เคาเต็น ประชุมพงศาวดารฉบับกาญจนาภิเษก**, [โรงพิมพ์คุรุสภาลาดพร้าว, กรุงเทพฯ, ๒๕๓๙] หน้า.๒๕๗-๒๕๘

แผนที่แสดงคลองขุดลัดในสมัยกรุงศรีอยุธยา ตั้งแต่ปทุมธานี-นนทบุรี-กรุงเทพฯ







สัญลักษณ์ที่ใช้ในแผนที่

△ แสดงตำแหน่งจังหวัด

● แสดงตำแหน่งแหล่งโบราณคดีสมัยก่อนประวัติศาสตร์

■ แสดงตำแหน่งแหล่งโบราณคดีสมัยทวารวดี

Young delta

old delta

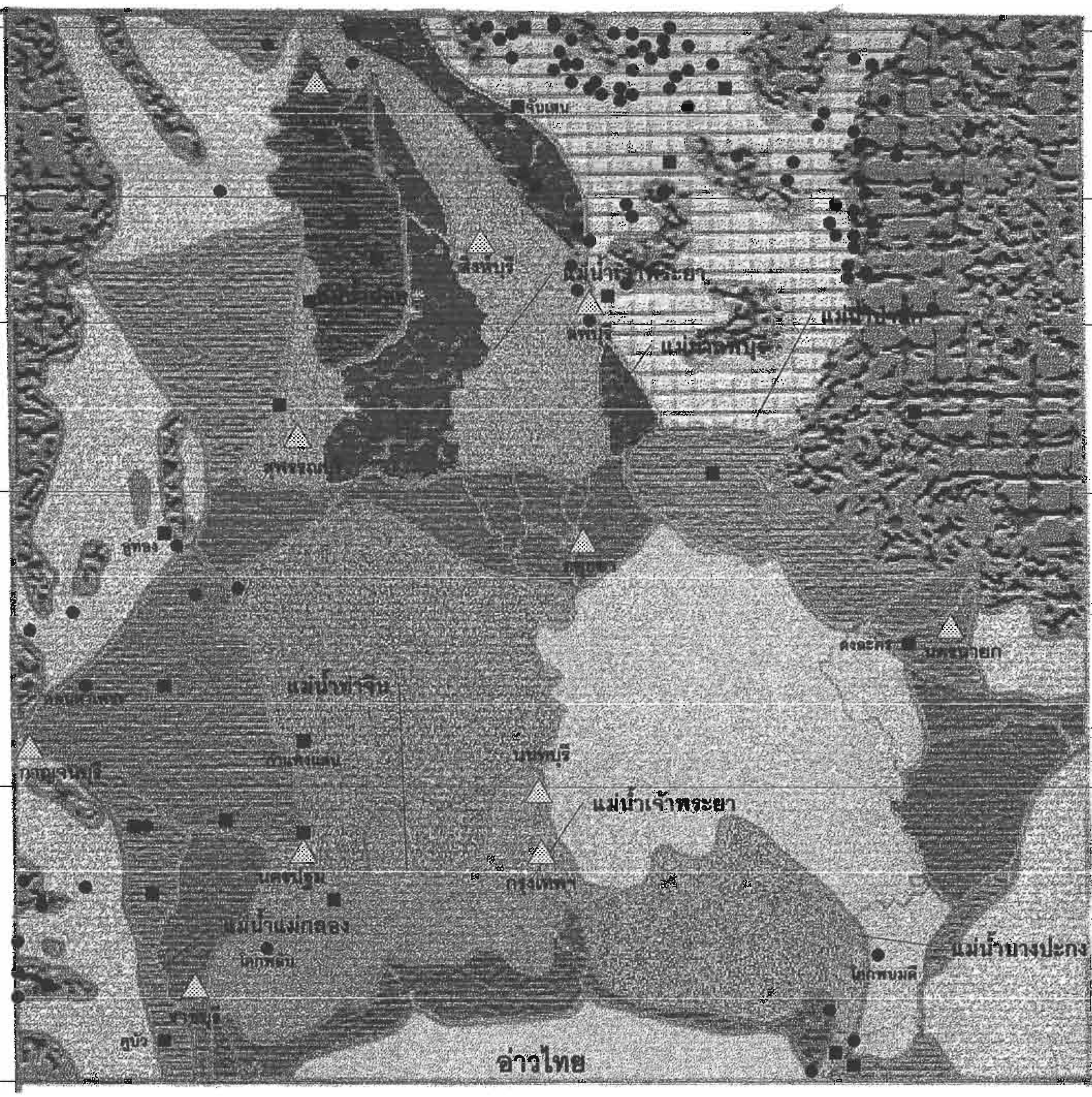
floodplain

terrace

fan

mountain

แผนที่แสดงลักษณะภูมิประเทศในบริเวณสามเหลี่ยมปากแม่น้ำเจ้าพระยา และตำแหน่งของแหล่งโบราณคดีสมัยก่อนประวัติศาสตร์และสมัยทวารวดี



สัญลักษณ์ที่ใช้ในแผนที่

△ แสดงตำแหน่งจังหวัด

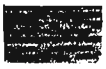
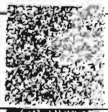
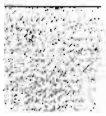
● แสดงตำแหน่งแหล่งโบราณคดีสมัยก่อนประวัติศาสตร์

■ แสดงตำแหน่งแหล่งโบราณคดีสมัยทวารวดี

N

แผนที่แสดงโครงสร้างของดินในบริเวณสามเหลี่ยมปากแม่น้ำเจ้าพระยา และตำแหน่งของแหล่งโบราณคดีสมัยก่อนประวัติศาสตร์และสมัยทวารวดี

สัญลักษณ์ที่ใช้แสดงคุณสมบัติของดินบริเวณสามเหลี่ยมปากแม่น้ำ

ประเภทของดิน	สัญลักษณ์	เนื้อดิน	ศักยภาพ	ชนิดของดิน	หมายเหตุ
Tidal zone		ดี	สูง	ดินตะกอนแม่น้ำ	มีความเค็มสูง
Young delta with acid sulfate marine clays		ดี	สูง	ดินตะกอนแม่น้ำ	มักพบว่ามีความเป็นกรดซัลเฟต
Young delta with neutral marine clays		ดี	สูง	ดินตะกอนแม่น้ำ	
Young delta with acid sulfate brackish clays		ดี	สูง	ดินตะกอนแม่น้ำ	มีความเป็นกรดซัลเฟตกระจายอยู่อย่างหนาแน่น
Young delta with neutral brackish clays		ดี	สูง	ดินตะกอนแม่น้ำ	
Fluvial portion of young delta		ดี	สูง	ดินตะกอนแม่น้ำ	
Floodplain		ดี	สูง	ดินตะกอนแม่น้ำ	
Active fan		หยาบ	สูง	Noncalcic brown	
Upper old delta		ปานกลาง	ปานกลาง	Noncalcic brown และlow humic gley	
Lower old delta		ดี	ปานกลาง	Low humic gley	
Dead fan		หยาบ	ต่ำ	Gray podzolic	
Terrace		หยาบ	ต่ำมาก	Laterite และ gray podzolic	บางแห่งมีชั้น laterite (แลง) หนา
Limestone terrace		หยาบ	ปานกลาง		ดีสำหรับปลูกพืชที่สูง
Mountains					

ปรับปรุงจาก Agricultural Development of a Tropical: A study of the Chao Phraya Delta,Yoshikazu Takaya;1987

Establishing rice legume cropping system in the Central Plain for better productivity and sustainability

Aphiphan Pookpakdi[1]

Abstract: *Agriculture of the Chao Phraya Delta reflex huge areas of rice production. Prior to 1965, most of the rice cultivation at the Chao Phraya were mainly grown in the rainy season. The crop has been characterized by photoperiod sensitive with low yield. However, farmer did not supplied large input for their rice production due to natural fertilization of nutrients which had been carried on by alluvial sediments from flooding which occurred annually. Alternatively rice plants received nitrogen from authotropic and hetertropic N_2 fixation.*

With the establishment of Chao Phraya Dam at Chainat in 1957, irrigation water has been supplies to rice planted areas, made it possible for farmers to grow high yielding rice varieties especially in the dry season. With the tendency of moving towards monoculture of rice, heavy use of chemical fertilizer and pesticides, rice yield and environment of the Chao Phraya deteriorated gradually.

Food legumes such as mungbean, soybean and groundnut were considered as the crops which could benefit farmers and help improved environments and soil fertility if they would be grown before or after rice crops. With rice based system having legumes as the components, infestation of pest and disease of rice would be reduced and fertility of soil could be increased through N2 fixation. Likewise economic yield of these legumes can help elevated farmer's income. Moreover, it was found that ploughing under of green manure leguminous crops such as Sesbania, Chrotalaria and Vigna increased the yield of rainy season rice of the Chao Phraya Delta region as well.

1 Introduction

Thailand has been considered as the Rice Bowl of Asia as the area devoted to rice production was over 8.4 million hectare. Out of the total rice production area, 77 % is non irrigated or rainfed (Somrith and Awakul, 1979). In the Central Plain of Thailand, which consist of flat to gently sloping delta and terrace land developed along the Chao Phraya river, mixture of irrigated, rainfed and deep water rice are grown. It has been estimated that 0.90 million hectares especially in the upper part of the central plain are grown to the rainfed

[1] Associate Professor, National Soybean Research Coordinator, Department of Agronomy, Kasetsart University, Bangkok, Thailand

lowland rice, the rest of them are irrigated rice and deep water rice (Somrith and Awakul, 1979).

Rice in the Central Plain is mostly of the non-glutinous varieties, as all irrigated rice lands are planted with modern high yielding varieties, while rainfed lowlands are mostly planted with improved traditional or local photoperiod sensitive varieties.

Figure I shows the area of wet land rice production and yield in Thailand for the 1995-96 crop, while figure II showed the area planted to wetland rice and production in different regions of the countries.

2 Farming technology

Before the completion of the huge diversion dam at Chai Nat in 1957 and the subsequent improvement of the irrigation network in the 1960s, flood water seems to have been one of the major water resources for rice growing in most part of the delta (Tanabe, 1994). However, since inundation occurred normally from August or September water supply must have depended on rainfall throughout most of the first half of the growing season. The annual large scale flooding used to be so unreliable in its intensity and duration from year to year that inundation water was too deep and stayed to long in some years. The natural flooding certainly played a significant role in water supply, though only during the second half of the growing period, for rice growing in most of the delta.

Figure 3 shows the areas, boundaries of rice farming of the Chao Phraya Delta Region.

FIGURE I: THE AREAS PLANTED TO WETLAND RICE, PRODUCTION AND YIELD IN THAILAND FOR 1995 - 96 CROP YEAR

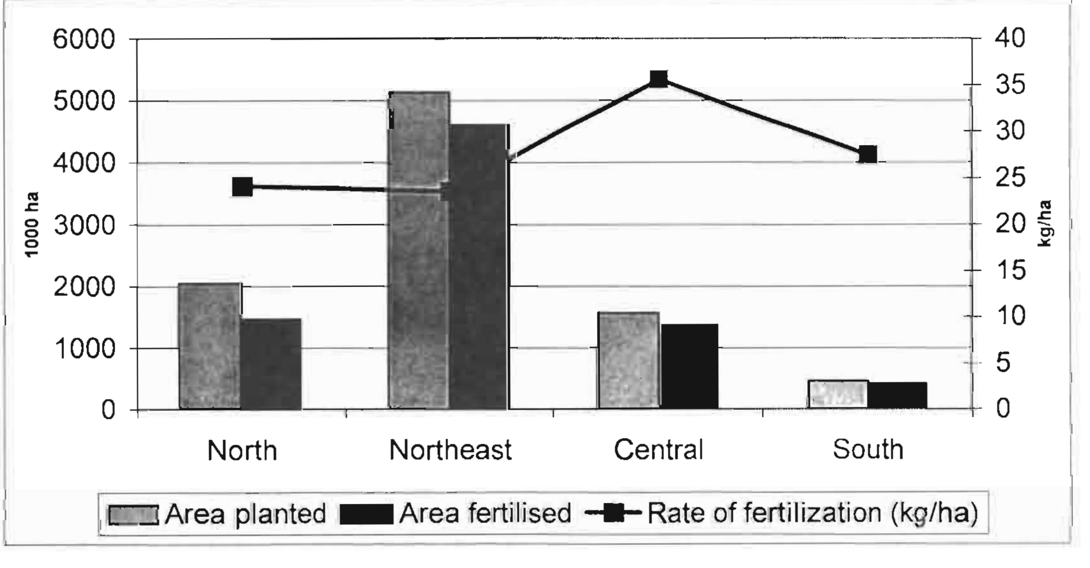
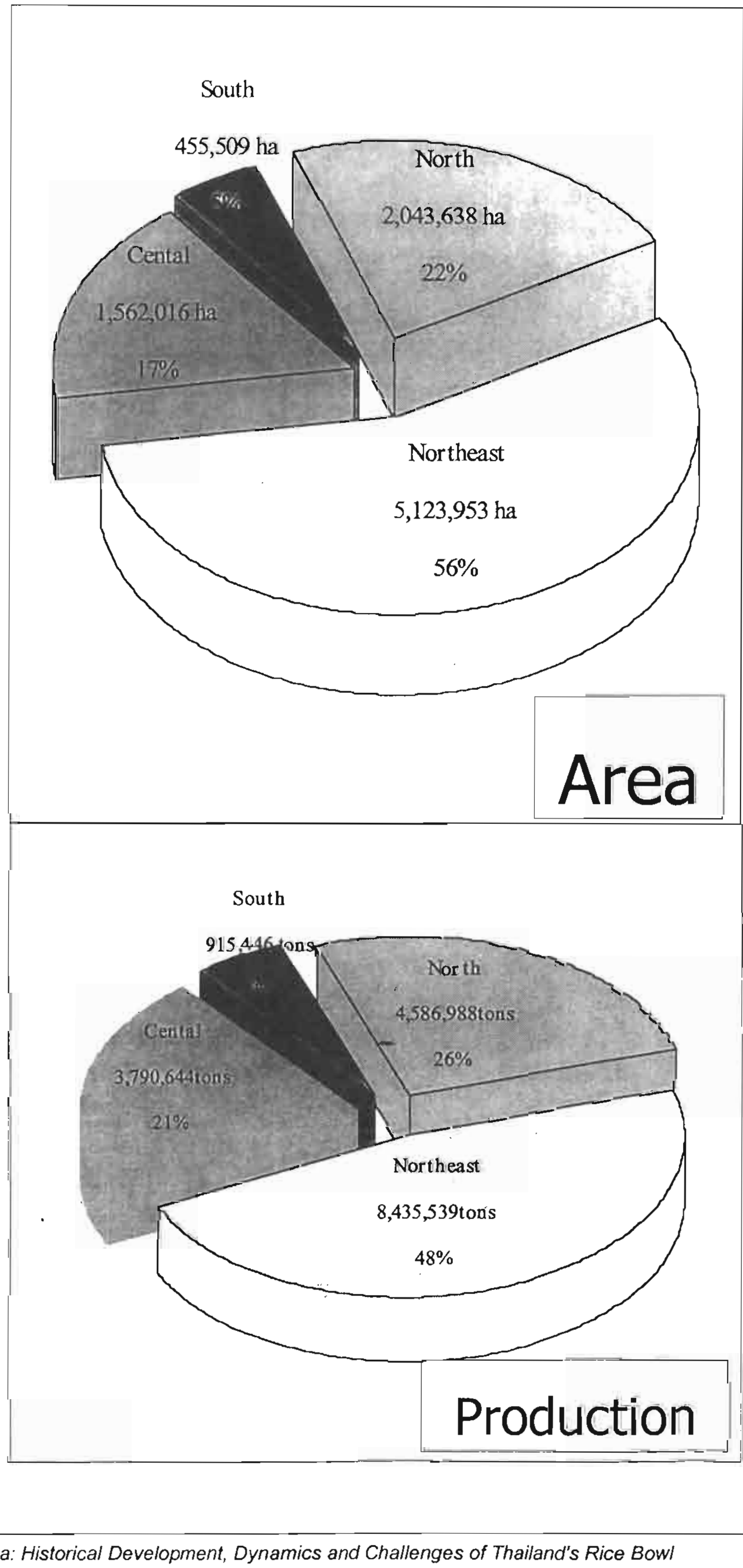


FIGURE 2: AREA PLANTED AND PRODUCTION OF WETLAND RICE IN DIFFERENT REGIONS OF THAILAND



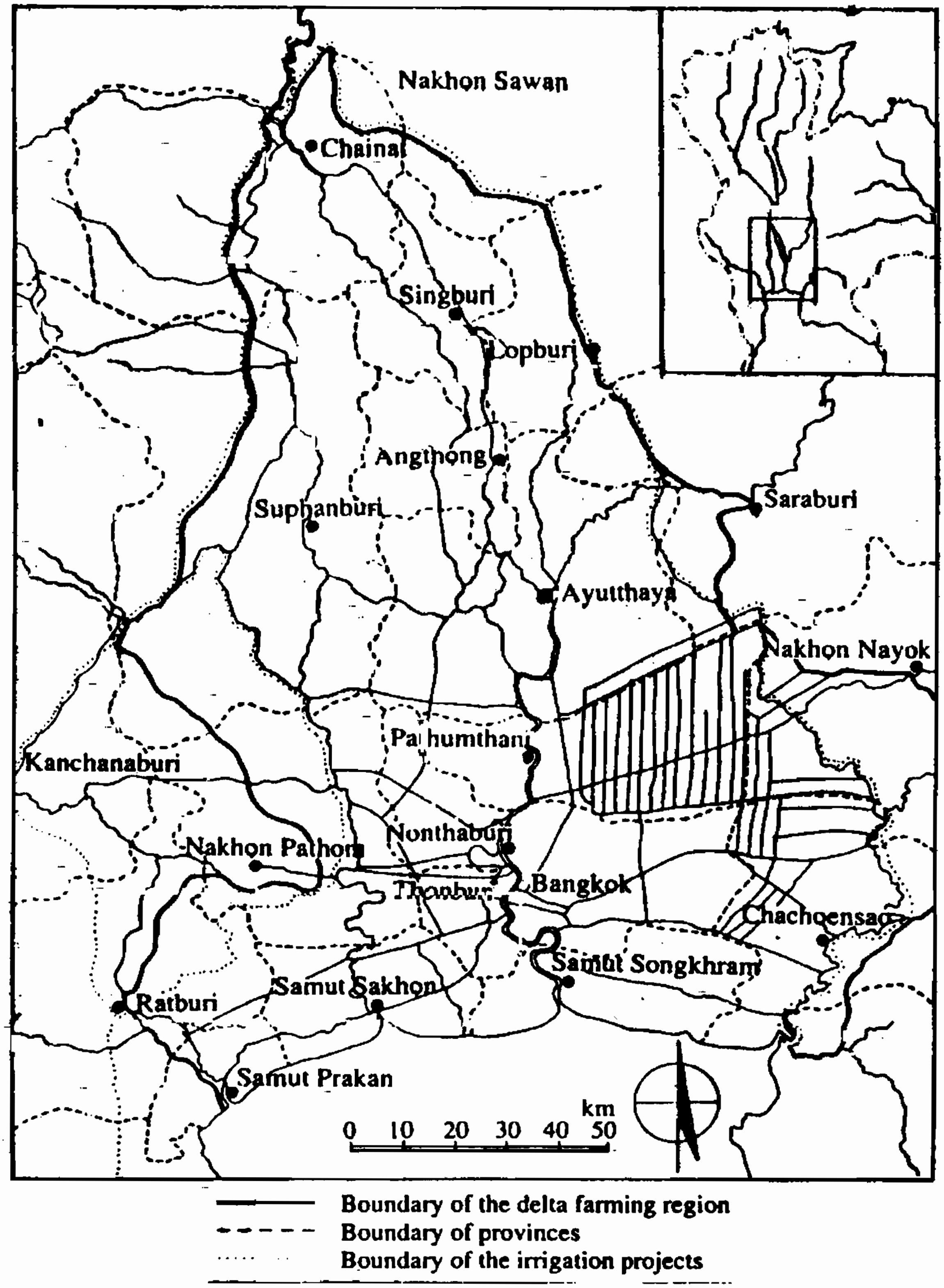


FIGURE 3 : CHAO PHRAYA DELTA REGION : BOUNDARIES AND RICE FARMING SYSTEM

The water environment of the delta type of rice farming before the Greater Chao Phraya Project was basically characterized by a total dependence on monsoon precipitation in the first half and virtually uncontrolled inundation in the second half of the growing period. This being the case, the cultivation method was generally naturally restricted to direct or dry seeded broadcasting rather than transplanting, the latter requiring an intensive water supply during the first half of the growing period. However, the canal could, to some extent, contribute to the diversification of this pattern and transplanting was practised in some areas where farmers could obtain water from the canals by lifting.

3 Cultural practices for wetland rice production

In the central plain of Thailand, dry seeded broadcasting and transplanting was generally used in rice cultivation. It has been reported earlier that the two methods of cultivation are used about equally because broadcasting is practised in the deep weter and semi-deep rainfed lowland areas, while transplanting is confined to the intermediate rainfed and double cropping areas (Department of Agriculture, 1975).

The broadcasting dry seeding culture of the delta is generally characterized by two farming stages which present a practical negotiation with the uncertain water conditions. The first is land preparation which traditionally took place after the beginning of the monsoon rains giving sufficient moisture to allow buffalo ploughing. The start of farming was formerly dependent almost entirely upon the uncertain pattern of monsoon precipitation, though this problem has now been overcome technically by the introduction of tractor and power tiller ploughing. At the second stage, this method is characterized by direct seed sowing on the field without the transplanting of seedlings at a later period. This operation also requires timing to adjust to monsoon rainfall. After these operations are completed, the field remains almost untouched and is subject to inundation up to the harvesting time. In contrast to the broadcast-sowing cultivation, the transplanting system practiced in the delta is basically similar to that in the intermontane basins, though there are many technical differences in detail.

Throughout the farming operations, broadcast sowing culture in relatively less labour intensive than the transplanting culture practiced elsewhere, whether in the intermontane basins or in the delta. This is mainly due to the fact that the broadcast sowing culture does not involve labour intensive and elaborate operations such as nursery culture and uprooting-transplanting. Thus in the broadcast sowing culture the peak period of intensive labour demand occurs normally only in harvesting while there are two peak periods at transplanting and at harvesting for the transplanting culture.

4 Fertilization of rice plant

4.1 Before the construction of Chainat Diversion Dam

Fertilization of rice plant before the construction of Chainat diversion dam occurred naturally. Inundation which happened annually carried alluvial deposits from the northern basin, such deposit contained huge amount of plant nutrients needed by rice plants. Therefore nutrients was supplied to rice crop during the reproductive stages and rice plant absorbed them for the benefit of panicle and grain production. Numerous amount of nutrients has been deposited in the soil. The mineralization of organic materials resulted from the decomposition of plant residual increase inorganic components of soil naturally. Those nutrients in the soil supplied the dietary requirement of rice plant sown in the dry seeded broadcasting in the early vegetative growth.

Supplement of nitrogen compound to rice plant in the delta has been occurred naturally also in the early days. Firstly, atmospheric N_2 fixation which occur by lightning supply approximately 10 x 10^6 metric tons of ammonia per year. Ammonium compound which is produced in the atmosphere convert itself to nitrate and subsequently carried by rainfall into the earth surface. Secondly, biological nitrogen fixation by bacteria and blue green algae supply approximately 30 kg N per hectare (Quispel, 1974) in rice soil, Flood water which kept still between August to November provided suitable environments for microorganisms performing the biological nitrogen fixation in rice, such microorganisms were Azobacter, Azospirillum, *Clostridium pasteurianum*, and blue green algae which is presently known as Cyanobacteria (Buchanan and Gibbon, 1974). The cyanobacteria can be recognizable as those composed of two genus, the Anabaena and Nostoc.

4.2 After the completion of Chainat diversion dam and subsequent improvement of irrigation networks.

After the completion of Chainat diversion dam and subsequent improvement of irrigation networks in 1960s, the entire Chao Phraya Delta region has been served by a magnificent water control scheme, Flooding has been artificially regulated fairly well and the irrigated area has increased very substantially through the distribution of water from the Chao Phraya where flood water had hardly reached. Numerous things have changed as a result of the irrigation networks.

Firstly, vast areas of transplanted rice had tremendously increased due to the fact that water can be controlled for one reason. On the other hand, the rice improvement program of the Ministry of Agriculture has introduced several high yielding rice cultivars resulted from breeding program utilizing parents from successful Green Revolution. Later, it was the wet broadcasting method of rice cultivation that has been introduced as a compromise of cultural practices between low input dry seeded broadcasting and high labour requirement in transplanting rice.

Secondly, when water level can be controlled in many part of the Chao Phraya Delta and floods in many areas has not occurred as before, irrigation facilities also made dry season rice crop cultivation possible. Farmer began to grow double rice crops or triple rice crops using high yielding non photoperiod sensitive varieties. To accelerate the production of rice they tend to utilize more chemical fertilizer.

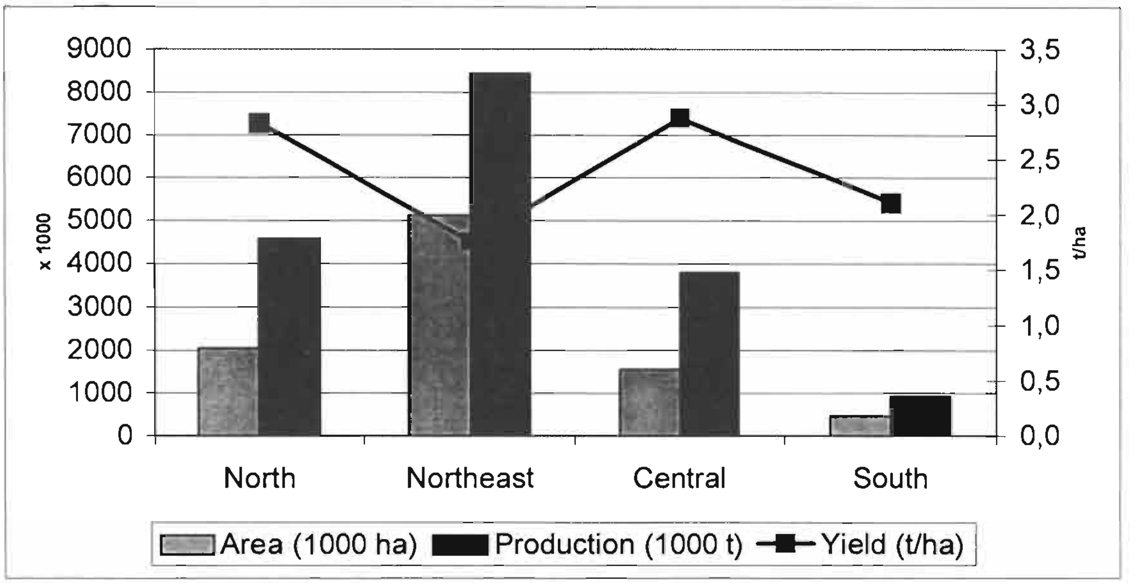
Figure 4 shows the chemical fertilizer use in wetland rice as shown in different regions of Thailand.

TABLE I : NITROGEN FIXATION AND NITROGEN LOSS (N BALANCE)

Items	Areas (hectare x 10^6)	Kg. N_2 fixed per ha. X year	Nitrogen loss per year x 10^6
Biological N_2 fixation			
Legumes	250	55-140	14-35
Non-legumes	1015	5	5
Paddy field	135	30	4
In soils and others	12,000	25-30	30-95
In the ocean	36,100	0.3-1	10-36
Industrial N_2 fixation			30
Atmospheric N_2 fixation			7.6
Naturally increases			0.2
Denitrification			
in land	13,400	3	43
in the sea	36,100	1	40
Leaching			0.2

Source : Quispel, (1974).

FIGURE 4: CHEMICAL FERTILIZER USE IN WETLAND RICE AS SHOWN IN DIFFERENT REGIONS OF THAILAND, CROP YEAR 1995 - 96.



5 The monoculture farming

As the result of the increase in rice production using high yielding non photosensitive varieties with an attempt to increase the yield and production, farmer are using more and more fertilizer. A drastic impact of rice monoculture has occurred. Numerous pests and diseases have been accumulated in the rice-rice system causing farmer to use more pesticide which in term resulted in pest resistance. Chemical fertilizers also cause the rice plant to be more susceptible to disease and insects. More spraying of chemical cause the elimination of natural enemies. Routine application of chemical fertilizer cause nutritional imbalance in crop. Therefore, the monoculture of rice crops in the central plain of Thailand, especially in the Chao Phraya Delta region, become unsustainable. The outbreak of brown plant hoppers and numerous diseases such as bacterial blight has occurred. Numerous areas of rice cultivation which received chemical fertilizer became acidic, for example the acid sulphate rice areas in Rangsit district of Pathum Thani.

The following are the problems of insects, diseases and adverse soil conditions occurred in the central Chao Phraya Delta.

5.1 Brown plant hoppers

The widespread growing of dwarf varieties of rice in Thailand has increased field populations of brown plant hopper more markedly than that of any other insect. Brown plant hopper outbreaks have caused serious economic losses in Thailand as well as in the Philippines, India and Indonesia. The discovery of the existence of different biotypes, each of which differs in the ability to attack resistant varieties, greatly complicates the use of monogenic resistance to effectively control *Nilaparvata lugens* (Jennings *et al.*, 1979).

5.2 Stemborers

Rice stemborers have generally been considered the major insect pest in Thailand. Four species are widespread in Asia and are of major significance : the striped borer *Chilo suppressalis*, the yellow borer *Tryporyza incertula*, the white borer *T. innotata*, and the pink borer *Sesamia inferens.*

5.3 The bacteria blight

The improved practices of rice culture used in the recent years, such as high nitrogen rates, dense planting, and continuous cropping, have contributed to the increased incidence of bacteria blight (*Xanthomonas oryzae*) in both temperate and tropical Asia (Jenning *et al.*, 1979) It has been reported that infestation outbreak occurred in Thailand in the mid 1980s Because chemical control measures are not practical, resistant varieties must be used to minimize disease loss.

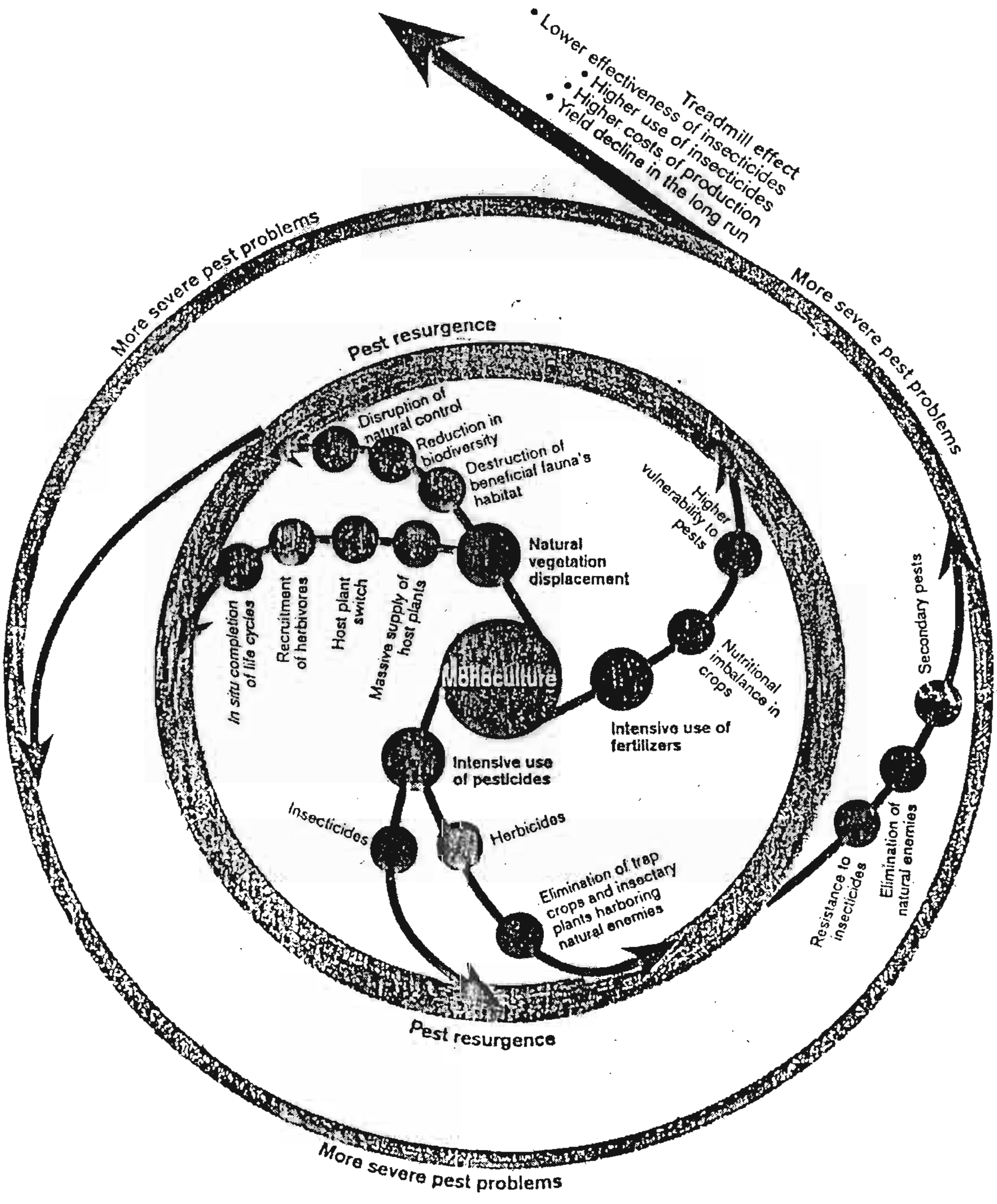
5.4 Blast

Blast is the most wide spread rice disease and its causal organism *Pyricularia oryzae* is the most variable pathogen. Neck blast causes the most serious yield losses in rice in Thailand as well as in Southeast Asia.

5.5 Tungro virus

Tungro virus disease occur in rice because the virus is transmitted by an insect: the green leaf hopper *Nephotettix virescens.* The disease assumed major economic significance in tropical Asia since it was first identified 36 years ago. Epidemics on million of hectares of rice have caused substantial production losses in Thailand, India Indonesia and the Philippines.

FIGURE V THE ECOLOGICAL CONSEQUENCES OF MONOCULTURE WITH SPECIAL REFERENCE TO PEST PROBLEMS AND THE AGROCHEMICAL TREADMILL



5.6 Adverse soil conditions

More than million ha of land that is physiographically and climatically suited for rice lies idle in the central Chao Phraya Delta region especially in the river basins. Large areas of these regions have adverse soils that can be brought into cultivation with the combination of flooding, proper soil management and the use of adapted varieties. Rice is the only crop logically suited to these areas because it thrives in submerged soil. However, monoculture of rice caused the extended period of flooding improper soil management methods such as over-puddling of soil, which resulted in the destruction of the soil structure, over absorption of nutrients by rice plants which are growing simultaneously. Although chemical fertilizer has been added, however, adverse soil conditions and nutrients imbalances in the soil had occurred due to rice monoculture.

6 Establishment of rice-legume cropping system

In order to bring back stability and sustainability to rice systems in the Chao Phraya Delta, an attempt was made to grow leguminous crops in the paddy rice areas before wet rice crop and also after wet rice was harvested. In order to decide for the suitable area where legumes must be incorporated to the system, two categories of rice land must be considered.

6.1 Rainfed lowland areas

Normally the dried seed broadcasting rice were grown in the rainfed lowland areas using the local photoperiod sensitive varieties. Long period of rice growing started even in May of each year and harvesting of rice was in December. By altering rice culture from dried seeded broadcast rice into transplanting using the same varieties, short growing season of legumes such as mungbean can be grown in the system, see Figure VI.

Mungbean can be grown before rice crop since the maturation of this legume is only 60 days. When these patterns were tested as early as in 1978 rainfall which started early in May gradually increased until it reached the first peak in June. In such case, farmers normally transplant rice in late July or early August and an upland crop grown before rice must be planted in May and harvested in early July before flooding occur. Mungbean which matures 60-65 days after planting was found suitable. Soybean can be grown for green pod production but the local market is limited, its long maturity period does not allow growing it for seed (Pokpakdi, 1979). As for the crop after rice, mungbean was found suitable and produced a yield ranging from 400 to 700 kg/ha in the area, depending on whether soil moisture depletion occurred in the dry season cropping since there's normally no irrigation available in the rainfed lowland areas.

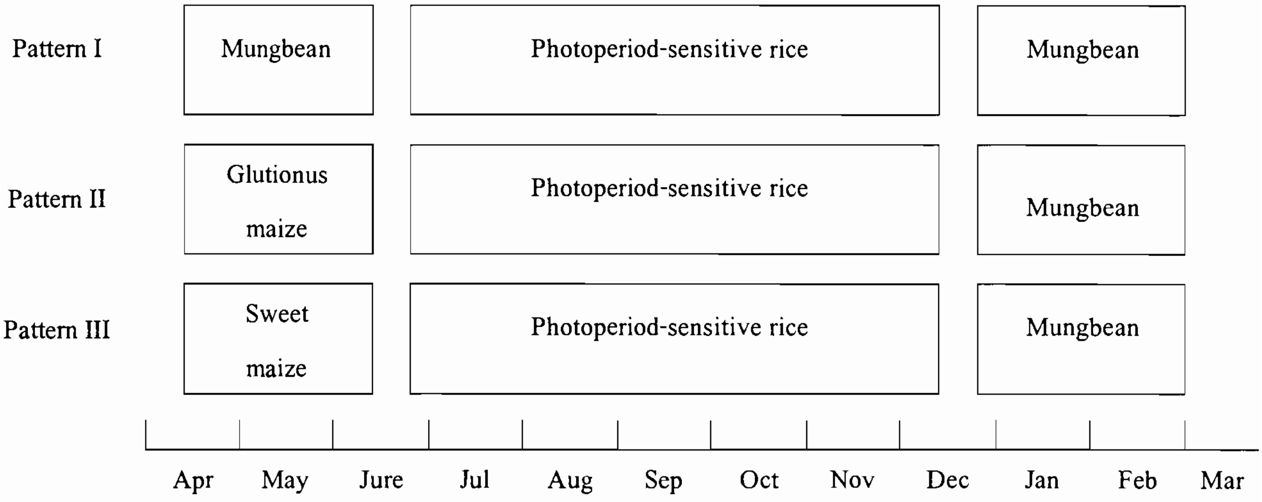


FIGURE VI SUITABLE CROPPING PATTERNS FOR BANGPAE DISTRICT OF RACHABURI, THAILAND (POOKPAKDI, 1979).

Although mungbean can be grown successfully after rice harvested in December, late planting of mungbean in February results in poor growth and low yield due to the lack of moisture (Pookpakdi, 1979). The growth of mungbean in January depends on soil moisture. Broadcasting seeds immediately after rice harvest and ploughing once by animal to barely cover the seeds with soil were suitable practices for mungbean after rice.

6.2 Irrigated land growing high yielding varieties.

This is the general area where monoculture of rice takes place. Normally the condition of rice cropping were so poor due to the accumulation of pest, diseases and adverse soil problems resulted in the continuous cropping of rice. High yielding varieties of legumes such as soybean and groundnut had been urged to replace second rice crops.

The primary strategy for increasing soybean production is to increase the area sown by expanding production into new agro-ecological areas. Currently, emphasis is being placed on expanding production in the low central plain region. The government is keen to use irrigated soybean to replace dry season rice. The priority received by the central plain is attributable to the fact that many areas are accessible to irrigation, transportation and infrastructure and have fertile soils and skilled farmers. In addition to expanding the area of production, the government is also keen to increase the relatively low yields. The objective is to improve the profitability of the crop to make it more attractive to farmers, and in particular, to make it more competitive with rice. The aim is on one hand, to encourage farmers to substitute soybean for rice, and on the other, to create circumstances whereby the present incentive schemes for soybean production can be progressively dismantled

TABLE II. AREA SUPPLIED BY IRRIGATION DEVELOPMENT PROJECTS AND PUMPING IRRIGATION FOR DRY SEASON CULTIVATION IN SOME OF THE CENTRAL PLAIN REGION OF THAILAND (1989).

Selected Provinces	Irrigated areas (hectares)	Pumping irrigated areas for dry season (hectares)
Uthai-thani	83,784	2,154
Chainat	133,777	2,640
Singburi	67,840	544
Rachaburi	128,240	608
Nakornpathom	132,654	8,992
Whole Central Plain	2,108,016	44,422

Not only soybeans were grown in the dry season of the central plain area replacing dry season rice crop other leguminous productive crops such as the vegetable soybean and groundnut were planted in selected provinces of the central plain replacing dry season rice crops as well (Table III)

TABLE III AREA PLANTED TO GROUNDNUT AND YIELD IN SELECTED PROVINCES OF THE CHAO PHRAYA DELTA, 1996-1997 CROP YEARS.

Selected Provinces	Area planted (ha)	Yield (kg/ha)
Uthai-thani	190	1687
Sing buri	400	2375
Chainat	230	1912

Source : Somsak Srisombon per. comm.

7 Advantageous impact on rice-legume cropping system

7.1 Impact on reduction of pest and disease

The growing of food legumes before and after rice in double cropping or triple cropping of rice-(soybean, mungbean and groundnut) reduced the accumulation of insect pest and disease markedly as compared to those occurred in rice monoculture. As reported earlier at IRRI by Raros (1973) that the most effective way of reducing the drastic effect of pest and disease in cropping system could be done through crop rotation. It was reported in 1999 that monoculture of rice at Bangrakam, Pitsanulok resulted to the drastic reduction of rice yield due to brown plant hopper. However at Suphanburi, Ratchaburi and Nakorn Pathom where soybean and mungbean were sown in the dry season replacing rice crop, there were no incident of brown plant hopper attacked in 1999 crop year.

7.2 Fertility restoration in rice land area

Whether the fertility restoration in rice land after the cultivation of leguminous crops could be detected or not, it was certain that leguminous crops such as mungbean soybean and groundnut would add to the soil with fertility and nitrogen components. Experiments conducted at Chainat and Kamphaeng Saen (Pookpakdi *et al.*, 1998) showed that soybean planted in the dry season after rice fixed nitrogen as detected by relative ureide of 70-80 % Therefore, it was obvious that the subsequent rice crop should take advantageous of the impact on the fertility restoration caused by these soybeans accessions. (Table IV).

TABLE IV RELATIVE UREIDE (%) AS SHOWN AS MEAN OF PERCENT UREIDE BETWEEN 41-55 DAYS AFTER SOWING OF 5 SOYBEAN ACCESSIONS PLANTED AT KAMPHAENG SAEN AND CHAINAT IN THE DRY SEASON.

Cultivars	Kamphaen Saen Percentage ureide (%)	Chai Nat Percentage ureide (%)
CPAC 150-76	82.2	67.3
CPAC 562-76	73.8	74.5
CPAC 98-76	79.0	75.9
CPAC 639-76	80.0	78.5
CPAC 39-76	82.3	78.1
Mean	79.6	74.8

Source : Pookpakdi *et al.*, (1998)

8 Conclusion

This paper described the natural setting of rice production system of the Chao Phraya Delta region. Before the completion of Great Chao Phraya Dam at Chainat and the irrigation network, rice which was grown were mainly photosensitive local varieties received ferlilizer naturally from alluvial sediments carried through inundation which occur annually. The natural and biological system fixed nitrogen through the atmospheric N_2 fixation by lightning and also through the biological N_2 fixation by nitrogen fixing bacteria and bluegreen algae. After the completion of Great Chao Phraya Dam, natural fertilization provided to rice crop had been decreased tremendously due to the fact that annual flooding has not been occurred annually any more.

As the water can be controlled and provided more effectively through the irrigation project. High yielding rice varieties were planted and monoculture system of rice production had occurred. The drastic impact of mono rice culture appeared greatly especially from onward.

More pest and disease infestation occurred in double crop rice, in addition nutrition imbalance had occurred in rice land soil.

To sustain rice production system, the replacement of leguminous crop such as mungbean, soybean and groundnut had been practiced with the attempt of replacing second dry season rice for legumes. With the leguminous crops in the system, the reduction of pest and disease infestation had occurred. Through the symbiotic N_2 fixation of leguminous crops, the Chao Phraya Delta rice land return to better soil fertility and ample rich of nutrient slowly.

REFERENCES

Buchanan, R.E. and N.E. Gibbons, 1974. Bergey's Mannual of Determinate Bacteriology, 8th ed. Baltimore, Williams and Wilkins.

Department of Agriculture, 1975. Reports on primary surveys on rice cultivation in 1973-74. Planning Division, Department of Agriculture, Ministry of Agriculture and Cooperatives, Bangkok, Thailand 58 pp.

Jenning, P.R., W.R. Coffman, and H.E. Kauffman, 1979. Rice improvement. International Rice Research Institute, Losbaños, Philippines.

Pookpakdi, A. 1979. Performance of mungbean (*Vigna radiata* (L.) Wilszek) in rice-based cropping system in Central Thailand. Proceedings of the Symposium "Legume in the tropics." 13-17 November 1979. University Pertanian Malaysia. Serdang, Selangor, Malaysia.

Pookpakdi, A. 1991. Potential soybean production in the Northeast and Central Plain of Thailand. Priorities of Soybean Development in Asia, Proceedings of the Workshop held in Bogor, Indonesia, December 3-6, 1991, Boger : CGPRT Centre, 1992 400 pp.

Pookpakdi, A. 1998. The study on suitability of long juvenile trait soybean for dry season cultivation in the central plain of Thailand. Proceedings of the National Soybean Research Conference VI August 1998 Sukhothai Tham-mathirat Open University, Nonthaburi, Thailand.

Quispel, A., ed. 1974. The Biology of Nitrogen Fixation Amsterdam, Oxford : North Holland.

Somrith Boriboon and Sermsak Awakul, 1979 Rainfed lowland rice in Thailand *In* Rainfed lowland Rice, International Rice Research Institute, Losbaños, Philippines.

Tanabe Shigeharu, 1994. Ecology and practical technology, White Lotus, Bangkok Cheney Co. Ltd. Bangkok 10501, Thailand 300 pp.

Production of rice and associated crops in deeply flooded areas of the Chao Phraya delta

D. W. Puckridge[1], Tawee Kupkanchanul[2], Wilailak Palaklang[2] and Kalaya Kupkanchanakul[2]

ABSTRACT: *Thailand has approximately 500,000 ha of deepwater rice (OAE, 1991) in the Chao Phraya Delta. Most areas are rainfed with water levels uncontrolled by farmers. The average grain yield of deepwater rice (DWR) in the Central Plain is around 2.2 t/ha, similar to the average national rice yield. The main yield limiting factors are problem soils, drought in the pre-flood period part of the growing season, limited fertiliser use, and unpredictable depth and duration of flood. However, most farmers in DWR areas of Thailand want to continue growing DWR. It is the only crop that can survive in the flood period, and there is a lack of alternative off-farm occupations. The potential of dry season crops is limited due to lack of irrigation water. On less-acid soils, however, in the pre-flood period of 3-4 months from the beginning of the wet season there is good potential for non-rice crops with short growth duration and drought resistance. This paper reviews environment and production of DWR, the development of new varieties, response to fertiliser, and some alternative cropping possibilities.*

1 Introduction

> "*There is, moreover, a certain kind of land where the rice grows naturally, without sowing. When the water is up to one fathom* [1.8 m], *the rice keeps pace with its growth. This I think, must be a special variety*". [Chou Ta-Kuan, reporting on his visit to Cambodia in 1296-1297] (Siam Society, 1987)

The history of Thailand is closely linked to the flood plains of the Chao Phraya Delta, where deepwater rice is widely distributed (Catling, 1985) and has been a main support of the people. Deepwater rice is defined as rice that is flooded deeper than 50 cm for one month or longer during the growing season (Catling *et al.*, 1988c), with the term floating rice used for that growing in the very deeply flooded areas. In recent years the DWR crop has declined from 800,000 ha to 500,000 ha due to changes in flooding patterns with building of roads and embankments, introduction of fish and shrimp farms, and the utilization of land for

[1] International Rice Research Institute (retired)

[2] Rice Research Institute, DOAC, Thailand.

industrialization, urban expansion and speculation. It is still providing around one million tons of rice each year in the low-lying areas that act as a safety escape for floodwaters near Bangkok. Studies of rice and other crops and alternative uses for these annually flooded fields are therefore topics of economic and social importance. As deepwater rice is the main crop, we will first discuss DWR and the conditions under which it is grown, then consider other crops which can fit into the system.

Flooding usually occurs in the later stages of plant growth and can last for several months (Figure 1) The stipulation that flooding must be sustained for at least one month is to distinguish deepwater rice areas from other flood-prone areas. These include the coastal wetlands, where water may rise more than 50 cm by tide action, and the flash-flood areas where rice may be temporarily submerged for only a few days. Most deepwater rice survives by elongation of stems, whereas other rice types lack this characteristic and are destroyed by deep water. Floating rices can survive and produce grain when floodwaters reach maximum depths of 4 metres or even more. In this paper deepwater rice (DWR) is used as a convenient inclusive term to include the floating rices grown in very deep water, the intermediate deepwater rices which elongate to a lesser extent than floating rices, and the tall non-elongating rices which are popular for water depths of 50-100 cm.

Deepwater rice is widely spread. It is grown on the flood plains and deltas of rivers such as the Ganges and Brahmaputra of India and Bangladesh, the Irrawaddy of Myanmar, the Mekong of Vietnam and Cambodia, the Chao Phraya of Thailand, and the Niger of West Africa. In Asia it is grown from latitude 27^{o} N in Assam and Uttar Pradesh, India, to latitude 3^{o} S in Indonesia. About 9% of the total area of about 11 million ha (IRRI 1997) is cultivated on the Chao Phraya basin of Thailand.

Farmers who live in areas subject to deep flooding are skilled at maintaining a livelihood in a high-risk environment. However, land and labour productivity remain at low levels due to low cropping intensity and lack of the associated agricultural growth induced by non-farm rural activities. Rice is the only food crop that can withstand deep flooding during the wet season, and in some seasons there is no harvest at all. The dry period is often too short or has insufficient water for production of other food crops. Farmers to date have benefited little from the 'green revolution' because of limited success in disseminating appropriate high-yielding varieties.

In more favourable areas households have increased food production and income through management interventions such as mixed cropping in the pre-flood period and fish production during the flood. For example, in Bangladesh and north-eastern India investment in shallow tube wells and low-lift pumps has resulted in a crop substitution program where much of the wet season DWR has been replaced by one crop of dry season irrigated rice. Over much of the Mekong Delta of Vietnam 2-3 irrigated rice crops have replaced the single crop of DWR. Short duration pre- or post-flood rice crops have also replaced DWR in some areas of the Chao Phraya Delta.

Not all the results associated with changes to intensive production have been positive, particularly with regard to environmental protection. Reduced fish habitat, increased soil salinity, and polluted drinking water for people and animals are some of the major problems associated with the departure from traditional rice cultivation practices. Converting low-lying coastal rice paddies into ponds for brackish water shrimp farming has no doubt increased the productivity of resources and farmers' incomes in many Asian countries, but is also causing severe environmental and social problems.

On the other hand, the productivity of deep-water lands can be by improved DWR varieties and resource management practices and alternative crops appropriate to this ecosystem. Varieties with high yield incorporated with the traditional capacity to elongate in deep water have become available.

2 Habitat and production environment

River water is the most important source of flooding in the lower basin of the Chao Phraya in Thailand, where the authorities dump surplus water at high river levels (Catling 1992). The Chao Phraya River rises in the northern mountains of Thailand. Its entire delta was once part of the Gulf of Thailand, which has been filled in by sediment carried down from the north. The floodplain is braided with numerous small channels and other rivers — notably the Pa Sak — join the Chao Phraya as it flows to the sea. Monsoon rains in the watersheds bring the river down in full flood. On reaching the flat topography, the flow rates slow and over-bank spills of turbid silty water begin to flood the land. The network of canals links rivers in the delta and helps to distribute the water. Around Bangkok the delta is seldom more than 2 m above sea level, and the flooded rivers cause a large part of the local rainfall to become ponded on the land. Drainage is further restricted by high tides, which often cause reverse flow of the Chao Phraya beyond Ayutthaya. The canals and sluices effectively control early flooding and can retain water on the land at the end of the wet season, but in high flood years peak flooding can not be effectively controlled. This occurs about 3 years out of every 10, and sudden flood surges of 50-100 cm may occur. The initial inundating surge of water commences June to August, reaches a peak in October or November, and recedes in December and early January (Catling, 1992).

Most deepwater rice grows under rainfed dryland conditions for 1-3 months before being inundated with floodwater, which coincides with the highest rainfall period. Flooding in the rice fields is thus accentuated by local or nearby rainfall in conjunction with the raised water levels from swollen rivers. For example, in 1990 heavy rains over most of the surrounding elevated areas of the Central Plain caused floodwater levels at HTA and surrounding areas to rise from 70 cm to 120 cm in three days and many DWR crops were destroyed.

The water regime has the most obvious effect on crop production in deepwater areas. The time of onset of flooding and the number of days the field is flooded during the crop growth period is very important (Puckridge et al 1988b). Classification of areas by time of arrival of floodwater, rate of rise of water level, range of maximum water depths and time of recession of the flood is essential for selection of DWR varieties.

Although precise data on flooding patterns are of fundamental value to targeting improved varieties and production practices, there is a paucity of long-term daily water records from actual DWR fields. The best records have been kept in Bangladesh and Thailand (Puckridge et al. 1988b). The onset of flooding can vary greatly between years. In Thailand it may be 50 to 120 days after emergence of direct sown crops, while in Bangladesh it can be from 20 to 60 days. Floodwaters commonly rise at a rate of about 2-3 cm/day in Thailand, but it can be over 10 cm/day for extended periods in Bangladesh. The most rapid increases in water depth tend to be early in the season, when the plants are most vulnerable. Maximum water depth differs with location, and at the same location may vary 50-100 cm between years. The date of flood recession at the end of the season is more regular than arrival of floodwaters in the field, and determines desired time of maturity of the crop. In most cases DWR is usually harvested after water drains from the fields, but in some slowly draining areas it must be harvested from boats or have very late maturity. Farmers use different types of DWR because water depth can change with topography in a short distance, particularly in areas with dish shaped depressions.

Some fields may temporarily flood from rainfall or river overflow, but after a few days the flash floods subside. Most rice varieties can survive only 3-4 days of submergence, but some have been identified that can persist under water for 10 days or more. Some varieties can survive both flash floods and stagnant floods of up to about 80 cm later in the season. Varieties of such type include Khao Tah Haeng 17 and Leuang Pratew 123. These varieties, though cultivated in low-lying areas, do not elongate. Important traits are height of 150-180 cm to withstand water depths to around 80 cm, photoperiod sensitivity for flexibility in planting time, tolerance to drought, submergence and soil-related stresses. Although elongation is essential for deep water that remains in the fields, it is a disadvantage for short term flooding. If plants elongate in response to flash floods they will lodge (fall down) after the flood subsides and yield will be reduced.

The first floodwater spreading from rivers is usually turbid, but most of the silt is deposited near the main channels. Contrary to earlier belief, sedimentation rates in DWR fields are variable and generally low, and silt is not a principal source of fertility (Catling 1992). Flooding from rain usually results in clear water that generally causes less damage than silted or turbid water. Physical and chemical properties of the floodwater have an important role in growth and nutrition of the rice crop. Marked diurnal cycles in oxygen, carbon dioxide and pH occur due to the activity of photosynthetic aquatic biomass; Highest CO2 concentrations in water occur in the afternoon, and the lowest at dawn (Setter et al. 1988a,b).

Soils. Deepwater rice soils are alluvial, ranging from sandy loam to heavy clay. Heavy silt deposition is usually associated with proximity to rivers, Many soils are fertile, but adverse acid sulphate soils are common. Soil pH ranges from 3.5 to 8.5 but is mostly acidic. Acid sulphate soils are a major problem in the south-eastern part of Thailand's central plain.

Rainfall. Catling *et al.* (1988c) give details of climate in the major production areas. The mean annual rainfall of deepwater rice in Thailand ranges from about 1200 mm in the western part of the delta to 1700 mm in the east. About 60% of the rainfall occur during the flood period, and thus up to one meter of rain can be added to the floodwater originating from rivers. This is close to the average flood depth and helps to explain the general occurrence of clear water flooding. In Thailand DWR crops are sown in April-May and in the 2-4 months before floods arrive there can be periods of extreme drought stress. Severe drought in the northern delta damaged the rice crop in 1993, but in contrast the same area had disastrous floods in 1994 and 1995. Drought tolerance is an essential trait for DWR, and varieties from Thailand have been an important source of drought resistance for other rice types (DeDatta and Malabuyoc 1988).

Temperature. Day temperatures below 22^{O}C can cause sterility in rice, but in Thailand cool periods during flowering are rare and temperatures from October to December generally remain favourable for panicle initiation and flowering. Water temperatures near the surface range from 29^{O} to 35^{O}C from July to October. In deep water slightly lower water temperatures occur just above the soil. Water temperatures drop below 28^{O}C in November and below 25^{O}C in December (Catling et al 1988c).

Mineral toxicity. Mineral toxicity can occur in saline, sodic, acid sulphate, peat and dryland soils. They rarely occur in isolation. Some of the most common mineral toxicity problems limiting the growth and yield of rice are iron (Fe), manganese (Mn), aluminium (Al), boron (B), and hydrogen sulphide (H_2S). Aluminium toxicity occurs in most acid sulphate soils during the initial phase of flooding. The toxicity may persist for many weeks if soil reduction and rise in pH after submergence of acid sulphate soil is very slow. Soil pH of less than 4 and Al in soil solution of 1 ppm will indicate toxic levels of Al.

2.1 Deepwater rice cultural types

Despite the severe environment DWR has a long history of adaptation and provides a sustainable and environmentally friendly form of agriculture. It is over seven hundred years since Chou Ta-Kuan observed DWR in Cambodia (Siam Society, 1987), and although a significant change to irrigation has been occurred where water is available, conversion to irrigation in DWR areas is limited. In most of the current DWR areas rice is the only food crop possible during the wet season and farmers expect to continue growing it.

It was assumed that virtually all Asian deepwater and floating rices belonged to the *Indica* geographic race occurring in tropical monsoon climates from 0° to 25° North and that none could be classified with *Japonica*. However, Inouye and Hagiwara (1982) found that several showed distinct *japonica* characteristics. Other evidence points to the diversity of the DWR and its varied evolutionary background. It also helps to explain the extreme variability within indigenous areas and the difficulties sometimes encountered with hybridisation in variety improvement programmes (Catling 1992).

Many types of DWR can be found in a region. Different maximum water depths require distinct types of DWR and farmers may use several varieties of DWR where water depths change with topography in a short distance. For 50-80 cm water – flash flood tolerant, non-elongating varieties are usual; for 80-150 cm water – slow elongating (2-3 cm/day) varieties; and for deeper than 150 cm water – fast elongating (15-20 cm/day) varieties. The rices in the first two categories have the greatest potential for yield increase.

2.2 Special characters of deepwater rice

Deepwater and floating rices have three special adaptations; (1) elongation of stems and leaves; (2) kneeing which is the upward bending of the terminal parts of the plant and (3) the ability to develop nodal tillers and roots from upper nodes in the water. Kneeing keeps the reproductive parts above water as the floods subside. The first two traits are accentuated in floating rices such as Leb Mue Nahng 111, Pin Gaew 56, Plai Ngahm, Khao Luang and Tewada in Thailand. Nodal tillers arising during the flood period can sometimes compensate for sparse stands.

2.2.1 Elongation

Elongation ability is an escape mechanism for survival from partial or total submergence. Total plant elongation, including increase in lengths of leaf blades, leaf sheaths and stems may be as much as 20-25 cm in 24 h during initial flooding (Choudhary and Zaman, 1970). The stems produce new nodes where leaves are attached and the internode, which is the section of stem between the nodes, can increase in length when submerged. Elongation of leaf blades and leaf sheaths is important for survival of seedlings but internode elongation is the most important mechanism for increasing plant length in very deep water (Vergara et al 1975). Internode elongation commenced between 4 and 6 weeks of age for most of 100 lines of DWR plants growing in rising water (Puckridge *et al.* 1990a). The elongation induced after panicle initiation affects the final 4-5 internodes and is not influenced by water depth (Morishima 1975, Bekhasut *et al.* 1990). Elongation stops after flowering in all varieties

Catling (1992) concluded from review of the literature that there is general agreement that elongation and floating traits in cultivated rice of Asia are derived directly from a perennial *Oryza rufipogon* wild progenitor, or from an intermediate perennial-annual type in swampy lowlands. Floating rices of South Asia such as Jalmagna (India), Baisbish and Rayada 16-3 (Bangladesh) are faster elongators than the Thai rices Leb Mue Nahng 111, Pin Gaew 56 and Plai Ngham. Hence they are better adapted to rapidly rising water.

Total length of stems, comprising many internodes, is usually considerably more than the depth of water. Plants move by wind away from a vertical habit, thus having more stem sections under water and receiving more stimuli for elongation. Long internodes indicate rapid water rise. Bekhasut *et al.* (1990) reported for plants developing a total of 19 internodes that up to 14 showed marked elongation (5-30 cm) due to increase in water depth. The longest were the early-formed internodes at the base of the plants (numbered 2-5), produced when water was rising most rapidly. New nodes were produced at interval of 10-12 days, and only the most recently formed internodes elongated. Because of a period of stable water level, internodes 6-10 elongated less than internodes 11-14 which developed during a second rise in water level.

Elongation of internodes was considered by Sugawara and Horikawa (1971) to be due to increase in number of cells, while Nasiruddin *et al.* (1977) ascribed it to a lengthening of cells. Kende *et al.* (1984) reported that submergence or exposure to ethylene of whole plants led to as much as ten-fold increase in number of cells in the zones that elongated between 0 to 3 days after treatment. Their plants were at least 29 days old before internode elongation could be stimulated by ethylene treatment. Takahashi (1988) found that approximately half of the total cell population in the longitudinal direction of the internode was already formed when the internode reached 10% of its final length.

Both processes are involved. Partial submergence of DWR results in an increased rate of cell division and elongation in the intercalary meristem of the internode (Rose-John and Kende 1985, Bleecker *et al.* 1987, Kende and Raskin 1988). There appear to be four biochemical processes involved — submergence lowers the level of oxygen in rice internodes, low oxygen levels stimulate ethylene synthesis, ethylene accumulates in the submerged internodes; and finally ethylene concentration increases the sensitivity of the tissue to giberellic acid or increases the concentration of physiologically active giberellins. Production of ethylene by submerged plant parts in DWR fields near Ayutthaya was indicated by ethylene concentration of 1-2 ppm in the floodwater, compared with only 0.1-0.2 ppm in the plant canopy above the water surface (Setter et. al 1988b).

2.2.2 **Kneeing**

Kneeing is the bending upwards of the upper parts of the culms (stems) as water levels fall and rice plants lodge during the recession of floodwater. When culms lie on the water surface and the upper leaves are held vertical above the water, the plants appear to float even though the base of the plant is still attached to the soil, hence the common name floating rices. Kneeing keeps the canopy and panicles erect and above water level. It maintains grain quality by preventing submergence of the panicles in water, and protects the grain from damage by aquatic fauna (Vergara *et al.*, 1977; Vergara, 1985). Traditional deepwater rices have good kneeing ability but some modern varieties lack this trait. It should be considered as an objective of any DWR variety improvement program (Haloi, 1989).

2.2.3 Submergence tolerance

Submergence tolerance and elongation ability are essentially distinct plant traits that represent opposite mechanisms or strategies for flood adaptation, and attempts to combine them fully in a single rice variety have failed. Deepwater rice may be completely submerged if floodwaters rise rapidly, but elongation is usually sufficient to raise part of the foliage above the water level. Photosynthesis can then continue and starch and sugars in emergent leaves and in plant parts under the water are maintained (Setter *et al.*, 1987b) and further elongation can take place. Submergence tolerance is most useful for non-elongating rices that may be submerged for a few days by rapidly increasing and then decreasing water levels.

Submergence-tolerant rice may survive complete submersion by water for 10 days or more, depending on water conditions, and resume growth after the water has subsided. However, the effects are highly dependent on the growth stage. Young plants are least tolerant. Submergence at the seedling stage kills weak plants, drastically reduces growth and inhibits tiller formation.

Submerged rice has a limited supply of carbohydrates (energy) for survival and it rapidly declines (Setter *et al.* 1987b; Setter *et al.* 1988a). Recent research has focused on the way plants use this carbohydrate during submergence for growth and for maintenance processes essential to survival. These include water relations in the cell, the recycling of membranes and the expression of anaerobic genes. Since carbohydrates are limiting, it is considered likely that during submergence elongation growth competes with maintenance processes essential to survival (Setter and Laureles 1996). They used an inhibitor of GA biosynthesis (paclobutrazol) to reduce elongation growth during submergence. When this chemical was applied , either before submergence or in the floodwater, elongation was inhibited and survival of rice plants improved dramatically. For instance, an intolerant cultivar (Calrose) had 100% survival of after 10d submergence when sprayed with paclobutrazol before submergence, as opposed to no survival in the unsprayed control. They also found that a GA-deficient mutant, which did not elongate during submergence, had unexpectedly high tolerance to submergence. Conversely, when elongation was increased by giberellic acid application, submergence tolerance was reduced.

Waitruardrock et al. (1992) tested the extent to which different DWR varieties could sustain elongation. Twenty DWR entries were sown in a pond with controlled water level at Huntra Rice Experiment Station. At 6 weeks after emergence the water level was increased to 80 cm and all plant tops were cut off at the water surface. Plant were cut once only at 6 weeks, or at 2, 4 or 8 days intervals after the first cut. Heights of plants above water level were measured every 2 days after the first cutting. Plants cut once reached a height of 70-80 cm above water and were not adversely affected by cutting, whereas elongation of plants cut at intervals of 2-4 days declined rapidly, indicating depletion of reserves (Figure 2). After 18-20 days plants cut at 2 or 4 day interval ceased elongation and died. Stem glucose content was used as an estimate of the apparent energy resources of four of the rices tested. The varieties RD 19 & Huntra 60, which have medium elongation ability, had higher glucose contents than Pin Gaew 56 and Leb Mue Nahng 111, which elongate rapidly. Pin Gaew and Leb Mue Nahng appeared to be more efficient users of carbohydrate reserves, being able reduce glucose to levels lower than in RD19 and Huntra 60 and thus to elongate more.

2.3 Deepwater rice in the Chao Phraya Delta

Current production is approximately 500,000 ha of DWR (OAE, 1991) with a mean grain yield of 2.2 t/ha, similar to the national average yield for all rice types. Compared with other DWR countries, the average farm size of 4-7 ha and fields of >1.5 ha are large. Hundreds of local cultivars have been grown and until quite recently simple cultural methods and farming equipment were used. Farming systems dramatically changed in the 1960's and 1970's with introduction of tractors and flood control schemes. In the early 1990's DWR in Thailand was still reaped by hand sickles, but most threshing was done by contractors using mobile threshing machines. Manual harvesting is now being replaced by field operation of locally produced combine harvesters; developed from axial flow threshers previously used as stationary machines.

Even though there are canals and some flood control, Thai DWR areas are rainfed with water levels uncontrolled by farmers (Puckridge et al. 1989). The climate has a harsh and pronounced dry season from December to March. Dry DWR stubble is burnt in February and March. Contractors with large 4-wheel tractors pulling 7-disc ploughs now do most of the ploughing, often before the opening rains of the season in April-May. There are one or two ploughings and occasionally the second ploughing covers the seed. Seed is usually broadcast on roughly ploughed dry soil to await rain. Early rainfall is sporadic, maximum temperature is 35-36^{o} C and evaporation rates are 6-8 mm/day. Early sown DWR is often exposed to severe drought stress before the flood arrives. In drought years farmers may be forced to sow more than once.. Santasumaron (unpublished) surveyed 110 farm fields and found seed rates up to 200 kg per hectare, sowing date was extremely variable and not closely related to rainfall pattern. The most common cultivars in her survey were Khao Puang (17 fields), Plai Ngahm (10), Kao Banna (5) and Nhang Kiew (5).

Puckridge et al. (1994) surveyed 87 farmer's fields in the Central Plain of Thailand in 1988-89. Flooding started from 22 to 122 days after seedling emergence, with a mean of 66 days Maximum water depths ranged from 30 to 210 cm. Thirty-seven DWR varieties were found. The mean farmer application of nitrogen (N) for 52 fields sampled in 1989 was 15.2 kg N ha^{-1}. Above-ground plant dry mass at maturity ranged from 2.7 t ha^{-1} to 20.5 t ha^{-1}, with a mean of 10 t ha^{-1}. Plant nitrogen content at maturity ranged from 23 to 115 kg ha^{-1}, with a mean of 66 kg. Eighty percent of plant N was accumulated during the flood, but pre-flood plant production had a significant correlation with above ground dry mass at maturity, indicating the importance of good early crop development. Yield ranged from 0.65 to 4.87 t ha^{-1}, with a mean of 2.13 t ha^{-1}. This compares with an earlier estimate of average yield of DWR of close to 2.0 t ha^{-1}, with yields ranging from zero to over 4.0 t ha^{-1} (Catling *et al.*, 1982b).

During the 1992-1993 cropping season a sample of 889 farmers were selected at random from 184 villages in 20 provinces with major DWR areas in the North, Central and Northeast of Thailand by Charoendham et al. (1995). The survey aimed to identify general conditions of DWR cultivation, technology used and general ideas on future situation of growing DWR. The results are summarised below.

1) The total cultivated areas for DWR were estimated at approximately 504, 000 ha, with a mean cultivated area per family of 5-7 ha. About 68% of the farmers owned the lands they were farming.
2) The mean maximum water depth during the growing season ranged from 86-192 cm. Water depths of 50-100 cm covered 263,000 ha. The rate of increase in water depth ranged from 3 to 13 cm/day. The duration of near maximum water depth was 29-46 days.
3) Land preparation — 94% of farmers burned stubble before ploughing, 74% ploughed twice without harrowing. The land usually dried before second ploughing (75%).
4) Planting method — 93% broadcast dry seeds, 6% broadcast pre-germinated seed and only 1% transplanted DWR.
5) Eighty-four varieties of DWR were recorded. Local varieties were grown by 75% of farmers. They considered the recommended varieties to be unsuited to their areas, to have uncertain or low yields, to be no better than the local varieties, or else they followed neighbours practice.

6) Fertiliser — 72% of farmers used chemical fertiliser. Ammophos (16-20-0) was the most popular (81%). Seventy percent applied fertiliser once, at the time of water arrival. For those who applied fertiliser twice (30%), the first application was at 20-30 days after seedling emergence or at water arrival, and the second about panicle initiation stage.
7) Farmers variety requirements were for maturity mid December - early January, desired height 150-200 cm with good elongating ability, drought & submergence tolerance, prolific tillering, non-lodging, long panicle, good kneeing, medium-non shattering panicles, and long slender grain with aroma and good cooking quality.
8) Yield constraints mentioned by farmers were weeds (90% of farmers), drought 55%, rats 54%, insects 25% (Brown Planthopper, Stemborer, Green Leaf Hopper And Thrips), flooding 22%, crabs 22%, birds 11%, and diseases 10% (Blast and Ragged Stunt virus).
9) The mean yield calculated from farmer's assessments was 2.2 t/ha.
10) The major weeds were *Melochia corchorifolia* L., *Ipomea aquatica* Forssk, *Aeschynomene* spp & *Sesbania* spp. Eighty six percent of farmers sprayed herbicides following the instructions. Most (92%) sprayed once only and 67% sprayed at beginning of flooding.
11) Cropping pattern: 93% of farmers left the fields fallow before and after DWR, the other 7% grew crops such as cucumber, watermelon, long bean, maize, chilli, tomato and mung bean.
12) On average farmers sold 83% of the DWR produced, kept 8% for seed and used 6% for family consumption.
13) Future trends: 89% of farmers want to continue growing DWR. It is the only crop that can survive in the wet season, and there is a lack of alternative work.

2.4 Pests of deepwater rice

Catling and Islam (1999) recently reviewed the pests of DWR. This section on pests was summarised from information provided by Dr. Catling. Further details and full references are in the review.

Deepwater rice tends to share the same fauna as lowland rice, and pests such as yellow stem borer, and brown planthopper move between DWR and other rice crops (Catling et al, 1988a). The DWR pest complex is dynamic and changeable. Early damage caused by nematodes, rats, stunt viruses and some borers that weaken plant vigour and elongation capacity, may reduce plant stands. Although compensatory tillers (nodal tillers) replace some of the injured stems, the overall yield is decreased by a loss of bearing stems and the production of smaller panicles. On the other hand, injury caused by leafeaters and foliar diseases in the preflood and early elongation stages, unless severe, is probably offset by new leaves produced during elongation with little or no yield loss (Catling, 1992).

The preflood period of DWR is conducive to moderate build-ups of canopy-living insects whose numbers are limited by the synchronous planting of large areas, the sparse stands, and poor plant condition (Catling, 1992). During the main flooding period, however, the presence of succulent DWR stems and leaves, and milder weather extremes are favourable for several major pests that are able to deal with deeply flooded conditions. The abrupt change to deep flooding profoundly affects the composition, population structure and density of the flora and fauna. Species less affected by deep flooding are those living in the top canopy and those possessing definite aquatic adaptations. Rice insects either move to adjacent irrigated rice, other dry season crops and alternate host plants, or aestivate or enter diapause.

Major pests.

Yellow Stem Borer (YSB) is the major pest of DWR. Living exclusively on rice and Oryza wild rices, it has been associated with cultivated rice for thousands of years and may have originated in the DWR environment (Catling and Islam 1982). It is a terrestrial species that requires high levels of moisture and is uniquely adapted to the aquatic environment. During the elongation stage, larvae and pupae inside the stem are either below or near the water surface (Catling and Islam 1995; Islam, 1994). Larvae and pupae not only survive in totally submerged stems, but the stem lumen affords protection from parasites and predators (Islam, 1992). The sixth instar packs an exit hole with special membranes to keep out the water so that the adult can emerge from the submerged stem. The long vegetative stage of DWR enabling the progression of two or three field generations is a major reason for high levels of stem damage at the end of the season. Generally pre-flood infestations cause little if any yield loss (Catling et al. 1987). However, in most fields by flowering stage >20% and by late ripening stage 35-44% of the stems have been damaged by stem borers. Catling et al (1984-85, 1987) and Islam (1991) indicate that yield loss is caused by: (i) a loss of bearing stems due to the production of deadhearts (the outright death of stems), or from damaged but symptomless stems attacked in the vegetative stage and later covered by rising water; (ii) smaller panicles borne by compensatory nodal tillers, (iii) the production of whiteheads in the reproductive phase, and (iv) a decrease in filled grains and lowering of panicle weight from late damage. They concluded that yield losses of 15-20% are caused in many fields every year. Despite a large complex of natural enemies it is unlikely that parasitism rates can be easily improved (Catling, 1992). No strong source of varietal resistance was found after screening many hundreds of DWR genotypes and many advanced breeding lines and traditional cultivars are highly susceptible (Catling et al, 1988b). Attempts at chemical control (Islam et al, 1988) have not been promising. Thus YSB, the major pest, represents a major challenge in DWR.

Rats are significant pests of DWR throughout the region (Catling et al, 1988a). Two bandicoot species are important in Thailand. They are aggressive, opportunistic species having similar habits and characteristics. *B. bengalensis* is present throughout the DWR season, *Rattus losea* persists in a reproductive state in deeply flooded fields and increases in numbers at harvest time, while *Rattus argentiventer* is less active when the bunds are submerged (Somsook et al, 1986). Bandicoots bite open the leaf sheath to reach the tips of growing shoots causing the terminal leaves to die and produce a deadheart, cut off stems 2-4 cm above the water at an oblique angle, and cut panicles at ripening stage. In parts of the Central Plain, rat damage has been so heavy that farmers were obliged to cease growing

DWR for several years (Catling, 1992). The degree of damage varies between fields and years, and is most intense around burrows and along rat pathways (Ahmed et al, 1986). Fertilized plots having denser stands are damaged earlier and more severely than unfertilized plots, and panicles of late maturing cultivars are attacked more heavily. Varietal differences in susceptibility to rat damage were observed in Thailand, but no resistance was discovered. The variety LMN 111 is often the most severely damaged in DWR experimental plots. Baits mixed with brodifacuom, DRC-4575, difenacoum and zinc phosphide, can reduce rat field populations by 87-94% (Poche and Mian, 1986). Rats are more effectively controlled if farmers take concerted action and carry out standard control recommendations based on regular baiting.

Sporadic, Localised and Minor Pests.

Bacterial and fungal diseases generally occur either too early (before completion of tillering) or too late (after development of the panicle) to cause substantial yield loss. Vigorously elongating plants apparently outgrow many early infections (Catling, 1980). The major disease is probably bacterial leaf blight where wind and leaf cutting by farmers may increase damage. The brown spot diseases sometimes occur in drier areas of north India before flooding, especially in years of drought stress (Catling et al, 1988a). Farmers do not spray.

Virus diseases. Ragged stunt (RSV) and tungro are sporadic diseases causing stunting and loss of stems (Catling et al 1982a). An epidemic of RSV occurring in Thailand in 1981-82 was probably spread by brown planthopper vectors migrating from irrigated rice (Pattrasudhi and Catling, 1988; Disthaporn et al, 1985). Another epidemic in Thailand in 1990-91 caused severe damage to DWR stimulated the search for varietal resistance.

Leaffolder, grasshoppers and thrips are more abundant before flooding (Catling, 1980; Catling and Islam, 1999). One tettigoniid and the field cricket may continue at moderate levels during flooding but they do not cause serious outbreaks (Catling, 1992).

Farmers follow few of the cultural control measures recommended in the literature (Catling and Islam, 1999). Although most Thai farmers spray herbicides before flooding, pesticide use in DWR is problematic because of application difficulties, the danger of environmental contamination and cost-benefit considerations. Pesticides should not disturb natural enemies, be safe for edible fish, and not contaminate the open waters used by rural people (Catling, 1992).

2.5 Weeds

Although weeds compete with DWR, many are used for food or medicine and cannot be regarded just as weeds. For example, *Ipomea aquatica* Forssk. (water spinach) is an important vegetable in Thailand and other parts of Asia, and *Echinochloa colona* (L.) Link. is cut as fodder for milk cows.

Pre-flood weeds in DWR fields may be divided into groups (Catling 1992, Catling and Islam 1999)). The first are dryland species which either complete their growth cycle before deep flooding occurs, or are drowned when the water rises, such as short grasses like *E. colona* and *Digitaria spp.*, and sedges like *C. iria*. A second group establishes in the pre-flood period but is adapted to rising water and prolonged flooding and thus continues to compete with DWR. During flooding a number of aquatic weeds quickly colonise the open spaces in DWR fields and the unplanted areas. The most notable is *Ipomea Aquatica* (a creeping vine) which grows vigorously in the pre-flood period and readily survives deep flooding by putting out long floating runners. Nantasomsaran (unpublished) conducted a systematic survey of weeds in DWR fields in Thailand over three years, 1988 to 1990. In the first two years the fields and sample areas were selected jointly with a related N-uptake study (Puckridge et al.1994). In 110 fields sampled pre-flood 78 species were found, and for 84 fields sampled at flood recession 81 species were found. Annual grasses dominated the pre-flood period, and *E. colona* was the most common weed. In most fields it occurred at mean densities of 25-100 plants/m2. Also important were four other annual grasses: *Leptochloa chinensis* (L.) Nees., *S. gracilis*, *Echinochloa crus-galli* (L.) P. Beauv., and *Ischaemum rugosum* Slisb., of which the last two are emergents that survive deep flooding. Next was the broad-leaved *I. aquatica*, the only weed classified as emergent and aquatic, followed two annual sedges, *C. iria* and *Fimbristylus miliacea* (L.) Vahl, and two broad-leaved annuals, *Melochia concatenata L.* and *Alternanthera philoxeroides* (Mart.) Griseb.

Wild rice, *Oryza rufipogon* Griff., is as an important weed of DWR, but was not common in Nantasomsaran's survey. It is locally important in some areas of Thailand (Puckridge *et al.*, 1988a), and some fields have been abandoned because of it (Hyakutake *et al.*, 1984). Water hyacinth, *E. crassipes*, the major flood weed in Bangladesh (Catling, 1992) was not recorded at all in the Thai fields, even though it is abundant in rivers and water channels. The flood control systems at the beginning of the season may effectively prevent the entry of this potentially serious weed.

Total weed numbers were more than double in fields ploughed two or three times than in those ploughed once only. The improved seedbed resulting from increased cultivation may favour germination and growth of grass weeds. Differences in rice seed rate had no significant effect on weed populations. Thai farmers apply 2,4-D as a spot spray against broad-leaved weeds such as *M. concatenata, I. aquatica* and *Aeschynomene spp.* but frequently the herbicide is applied too late to be very effective. Farmers do not consider grasses very important provided the fields flood deeper than 60 cm (Vongsaroj *et al.*, 1988). Despite the importance attached to weeds in DWR, very few weed loss assessments have in fact been carried out. In many experiments in Thailand, effective control of broad-leaved weeds before flood inundation with herbicides showed no yield benefit unless weed populations were very dense (Vongsaroj *et al.*, 1988).

3 Crop research

Prachinburi Rice Research Center (PCR) and its satellite Huntra Experiment Station are responsible for most aspects of deepwater and floating rice research in Thailand. The PCR was established in 1975 and laboratories and other facilities have been upgraded to regional research center status. It is 150 km east of Bangkok, approximately 3 m above sea level, flooded in the wet season with 1-2 m of water, and with average annual rainfall of about 1700 mm. Soil is moderate acid sulfate with a pH of about 4.5. It has a total area of 120 ha; 20 ha are used for research and 67 ha for seed multiplication. PCR has well qualified staff, good equipment and excellent facilities for training researchers and farmers.

Huntra Experiment Station (HTA) is 75 km north of Bangkok near Ayutthaya and was founded in 1941. It has less acidic soil than PCR, and a different flooding pattern It is used primarily for deepwater and floating rice and cropping systems research. Huntra has 28 deep rectangular ponds of varying sizes with full water control where rice can be subjected to water depths to 2m. There are also 55 ha of rice fields subject to natural flooding, where maximum water levels vary from 50 to 150 cm between years. About 20 ha is normally used for variety improvement, agronomic and other experiments, the remainder for seed multiplication. Annual rainfall is around 1,300 mm.

Research at PCR and HTA is divided into 5 units:

- Plant Science:- rice breeding to improve production, grain quality, resistance and/or tolerance to some insects and diseases, and adaptability to adverse environments; and studies of genetics, and physiology
- Plant Production and Technology: - agronomic management, soil science, weed science and cropping systems.
- Plant Protection: - research on insect pest and disease management.
- Seed Technology and Production: - germination testing, seed dormancy characteristics, maintenance of genetic purity and seed multiplication of recommended varieties and promising lines.
- Post-Harvest Technology: assessment of grain quality, grain storage, cooking and consumption quality and transformation of products.

Research policies reflect the following development objectives;

- Increasing profit margins through decreasing unit input costs.
- Improving quality of products in response to local and export market requirements.
- Increasing agricultural production through improved soil and water management.
- Identification of appropriate production technology related to specific farmer's needs.
- Solving assigned problems of national or regional priority.

3.1 Variety improvement

Breeding new varieties of DWR for the extremely diverse environment is a great challenge to rice breeders. It is difficult to attain the genetic potential of a DWR variety because of the range of constraints that occur during the season. A theoretical example is given in Figure 3. Under ideal conditions a variety may be genetically capable of yielding 6.5 t/h. The series of favourable and unfavourable events during the season, however, can affect the number and size of stems produced per unit area and determine the eventual number and size of grain bearing panicles. Consequently the achieved yield may be less than a third of the potential.

It is obviously not feasible to select a single genotype for all or even most of the traits needed for the different environments. Each trait for which selection is practised reduces the effective size of the breeding population. Inclusion of non-essential traits therefore needlessly loads the breeding program and reduces the output of superior types. Then there are 'competing' characters involved in the different strategies of flood adaptation. For example, submergence tolerance and elongation ability represent opposite mechanisms for flood adaptation. Many attempts to combine them fully in a single plant have failed.

On the other hand, breeding appropriate high-yielding rice varieties is considered the most favourable, effective, and efficient means to increase rice production under adverse environmental conditions. Most rice producers have limited resources and inputs such as fertilisers and chemicals are expensive. In contrast, seeds of new cultivars can be readily distributed among growers who seek crop improvement. Furthermore, rice cultivation that is less dependent on chemical inputs ensures an ecosystem that is potentially more sustainable (Senadhira, unpublished).

Good understanding of the target environment is important. Environmental characterisation will indicate whether there is potential for increasing production by improved varieties and/or management. Farmers grow only the varieties with highest adaptability and stability. If their varieties have defects that constrain yield, e.g. susceptibility to pests and diseases, or that do not allow high production (poor plant type), the potential for improvement is high. However, farmers often do not accept new varieties if they require different or improved management practices. Each replacement should possess the ability to produce higher yields than presently grown types, under the same management practices, but should also be responsive to introduction of improved management.

Improving existing varieties is a logical approach, but there are constraints. Floating rice varieties in very deep flood areas do not show much potential for improvement. Transferring their good traits to other varieties could be more promising. For intermediate depths a new deepwater rice plant type has been developed where need-based elongation (only elongate if water is deep) and erect leaves are the main features. The new plant type has the appearance of a semi-dwarf high yielding variety in shallow water and is expected to perform better than present varieties up to maximum water depth of about one meter.

Prototypes of this new type have been developed in Thailand and at IRRI. Huntra 60, IR11141-6-1-4, and RD19 are close to this plant type except for their leaf characteristics, and have good yield. In an experiment designed to reduce the effect of environmental differences, the DWR variety Huntra 60 and the irrigated variety IR72 were grown in adjacent ponds. Huntra 60 (maximum water depth 80 cm) yielded 5.3 t ha-1, not significantly different from the 5.8 t/ha of IR 72 in 10 cm water (Mazaredo et al. 1996). This experiment established that a DWR variety could produce comparable yields to a high yielding irrigated variety despite growing in deep water.

The demand for new varieties is a continual process because of need for increased productivity, quality, and more resistance to pests and diseases. In the DWR ecosystem many factors influence variety improvement, but because of its relatively small extent, policy makers often consider DWR as a low priority crop. Furthermore, harsh soils, floods and climatic stresses make many people think that rice in this ecosystem is impossible to improve.

Success in developing better varieties through hybridisation depends entirely upon the efficiency of evaluating segregating populations. Traits most important are elongation, survival of temporary submergence, and resistance to drought, salinity, P deficiency, Zn deficiency, Fe toxicity, and Al toxicity. Traits common to all rices such as resistance to major pests and diseases, and grain quality are also important. Relative importance of these traits differs from one target environment to another, and essential traits must be prioritised for selection purposes.

Because DWR is grown only during the wet season the breeding cycle is very long. Natural field conditions must be used for selection and the degree of stress; for example depth and duration of floodwater, is always a major problem. Under such conditions, effective selection can be done only when the stress level is appropriate, and development of new varieties takes many years. Irrigated rices such as IR8 and IR36 were released after 4-5 years, but a DWR variety such as HTA 60 has seldom been released in less than 10 -15 years. The extreme is the variety "Prachinburi 1" which was tested in Thailand for 22 years before its official release as a recommended variety in September 1998. It started as a composite cross from F2 seed of 29 crosses of DWR+FR with RLR+IR lines at Suphanburi Rice Experiment Station in 1976 and became the fixed line SPR76 com3-5-2 in 1979. Research station trials were followed by farmer field trials in 1986, after which there was extensive testing for N response and pest resistance (Blast, BPH, GLH + SB) before the production of Breeder Seed and Foundation Seed. This is an extreme example, partly determined by over-strict requirements by official release committees.

3.1.1 Selection methods

Pure line selection has been the start of many breeding programs in Asia, and can give rapid payoff for the breeder. Pure line selections are usually made directly in farmer's fields from materials already well adapted to local conditions, but which are genetically variable. It is a rapid, straightforward method giving uniformity and yield increase of up to 10-15 percent, but larger gains are unlikely. Varieties such as Pin Gaew 56 (released in 1956) and Leb Mue Nahng 111 (released 1959) were developed through this procedure.

The pedigree method is most effective when there are clear breeding objectives and adequate resources. This method has been followed at IRRI and in Thailand and other research centres in Asia. As for other cultural types of rice, DWR pedigree lines are tested concurrently for resistance to diseases and insect pests, and for tolerance to appropriate deepwater stresses. Selection and screening for essential characters like submergence tolerance and elongation ability should be conducted under both natural and controlled conditions. RD 19 was developed through this method.

Bulk breeding is a reliable, time-honoured method that is simple and labour saving. Formerly it was less commonly used in the tropics but effective new techniques and better facilities, especially controlled water tanks, have made it a standard method for working with large numbers of rice progenies when breeding for submergence tolerance and elongation ability. Bulk populations can be grown under stress conditions and the surviving plants bulk harvested. The advantage of this method is that it is easy to manage and requires few resources. It is particularly effective when selection pressure is high, as undesirable genotypes are naturally removed from the population. Surviving plants are transplanted into regular shallow-water fields for further evaluation or, in the case of early maturing elongating deepwater populations, are harvested direct from standing water. The bulk and modified bulk selection procedures can be extended to the F3 generation, increasing the capacity to handle and select from large populations.

Re-selection was used in Thailand to improve grain quality of RD19, which was derived from a cross between IR262-43-8-11 (a semi-dwarf high yielding line) and Pin Gaew 56 (traditional floating rice of Thailand). Under shallow water conditions RD19 appears similar to a modern semi-dwarf but can elongate in water rising up to about 1-m depth. But despite good yield, farmer acceptance of RD19 has been extremely poor because of its high grain chalkiness. Re-selection begun in 1987 using 1,400 individual plants resulted in four new lines with yield comparable to the original RD19 but with chalkiness reduced to about one fifth (Kupkanchanakul, unpublished).

3.1.2 Photoperiod sensitivity.

Deepwater rice is grown from the equator to 29^{o} N and daylight ranges from 10 to 14. Most varieties are photoperiod sensitive, meaning that date of flowering is affected by day length. Varieties have a minimum photoperiod (day length) for inducing reproduction and a longest photoperiod beyond which they cannot produce panicles (Vergara and Chang, 1976). For example, the time to flowering of Leb Mue Nahng 111 from initiation of treatment was 60 days with 10 hours light each day, but 126 days with 12-hour light. The advantage of photoperiod sensitivity is that it determines flowering date in relation to day length and not length of the growing season. It is one of the most important traits determining the adaptability of deepwater rice to different areas because it induces properly selected varieties to flower after the flood water level reaches its peak. Unfortunately photoperiod sensitivity is also a barrier to transfer of productive deepwater rices between countries. When introduced varieties have different maturity than local varieties it is very difficult to make crosses between the introduced varieties and local rices to produce improved types. If Thai varieties are planted in India they flower too late, after mid December, when low temperatures cause sterility and reduce yield. Conversely, varieties from India and Bangladesh introduced into Thailand are induced by daylength to flower much earlier than normal, as early as September when the water is still rising. The panicle may be submerged and the grain spoiled or eaten by fish.

3.1.3 Breeding for improved elongation ability

Differences between varieties in elongation ability usually become noticeable at about 80-100 cm water depth, and there has been no easily identifiable indicator other than plant length (stem and leaves). Prechachart *et al.* (1975) developed a pond method for screening large numbers of lines under controlled conditions, in which plants were scored on ability to maintain foliage above the water level. Most screening is now done with large plant populations in ponds. However, scoring is a subjective method, and Waitruardrok et al. (1992) proposed direct measurement 2-4 days after cutting at the water surface. This can be done in shallow water, for example 60 cm, and give a rapid and measurable result which can be analysed.

Elongation ability is a stable and heritable trait. The number of internodes and length of culm elongation in DWR appear to be controlled by different genes (Morishima 1975). Supapoj *et al.* (1977) reported that populations from crosses between floating and non-floating varieties segregated with only a small portion of true floating type and more of intermediate types. Hamamura and Kupkanchanakul (1979) identified partial dominance and multigenic nature of floating ability. Nasiruddin *et al.* (1982b) suggested multigenic control but were not certain of its degree of dominance. In some crosses, partial dominance was indicated, but there were cases where dominance was found. They also suggested that hybrid populations should be flooded for a short period only and that the parents, F1 and F2 be grown in the same environment to avoid variation. Tripathi and Balakrishna Rao (1985) reported that a single dominant gene controlled early nodal differentiation.

Suge (1988) examined the genetic behaviour of internode elongation in relation to ethylene and giberellic acid. F_1 plants of a cross between elongating and non-elongating types showed intermediate values for internode elongation and for ethylene concentration. Suge considered that there are two complementary major genes, one controlling GA3 production and another controlling responsiveness to ethylene.

Thakur and HilleRisLambers (1989) studied two F2's involving floating rice and non-elongating semi-dwarf, four F2's involving floating rice and an elongating semi-dwarf, and two F2's involving elongating and non-elongating semi-dwarf parents with 20 day-old seedlings. They reported that floating rice combinations with non-floating semi-dwarf parents segregated into a ratio of 9 elongating and 7 non-elongating.

Dwivedi and Senadhira (1993) reported estimates of genetic parameter by diallel and generation mean analysis revealed the importance of additive and non-additive gene action with preponderance of additive gene action. Involvement of at least one group of genes for plant elongation was detected. However, positive and significant dominant and dominant x dominant effects indicated the presence of complementary type of epistasis. It implied that genetic control of this trait could be affected by different gene action in different crosses, depending upon the genetic background of the parental lines.

3.1.4 Breeding for submergence tolerance

Although submergence tolerance and elongation now appear to be partly exclusive traits, there has been much screening for submergence tolerance of DWR lines. It is particularly important for tall non-elongating DWR varieties exposed to flash floods in early growth. A simple mass screening method for submergence tolerance using controlled water level in ponds was developed in Thailand (Boonwite *et al.*, 1977; Supapoj *et al.*, 1979). Mass screening in ponds is now the most common method for testing submergence tolerance. Seedlings 30 days old are transplanted in the pond and 30 days after transplanting, the pond is filled to 150-cm water depth for 10 days or until the death of a susceptible check. Submergence tolerance scoring is done immediately after draining water and 14 days later.

Existence of genetic differences for submergence tolerance in rice germplasm has been reported by many (e.g. Ramiah and Rao, 1953). A systematic screening of the world rice collection at IRRI and elsewhere has resulted in identification of some traditional submergence tolerant rice cultivars. Segregation analysis indicated that at least three dominant genes are involved for controlling submergence tolerance; two with duplicate gene action, while the third is complementary to either of the first two. At least one major gene, a closely allied group of genes, or at least two dominant genes was involved. All of the investigations found highly significant additive and non-additive gene effects (Senadhira, unpublished)

3.1.5 New techniques and novel germplasm

Since DWR cultivars are usually subject to flood and complex abiotic stresses associated with acid sulphate soils, salinity, iron and aluminium toxicity, and zinc and phosphorus deficiency, the traditional varieties grown under these conditions possess tolerance for many of the stresses. However, most lack high-yielding traits such as broad, erect, dark leaves or many productive tillers with heavy panicles. Transfer of appropriate traits from high-yielding genotypes to traditional cultivars and the incorporation of stress tolerance would increase the yield potential. Hybridisation between two types can develop desired types, but the efficiency of selection of segregating populations for tolerance for abiotic stresses is so slow that there has been little progress in variety improvement.

The rapid development of DNA marker technology provides great opportunities to use the new tools and minimise screening problems. Some agriculturally important genes for photoperiod sensitivity and resistance to blast, bacterial blight, and tungro have been mapped. However, actual application of marker-aided gene transfer is yet very limited. In the next decade or so, it is expected that DNA markers will be available for major abiotic stresses and also less expensive procedures.

Marker-aided selection (MAS) techniques can increase selection efficiency to as high as 100% and permit simultaneous selection for a number of traits. They offer great opportunities for dealing with abiotic stresses. Cultivars needed for developing the techniques have been identified, but the DNA-level polymorphism between traditional cultivars and other yield-improving types will determine the rate of progress. For example, the mechanisms of tolerance to flood, zinc deficiency, and iron toxicity must be determined to accelerate the development of MAS for those stresses. Advances could lead to enhanced tolerance levels by pyramiding different mechanisms to produce novel genotypes.

Even in a small-scale breeding program, there are thousands of plants to evaluate. Evaluations under controlled conditions done at later breeding stages are very expensive and MAS can reduce costs to less than one tenth. Furthermore, the technique requires less capital expenditure, is very rapid (2-3 days compared with many seasons by field technique), highly reliable, and can be used simultaneously for other traits (Senadhira, unpublished).

Improved rice varieties with high available nutrients for human consumption such as iron and zinc could also provide better nutrition to even the poorest people. One recently developed rice variety has good yield and shown high bioavailability of the iron in feeding trials with rats (Graham et al. 1998). This must now be confirmed for humans. However, more adapted high micronutrient varieties must be proven in order to fit the many different environments in rice producing areas, with careful trials to measure the extent to which iron-rich rice can reduce iron malnutrition in rural communities. Deepwater rices from coastal areas of Bangladesh are a source of iron and zinc efficiency.

3.1.6 Collaborative plant breeding

Collaboration between researchers in Asia has been valuable in developing techniques and genotypes for improving the yield, yield stability and nutritive value of deepwater rice. Potential outputs include marker aided selection techniques (MAS) for genotypes for excess water- and soil-related stresses, novel genotypes for increasing yield and improving yield stability, and rices with high available iron and zinc content in the grain to help combat iron and zinc malnutrition in humans.

But plant breeding is but one input into a complex system that includes a wide range of socio-economic conditions. There are very limited resources available for research on the DWR ecosystem in any one country, hence international co-operation and appropriate funding can make a major difference to the rate of progress and impact.

3.1.7 Grain quality

In Thailand traditional DWR is considered of poor grain quality owing chalkiness which lowers milling recovery. The Thai DWR breeding program has concentrated on improving grain quality, aiming for translucent grains with a minimum length of 7.0 mm. Nearly all new lines in the Thai breeding program have good grain quality. One promising line with good grain quality, good cooking, tall stature, and photo-period sensitive flowering time about end October ~ 10 days after KDML105 at PCR is suitable for both rainfed lowland and deepwater areas of 50-100 cm where fields are dry by the end of November. Other promising lines from mutation breeding using Gamma rays have clear grain, better milling characteristics, more resistance to blast disease, and have essential DWR traits. Examples are HTA60'93 G1-66-10, HTA60'93 G1-67, and PNG'93 G1-73-18.

3.2 Crop nutrition

The deepwater areas act as a natural release for floodwaters from the rivers, and retain many of the natural nutrients that would otherwise be washed into the sea. Adapted DWR varieties, which have been used for centuries and produce around 2 t/ha of rice without added fertilisers, reduce the level of nutrients in floodwater spreading out from rivers to almost negligible levels (Setter *et al.* (1987a).

Roy (1975), in a review of several hundred trials in Bangladesh, concluded that traditional DWR varieties generally do respond to fertiliser, but that the degree of yield response varies with soil conditions, the extent of flooding and rainfall in the pre-flood period. In some DWR areas fertiliser application tends to increase dry matter production but not grain yield (Francis, 1983; Jugsujinda *et al.* 1982; Puckridge and Thongbai, 1988). In other areas there can be good response, but generally DWR farmers apply little fertiliser. In a survey of 52 Thai DWR farms Puckridge et al. (1994) found that fertiliser applications were mostly small amounts of N and P, with the highest rates used on acid sulphate soils. Only three farmers used more than 40 kg N ha^{-1}, 35 averaged 23 kg ha^{-1} each of N and P, and seventeen did not apply fertiliser at all. Fields with fertiliser, usually a combination of N and P, averaged about 30 % higher yield than unfertilised fields on the eastern plain, but effects of fertiliser could not be separated from effects of cultural practices and environment.). Plant analysis showed that most of the N was accumulated during flooding, and that nitrogen uptake before flooding averaged only 15 kg ha^{-1}, and was not directly correlated with grain yield. Rainfall, soil type, drought, and variety affect crop production in DWR and understanding nutrient balances in these ecosystems is difficult.

On-station experiments with different N rates in two DWR areas in Thailand indicated a marked reduction in yield if plant N before flooding was less than 20 kg N ha^{-1} (Puckridge *et al.* 1991). On acid sulphate soils at Prachinburi Rice Research Centre Wiengweera *et al.* (1988) showed that yields of DWR increased about 80% with 75 kg N ha^{-1}. A problem for such experiments is the extreme variability brought about by the long growing season, soil variability, water depth changing with date and season, and genetic differences in height of plants that makes it difficult to obtain consistent statistically significant effects. An example is given in Figure 4. Despite careful maintenance the experiment had high variation (C.V. = 29%). Maximum water depth was around 100 cm. The interaction (entry x treatment) plot yields, means of three replications, ranged from zero to 401 g/m^2 ($P < 0.01$). The treatment means of 141 to 251 g/m^2 ($P < 0.01$) indicate the effectiveness of nitrogen application, but even though the acid soils are generally responsive to phosphorus it did not show much effect in this trial, probably due to residual effects of previous application. Average effects over seasons determine the economic effectiveness of fertiliser applications.

In the western delta, where DWR farmers generally do not apply fertiliser, dry matter production (biomass) and yields are relatively high and fertiliser responses often small and unpredictable (Puckridge and Thongbai, 1988). To produce high yields in unfertilised fields that have been continuously cropped for centuries there must be alternative sources of nitrogen. Vacharotayan and Takai (1983) analysed river water and calculations from their data indicate that one meter depth of river water entering the fields in Thailand would provide around 13 kg N, 1.6 kg P, and 42.9 kg K ha $^{-1}$. Another source could be biological fixation. A large part of the DWR plant is under water, offering a larger biomass for colonisation by aquatic microorganisms than rice in shallow water. Kulasooriya *et al.* (1981) estimated by extrapolation from pot studies that organisms such as blue-green algae living on DWR could fix about 10-20 kg N ha^{-1} crop^{-1}. Algal populations tend to be higher in less acid floodwater (Whitton and Catling, 1986). Puckridge et al. (1994) found a trend for increased N uptake during flooding as the pH increased from 5.8 to 7.5, but further information is needed on these topics.

The introduction of the new plant type is expected to result in higher yields, and to be more efficient in utilisation of both natural and applied sources of nutrients. But fertiliser response will still be difficult to predict. How is plant N uptake related to soil type, high or low producing fields, and the pre-flood and flood periods? When farmers do not apply nitrogen to DWR is it an economic decision, a yield limitation or an indication of natural sustainability?

3.3 Multiple cropping

Although crops such as mungbean, corn and sesame are commonly grown after DWR in Bangladesh, this practice is limited in Thailand due to lack of irrigation or appropriate soils with stored water. However, in the western plain the pre-flood period of 3-4 months from the beginning of wet season to the time of arrival of flood has good potential for non-rice crops with short growth duration and drought resistance. Kupkanchanakul *et al.* (1988) reported promising yields of sunflower, mungbean, sesame, and cowpea and baby corn, with DWR broadcast into the field crop before maturity. The crop characteristics for pre-flood production in intercrops with deepwater rice are short growth duration of less than three months, tolerance for drought and water logging, vigorous seedling growth and development, and high local market demand. Both field mungbean and sesame crops have good local markets. Although sunflower can give good yields, the low price of the harvested product in Thailand compared with the high cost of hybrid seed and cultural practices makes it less attractive. The strong sunflower stems also need to be removed from the field otherwise they are a problem in harvest of the rice crop.

The cropping system experiments reported below were conducted for four years, 1988-1991, at the Huntra Rice Experiment Station near Ayutthaya, Thailand (Puckridge et al 1990b, Sattarasart et al. unpublished). The soil at Huntra is a Thio-gypsic Tropaquept of Ayutthaya series (Motomura et al., 1979), a silty clay moderately high in organic matter and with moderate fertility. The soil is acid with pH 5.0 to 5.5. The topography is flat and drainage is poor, typical of much of the delta.

Deepwater rice, mungbeans (*Vigna radiata*), sesame (*Sesamum indicum*) and sunflowers (*Helianthus annuus*) were sown in randomized complete block experiments with four replicates. Details of sowing and emergence dates, flood arrival and harvest dates are given in Table 1. Deepwater rice was sown as a sole crop or mixed with a field corp. There were two times of sowing of DWR, either broadcast at the same time as the field crops (initial sowing) or broadcast onto the soil surface in standing field crops near their harvest (delayed sowing). The date of the second sowing of DWR depended on the stage of development and density of the canopy of the field crop and the rainfall. This date determined the stage of growth of the DWR for survival when the flood arrived. Soil preparation consisted of one ploughing with a 7-disk plow followed by two or three passes of a spring-tine harrow to level the soil and provide an even seed bed. There was no additional tillage for the second sowing of deepwater rice into the field crops, but manual hoeing roughened the soil surface of the bare plots of the deepwater monoculture.

The DWR cultivar was Huntra 60, sesame was a local variety of red sesame; and sunflower the hybrid Hysun 33. The mungbean cultivar Uthong 1 was used in 1988, and Kampangsaen 1 in 1989-1991. The seed rate was 125 kg ha^{-1} for broadcast DWR and 19 kg ha^{-1} for broadcast sesame. For broadcast munbeans the rate was the recommended rate of 19 kg ha^{-1} in 1988, but establishment was poor. The rate was increased to 31 kg ha^{-1} in 1989 and 1990, but dense foliage of the mungbean depressed the DWR plant population and the rate was reduced to 19 kg ha^{-1} in 1991. Mung beans and sesame in rows were sown to give approximately 2 cm between plants. Sunflowers were 50 cm between plants within rows 75 cm apart. Fertilizer rates followed local extension department recommendations for crop production, using 69-87-0 N-P-K kg ha^{-1} applied to DWR monoculture and 52-23-43 to the field crops. Monocrotophos 0.1%, was applied for control of insects each week between 30 and 75 days after emergence. Weeds were removed by hand from the field crop plots, and 2,4-D was applied in DWR before flooding for control of broad leaf weeds. Plot size was 8m x 8m. The harvested area was 6m x 6m for mungbeans, sesame and deepwater rice, and 6m x 6.75m. for sunflower. Treatments are listed in Table 2. The "paired rows" indicate two rows of field crop alternating with two rows deepwater rice, or two rows of a field crop alternated with a two-row space for treatments in which deepwater rice was broadcast. "One row" indicates single rows spaced 50 cm apart for mungbeans and sesame, or 75 cm apart for sunflowers. In the first year water-logging on the heavy soils affected plant growth. In the third and fourth years drains 20-30cm deep and 9 m apart excavated between plots to remove surface water after heavy rains prevented the problem

Over the four years of trials competition from DWR in mixed crops reduced the yield of mungbean by 27% or the yield of sesame by 43% compared with a crop without DWR (Table 2). Competition in mixed crops is for water, light and nutrients, and the small sesame seedlings may be less competitive in the early stages than mungbean. Sunflower, with wide spacing between rows and tall vigorous plant habit, is a strong competitor and its yield was reduced only 13% by DWR competition. The main constraint to production of sunflower was low percentage establishment. Over three years competition from field crops sown with the rice reduced DWR yield by 5% to 14%. The highest DWR yields were when mixed with mungbean, even though mungbean appeared to be more competitive than sesame. With delayed sowing of DWR into the standing field crop, poor establishment of DWR due to competition for light and water reduced DWR yields by as much as 40%. The complete loss of DWR due to the sudden rise of floodwaters in 1990 emphasised the value of including the field crops in the cropping system. Risk of failure of the DWR was higher with delayed sowing, and is not recommended despite the higher yield of field crops. Sowing both crops together gave good establishment and is best for areas where floods come early. Although establishment of field crops was better in rows, broadcast yields were equivalent and used less labour.

Although the area of Thailand reported here has favourable conditions, to date little use has been made of the obvious potential. Near urban areas there are alternative work opportunities, and little economic pressure for increased input. However, as mechanisation increases this situation may change. In NE India, the economic situation is different, and farmers are adding other crops to their deepwater rice. In Bihar over the four years 1986-89 the net return after expenses for rice with mungbean was 2.17 times that of rice alone, and sesame with rice gave 3.83 times the return of rice alone (Thakur et al 1994). The return was even better with sesame, where the rice equivalent yield of rice with sesame was 3.65 t ha^{-1}, compared with 1.98 t ha^{-1} for rice alone.

Although field crops under natural rainfall can be successfully grown in the western delta, in the south-eastern delta many farmers grow short duration rice before or after flooding. Depending on the flooding pattern they are grown March-April to July-August or November to March, leaving the fields fallow during the flood. Some farmers follow the off-season rice crop with DWR. Unfortunately, in this year 2000, flooding caused severe damage to the early rice.

4 Future prospects

The major reductions in deepwater rice appear to have already taken place. Farmers are still growing DWR rice in their fields and anything that can be done to increase crop production will be of great social and economic benefit. Increased production will not come solely from improved DWR varieties. There is a complex interaction between all facets of production which affect realisation of the potential of each component of the system (Figure 5). The achieved production and community welfare will depend on how these components are integrated. Socio-economic analyses can be of great value in establishing priorities. Such analyses should determine biophysical and socio-economic constraints to productivity, priority research, and the social benefit costs of alternate land use practices. The effect of different land use patterns on productivity, employment and sustainability in flood-prone ecosystems is an important policy question. Infrastructure developments – communications, roads and electricity – provide alternative occupation possibilities which generate cash for improved crop management. Enhancing the sustainability of deepwater ricelands and developing appropriate soil and water management techniques will increase productivity, sustain natural resource quality and reduce poverty

In DWR areas the water regime – flood and rain – will continue to be the dominant factors. Conventional breeding and selection activities have difficulty in differentiating between flod, nutrient imbalance effects and other yield limiting factors, so it has been difficult and meet the objectives of breeding programs. However, based on successful research to date it is expected that yield potential of DWR areas for rice and other crops can be raised. A main objective of breeding research is to develop molecular marker aided selection procedures and protocols for mass screening for tolerance to flooding and adverse soils. Improved nutritional quality of grain is desirable by-product with great potential. Improved varieties such as Prachinburi 1 and Plai Ngham Prachinburi should be promoted and spread widely. They are not spreading because of the high price of seed and a preference of farmers to exchange rather than to purchase foundation seed. Such exchange is not provided for in official regulations.

Acknowledgements

Grateful acknowledgement is made for contributions of R. Thakur, J. L. Dwivedi, S. K. Bardan Roy, S. B. Mishra, and the late D. Senadhira for information originally submitted for the monograph "Breeding Flood-prone Rice" (Puckridge and. Senadhira 1995). Special thanks also to H. D. Catling for providing information for the section on pests and diseases and writing the book "Rice in Deepwater" which is an inspiration to all workers in flood-prone ricelands.

References

Ahmed, M.S., Mian, Y, Haque, E. and J.E. Brooks. 1986. Rat damage characteristics and assessment methods in deep water *rice. Bangladesh J. Sci. Res.* 4(2), 131-46.

Bekhasut, P., Puckridge, D.W., Wiengweera, A., and T. Kupkanchanakul. 1990. Sequential elongation of internodes of Deepwater Rice at different water depths. *Field Crops Res.*, 24:195-209.

Bleecker, A.B., Rose John, S. and Kende. 1987. An evaluation of 2,5-norbornadiene as a reversible inhibitor of ethylene action in deepwater rice. *Plant Physiol.* 84:395-98.

Boonwite, C., Setabutara, C., Jackson, B.R., Prechachart, C. and P. Anugul. 1977. Screening for submergence tolerance using a deepwater pond. In *Proceedings of the 1976 Deepwater Rice Workshop, Bangkok, Thailand.* International Rice Research Institute, Manila. pp. 101-108

Catling, H.D. 1980. *Deepwater Rice in Bangladesh: a Survey of its Fauna with Special Reference to Insect Pests.* Deepwater Rice Pest Management Project, Bangladesh Rice Research Institute and Overseas Development Administration of the UK, pp. 100 (mimeo).

Catling, H.D. 1985. *An agro-ecological characterisation of the deepwater areas in the Chao Phaya Basin of Thailand with a subdivision into five regions.* International Rice Research Institute, Manila. Mimeo, 27 pp.

Catling, H.D. 1992. *Rice in Deep Water.* London: International Rice Research Institute and Macmillan Press. 542 pp.

Catling, H.D. and Z. Islam. 1982. The problem of yellow rice borer in Asian deepwater rice. In: *Proceedings of the 1981 International Deepwater Rice Workshop, Bangkok, Thailand* pp. 451-8. International Rice Research Institute, Manila.

Catling, H.D. and Z. Islam. 1995. Studies on the ecology of the yellow stem borer, *Scirpophaga incertulas* (Walker) (Pyralidae), in deepwater rice in Bangladesh. *Crop Prot.* 14(l), 57-67.

Catling, H.D. and Z. Islam. 1999. Pests of deepwater rice and their management. *Integrated Pest Management Reviews* 4: 193-229.

Catling, H.D., Boonyaviwatana, S. and R. Pattrasudhi. 1982a. Incidence of ragged stunt in floating rice in Thailand. *International Rice Research Newsletter 7(3)*, 11.

Catling, H.D., Puckridge, D.W., Boonyaviwatana, S., Pattrasudhi, R., Kupkanchanakul, T., Tanasate, M. and P. Supapornhaemin. 1982b. Deepwater Rice crop-cuts for 1981. In: *Report of Deepwater Rice Planning Meeting, March 1982*. Department of Agriculture, Bangkok, pp 39-40.

Catling, H.D., Islam, Z. and R. Pattrasudhi. 1984-85. Seasonal occurrence of the yellow stem borer *Scirpophaga incertulas* (Walker) on deepwater rice in Bangladesh and Thailand. Agriculture, *Ecosystems and Environment* 12, 47-71.

Catling, H.D., Islam, Z. and R. Pattrasudhi. 1987. Assessing yield losses in deepwater rice due to yellow stem borer, *Scirphophaga incertulas (Walker)* in Bangladesh and Thailand. *Crop Prot.* 6 (1), 20-27.

Catling, H.D., Islam, Z., and L. Rahman. 1988a. Status of pests and diseases in Asian deepwater rice. In *Proceedings of the 1987 International Deepwater Rice Workshop*, Bangkok, Thailand. International Rice Research Institute, Manila. pp. 525-537

Catling, H.D., Islam, Z. and R. Pattrasudhi. 1988b. New methods of screening deepwater rice for yellow stem borer resistance. In: *Proceedings of the 1987 International Deepwater Rice Workshop, Bangkok, Thailand* pp. 539-49. International Rice Research Institute, Manila.

Catling, H.D., Puckridge, D.W., and D. HilleRisLambers. 1988c. The environment of Asian deepwater rice. In *Proceedings of the 1987 Deepwater Rice Workshop*, Bangkok, Thailand. International Rice Research Institute, Manila. pp. 11-34

Charoendham, P., Palaklang, W., Niyomvit, L., Prommanart, P. and N. Charoensilp. 1995. *Survey of Deepwater Rice Cultivation in Thailand 1992/1993*. Prachinburi Rice Research Center. Mimeo.

Choudhary, M. A. and S.M.H. Zaman. 1970. Deepwater rice of East Pakistan. Paper presented at the *International Rice Commission Working Party on Rice Production and Protection*.13th Session, Teheran, Iran. (1970). 19 pp. (mimeo).

DeDatta, S.K. and J.A. Malabuyoc.1988. Drought tolerance screening for deepwater rice. In *Proceedings of the 1987 International Deepwater Rice Workshop*, Bangkok, Thailand. International Rice Research Institute, Manila. pp. 199-208

Disthaporn, S., Catling, H.D., Chettanchit, D. and M. Putta. 1985. Effect of time of infection of rice ragged stunt virus on deepwater rice. Int. J. Tropical Plant Diseases, 3, 19-25

Dwivedi, J.L. and D. Senadhira. 1993. Inheritance of internode elongation in deepwater rice induced by treating seedlings with gibberellic acid. *Oryza* 30 (1):41-45.

Francis, P. 1983. Note on fertiliser responses in Bangladesh. *Deepwater Rice Newsletter*, International Rice Research Institute, Bangkok. 5 (2/83): pp.1-2.

Graham,R., Senadhira,D., Beebe,B., Iglesia,C., and I. Monasterio. 1998. Breeding for micronutrient density in edible portion of staple food crops: conventional approaches. *Field Crops Research* 60, 57-80.

Haloi, B. 1989. Physiological characters associated with deepwater rices. *Oryza* 26:168-172.

Hamamura, K. and T. Kupkanchanakul . 1979. Inheritance of floating ability in rice. *Japan. J. Breeding.* 29 (3):211-216.

Hyakutake, H., Zungsontiporn, S., Wanichanantakull, P., Supatankul, C., Vongsaroj, P. and O. Wonkasem. 1984. Distribution, habitats, seed germination and ecological characteristics of wild rice *Oryza perennis* and its response to herbicides. Report No. 2. National Weed Science Research Institute and Department of Agriculture, Thailand. 105 pp. (mimeo)

Inouye , J. and T. Hagiwara. 1982. Character association among isozymic genotype, grain type and phenol reaction of grains in Bangladesh floating rice varieties. *Japan J. Trop. Agric.*, 26, 68-73

IRRI 1997. *Rice Almanac.* Second edition. International Rice Research Institute, Manila. 181 pp.

Islam, Z. 1992. Mortality of yellow stem borer, *Scirpophaga incertulas* (Walker), larvae and pupae in deepwater rice stem. *Bangladesh J. Zool.* 20(2), 367-9.

Islam, Z. 1994. Key factors responsible for fluctuations in rice stem borer populations in deepwater rice ecosystems. *Insect Science and Its Application* 15(4), 461-8.

Islam, Z., Catling, H.D. and Pojananuwong, S.. 1988. Attempts to control stem borer in deepwater rice with insecticides. In: *Proceedings of the 1987 International Deepwater Rice Workshop,* Bangkok, Thailand. International Rice Research Institute, Manila, pp. 551-8.

Jugsujinda, A., Satawathananont, S., Hirunyupakorn, W., Charoendham, P. and N. Kroppetch. 1982. Fertiliser management for deepwater rice soils. In: *Proceedings of the 1981 International Deepwater Rice Workshop,* Bangkok, Thailand. International Rice Research Institute, Manila, pp 365-372.

Kende, H. and I. Raskin. 1988. Growth and aeration in deepwater rice. In *Proceedings of the 1987 International Deepwater Rice Workshop,* Bangkok, Thailand. International Rice Research Institute, Manila, pp. 287-300.

Kende, H., Metraux, J.-P. and I. Raskin. 1984. Ethylene –induced growth response in submerged deep-water rice. In Fuchs, Y. and Chalutz, E. (Eds). *Ethylene: Biochemical, Physiological and Applied Aspects.* Martinus Nijhoff/Junk, The Hague, pp. 121-128.

Kulasooriya, S.A., Roger, P.A., Barraquio, W.L. and I. Watanabe. 1981. Ephiphytic nitrogen fixation on deepwater rice. *Soil Sci. Plant Nutr.*, 27:19-27.

Kupkanchanakul, T., Puckridge, D.W., Thongbai, P., Petchrit, K., Kupkanchanakul, K., and A. Sattarasart. 1988. Pre-flood crop production in deepwater areas. In *Proceedings of the 1987 International Deepwater Rice Workshop,* Bangkok, Thailand. International Rice Research Institute, Manila, pp. 469-479.

Mazeredo, A.M., Laureles, E.V. and T.L. Setter. 1996. Growth and yield of modern deepwater rice: comparisons with modern irrigated rice. *Field Crops Research* 46: 105-116.

Morishima, H. 1975. Floating ability as an adaptive character of the rice and its measuring method. In: Proceedings of the International Seminar on Deepwater Rice, August 1974. Bangladesh Rice Research Institute, Joydebpur, Dacca, pp. 109-114

Motomura, S., Seirayosakol, A., Piyapongse, P. and W. Cholitkul. 1979. Field observations and laboratory analyses of paddy soils in Thailand. Ministry of Agriculture, Forestry and Fisheries, Iabaraki, Japan, 363 pp

Nantasomsaran, P. 1995. Weeds in deepwater rice. Unpublished report. Department of Agriculture and Cooperatives, Bangkok, Thailand.

Nasiruddin, M., Ahmed, M.S., Zaman, S.M.H. and E. Haq. 1977. Effects of flooding on morphological characteristics of floating rice varieties of Bangladesh. In Proceedings of the 1976 Deepwater Rice Workshop, Bangkok, Thailand. International Rice Research Institute, Manila. pp.67-74.

Nasiruddin, M., Waheb, A. and B.A. Dewan. 1982. Genetics of plant and internode elongation in rice. In: *Proceedings of the 1981 International Deepwater Rice Workshop,* Bangkok, Thailand. International Rice Research Institute, Manila, pp.113-120

OAE 1991. Report on Survey of Major Rice Crop Year 1990/91. Office of Agricultural Economics, Ministry of Agriculture & Co-operatives, Bangkok, Thailand 1991.

Pattrasudhi R. and H.D. Catling. 1988. An epidemic of rice ragged stunt virus in deepwater rice in Thailand. In *Proceedings of the 1987 Deepwater Rice Workshop*, Bangkok, Thailand. International Rice Research Institute, Manila. pp. 563-567

Poche, R.M. and M.Y. Mian. 1986. Effectiveness of four rodenticides in deepwater rice. *Zeitschrift fur Angewandte Zoologie* 73, 37-48.

Prechachat C, Sariqbutr A, Jackson B R (1975) Breeding improved rice for deepwater condition in Thailand. SABRAO 7(2):131-136.

Puckridge, D.W. and P. Thongbai. 1988. Fertilizer management in deepwater rice. In *Proceedings of the 1987 Deepwater Rice Workshop*, Bangkok, Thailand. International Rice Research Institute, Manila. pp. 387-406.

Puckridge, D.W., Chankasem, L., Vongsaroj, P., Thongbai, P. and S. Chinawong. 1988a. Effects of tillage and sowing methods on control of wild rice *Oryza rufipogon* in deepwater rice. In *Proceedings of the 1987 Deepwater Rice Workshop*, Bangkok, Thailand. International Rice Research Institute, Manila. pp. 593-598.

Puckridge, D.W., Panichagoon, P. and P. Thongbai. 1988b. Analysis of floodwater patterns. In *Proceedings of the 1987 Deepwater Rice Workshop*, Bangkok, Thailand. International Rice Research Institute, Manila. pp. 35-46.

Puckridge, D.W., Catling, H.D., Vonsaroj, P., Boonyawivatana, S., Niyomwit, L., and P. Thongbai. 1989. Factors affecting deepwater rice in the Central Plain of Thailand. *Field Crops Research*. 19:263-283.

Puckridge, D.W., Kupkanchanakul, K., Peasaschar, K., Sripongpankul, S. and S. Runtan , 1990a. Influence of time of flooding on development of basal internodes. In: *Report of Deepwater Rice Planning Meeting 1990*, Department of Agriculture, Bangkok.

Puckridge, D.W., Sattarasart, A., Kupkanchanakul, T. and S. Runtan 1990b. Production of upland crop-deepwater rice intercrops with concurrent or delayed sowing of deepwater rice. In: *Report of Deepwater Rice Planning Meeting*, March 1990. Department of Agriculture, Bangkok, pp:9-12.

Puckridge, D.W., Wiengweera, A., Thongbai, P., Sangthong, P., Sattarasart, A., Kongchum, M. and S. Runtan. 1991. Nitrogen uptake by deepwater rice during the pre-flood and flooded phases, in relation to dry-matter and grain production. *Field Crops Research 27*:315-336.

Puckridge, D.W., Kongchum, M., Thongbai, P, Sattarasart, A., and S. Sinoupakarn. 1994. Nitrogen uptake and yield of deepwater rice in the Central Plain of Thailand. *Field Crops Research* 37: 193-204.

Puckridge, D.W. and D. Senadhira (Eds). 1995. *Breeding flood-prone rice.* International Rice Research Institute, Manila. (mimeo 115 pp.).

Ramiah, K. and M.B.V.N. Rao. 1953. Rice Breeding and Genetics. *Indian Council Agri. Research Monograph 19.*

Rose-John, S. and H. Kende. 1985. Short-term growth response of deepwater rice to submergence and ethylene. *Plant Sci.,* 38:129-134.

Roy, A.C., 1975. Soil characteristics and fertiliser response in the cultivation of Deepwater Rice in Bangladesh. In: *Proceedings of the International Seminar on Deepwater Rice, August 1974.* Bangladesh Rice Research Institute, Joydebpur, Bangladesh, pp 148-162.

Setter, T.L., Kupkanchanakul, T., Pakinnaka, L., Aguru, Y. and H. Greenway. 1987a. Mineral nutrients in floodwater and floating rice at water depths up to 2 meters. *Plant Soil* 104:147-150.

Setter, T.L., Waters, I., Greenway, H., Atwell, B. J. and T. Kupkanchanakul. 1987b. Carbohydrate status of terrestrial plants during flooding. In: Crawford, R. M. M.. Ed.), *Plant Life in Aquatic and Amphibious Habitats*. British Ecological Society Symposium No. 5. Blackwell Scientific Publications, Oxford. pp. 411-433

Setter, T.L., Jackson, M.B., Waters, I., Wallace, I. and H. Greenway. 1988a. Floodwater carbon dioxide and ethylene concentrations as factors in chlorosis development and reduced growth of completely submerged rice. In *Proceedings of the 1987 Deepwater Rice Workshop*, Bangkok, Thailand. International Rice Research Institute, Manila. pp. 301-310

Setter, T.L., Kupkanchanakul, T., Kupkanchanakul, K., Bhekasut, P., Wiengweera, A. and H. Greeway. 1988b. Environmental factors in deepwater rice areas in Thailand: oxygen, carbon dioxide and ethylene. In *Proceedings of the 1987 Deepwater Rice Workshop*, Bangkok, Thailand. International Rice Research Institute, Manila. pp. 55-66.

Setter, T.L. and E.V. Laureles. 1996. The beneficial effects of reduced elongation growth on submergence tolerance of rice. *Journal of Experimental Botany* 47(303), 1551-1559.

Siam Society. 1987. *The Customs of Cambodia*. A book translated into English by J. Gilman d'Arcy Paul from the French version by Paul Pelliot of Chou's Chinese original. Siam Society, Bangkok.

Somsook, S., Tongtavee, K., Catling, H.D., Keawta, T. and S. Hongnag. 1986. Survey of rodents and damage assessment in deepwater rice. Thai J. Agric. Sci. 19: 299-306.

Sugawara, T. and T. Horikawa. 1971. Studies on elongation of internodes in floating rice plants — morphological and histological observation [in Japanese, with English summary] *Bull. Coll. Agric Utsumomiya Uni.* 8(1):25-46.

Suge, J. 1988. Physiological genetics of internode elongation in submerged deepwater rice. In *Proceedings of the 1987 Deepwater Rice Workshop*, Bangkok, Thailand. International Rice Research Institute, Manila. pp. 275-286

Supapoj, N., Setabutara, C., Kupkanchanakul, K. and E. Shuwisiku. 1977. Segregation for elongation ability in two crosses of floating rice with ordinary low land rice: 1. Estimation of heritability and implication of selection efficiency. In *Proceedings of the 1976 Deepwater Rice Workshop, Bangkok, Thailand.* International Rice Research Institute, Manila. pp. 29-36

Supapoj, N., Prechachat, C. and K. Kupkanchanakul. 1979. Screening for flood tolerance in the field. In *Proceedings of the 1978 International Deepwater Rice Workshop*, Calcutta, India. International Rice Research Institute, Manila. pp. 135-138

Takahashi, K. 1988. Hormonal regulation of internode elongation in rice shoots. In *Proceedings of the 1987 Deepwater Rice Workshop*, Bangkok, Thailand. International Rice Research Institute, Manila. pp. 245-255

Thakur, R. and D. HilleRisLambers. 1989. Inheritance of plant elongation ability at seedling stage in rice. *Euphytica* 41:227-233.

Thakur R, Singh A.K., Singh R S, Singh S S (1994) Development of sustainable deepwater rice farming systems in Bihar, India. Technical Exchange 3(2):7-9.

Tripathi, R.S. and M.J. Balakrishna Rao. 1985. Inheritance studies of characters associated with floating habit and their linkage relationship in rice. *Euphytica* 34:875-881.

Vacharotayan, S. and Y. Takai. 1983. *Paddy nitrogen economy.* NODAI Research Institute, Tokyo University of Agriculture, Tokyo, Japan. 199 pp.

Vergara, B.S. 1985. Growth and development of the deepwater rice plant. *IRRI Research Paper Series*, Number 103, International Rice Research Institute, Manila. 30 pp.

Vergara, B.S., Mazaredo, A., De Datta, S.K. and W. Abilay 1975. Plant age and internode elongation in floating rice varieties. In: *Proceedings of the International Seminar on Deepwater Rice, August 1974.* Bangladesh Rice Research Institute, Dacca. . pp. 178-183

Vergara, B.S. and T.T. Chang. 1976. *The flowering response of the rice plant to photoperiod: a review of the literature.* Fourth Edition. International Rice Research Institute, Manila, 61 pp.

Vergara, B.S., Visperas, R., Peralta, J., Shuwisitkul, E., Karin, S., and S. Sophonsakulkaew. 1977. Screening for kneeing ability. In *Proceedings of the 1976 Deepwater Rice Workshop, Bangkok, Thailand.* International Rice Research Institute, Manila. pp. 123-124

Vongsaroj, P., Puckridge, D.W., Chinawong, S., and S. Chomvilai. 1988. Assessment of some weed control methods for deepwater rice. In *Proceedings of the 1987 Deepwater Rice Workshop,* Bangkok, Thailand. International Rice Research Institute, Manila, pp. 583-591.

Waitruardrok, T., Kupkanchanakul, K. and D. W. Puckridge. 1992. Influence of frequency of cutting on plant reserves and rate of elongation of deepwater rice. In: *Report of Deepwater Rice Planning Meeting 1992.* Department of Agriculture, Bangkok, pp 39-40.

Whitton, B. A. and H.D. Catling 1986. Algal ecology of deepwater rice-fields in Thailand. Arch. Hydrobiol., 105:289-297.

Wiengweera, A., Puckridge, D.W., and P. Bhekasut. 1988. Testing Deepwater Rice for response to nitrogen and phosphorus. In *Proceedings of the 1987 Deepwater Rice Workshop,* Bangkok, Thailand. International Rice Research Institute, Manila, pp. 413-421

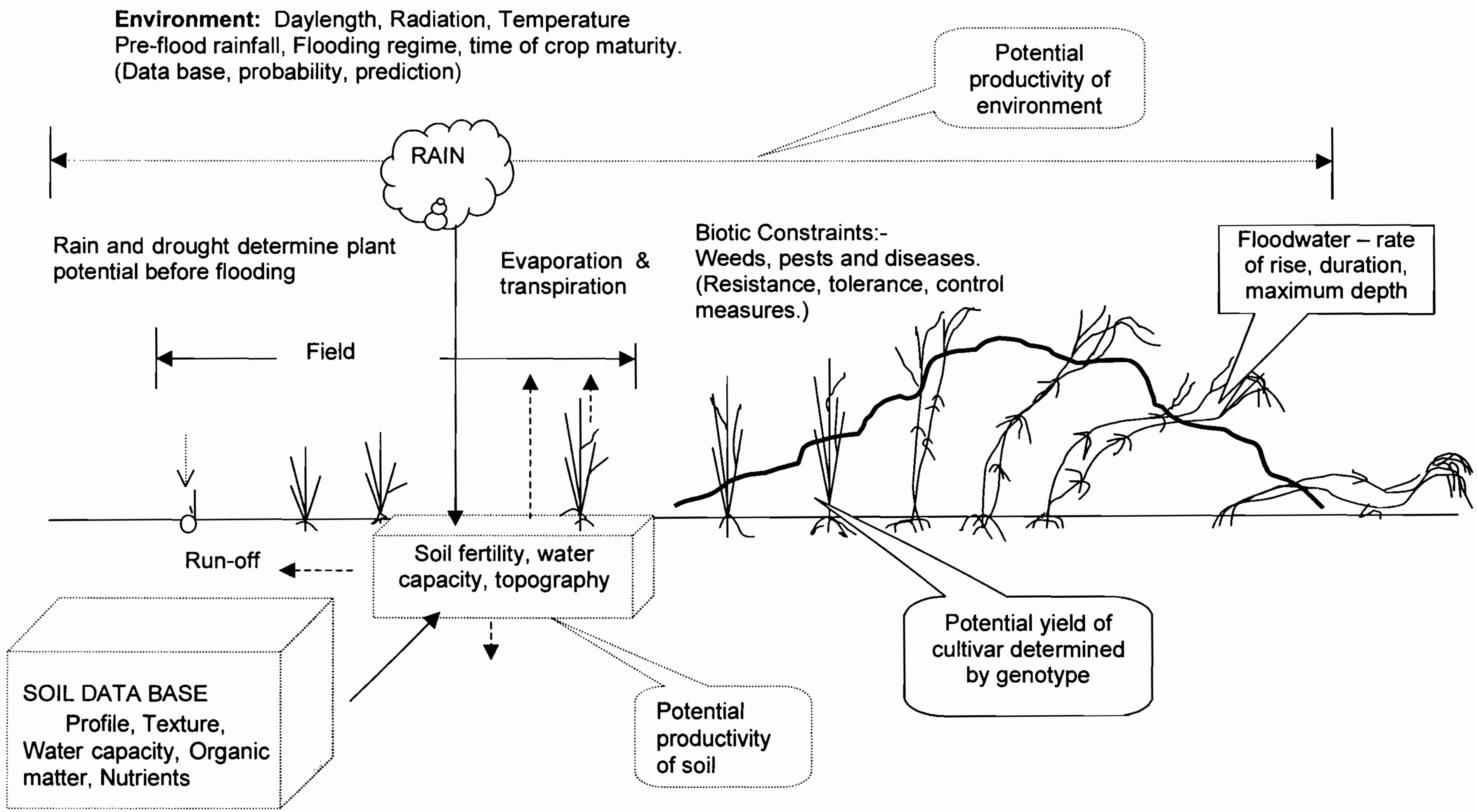


Figure1. Concepts of growth and production for a deepwater rice crop during the pre-flood and flooded phases indicating determination of eventual yield by environmental and biotic factors and genetic adaptability of the variety, with examples of data required to analyze the ecosystem

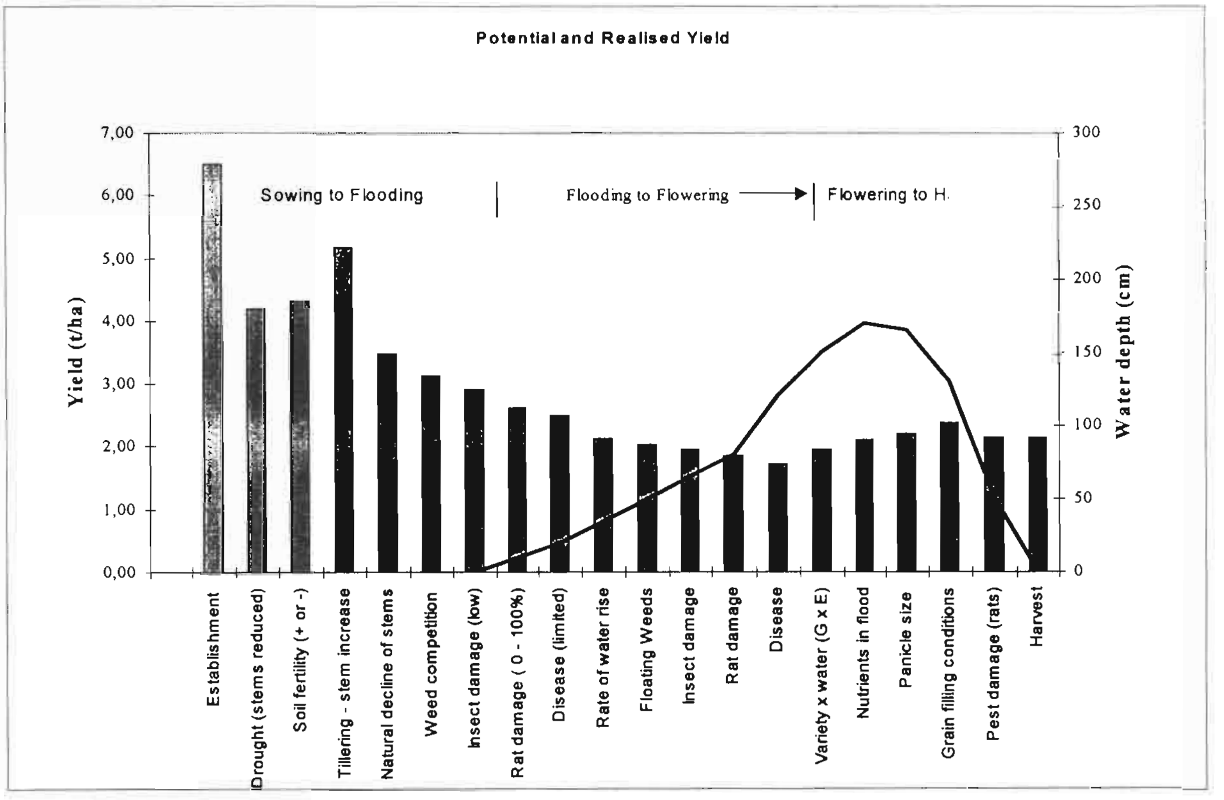


FIGURE 2. EFFECT OF FREQUENCY OF CUTTING ON MEAN ELONGATION (RATE OF INCREASE IN HEIGHT) OF 15 DWR ENTRIES AFTER REMOVING TOPS OF PLANTS LEVEL WITH THE WATER SURFACE AT 80 CM (MAXIMUM ELONGATION RATE WAS 16.8 CM PER DAY FOR LMN 111.) HUNTRA RICE EXP. STATION, THAILAND 1992.

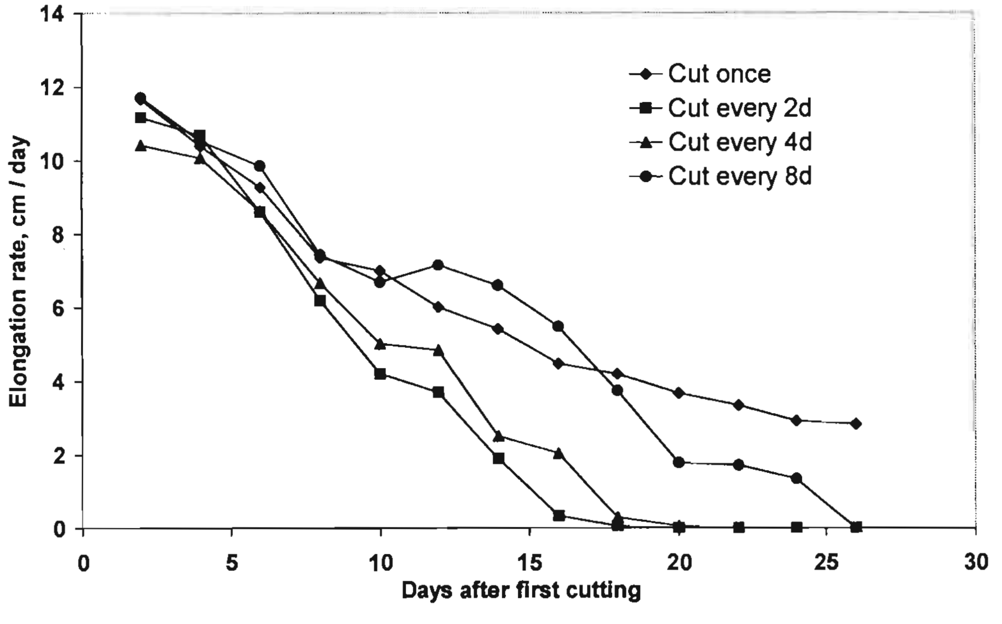


FIGURE 3. Illustration of the cumulative effect of a sequence of events on the eventual yield of a variety of deepwater rice which has a potential yield under ideal conditions of around 6.5 tons per hectare. The potential is shown by the bar at "establishment". Some events have a negative effect on yield, a few have a positive effect, but all affect the final yield of the crop. The sequence changes from season to season. Minimisation of the negative factors (constraints) allows the crop to approach its potential..

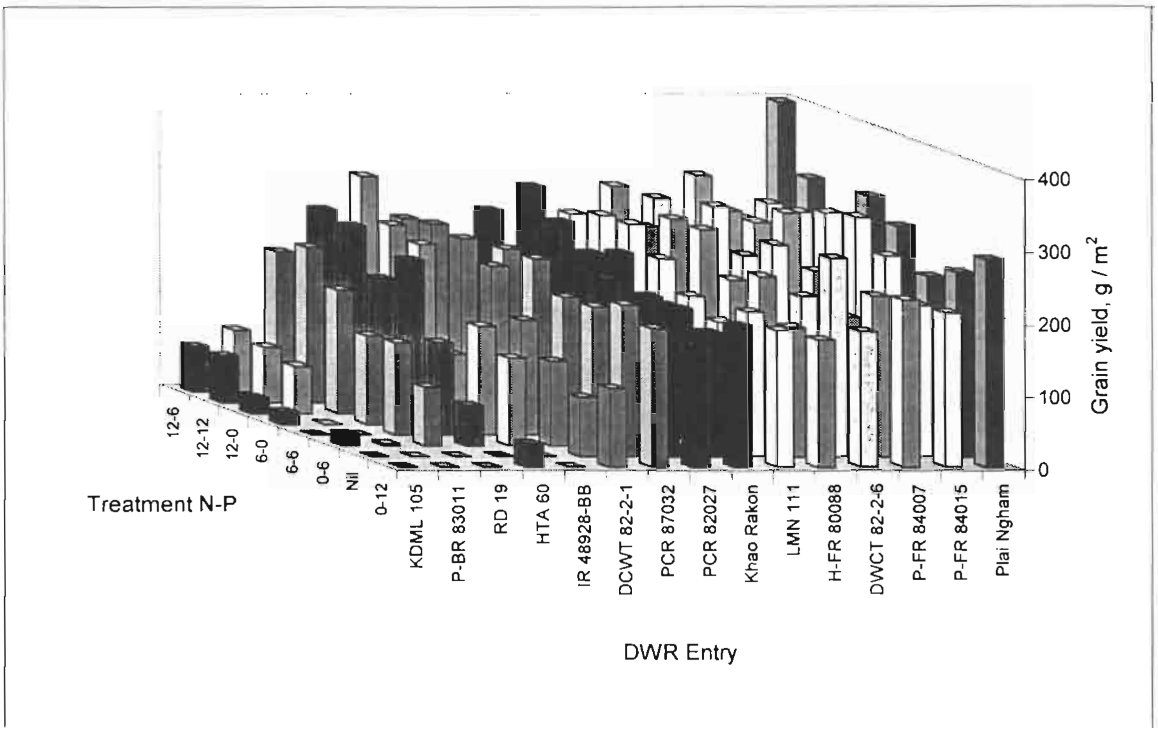


Figure 4. Yields of 15 DWR rice entries (mean of three replications) tested with eight nitrogen and phosphorus combination (N-P) showing their response to N and P and the extent of interaction. Plai Ngham was later released as a variety. Prachinburi Rice Research Center, wet season 1995.

Figure 5. The ultimate productivity of a system depends on the potential of each of the components and none can be viewed in isolation.

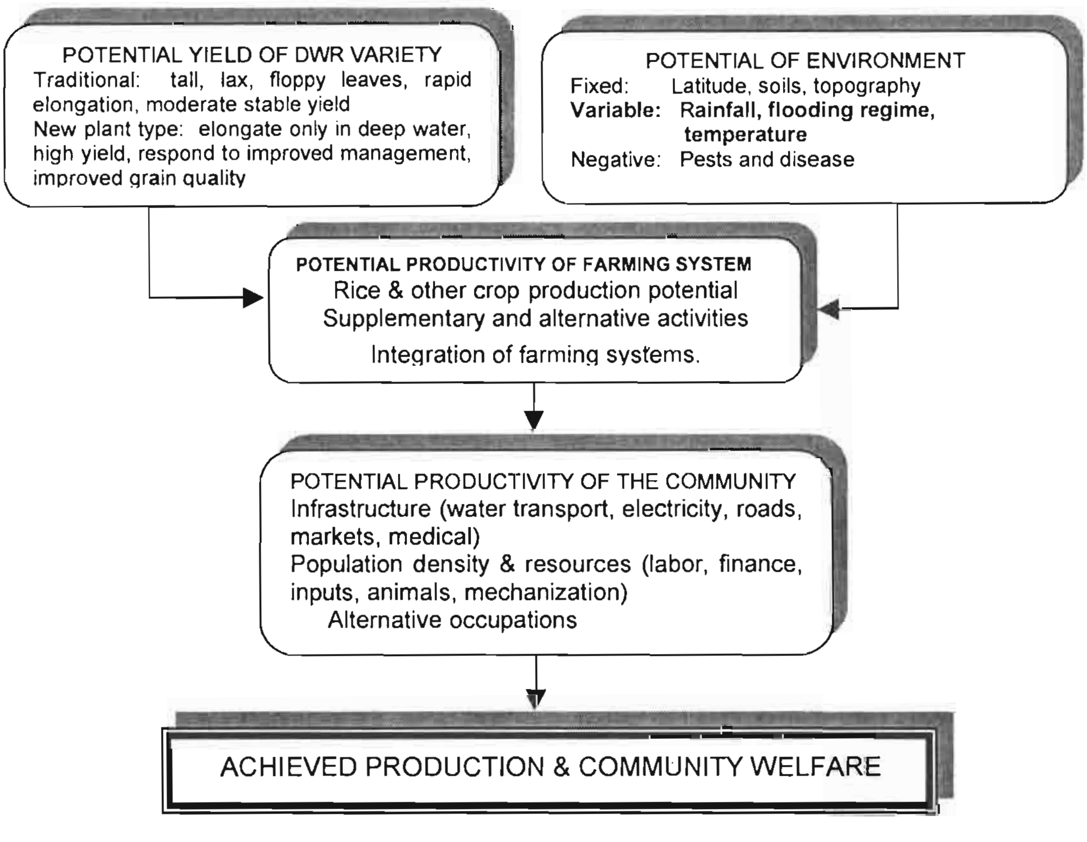


Table 1 Sowing and emergence dates, flood arrival and other cultural details for deepwater rice and field crops in inter-cropping experiments at Huntra Rice Experiment Station, Thailand, Wet seasons 1988-91.

	1988	1989	1990	1991
Date of first sowing (S1)	28-Apr	3-May	9-May	14-May
S1 plants emerged	7-May	15-May	15-May	27-May
Delayed DWR broadcast (S2)	11-Jul	30-Jun	18-Jul	8-Jul
Flood arrival date	27-Aug	28-Aug	7-Sep	9-Sep
Days after S1	121	117	121	105
Days after S2	47	59	51	63
Harvesting date				
Mungbean (3-4 times)	2-10 Jul	29 Jun-22 Jul	9-31 Jul	20 Jul-13 Aug
Sesame	16-Jul	31-Jul	4-Aug	13-Aug
Sunflower	2-Aug	3-Aug	10-Aug	23-Aug
Deepwater rice	3-Jan-89	2-Jan-90	Dec	28-Dec

Crop problems

1988 Insect damage and water logging of non-rice crops

1989 Drought, water-logging of non-rice crops, poor germination of DWR

1990 Poor germination of sunflower, DWR destroyed by sudden high flood.

1991 Poor establishment of sunflower, rapidly rising floodwater.

Table 2. Yield of field crops (kg ha-1) when grown as inter-crop rows or mixtures with DWR, or followed by delayed broadcast DWR, and subsequent yield of DWR (t ha-1). Huntra Rice Experiment Station, Thailand, Wet seasons 1988-91.

Treat.	Field crop	DWR	1988		1989		1990		1991	
	Type and Row spacing	Method, time sown	Field crop	DWR	Field crop	DWR	Field crop	DWR	Field crop	DWR
Rice alone										
1	None (check)	B'cast, 1	-	3.14 a-d	-	3.69 a	-	0	-	3.55 cd
2	None (delay check)	B'cast, 2	-	2.82 def	-	2.97 bcd	-	0	-	4.61 ab
Mungbean										
3	Pair 25 cm	Rows, 1	288 b	2.85 c-f	-	-	-	-	-	-
4	Pair 25 cm	B'cast, 1	299 b	2.86 c-f	894 d	3.40 ab	1,685 a	0	-	-
5	B'cast	B'cast, 1	173 b	3.41 a	1,214 bc	3.23 abc	1,279 c	0	286 c	4.12 abc
6	B'cast	B'cast, 1	-	-	1,299 ab	2.98 bcd	-	-	-	-
7	One 50 cm	B'cast, 1	-	-	991 cd	2.94 bcd	1,426 bc	0	736 b	4.68 a
8	Pair 25 cm	B'cast, 2	543 a	3.21 abc	1,503 a	0.72 f	1,491 ab	0	-	-
9	One 50 cm	B'cast, 2	-	-	1,400 ab	0.64 f	-	-	1,103 a	3.74 cd
Sesame										
10	Pair 25 cm	Rows, 1	383 b	2.57 f	-	-	-	-	-	-
11	Pair 25 cm	B'cast, 1	365 b	2.94 b-f	800 b	2.64 cde	631 b	0	-	-
12	One 50 cm	B'cast, 1	-	-	916 b	2.35 de	569 b	0	605 b	3.83 c
13	B'cast	B'cast, 1	-	-	-	-	809 ab	0	745 b	4.00 bc
14	Pair 25 cm	B'cast, 2	644 a	3.03 b-e	1,355 a	0.37 f	1,005 a	0	-	-
15	One 50 cm	B'cast, 2	-	-	1,528 a	0.46 f	-	-	1,185 a	3.13 d
Sunflower										
16	One 75 cm	Rows, 1	846 a	2.91 b-f	1,259 a	2.17 e	-	-	-	-
17	One 75 cm	B'cast, 1	729 a	3.27 ab	1,253 a	3.06 a-d	422 a	0	707 a	4.03 bc
18	One 75 cm	B'cast, 2	1,221 a	2.74 ef	1,464 a	0.49 f	621 a	0	670 a	3.54 cd

Notes : Yields in a field crop group in a column with the same letter are not significantly different by DMRT. DWR comparisons are between all treatments. B'cast = Broadcasting method. Time of sowing: 1=Sowing at start of experiment, 2 = Delayed sowing of DWR.

Incidence of Bangkok city development on peri-urban agricultural patterns and cropping systems evolution

Buntoon Chunnasit[1], Jacques Pagès[2], Onouma Duangngam[3]

Abstract: *The very rapid growth of Bangkok city over the last decades, which cannot be confined to Bangkok administrative boundaries, has many impacts on the neighbouring provinces, at diverse levels : population density, economic activity, industrialisation, transportation,...all of these process ending in a growing pressure upon natural resources : land, water, but eventually air and light.*

Agricultural activity is strongly relying on availability, both in terms of quality and quantity, of these resources and as such, Bangkok development has induced many changes in agricultural sector.

Combination of different methodologies (statistic data processing, in-depth on-farm enquiries together with rapid survey over a sample of more than hundred farms, markets follow-ups) unveiled the wide diversity of situations, cropping patterns and production results. Data analysis by mean of GIS tools led to perform a mapping of production areas, expressing a spatial distribution of crops. This zoning is the result of different farmers strategies, related to different cultural or historical background as well as the evolution of their physical environment.

In the framework of the elaboration and implementation of cities master plans, objectives of city policy makers and farmers behaviour can thus show discrepancies, resulting in possible conflicts. Methodologies able to describe the dynamic of urban and periurban agriculture as an answer to the fast evolution of its global environment must then be evolved in order to provide to both the policy makers and the periurban growers, negotiation tools for the sustainability of agricultural activity within urban space.

[1, 3] Faculty of Agriculture, DORAS Centre, Kasetsart University 10900 Bangkok

[2] CIRAD, DORAS Centre, Kasetsart University 10900 Bangkok

1 Introduction

Agriculture has always been at the core of Thailand development and if Thai rice is well known world-wide, a few other agricultural productions are giving to this country a predominant place above all, i.e. cassava, rubber, shrimps, ...

Supported by the income derived from its agriculture, Thailand engaged in industrialisation process and as a matter of fact, infrastructures and services sector developed rapidly over the last decades.

The fastest developing site of the country, the Central Plain, still the major area for rice cultivation due to its climate and the water resources from Chao Phraya and Mae Klong Rivers, allowing up to 3 or 4 cycles per year, is also the framework of an intense urbanisation phenomenon, centred on Bangkok (DORAS project, 1997). With a growth rate of about 40 % during the 1980s, Bangkok and its 10 million people conurbation are rapidly inducing deep and often irreversible changes in the Central Plain agricultural and socio-economic landscape (Eiumnoh A., Parkpian P., 1998).

Rice paddy fields are progressively and rapidly giving way to more intensive cropping systems based on vegetable, ornamentals, herbs, fruit trees, coconuts...

Between 1989 and 1995, in Thailand Central Plain vegetable areas increased by more than 35 % when fruit trees increased by about 20 %. At the same time, paddy land slightly decreased by 2.7 % and field crops (sugarcane) by 3.4 %.

At the fringe of estates development, fallow lands are often met, unveiling landowners speculative strategies.

Bangkok and related urban centres have thus induced many changes in their environment and the close agricultural sector.

Competition, as for natural resources use, but also complementarity, as in the chain production / consumption, are the two main trends which can characterise urban - agriculture relationships. This specificity has been used as the basic guideline to define Periurban agricultural sector (Mbaye A., Pagès J. and de Bon H., 1998 ; Ellis F. and Sumberg J., 1998).

The price of land has increased where plots can be used as an estate settlement, resulting in an overexploitation of the remaining agricultural plots, or in their abandon and the cultivation of less favourable areas.

Water has to be shared between irrigation, industrial usage and urban consumption. Pollution by city wastes must now be considered, resulting in a reduced availability for farming.

City expansion comes along with a correlative development of transportation infrastructures as well as traffic activity. Roads are criss-crossing the agricultural landscape, spreading out of the city core the pollution linked to vehicles operation. Heavy metals deposits can then be found on plants, and in canals in the fields along the roads. In the most active areas, light can be shaded by fog and photosynthesis process reduced, inducing a lower potential productivity.

City' vicinity also leads to changes in socio-economic conditions of production sector. Apart from the cost of land rental, inputs required to achieve high level productivity, labour force is becoming more expensive, the relatively high wages which can be fetched in the nearby industry and services upscaling the cost of living in the whole city area, periurban agriculture included. Production costs are then increased, and as the skill and knowledge, necessary to produce the high quality standards required by urban consumers arise, manpower is impacting heavily on agriculture sustainability.

In this very dynamic environment, agricultural producers must express a strong capacity for adaptation and evolution, both diversifying and intensifying their strategies and their practices as an answer to any change in their surroundings.[4]

New plants, new technologies are thus investing farmers' fields and the once rice cultivators are now growing a wide range of vegetable, some of them just being domesticated, or just introduced from remote places in the world. Cultivation techniques required to attain the best production, either in quantity or in quality are often barely known, and the incidence of these changes on environment is more than often not considered.

In the meantime, Governemental agencies, as well as private sector (production, post harvest technology, marketing) are aiming at a better quality for production and establish closer links with international organisations and European countries, in order to implement in Thailand normae regulations and production references guidelines.

Development agencies, training institutions and research organisation are part of the panoply that the Thai government is mobilising to assist producers and citizens for a better mutual understanding and living together.

As in many countries, in Thailand, research infrastructures are closely related to implementation and training services.

In the particular concern of periurban agriculture[5], a research activity has been engaged in Kasetsart University, within the Development Oriented Research on Agricultural Systems (DORAS) Centre. Research programmes are carried out using system approach methodology, generally in close partnership with end-users of research products.

---

[4] Apart from typical agricultural activity, aiming at producing food or plant material, there is a trend to develop other sources of income, based upon non-directly productive agricultural resource, such as water pond, land space, hosting facilities,...These increased roles of agricultural sector, not presented in this paper has been reported in other countries as well, and is usually designed as related to the multifunctionnality of agriculture (*Losada H., Martinez H., Vieyra J., Pealing R., Zavala R. and Cortes J., 1998 ; Midmore D.J., 1998*)

[5] Which must be understood here in its broadest meaning, including urban agriculture

The field of research is "agriculture within urban space". It is based on the definition of Periurban Agriculture, generally agreed upon: the agriculture which competes with the city in the use of natural resources (land, water, energy, labour). Important sectors of this agriculture include horticulture (vegetable, fruits, mushrooms, roots and tubers), livestock, fodder and milk production, aquaculture and forestry.

Problems at stake have been identified as requiring mainly three types of actions :

- assistance to producers in order for them to achieve sufficient levels of good quality products, and particularly to meet urban requirement on food supply ;

- knowledge and practices pertaining to the sustainability of agriculture within urban environment, and particularly to the improved management of natural resources ; ultimately, this would give information leading to measure the degree of sustainability of this agriculture (Nugent R.A., 1999)

- deliverance of useful information on agriculture in urban environment, so that agriculture can be acknowledged by policy makers and urban planners.

This paper presents the first findings on this agriculture, assessing its diversity, its variability but also pointing out to some specific evolution either qualitative or geographic, with definite trend which must be taken into consideration in order to establish or implement cities master plans.

2 Methodology

The methodology applied is derived from system analysis, and combine many tools such as statistics, survey, GIS … as it is commonly performed in this type of study (Banzo M., 1998) ;

Results gained so far are derived from statistical processing of data issued by the Ministry of Agriculture and Cooperatives and the Ministry of Interior (census year 1998, 1999). These data have also been considered with complementary information gathered through on-farm surveys (December 1998 till august 2000), enquiries and bibliography analysis. In order to get knowledge upon marketing sector, a survey is also being carried out at market place level (mainly Talat thai). The area which has been considered is composed of the 350 tambons of changwat Chachoengsao, Nakhon Pathom, Nonthaburi, Pathumthani, Samut Prakhan, Samut Sakhorn and Bangkok Metropolitan Authority. An assessment of economic value of periurban agriculture has also been prepared, though the high degree of variability of data collected may hamper heavily this type of attempt (Hormann D.M., 1999).

3 Results

3.1 Urbanisation and agricultural activities

Preliminary remark: due to the expertise of the team of researcher engaged in the programme, most of work carried out so far deal with plant production. Only a few data have been gathered regarding animal production, but this field indeed will have to be address in the forthcoming studies.

The incidence of urbanisation process can be assessed through the change in the general landscape of city suburbs. Agricultural land are quickly evolving towards human settlement and all the related infrastructures. Study of the seven changwats unveil different ratio of agricultural land use compared to their acreage. These ratio can be related to population density, which gives an indication of urban pressure upon natural resources and particularly land use (table 3 hereafter as shown in the table 2 and 3 below, as well as graph 1. 2, as well as population density).

TABLE 1 : AGRICULTURAL LAND USE

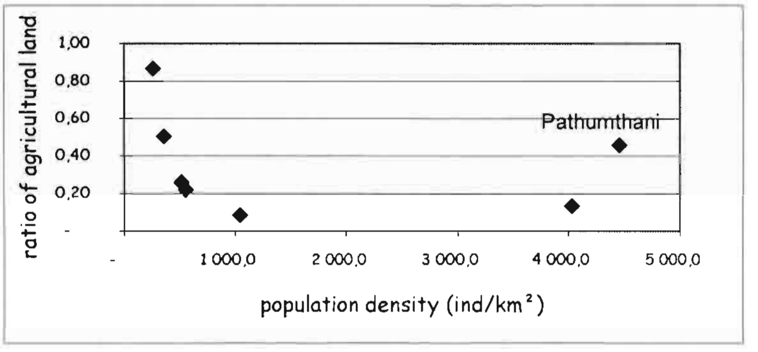
Changwat	total area (ha)	agricultural area (ha)	Ratio Ag/total
Chachoengsao	237 042	205 352	**0,87**
Nakhom Pathom	221 009	111 864	**0,51**
Nonthaburi	142 715	31 384	**0,22**
Pathumthani	150 224	68 884	**0,46**
Bangkok	156 609	21 276	**0,14**
Samut Prakhan	97 042	8 614	**0,09**
Samut Sakhorn	86 355	22 500	**0,26**

Source: Statistic Ministry of Agriculture and Cooperative, 1998

TABLE 2 : POPULATION DENSITY (REF. NATIONAL CENSUS 2000)

Changwat	total area (ha)	population	density ind/km²
Chachoengsao	237 042	632 533	266,8
Nakhom Pathom	221 009	809 062	366,1
Nonthaburi	142 715	810 254	567,7
Pathumthani	150 224	6 690 402	4 453,6
Bangkok	156 609	6 320 174	4 035,6
Samut Prakhan	97 042	1 014 449	1 045,4
Samut Sakhorn	86 355	457 078	529,3

GRAPH 1 : RELATIONSHIP POPULATION DENSITY AND AGRICULTURAL USAGE OF LAND



The **graph n°1** shows the incidence of an increase population density on the use of land for agriculture.

Anyway, the particular case of Pathumthani changwat already stresses the fact that, in spite of a high population pressure upon land, even higher than encountered in BMA, it is still possible de maintain an agricultural land use similar to less densely changwat, such as Nakhon Pathom.

In the case of Pathumthani, we will see that this rather high ratio of agricultural land use is due for the most to a sole cropping system : orchard of orange trees.

Though located in a very similar physical environment (climate, soil and water), cropping patterns evolved by farmers present many distinct characteristics, in terms of type of crops, land and water management, economic importance.

The following table (table 3) shows difference between cropping systems and the relative importance of cropped areas at changwat level and tambon level.

TABLE 3 : COMPARATIVE CROPS AREA IMPORTANCE AT CHANGWAT LEVEL (1998)

%area	Rice	Vegetable	fruits	perennial	ornamentals
Chachoengsao	38	7	31	54	1
NakhonPathom	24	51	23	11	39
Nonthaburi	8	11	7	2	19
Pathumthani	19	12	19	1	1
SamutPrakhan	2	12	7	17	-
SamutSakhorn	1	3	9	13	15
Bangkok	8	4	3	1	25
total area (ha)	**480 307**	**20 401**	**96 115**	**39 119**	**5 014**

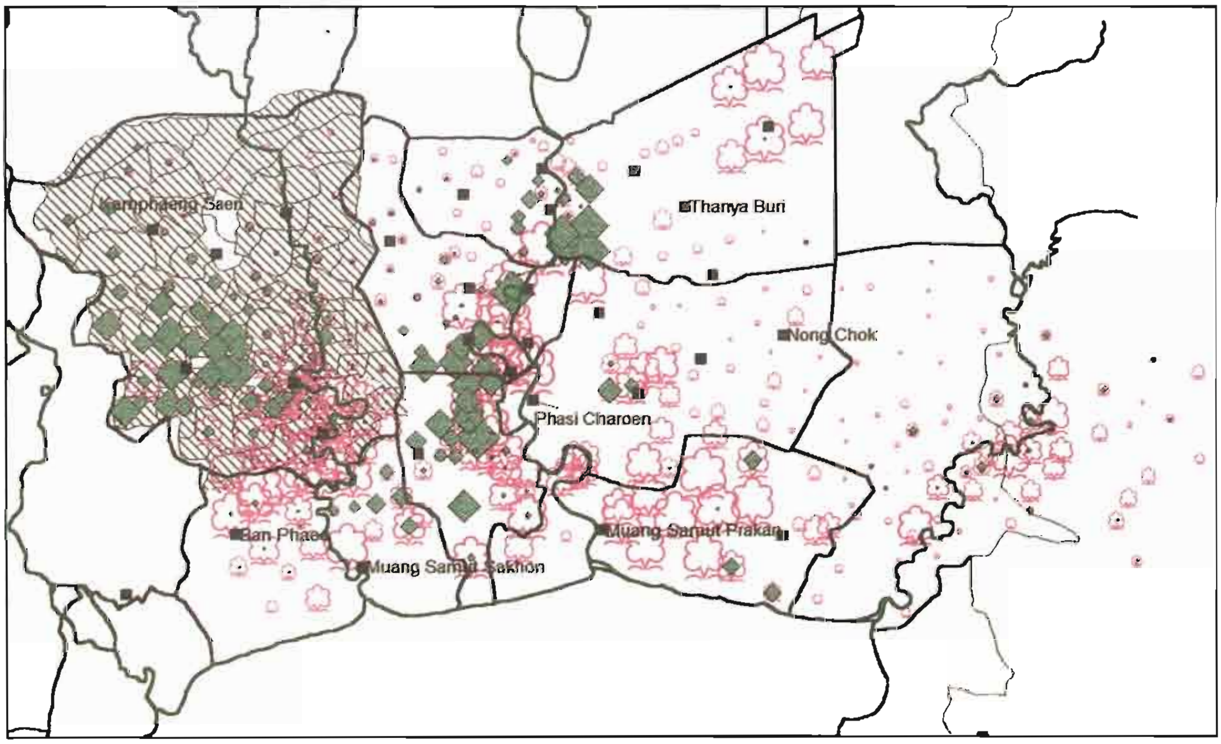
At a first glance, the two changwats of Chachoengsao and Nakhon Pathom appear to be more concerned by agricultural production than the five other ones. Ranking either first or second for rice paddy fields, orchards and cassava, Nakhon Pathom moreover holds the first place for area under vegetable or ornamental cultivation.

The two coastal changwats of Samut Prakan and Samut Sakorn, on the other hand, have devoted most of their agricultural land to perennial crop or vegetable, and the rice paddy fields are occupying a relatively small area compared to the other changwats.

Bangkok eventually allocated most of its 21.300 ha of agricultural area to ornamental plants, a more relevant system whenever space is limited.

Another indication given by this table is the fact that, relative importance given to the different type of crop are unequal between changwats. This suggests a certain geographic specialisation of the cropping patterns.

This characteristic is better expressed in the map 1, hereafter. For a better reading, only vegetable and fruit areas have been represented.



***Map 1** : Spatial distribution of cropped area*

Tree symbol refer to relative importance of orchard area,

Square symbol refer to vegetable area.

Apart from stressing the specialisation mentioned before, this map also points out to the fact that tambon level analysis is a more relevant study level, unveiling the heterogeneity of any changwat. In Changwat Nakhon Pathom (lined area on the map) for example, most of fruit production is located in the southern tambon, while vegetable area is more central, close to Kamphaengsaen city, and very few of these crops in the northern zone.

Observations carried out so far give two types of valuable information :

in the process of **implementing quality labels**, production areas are key knowledge, which eventually will open way to geographic indicators.

in order to evolve **local master plans**, taking into account both agriculture and city dweller needs, the many different roles that agriculture could play are to be considered. Landscape is one of these roles, and knowledge of production areas spatial distribution is determining. Landscape could then be designed, whether is derives from plants themselves and their specific architectures (grass shape, bushy shape, forest shape) or by land (open field, greenhouse, raised bed) or water management (irrigated flooded, rainfed system) (Forster T.E., 1997).

3.2 Periurban agriculture and city feeding

While in the preceding chapter, landscape role of agriculture has been mentioned, one of the main objective of agricultural activity, food supply must also be considered (Mougeot L., 1999).

Surveys performed at market levels showed that most of the vegetable and fruit production, performed in changwats considered here, is devoted to local cities supply. These productions however are far from being sufficient to fulfil the requirement of city dwellers, both in terms of quantity[6] and diversity. Other Thailand region, i.e. Chiang Mai or Rayong areas, are thus contributing to the overall supply, and import from foreign countries are also observed.

Table 4 hereafter shows the different contributions of the seven changwats, to Central Plain food supply.

TABLE 4 : COMPARATIVE PRODUCTION AT CHANGWAT LEVEL (1998)

Changwat	Rice	Vegetable	Fruits	Perennial
Chachoengsao (T)	**710448**	15173	45140	**107920**
%	*33*	*6*	*8*	*19*
Nakhon Pathom (T)	**569985**	**120411**	**145643**	41807
%	*26*	*45*	*25*	*7*
Nonthaburi (T)	190280	41029	17160	3623
%	*9*	*15*	*3*	*1*
Pathumthani (T)	449477	**43600**	141519	3467
%	*21*	*16*	*24*	*1*

[6] on a base of 200 g of vegetable per day and per capita (UNDP norm), the requirement of the 7 changwats is about 1.2 millions tons of vegetable per year, i.e. the local production covers 25 % of these needs.

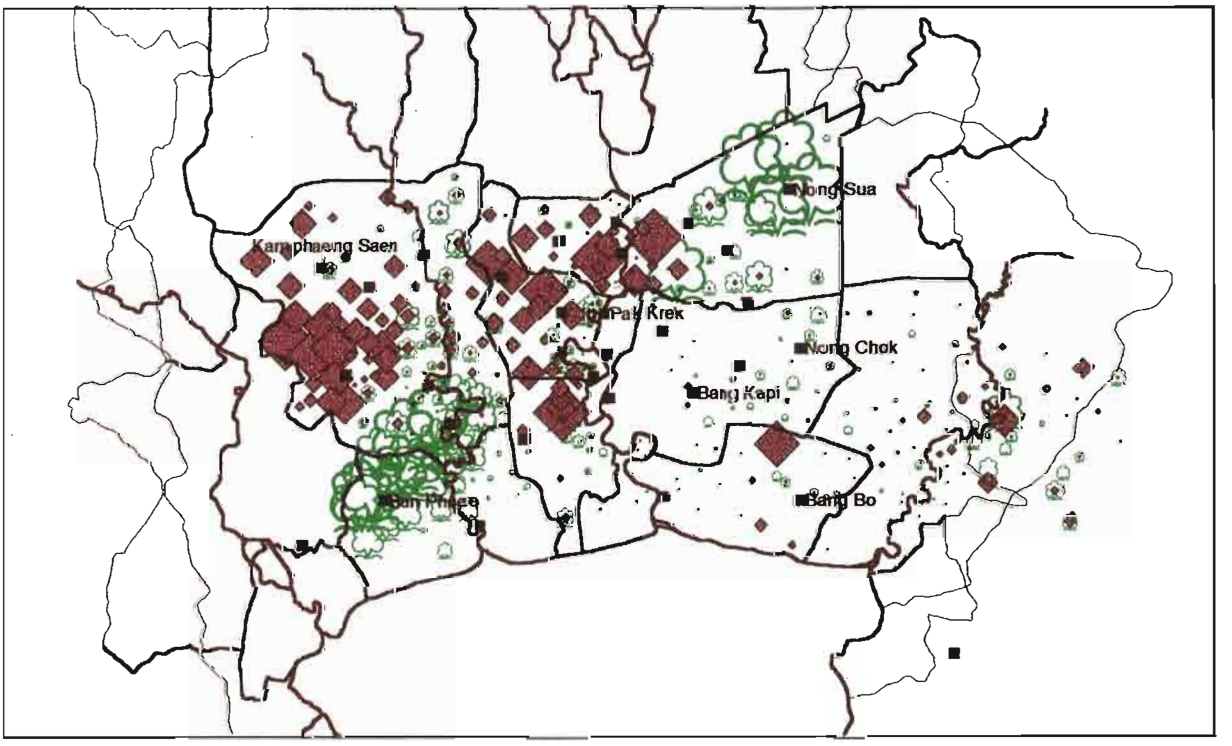
SamutPrakhan (T)	58198	8004	4580	13549
%	3	3	-	2
SamutSakhorn (T)	15610	13975	**206660**	**388421**
%	1	5	**35**	**69**
Bangkok (T)	179256	24930	29445	12122
%	8	9	5	2
total prod (T)	*2173254*	*267122*	*585567*	*565956*

Comparison between table 3 and 4, underlines the fact that changwats with the most important acreage in a given crop are not necessarily the most productive ones.

If Chachoengsao appears definitively as the rice producer amongst the pool of changwats concerned, Samut Sakhorn is well ahead of it in fruit production activity, assuring by itself more than 35 % of the whole production.

These observation are confirmed in a spatial distribution comparison between production and cultivated area. In the map 2. hereafter, vegetable and fruit production are reported.

MAP 2 : PRODUCTION SPATIAL DISTRIBUTION FOR VEGETABLE AND FRUIT



Tree symbol : fruit production

Square symbol : vegetable production

Though there are significant areas of orchard in Bangkok and Chachoengsao sectors, these two changwats do not appear as fruit producers. Production in Chachoengsao sector is mainly performed in the close vicinity of Chachoengsao city, and is devoted to this specific market.

A more detailed analysis of these data will point out that there is a wide range of crops which are listed under the name "vegetable" or "fruit". And it is necessary to carry out an in-depth study in order to better assume difference between location. As an example, Pathum Thani fruit production is widely composed of Java apples, when Chachoengsao one's consists mainly of mangoes.

Another example of this diversity, referring to vegetable production, is given in the table 5, hereafter.

TABLE 5 : COMPARATIVE IMPORTANCE OF SOME SPECIFIC VEGETABLE PRODUCTS BETWEEN CHANGWATS

Product (T)	Chachengsao	Nakhon Pathom	Nonthaburi	Pathum Thani	Samut Prakan	Samut Sakon	Bangkok
Whole production	15 173	120 411	41 029	43 600	8 004	13 975	24 930
Range of products	Up to 26	Up to 37	Up to 38	Up to 15	Up to 3	Up to 11	Up to 12
Chinese keys		13 510					
Galangal	1 523						
Baby corn		10 461					
Chinese kale	3 262	13 936	13 905	14 413		6 566	4 855
Acacia insauvis		11 356					
Cucumber	1 292						
Yard long bean		5 403					
Sacred basil							3 577
Sweet basil							6 271
Water mimosa					6 843		
Pakchoï		7 188		7 793		3 056	
Water convolvulus			2 537	4 676			3 217
Green wax gurd	2 620						
Eggplant		5 954					
Chilli		6 351					
Lettuce			2 759	7 647			
Chinese radish			3 135				

This table shows that changwat differ by the range of vegetable grown, as well as the importance given to some specific crop. Range varies between 3, in the case of Samut Prakan, to 37 and 38 for Nakhon Pathom and Nonthaburi.

There does not seem to be any correlation, as one could have expected, between the diversity of the offer from the production sector, and the pressure of the demand, which might have been assessed through population density (see table 2). There is also no relationship between the importance of the production and this range.

In any case, more than half of the total production is achieved with 1 to 7 products.

Amongst these products, some of them are grown in significant only in one or two changwat. A closer look to data, will also show that even within each the changwat, some tambon are really specialised and provide most of the production of the changwat for some crop (for example, 90 % of water mimosa grown in Samut Prakan, is produced in tambon Sri Sa Chorake Noi).

From the point of view of production it is thus possible to underline some key features :

the relationship between cropped area and production achieved does not appear to be a linear one. This could mean that all the **producers** engaged in agricultural activity **are not always looking for productivity**. This could also mean that in spite of the fact that farmers are willing to produce a given crop in some location, conditions (environmental or socio-economic) are not suitable for this crop.

some tambon are contributing to overall food supply with relatively high amounts of agricultural products. This indicates a **certain specialisation** as well as an intensification of production, i.e; a good environment and skilled producers.

3.3 Economic importance of periurban agriculture

Amongst others, preceding results pointed out the fact that there are many differences between tambons in a same changwat, in terms of amount of production achieved, and that it is necessary to work at tambon level to better apprehend the diversity of periurban agriculture.

Another of its not so well-known characteristic is the part it plays in the overall economic of urbanised area.

An attempt to evaluate the economic generation derived from this specific agriculture has been carried out. At this stage of the work it must nevertheless be pointed out that the economic value of every crop taken for calculation is an average value. Data are derived from surveys at market level, performed during years 1999 et 2000. This same survey showed that the selling price of vegetable is highly variable, depending on the season, some particular event, and the quality of production.

The table 5 hereafter gives data related to the major vegetable crops, as figured in the previous table. Map 3 is an attempt to give a spatial representation of economic value at tambon level, based upon production result and estimated price.

Still keeping in mind that this representation is based upon estimation and average values, it seems nevertheless that the highest economic value is derived from the farthest location from urban areas. There are some particular case, like tambon Bang Porm in BMA, rather close from Bangkok centre and with a high return, averaging 75 millions B. Flower and ornamentals, as well as vegetable and fruits produced in this area, are at the base of this result.

TABLE 5 : PRICES RANGE OF MAJOR VEGETABLE AT TALAT THAÏ MARKET

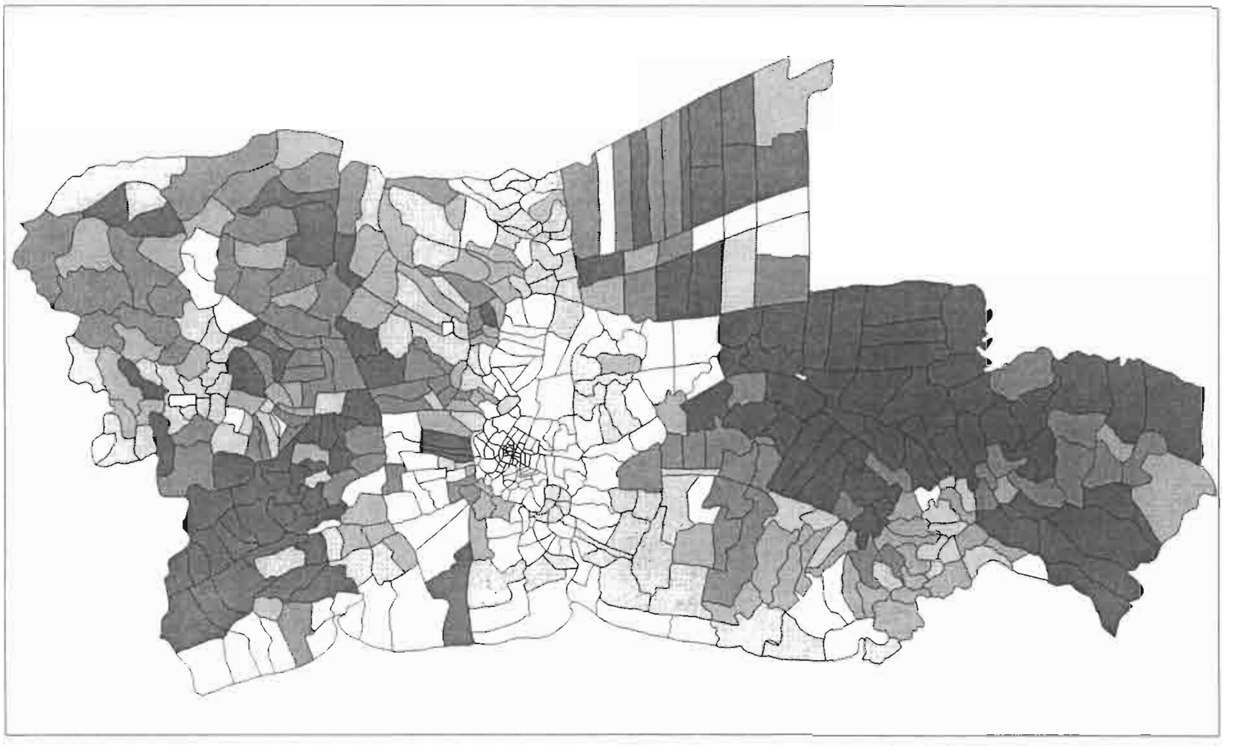
B/kg	Min price	Max price	Average
Chinese keys	10	28	15.2
Galangal	3	16	7
Baby corn	10	48	19.5
Chinese kale	2	30	10.4
Acacia insauvis	2	12	5
Cucumber	2	19	6
Yard long bean	3	50	17
Sacred basil	4	30	9.4
Sweet basil	4	30	9.7
Water mimosa	3.4	20.6	7.3
Pakchoï	2	18	7.3
Water convolvulus	4	30	10.3
Green wax gurd	2	12	5.7
Eggplant	1.7	21	7.1
Chilli	9	70	25
Lettuce	4	50	15.5
Chinese radish	2	15	7

MAP 3 : SPATIAL DISTRIBUTION OF ESTIMATED ECONOMIC VALUE DERIVED FROM PERIURBAN AGRICULTURE (FRESH PLANT PRODUCT DEVOTED TO LOCAL MARKET)

Considering the numerous constraints faced by agricultural activity within urban space, this preceding observation could lead to the conclusion that from an economic point of view, periurban agriculture is not an income generating activity, and this sole economic aspect cannot insure its sustainability.

But a given fact, supported by on-farm surveys, is that farmers are still going on with agriculture. This is confirmed by the discrepancy between cropped areas and production areas.

One must assume that other input, apart from economic ones, are heavily contributing to the sustainability of periurban agriculture. These input must be defined and assessed, in order to apprehend the incidence of city development projects on this agriculture.



0 to 4 millions B / tambon	4 to 10 millions B/ tambon
10 to 26 millions B /tambon	More than 26 millions B/tambon

4 Conclusion

Periurban agriculture encountered in the surroundings of Bangkok conurbation is very composite. Type of crops, production results, economic importance, all of these criteria point out the diversity of situations and the lack of homogeneity of this specific sector of activity.

Difference at tambon level have been observed, making it difficult to apprehend periurban agriculture by mean of limited surveys and extrapolation. Knowledge must be gained at tambon level, through in-depth enquiries, completed by market survey and agricultural census data processing. The lack of clear correlation between cropped area and production achieved, leads to the conclusion that the sole agricultural production is not always the goal aimed at by farmers.

There is still need for study particularly in the field of production environment, so as to understand origin of local low productivity area. Physical parameter, i.e. natural resources quality and availability, but also socio-economic one must be considered and their incidence on farmers behaviour and production results will have to be defined. Another study aiming at supporting city development project has already stressed the importance of ethnic origin and farmers' history in cropping system adoption.

The methodology applied in this work and results already at hand are part of a more comprehensive set of data and tools, still to be implemented in order to provide policy makers and producers with information supporting the elaboration of city master plan and quality standards related to specific agro-environment.

Agricultural activity in the close vicinity of big cities must then be considered through the numerous roles, economic, but also food quality, jobs opportunity, heritage and culture preservation,.... which it plays, so as to better understand the mechanisms which are supporting farmers' strategies and behaviour. This will suppose multidisciplinary team of scientists, in close partnership with concerned stakeholders : city policy makers, but also city dwellers and periurban farmers.

References

Banzo M. 1998. Processus d'urbanisation de la frange périurbaine de Mexico : approche méthodologique. L'espace géographique, n°2: 143-154

DORAS 1997. « Agricultural and irrigation patterns in the Central Plain of Thaïland – preliminary analysis and prospects for agricultural research and development ». DORAS Project, Kasetsart University Bangkok Thaïland

Eiumnoh A., Parkpian P 1998. Impact of peri-urban production on soils and water : a case of Bangkok Plain, Thaïland comm. Congress in K.U. « Periurban vegetable production in the Asia Pacific region for the 21st century, 29.9-1.10.98, 23 p.

Ellis F. and Sumberg J., 1998. Food production, urban areas and policy responses. World development (Oxford), 26 ; 2 :213-225

Forster T.E. 1997. The role of the living landscape as an element of sustainability in Asian Cities during the 21st century. Comm. Pomet 97 Conference « Sustainability in the 21st century : the challenge for Asian cities

Hormann D.M 1999. Conceptual evaluation of urban and periurban production and marketing of fruits and vegetables in developing countries. Urban and periurban agriculture in Africa. Workshop Netanya June 1996 :267-296

Losada H., Martinez H., Vieyra J., Pealing R., Zavala R. and Cortes J., 1998. Urban agriculture in the metropolitan zone of Mexico City : changes over time in urban, suburban and peri-urban areas. Environment and urbanization, 10/2 :37-54

Mbaye A., Pagès J. and de Bon H., 1998. Vers une gestion concertée des ressources naturelles en zone périurbaine - Le cas de la région de Dakar (Sénégal). in Agriculture Péri-urbaine en Afrique Sub-saharienne, CIRAD, Montpellier, France : 125-139

Midmore D.J., 1998. Importance of periurban vegetables to Asian cities. Comm. Congress in K.U. « Periurban vegetable production in the Asia Pacific region for the 21st century, 29.9-1.10.98, 15 p.

Mougeot L. 1999. For self reliant cities : urban food production in a globalizing south. in For Hunger-proof cities - sustainable urban food systems, ed. M.Koc, R.MacRae, L.Mougeaot and J.Welsh : 11-25

Nugent R.A. 1999. Measuring the sustainability of urban agriculture. in For Hunger-proof cities - sustainable urban food systems, ed. M.Koc, R.MacRae, L.Mougeaot and J.Welsh : 95-99

Vegetation patterns in the Chao Phraya Delta, 1997 dry season using satellite image data

Tomita, A., Inoue, Y., Ogawa, S., and Mino, N.[1]

Abstract: *Vegetation patterns in the Chaophraya Delta of Thailand during the dry season vary considerably by year and location, and is apparently due to irrigation policy and management.*

Satellite remote sensing is a unique tool for acquiring a snapshot-image information, which facilitates interpretations of such variations in vegetation patterns.

Multi-temporal images were processed for each delta province to obtain basic information and understandings by province. It was also convenient for augmenting statistical data in quantitative assessment of agricultural information.

Vegetation patterns derived from this study showed various features, changing from lower part to upper part, from the center to the marginal area.

1 Introduction

During the dry season, rainfall in the Chaophraya Delta is insufficient to support agricultural activities, which must depend on irrigated water during this period. The great majority of the land cover here is used for rice cultivation. The availability and allocation of water are not uniform in the different regions of the delta. In some areas these factors are apparently used to determine the location and timing of planting. Differences in water availability and water management policy result in inconsistent crop patterns in neighboring districts.

We examined the possible merits of using satellite remote sensing, especially optical sensors, in determining planting patterns in the delta. After considering the many data resources available, satellite data acquired during the dry season of the 1996/97 crop year were collected and used in this study.

[1] All authors from National Institute of Agro-Environmental Sciences

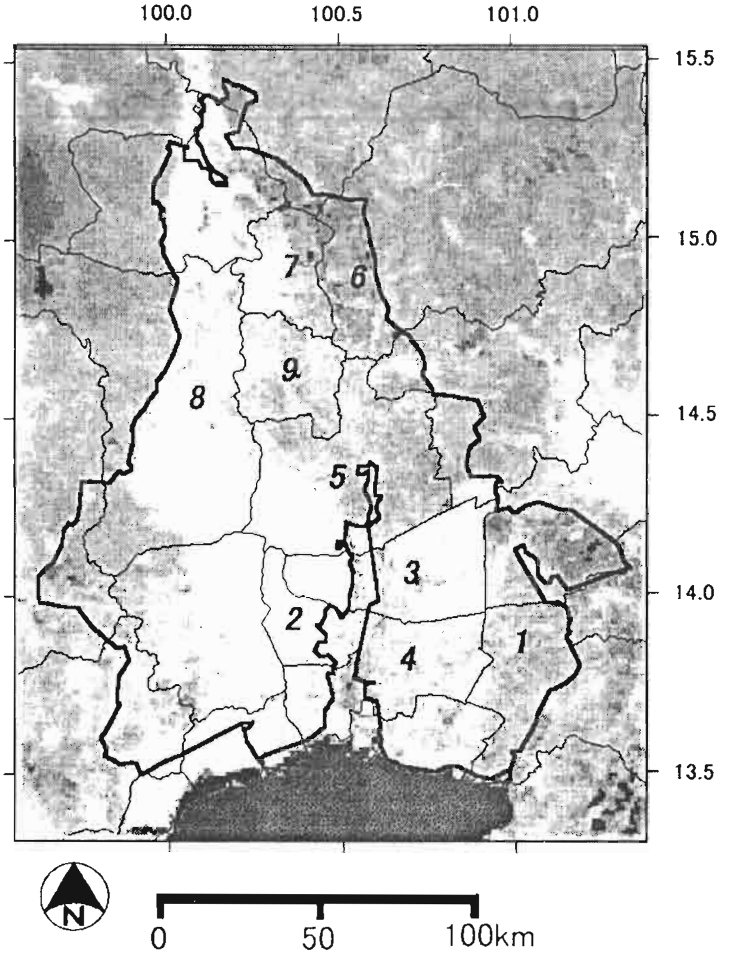


Figure1. Study area. Bold line indicates the study area. Thin lines indicate boundaries of provinces. Numbers indicate the provinces investigated in this study: 1. Chachoengsao, 2. Nonthaburi, 3. Pathumthani, 4. Bangkok, 5. Ayuthaya, 6. Lopburi, 7. Singburi, 8. Suphanburi, 9. Angthong. Background image: NDVI image derived from NOAA/AVHRR acquired on March 19, 1997.

2 Data and processing

Dry season rice is planted wherever irrigation water is available, mainly the area covered by networks of irrigation canals operated by the Royal Irrigation Department (RID). This study concentrates exclusively on areas in the delta region covered by RID projects.

Three different satellites/sensors were used: NOAA/AVHRR, ADEOS/AVNIR, and JERS-1/VNIR, as shown in (Table 1) above. The dry season of the 1996/97 crop year (Nov96/June97) was selected based on the availability of satellite data, which was determined by the operation periods of Japanese satellites: ADEOS and JERS-1 and the rate of cloud-free image acquisition.

NOAA/AVHRR sensors are composed of five spectral bands. Two of them, one for visible and the other for near-infrared, are suitable for vegetation monitoring. Though the spatial resolution of the sensors, about 1-km, is not very high compared with other satellites, it is still useful for detecting very large-scale phenomenon, such as changes in seasonal vegetation patterns.

TABLE1. SATELLITE DATA USED IN THIS STUDY

Category	Satellite/Sensor	Acquired Date	Coverage Area	Quality
Low resolution, High frequency	NOAA/AVHRR	14-Jan-97	ALL	Excellent
		10-Feb-97	ALL	Excellent
		19-Mar-97	ALL	Excellent
		15-Apr-97	ALL	Good
		6-May-97	ALL	Good
		11-Jun-97	ALL	Good
High resolution, Low frequency	ADEOS/AVNIR	27-Dec-96	ALL	Excellent
		10-Jan-97	LE, LW,UE	Excellent
		25-Jan-97	LE	Excellent
	JERS-1/VNIR	29-Jan-97	LW, UW	Excellent
		13-Mar-97	UW	Fair
		13-May-97	LW,UE	Fair

During nearly the entire season, complete delta monitoring by NOAA/AVHRR was possible, since its image covers the entire delta region in one view, and cloud-free data was available throughout the season. Clear images were selected from about one scene each month from January to June, 1997. Additionally, ADEOS/AVNIR and JERS-1/VNIR multi-spectral images were used to obtain high-resolution optical data for specific dates and locations. Though the images cover a limited area, they provide indispensable insights to local land cover in relatively high resolution.

All high-resolution images were geometrically corrected by comparison with topographic maps of Thailand with a scale of 1:50,000. The NOAA/AVHRR images were corrected by topographic maps of Indochina with a scale of 1:500,000. Resampling the data in accordance with UTM ZONE47, pixel sizes were defined as 1km for NOAA/AVHRR, 16m for ADEOS/AVNIR, and 18m for JERS-1/VNIR. Though not all the maps were available in this study, to cover the entire study area, we ignored some uncertainty regarding the accuracy of geometric registration. Relative accuracy of image to image matching was considered more important than the accuracy of the geometric registration itself, since the multi-temporal images would be superimposed on each other.

The Normal Difference Vegetation Index (NDVI), designated as follows, was computed for every image from all three satellites.

$$NDVI = (NIR - RED) / (NIR + RED). \qquad (1)$$

Here NIR indicates the near-infrared band of multi-spectral sensors and RED indicates the red band. NDVI is used for enhancing vegetation cover information.

It was assumed that superimposed NDVI images would provide better data than original multi-spectral images. Therefore, the displayed set was comprised of Multi-temporal Colour NDVI Composition (MCNC) images, as demonstrated by Gomarasca (1993), where the three basic colors (Blue, Green, Red) were assigned to each NDVI image acquired on two or three different dates. Vegetation is correlated with the vegetation index. Thus the color on screen, produced by the combination of the three basic colors, designates the combination of vegetation intensities on different dates. This depicts both spatial and temporal variations in vegetation.

MCNC method, therefore, was applied for interpretation of land cover, along with references to crop calendar. This image data was also used for computer classification of land use, based on NDVI time profiles.

3 Land use /cropping pattern definitions and classification

To date, the only regions of the delta that have been cross-checked by ground surveys are; North Rangsit, Western Ayuthaya, and Ko Krek. The surveys were targeted to confirm land use in areas which were shown to be complicated in the MCNC images. It was assumed that these areas were cultivated for other crops as well as for rice.

Year	1996		1997			
Province Month	Nov	Dec	Jan	Feb	Mar	Apr
1.CHACHOENGSAO	0.49	0.42	0.02	0.02	0.01	0.03
2.NONTHABURI	0.00	0.00	0.95	0.05	0.00	0.00
3.PATHUM THANI	0.00	0.13	0.59	0.26	0.01	0.01
4.BANGKOK	0.34	0.14	0.47	0.05	0.00	0.00
5.AYUTHAYA	0.00	0.06	0.63	0.06	0.22	0.03
6.LOPBURI	0.00	0.00	0.00	0.04	0.72	0.24
7.SINGBURI	0.00	0.00	0.06	0.47	0.30	0.16
8.SUPHANBURI	0.04	0.22	0.38	0.29	0.03	0.04
9.ANG THONG	0.00	0.12	0.03	0.19	0.64	0.02

TABLE2. RICE PLANTING RATIO IN THE 1996/97 DRY SEASON.

Source: Office of Agricultural Economics

Agricultural statistics were used for reference, particularly a table of the Rice Planting Ratio (Rp), which is defined for each province as follows.

(Rp for the month) = (Planted area for the month) / (Entire planted area for the season). (2)

The multi-temporal NDVI image sets obtained from NOAA/AVHRR were classified by the Unsupervised/ISODATA method. Classification results were examined by referencing MCNC NOAA/AVHRR images to define the 1996/97 dry season vegetation pattern in the delta. Referring to NDVI time profiles averaged for each class, rice-cropping patterns were summarized into three categories: Early, Main, and Late.

Agricultural statistics of the planting ratio were also summarized for every two month period as follows.

Early (Nov/Dec 1996), Main (Jan/Feb 1997), and Late (Mar/Apr 1997), to compare statistical data with classification results from NOAA/AVHRR for two month periods.

4 Cropping patterns identified by satellite data

For convenience, the region under study was divided into four separate areas designated as; Lower-eastern (LE), Lower-western (LW), Upper-eastern (UE), and Upper-western (UW).

LE is defined as the eastern side of the Chaophraya River in the lower delta, including Chachoengsao, Bangkok, and eastern Pathumthani (Rangsit). LW is defined as the west of the Chaophraya River, including the western half of Ayuthaya as the north-bound limit. UW is north of LW, and UE is north of LE.

In studying the LE, identification of growing stages by both multi-temporal and single date images was successful.

According to a cropping map produced by NOAA/AVHRR, planting seemed to have started in the lower-eastern delta (A1), in the Early term. Area A1 lies mainly in Chachoengsao province. Thus statistics for this province directly reflect this activity. A high-resolution MCNC map covering the entire area was available. This provided a good combination of acquisition dates to monitor growing stages of rice indicated by vegetation changes. The stages identified were as follows: land preparation, growing, maturity, and harvest. The growing and the maturity stages were visually well distinguished by natural color combinations in single date images. The growing stage cold be investigated further by detecting changes in land use change using each single date images. Therefore, the data on cropping patterns in the fist half of the dry season, from November to January, are quite reliable by combinations of multi-temporal NOAA/AVHRR derived NDVI images, multi-temporal high resolution images, and single date high resolution images. For the rest of the dry season, however, cropping patterns were revealed in rather coarse resolution since only NOAA/AVHRR data was available.

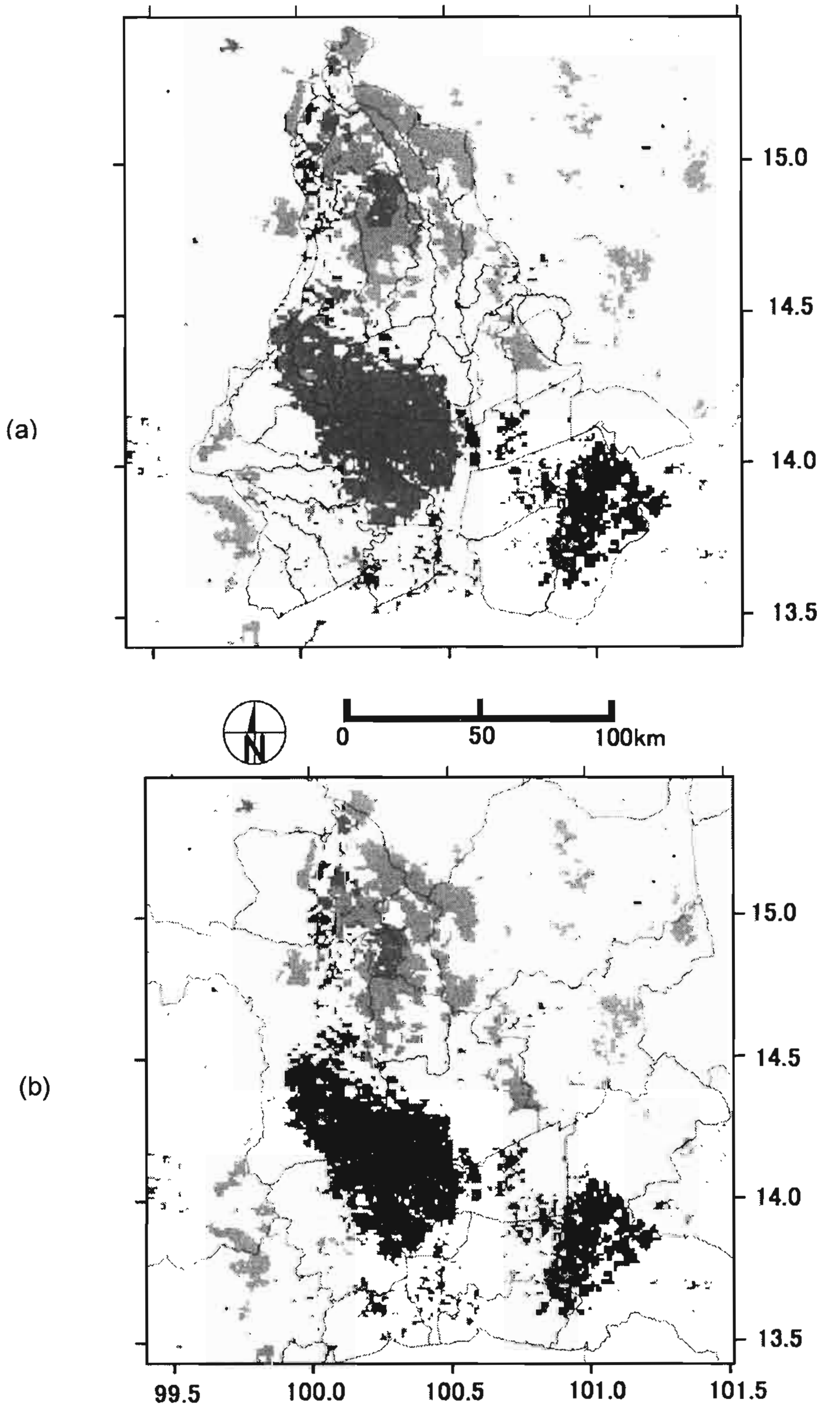


FIGURE2. RICE CROPPING PATTERNS IN THE CHAOPHRAYA DELTA (1996/97 DRY SEASON), DERIVED BY NOAA/AVHRR DATA SET. (A) WITH BOUNDARIES OF IRRIGATION PROJECTS. (B) WITH BOUNDARIES OF PROVINCES.

(a)

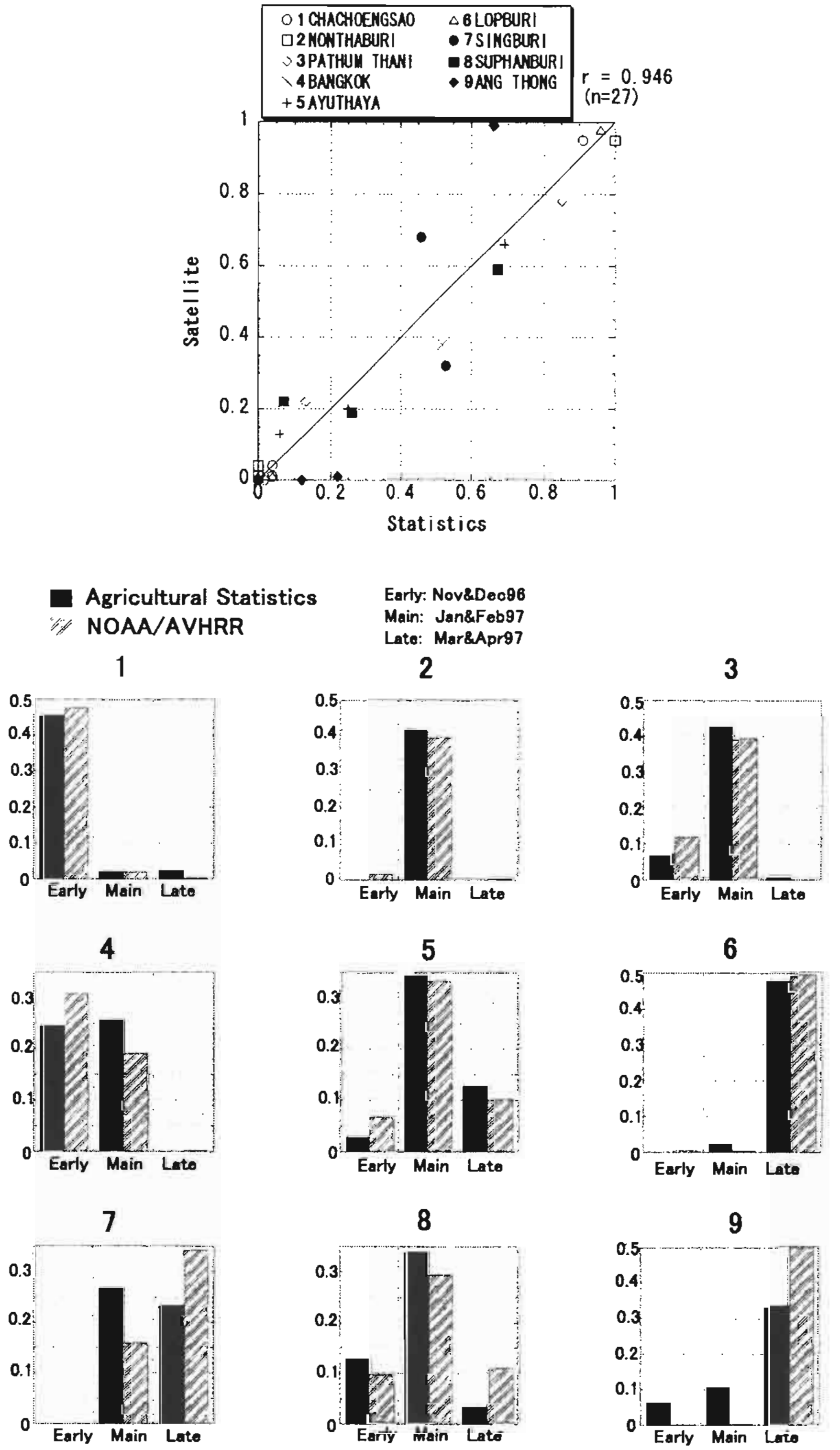


FIGURE3. COMPARISON OF PLANTING RATIO DERIVED FROM NOAA/AVHRR AND REFERENCED FROM AGRICULTURAL STATISTICS. (B) PLANTING RATIO AGAINST PLANTING TERM, FOR EACH PROVINCE.

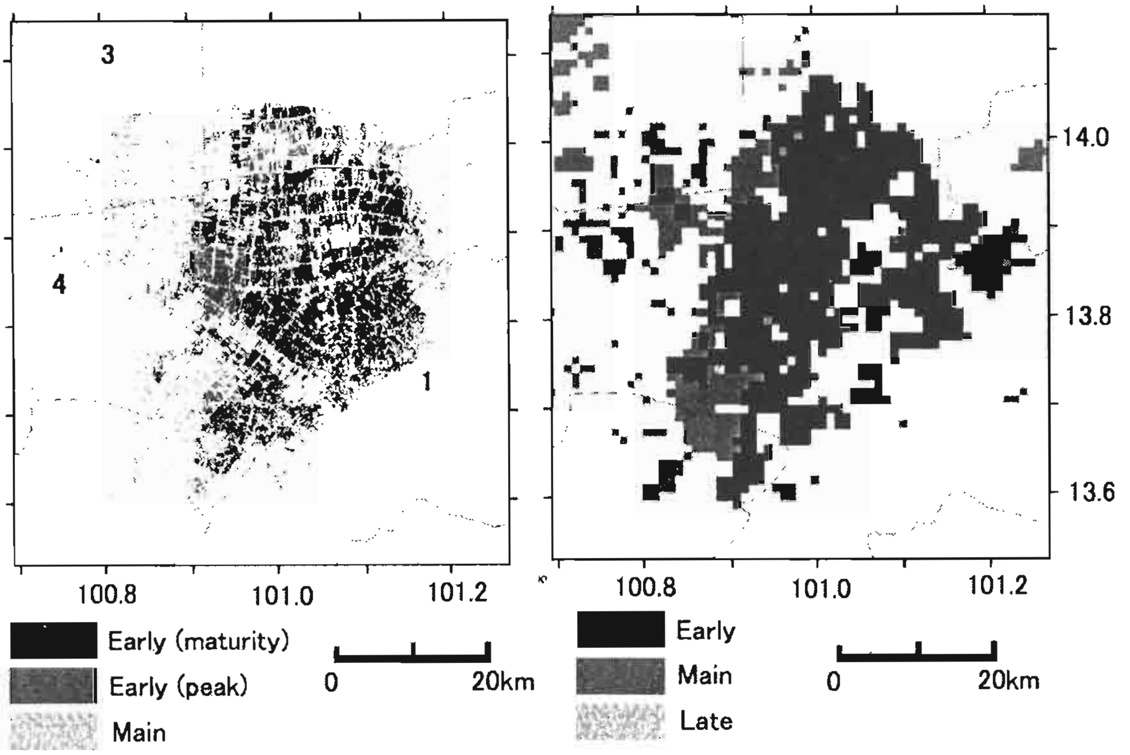


FIGURE 4. CROPPING PATTERNS IN A1 AREA.

(a) Derived from High-resolution data set. (b) Derived from NOAA/AVHRR data set.

In the second planting period, Main term, rice planting occurred in the vast area, A2, located in the LW area. This area lies in the provinces of onthaburi, Ayuthaya, Nakhon Pathom, Pathumthani, and Suphanburi. This activity is confirmed by the statistics of Nonthaburi province.

During the last period, Late term, planting was found mainly in the upper delta. The upper-eastern area (UE) appeared to be the last plantingarea in the delta. Rice planting was detected only in the Late term as typically in the statistics of Lopburi. In UE, changes in the water condition of the soil, from dry to wet, were detected in the paddy fields. Thus visual interpretation of the original band combination, in addition to MCNC, was effective.

There is mixed agricultural land use of sugarcane and rice in the upper delta as reported by Molle (1998) and DORAS (1996). MCNC images f ADEOS/AVNIR and JERS-1/VNIR showed a mixed land use pattern especially in the upper-western area, which indicates the presence of sugarcane fields interspersed among the rice paddy fields.

5 Conclusions

Overall features of cropping calendars in th Chaophraya Delta, during the dry season of 1996/97, were revealed by NOAA/AVHRR data. Bimonthly estimation showed good agreement with statistical data. An original NOAA/AVHRR data set was used in this study, however, future studies should substitute data from NOAA 10-day, or bimonthly composite data set, in order to improve the performance of analysis.

High-resolution data, when available, showed excellent performance. We could expect at least one or two clear images for any location in the delta during the period of December to January, when air conditions were the clearest of the year. Theeffectiveness of high-resolution data varied by location, due to the differences in data available, timing of planting, and land use. We depended on high-resolution images to detect complicated land use, such as mixed cultivation for rice and sugarcane in the upper-western area. MCNC maps derived from high-resolution data were also used for determination of ground survey points.

Though high-resolution data showed excellet performance in this study, both ADEOS and JERS-1 satellites have been taken out of operation, and real-time data is no longer available. Other data resources should be considered for more recent years, or for real-time monitoring, taking into account their cost and benefits.

Acknowledgements

Thanks are given to Dr. M. Tamura, NIES for providing NOAA/AVHRR data. NASDA is acknowledged for providing ADEOS and JERS-1 data. NASDA also preserves all rights for the data provided.

References

DORAS Project. 1996. Agricultural and irrigation patterns in the Central Plain of Thailand. Kasetsart University, 79p.

M. A. Gomarasca; P. A. Brivio and and F. Pagnoni. 1993. One century of land use changes in the metropolitan area of Milan (Italy). *Int. J. Remote Sensing*, 14, 211-223p.

J. P. Malingreau. 1986. Global vegetation dynamics: satellite observations over Asia. *Int. J. Remote Sensing*, 7, 1121-1146p.

F. Molle. 1998. Water management and agricultural change: A case study in the Upper Chao Phraya Delta. *Southeast Asian Studies*, 36, 32-58p.

F. Molle. Spreading over time and space: dry-season cropping calendars. (Personal contact).

C. S. Murthy; P. V. Raju; S. Jonna; K. Abdul Hakeem and S. Thiruvengadachari. 1998. Satellite derived crop calendar for canal operation schedule in Bhadra project command area, India. *Int. J. Remote Sensing*, 19, 2865-2876p.

Remote sensing and GIS to study the sub-urbanization dynamics: a case study in northern Bangkok, Thailand

Tran Hung[1], Yoshifumi Yasuoka[1]

ABSTRACT: *As Bangkok Metropolitan is expanding, prime agricultural land and water basins are rapidly transforming into land for housing, roads, and industry. Based on a case study in one of the fastest growing suburban areas – the Pathum Thani province – the paper demonstrates the usefulness of remote sensing techniques integrated with GIS to study the dynamics of sub-urbanization and to address the pressured development problems. Various satellite image data from 1986 to 1999 were analyzed within a digital image processing system to provide up-to-date information of the whole area. The extracted information from remotely sensed data was then merged with other sources of geo-coded information in a GIS to create a comprehensive spatial database, including not only physiographic but also socio-economic data. This permitted the integration of several layers of information with the remotely sensed data in both temporal and spatial dimensions. Dynamical pictures of the urban expansion, the infrastructure expansion and the loss of paddy land in the area during the 1970 – 1999 period were derived. On the other hand, with the combination of detailed socio-economic information (from NRD-2C database), the spatial pattern of sub-urbanization was revealed at localized (tambon) level. The application of spatial data analysis techniques, then, provided insights into underlying factors of sub-urbanization process during the last 29 years. The trend and resultant important factors in the past development of the area could be used to evaluate existing development programs. The integrated RS/GIS/spatial analysis system was proved effective in defining the dynamics of sub-urbanization in Pathum Thani area, and could be recommended for other sub-urban areas. The case study also demonstrated that RS and GIS techniques have grown far beyond scientific tools and in fact is becoming a semi-operational technical tool for planners and decision-makers at various administrative levels in dealing with complex development problems.*

Keywords: *Remote Sensing, GIS, Sub-Urbanization, Urban-Rural Interaction, Information Integration, Spatial Data Analysis, Thailand*

[1] Institute of Industrial Science, University of Tokyo; 4-6-1 Komaba, Meguro-ku, Tokyo 153-8505, Japan. Tel: +81-3-5452-6415 Fax: +81-3-5452-6410 E-mail: tranhung@iis.u-tokyo.ac.jp

1 Introduction

Bangkok, one of fast-growing Asian Metropolis agglomerations with population of more than 10 million, is a primate city of Thailand. Most industries were concentrated in the Bangkok Metropolitan Region (BMR), where geographical and institutional conditions were most favorable. As cities expand, prime agricultural land and habitats such as forests and water basins were transformed into land for housing, roads, and industry. High economic growth and increased employment opportunities caused substantial influx of labor immigration. The sub-urbanization has speeded up with 52% of urban population in 1990, increased to 61% in 1995 and predicted to reach 82% in 2020. The changes of land-use affected social, economic and ecological conditions. Effective urban land use planning can help guide urban development away from vulnerable ecosystems, which appears impossible without deep understanding of processes governing the change dynamics and their inter-relations in Pathum Thani province.

Remote sensing technology has been recognized as a useful means of supplying up to date information on activities, within the urban environment (Lillesan and Kiefer, 1990). The synoptic view of urban land-cover provided by satellite is an important complement to in-situ measurements of physical, environmental and socioeconomic variables in urban settings. Remotely sensed data may also be used to map, monitor and estimate the properties of environmental features. The land cover information, properly classified, can provide an areally and temporally explicit view of societal and environmental attributes. Thematic mapping from remotely sensed data is found in numerous fields of study including land use planning. Operational satellites such as LANDSAT / SPOT provide the ability to monitor spatio-temporal dynamics of built-up and infrastructure features with frequent repetitiveness. Remote sensing data can be readily merged with other sources of geo-coded information in a GIS. This permits the overlapping of several layers of information with the remotely sensed data, and the application of a virtually unlimited number of forms of data analysis (Lillesand and Kiefer, 1990). The integration of RS and GIS provides more effective functional, spatial, and temporal information potential that cannot be achieved by each alone. Hence, in this research an effort had been made to provide all-aspect information of land-use dynamics in Pathum Thani province during 29 years (1970-1999) for planners under the urban expansion pressures. Specifically, the study had concentrated on answering the following questions:

1. How the land-use in the area has been changed during the last 3 decades and where and when most changes have occurred?
2. Which are the important factors affecting those changes? Understanding land-use dynamics of the study area during past 29 years (temporal dimension) and suburban spatial structure (spatial dimension).
3. Which implications could be extracted from these findings?

The other objective of this study was to demonstrate the applications of an integrated GIS/Image Processing System for suburban land-use change analysis.

2 Study area

Situated about 30 kilometers north of Bangkok, Pathum Thani province is one of the most dynamic suburban areas of the Bangkok City (Figure 1). With an area of 1524 km^2, the province, which is the heart of the Chao Phraya delta, bears highly artificial systematic dense canal networks (under North Rangsit Irrigation Project in the East and Phraya Banlu Project in the West). The natural conditions such as flat topography, good alluvium soil and sufficient irrigation system favor the development of intensive agriculture for years in the study area, primarily for rice crop cultivation. However, with the expansion of Bangkok Metropolitan Administration (BMA), the rice land-use, which has dominated more than 20 years before, has been changed steadily to other land-uses such as urban and industrial areas, fruit tree, vegetables plantation (Figure 2). Indeed, the economic structure of the province has changed dramatically during the last decade due to the relocations of industries from BMA. In 1998, there were 350 factories creating 221,000 employment opportunities in the province. The substantial amount of young working age group were engaged as employees in the growing industrial sector. In 1996 only 22.8 % of total population remained on agriculture activities, the others worked on industrial and service sectors. The Gross Provincial Product (GPP) of Pathum Thani, which was 46,583 million Baht in 1990, has increased rapidly to 91,979 million Baht in 1996. Industrial sector took the largest share in GPP and was followed by trade, electric and water supply and agriculture. GPP per capita of the province is Baht 246,581 in 1996, which became highest as compared to 6 provinces in the BMR.

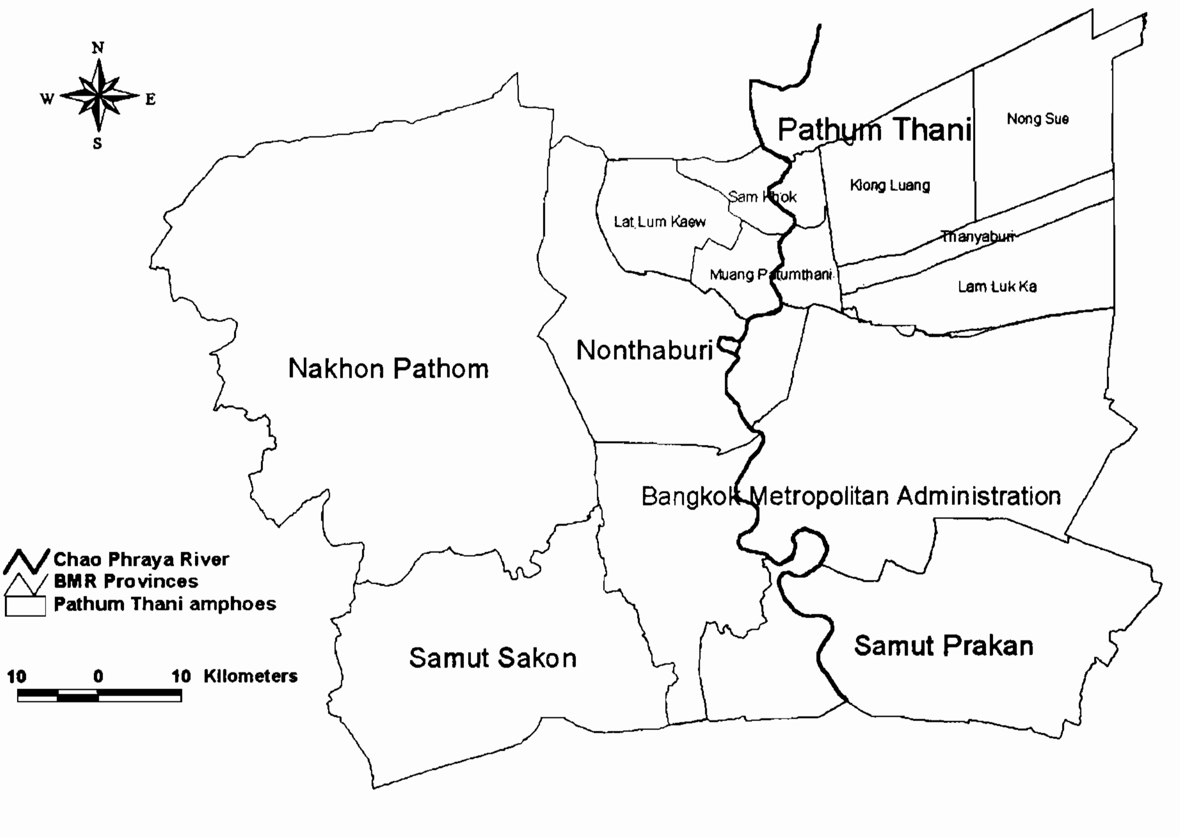


Figure 1. The location map of Pathum Thani province in relation with Bangkok Metropolitan Region and Chao Phraya river

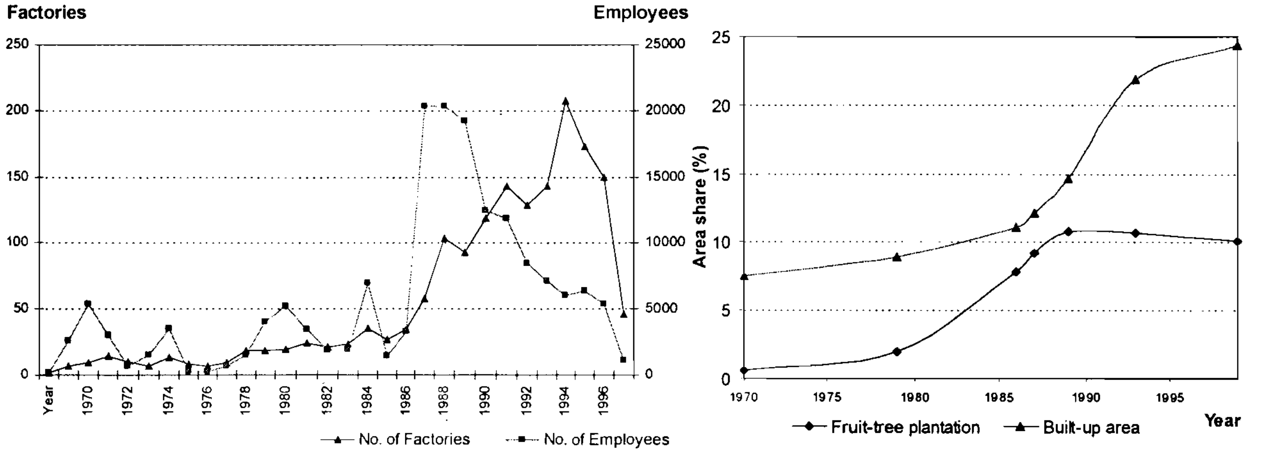


Figure 2. The increases in industrial establishments and the percentages of built-up and fruit-tree plantation in Pathum Thani province during 1970-1999

With increasing institutional building development (9 universities, public and private colleges, and various government departments) Pathum Thani is well connected with Bangkok Metropolis. This together with well-developed road network has added additional urban expansion pressure from Bangkok on the province. High economic growth and rapid sub-urbanization in Pathum Thani province have caused substantial influx of labor immigration, which accounted up to 200,000 unregistered persons as compared to the 616,000 official population figure in 1998. Rapid land-use change in the area gave rise to serious problems such as: inefficiency of land utilization, inadequate urban facilities and infrastructure, traffic congestion, pollution and other environmental problems (Vibulsresth *et al*, 1992). All these rapid developments and associated social and environmental problems have required a systematic up-to-date information base in order to detect and analyze development problems for purposeful and regulative planning. Moreover, as new Tambon Administrative Organization (TAO) came into force in light of Thailand's decentralization strategy since 1995, the coordination between 52 TAO and 13 municipalities in Pathum Thani became an additional issue in development planning.

3 Integrated methodology

The overall approach of this study is to utilize the temporal capabilities of remotely sensed data to monitor the land-cover / land-use changes during the 1986-1999 period. The extracted information from satellite images then was integrated with various geo-coded physiographic and socio-economic data within the framework of a comprehensive GIS spatial database to analyze the dynamics of sub-urbanization in Pathum Thani province. The image processing/GIS systems used are ERDAS Imagine 8.5, ARC/INFO, ArcView 3.2, Visual FoxPro 5.0 and statistical analysis used SPSS for Windows 9.0 and SpaceStat 1.90.

3.1 Information extraction from remotely sensed data

Various satellite images such as MSS (1986), SPOT (1989, 1993) and TM (1989, 1992, 1999) were obtained for the study area to provide temporal land cover and land use information. Dry season scenes were used since there are less cloud covers and thus permit a better distinction between forested, agricultural and urban or built-up land covers. Satellite images were corrected for atmospheric attenuation and geo-referenced to a common 1:50,000 UTM topographic map base. The TM and SPOT images were then re-sampled to 25-m squares with a nearest neighbor interpolation algorithm. The geo-corrected images were then submitted to image analysis system (ERDAS Imagine) to update road and irrigation networks, stratify scenes into vegetation/non-vegetation areas using NDVI and built-up/non-built-up areas using Edge Density Texture Measure (Hlavka, 1987). The image classification used the *optimal structure-tree classification* algorithm (Andrianasolo, 1990). The ancillary data such as existing land use maps and stratified maps were used to improve classification maps in the post-classification procedures. The image analysis had been done on single-date images individually and the change detection was based on post-classification techniques with raster GIS functions involving image co-registration and overlaying. The images were classified according to several basic land surface types. Although the classification process was capable of reasonably separating 15-18 land cover classes, given the objectives of the study and real situations of the area, the final analysis consolidated these into 7 land-cover categories: built-up, paddy, fruit-tree plantation, water-body, fallow land and unclassified vegetation (horticulture, coconut, palm trees, etc.) with assistance of existing land-use maps. The aggregating into more broad land-use categories has also increased significantly the accuracy of image classification, making classified images more compatible with existing land use maps. The details of image analysis procedures used in this study could be found in Tran (1994). The classified images were, then, integrated with other environmental and societal data sets through raster-to-vector data conversion to update and build time-series data.

3.2 Spatial GIS Database Integration

With regional development issues in the focus, data in Pathum Thani area, Thailand were collected from various government offices in the form of physio-graphic data (e.g., topographic, administrative, land-use, industrial locations as well as transportation network maps) and socio-economic indicators. The spatial physio-graphic data sets from paper maps were classified, digitized and fed into vector GIS (Arc/Info), which contain following major layers: administrative boundaries, land-use (1970, 1979 and 1987), irrigation- and road-network and industrial locations. With classified images in raster formats, the loose integration approach was applied to manage the GIS spatial database in both formats with the flexibility to convert from one to another in a particular analysis.

The major source for socio-economic data was the National Rural Development Database (NRD-2C), which provides surveyed data at village level after each two years from 1986 composing of more than 100 economic and social indicators. The data were also collected from other government documents, statistical records at provincial and municipal offices. They were selected, reclassified and combined based on the basic administrative unit IDs – village code number in dBase IV format. A program in Visual FoxPro 5.0 was written to automate the process of extracting, normalizing and combining socio-economic indicators including population, income, education, health, natural environmental conditions, services, agriculture and industrial activities, work force, capital investment, employment, etc. (Tran, 1998).

As for regional researchers to produce regional empirical models of urban-rural interactions or for policy makers to formulate strategic development plans, social and environmental data must be converted into a common spatial structure (e.g., set of areal units). As indicated by Tran and Yasuoka (2000), it is recommended to summarize/regionalize spatial physio-graphic data by *administrative units* in order to be compatible with socio-economic data. Based on the internal homogeneity criteria (within-unit variance and spatial autocorrelation index), *tambon* level was chosen as the desirable level of aggregation for data integration (Tran and Yasuoka, 2000). The selected socio-economic data were aggregated from village to *tambon* level, and were normalized as relative shares of the total population of each respective *tambon*, in order to further reduce the effect of unequal sizes of *tambon*. The data management in GIS used to integrate those diverse data sets (physio-graphic and socio-economic data) to a common spatial structure (e.g., set of areal units) and to determine analyses possible with those data. The spatial physio-graphic data such as land use types, road networks, irrigation networks, industrial factories were aggregated to tambon level using spatial overlay and logical-statistical analysis functions in GIS (Arc/Info). Some accessibility measures such as median distance from residential areas to nearest roads and nearest factories were derived through GIS spatial joins functions utilizing the locational information of data (Tran and Yasuoka, 2000).

With all aggregated socio-economic data and regionalized spatial physio-graphic data to common tambon level, the GIS join function through a key item – *tambon* ID – was used to complete the spatial GIS databases for Chiang Mai – Lamphun and Pathum Thani areas. The GIS databases, thus, containing comprehensive spatial information characterizing development states of the Pathum Thani area (in 1979, 1989 and 1999) for each tambon in terms of:

- *spatial physio-graphic data*: % of urban land-use, industrial land-use, agricultural land-use, road length density, irrigation length density, median distance from industrial land to closest residential areas, median distance from residential area to the nearest road;

- *demographic aspect*: population density; *economic aspect*: average household property taxes, travel time to nearest town and commercial center, % of farmer, per capita number of vehicles, number of factories, per capita industrial capital investment, % factory employees, average household income, % people working far from home; and *social aspect*: level of primary education, secondary education, illiterate rate, etc.

3.3 Change Analysis

From the integrated GIS database, the land use changes were extracted. The land-use category under interest was reclassified and reselected from simplified classified images and existing land-use maps (for all of 7 dates – 1970, 1979, 1986, 1987, 1989, 1993, 1999) using the Boolean logic and then aggregated to respective administrative level. For each administrative unit (e.g., for whole province, a particular amphoe or tambon) time series were constructed for paddy loss, plantation expansion, built-up area expansion and associated socio-economic indicators to show the trends of development in time. On the other hand, to understand the land-use conversion over time, the change detection between 1979 and 1999 (Table 1) was done on respective classified images in raster format using image registration and overlaying functions.

Based on the time series curves (Figure 3) the period of 1979-1989 was selected as the representative stage of land use change in the area. The averages speed of change during that period in terms of paddy loss, urban expansion, road network expansion were used as surrogate variables to study the land-use dynamics in spatial dimension. The trend surfaces were then generated using sloping weighting spatial interpolation for road network, built-up area and fruit-tree plantation expansion with speeds of changes calculated for each grid cells size of 1 x 1 km (Figure 5).

3.4 Spatial Analysis to study Urban-Rural Relations

The resulting spatial data sets in unique format are useful for further empirical analysis of regional spatial development patterns and relationships between land-use and socio-economic variables using various multivariate statistical and spatial statistical analysis techniques. With these GIS databases, policy makers can easily explore data and their spatial coincidences at locations of interest, visualize spatial patterns in economic, social and demographic aspects at times of interest, visualize time trend of regional development based on social / environmental indicators of interest, and create various tambon development index based on combined indicators for planning and management. On the other hand, with more sophisticated analysis and modeling tools, researchers could go further in analysis to gain insights into regional development problems.

4 Research findings and discussions

4.1 Land Use Changes during 1970-1999

The general structure of land-use in the study area has changed significantly for three most important land-use types: paddy land, fruit-tree plantation and built-up areas. During the period of 1979-1999 as shown in Table 1, there were two dominant changes in land-use patterns occurring in the study area as follows: (1) considerable areas of paddy fields were converted into built-up construction and wasteland-preconstruction areas (13.65 % of paddy land in 1979) and; (2) considerable areas of paddy fields are converted into fruit-tree plantation (11.03 % of paddy land in 1979). However, this tendency of changes was slightly shifted during the last few years: the paddy land was continued be converted into built-up areas, while some of plantation farms were abandoned and/or replaced by built-up constructions (28.92 % of plantation areas in 1989).

Table 1. Transitional Matrix of Land-Use Conversion during 1979-1999

Major Land use	Year 1979 Area (ha) (%)	Year 1999					
		Paddy	Plantation	Horticulture	Fallow	Waterbody	Built-up
Paddy	122752.80 (80.84%)	75312.80 (61.35%)	13541.76 (11.03%)	20100.48 (16.37%)	133.28 (0.11%)	0	13555.52 (11.04%)
Plantation	3224.48 (2.12%)	0	1616.32 (50.13%)	0	1296.96 (40.22%)	0	302.72 (9.39%)
Horticulture	2184.32 (1.44%)	0	417.44 (19.11%)	456.48 (20.9%)	494.72 (22.65%)	0	815.68 (37.34%)
Fallow-land	4043.36 (2.66%)	0	0	0	2030.56 (50.22%)	0	2012.80 (49.78%)
Water-body	1193.76 (0.79%)	0	0	0	0	1193.12 (100%)	0
Built-up	18454.72 (12.15%)	0	0	0	0	0	18454.76 (100%)
Total	151853.44 (100%)	75312.80 (49.65%)	15575.52 (10.68%)	20556.96 (14.98%)	3955.48 (0.84%)	1193.12 (0.60%)	35141.48 (20.37%)

In the time dimension, the figure 3 clearly shows significant and in-conversable losses of paddy land over the years to the expansion of urban areas and fruit-tree plantations. These losses were not evenly distributed across the province though, as Thanyaburi and Muang were the leading suburbanized amphoes with only 30 – 34% of total land left for paddy plantation in 1999. Within agricultural practice, the most common change was the transformation of paddy land (mostly wet season rice) to orange tree plantation, orchards or vegetable cultivation. The spatial distribution of fruit-tree plantations slightly changed over the years but is mainly concentrated in Nong Sue and Thanyaburi districts, which had the share of 32.5 and 24.5% of total land in 1999 respectively. The trend of the fruit-tree plantations expansion (as illustrated in Figure 3) could be described as a three-stage expansion model with slow introduction stage (before 1979), rapid expansion stage (1979-1987), and smooth mature stage (1987-1999). This land conversion was mainly due to favorable natural condition (soil, irrigation and road network) and relative cheap land price and its availability, which attracted the investment of rich farmers from south of Bangkok. In Thanyaburi and Klong Luang amphoe since 1987, however, some plantation areas have been replaced by built-up construction or were sold for pre-construction wasteland.

4.2 The Sub-Urbanization Dynamics

The sub-urbanization process in the study area had started about 20 years ago with rapid growth occurred since 1984 closely following the expansion of the road network (as shown by a high correlation between the speed of road expansion and speed of built-up areas expansion in figure 3). The sub-urbanization appeared to slow down after 1990 with mainly in-fill development as it reached the mature stage. Among Pathum Thani amphoes, Muang, Thanyaburi and Klong Luang districts had most densely built-up areas with their share of 38.7, 30 and 26.5% of total land in 1999. The speeds of expansion are also highest in Muang and Thanyaburi districts – about 3.2-3.8% per year during the 1979-1989 period.

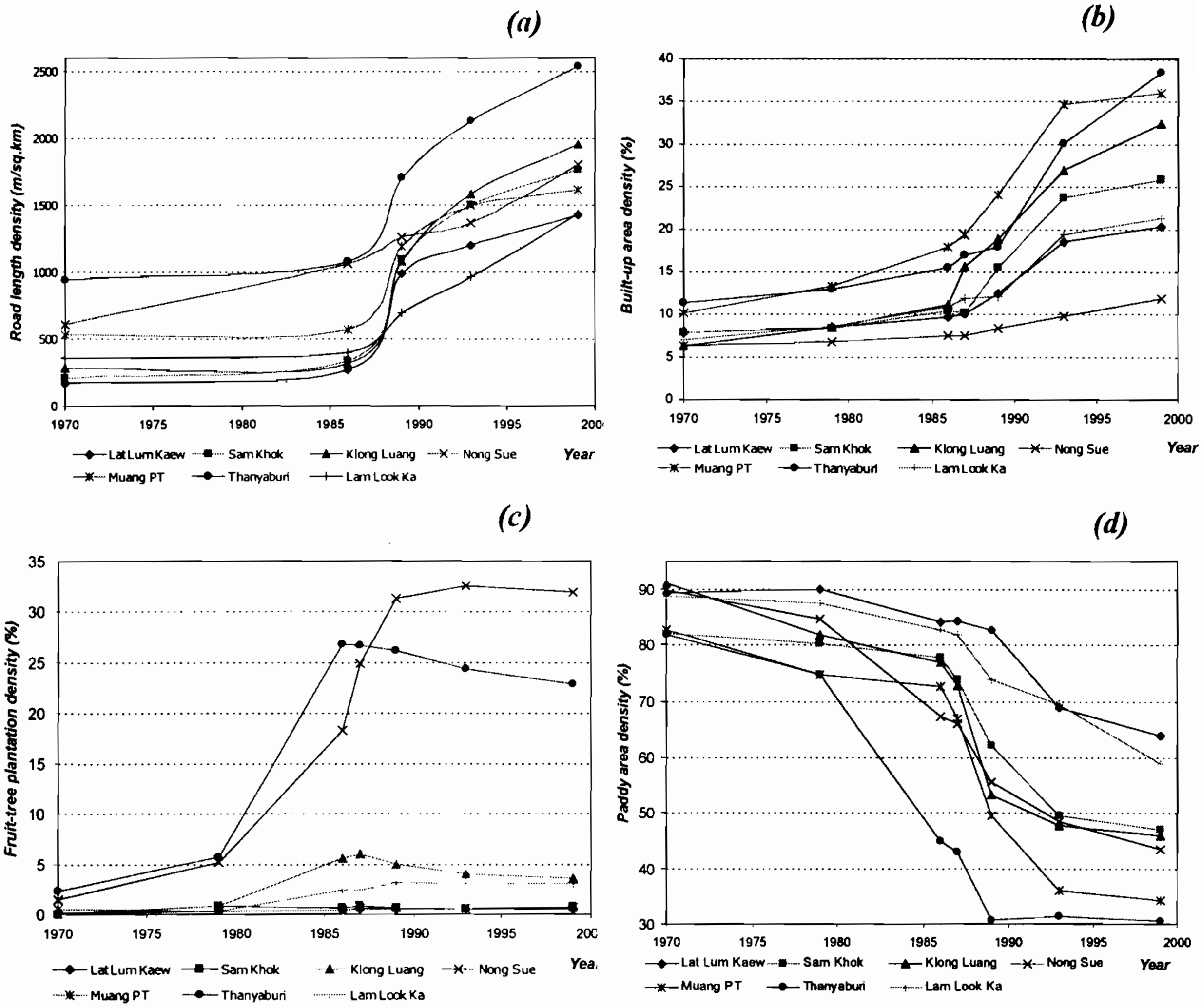


Figure 3. The expansion of (a) road network; (b) built-up areas; (c) fruit-tree plantation and loss of (d) paddy land in each district of Pathum Thani province during 1970 - 1999

The Nong Sue has the least built-up area in the province – only 11.4 % of total land in 1999 and also lowest speed of expansion – 0.5% per year during 1979-1999 period. The spatial patterns of urban development were changing over the years. It started expanded from

Bangkok Metropolis along national highway No. 1, then other major roads (Rangsit – Nakhon Nayok, highways No. 306, 346) creating the axis of development. The later in-fill development in the form of industrial and associated residential establishment has enlarged the urbanized area in perpendicular to the "ribbon" direction.

The trend surface of built-up expansion shown in Figure 5 represents the hierarchy of suburban centers: Rangsit, Muang municipal area. They were serving as growth centers, connected by highways and interact with each other to give the patterns of the spatial urban expansion in the study area. The two centers have rapidly filled in between with highest speed of built-up expansion. The main direction of urban expansion in Pathum Thani was along the so-called Northern Corridor (Rangsit – Bang Pa-in), where most industries and major infrastructure projects located. During the last decade, the urban expansion was shifted to the east along Rangsit – Nakhon Nayok highway, to the west along highway No. 346 (Figure 4). With Bangkok outer ring roads completed in 1996, it will certainly attract new urban and industrial expansion along. In addition, as shown in figure 4, there were quite a number of scattered new urban and industrial developments in forms of infrastructure and housing projects into the protected areas, indicating the difficulties in controlling urban development in Pathum Thani province.

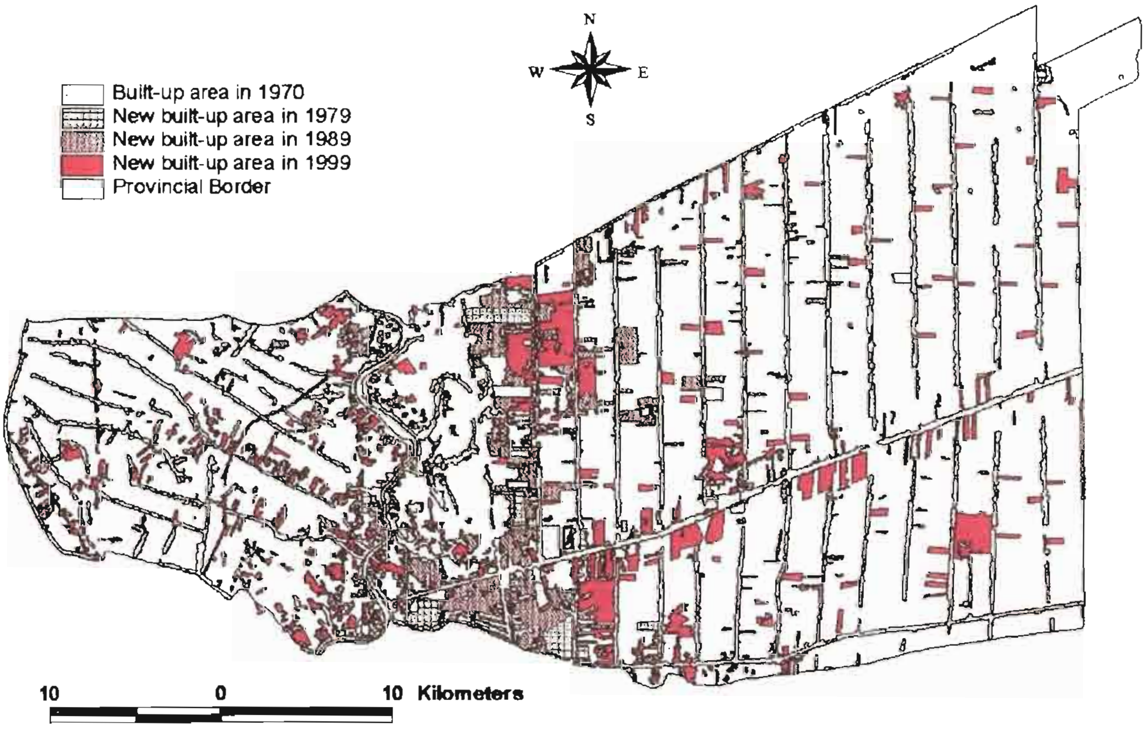


Figure 4. The built-up area expansion during 1970 – 1999 in Pathum Thani province (based on comparison of existing land use maps and classified satellite imageries)

Industrialization and urban-biased development policies have resulted in very imbalance growth patterns in the province. New factories, particularly medium and large-sized, were further likely to concentrate in the suburban areas due to: relatively lower price of land, convenience of transportation due to the location near the roads and highways, easier access to cheap local labor, and lack of regulative planning. The rapid sub-urbanization process appeared significantly affect the socio-economic life of the population in the province. Factor analysis based on all surrogated physio-graphic and socio-economic variables revealed two major development processes during the 1979-1999 period in the province namely: *industrialization* and *changing in agricultural practice* (Tran, 1994). The *industrialization*, which closely relates to industrial establishments, built-up expansion, has caused major influx of labor immigration into the province (based on correlation analysis). Furthermore, it significantly changed the labor structure by attracting the farmers from agriculture activities, increasing female labors in factories and services. Figure 6 shows the spatial distribution of the changes in labor structure between 1986 and 1996 by tambons, which very much resembles the spatial patterns of urban expansion (Figure 4 & 5) in the province. The *changing in agricultural practice*, which closely relates to the expansion of fruit-tree plantation, has almost no impact on population distribution and mainly governed by well-developed road- and irrigation-networks.

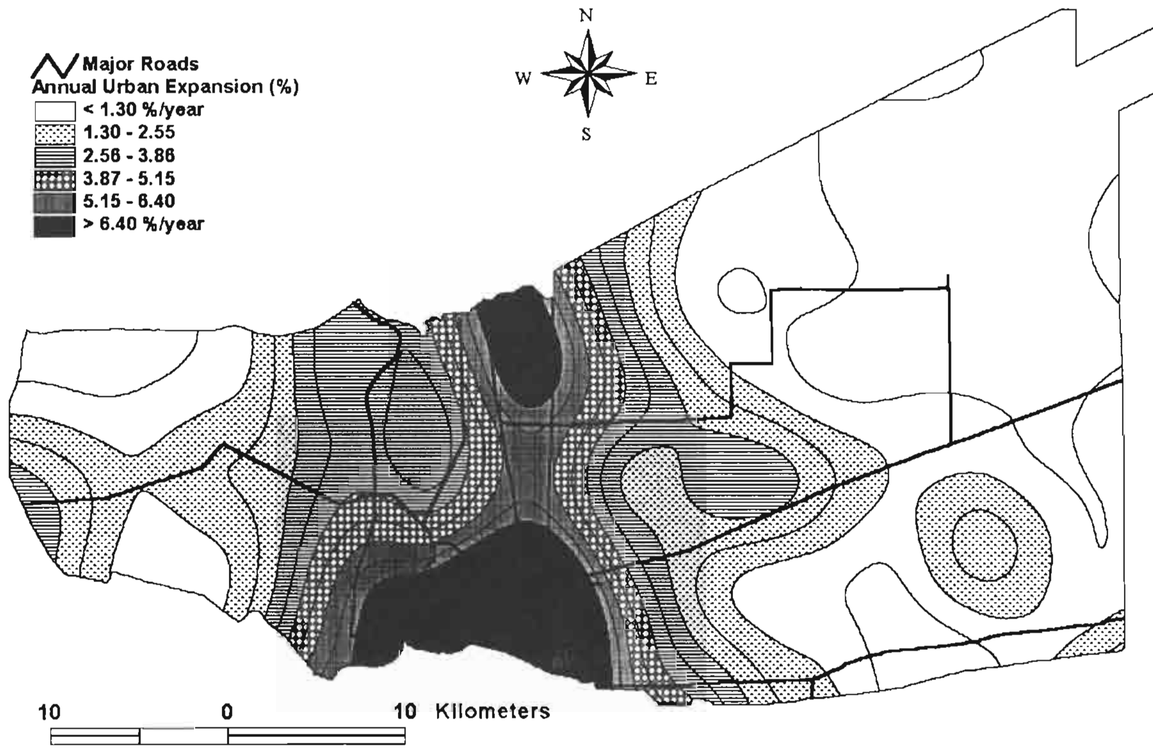


Figure 5. Interpolated surface of average speed of urban expansion in Pathum Thani province during 1979 – 1989 period (using *slope weighting interpolation* method)

5 Conclusions

The case study of Pathum Thani province in this paper highlighted the importance of satellite remote sensing in providing accurate and up-to-date land-use/land cover information. The multi-approach was well illustrated by incorporation of various satellite imageries and of various types of physio-graphic and socio-economic information within a framework of comprehensive GIS. The integrated GIS were efficient and useful technical tool in integrating social and environmental data in order to build an integrated GIS database for monitoring and analysis purpose. With decentralization planning on increase in Thailand, these comprehensive GIS databases at tambon level could provide needed details to local decision makers at the newly-created administrative level – Tambon Administrative Organization (TAO). On the other hand, provincial planners could use this integrated methodology as a semi-operational technical tool in dealing with continued urban expansion pressure from Bangkok Metropolis at various administrative levels.

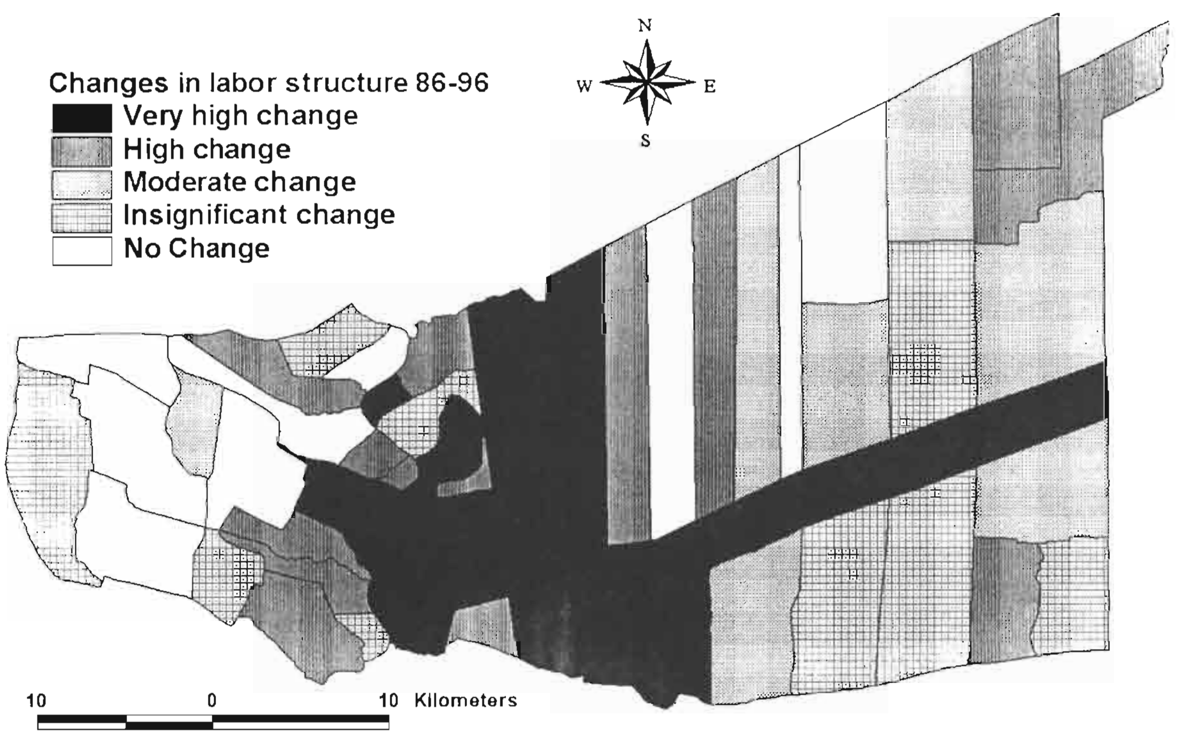


Figure 6. The changes in labor structure between 1986 and 1996 by tambons in Pathum Thani province

Furthermore, with the developed spatial databases, GIS can serve as an efficient technical vehicle for spatial analysis and spatial modeling functions to gain insights into regional development problems, e.g., to evaluate development impacts in the past, and to enhance regional development strategies through facilitating various scenarios. At the present, some analyses, which involve also environmental aspects, are undertaking in order to have more understanding on urban-rural interactions and its impacts on the environment in the area.

References

Hlavka C.A., 1987. Land-use mapping using edge density texture measures on Thematic Mapper simulator data. IEEE GE-25 1 104-107

Lillesan T.M., Kiefer R.W, 1990. Remote Sensing and Image Interpretation. John Wiley & Sons Inc., New York

Tran H., 1994. Synergism of Remote Sensing and Geo-Information System in Land-Use Spatial and Dynamical Analysis: A methodological approach in case study of Pathum Thani area, Thailand. Master's Thesis, Asian Institute of Technology, Bangkok, Thailand

Tran H., Andrianasolo H. & Nualchawee K., 1997. Spatial data analysis and GIS applied to study the urban-rural linkage in Chiang Mai - Lamphun area, Thailand. *Proceedings of the 18th Asian Conference on Remote Sensing, Kuala Lumpur*, October 1997, Malaysia, pp. K.2.1-K.2.6

Tran H., Yasuoka Y., 2000. Integration and Application of Socio-economic and Environmental Data within GIS for Development Study in Thailand. *The 21st Asian Conference on Remote Sensing*, Taipei, December 2000, Taiwan

Vibulsresth S. *et al*, 1992. Rapid change from rice paddy to other land uses - Drastic development in northern suburbs of Bangkok for ten years from 1979 to 1989. Journal of Remote Sensing for Environment, Tokyo, Japan

Evaluation of landuse changes in the lower East-Bank area on the basis of remote-sensing

Kiyoshi Torii[1], Yoshiaki Mori[2], Takashi Kume[1], Katsuji Shimokouji[2], Kazutoshi Hoshikawa[3], Papant Svetanant[4] and Phaisal Lekthai[4]

Abstract: *Irrigation development in Chao Phraya delta started in 1952 has changed agriculture in this area greatly. It has dissolved drought damage, increased rice yields and enabled introduction of crops such as sugarcane by breaking with single crop of rice. Consequently, the yields are stabilized awakening farmers urge to work and causing a rise in price of land.*

Entering 1980s when Thailand started industrial development, the area from Rangsit Irrigation Project Area to the coastal area of Thai Gulf was exposed to waves of rapid industrialization resulting in marked changes in landuse and environment. We have watched long-range changes in land covers in this district using satellite images. Together with advancement in computer technology, accuracy of surface monitoring by satellite images has improved remarkably and enormous softwares having rich contents for processing them have become popular. In the present study, we re-examined changes in landuse and land cover in the history of this district based on satellite images in the attempt to evaluate a large-scale irrigation system such as this in a long-term view.

1 Introduction

The study area in the suburbs of Bangkok is the most industrialized district at present. In the area located on the east side of upstream in Chao Phraya plain, large-scale development known as Rangsit Irrigation Project has been practiced from old times by Thai government. But, development

[1] Graduate School of Agriculture, Kyoto Univ. Address: Sakyo, Kyoto, JAPAN 606-8502, E-mail:torii@kais.kyoto-u.ac.jp

[2] Graduate School of Agriculture & Life Sciences, Univ. of Tokyo

[3] Department of Agriculture, Shinshu University

[4] Faculty of Economics, Chulalongkorn Univ.

has hardly been attempted in the area from its downstream to the coastal zone due to poor geographical conditions such as low wet lands and risk of floods. However, with the remarkable advancement in industry in Thailand, building of large-scale industrial estates was started in this area several years ago because the area was near Bangkok, easily accessible to the airport and conveniently accessed from sea as being seaside. Furthermore, environment of landuse is changing drastically even in the area adjacent to sea, where natural fishery was practiced until quite recently, due to popularization of shrimp farming in extensive areas.

We have attempted evaluate drastic changes in landuse such as this using satellite images of Landsat, SPOT, MOS-1, TERS-1, ADEOS-AVNIR, etc.[1)2)3)4)]. In this study, we focused on the area extending from Rangsit Irrigation Project Area sandwiched between Chao Phraya and Bang Pakhong to Thai gulf.

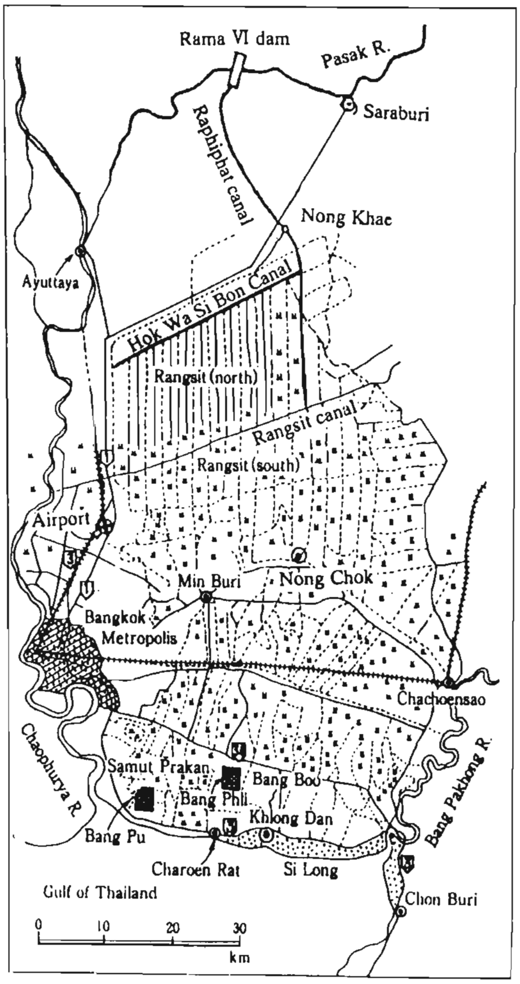


Fig. 1 Outline map of the Rangsit zone

2 Outline of the study area

Fig. 1 shows the outline of the study area. This is the excerpt from the map of 1:250,000 scales published in 1982. The landmarks of this area are Chao Phraya River at the western end, Gulf of Thailand at the southern end and Bang Pakhong River at the eastern end. The National Highway Route 1 and railway are running from Bangkok northward along Chao Phraya River while the National Highway Route 3 is running southward along Chao Phraya River, turning westward from Samut Prakan along the coastal line of Gulf of Thailand through Chon Buri to Pattaya.

There is a railway connecting Bangkok and Chachoen Sao almost straight and a drainage canal dug in the inverted V-shape immediately south of the railway as if to connect Chao Phraya River and Bang Pakhong River is outstanding very much. The highway from Bangkok to Pattaya passing 10 or 12 km inside the coastline is also a big landmark. It is possible to examine this area by dividing into five districts, Rangsit north, Rangsit south, Bangkok Metropolis, Samut Prakan and Chachoensao. Further, Bang Phli and Bang phu, where large-scale industrial estates are being built recently are also entered as the points drawing attention.

3 Satellite image data

Table 1 shows the types and dates of observation of the satellite image data used in this analysis. The Landsat data No. 1 in Table 1 was observed more than 20 years ago and it is a valuable data to examine land cover at the time though its resolution is poor. Concerning SPOT No. 2, it is most clear with resolution of 20 m but the area covered is narrow as about 60 km.

TABLE 1 SATELLITE IMAGE DATA USED IN THE ANALYSIS

No.	1	2	3	4	5
Satellite name	Landsat 3	SPOT	Landsat TM	Adeos	SERS-1 OPS
No. of bands	4	3	7	4	3
Pass-row	138 – 50	263 – 323	129 – 50	1010 – 135	
Date of observation	1979.11.13	1986.12.22	1993.12.25	1997.01.10	1997.12 02
Cloud (%)	30	0	0	0	0

Fig. 2 shows the image observed by Landsat 3 MSS on November 13, 1997. Although accurate analysis is difficult due to the resolution of 60 to 70 m and coarse image, it is a valuable data of the record at the time. In this period, artificial structure was hardly present and only the klong and the National Highway Route 3 are noticeable. Fig. 3 is the image observed by SPOT HRV-X on December 22, 1986. The resolution of the image by SPOT HX was 20 m offering a clear image. The building site of the industrial estate in Samut Prakan started around this period can be noted. Fig. 4 is the multiple band image of ADEOS AVNIR observed on January 15, 1997. This satellite has resolution of 18 m with 4 bands and offers very clear image. This image shows development of Bang Phli industrial estate with residential areas extending along the roads in the neighborhood. The conditions are the same in the surroundings of Bang Phu industrial estate near the river mouth showing expansion of residential areas along the roads in the neighborhood. Thus, by reviewing the study area in time series, rapid changes in landuse and land cover are clearly grasped by satellite images as those in Samut Prakan.

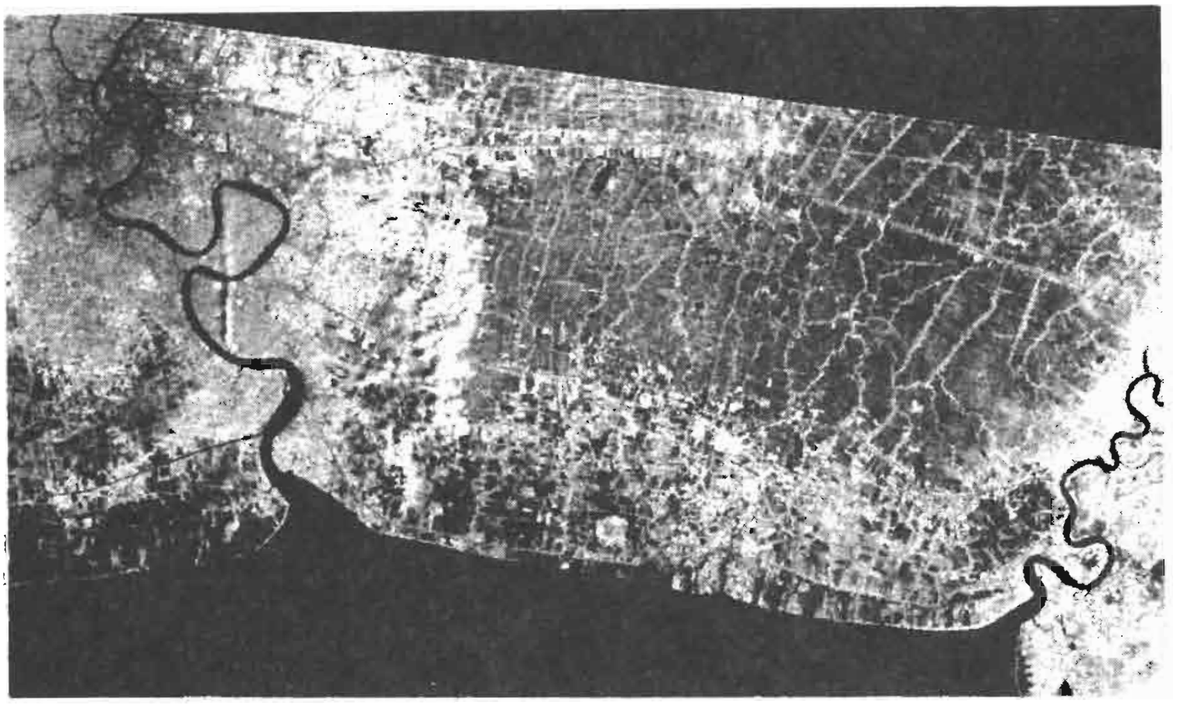


FIG. 2 LANDSAT MSS IMAGE, 138 – 50, NOVEMBER 13, 1979

4 Rangsit irrigation project

Chao Phraya River is the biggest river in Thailand and it flows down the central plain gathering. water from Nan, Yom, Wang and Ping Rivers and merging with Pasak River in the middle reaches. Although Thailand is thought generally to have tropical climate, lot of rainfalls and abundant water, its annual rainfall is between 1,300 and 1,700 mm is actually and it is similar to the rainfall in the area along the Seto Inland Sea of Japan which has the lowest rainfall. While this area has become a grain belt with implementation of a large-scale irrigation project, it was a barren plain before introduction of irrigation water. The history of agricultural development in this area began in 1891.

Since then, canals were dug from Pasak River which is the branch of Chao Phraya and Hakhon Hayok River which is the branch of Bang Pakhong River, introducing irrigation water and settlement of farmers actively until 1940. The Great Chao Phraya Irrigation Project was started in 1952 and a sluice dam known as Chao Phraya Dam was completed in 1957 at Chainat in the midstream of Chao Phraya River. With this project, the irrigation water flowed down from the upstream dams such as Bhumibol Dam with the effective reservoir capacity of 8,600,000,000 m^3 and Sirikit Dam was diverted at Chao Phraya Dam and a large amount of water was sent to Rangsit area through Pasak Canal completing the irrigation water network shown in Fig. 1 and enabling plating 72,000 ha of paddle fields.

FIG. 3 SPOT HX IMAGE OF CHAO PHRAYA RIVER MOUTH, DECEMBER 1986.

FIG. 4 ADEOS AVNIR IMAGE, 1010-135, JANUARY 25, 1997

While paddy rice was the main agricultural product until then, orchards growing mandarin orange and mango were introduced to this area in late 1970s and full-scale management of orchards has begun recently with the planted area amounting to 20 to 30% in Rangsit North district. In addition, the areas occupied by fish-breeding ponds are also getting noticeable. Moreover, factories have been built actively in the areas along the National Highway Route 1 in this district resulting in the increase in population. In connection with this movement, paddy fields in this district are beginning to turn into residential lands. In some cases, blocks of 2 or 3 Rai (0.32 – 0.48 ha) are converted into orchard blocks with vast areas in the background and, after building a house in each block, these are sold generally as an upper-class residential area with orchard. It is also pointed out that such a social phenomenon is one of the factors accelerating changes in landuse mentioned above. Don Muan Airport of Thailand is located near the boundary line between Rangsit North and Rangsit South and, thus, the outline of the Rangsit Irritation Project can be grasped visually from a landing airplane. While it seems that, originally, large-scale paddy fields were marked off orderly, orchards are intermingled in paddy blocks and houses, fish ponds and barelands probably under construction of residential lands are observable now.

5 Satellite image data and field survey

Fig. 3 shows the satellite image of Samut Prakan district including Chao Phraya river mouth taken by SPOT XS. Fig. 4 shows the Adeos AVNIR image. As shown in Table 1, the former image was observed in December 1986 and the latter in January 1997 and there is a gap of 11 years between them.

One of the authors lived in Bangkok from 1980 to 1983 and passed the study area on many occasions as well as carrying out field surveys many times until now. We inspected the changes in landuse using the image data mentioned above, topographical map published in 1982 and the data obtained by field surveys.

5.1 Increase in shrimp-breeding ponds

The area where the National Highway Route 3 is running along the coast in Fig. 1 used to be a low wetland suffering from constant flooding. It was covered with mangroves and palms and primitive fisheries and salt pans were practiced. In the field survey in November 1989, the area in Klong Dan where the National Highway Route 3 passing eastwards from the Chao Phraya river mouth and passing Charoen Rat curved inward and the area of 2 or 3-km width sandwiched between the coastline of Silong and the National Highway were mostly converted into shrimp-breeding ponds, which were increasingly constructed by clearing woodlands of mangroves. Because of this, the form of landuse changed rapidly.

While shrimp breeding in Thailand has been practiced most energetically in Samut Sakhon province situated in the west of the study area, the national statistics of Thailand shows that the shrimp breeding farms have increased 3 times or more both in the number and area and their production has become 6 times. This situation is fully comprehensible from the satellite image.

TABLE-2 PRODUCTION OF SHRIMP CULTURE IN THAILAND

Year	No. of farms	Area (ha)	Production (t)
1976	1,544	12,296	2,523
1980	3,572	26,036	8,063
1985	4,939	40,769	15,841
1986	5,534	45,368	17,886
1987	7,221	52,149	23,566

5.2 Construction of industrial estate[5]

Thailand is drawing attention from all over the worlds as the country of low risk based on the facts that it is politically stable, has good economic performance, offers high-quality and low-cost labor force and is a Buddhist country raising little trouble based on religious differences. Consequently, the investment from various countries in the worlds to Thailand has increased sharply since the late 1980s. In response to this trend, large-scale industrial estates have been constructed under the leadership of Industrial Estate Authority of Thailand (IEAT) of Thai government.

Bang Phli has the largest scale of 4,465 Rai (about 714.4 ha) and an industrial estate of 3,747 Rai (about 600 ha) was also constructed at Bang Pu near the river mouth.

TABLE-3 AREAS OF THE INDUSTRIAL ESTATE IN THE STUDY AREA

Name	Year of completio	Area (ha	Location
Bang Chiang	1972.0	107.0	30 km east of Bangkok
Latkrabang	1979.0	374.0	35 km east of Bangkok
Bang Pu	1977.0	461.6	Samut Prakan
Bang Phli	1984.0 1980.0 1990.0	266.4 240.0 208.0	Samut Prakan
Prachapol		131.2	Latkrabang
Theparak		131.8	Samut Prakan

An estate of 2,900 Rai (about 465 ha) was construction at Latkrabang district as well. Bang Pu industrial estate can be viewed from a small hill in the noted place of Ancient City near Chao Phraya river mouth. Large-scale industrial estates have appeared suddenly in the mangrove woods and shrubs in low wetlands and road networks connecting these and high ways have been prepared together with houses built along the roads; the areas of industrial estates and residential areas along the roads are expanding. Two industrial estates of Bang Phli and Bang Pu are clearly visible in Fig. 3 and expansion of their areas is shown in Fig. 4. In Photo. 1 taken within the industrial estate of Bang Phu on December 24, 1999, development of the estate establishing itself in the district can be seen.

5.3 Closing of Klong river mouth

The National Highway Route 3 was constructed in the low wetland adjacent to the Gulf of Thailand by mounting the ground in the vicinities like construction of an embankment. Therefore, both sides of the national highway resembled digging of canals and the networks of drainage canals left in natural state were connected to the klongs present in parallel with the national highway and, at the same time, interrupted by roads. Bridges were built only on large Klongs in places, where they flowed into the Gulf of Thailand.

PHOTO. 1 INDUSTRIAL ESTATE OF BANG PHU, DECEMBER 24, 1999.

PHOTO. 2 SLUICE GATE AT CHAROEN RAT, DECEMBER 24, 1999.

The exits of almost all klongs flowing out from inland to the Gulf of Thailand are closed by gates. Photo. 2 shows the example of closing gate. Consequently, the national highway has become to act as a dike preventing invasion of salt water from the sea. The biggest exit of klongs is located at Charoen Rat judged from the observation of satellite images and the field survey and its drainage pump plant was constructed in the late 1980s by the support of the Japanese government.

As the water in the low wetland inside the National Highway Route 3 and seawater in the Gulf of Thailand were shut off completely in such a form, the water in Klongs which was considered to include salt water in the low wetlands of the inland was replaced by fresh water. This consequently permitted irrigation in paddy fields utilizing keel wheels and pumps and rice growing was practiced in some places even in the dry season when cultivation was normally impossible.

The following points are inferred from the study combining the above satellite image data and field survey results.

(1) In Rangsit Irrigation Project area, in the north in particular, the landuse which used to be restricted to paddy fields is changing into complicated form of landuse consisting of orchards, fish-breeding ponds and residential lands.

(2) The costal zone between the National Highway Route 3 and the Gulf of Thailand was covered with palm and mangrove woods formerly but it is turning into shrimp breeding ponds rapidly in the recent few years.

(3) In the inland of the National Highway Route 3, the water in Kongs has been freshened due to closing of the Klong exits into the Gulf of Thailand and a change into paddy fields seems to be progressing as observed in Charoen Rat.

(4) Industrial estates extending over some hundreds of hectares are under construction by the government organizations and private developers as in Bang Phli and Bang Pu and the lands surrounding these industrial estate are changing into residential areas recently for the workers engaged in factories and estates.

6 Satellite image analysis

As shown in Table 1, we have accumulated satellite images gradually since 1979. In the present study, we selected the study area from these images on the ground that it would be analyzable, show the trend in landuse changes and allow ground truth. Fig. 4 is the ADEOS AVNIR image observed in 1997. It includes the area along Chao Phraya River from Rangsit North to the coastline. We took up the area which included the industrial estates of Bang Pu and Bang Phli in Samut Prakan province and which was surrounded by the major highways as the study area (the area surrounded by thick lines). We advanced analysis by focusing to artificial structures such as roads and buildings categorized as Urban in this polygon. We classified the study area into five land covers, namely bareland where artificial structures were to be constructed, water body, wetland and paddy where vegetation and water were mixed and performed classified calculation. We performed geometric correction to adjust the scale before classified calculation. Fig. 5a shows the result of the supervised classification based on the SPOT HRV image in 1986 and the histogram in the classification parameter is expressed in pixels. Fig. 5b shows the classification result of the Landsat TM image in 1993. Likewise, Fig. 5c and Fig. 5d show the analytical results of the ADEOS AVNIR image in January 1997 and of the JERS-1 OPS (VNIR) image, respectively.

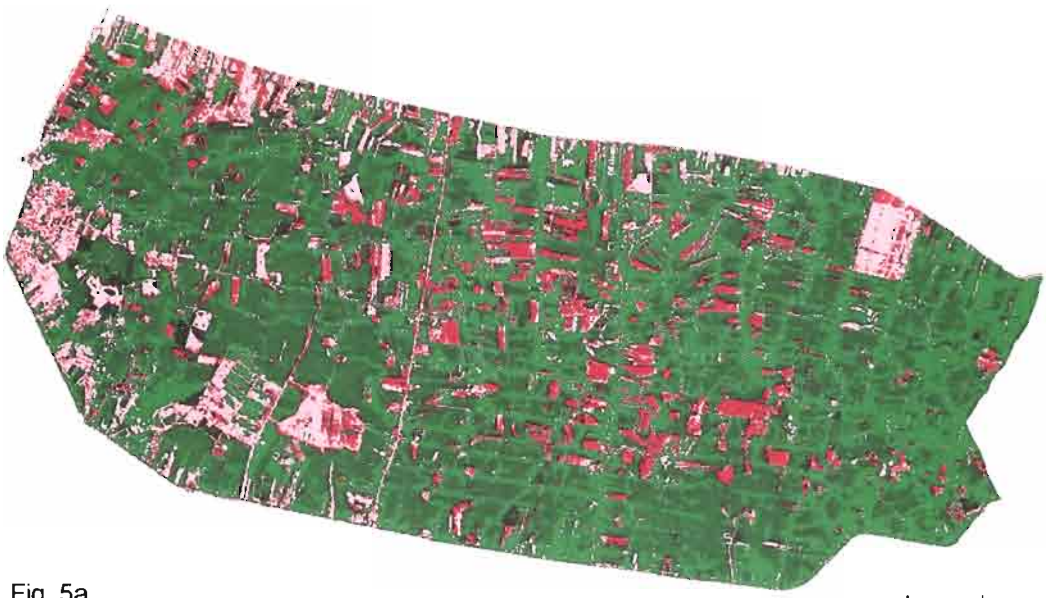


Fig. 5a

SPOT 1986/ 12/ 22

Legend

Class_Names	Histogram
Urban	45088
Paddy	217611
Wetland	130587
Water	8443
Bareland	53622

Fig. 5b

LANDSAT 1993/ 12/ 25

Legend

Class_Names	Histogram
Urban	47588
Paddy	65109
Wetland	47611
Water	1126
Bareland	28329

Fig. 5c

ADEOS 1997/ 01/10

Legend

Class_Names	Histogram
Urban	177367
Paddy	161971
Wetland	219091
Water	15073
Bareland	86127

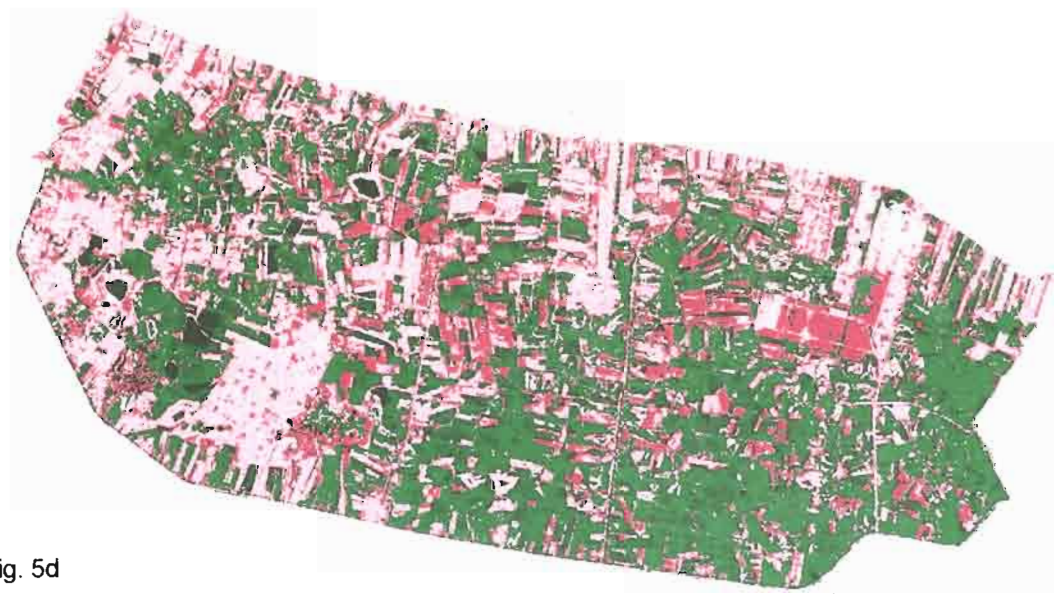


Fig. 5d

JERS 1997/ 12/ 02

Legend

Class_Names	Histogram
Urban	166421
Paddy	105239
Wetland	140956
Water	8998
Bareland	109115

As the area in the study area is naturally the same all along, the pixel size in each image was adjusted and the areas of the respective classes were calculated. Table 2 shows the results expressed in hectares. Fig. 9 shows the graph showing the trend in annual landuse changes. As seen from this graph, the area occupied by artificial structures indicated as Urban increased sharply from the late 1980s to 1990s followed by a gentle growth thereafter. In contrast, paddy lands easily accessed by man decreased in area drastically probably turning into bare land or urban land.

It is also seen that the areas of Water body and Wetland which keep people at distance are not so changed.

TABLE 2 ESTIMATION OF LANDUSE CHANGE BY SATELLITE IMAGES

Category	1986.12.22	1993.12.25	1997.01.10	1997.12.02
Urban	1,717	4,349	4,664	5,438
Wetland	8,289	5,951	4,259	3,439
Water	322	103	396	294
Bareland	2,042	2,589	2,265	3,566

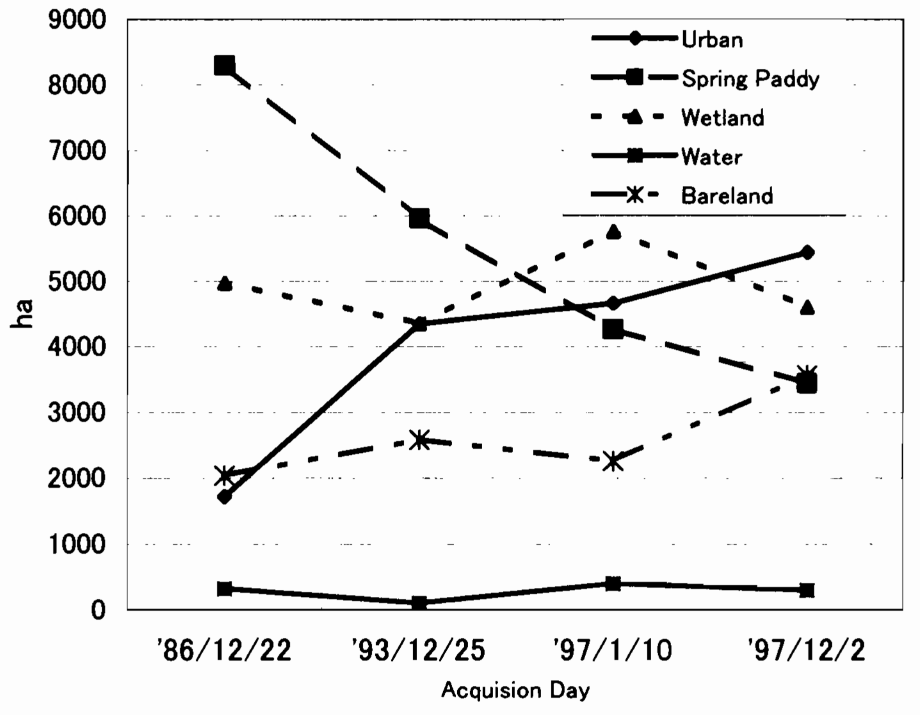


FIG. 6 TREND OF LANDUSE CHANGES BASED ON SATELLITE IMAGES

7 Conclusion

In the present study, we could obtain a very efficient image processing software as our application for the Basic Study (A), Science Research Fund of the Ministry of Education was accepted. We could extract significant spatial information from satellite images by performing geometric correction to adjust scales. Although it is hardly said that we are well-acquainted with this high-performance software, we think that an interesting result was drawn. As the study area was not easily accessed by the analyzer, the result obtained must be verified in detail in some other occasion. However, we realized that accurate information could be extracted by dividing the area into relatively small blocks and compiling the analysis carefully.

Ending the paper, this study has been conducted as the Basic Study (A), Science Research Fund of the Ministry of Education (represented by Kiyoshi Torii) and we would like to express out appreciation to those concerned as well as NASDA Japan for offering satellite images.

References

1) Torii, K. et al.: Approach to the survey on the agricultural development in Thailand using SPOT image data. Proc. of Japan Photogrammetry Annual Meeting, pp. 141–146 (1989).

2) Torii, K. et al.: Transition of Land Use in Bangkok Coastal Area Using SPOT Image Data; Proc. of the 10th Asian Conference on Remote Sensing, pp. G-6-1 – G-6-6 (1989).

3) Torii, K. et al.: Analysis of landuse changes in the south-east coastal zone of Bangkok using satellite image data. Proc. of Japan Photogrammetry Annual Meeting, pp. 143 – 148 (1991).

4) Torii, K. et al.: Analysis of Landuse Change in Bangkok Coastal Area Using Satellite MSS Data. Proc. of the 12th Asian Conference on Remote Sensing, pp. G-4-1 – G-4-6 (1991).

5) General Economic Condition in Thailand (1990-92 edition): The Japanese Chamber of Commerce in Bangkok.

Fig. 7 Study area in Adeos AVNIR image, 1005 – 140 (+2), January 10, 1997

Dengue Haemorrhagic Fever (DHF) in the Central Plain of Thailand. Remote sensing and GIS to identify factors and indicators related to dengue transmission.

Philippe Barbazan[1,2], Jochen Amrehn[3], Sittipong Dilokwanich[3], Jean-Paul Gonzalez[1,2], Kanchana Nakhapakorn[4], Kawai Oneda[5], Anuchai Thanomsinra[3], and Sutee Yoksan[2]

Abstract *: In Thailand, since the first epidemics in 1958, there has been a global upward trend in incidence of Dengue Hemorrhagic Fever (DHF), an acute and severe form of dengue virus infection, which remains a major public health concern. The dengue is due to an arbovirus mainly transmitted by Aedes aegypti, a mosquito living close to human communities. The intensity of the transmission (i.e. number of cases and speed of the spread of the disease) is dependant on the number of vectors, the serotype of the virus, the herd immunity and the environment.*

In the Central Plain of Thailand despite an apparent very homogenous environment (altitude, climate, type of agriculture) the incidence of DHF exhibits strong variations at the province and sub-province levels. A Geographical Information System using epidemiological data, as well as information about the Land-use, demography, geography, climate has been built to identify indicators likely to help to describe areas and periods at risk for dengue transmission.

A particular approach is focusing on the structure of the urban environment, the main field for dengue transmission. Different degrees and types of urbanisation appear to be linked to different intensities of dengue transmission. The main output of this study will be a method to describe areas at risk for high level of transmission and to forecast epidemic periods allowing a quick launch of dengue control activities. This study developed in the Central Plain of Thailand will be extended to other parts of the country and the same methods maybe applied to similar environments in other countries where the dengue is endemic.

Key Words: Dengue Hemorrhagic, Risk areas, Remote sensing, GIS, Thailand.

[1] CVD / IRD-RCEVD Project, Mahidol University at Salaya, Thailand

2 CVD, Mahidol University at Salaya, Thailand

3 Faculty of Environment and Resource Studies, Mahidol University at Salaya, Thailand

4 Star Program, Asian Institute of Technology, Thailand

5 Departments of Biology and Epidemiology, The University of Michigan, United States

1 Introduction

Dengue fever is due to an arbovirus mainly transmitted by *Aedes aegypti* and yearly causing in the tropical area tenths of millions of cases. Since its apparition during the 50's the Dengue Haemorrhagic Fever (DHF), a sever form of dengue infection, has followed a global upward trend in incidence and has been a main public health problem in South East Asia (SEA) and countries of the tropical zone. Despite in many countries the DHF case fatality rate has decreased, such as in Thailand, from 6-8% in the 1960s to a mere 0.3% in 1996, epidemics still lead to the first cause of children hospitalization in SEA and associated to the persistent endemicity of the disease, induce a high cost to regional economies (15 to 20 million US$ per year in Thailand) linked to the symptomatic treatment of patients and vector control activities. No specific treatment against the virus neither vaccination is available. Along with the setting up of adulticide spraying campaigns to quickly stop the transmission during epidemics, vector control activities chiefly aim at eliminating breeding sites through community participation. However, the efficiency of prevention and control activities is too slow to reach the level sufficient to interrupt the transmission during epidemic periods, since it takes quite a long time to set up These activities are also difficult to maintain during the non-epidemic periods, due to the defection of the populations towards activities with no perceptible results. In addition, in Thailand and in most of the Southeast Asian countries where the dengue is endemic, the needed infrastructure can be maintained neither permanently nor simultaneously for the whole country.

A quick launch of control activities appears necessary to improve their efficiency but despite the efficient system to survey the DHF (and 60 other diseases) developed by the Thai Ministry of Public Health, the great diversity in the epidemiological pattern of the DHF makes epidemics difficult to predict. The transmission cycle of the disease is the result of a complex system based on several main constituents: the number of vectors, the type of virus, the density of susceptible hosts and the environmental conditions acting on the output of transmission.

Two main patterns may describe the fluctuations of DHF incidence. The cyclic pattern corresponds to the seasonal variations of transmission. The incidence reaches a peak during the hot and rainy season (May-October in the Central Plain). The end of the rainy season leads to a return to a lower level of transmission. This phenomenon is repeated every year and characterizes the endemic mode of transmission. The non-cyclic pattern corresponds to important rises in the incidence of DHF and to the very basis of the epidemics characterization; they are non-seasonal increases of variable duration, separated by periods of lower incidence lasting two to five years.

To make the best of these control activities, it is important to have them focused on epidemic periods and to intervene as early as possible. This is made difficult as in Thailand the epidemic outbreaks are apparently uncertain and the range of the "normal" seasonal fluctuations is wide. For instance, the average ratio of the monthly minimum number of cases to the monthly maximum was 1/13 in Nakhon Pathom a province located (50km West of Bangkok) from 1983 to 1998. Therefore "abnormal" fluctuations of the epidemic sort must be defined in relation to this large amplitude of natural fluctuations.

Moreover, spatial variations in incidence add more complexity to the transmission description as the incidence ranged from 0 to 180 cases (per 100 000 inhabitants) in the sub-districts of Nakhon Pathom province during the last ten years.

The goal of this study is to describe the epidemiology of DHF in an area where the environment exhibits relatively homogenous features, the Central Plain of Thailand. This region has been chosen because the homogeneity in climate, altitude and activities of inhabitants allows reducing the amplitude of the factors to be studied to describe the DHF epidemiology. From that description, regional common characteristics of DHF transmission are identified and specific analysis performed. Factors likely to be involved in the spatial and temporal variations of the transmission are described.

2 Methods

Satellite images will furnish an up to date and quantitative view of the land cover heterogeneity, mainly of the urban area (from a supervised classification) and its recent extension and modification (comparison of images acquired 10 years apart). Relative localization of urban communities (i.e. polygons from the classification and from field survey by Global Positioning System) will be associated to the Geographical Information System layer on road network and inform on the way dengue serotypes circulate. The comparison between DHF incidence and class distribution (from Remote Sensing) will enlighten those significantly associated to dengue transmission. The national census will furnish layers for demography and health and water networks (water storage).

Storage and processing of data and information. A Geographical Information System (GIS) has been build to store the data related to the study, including their geographical coordinates (latitude, longitude and sub-district code). Statistics and other type of queries including spatial comparison are performed through the GIS. Data refer to different domains: epidemiology, demography, land use, climate, socio-economic information (water network, types of roads).

Definition of epidemic periods. A statistical tools designed to facilitate an early detection of an epidemic emergence versus seasonal variations, has been developed using a statistical departure from the monthly average as a threshold for the risk of emergence of an epidemic phenomena (not described here). From this criterion, an analysis of the distribution and dynamic of DHF epidemics in the districts of the Central Plain of Thailand is done and is related to the type of Land Use prevailing in these areas.

The Land use description. The Land use description is approached from the classification of remote sensing images (SPOT, Landsat). A satellite image is made of pixels (spatial unit, 20m x 20m for SPOT; 30m x 30m for LANDSAT). Each pixel has a specific radiometry in each of the channels or bands of the satellite (3 bands for SPOT; 7 bands for Landsat) depending on the objects on the ground. The radiometry value arbitrary range from 0 to 255. A classification aims at pooling pixels having the same range of values in one or more of the bands. In a supervised classification some objects on the ground which nature is known from field knowledge or maps, such as urban area, crop, river, are used to build a homogenous training areas. In this area the range of the radiometric values of the pixels is measured, in one or more bands (bands 1, 2, 3 for SPOT; 1, 4, 5 for the study of urban areas in Landsat TM). In a second step, a program selects every pixel in the image which radiometry is in the same range than the training area. It is assumed that they constitute a class of objects of the same nature than the training area.

This procedure has been used to classify the Landsat image (and SPOT, not shown here) covering the Nakhon Pathom province for the urban class (and water, vegetation and flooded areas, not shown here).

The size and distribution of polygons corresponding to the urban class in the 106 sub-districts of Nakhon Pathom province is then compared with the incidence of DHF.

3 Results

Incidence of DHF in Thailand 1958 - 1998 (figure 1). Since the 50 the DHF incidence exhibits a constant positive trend. The main epidemics (number of cases) occurred in 1987 and 1997-1998.

Incidence of DHF in the Central Plain of Thailand 1992 – 1998. Figure 2 Despite a great heterogeneity, for a given year, in the level of incidence in the 19 provinces of the Central Plain, ranging from 1 to more than 20, a strong homogenous pattern of transmission characterizes this area when compared to the other Thai provinces. Referring to seasonal variations, the amplitude of the difference in incidence between the higher and the lower months, is significantly smaller than what is observed in other provinces (3.47 versus 7.03; stdev 5.79 versus 8.59; p=0.1). Moreover, the outbreak occurred simultaneously in the 19 provinces, all of them being involved, when it lasted from the end of 1996 to 1999, or did not occur, in other provinces

Case study in Nakhon Pathom province. Figure 3, Population per sub-district. Figure 4, Incidence of DHF in Nakhon Pathom province 1997-1998; and Figure 5 epidemic months obtained by using a significant (1 stdev) departure from the average as a threshold. The epidemic months occurred from June 1997 to May 1998.

Results of the classification, Figure 5 and Figure 6. The urban class obtained from the Landsat image appears mainly concentrated in the South and South Eastern parts of the province and along a network corresponding to the roads. The correlation between the extend of the area covered by the urban class and the number of inhabitants in the 106 sub-districts is 0,8.

GIS development. Integration of different layers of information, epidemiological, remote sensing and economic, to identify risk areas in Nakhon Pathom province.

The highest incidence and most of the epidemic months were found in sub-districts located in the second range of sub-districts, compared to the main roads and in those with a medium density of urban class.

4 Discussion

Surveillance of epidemics. The surveillance of epidemics involves the survey of a host population directly (incidence) or indirectly (e.g. practitioners' activity), of the vector pre-imaginal and adult stages and, of the predominance of serotypes in a specific area. The entomological surveys used for the estimation of the larval, pupal or imaginal populations are not very satisfactory inasmuch as they are difficult to be linked with dengue incidence. Moreover, it has been possible to describe some epidemics in different countries, including in Thailand that can break out or go on during the low vector density season (dry season). The follow-up of the climatic indicators, temperature and rainfall especially, is strongly related to their impact on entomological indicators. Although temperature in particular allows the definition of areas and periods at risk for dengue virus transmission, it does not permit the prediction of an epidemic outbreak.

The emergence of a new serotype, or one that has not been observed for a long period in a given population, can also be considered as a risk indicator. But this method is costly, as it requires systematic blood sampling from suspected cases for identification of the serotype. Similarly, the search for virus from potentially infected vectors even if it is being facilitated by the use of molecular biology cannot be done as a routine activity. Moreover, the study of serotypes prevalence in the Thai population is complex since dengue is endemic, with 4 serotypes described in the past ten years, and where two or more can be found simultaneously in a same area. The rate of immune protection of the population being over 90% (from 3% to 97% among children <1 to 10 years of age in Rayong province prior to the 1980 epidemic; over 95% among 2000 males 20 to 25 years of age coming from all over the country in 1998) limits also the use of seroconversion survey to forecast epidemics.

It then appears that if several tools are available for the surveillance of DHF, in Thailand ands other endemic countries, their permanent use at a countrywide scale is not feasible.

The tools developed in our study aims at identify periods at risk at the province level, from the comparison of monthly incidence with retrospective data. Once the warning has been produced; a more precise study at the district and sub-district scale may help to identify which types of urban structure is the main target for the development of the outbreak, and to focus the control activities on these parts of the. In the Nakhon Pathom province, the sub-districts reached by the epidemic during the first 3 months of the outbreak covered less than 15% of the total province.

A better identification of areas at risk is necessary as DHF is classically described as urban, but this term covers a wide range of social and cultural situations. Moreover an increase of the incidence in rural areas as compared to urban is described since the last ten years enlightening a qualitative change in the epidemiology of DHF in Thailand. Urban should rather only means that virus transmission occurs near houses, prior to the spread of the disease to villages and towns, which is dependent on the structure and organization of the urban communities. Moreover, Southeast Asia presents a challenging emerging economy with a fast growing population and urbanization, both having a determinant impact on Dengue Fever transmission, its mechanisms and also the risks of DHF epidemics. Remote Sensing approaches of transmissible diseases have been recently developed but few studies focus on dengue transmission. The major obstacles refer to the scales at which transmission may be studied and the difficulty to discriminate different types of urbanization. In our study, the remote sensing approach is used to identify the type of urban structure where high level of transmission is mainly recorded.

The heterogeneity observed and in our study and the highest incidence recorded in sub-district with medium density of urban class and relatively distant from the main roads, are apparently in contradiction with the main description of DHF risk areas. They are described as the densest urban areas where the virus can spread easily and located near high traffic roads allowing the importation of virus by infected travelers. But the results have to be considered in a temporal perspective developed from 2 main observations. If at least 2 or 3 serotypes circulate simultaneously in most of the provinces of Thailand, they did not necessarily arrived at the same time and the immunity induced by each serotype may greatly vary. The spread of each serotypes in different parts of the provinces is linked to the displacements of infected people carrying the virus and to the season, allowing or not the dispersal of the virus over a large part of the province.

Two hypothesis based on the different level of herd immunity can contribute to explain the observed heterogeneity. A first model assumes that the serotype responsible of the 1997-1998 epidemic was endemic since several years, circulating at a low level of incidence in the most urbanized part of the province, inducing an increasing immunity in that population but never able to reach the neighboring districts distant from several kilometers. In a second model, the 1990 epidemic (supposed to be due to the same serotype than the 199è-1998 epidemic) reached the most dense urban areas, but stopped, for example because of the dry season, before to reach the other sub-districts. In the 2 situations the arrival of the serotype involved in the former transmission process, in 1997 in the sub-districts with a lower immune protection could lead to a localized epidemic, spreading to densely urbanized areas of the province only at the onset of the rainy season, because of the increasing vector population. Serological and virological studies, allowing to identify the virus responsible of different epidemics will help to test the validity of these hypothesis.

This study aims to a better use of known strategies to prevent and control DHF by an innovative use of new spatial technologies in DHF study. A geo-referenced database (GIS) will be built, computing epidemiological data on DHF and associated features from endemic areas of Thailand: demography, climate, environment, remote sensing, urbanization, socio-economic development. The GIS will be kept up to date by constant actualization of the data. Main outputs will be the production of durable indicators of risk, validated by prospective studies and constantly enriched by the comparison with observed information. These indicators will allow to continuously identify areas and periods at risk of increasing incidence and help to design and focus adapted strategies for prevention and control.

Acknowledgements

We thank the CDC Thailand department of the MOPH, who furnishes regularly the data on DHF incidence. We acknowledge the Mahidol University, the Institute for Science and Technology for Development, the Center for Vaccine Development Team, and the Department for Technical and Economic Cooperation (Thailand) for providing exceptional facilities for our research activities. We thank Professor Natth Bramapavarati for his constant support.

Financial support. This study was supported by the Department for Technical and Economic Cooperation, Thailand, the Center for Vaccine Development, Mahidol University, Thailand and the Department of Societies and Health, IRD, France.

References

DENGUE AND DHF

Gubler DJ, Kuno G, eds. *Dengue and dengue Hemorrhagic fever.*. Wallingford, UK: CAB International, 425-462.

DENGUE TRANSMISSION.

Kuno G, 1995. Review of the factors modulating dengue transmission. *Epidemiol Rev 17:* 321-335.

Focks DA, Daniels E, Haille DG, Keesling JE, 1995. A simulation model of the epidemiology of urban dengue fever: literature analysis, model development, preliminary validation, and samples of simulation results. *Am J Trop Med Hyg 53*: 489-506.

Jetten TH, Focks DA, 1997. Potential changes in the distribution of dengue transmission under climate warming. *Am J Trop Med Hyg 57:* 285-297.

DENGUE IN THAILAND.

Nimmannitya S, 1978. Dengue haemorrhagic fever in Thailand. *Asian J Infectious Diseases 2:*19-21.

Nimmannitya S, 1987. Dengue haemorrhagic fever in Thailand. *Southeast Asian J Trop Med Pub Hlth* 18: 291-294.

Chareonsook O, Foy HM, Teeraratkul A, Silarug N, 1999. Changing epidemiology of dengue hemorrhagic fever in Thailand. *Epidemiol Infect 122:*161-166.

Sommani S, Okanurak K, Indaratna K, 1995. Social and economic impact of dengue haemorrhagic fever in Thailand. Social and Economic Research Unit, Faculty of Tropical Medicine Mahidol University, Bangkok.

Ungchusak K, Kunasol P, 1988. Dengue hemorrhagic fever, 1987. *Southeast Asian J Trop Med Pub Hlth, 19:* 487-490.

DENGUE SURVEILLANCE

WHO, 1986. Dengue Haemorrhagic Fever : Diagnosis, Treatment and Control. World Health Organization, Geneva

Stroup DF, 1994. Special analytic issues. Teutsch SM and. Churchill RE, eds. *Principles and practices of Public Health Surveillance*, New York: Oxford University Press, Inc, 136-149.

Chan KL, 1985. Methods and indices used in the surveillance of dengue vectors. *Mosquito Borne Dis Bull, 1:* 79-88.

Deparis X, Chungue E, Pauck S, Roche C, Murgue B, Gleize L, 1998. Surveillance épidémiologique de la dengue: Méthode et intérêt lors de l'épidémie de dengue 2 en Polynésie française en 1996. *Trop Med and International Health 3:* 566-570.

Sangkawibha N, Rojanasuphot S, Ahandrik S, Viriyapongse S, Jatanasen S, Salitul V, Phanthumachinda B, Halstead SB, 1984. Risk factors in dengue shock syndrome: a prospective epidemiologic study in Rayong, Thailand.I. The 1980 outbreak. *Am J Epidemiol 120:* 653-669.

Chungue E, Boutin JP, Roux J, 1991. Dengue surveillance in French Polynesia: an attempt to use the excess number of laboratory requests for confirmation of dengue diagnosis as an indicator of dengue activity, *Europ J Epidemiol 7*: 616-620.

Rigau-Pérez JG, Millard PS, Walker DR, Deseda CC, Casta-Vélez A, 1999. A deviation bar chart for detecting dengue outbreaks in Puerto Rico. *AM J Pub Hlth*, 89, 374-378.

Figures

Figure 1. Incidence of DHF in Thailand, 1958 – 1998.

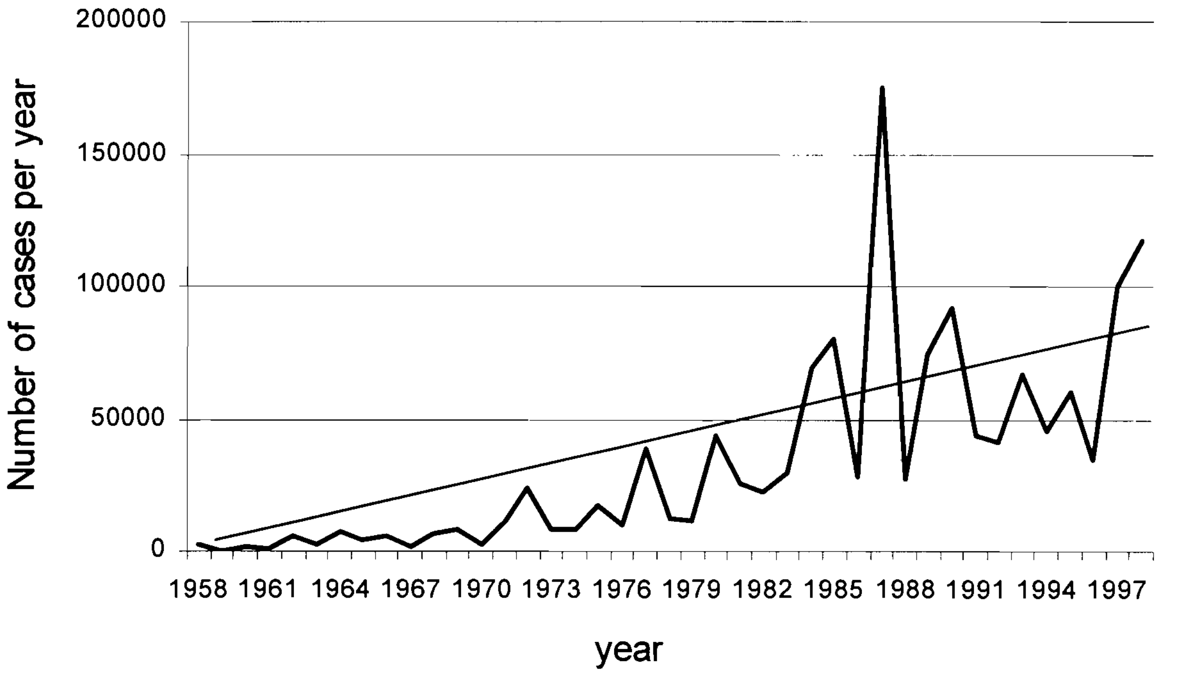


Figure 4. Spatial Heterogeneity in DHF Incidence at the Sub-district scale. DHF Cases / 100,000 Inhabitants, 1997 – 1998 in the 106 sub-districts of Nakhon Pathom Province, Thailand.

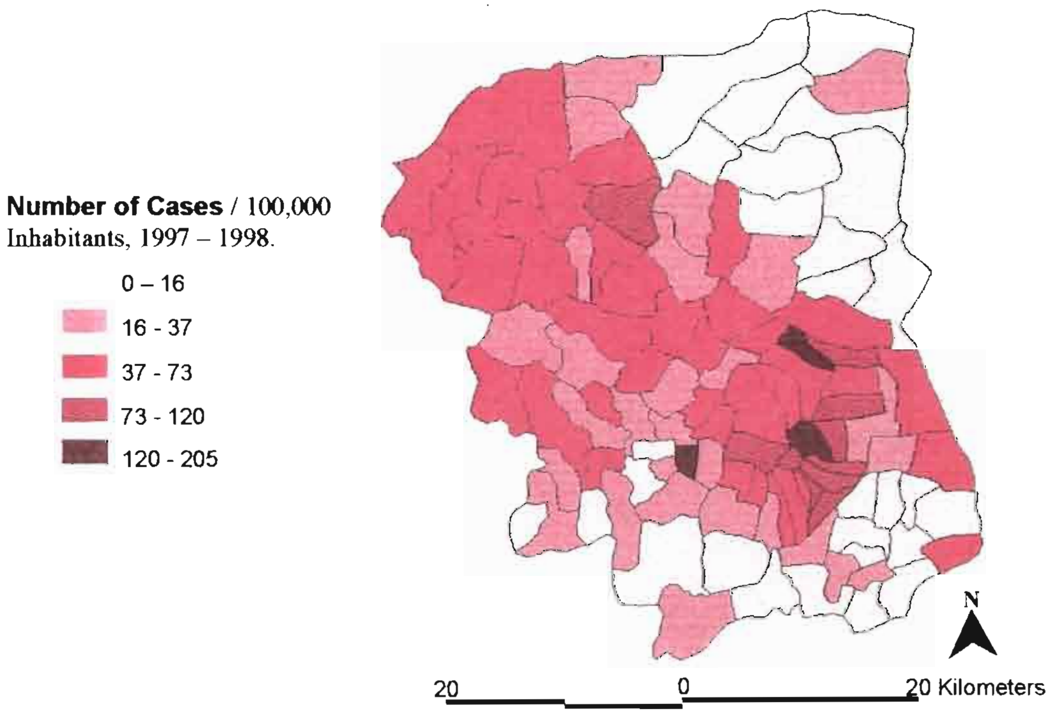


Figure 5. Population in Nakhon Pathom, 1997 (from National Census).

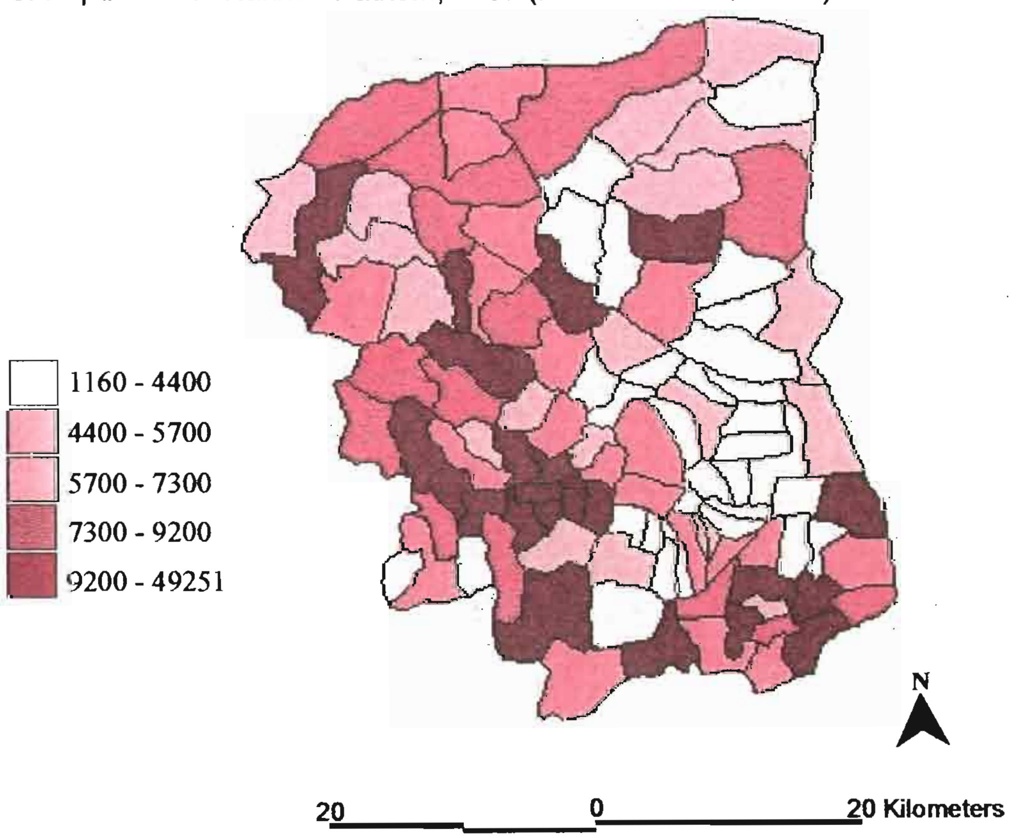
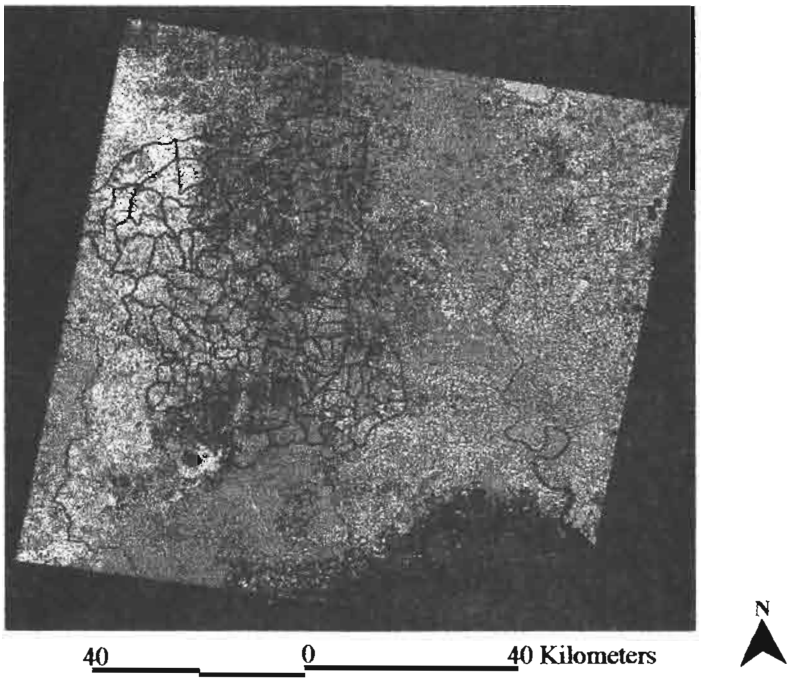


Figure 6: A search for risk areas for DHF. Use of Remote Sensing. Approach in the study of DHF spatial variations. Landsat TM cover of Nakhon Pathom Province, Thailand



Landsat –TM5, 06/1997. Path/Row : 129/51. Colour Composite : R : 1 - G : 4 - B : 5

—— Sub-districts boundaries in Nakhon Pathom Province

Figure 7: Remote Sensing. Approach in the study of DHF spatial variations. Result of the supervized classification Urban class obtained from training areas in a Landsat TM cover of Nakhon Pathom Province, Thailand

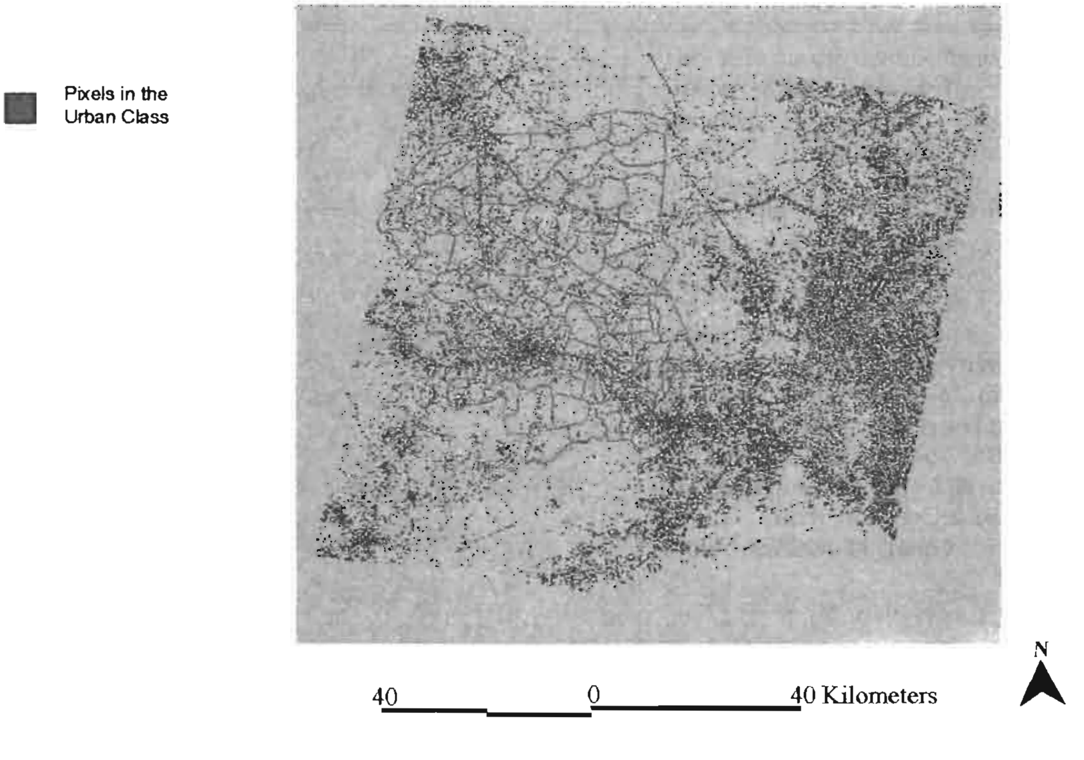


Figure 8. GIS application. Epidemic sub-districts in Nakhon Pathom Province, 1997 - 1998, urban class and road network.

Geo-environment and effect of sea level rise in the Chao Phraya Delta

Masatomo Umitsu[1]

Abstract: *Landforms and sediments of the Chao Phraya Delta are analyzed, and the effect of future sea level rise in the delta is discussed in relation to the geo-environment. Landforms of the Chao Phraya Delta are classified into the deltaic floodplain in the north, the deltaic plain in the central and south, and the tidal plain in the southernmost regions of the plain. Elevation of the tidal lowland in the southernmost region is around 1 m a.s.l., and its surface is very flat and low. Most of the region is originally lower than high tide level, and the sediments of the region are thin tidal flat silt or clay over thick marine sediments. The deltaic plain with elevation 2-3 m has been formed as a tidal and deltaic plain since the Holocene high stand around 6000 years BP. The surface sediments of the region which cover marine sediments are soft silt and mostly consisted as tidal flat origin. There are a little fluvial landforms and their sediments in the deltaic plain. Fluvial landforms as natural levees and flood basins develop in the region of deltaic fluvial plain. Surface sediments of the region are characterized with fluvial silt or clay that cover tidal silty sediments.*

The tidal plain of the delta is the region where the direct impact of the sea-level rise may occur. Coastal erosion is already in progress, and there is a possibility of submergence of the region according to the sea level rise. Acceleration of badly drainage condition is anticipated in the deltaic plain, because the surface gradient of the region is very low and the relative gradient of the drainage is going to decrease according to the sea level rise. As there is a little relief in the deltaic plain region except the artificial reclaimed land, the impact of sea level rise might effect widely. Land subsidence of the region also accelerates the effect of sea level rise. In the deltaic floodplain, difference of flooding condition can be seen in relation to the micro landforms. Natural levees and other higher places suffer a little flooding or escape from floodings. On the contrary, swampy areas of a flood basin suffer severe flooding. Most of them develop in the area surrounded by natural levees. The flooding condition has possibility to be accelerated according to the future sea-level rise.

1 Introduction

There are various landforms and coastal environments on the coasts of the Asia-Pacific region (Bird, E. C. F. and Schwartz eds., 1985). Among those landforms, deltas are one of the most important landforms for the life of people in Asia. As the characteristics of deltaic landforms are low and flat, they will be easily affected by future sea-level rise (Milliman, J. D.

[1] Dept. of Geography, Nagoya University, e-mail: umitsu@lit.nagoya-u.ac.jp

and Haq, B. U. ed., 1996). Especially, the effect of the sea-level rise is considered not only as direct coastal erosion and submergence but also indirect effects such as flooding, salinity problems so on.

Many efforts have been made to protect coasts against cyclones, coastal erosion and so on during the historic period. But the result is different in each region according to the historic and socio-economic backgrounds.

Regional characteristics of coastal regions are also related to historic background and socio-economic conditions of each region. It is very important to clarify the regional characteristics of the changing coastal region and evaluate the affect of future sea-level rise (UNCRD/CIRDAP, 1992; Warrick, R. A. and Ahmad, Q.K. ed. , 1996).

It is especially important to clarify the regional characteristics of the deltaic regions and consider the effects of sea-level rise in Asia, because the population dense is and economic activity is great in the deltaic regions.

In this paper, effects of sea-level rise in the Chao Phraya delta are discussed in relation to regional geo-environment.

2 Geo-environmental classification of the delta

The Chao Phraya delta is located in central Thailand, and draining into the Gulf of Thailand. Geomorphologic boundaries between the Holocene alluvial surface and older surfaces are relatively clearly shown in Satellite images (Landsat TM, JERS-1, MOS-1), and it is almost along the inner limit of marine or tidal flat sediments. Landforms of the Chao Phraya Delta are classified into three regions: the deltaic floodplain in the north, the deltaic tidal plain in the central and south, and the tidal plain in the southernmost regions of the plain (Fig. 1).

Elevation of the tidal plain is around 1 m a.s.l., and its surface is very low and flat. Most of the region was originally lower than the highest tide level, and the sediments of the region are thin tidal flat silt or clay over thick marine sediments.

The deltaic tidal plain with an elevation of 2-3 m, has been formed as a tidal and deltaic lowland since the Holocene highstand around 6000 years BP. The surface sediments of the region which cover the marine sediments are soft silt and mostly consist of tidal flat origin. There are few fluvial landforms and their sediments are also rare in the deltaic tidal plain. Fluvial landforms such as natural levees and flood basins develop in the deltaic floodplain. Surface sediments of the region are characterized by fluvial silt or clay that cover tidal silty sediments. Lower deltaic surface along the lower reaches of the Chao Phraya river can be seen in the CORONA Satellite images, and also the well developed natural levees can be seen in the west flank of the deltaic flood plain.

The Holocene sediments in the central plain mainly consist of silt and clay and occasionally organic matter. They are classified into four units: basal peat, marine, tidal and fluvial units from the lower to the top horizons. Radiocarbon ages of the basal peat and mid-Holocene tidal sediments show approximate former relative sea-level change.

The maximum height of the sea-level was higher than 2 meters above the present sea-level, and was recorded at around 6000 yrBP. As shown in Somboon (1990), Holocene transgression extended towards the region around Ayutthaya, 100 km from the present coast, and most of the Chao Phraya Delta was submerged according to the transgression. Late Holocene tidal sediments develop in the central and southern parts of the plain, and they show that the plain expanded according to the retreat of tidal plain towards the south. Slight regression can be seen around ca 4,500 yrBP. Late Holocene tidal sediments develop in the central and southern parts of the plain, and they show that the plain expanded according to the retreat of tidal plain towards the south.

3 Impacts of sea level rise to the Chao Phraya delta

Effect of the future sea-level rise is one of the serious problems in the low and flat deltaic regions of Southeast Asia, and the issues of sea level rise are also being considered in the Chao Phraya Delta (Somboon, J. R. P. and Thiramongkol, N., 1993; Sabhasri, S. and Suwarnarat, K., 1996). Geo-environments of the Chao Phraya delta are very susceptible to sea-level rise. It is assumed that sea-level rise influences the regions of the delta in various ways.

Elevation of tidal plain is 1-2 m and the sediments of the area consist of very soft silt or clay. This elevation is almost the same as the high tide level of the Gulf of Thailand.

In some places, land was reclaimed 1-2 m over the original surface, but most area of the tidal plain is not reclaimed and is used as aquacultural ponds and salt pans.

In particular, the embankments that are surrounding the tidal plain are low and weak condition, and they are vulnerable to coastal erosion.

Actually, in the western part of the Chao Phraya river mouth, rapid coastal erosion is now going on, and protection for coastal erosion in the area is not enough (Vongvisessomjai, S. et al, 1996). If sea-level rise occurs in the future, severe coastal erosion will be the most serious problem in the area. Even if sea-level rise is less than 50 cm, horizontal retreat of the shoreline will be a considerable distance from the present coast. Under the weak protection for the coastal embankment, coastal erosion may progress very rapidly. Soft silt and clay deposits of this area also accelerate rapid erosion.

On the other hand, the area of deltaic tidal plain is located on the inner side of the delta, but the area is also low-lying and has little relief. This environment will also be easily affected by sea-level rise. Serious subsidence has occurred in this area, and the current ground level has been lowered to 1 or 2 m (Photo 1). In several places, the ground level is lower than present mean sea-level. Therefore, drainage condition of the area have become very poor, and flooding may occur easily in the rainy season.

Somboon, J.R.P. and Thiramongkol, N. (1993), Nutalaya, P. (1996), and others have already discussed land subsidence of the area, and they also pointed out the problem in relation to sea-level rise.

Acceleration of the already poor drainage conditions is anticipated in the deltaic tidal plain because the surface gradient of the region is very low and the relative gradient of the drainage is going to decrease as a result of sea level rise. As there is little high ground in the deltaic tidal plain region except the artificial reclaimed land, the impact of sea-level rise may greatly effect the region. Land subsidence also accelerates the effect of sea-level rise.

Difference in flooding conditions can be seen in the deltaic floodplain according to the micro landforms (Fig. 2, 3). Natural levees, that are slightly higher than the surrounding region, develop along the several river channels in the western flank of the deltaic flood plain. On the other hand, there are a few micro landforms such as natural levees on the eastern flank of the deltaic flood plain, because the area has been cultivated for a long time and the original topography was already changed.

These geo-environmental differences show different flooding conditions. As the original landforms are preserved in the western flank of the deltaic floodplain, the region is easily flooded according to the increase of river discharge. Natural levees and other higher places, however, suffer little flooding or no flooding at all. On the contrary, swampy areas of a flood basin suffer severe flooding. Most of them develop in areas surrounded by natural levees.

On the other hand, settlements in the eastern flank of the deltaic floodplain are located on the fields that are well consolidated for arable land. If the drainage condition becomes poor, broad areas of the eastern flank of the deltaic flood plain will deteriorate (Photo 2). The flooding has the possibility to accelerate as a result of future sea-level rise.

4 Conclusion

There are considerable differences in the geo-environment of the Chao Phraya delta, and the effects of sea-level rise will cause these areas to react differently. If the prompt measure is not taken for the sea-level rise, the following effects may happen in each region.

In the region of tidal lowland along the present coast, vulnerability is characterized by coastal erosion and submergence of low-lying tidal land. Low elevation of the tidal delta caused by land subsidence may easily be affected by floodings and the condition will accelerate in response to the sea-level rise.

In ăreas of further inland on the deltaic floodplain, the contrast of geo-environment can be recognized in eastern and western flanks in terms of land consolidation. If the drainage function is not enough against the sea-level rise, the eastern flank might become a broad poor drainage area. On the other hand, most natural levees are free from floodings in the western flank of the deltaic floodplain. Serious problems may occur in the part of flood basin surrounded by natural levees..

Further examination should be undertaken using estimation of sea-level effects based on the combination of geo-environmental and socio-economic conditions.

Acknowledgement

The authors would like to express our sincere gratitude to Mr. Sin Sinsakul, Mr. Suwat Tiyapairach and Dr.Niran Chaimanee for their kind support to my fieldwork in the Central plain. JERS-1 data are used under the permission of RESTEC.

References

Bird, E. C. F. and Schwartz eds. (1985) The World Coastline. Van Nostrand Reinhold Company, New York, 1071 pp.

Milliman, J. D. and Haq, B. U. ed. (1996) Sea-level Rise and Coastal Subsidence. Kluwer Academic Publishers, 369pp.

Nutalaya, P., Young, R. N., Chumnankit, T. and Buapeng, S. (1996) Land subsidence in Bangkok during 1978-1988. in Milliman, J. D. and Haq, B. U (eds.) Sea-Level Rise and Coastal Subsidence, 105-130.

Sabhasri, S. and Suwarnarat, K. (1996) in Milliman, J. D. and Haq, B. U (eds.) Sea-Level Rise and Coastal Subsidence, 343-356.

Somboon, J. R. P. (1990) Geomorphology of the Chao Phraya delta, Thailand. Ph.D. Thesis, Kyoto University, 86 p.

Somboon, J. R. P. and Thiramongkol, N. (1993) Effect of sea-level rise on the north coast of the bight of Bangkok, Thailand. Malaysian Journal of Tropical Geography, 24, 3-12.

UNCRD/CIRDAP (1992) Development of Modules for Training on Integrated Approach to Disaster Management and Regional /Rural Development Planning. UNCRD-CIRDAP workshop and seminar, Phase III, vol. II, 334 pp.

Vongvisessomjai, S. et al, (1996) Coastal erosion in the Gulf of Thailand. in Milliman, J. D. and Haq, B. U (eds.) Sea-Level Rise and Coastal Subsidence, 131-150.

Warrick, R. A. and Ahmad, Q.K. ed. (1996) The Implications of Climate and Sea-level Change for Bangladesh. Kluwer Academic Publishers, 415 pp.

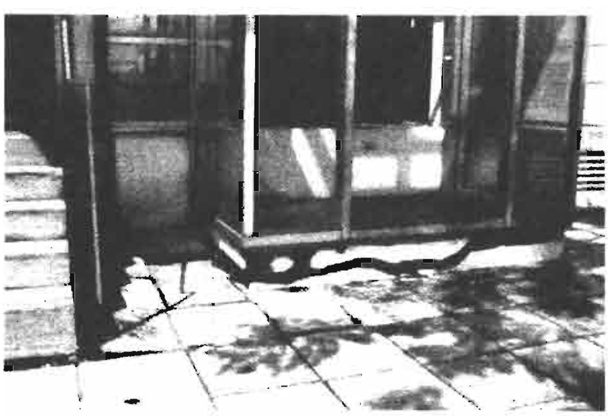


Photo 1
Land subsidence in the suburbs of Bangkok

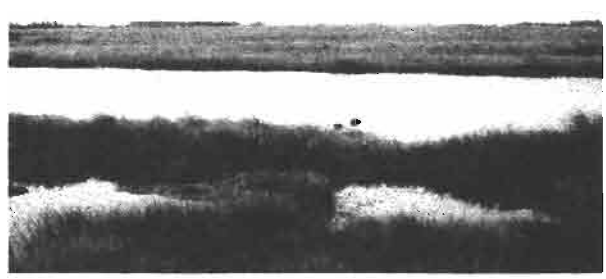


Photo 2
Poor drainage area of the deltaic floodplain in the Chao Phraya delta

Figures

FIG. 1 LANDFORM CLASSIFICATION MAP OF THE CHAO PHRAYA DELTA

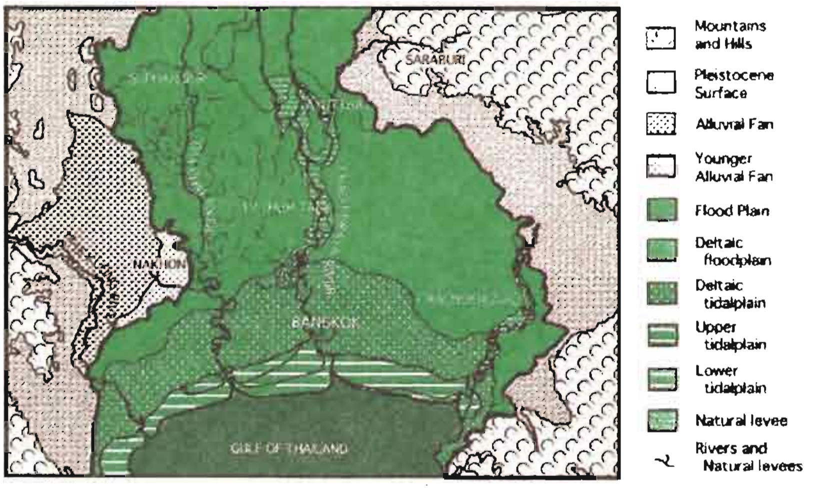


Fig. 2
JERS1 satellite image of the eastern flank of deltaic floodplain in the Chao Phraya delta.

Fig. 3
JERS1 satellite image of the western flank of deltaic floodplain in the Chao Phraya delta

Inland low-salinity shrimp farming in the central plains region of Thailand

Brian W. Szuster[1] and Mark Flaherty[1]

ABSTRACT: *Thailand is the world's largest producer of farmed black tiger shrimp which earned approximately $2 billion US in export revenues during 1999. The need for large volumes of brackish water to fill pond enclosures has traditionally limited the cultivation of tiger shrimp (a marine species) to a relatively narrow band of coastal land. Thai farmers have discovered, however, that it is both feasible and profitable to grow tiger shrimp in areas far removed from the coast by trucking hyper-saline water inland and mixing it with freshwater drawn from irrigation canals or natural streams. Small-scale tiger shrimp farms are now common in traditional rice growing areas such as Chachoengsao, Prachinburi, Supanburi and Nakhon Pathom. The development of low salinity culture techniques has been a major factor which facilitated the spread of tiger shrimp farming into freshwater areas. Other contributing factors include the substantial economic profits that shrimp culture provide as compared to rice cultivation, government policies that promote shrimp farming as a means of rural economic development, and the belief that inland freshwater areas are free from virulent shrimp pathogens.*

The rapid development of inland shrimp farm in the Central Plains region has, however, been accompanied by growing concerns over the potential environmental impacts associated with this activity. Specific impacts include soil salinization, water quality degradation as a result of effluent disposal, and water use conflicts with competing activities such as rice farming. Although many inland low salinity shrimp farms are small (less than 1 hectare in size) over 22,000 hectares of pond area were identified in a recent national inventory of this activity. This magnitude of development suggests that inland shrimp farming may have the potential to effect both local and regional soil and water resources.

1 Introduction

Inland shrimp farming is a relatively recent development in aquaculture that allows a marine species (the black tiger shrimp Penaeus monodon) to be raised in freshwater areas under mesohaline conditions (3–10 ppt). The emergence of low salinity shrimp farming within rice-growing regions of central Thailand has raised concerns regarding potential environmental

[1] Department of Geography, University of Victoria. PO Box 3050, Victoria, B.C., CANADA V8W 3P5. E-mail: bszuster@uvic.ca

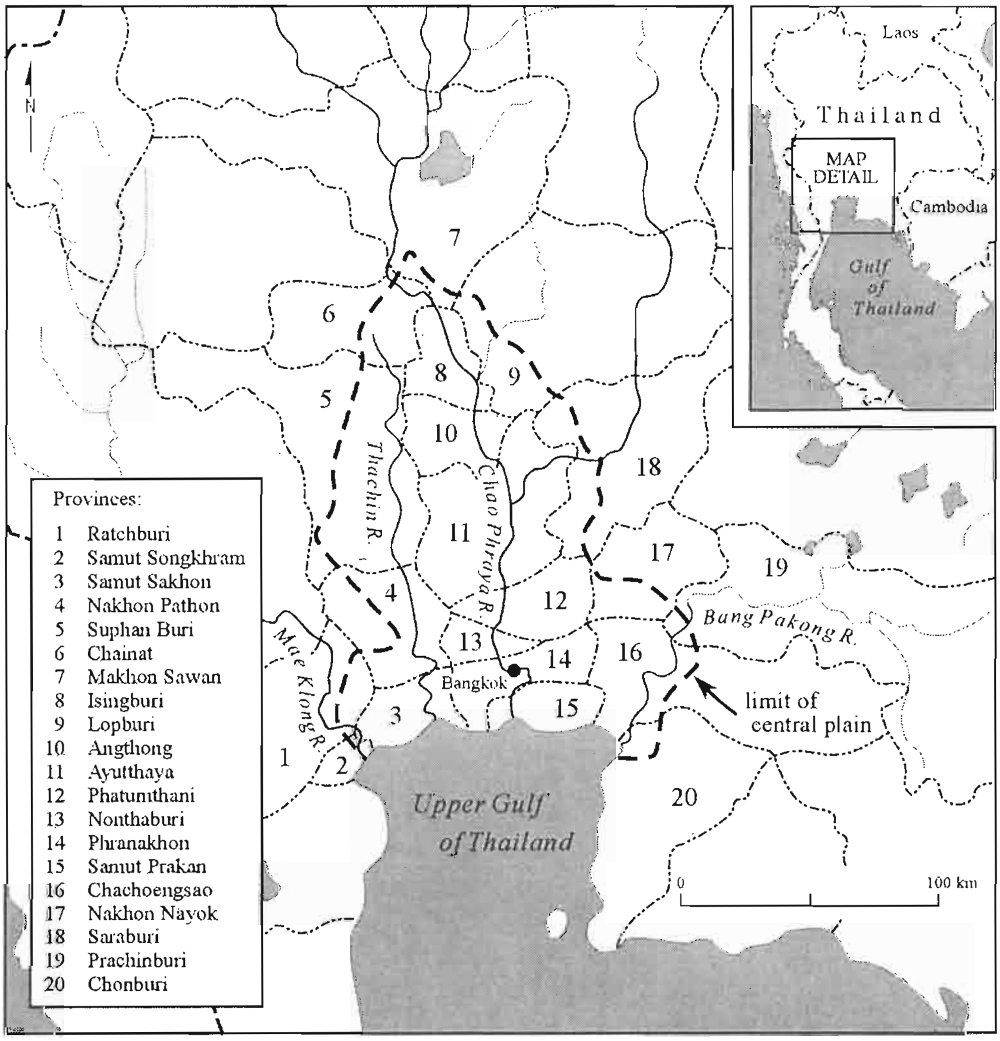
impacts, and the suitability of conducting this activity within highly productive freshwater agricultural areas. Specific environmental impacts of concern include soil salinization, water quality degradation as a result of effluent disposal, and water use conflicts with competing activities such as rice farming (Flaherty et al, 2000; Pongnak, 1999). This paper provides an overview of inland low-salinity shrimp farming in central Thailand. It describes the evolution of this form of aquaculture, discusses husbandry techniques, and examines the controversy over potential environmental impacts. For the purpose of this discussion, low-salinity tiger shrimp culture in freshwater areas is henceforth referred to as inland shrimp farming.

2 Development and evolution of inland shrimp farming

The need for large volumes of brackish water to fill pond enclosures has traditionally limited the cultivation of black tiger shrimp to a relatively narrow band of coastal land within tropical regions. This was certainly the case during the first wave of intensive aquaculture development in central Thailand during the 1980s, when shrimp farms in the Upper Gulf Region were established within the estuaries of the major rivers such as the Chao Phraya, Bang Pakong, Tha Chin, and Mae Khlong (Figure 1). Dry season saline intrusion is a common characteristic of these low gradient systems, and the seasonal availability of brackish water within streams and irrigation canals encouraged the construction of a second generation of tiger shrimp farms some distance upstream in areas such as Chachoengsao (Flaherty and Vandergeest, 1998). Brackish water is unavailable in upstream areas during the wet season, however, when higher stream flows counteract tidal influences. Low salinity shrimp culture was originally developed to overcome this limitation and provide a second annual crop (Flaherty et al., 1999). Culture techniques evolved through experimentation led by local shrimp farmers (Banpasirichote, 1993). These individuals discovered that if saline water was trucked-in from the coast when natural supplies of brackish water were unavailable, tiger shrimp post-larvae could be acclimatized to a low-salinity environment (Miller et al., 1999). Although familiarity and availability were the primary reasons for utilizing tiger shrimp in these experiments, this species is well known for its tolerance to significant variations in temperature and salinity (Laubier, 1990).

Low salinity shrimp farming expanded rapidly after the technical viability of this culture system was established, and farmers discovered that the high profits derived from shrimp production could easily offset increased costs associated with trucking salt water from the coast. These factors facilitated the spread of inland shrimp farming into freshwater agricultural areas that never experience seasonal salt water intrusion. Farms that draw freshwater from the existing rice irrigation infrastructure, and purchase saline water from tanker truck operators, now exist hundreds of kilometers from the coast in areas such as Changwats Prachinburi, Supanburi, Nakhon Pathom and Nakhon Nayok (Department of Land Development, 1999a).

FIGURE 1. CENTRAL PLAINS REGION OF THAILAND



The development of shrimp farming in freshwater areas was also hastened by on-going problems with water-borne viral disease outbreaks (e.g., white sport virus, yellow head) that substantially reduced production in coastal shrimp farming areas. Poor environmental conditions along the coast, combined with the susceptibility of coastal shrimp farms to disease, led some analysts to predict that overall Thai farmed shrimp production may decline (Dierberg and Kiattisimkul, 1996). With the development of low salinity shrimp culture techniques, however, farmers no longer required direct access to contaminated coastal waters. Development opportunities are limited only by basic site suitability criteria (e.g., relatively flat land and a reliable source of freshwater), salt water transportation expenses, and land leasing costs (Flaherty and Vandergeest, 1998). Inland shrimp farming could have represented as much as 40 percent of Thailand's total cultured shrimp production by late 1998 (Limsuwan, 1998), and an inventory conducted during this period by the Department of Land Development identified 22,455 hectares of land devoted to inland shrimp farming in the central region (Table 1).

TABLE 1 INLAND SHRIMP FARMS IN THE CENTRAL REGION OF THAILAND *

PROVINCE	AREA (ha)	PROVINCE	AREA (ha)
Chachoengsao	8375	Ang Thong	193
Prachinburi	4577	Khrung Thep	51
Nakhon Pathom	2204	Lopburi	48
Nakhon Nayok	1752	Chai Nat	46
Chonburi	1631	Nakhon Sawan	44
Suphanburi	1359	Nonthaburi	22
Samut Prakan	518	Kanchanaburi	19
Ayutthaya	451	Saraburi	16
Ratchaburi	350	Singburi	12
Phetchaburi	322	Uthaithani	10
Pathum Thani	244	Samut Songkhram	5
Samut Sakhon	206		

* Source: Department of Land Development, 1999a

The expansion of inland shrimp farming into Thailand's irrigated rice growing areas was halted in 1998 when the Royal Thai government banned inland shrimp farming in all freshwater provinces on the basis of a recommendation from the National Environment Board (Srivalo, 1998). Governors in coastal provinces were subsequently instructed to designate land within these areas as freshwater (where shrimp farming would be banned) or brackish water (where shrimp farming could continue). A joint committee including representative of the Departments of Land Development, Pollution Control, and Fisheries is also currently considering the fate of inland shrimp farming in seasonally brackish areas such as the Bang Pakong River Basin that are not easily classified using this approach. The Bang Pakong River Basin includes portions of Chachoengsao, Prachinburi, Chonburi, and Nakhon Nayok provinces, and the joint committee will submit a report and recommendations to the Thai government by January 2001.

In spite of the prohibition on shrimp farming within freshwater provinces over the past 2 years, concerns continue to exist over the capacity of the Thai government to enforce the ban, the manner in which brackish water and freshwater areas have been designated, and the possibility that the ban on inland shrimp farming could be relaxed (Flaherty et al., 2000). These concerns are reinforced by several factors. Shrimp farming plays an important role in the Thai economy, with sales to the United States, Europe and Japan earning approximately $2 billion USD in export revenue during 1999 (Bangkok Post, 2000a). The Thai government has also been a staunch supporter of shrimp farming, and is presently encouraging farmers to raise more shrimps so as to offset a worldwide shortfall caused by disease outbreaks in

Latin America (*ibid*). Although there may be some potential for increasing shrimp production through the intensification of existing farms, this strategy is accompanied by a higher risk of disease outbreaks and crop failure. It is likely, therefore, that increased production will require additional pond area which will be supplied by new operators entering the industry and/or existing farmers expanding their operations. With the further development of shrimp farming in Thailand's coastal areas increasingly constrained by high land values, more effective protection of mangrove forests, and concerns over the risk of disease owing to poor environmental conditions (Dierberg and Kiatismkul, 1998; Vandergeest et al., 1999), renewed pressure is likely to develop for the expansion of shrimp farming into freshwater areas (Bangkok Post, 2000b)

3 Husbandry and operating procedures

Inland shrimp farming practices are generally similar to those used in typical coastal operations which feature high stocking densities, aerated ponds, and a reliance on pelletized feeds, fertilizers and chemo-therapeutants. The primary difference is that while coastal farms use naturally occurring seawater (15-30 ppt) to fill and replenish pond enclosure, inland farms combine freshwater with saltwater purchased from coastal salt pans or saltwater concentrate operations. This approach achieves an initial pond salinity level between 4 and 10 ppt. Further freshwater inputs are subsequently used to offset evaporation and seepage losses, and this process can reduce pond salinity levels to near zero by the time of harvest unless supplementary salt is applied (e.g. trucked saline water or bagged salt). Even though naturally occurring brackish water is seasonally available in some areas of the Central Plains Region during the dry season (e.g., Bang Pakong River Basin) few inland shrimp farms will use this supply source due to the potential presence of viral pathogens and other contaminants such as pesticides (Ponza, 1999).

Thailand's transition from a small-scale producer into the world's largest exporter of cultured shrimp, has been facilitated by the development of over 1,500 small-scale "backyard" hatcheries (Kongkeo, 1994). A substantial low-salinity hatchery sector has developed in provinces such as Chachoengsao to support the inland shrimp farms, and these operations have made several adaptations to produce shrimp at the post-larvae (PL) stage of development that are acclimatized to a lower than normal salinity. Acclimation begins during the early post-larval stages in fry rearing tanks containing full strength seawater. Over a period of three to five days, salinity levels are gradually reduced from 30 ppt to 10 ppt by adding freshwater. The PL are ready for sale and delivery to farms when they are 12 to 15 days old.

A variety of methods are used to continue the acclimation process after the PL are delivered to the farm site (Miller et al, 1999; Ponza, 1999). The simplest method involves slowly mixing water contained in the PL transport packages with pond water until a salinity similar to the grow-out environment is achieved. A second technique involves maintaining the PL in a separate nursery pond for 45-60 days where they are acclimatized to lower salinity levels. The PL are then transferred to the larger grow-out pond by means of lift or bag nets. The most common PL acclimation method is, however, the use of a small PVC or earthen bund nursery pen constructed within the grow-out pond. In this approach, the grow-out pond is initially filled with fresh water to a depth of 30 to 80 centimeters, and saltwater is pumped into the nursery pen. For a typical 0.6 hectare grow-out pond using the nursery pen method, two 15 metric tonne truck loads of 60 ppt water are required to raise the salinity of the nursery pen water to approximately 10 ppt. (Miller et al, 1999). Sections of the plastic PVC paneling or bund are removed over the first 7 to 10 days and replaced with mesh to allow the saline pen water to slowly mix with freshwater in the rest of the grow-out pond. The PL are released from the nursery pen into the full grow out pond after the acclimation period is complete. Salinity in the full grow-out pond can range from 3 to 8 ppt at the end of the acclimation period depending on a variety of factors including pen size, water depth, and initial salinity levels.

Freshwater is generally added to the grow-out pond at a rate of 5 to 10 cm every 10 days during the grow-out period until a maximum pond water depth of 1.3 to 1.5 metres is achieved. The use of reservoirs to enhance water management during the grow out period is becoming more common, but these facilities can only be constructed on farms with adequate land holdings and the farmer must be willing to sacrifice production area (Flaherty et al, 2000). Reservoirs act as a buffer between water sources that contain disease pathogens or surface water pollutants, and can serve as receptacles for nutrient enriched harvest effluent. They are used to allow sediment to settle out of canal water before being added to the ponds, and reservoirs encircling the production ponds can also reduce saline water intrusion to adjacent rice paddies. The most common and simplest reservoir system is a water ditch barrier between shrimp ponds and surrounding rice paddies.

The standard grow-out period for inland culture systems is a relatively short 100-120 days. Harvest at inland farms occurs earlier than in most coastal operations as a result of falling salinity levels and the negative effect this has on shrimp health and development. Shrimp produced by inland farms average 50 pieces per kilogram at harvest (Ponza, 1999, Miller et al, 1999) which is quite small in comparison to coastal operations. Prices vary widely from crop-to-crop owing to international market fluctuations, but a typical price during the year 2000 for small shrimp sized at 50 pieces per kilogram is approximately $10 USD per kilogram (Shrimp World Incorporated, 2000). Although yields vary greatly between operations, a successful inland shrimp farm can produce 5 metric tonnes per hectare twice a year. Assuming the current farm gate price for small shrimp, a farmer with one hectare of his holdings devoted to shrimp culture would have a gross annual income of US $100,000 (based on two crops). This is at least 25 times the income of a typical rice farmer in central Thailand, and illustrates how lucrative shrimp farming can be compared to rice cultivation. It also explains why rice farmers who can raise the investment capital are willing to take a gamble on raising shrimp. In cases where rice farmers are unwilling or unable to invest themselves, there is ample opportunity for leasing paddy land to outside investors at rents that greatly exceed what they could obtain growing rice. Although than income estimate does not take account of the significant capital costs associated with pond construction, farm infrastructure such as pumps and aerators, and feed; successful shrimp farmers can commonly recoup their initial investment within one year. This assumes, of course, that they do not experience catastrophic disease problems which can lead to crop failures.

4 Environmental impacts

The ban on inland shrimp farming initiated a heated debate over the nature and significance of environmental impacts. Inland shrimp farmers were outraged at the imposition of the ban on their activities in freshwater areas, and argued that it was based on a biased environmental impact assessment information (Bangkok Post, 1998). Specific issues of dispute are the potential for salinization of agricultural soils, water pollution stemming from the discharge of pond effluents, and competition between agriculture and aquaculture for freshwater supplies.

4.1 Soil salinization

Salinization can occur directly through the deposition and accumulation in salts in soils located immediately beneath the pond enclosure, or indirectly as a result of seepage into adjacent agricultural areas. Indirect salinization impacts could also be produced through the disposal of saline effluents into streams or irrigation canals which are subsequently used to irrigate rice paddies or orchards.

The most recent estimate of land subject to direct salinization impacts as a result of inland shrimp farming in the central region is 22,455 hectares (Table 1) and we estimate salt loading to be roughly 2.7 metric tonnes per hectare per crop. This value assumes that 3 truckloads (15 metric tonnes each) of saltwater at 60 ppt are required for each hectare of inland shrimp pond. Since almost all farms produce two crops per year, annual salt inputs would be 5.4 metric tonnes per hectare per year. Use of the PL nursery pens reduces overall salt requirements, but this approach is not universal and salt inputs are substantially higher on farms that maintain pond salinity levels at 10 ppt throughout the grow-out period. This estimate also does not consider the common practice of adding bagged salt during the grow-out period to maintain salinity. Given these factors, a 5.4 MT per hectare annual salt loading figure should be considered conservative.

The significance and extent of indirect soil salinization effects are, however, much more difficult to assess. Recent studies conducted by the Thai Ministry of Science and Technology (1999) suggest that seepage can increase salinity in soils from 50 to 100 meters from the edge of inland shrimp ponds. Caution must be exercised in assessing the amount of land actually effected by indirect impacts because impact pathways are extremely complex and mitigating factors exist (e.g., natural soil flushing by monsoon rains). Given the size and agricultural importance of the areas potentially effected, however, the significance of direct and indirect soil salinization impacts should not be underestimated. Much of the land converted to shrimp pond was highly productive rice paddy, and the cost of returning this land to agricultural production if shrimp farming fails could be substantial (Land Development Department, 1999b).

4.2 Water pollution

While water quality problems are common in all shrimp farming areas, these can be especially problematic in inland regions where small streams and irrigation canals posses a relatively low assimilative capacity. The majority of the nutrients added to shrimp ponds in the form of fertilizer or pelletized feed are not incorporated into the shrimp, but end up being deposited in pond sediments or discharged as effluent (Funge-Smith and Briggs, 1998; Tookwinas, 1997.). Most small inland shrimp farms ponds completely drain grow-out ponds at harvest, and release large quantities of untreated effluent directly into adjacent water bodies. Only a relatively small number of large operations treat and recycle effluent within holding reservoirs. The decomposition of organic waste in surface waters reduces dissolved oxygen levels, can suffocate or smother aquatic fauna, and produces toxic chemicals such as ammonia and hydrogen sulfide (Primavera, 1998).

Inland shrimp farms operate somewhat differently than coastal operations, as very little effluent is released during the first 60 days of the grow-out cycle (Braaten and Flaherty, 2000). Feed requirements are relatively modest at this point, and additions of freshwater are usually sufficient to maintain water quality in the pond. During the latter half of the culture cycle, however, water exchange is used to maintain the growing environment and effluent is discharged. A significant amount of nutrient enriched effluent is also released during harvest when the ponds are completely drained. Very little information is available on the composition and impact of inland shrimp farm effluent, but it has been estimated that culture period and harvest effluent contain BOD concentrations of between 10 and 25 milligrams per litre (Pollution Control Department, 1996, Ingthamjitr, 1999). Although the effect of shrimp farm effluent on receiving waters is of concern, a much more serious issue exists with regard to the disposal of semi-liquid sludge that remain in the grow-out ponds after harvest. This material consists of uneaten feed, faeces, and sediments eroded from the pond enclosure (Funge-Smith and Briggs, 1998) and is a highly polluting with BOD concentrations of 1500 milligrams per litre or higher. Pumping pond sludge directly into adjacent water bodies is illegal, and this material is usually maintained on site where is it is kept in holding ponds or packed onto pond banks. The illegal dumping of pond sludge into freshwater bodies is not uncommon, however, due to a lack of farmer awareness and regulatory enforcement (Department of Pollution Control, 1996; Braaten and Flaherty, 2000).

Other important water pollutants originating in shrimp ponds are the chemo-therapeutant products added to the ponds by the farmers. These chemicals can leave the ponds through effluent, seepage through pond bottoms, and through the removal and disposal of bottom sludge. One of the most common and worrisome pond additives is antibiotics. Most commercial shrimp feeds are enriched with common antibiotics such as oxytetracycline. Studies of fish farms have shown that the majority of antibiotics added in feed are not assimilated by fish but go into environment (Weston, 1996). Once in the environment antibiotics can have a wide range of effects. In surface water, they may lead to antibiotic resistant pathogens or accumulate in the tissues of wild fish. If they accumulate in sediments, antibiotics may prevent natural bacterial decomposition and consequently alter the natural benthic environment (Chua et al, 1989).

5 Water use conflicts

It is not surprising that inland shrimp farming evolved within traditional rice growing areas of Thailand, as the activity requires substantial quantities of fresh water to fill pond enclosures and maintain environmental conditions during the grow-out period. The presence of plentiful fresh water supplies is critical to the success of inland shrimp farming, and irrigation infrastructure originally developed for rice cultivation is easily adapted to aquaculture. Water use impacts associated with shrimp farming typically involve excessive consumption or competition between rice and shrimp farmers for limited supplies (Miller et al, 1999).

Although limited information is available on inland shrimp farm water use, a recent study has been completed on this topic (Braaten and Flaherty, 2000). This study found that a typical inland shrimp farm consumes approximately 9000 m^3 of water per hectare per crop, and withdraws approximately 2600 m^3 per hectare per crop. These figures are roughly similar to the amount of water required to raise crops such as wet rice, banana or sugarcane, and suggests that inland shrimp farming should not have a significant effect on consumptive water use within irrigated agricultural areas. In non-irrigated areas, however, inland shrimp farming may still have the potential aggravate existing water use conflicts. The dry season is the optimum period for raising shrimp, and this preference may increase fresh water demand during a period of limited supply. Dry season demand for freshwater may even increase in areas that have saltwater naturally available as a result of intrusion, because shrimp farmers generally avoid this water source due to concerns over quality and virus transference. Water use conflicts are also possible as a result of groundwater pumping. A ban on groundwater pumping for aquaculture purposes has been imposed in coastal areas of Thailand to prevent subsidence and protect agricultural and domestic water supplies, but the prevalence of this practice in the inland shrimp farming sector is currently unknown.

6 Conclusions

Inland shrimp farming presents a situation where significant short-term economic benefits may be obtained, but at the risk of creating significant environmental impacts. Of the impacts discussed above, soil salinization is clearly the most critical issue due to the potential for inland shrimp farming to cause long term damage to agricultural areas which may be difficult and expensive to reverse (Ministry of Science and Technology, 1999). Cumulative effects are a second area of concern. Although many inland low salinity shrimp farms are less than 1 hectare in size, the existing magnitude and density of development in many areas may have the potential to degrade regional soil and water resources (Flaherty et. al., 2000). Cumulative effects represent the additive or inter-active effects of multiple small-scale activities (such as shrimp farming) on larger ecological units such as watersheds. Although the short-term impact of an individual inland shrimp farm on regional environmental quality is likely to be limited or negligible, the long-term cumulative effect of a large number of inland shrimp operations on regional soil and water conditions may be substantial due to the slow accumulation of salt and other waste products.

Current studies into the environmental impacts of inland shrimp farming in Thailand are focusing on the site-specific effects of individual operations. Although these studies will undoubtedly increase our understanding of specific environmental concerns, this approach cannot address the potential cumulative effects produced by large numbers of inland shrimps farms operating in dense concentrations. If inland shrimp farming continues in some form within Thailand, we believe that research into the long-term regional implications of this activity must be undertaken to insure the security of soil and water quality in Thailand's agricultural heartland.

REFERENCES

Bangkok Post. (1998). Biased study upsets inland shrimp farms. December 13.

Bangkok Post. (2000a). Bullish time for shrimps. September .20.

Bangkok Post. (2000b). Inland ban may be eased - Black tiger prawns fetch higher profits. September .27.

Banpasirichote, C. (1993). Community Integration into Regional Industrial Development: A Case Study of Klong Ban Pho, Chachoengsao. Chulalongkorn University Social Research Institute, Year End Conference. Jomtien, Thailand: December 10-11, 1993.

Braaten, R. and M. Flaherty (2000). Hydrology of Inland Brackishwater Shrimp Ponds in Chachoengsao, Thailand. Aquacultural Engineering. 23 (4):295-313.

Chua, T., Paw, J. and Guarin. (1989). The environmental impact of aquaculture and the effects of pollution on coastal aquaculture development. Marine Pollution Bulletin 20, 335-343.

Department of Land Development. (1999a). Zoning Maps for Shrimp Farming in Freshwater Areas. Ministry of Science, Technology and Environment, Bangkok, Thailand. (In Thai).

Department of Land Development. (1999b). Rehabilitating Land Effected by Shrimp Farming in Freshwater Areas. Ministry of Science, Technology and Environment, Bangkok, Thailand. (In Thai).

Dierberg, F. and Kiattisimkul, W. 1996. Issues, impacts, and implications of shrimp aquaculture in Thailand. Environmental Management 20, 649-666.

Flaherty, M., B.W. Szuster and P. Miller. (2000).Low Salinity Shrimp Farming in Thailand. Ambio 29 (3), pp. 174-179.

Flaherty, M., Vandergeest, P. and Miller, P. (1999). Rice paddy or shrimp pond: Tough decisions in rural Thailand. World Development 12, 2045-2060.

Flaherty, M. and P. Vandergeest. (1998). "Low salt" shrimp aquaculture in Thailand: Goodbye coastline hello Khon Kaen! Environmental Management. 22 (6):817-830.

Flaherty, M. and Karnjanakesorn, C. 1995. Marine shrimp aquaculture and natural resource degradation in Thailand. Environmental Management 19, 27-37.

Funge-Smith, S. and Briggs, M. 1998. Nutrient budgets in intensive shrimp ponds: Implications for sustainability. Aquaculture 164, 117-133.

Ingthanjitr, S. (1999). An Environmental Impact Assessment of the Tiger Prawn (Penaeus monodon) Culture in Nakhon Pathom Province. Technical Paper No. 16/1999. Fisheries Environment Division, Department of Fisheries, Ministry of Agriculture and Cooperative. Bangkok, Thailand.

Kongkeo, H. (1994). How Thailand Became the Largest Producer of Cultured Shrimp in the World. Paper presented at INFOFISH International Conference - Aquaculture Towards the 21st Century, Colombo, Sri Lanka.

Laubier, A. (1990). Penaeid prawns. Aquaculture: Volume 1. G. Barnabé (ed.). New York: Ellis Horwood, 1990.

Limsuwan, C.S. (1998). Closed Recycle System for Sustainable Black Tiger Shrimp Culture in Freshwater Areas. Paper presented at the Fifth Asian Fisheries Forum: International Conference on Fisheries and Food Security Beyond the Year 2000, November 11-14, 1998, Chiang Mai, Thailand.

Lin, C.K. (1995). Progression of intensive marine shrimp culture in Thailand. Swimming Through Troubled Water: Special Session on Shrimp Farming. C. Browdy and J. Hopkins (eds.). World Aquaculture Society, Baton Rouge, LA.

Miller, P., M. Flaherty, and B.W. Szuster (1999). Inland Shrimp Farming in Thailand. Aquaculture Asia. 4(1), pp. 27-32.

Ministry of Science, Technology and Environment. (1999). Environmental Impact of Shrimp Farming in Freshwater Areas. Committee on Inland Shrimp Farming. Bangkok, Thailand. (In Thai).

Pongnak, W. (1999). Case Study on the Impact and Conflict in Using the Nations Freshwater Land Resources for Farming Panaeid Shrimp. Greenline. No. 4 (June-September, 1999), pp. 6-15.

Primavera, J.H. (1998). Tropical shrimp farming and its sustainability. In: Tropical Mariculture. De Silva, S. (ed), Academic Press, New York, pp. 257-289.

Shrimp World Incorporated. (2000). Current Prices for Shrimp Imported to the United States. Internet site: http://www.shrimpcom.com. October, 2000.

Srivalo, P. (1998). Cabinet Bans Inland Shrimp Farms. The Nation, 8 July 1998.

Tookwinas, S. (1997). An intensive marine shrimp culture in freshwater area (Suphanburi province): The preliminary investigation on impact assessment. Thai Fisheries Gazette. 50(2): 153-164.

Weston, W. (1996). Environmental considerations in the use of antibacterial drugs in aquaculture. In: Aquaculture and Water Resource Management. D. Baird, M. Beveridge, L. Kelly and J. Muir (eds.), Blackwell: London, pp. 140-165.

Acknowledgements

The financial support provided by the following institutions is gratefully acknowledged: the Social Science and Humanities Research Council of Canada, the International Development Research Centre, and the University of Victoria. Logistical support provided by the Department of Aquatic Science at Burapha University in Bang Saen, Thailand is also recognized.

Evolution of Land-use in Urban-Rural Fringe Area: The Case of Pathum Thani Province. [1]

Orapan Srisawalak-Nabangchang, Warin Wonghanchao

Abstract: *Imperfect competition in the land market and speculative uses of land have often been cited among the main reasons for the economic crash in the middle of 1997 and the head down collision into economic recession from which Thailand has not yet recovered. Critical review of causes and effects highlight several underlying causes which originated from shortcomings or inadequacy of planning and management tools and control of land use which, in turn, determine efficiency and equity aspects of resource utilization. Explanations can also be found in the flaws of the institutional components, financial institutions' lending policies that contributed to availability of money supply to finance speculative and non-productive demands for land and the regressive system of land tax, which allowed for speculators to hold land with minimum, if not negligible opportunity costs. These variables coupled with rules and regulations governing procedures of land transaction all share blame for perpetuation of the imperfection of the land market.*

Using Pathum Thani, one of the five vicinity provinces of Bangkok, located in a very fertile area of the central plains as the Case Study Area, the paper analyses economic losses from unplanned expansion of Bangkok into urban-rural fringe areas. Characteristic of the changing land use patterns of suburban areas, major changes in land use have taken place in this Province. A large area of agricultural land has been converted for residential, commercial, recreational and industrial uses. During the so-called economic boom period, land market in Pathum Thani was particularly active for speculative purposes. Increasing land price, diminishing purchasing power of middle and lower income groups and deteriorating environment are among the major reasons which turned Pathum Thani and other vicinity provinces into dormitory towns for daily commuter work forces which form part of the day time population of Bangkok. In the context of sub-optimum level of land use control and motivated by conditioned by prospective demands and supplies of houses, services and amenities, developers and speculators were able to take a large area of land out of productive use. The rows of unfinished real estate projects and empty residential units are manifestations that

[1] The paper is a part of the research findings of an on-going study on "Land Tenure and Land Utilization, the Economic and Legal Measures for Maximization of Land Use" which is supported by the Thailand Research Fund. The authors would like to acknowledge in particular, the contribution of Mr., Sopon Chomchan of the Land Development Department, Ministry of Agriculture and Cooperatives and Dr. Utis Khaotien, Assistant Secretary General of the National Economic and Social Development Board for their contribution in terms of data support and inputs into the conceptual framework of the paper.

developers and speculators too suffered from the illusions of the bubble economy they have partly created.

The purpose of this paper has been to illustrate private and social costs and gains to the evolution of land use patterns in Pathum Thani. The economic analysis of impacts from changes in land use patterns focuses around three issues: (i) loss of productivity from land taken out of production for speculative purposes; (ii) forgone investment in development of land for agricultural production namely irrigation infrastructure and land reform measures; (iii) efficiency loss resulting from distortion in the land market where prices become conditioned by speculative demands for land as opposed to price resulting from competing land uses among economic activities.

The paper also discusses the inefficiency of land use from spatial planning criteria from uncontrolled urban expansion, such as concentration of up areas along the road network and mushrooming of sub-centres creating 'ribbon', the 'leap frog' pattern of spatial development and underutilization of hinterland areas. It also addresses issues of environmental externalities resulting from uncontrolled urban expansion. The manifestations of inefficiency in these areas are analysed in terms of divergence of private and social cost.

1 Background and Coverage of the Paper

Imperfect competition in the land market and speculative uses of land have often been cited among the main reasons for the economic crash in the middle of 1997 and the head down collision into economic recession from which Thailand has not yet recovered. Critical review of causes and effects highlight several underlying causes which originated from shortcomings or inadequacy of planning and management tools and control of land use which, in turn, determine efficiency and equity aspects of resource utilization. Explanations can also be found in the flaws of the institutional components, financial institutions' lending policies that contributed to availability of money supply to finance speculative and non-productive demands for land and the regressive system of land tax, which allowed for speculators to hold land with minimum, if not negligible opportunity costs. These variables coupled with rules and regulations governing procedures of land transaction all share blame for perpetuation of the imperfection of the land market.

Using Pathum Thani, one of the five vicinity provinces of Bangkok, located in a very fertile area of the central plains as the Case Study Area, the paper analyses economic losses from unplanned expansion of Bangkok into urban-rural fringe areas.

The paper is divided into 4 Section. Following this introductory section, Section 2 provides an overview of the development of urban land use pattern in Thailand briefly describing planning tools, legal, institutional and fiscal tools employed to control and regulate land use. Issues addressed in this section centre around the causal relationship between the pattern of spatial development and the structural problems of urbanization focusing in particular on adverse economic repercussions of non-rationalized land use. Reference is made to the institutional and legal support structures for urban land-use management, current policy instruments, which are directly or partially related to the assertion of planning and control measures on urban land-use.

The third part of the paper traces the development of land use in one of the five vicinity provinces of Bangkok, Pathum Thani. The interest of this Province is that development of urban spatial forms in this province clearly illustrate the causes and effects of uncontrolled urban expansion, such as concentration of up areas along the road network and mushrooming of sub-centres creating 'ribbon', the 'leap frog' pattern of spatial development and underutilization of hinterland areas. The economic of impacts from changes in land use patterns can be defined in three areas. These include (i) loss of productivity from land taken out of production for speculative purposes; (ii) forgone investment in development of land for agricultural production namely irrigation infrastructure and land reform measures; (iii) efficiency loss resulting from distortion in the land market where prices become conditioned by speculative demands for land as opposed to price resulting from competing land uses among economic activities.

The final Section concludes with general remarks of future directions of land use development and factors, which needs to be taken in consideration in policy formulation.

2 Urbanization of Thailand [2]

2.1 The Emerging Land Use Patterns

Land use in Bangkok Metropolitan Region has been classified into two broader zones, comprising of the inner city districts within 10 kms of the Rattanakosin Area which is the main concentration area for government offices, commercial activities, educational establishments and living quarters. The outer bound is defined as the next 10 kms ring functioning as the new central business district accommodating outward increase in the numbers of businesses and commercial activities. Presently, the key government operations and businesses and commercial activities are concentrated in these inner city bounds and it continues to be the major employment areas. Intensification of economic activities and continued demand for centrally located sites is the main reason for rise in land price in these locations.

The outer part of Bangkok is defined as the 20-40 km ring from the centre and linked to it by radial roads northwards and southwards to Nonthaburi and Samut Prakarn and eastwards and westwards to Chachoengsao and Nakhon Prathom. Around 25% of these suburban areas have been classified as residential areas, a ratio is likely to increase given the continued rise in land prices in the inner city area as well as the deterioration in urban pollution which are the main discouraging factors for middle to upper income level groups to live in the inner city area. The remaining 75% of the land are utilized for manufacturing and commercial activities while large parts of the land remain under agricultural production. The outward expansions of economic activities together with the economic and environmental factors are likely to intensify land use in these fringe areas. Though linked with the inner city by expressways and arterial roads, of adequate distributor roads and access roads and

[2] Parts of this Section have been revised from a paper entitled, The Use of Economic Instruments for Urban Land Management prepared by one of author, Orapan (Srisawalak) Nabangchang, for the Chulalongkorn University European Studies Programme (CUESP) supported by the European Commission in Brussels, completed in September 1999.

lagging development of urban amenities are said to be the prevalent problems of these areas.

Between 1960 and 1970, Bangkok has expanded (in spatial terms) by over 100% from an area of 96.4 sq.km to 189.7 sq. km with the incorporation of adjoining Thonburi province.[3] By the late 1990s, the population of Bangkok has escalated to 5.2 million equivalent to 9% of the total population, and its area has extended to 1,568 sq. km The functional area of the city would be greater than the population figures indicated since adjoining provinces such as Nonthaburi and Pathum Thani have become residential towns for commuters who work inside Bangkok. A large percentage of blue and white collar worker in these provinces in these two provinces as well as in Samutprakarn make up a sizeable day time population of the Metropolis. With the inclusion of the five vicinity provinces, the population of the extended Bangkok will be 8.1 million equivalent to 14.0% of the total population. [4]

Between 1994-1995, Thailand's average rate of population increase was 0.6%. With out-movement of people to the vicinity provinces, Bangkok's population actually reduced by an average of -0.2% during the same period. Population increase in the five vicinity provinces on the other hand was significantly higher than the national population growth rate ranging from 1.3% p.a.for Samutprakarn, 1.5% p.a. for Nakhon Pathom, 1.9% p.a. for Nonthaburi and equal rate of 2.5% p.a. for Pathum Thani and Samut Sakhon. [5]

The pattern of urban land use has been mainly influenced by private developers due mainly to weak enforcements of planning and control measures of concerned authorities in the public sector. During the early 1980s, density increased on the eastern side of the city while urbanization on the western part of the city was mainly at the expense of loss of agricultural land. The recent completion of the outer ring road will have the same effect in generating urban sprawl as the arterial road Vipavadee Rangsit road, Phahonyotin Road, the Ransit Nakhon Nayok Road have had in the past.

The declaration of '*Control Area'* places legal restraints on land usage, frontage access area, floor space allocations. A total area of 140,000 *rai* [6]to be preserved as the 'green belt area' on the east as well as on the western part of the metropolis on the eastern and the western part of the Metropolis. Housing developments continued to expand despite these legal restraints however. This was mainly due to rising market prices for land; lower returns from utilization of land for agricultural production as opposed to non-agricultural (i.e., primarily commercial, real estate development). Numerous private housing developments have been emerged to take opportunity of economic boom during the late 1980s, a period which increased business volume of professional developers and created many amateur developers. Vicinity provinces such as Nonthaburi, Pathum Thani, Samut Prakarn are

---

[3] Thailand Development Research Institute (TDRI), *National Urban Development Policy Framework,* Final Report, Vol. 2, Study Area 5, p. 2, A Study prepared for the Office of National Economic and Social Development Board and UNDP.

[4] Data Update, in *Government Housing Bank Journal,* Year 4, No. 13, April-June 1998, p.70.

[5] Population Census, Department of Local Administration, Ministry of Interior

[6] Local area measurement where 6.25 rai = 1 hectare

packed with recent private housing projects of varying price ranges. The expansion of road infrastructure and bridges across the Chao Phraya River has been accompanied by ribbon development, leap frog phenomenon with limited spread effects on the hinterlands. The slow down of the fever following the event of the Gulf war pushed many developers, professional and amateurs alike into bankruptcy. Nevertheless, land continues to be one of the less risky areas of investment. Since land tax is minimal, the opportunity cost for holding land as an asset was negligible and with financial institutions eager to lend large amount of capital using over-valued land as collateral, the Thai economy was heading for a predictable crash which eventually happened in the mid 1997.

2.2 Land-use related problems of urbanization

The damages in terms spatial forms from the above urban development process are evident in the present land use of BMA, i.e., insufficient road ratio, unsystematic road networks, numerous blind land parcels and an overall low efficiency in pattern of land use. The intensive competition demands that developers build in comprehensive services such as water supply, electricity, garbage collection services, security guards, etc., as part of their marketing strategies. While there are comprehensive services within private housing projects, there have been inadequate efforts in linking up these private housing projects with the broader road networks or to link up with local existing urban systems to which 'new communities' are superimposed. a large scale influx of new residents often create an overnight demand for public facilities creating bottlenecks in supply of amenities, waste water and solid-waste facilities. Excessive construction not only causes pilfering of top soil is observed to be causing damaging results from inundation[7] but construction of these real estate projects often involved filling up natural waterways and canals and altering the former drainage systems causing flooding problems.

In short, urbanization as a result of rapid economic development has many externalities that are reflected in the poor quality of life, congestion of living space, air and noise pollution, problems of transportation and inadequacies of urban services. With the lack of tradition for cost sharing of public utilities and amenities, the burden for provision of these services relied solely on public sector spending.

One major area of concern over un-controlled expansion of urban areas is the loss of agricultural land. Between 1974 and 1984, it has been estimated that urbanization of the metropolitan area resulted in an average loss of 32 sq. kms per year [8] and between 1984-1989, it has been estimated that an average of 18,000 *rai* per year of agricultural land has been converted to golf courses and residential housing projects. [9] Large scale transfer of prime agricultural land in Nonthaburi province has been converted to real estate areas during

---

[7] TDRI, *op cit.*, p. 7

[8] Dowall D.E., *The Land Market Assessment: A New Tool for Research and Policy Analysis*, paper presented in the International Conference on Property Taxation and Its Interaction with Land Policy, Lincoln Institute of Land Policy, September 22-26, 1991, Cambridge Mass., U.S.A., p. 452

[9] Estimated figure of the Office of Agricultural Economics, Ministry of Agriculture and Co-operatives.

the economic boom period and the province has become, in effect, the dormitory town for middle to upper income groups, the majority of whom represent the day-time residents of Bangkok Samut Prakarn, agricultural land has been converted into industrial and residential areas. Similarly, in Samut Sakhon: small-scale factories, mini-factories and industrial estates. Not much change in land use has been observed in the case of Nakhon Pathom during the economic boom period since a large area of land has already been converted to industrial areas, commercial and residential areas.

Inefficiency of urban land use is manifested in conflicting patterns of land-use. With weak enforcement of land use plans, it is not uncommon to find mixture of varying types of land use. Along the Pathum Thani's provincial highways for example, industrial factories are located amidst residential areas typically along side the arterial roads. Built up areas follow the transport corridors and areas of emerging economic activities such as the corridor to the designated industrial nucleus in the Eastern Region, the upper Central Region.

Urban sprawls and mushrooming of dormitory towns generally result in increases in average travelling distance, daily travelling hours and travelling expenses. Urbanites have become auto-dependent and energy-intensive society. Such changes not only incur private costs which are absorbed by the households, but they affect the real economic sectors pushing up unit cost of production from various forms of incremental costs mentioned.

2.3 Land Management Tools

2.3.1 Planning Tools

While solution from the public sector is slowed down by legal and bureaucratic procedures, the immediate answers provided by private sector initiatives which to alleviate problems in the short run may prove to be highly problematic for future management and control. One positive indicator for the future is that the externalities of urban living environment have been recognized as a development priority in the formulation of the Eighth Social Economic Plan is the acknowledgement of the inadequacy of provision of basic urban infrastructures in the Bangkok Metropolitan Area (BMA) and suburban areas.[10] The State recognizes that failure to efficiently manage and control land use, as reflected by the haphazard and unsystematic nature of urban land use, is due to the absence of a strategic plan and lack of appropriate town planning control measures. Reference is made to the lack of financial resources, to the inability of the State to bear all the costs, to the inability of local authorities to take independent initiatives as well as to the sub-optimum level of private sector participation.

Comprehensive plan which are prepared by Provincial City Planning Offices of the Department of Town and Country Planning (DTCP). In principle such plans are revised every five years, in situations where replacement plans are not approved of in time, there is a planning lag where no land-use regulations are in effect. The key implementing agencies are the Public Works Department and the Office of Accelerated Rural Development. The main thrusts of these plans are mainly infrastructural oriented. Due to weak enforcements,

[10]Concept and Strategy for National Development During the Eighth Plan, Seminar Document circulated in Meeting at Ambassador City, Phattaya, March 3-4, 1995 (Bangkok: NESDB), 1995

Comprehensive plans become no more than land-use zoning maps with no mechanisms for enforcement. The existence of the Town and Country Planning Office at the Provincial level cannot be taken as an indication of decentralization of land use planning given that 'planners' apply standard benchmark indicators and based on linear trend projections for the next 20 year period rather than being visionary or attempting to guide spatial form of development. Standard formulas are applied, i.e., service areas per population, amenities, etc. [11]

The more detailed 'Specific Plans' or municipality plans and municipality by-laws incorporate aspects of density control, environmental and conservation projects It is not, however, mandatory that all localities prepare 'Specific Plans'. Very few 'Specific Plans' are prepared because municipalities rarely have the manpower and expertise to prepare such plans. Moreover, for such plans to be effective, approval of the Central government is required which entails long bureaucratic procedures as opposed to the more consultative processes, which have now become the mainstream.

The preservation of agricultural green-belt zone with low population density has been one of the main areas of weak enforcement, given that these fringe areas has very high market potential if converted into other forms of non-agricultural usages particularly residential or housing projects. Prior to the economic crisis, land price in such areas have soared have resulted in large-scale transfer of land from agricultural uses. Similar to the Japan, many investors were seeking to capture capital gains in taxes and not interested in the potential of land to generate revenue from its use value per se. During such period, land is thus taken out of production and mainly held for speculative purposes.

Not only are there problems of inter-agency co-ordination within the Central government agencies located in Bangkok, there are also problems of co-ordination across jurisdiction of different provinces. Municipalities' jurisdiction covers only the legal boundary of the municipality. A number of preceding studies have observed that the 'urban areas' spread beyond the administrative boundary that it makes more sense to estimate the 'size' of the urban area by the population rather than by the land area. What has happened in most urban centres is the over-spill of the population, the urban sprawl into areas lying outside municipal boundary, then it 's no man-land and accompanying problems of supply of urban services, etc.

2.3.2 Legal Tools

In the context of Thailand, the legal provisions function more to provide the control functions and are not tools to shape or guide land development. There are various pieces of legislation that are related to different aspects of urban development that are pertinent to land use and urban land management. Key pieces of legislation include the Land Code Act, 1954, Condominium Act, 1979, Immovable Properties Acquisition Act, 1987 in addition to pieces of

[11] Kruger Consult, *Urban Environmental Management in Thailand: A Strategic Planning Process,* Final Report, A study prepared for the Office of the National Economic and Social Development Board and the Danish Cooperation for Environment and Development (DANCED), December 1996

legislation that deals with taxation of immovable properties such as the Housing and Land Taxation Act, 1932. [12]

Pieces of legislation that deal with city planning, land use and building control include the City Planning Act 1975, the Revolutionary Announcement no. 286 on land subdivision, the Building Control Act, 1979 and the Housing and Land Rent Control Act of 1961,[13] Real Property Services Act, 1975.

The power of eminent domain is stipulated in the Immovable Properties Acquisition Act, 1987. If fully capitalized, the power of eminent domain can be used to shape urban landscape through acquisition of land for use as public areas, green areas, or for installation of adequate amenities and urban services. To date, the exercise of the power of eminent domain has been limited. Public consultation for development projects, which has made mandatory by the Constitution of 1997, desirable as it may be, if not kept within bounds, can cause delays in reaching settlements for just compensation and open loopholes for interested parties to capitalize from negotiation outcomes.

These pieces of legislation creates a range of public stakeholders with ad hoc responsibilities with mandates to address isolated issues, solving immediate problems or issues with no in-built system for effective inter-Ministerial or inter-departmental co-ordination. General criticisms have been on the ambiguities, obsoleteness in view of the changing social-economic context and ineffectiveness due to weak enforcement or low penalties.

2.3.3 Fiscal tools

To date, taxes have not been used as tools to manipulate land use in Thailand. Two types of taxes levied on land Local Development tax and Housing and Land Tax. Local development tax is only levied on residential property and on land parcels that are not located adjacent to properties already subject to payment of Housing and Land Tax. It is a regressive tax, which is based, is the average agricultural land prices. That is the rate being 0.5% of land price for parcels of land with are lower than 30,000 Baht/*rai* while for parcels with assessed market value higher than 30,000 Baht pay a lower rate of 0.25% of assessed value of land. Exceptions are made for land leased for agricultural production will pay half the rates quoted. For owner cultivator, tax paid will not exceed 5 Baht/*rai*. Allowances can also be granted for residential area, for grazing land and for owner-occupier agricultural land for an area between 50 sq, *wah* to 5 *rai*. It is also stipulated that for the owner of property that is located adjacent to properties already subject to payment of Housing and Land Tax will be exempted from payment of Local Development Tax.

Housing and Land Tax is levied on leased property, commercial property, industrial property and warehouses at the rate of 12.5% of the annual rent value (or potential gross income of the property). The tax base is observed to be very narrow as it excludes residential property and unutilized property. For properties that are not leased out and therefore do not have a computed market value, it is up to the discretion of the official to estimate the 'likely' rental

[12] amended in 1942

[13] amended in 1966 and 1968

value. In line with the objective of promoting industrial production activities, exemptions are granted for properties, which house industrial machineries, which are installed and utilized for production/manufacturing purposes. In such cases, the property is only subject to one third of calculated tax is actually levied, an albeit rather peculiar allowance given that machineries generally cost more than the property itself.

From the above, two major shortcomings can be observed of the Thai land tax system. The first is that taxes have not been used tools to manipulate or control land use. The opposite can be said where low level of taxes levied on land have induced speculative land holding resulting in ineffective use of land resources. Second, the limited revenue from land resources also mean, in effect, limited funds which can be allocated to investments in improvement of urban environment, i.e., landscaping, or investment in urban infrastructures and amenities.

Given the sensitivity of land issues, the above shortcomings have been the subject of debate for many decades without any positive changes. Nevertheless, with pressures mounting for effective management of land in both rural and urban areas, efforts are underway to modernize these rather outdated systems of land taxation.

3 Pathum Thani Case Study

3.1 History of Settlement

During the Ayudhaya period, Pathum Thani has been the location where Mons from Motama were resettled. The first settlement was Ban Sam Kok, which later became Muang Samkok. Muang Samkok was given the name, Prathum Thani during the reign of King Rama II and in B.E. 2459, Prathum Thani was then officially modified to be the present name, Pathum Thani.

Presently Pathum Thani comprises of 7 districts, 60 Tambons and the 529 villages. There are 2 Muang Municipalities, 11 Tambon Municipality and 52 Tambon. Settlements originated from small communities on the bank of the Chao Phraya river and along the canal routes. Settlements, which grew rapidly, were Khlong Luang, Tanyaburi and Lam Lukka.

District	Date of official establishment
Thanyaburi	1902
Lam Lukka	1904
Khlong Luang	1904
Nong Sua	1913
	1917
Lad Lum Kaew	1916
Muang	1917
Sam Kok	1922

3.2 Changes in Land Use

Land on the west bank of the Chao Phraya river remained utilized until 1888 when a private company was granted concession to dig the "Rangsit Prayurasak canal as well as the secondary and the tertiary canals. Altogether 43 canals were dug. The main canal, the Rangsit canal was 8 *wah* [14]width, and 1,370 while the width of the secondary and the tertiary canals were respectively 6 *wah* and 3-5 *wah*s respectively.

The Khlong Rangsit Prayurasak canal is the so-called *Thung Luang* or the *Thung Rangsit*, or literally translated as the fields of Rangsit located on the east of the Chao Phraya river, with Khlong Prem Prachakorn to the west and the Nakhon Nayok river on the east. To the south are Khlong Saen Saeb, Khlong Bang Khanak. The area boundary to the north is Ayudhaya and Saraburi.

The original concession was for a period of 25 years. The agreement was that the concessionaire would cover all the expenses. In return, the State will grant ownership rights for land 1,600 meters on either side of the canal banks of the main canal and 1,000 meters of the secondary canal, subject to whether or not the land has already been claimed and already being utilized. The other condition were that the concessionaire was also required to leave 6 *wah* on either side as public land, apart from this restriction, the concessionaire had the legal rights to utilize, or dispose of the land in any manner they wish. The concessionaire was also responsible for maintenance work and collection of fees for any boats and transfer 20% of this revenue to the State. The construction works started in 1890 but three years later the contract was to be revised to allow for expansion of completion date. Th canal was completed in 1900.

The canal was a major influence on land use pattern in Pathum Thani particularly in the expansion of paddy land and attracted many new settlers in the *Khlong Thung Luang* area. The fertility of the land brought in many potential buyers. Names in the application list for purchase of land from the concessionaire increased rapidly and land price appreciated 37 times within a period of 14 years. It was estimated that around 2,000,000 *rai* were brought under paddy production.

The increasing competition for land and rise in market value was the origin of the roots of land conflicts in the Central Region of Thailand, which centred on tenancy farming. With the information that the concessionaire can take over possession of land on either side of the canals subject to there being no prior claims, a large number of aristocrats who knew the plan of the canal construction would use slaves and those under their command to occupy and lay claim over the land on their behalf primarily for the purpose of leasing land to farmers. In some cases, there were overlapping of claims since the concessionaire had already sold land to farmers who are already utilizing the land. The roots for land conflicts from tenancy farming and the phenomena of absentee landlords can therefore be said to have taken shape from then onwards.

[14] local measurement of length. One *wah* equals 2 meters.

What shaped land use in Pathum Thani in the earlier settlement period were the policy directions for the agricultural sector which had been very much influenced by the 'growth-oriented' concept. The opening up of the Thai economy saw a strong emphasis on the production of cash crops very much hinged upon the classical approach to economic development that the agricultural sector was to function as the centre for accumulation of capital hence, the fundamental drive towards economic development. The whole emphasis during the 1st and 2nd plan period has been focused on large investments to install the basic physical infrastructures, such as large-scale multi-purpose irrigation projects and road networks. Since emphasis was on growth, investment decisions have been somewhat locational bias focusing on areas with high development potential, primarily the fertile river basins of the Central Region of Thailand. To a certain extent, there was quantifiable reward in terms of output expansion, export expansion and inflow of foreign exchange earnings. With technological breakthrough of the Green Revolution, Thailand has been able to capture some of the benefits of technology breakthrough. Production continued to expand through a combination of area expansion, subsidized inputs and limited technological advances. At the turn of the 1970s, the distribution or lack of distribution of the fruits of growth surfaced. The economic ills turned into political instability that reached a tacit compromise with the launching of the land reform which, in principle, promised the distribution of the most important factor of production in a low technology context, land.

Immediately after the enactment of the Agricultural Land Reform Act in 1975, landowners in 101 District of 34 provinces were required to report the land under their possession. Altogether 812,256 reports were registered up to 1981, of which just under 70% were landholdings smaller than 20 *rai* per household. Only 6.82% of reportings from 27 districts of 12 provinces in the Central region were holdings larger than 50 *rai*. Thanyaburi, Nong Sua and Khlong Luang Districts of Pathum Thani Province were among districts of the Central Region with the highest concentration of holdings larger than 50 *rai*. Average size of land holdings larger than 50 *rai* in these three provinces were 202 *rai*, 170 *rai* and 169. 59 *rai* respectively. Pathum Thani was also the province with the highest concentration of tenancy farming. Around 58% of the reported land in Thanuyaburi district was under tenant farming, followed by Nong Sua District (56.78%). Pathum Thani has been among the few provinces where land reform measures in the traditional sense of redistributing private land from large landowners to the tenants and to small farmers.

A combination of factors, however made land reform in areas such as Pathum Thani, a losing battle from the start. It may have been due to the weak 'degree' of political back up that land landholdings were not expropriated but were purchased from the landowner through negotiation processes. Land was bought by the Agricultural Land Reform Office for the price of 2,000 Baht and sold to the beneficiaries for the same price on a hire-purchasing basis. Given the discrepancy with the market prices, farmers generally mortgaged the land for the value of 1,000,000 Baht/rai with the Bank of Agriculture and Agricultural Cooperatives who will issue a loan of 500,000 Baht/rai. The net return of 480,000 Baht/rai is the explanation why the majority of such loans becomes non-performing loans for the BAAC, but a highly profitable move on the part of the land reform beneficiaries. Outcomes such as this is partly explanatory for why land reform measures diverted the focus from redistribution of private land to issuing of occupancy rights for beneficiaries in public land which are mostly degraded forest areas.

But had land concentration changed? The low percentage share of larger parcels in 1998 suggests that land concentration is not as acute a problem as it may have been in the past. This could be partly attributed to the indirect effect of land reform, which stimulated subdivision of holdings. The major determinants, however, had been the operation of market mechanisms and the dynamics of land market in Pathum Thani conditioned primarily by its prime and strategic location and suitability for a range of alternative uses. With limited control of land use, allocation of land has been to the highest bidder. This was the underlying cause for the continued decline of agricultural land in Pathum Thani, particularly the districts, which adjoin Bangkok. Over the years, land use for residential, commercial and industrial activities expanded in a province where much investment had been made in agricultural infrastructure and in measures to ensure equitable distribution of land resources among tenant and small farmers.

Based on information from the Land Development Department, area classified as residential, commercial and industrial areas increased from 37,374 *rai* in 1971 to 212,661 *rai* in 1993, an increase of 20% p.a. The increase of 175,287 *rai* was mainly at the expense of agricultural land in this province. Housing projects, originally concentrated in Khlong Luang District and along the Phahon Yothin Rd. gradually moved to the Rangsit Nakhon Nayok Rd. and the Rangsit Bangpun Rd. in Muang District. In 1988, it was reported that there are 46 housing projects in Muang District. Based on a survey conducted between February and April of 1994, in Thanyaburi, Khlong Luang and Lam Lukka alone, there were already 114 housing projects.

One other major type of land use, which has become quite common from the beginning of the 1980s onwards, is orchard parcel lots. These refer to agricultural land being modified into orchard farms and sold and developed lots, with the sales price including labour charges for maintenance and harvesting of fruits. In some projects, there are usually on site facilities such as swimming pools and sport facilities while in others, land parcels are sold together with the house. Value of marketed produce is shared between the developer company and owner of the parcels. Conversion of land use to this activity was quite widespread in Khlong Luang, Thanyaburi, Lad Lum Kaew and Muang District. Based on surveys conducted in 1988, there were altogether 35 of these developments, around 85% of which were concentrated in Khlong Luang and Thanyaburi. During the so-called 'economic boom' period, orchard lots were considered to be a good form of investment and survey of landownership revealed that most of the buyers are higher income groups who was not interested in making any substantial income from the sales. It is believed that once the area becomes more developed, land price will appreciate and orchard plots will be converted to residential units since return per land unit is likely to be much higher. By this process, the first stage of transition is where land is transferred from direct users to a new form of absentee landlords, then eventually from agriculture to non-agriculture.

Apart from direct conversion of agricultural land to non-agricultural uses, land can be taken out of production indirectly. This is generally the case of land parcels located between lots that have been sold and are waiting to be developed, or parcels locked between housing projects, or between factories. Poor location, combined with problems of diseconomies of scale is among the reasons why these land parcels have been left unutilized. A larger number of parcels have been bought by external buyers either for resale, or to be used at later stages when amenities have been developed. It is estimated that loss of productive value of land in this manner can be as high as 18,942 *rai*.

Between 1989 and 1999, the number of industrial establishments increased by nearly 300%. Even after the economic crisis of 1997, the numbers of industrial establishments continued to increase in Pathum Thani. [15] Other competitive bidders for land have been for golf courses. The mushrooming of housing projects creates prospects for department stores and supermarkets. Presently, there are 9 department stores, 5 of, which are concentrated in one, district alone, namely Thanyaburi.

The economic crisis that surfaced during the middle of 1997 had quite a significant impact in slowing down the dynamics of the land market in Pathum Thani. Signs of the approaching recession was noted even in 1996. The value of land transactions in 1996, as reported by the Department of Lands for land sales and mortgages dropped by 15% and 23% respectively. Only the value hire-purchasing transactions continued to increase in 1996 from the 1995 base by 27%. In 1997, however, values of all types of land transactions, i.e., sales, hire-purchases and mortgages fell by around 50%. [16] The numbers of land transactions also fell by similar ratios. [17]

To summarize, expansion of the non-agricultural uses have been at the expenses of the loss of agricultural land. The evolving land use pattern has been mainly due to the operations of market mechanisms. In principle, allocation of land to the highest bidder should create efficiency since land is utilized by operators who can generate highest return from the land. Nevertheless, in the case of Pathum Thani, even if economic efficiency can be achieved, the outcomes must be considered against public investments concentrated in this province primarily to support agricultural production and to establish an equitable distribution of land resources.

Pathum Thani is also an illustration of contradictions of public policies. One case referred to above is the irony of the BAAC issuing mortgaged loans for land held by land reform beneficiaries thereby being directly responsible for the undesirable transfer of land from the immediate agricultural producers. The outcome of all these contradictions of public sector policies, sub-optimum delivery of services, combined with the operations of market mechanisms have resulted in inefficiency of land use, in physical and environmental aspects as well as by equity and economic considerations. Public investments in expanding road infrastructures, for example, generally render greater benefits for vehicle owners or those who has the choice of the mode of travelling and do not rely on public transport. More money is pumped into to expanding road networks while proportionally smaller sum is invested in public transport. Situations appear to be that of a race between the public sector perpetually

[15] Based on statistics of the Provincial Industrial Office, 141 new establishments were registered in 1997 and in the three successive years, i.e., 1998, 1999 and year 2000, the numbers of newly registered industrial establishments were 77, 100 and 16 respectively.

[16] Value of sales, hire-purchases and mortgages fell by 45%, 50% and 54% respectively.

[17] The number of transactions in the form of sales, hire-purchases and mortgages fell by 45%, 21% and 54% respectively.

trying to expand road network but could never quite keep up with continued increase in demand for roads due to rise in number of private vehicles. On the other hand, the losers are lower income people who are not a participant of this race but who nevertheless suffer longer travelling hours because road expansion can never keep up with expansion of private cars and greater period of exposure to air and noise pollution. Location of housing projects resulted in the increase in numerous blind land parcels and in many cases have impact on pattern of drainage and water flows. The other side of urbanization is the waste it generates from production processes and for consumption.

4 What are the future directions

Dramatic changes in rationalization of land use are unlikely given that all major determinants of changes in the past are still prevalent. Among the important determinants of land use include expansion of road networks, changing land prices and various aspects of government policies such as land taxation, investment promotion measures and the move towards liberalization of the financial markets.

4.1 Expansion of road networks

Road expansion reflects to a certain degree the misguided transport policies, which place greater emphasis on movement of vehicles rather than movement of people through investment in public transport services. Not only was there a significantly greater proportion of investments in road construction compared to expansion of public transport facilities but the low interest rate on loans have created incentives for potential car buyers who would otherwise be unable to afford the purchases. The increase in the number of vehicles outpaced the expansion of road surface. In part, the steady increase in the number of private vehicles has been due the inadequacy of supply of public transport services as depicted by the overloaded buses with passengers squeezed inside and the 'excess' passengers dangling from the door ways. The increase in the numbers of privately owned and operated minibuses are also indicators of supply constraints of the public sector transport services. This meant that as soon as households can afford private cars, they will compensate the higher expenses per trip for the higher utility value of being safely seated in private cars. But apart from the actual need for private cars, the cultural factor has much to explain for the daily increase in the number of cars. Private car ownership has become somewhat of a status indicator, i.e., whether or not one has a car and what type of vehicles have become assumed indicators of one's ranking in s

In summary, the expansion of road networks has been and will continue to be a major factor in pushing out the urban boundary, particularly for areas within two hour radius traveling distance from Bangkok.

4.2 Increase in land price in inner city area of Bangkok

The increase in land price in inner city area of Bangkok beyond affordability of lower and middle-income class has been one of the major determinant factors for the rapid increase in the built up areas of Pathum Thani. Continued rises in land prices in the CBDs and urban areas is likely to reinforce existing pattern of resettlement of lower and middle income classes towards the suburban areas. Competition for land in Pathum Thani, similar to other vicinity provinces is therefore likely to intensify pushing up land prices further. Thus without intervention measures, less competitive land uses for agricultural production will continue to be outbid by competing land uses resulting in further reduction of agricultural land.

4.3 Government policies

Government policies can have both direct and indirect impact on emerging land use patterns.

4.3.1 Land Tax

Land tax policies are also among the reasons for inefficiency of land use and have indirectly encourage land purchase for speculative purposes. With a regressive land tax system, the opportunity cost for holding land for speculative purposes is almost nil. Thus, there is no urgency to develop or dispose of the land. Moreover, from land ownership has been the more stable storage of wealth and one form of investment in which Thai investors do not have to face competition from foreigners. For several decades, there has been discussion of introducing the concept of progressive land tax and property tax. Given the political sensitivity of the issue, however, decision-makers of each successive government have remained indecisive on these matters. Undeniably, before any comprehensive land tax system can be introduced, much groundwork needs to be accomplished in terms of developing a comprehensive and reliable land information system. Human resources development is also a critical area of need although this should be more focussed on capacity in land valuation skills and as opposed to the past and present emphasis on physical planning skills.

4.3.2 Liberalization of the Financial Markets

Among the major underlying causes of Thailand's economic crisis is the global capital flows which have the tendency to distort national economic in such manners that weak economies are unlikely to cope. Similar to many of the developing economies, Thailand plunged into economic transition without first developing a social safety net. These are painful lessons, which changed the story of the economic miracle into one of economic calamity. Since the mid 1997, industrial growth plummeted to -0.1% in 1997 while value added from service sector to GDP reduced by 1.1%. All macro-economic indicators reflect a rather glum picture, GDP growth in 1997 was -0.4%, GDP investment reduced by -19% and GNP per capita reduced by -2.1%.

The consequences of the liberalization of the financial markets have been in misallocation of financial resources, over spending and upsurge of short-term borrowing which had not been realistic link to the absorptive capacity and the potential of the domestic economy. The outcomes are the high number non-performing loans, partially in the real sector, but mostly in the property sector. A combination of factors generated and intensified problems in the financial institutions such as mismanagement of both public and private sector, inefficient supervision of authorities and lack of accurate information. This generated lack of public confidence further aggravated by the expansion of external debts, indecisive and slow process in problem solving and political instability. Ultimately, these problems had adverse repercussions on the real economic sectors and caused lack of liquidity in the system.

Developments in the financial markets have slowed down the conversion rate of land use, although the loss of productive uses of land already taken out of production are likely to remain until there are clearer signs of economic recovery.

4.3.3 Preparatory Measures for Anticipated Changes.

The way ahead must be mapped out by taking careful considerations of the situational constraints discussed above. If market mechanisms are allowed to operate in the absence of intervention, Pathum Thani will continue to be the destination of urban sprawls and associated economic and environmental externalities. If intervention measures are to be imposed, there must also be recognition of the social, economic and physical changes that have already occurred so that plan formulation and identification of mechanisms are not inconsistent with the situational realities. Otherwise, intervention measures themselves create their own externalities. Development controls, for example, by granting or denying planning decisions related to land use, will alter the value of land and spatial patterns [18] Likewise, the imposition of zoning immediately limits the supply of land for any specific usage and hence the possibility of increases in land price. Imposition of zoning also entails introducing two additional cost items, namely the cost incurred by the public sector to implement and the cost borne by the private sector to comply. Distortions of price, in turn, are observed to have discriminatory effects against lower income group in two important respects, accessibility and affordability. Thus rationalization of land use requires a combination of regulatory measures and economic incentives to ensure a balance between the usage of land for economic activities and environmental concerns, the latter being the precondition for maintaining the quality of life of the people in the urban areas.

What must be said of the institutional framework of land use management is that there are no shortages of plans. While plans are indications of what is desirable, the absence of effective enforcement measures renders plans ineffective and not cost-effective in view of time and planning expertise invested for their preparation. Hence, while the planning blueprints do matter, equally important are the means to execute details of such blueprints. Valuable lessons are that public agencies and local authorities by themselves, cannot introduce measures to rationalize land. Working partnerships are indispensable not only for responsibility and cost sharing purposes, but also because of the limitations of control functions and the need for resources users to identify and internalize those measures.

Finally, land use planning cannot be undertaken in isolation of planning processes of other sectors. Hitherto, land use planning has not been utilized as a tool for directing the spatial forms of urban development or to rationalize the location of economic activities to allow for capitalization on economies of scale and cost effectiveness of production and marketing operations. Not only do planners need to comprehend the interconnectedness between the economic sectors, but also in terms of the relationship between the rural and urban sectors, particularly in urban-rural borderline cases such as Pathum Thani. Planning efforts that are carried out in autonomous and unrelated manners generally intensify competition not only for sources of funding but also for raw material, for labour and for land. If and when this happens, the public intervention becomes themselves externalities and the prime obstacles to achieving optimum land use pattern.

[18] Rydin, Y. *Urban and Environmental Planning in the UK*, (London: Macmillan), 1998. P. 6

Potential effects on rural economies of conversion to sustainable farming systems : a case of Sa See Moom rice farmer group, Kamphaengsaen, Nakhon Pathom province

Sanjay Kumar Yadav, Pote Boonruang, Savitree Rangsipaht, and Supaporn Thaipakdee[1]

Abstract : *The main focus of this study conducted during February 2000 is to present the potential effects of sustainable farming systems on farm household economies using a structured interview schedule in a survey to collect primary data from the total population of 125 farmers holding Sa See Moom Rice Farmer's Group status. Data analysis is done through various statistical measures. The results are revealed to be as follows:*

Most of what the farmers use in the area drawn heavily on the high-input conventional farming practice is found being exceeded over the low-input or sustainable farming practices. This is indicated in terms of productivity, on-farm income, food security, employment opportunity and gross margin. This, of course, partially may be due to the practices originally benign under conditions of the farm-level impacts of low-input rice and other various crops planted for the farm household economies including non cash income, assets and non-cash costs have not been quantified to enable to bring about the productive capabilities and enhance resilience of individuals, groups and organizations to deal with rapidly changing economic and social circumstances resulting from their own unique needs and preferences.

The hypothesis testing, under low-input farming practices, indicates that there is a statistically significant difference in income and employment opportunity due to the land at 0.01 and 0.05 levels respectively. The rest variables including labor, capital, management, and market are found being statistically non significant to cause difference at 0.05 level. Land is accounted for causing 71.0 percent and 13.8 percent of the variation in income and employment opportunity respectively. Similarly, technology is found being a statistically significant to cause difference in cost at 0.05 level. Technology is accounted for causing 14.2 percent of the variation in cost. Under high-input farming practices, out of the variable categories : land, labor, capital, management and market ; only land and technology are found being statistically significant to cause difference in income at 0.01 and .0.05 levels respectively. The

[1] Department of Agricultural Extension and Communication, Faculty of Agriculture, Kasetsart University, Bangkok 10900, Thailand

combination of land and technology is accounted for causing 67.7 percent of the variation in income. Land is also found statistically being negatively significant to cause difference in cost at 0.05 level. Land is accounted for causing 15.6 percent of the variation in cost. None of the output variables, including productivity, income, food security, employment opportunity and cost, is being statistically significant to cause difference in farmers' acceptance.

The findings suggest that continued research-extension-application in insuring essential functions to generate information and organic technologies as effective substitute of chemical inputs, effective policies to support the farmers' decision making to adopt sustainable farming technologies, wise use of land and farming technologies by the farmers to increase income and employment opportunity and implementation of effective extension technique such as training courses, demonstrations, field trips, and group discussions related to sustainable agriculture are some essential recommendations in order to facilitate the adoption of sustainable farming system in the future.

Key words : *rural economies, sustainable farming systems, rice farmers' group, agricultural extension*

1 Introduction

Agriculture is the foundation of Thai economy. It plays an important role in country's food security, earning foreign exchange through food export, and the supply of raw materials for industry.

Thailand is one of the leading food exporting countries in the world. It ranks the tenth in terms of trade surplus for food. It is the world leading exporter of rice, rubber, cassava products, canned pineapple, sugar, poultry and fishery products (Rojanaridpiched et al, 1998).

The modern agricultural technologies (Green Revolution Technology) such as, seeds of high yielding varieties (HYV), chemical fertilizers, and pesticides, have significantly contributed to increase the overall productivity of the agricultural products, and thus enabled the country to achieve self-sufficiency in terms of food and become the food exporter. On the other hand, some of those technologies, such as chemical inputs, have serious negative impacts on the humans, animals, and environment. Thus, the livelihood and the quality of life of Thai people (both present as well as the future generations) are likely to be in Jeopardy (OEPP, 1997).

Therefore, people from all walks of life are raising their voices strongly for the transformation of modern commercial agriculture (i.e. conventional agriculture) into sustainable agriculture.

The 8^{th} National Economic and Social Development Plan (NESDP) has also emphasized to develop the potentialities and creativity of Thai people to plan, develop, and adopt sustainable agriculture and conserve natural resources and environment in order to have a better quality of life (NESDB, 1997).

2 Statement of the Problem

Thailand is basically an agricultural country, where majority of the people (i.e. 61 per cent of the country's total population) depend on agriculture for their livelihood (DOAE, 1997).

Farmers are the backbone of the nation. They are the farmers, who produce food for all people as well as contribute significantly to the national income. But the socio- economic conditions (i.e., standard of living and the quality of life) of the farmers and their family members is much lower than the other groups of people (i.e., who are engaged in non-agricultural sectors) in the society.

This condition is clearly reflected by the per capita income. The per capita income of farmers is only 12,524 baht where as that of the others is 156,440 baht (DOAE, 1997).

In such condition, there is a great need for the farmers to increase production and income in order to improve the quality of life of their family members and bridge the existing socio-economic gap between the farmers and other groups of people in the society. At the same time, there is also a need for the transformation of current modern agricultural production system into sustainable agriculture in order to maintain the sustainability of natural resources and environment, and the well-being of the people (both producer and consumer) to cope with the rapid changes under globalization.

The transformation process of current agriculture into sustainable one at full scale is not possible unless and until, the sustainable agriculture either more profitable or at least as much productive and profitable as current (modern) agriculture.

Therefore, from this perspective, the researcher's main point of interest is to find out "what will be the potential effect of the transformation or conversion of current (modern) agriculture into sustainable agriculture on the rural economies?"

3 Objectives and scope of the study

The main objective of the study is to assess the potential effects of sustainable farming system on farm household economies (i.e. productivity, income, food security, employment opportunity and cost).

Since, there may be several types of potential effects on the rural economies of conversion to sustainable farming system. But all effects cannot be studied by any single study. So, due to limited time and budget, the scope of the study has been confined to the economic perspective only. As a consequence, this study has focused on the potential economic effects of sustainable farming system on the farm household economies.

In general, the findings of this study are expected to be useful and applicable not only in the context of Sa See Moom but also in the context of the whole Thailand as well as other Asian countries having similar conditions. But specifically, as the nature, magnitude, causes and solutions of the problem vary according to the place, time, needs, expectations, resources and goals of the people as well as changing socio-economic, cultural and political environment of the society, the usefulness and applicability of the result of this study will depend upon the situation.

4 Methodology

The study has been conducted in the Sa See Moom Rice Farmer's Group of Sa See Moom sub-district, Kamphaengsaean district, Nakhon Pathom province, Thailand. All members of the rice farmer group (i.e.175) have been considered as both the population as well as the respondents for this study. But out of the total respondents, the data have been collected only from 125 respondents, because the rest of the farmers have changed their business and left the group. Survey research design has been employed to collect the data. The interview schedule consisting of both open as well as close ended questions has been used as research instruments to collect the data. The interview schedule has been presented into the five parts. They are : (1) current socio-economic status of the farmers, (ii) low-input/high-input farming system, (iii) rural economies, (iv) farmer's acceptance, and (v) problems and suggestion. In order to determine the validity and reliability of the research instrument, the schedule has been pretested with 21 farmers of Thung Luke Nok sub-district of Kamphaengsaen district prior to using it in the real survey work for collecting primary data. After analysis, the schedule has been found valid and reliable.

After collecting the data, based on the cost involved in per rai of land (1 Rai = 0.16 hectares) for chemical inputs used by the respondents in the farming, the respondents have been divided into two groups, i.e. high-input user and low-input user. The average of the cost of chemicals for per rai of land has been found out for all the respondents. The farmers who have used money $\leq$ (less than or equal to) average of the cost of chemicals have been considered as low-input user where as those farmers who have used > (more than) the average have been considered as high-input user. Then, the influence of independent variables over dependent variables has been analyzed group wise. The data have been analyzed by employing SPSS/FW (Statistical Package for Social Science for Window). Frequency count, percentage and arithmetic mean have been used to describe the socio-economic status of the farm households. Similarly, multiple regression has been employed to determine the influence of independent variables on the dependent variables to test the hypotheses. Five percent level (α = .05) has been considered as the minimum level of significance for testing the hypotheses. The gross margin has been employed to determine the profitability of the farming systems.

5 Result and discussion

The result of the study have revealed that :

The maximum, average and minimum productivity of rice are 1200 kg, 525.57 kg and 100 kg per rai respectively under low-input farming condition whereas the maximum, average and minimum productivity of rice under high-input farming condition are 1285.30 kg, 628.21 kg and 266 kg per rai respectively (Table 1).

The maximum, average and minimum on-farm income under low-input farming condition are 50,000 baht, 13,084.38 baht and 540 baht per annum respectively. Similarly, the maximum, average and minimum on-farm income under high-input farming condition are 160,000 baht, 18,793.40 baht and 1,000 baht per annum respectively (Table 2).

Under low-input farming condition, 78.1 per cent of the respondents have the sufficient food for the whole year whereas 21.9 per cent of the respondents have not sufficient food for the whole year. Similarly, under high-input farming condition, 82.0 per cent of the respondents have sufficient food for the whole year whereas 18.0 per cent of the respondents have not sufficient food for the whole year. On an average, the respondents have food security for 10.39 months and 10.53 months under low-input farming condition and high-input farming condition respectively (Table 3.)

Under low-input farming condition, 64.1 per cent of the respondents have sufficient job for the whole year in their farm whereas 35.9 per cent of the respondents have not sufficient job for the whole year in their farm. Under high-input farming condition, 65.6 per cent of the respondents have sufficient job for the whole year in their farm whereas 34.4 per cent of the respondents have not sufficient job for the whole year in their farm. On an average, the respondents have job in their farm for 10.09 months and 10.33 months under low-input farming condition and high-input farming condition respectively (Table 4)

The maximum, average and minimum cost of production of rice are 1,408 baht, 667.01 baht and 310 baht per rai respectively under low-input farming condition. Under high-input farming condition, the maximum, average and minimum cost of production of rice are 1,940 baht, 1,015.17 baht and 538.7 baht per rai respectively (Table 5).

The maximum, average, and minimum gross margin under low-input farming condition are 4,436 baht, 1,443.44 baht and – 976 baht per rai respectively whereas under high-input farming condition, the maximum, average and minimum gross margin are 4,025.30 baht, 1,447.48 baht and –66.50 baht per rai respectively (Table 6)

Out of all independent variables, such as land, labor, capital (credit and technology), management and market, non of them has been found statistically significant to cause difference in productivity and food security at 0.05 level of statistical significance under both low-input farming condition as well as high-input farming condition. There might be some other variables responsible for causing variation in productivity and food security which are not included in this study.

None of the independent variables such as land, labor, capital (credit and technology) has been found statistically significant to cause difference in employment opportunity at 0.05 level of statistical significance under high-input farming condition. There might be some other variables responsible for causing variation in the employment opportunity which are not included in this study.

Out of independent variables, such as land, labor, capital (credit and technology), management and market, only land has been found statistically significant to cause difference in income at 0.01 level of statistical significance under low-input farming condition. Land is accounted for causing 71.0 percent of the variation in income (Table 7).

Out of independent variables, such as land, labor, capital (credit and technology), management and market, only land has been found statistically significant to cause difference in employment opportunity at 0.05 level of statistical significance under low-input farming condition. Land is accounted for causing only 13.8 of the variation in employment opportunity (Table 8). There might be some other variables responsible for causing 86.2 per cent variation in employment opportunity which are not included in this study.

Out of independent variables, such as land, labor, capital (credit and technology), management and market, only technology has been found statistically significant to cause difference in cost at 0.05 level of statistical significance under all variable low-input farming condition. The technology is accounted for causing 14.2% of the variation in cost (Table 9). There might be some other variables responsible for causing 85.8% variation in cost which are not included in this study.

Out of independent variables, such as land, labor, capital (credit and technology), management and market, only land and technology have been found statistically significant to cause difference in income at 0.01 and 0.05 levels of statistical significance respectively under high-input farming condition. The analysis has indicated that the combination of land and technology is accounted for causing 67.7 per cent of the variation in income (Table 10).

Out of independent variables, such as land, labor, capital (credit and technology), management and market, land has been found negatively significant to cause difference in the cost at 0.05 level of statistical significance under high-input farming condition. Land is accounted for causing 15.6% of the variation in cost (Table 11). There might be some other variables responsible for causing 84.4% of the variation in cost which are not included in this study.

None of the output variables such as productivity, income food security, employment opportunity and cost, has been found statistically significant to cause difference in farmer's acceptance for the conversion of high-input farming system into low-input farming system at 0.05 level of statistical significance. There might be some other variables responsible for causing variation in the farmer's acceptance which are not included in this study.

TABLE 1 FARM PRODUCTIVITY UNDER LOW-INPUT AND HIGH-INPUT FARMING CONDITION.

S.No	Name of commodity	Yield (kg/Rai)			
		Low-input condition		High-input condition	
1	Rice	$(\bar{x})$ = Max = Min =	525.57 1,200.00 100.00	$(\bar{x})$ = Max = Min =	628.21 1285.30 266.00

TABLE 2 ON-FARM INCOME UNDER LOW-INPUT AND HIGH-INPUT FARMING CONDITION.

S.No	Commodity	Income (Baht per annum)			
		Low-input condition		High- input condition	
1	Rice	$(\bar{x})$ = Max = Min =	13,084.38 50,000.00 540.00	$(\bar{x})$ = Max = Min =	18,793.40 160,000 1,000

TABLE 3 FOOD SECURITY STATUS UNDER LOW-INPUT AND HIGH-INPUT FARMING CONDITION.

S.No	Type of farming system	Food security status	
		Sufficient for the whole year	Not sufficient
1	Low-input farming	50 (78.1%)	14 (21.9%)
		$(\bar{x})$ = 10.39 month, Max = 12 months, Min = 1 months	
2	High-input farming	50 (82.0%)	11 (18.0%)
		$(\bar{x})$ = 10.53 months, Max = 12 months, Min = 1 months	

TABLE 4 EMPLOYMENT OPPORTUNITY UNDER LOW-INPUT AND HIGH-INPUT FARMING CONDITION.

S.No	Type of farming system	Job opportunity	
		Throughout the year	Not throughout the year
1	Low-input farming	41 (64.1%)	23 (35.9%)
		$(\bar{x})$ = 10.09 month, Max = 12 months, Min = 2 months	
2	High-input farming	40 (65.6%)	21 (34.4%)
		$(\bar{x})$ = 10.33 months, Max = 12 months, Min = 4 month	

TABLE 5 PER UNIT FARM PRODUCTION COST UNDER LOW-INPUT AND HIGH-INPUT FARMING CONDITION

S.No	commodity	Production cost (Baht /Rai)			
		Low-input condition		High input condition	
1	Rice	$(\bar{x})$ = Max = Min =	667.01 1,408.00 310.00	$(\bar{x})$ = Max = Min =	1,015.17 1,940.00 538.7

TABLE 6 PER UNIT GROSS MARGIN UNDER LOW-INPUT AND HIGH-INPUT FARMING CONDITION.

S.No	Type of farming system	Gross margin (Baht/Rai)	
1	Low-input farming	$(\bar{x})$ = Max = Min =	1,443.44 4,436.00 -976.00
2	High-input farming	$(\bar{x})$ = Max = Min =	1,447.48 4,025.30 -66.50

TABLE 7 INFLUENCE OF LOW-INPUT FARMING SYSTEM VARIABLES ON INCOME.

Low-input variables	Regression co-efficient	R2	Adjusted R2	F	Sig.
Land	.829	.710	.679	23.226	.000**
Labor	-.149				.057
Capital	-.132				.072
- Credit	-.095				.192
Technology	.102				.238
Management	-.068				.415
Market					
Constant (a) 8123.215					

* Statistical significance at 0.05 level ** Statistical significance at 0.01 level

TABLE 8 INFLUENCE OF LOW-INPUT FARMING SYSTEM VARIABLE ON EMPLOYMENT OPPORTUNITY.

Low-input variables	Regression co-efficient	R2	Adjusted R2	F	Sig.
Land	.307	.138	.048	1.526	.017*
Labor	-.111				.406
Capital	.075				.548
- Credit	.015				.903
Technology	.018				.901
Management	-.189				.188
Market					
Constant (a) 13.224					

* Statistical significance at 0.05 level ** Statistical significance at 0.01 level

TABLE 9 INFLUENCE OF LOW-INPUT FARMING SYSTEM VARIABLES ON COST.

Low-input variables	Regression co-efficient	R2	Adjusted R2	F	Sig.
Land	.061	.142	.052	1.572	.627
Labor	.018				.890
Capital	.008				.947
- Credit	.270				.033*
Technology	-.109				.462
Management	-.172				.230
Market					
Constant (a) 853.292					

* Statistical significance at 0.05 level ** Statistical significance at 0.01 level

TABLE 10 INFLUENCE OF HIGH-INPUT FARMING SYSTEM VARIABLES ON INCOME.

High-input variables	Regression co-efficient	R2	Adjusted R2	F	Sig.
Land	.825	.677	.642	18.902	.000**
Labor	-.101				.237
Capital	.072				.363
- Credit	.163				.047*
Technology	.029				.780
Management	-.101				.325
Market					
Constant (a) 7822.322					

* Statistical significance at 0.05 level ** Statistical significance at 0.01 level

TABLE 11 INFLUENCE OF HIGH-INPUT FARMING SYSTEM VARIABLES ON COST.

High-input variables	Regression co-efficient	R2	Adjusted R2	F	Sig.
Land	-.314	.156	.062	1.658	.024
Labor	.220				.114
Capital	.110				.389
- Credit	-.043				.743
Technology	.169				.314
Management	-.270				.106
Market					
Constant (a) 1317.942					

* Statistical significance at 0.05 level ** Statistical significance at 0.01 level

6 Conclusion

Based on the findings of the study, it can be concluded that :

low-input (sustainable) farming system is slightly less productive and profitable as compared to the high-input (conventional) farming system. The reason may be that most of the low-input users have not been found to use the low-input farming technologies such as organic manures, legume based crop rotation, and integrated pest management due to which the low-input farming system which could not express its full potential in terms of productivity and income.

Out of all input variables such as land, labor, capital (credit and technology), management and market, only land and technology have been found statistically significant to cause difference in the output variables. Land has been found statistically significant to cause difference in income, employment opportunity and cost. Technology has been found statistically significant to cause difference in income and cost.

Under the low-input farming condition, land has been found statistically significant to cause difference in income and employment opportunity at 0.01 and 0.05 level of statistical significance respectively which means that the income and employment opportunity can be increased by increasing the land size. Similarly, technology has also been found statistically significant to cause difference in cost at 0.05 level of statistical significance which means that the use of technology can increase the cost.

Under high-input farming condition, the land and technology have been found statistically significant to cause difference in income at 0.01 and 0.05 level of statistical significance respectively which means that the income can be increased by increasing the use of the combination of the land and technology. Land has also been found negatively significant to cause difference in the cost at 0.05 level of statistical significance which means that an increase in land size decreases the cost.

7 Recommendations

In order to facilitate the adoption of sustainable farming system in the future, the following recommendations have been made :

1. As this study has indicated that income and employment opportunity can be increased by increasing the use of land and technology, putting a large amount of land under cultivation may create another environmental problems. So, the emphasis here should concentrate on the main problem directly affecting the achievement of sustainable land use and development strategy to advance the achievement of land and technology. Accordingly, it should focus on how to deal with them in order to increase income and employment opportunity contributing to improve rural economies with significant responsibilities in the development process, thereby increasing the likelihood of its being positively received by the group and of helping to ensure sustainable resource development.

2. For this group with so many requirements demanding all or more of the resources that priorities must be determined and followed, the recommended criteria thus place due emphasis on a positive intellectual approach via effective and efficient policy strategies, plans, and local farm programs to provide a foundation in strengthening and enhancing a continually updated supply of information-technology for the farmers' group and an informational servicing capability specification of activities and functions to be performed as central to replace the current high-input (conventional) farming system with low-input (sustainable) farming system with the short-term rural economic viability.

3. The emphasis should be on questions and issues concerning the :

inter-relatedness of such units and dimensions of the overall system (structure) as research-extension-farmer—linkages, training, social organization and management mechanisms involving a knowledge of the overall social, economic, cultural background of the society in addition to its agricultural pattern. These concerns call for a greater scope, intensity, and quality of effort of extension programs if farmers are to receive relevant and realistic assistance and advice on a firsthand and timely basis with reliable information and other services. This is necessary for the extension strategies and continued training technique to assure coherence and efficiency of effort, and relevance and effectiveness of results in performing the true functions of practical work in relation to the practical needs that people collectively provide for supporting themselves in what they want to do in the environment and conditions on which they work at the farmers level to integrate farming system rather than rice monoculture.

4. Future strong productive research-extension-application development linkages should be strengthened seriously with special attention to forge practical experiences both technical agriculture and integration function concerning sustainable resource management to deal with only as to complete the systems paradigm. This, of course, could be visualized as being important not only with the extension agencies but also with all other agencies including credit agencies, farmers organizations, marketing agencies, and even private organizations dealing with agricultural development at the local community. This suggests that the communication interaction stance must also carry over into the action taken to generate reliable information and organic technologies as effective substitute of chemical inputs, effective policies and management mechanisms. This in essence is to support the farmers' decision making to adopt sustainable farming technologies, wise use of land and technologies by the farmers to improve farm productivity to increase income and employment opportunities apart from implementation of effective extension strategies, methods, techniques, and devices such as continued training, demonstrations, field trips, and group discussions related to sustainable resource management practices in agriculture as being central requirements. To insure that this activity is properly oriented to the intended information users they should participate in all operational decisions on what is done on their behalf and how findings are to be effectively used.

References

DOAE. 1997. Important Agricultural Information in Thailand. Bangkok, Thailand : Department of Agricultural Extension.

National Economic and Social Development Board. 1997. The 8th National Economic and Social Development Plan (1997-2001). Bangkok, Thailand : National Economic and Social Development Board, Office of the Prime Minister.

Office of Environmental Policy and Planning. 1997. Policy and National Action Plan for Sustainable Development of Thailand. Bangkok, Thailand : Prepared by Faculty of Economics, Kasetsart University.

Rojanaridpiched, C.,E. Sarobol and A. Aungsuratana. 1988 "Measures for Sustainable Development of Thailand ; A Case Study on Agricultural Sector". Journal of Policy and Culture. 3 (March 1998) : 107.

Water quality situation in the Chao Phraya Delta

Wijarn Simachaya[1], Pimon Watanamahart[1], Vuttichai Kaewkrajang[1], and Akaluk Yenpiem[1]

ABSTRACT: *The Pollution Control Department (PCD) has been monitoring the water quality of the Chao Phraya Delta (Chao Phraya, Tha Chin, and Meklong Rivers) for decades. The results indicated that river quality in the lower parts of the Chao Phraya and Tha Chin Rivers have been degraded and the levels of parameters concerned have been lower than the Surface Water Quality Standard and its Classification. The major water quality problems for the year 1999 were low dissolved oxygen (DO) (27.5 %), high ammonia-nitrogen (25.5 %), high fecal coliform bacteria (23.0 %), high turbidity (14.4 %), high organic matter (biochemical oxygen demand, BOD) (5.0 %) and others (4.6 %). Major sources of water pollution are from communities, industries, and agriculture, which contributed proportion of sources varied from region to region. For example, major source of pollutant discharged in the lower part of the Chao Phraya River is from communities, while industries is play major contribution in the lower part of the Tha Chin River.*

The implications of water quality impairment in the delta are serious. Fish kills during dry season were believed to have been caused by sudden DO depletion, which may have resulted from flushing of land-based wastes into the main streams during heavy rainfall after extended dry period (a condition typical in the monsoon-driven climate). Such conditions occur regularly in the middle and upper sections of the Tha Chin River. The middle sections of the rivers are strongly influence by excessive wastewater from domestic and industrial sources as well as pig farms. The lower sections of The Chao Phraya and Tha Chin Rivers is further degraded, and continue to deteriorate there as a result of the rapid population growth currently being recorded in the delta.

Basin management approach is trying to apply for controlling both point and non-point source pollution. With the budget limitation, priority on implementation of the wastewater management projects should be based on carrying capacity or assimilative capacity of receiving waters. Future decision for the water quality management intended to reduce wastewater should not only focus exclusively on domestic loadings, but also should include measures for controlling other urban and rural sources, especially industries and pig farms. Additionally, nutrient loads from agricultural areas must be considered integral to future planning strategies. Even though farms currently

[1] Water Quality Management Division, Pollution Control Department, 404 Phaholyothin Centre Bldg, Fl 8 th, Phaholyothin Rd, Phayathai, Bangkok 10400, THAILAND Tel: (662) 619-2208, Fax: (662) 619-2210, E-mail: wijarn.s@pcd.go.th

contribute only a small fraction of overall waste loading, a widespread tendency to increase intensive agricultural practices can be discerned throughout the region and pollutant loading can be expected to increase dramatically as this occurs.

1 Introduction

The Chao Phraya Delta comprises of three major basins, Chao Phraya, Tha Chin, Meklong Basins (Figure 1). These rivers supply water, support fisheries, transportation and recreation and receive wastewater discharge. There are many environmental problems such as water pollution and ecological deterioration in these basins. Deterioration of river water quality has the greatest environmental impact. There are a variety of sources of water pollution in these basins including communities, industries and agriculture. Water pollution, through point and non-point sources, has become a major environmental concern in these basins. Major point sources of pollution, to these river basins include domestic and industrial waste discharges as well as some agricultural point sources such as pig, poultry, fish and other farms. Non-point sources include agricultural areas such as paddy fields, dry and vegetable farms, which constitute the main land uses in these basins. These rivers have water quality problems, which have been a major concern to citizens and officials for more than two decades. Hence, the formulation and evaluation of pollution control measures, which include measures to control, prevent and remedy environmental problem caused by pollution are processing in order to set national water quality standard and monitor the quality of these rivers.

PCD has monitored water quality in the Chao Phraya Delta for decades. The results of the rivers' water quality monitoring indicated that the lower parts of the Chao Phraya and Tha Chin Rivers have been facing water pollutant problems with lower quality than the Surface Water Quality Standard and its Classification. The major source of pollutant discharge in the lower part of the Chao Phraya River is communities, while industries and agriculture play as a major contributor in the lower part of the Tha Chin River.

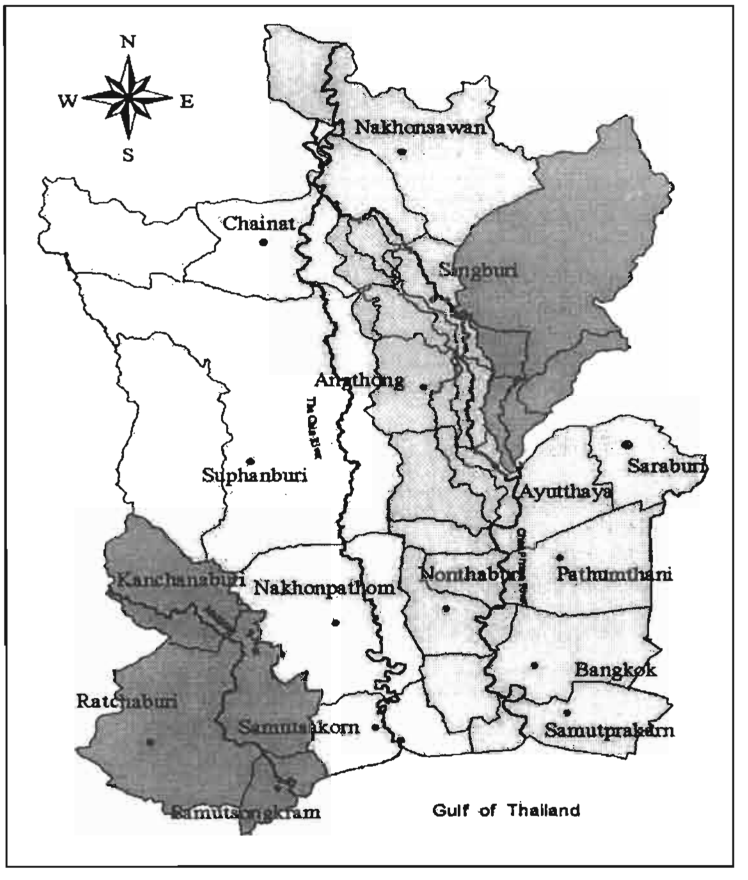
The objectives of this paper are to evaluate and review water quality, to identify major water quality problems and their potential sources, and finally to assess water quality management strategies in the major rivers of the Chao Phraya Delta.

2 Water quality of the Chao Phraya delta

2.1 Water Quality Standards

The National Environmental Board was notified the Standard of Surface Water Quality and its Classification for the country's surface water in 1994 (Pollution Control Department, 2000a). This issue is used to support the receiving water based on major beneficial uses. There are 5 classes that are considered for surface water quality as follows:

FIGURE 1 LOCATION OF THE CHAO PHRAYA DELTA



- Class 1: Extra clean for conservation purposes
- Class 2: Very clean used for (1) consumption which requires ordinary water treatment processes (2) aquatic organism conservation (3) fisheries, and (4) recreation (for example, DO (Dissolved oxygen) > 6 mg/L, BOD (Biochemical oxygen demand) < 1.5 mg/L, TCB (Total coliform bacteria) < 5,000 MPN /100 mL)
- Class 3: Medium clean used for (1) consumption but passing through ordinary treatment process and (2) agriculture (for example, DO > 4 mg/L, BOD < 2 mg/L, and TCB < 20,000 MPN/100 mL)
- Class 4: Fairly clean used for (1) consumption, but requires special treatment process and (2) industry (for example, DO > 2 mg/L, BOD < 4 mg/L)
- Class 5: Water is not classified in class 1 – 4 and used for navigation

The rivers in Chao Phraya Delta have also been classified into various classes as shown in Table 1.

TABLE 1 CLASSIFICATION OF THE RIVERS IN THE CHAO PHRAYA DELTA

Control Areas (kmth from the river mouths, RKM)	River Classification (Class)
1. Chao Phraya River	
• 7 – 62	Class 4
• 62 – 142	Class 3
• 142 – 379	Class 2
2. Tha Chin River	
• 0 – 82	Class 4
• 82-202	Class 3
• 202-325	Class 2
3. Meklong River (0 – 140)	Class 3

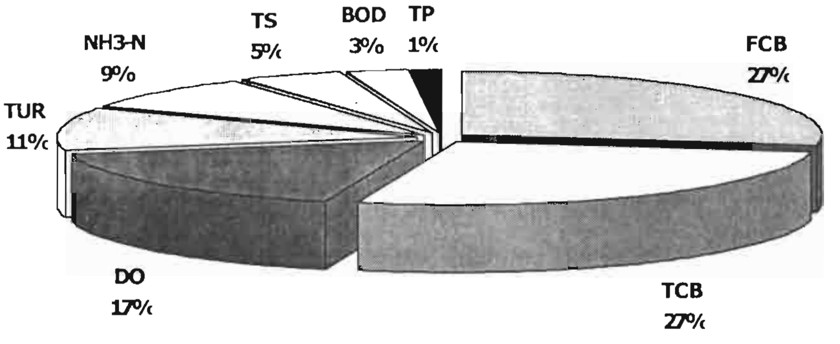
2.2 Water quality monitoring programs

The Chao Phraya River was subdivided into 3 sections and the water-quality classification of each sector is shown in Table 1. There are 18 monitoring stations covering the 3 sections of this river. The Tha Chin River was also subdivided into 3 sections and the water-quality classification of each sector is shown in Table 1. There are 13 monitoring stations covering the 3 sections. Meklong River has only one section (Class 3 of the Standard) with 10 monitoring stations in this river. Water quality sampling are routinely taken 4 times a year. Water quality parameters measured are physic-chemical parameters (Temperature, pH, conductivity, turbidity, total suspended solids, total solids, biochemical oxygen demand (BOD), dissolved oxygen (DO), total phosphorus, ammonia-nitrogen, nitrate-nitrogen and heavy metals) and biological parameters (fecal and total coliform bacteria). The method of water sampling and analysis procedures follows the Standard Method for the Examination of Water and Wastewater published in 1998 (Pollution Control Department, 2000a).

2.3 Chao Phraya River

The Chao Phraya River is the largest river in Thailand. The Chao Phraya River has been subdivided into three sections: lower (RKM 7 to 62), middle (RKM 62 to 142) and upper (RKM 142 to 379) based on the river water quality standard and its classification. Water quality monitoring results during the last decade (1984 – 1995) showed that water quality in the upper region were better than in the middle and lower parts of the river, respectively. Simachaya and Noikeang (2000) reported that the first three major polluted contributors in the Chao Phraya River regarding the respective parameters (Figure 2) are high coliform bacteria both total and fecal (54 %), low DO (17 %) and high turbidity (11 %).

FIGURE 2 PROBLEM'S PARAMETERS IN THE CHAO PHRAYA RIVER 1991-2000



In the lower part of the river, from the river month in Samut Prakarn Province (RKM 7) to the Rama VI Bridge in the Bangkok (RKM 62), the river was seriously polluted especially from organic contamination. The most alarming water quality problem in this part was low concentrations of DO during the dry period. DO levels of most monitoring stations were lower than the regulated value in the established water quality standard for industrial use (not less than 2 mg/L). The average DO value in this section from1978 to 1999 was 1.7 mg/L and the P20 (20th percentile) value during that period of time was only 0.5 mg/L (Table 2). From Figure 3, DO values in this section were very low especially from the river mouth to Pak Khlong Thevet in Bangkok. The DO levels in most monitoring stations in the year 2000 were still lower level than the DO standard levels of the lower part of the Chao Phraya River (the observed DO values ranged from 0 to 0.9 mg/L). BOD levels in this section were mostly below the established water quality standard (not more than 4 mg/L) with averaging BOD 2.6 mg/l and the P80 (80th percentile) 3.5 mg/L. TCB (Total coliform bacteria) values were found the maximum as 16,000,000 MPN/100 mL, average as 200,000 MPN/100 mL and P80 as 160,000 MPN/100 mL. Concentrations of TP (Total phosphorus), NH_3-N (Ammonia-nitrogen) and NO_3-N (Nitrate-nitrogen) in this section were averaged 0.22, 1.55 and 0.85 mg/L, respectively. For NH_3-N, the standard was set to be not more than 5 mg/L, for the river classifications 2, 3, and 4 (see Appendix). For the lower section of the Chao Phraya River, DO, FCB (Fecal coliform bacteria) and TCB were the major problems of water quality degradation by averaging 80, 75 and 71 %, respectively during 1991 to 2000 (Table 3). The major contributors to water pollution in this section were generated mainly from domestic and industrial activities.

TABLE 2 THE MOST ALARMING WATER QUALITY PARAMETERS OF THE CHAO PHRAYA RIVER 1978 TO 1999

	DO		BOD		TCB	
River Reaches	Average	P20	Average	P80	Average	P80
Lower	1.7	0.5	2.6	3.5	200,000	160,000
Middle	4.6	3.9	1.5	1.9	80,000	22,000
Upper	6.3	5.5	1.5	1.8	350,000	35,000

TABLE 3 PERCENTAGE OF PROBLEMS OF EACH WATER QUALITY PARAMETER OF THE CHAO PHRAYA RIVER 1991-2000

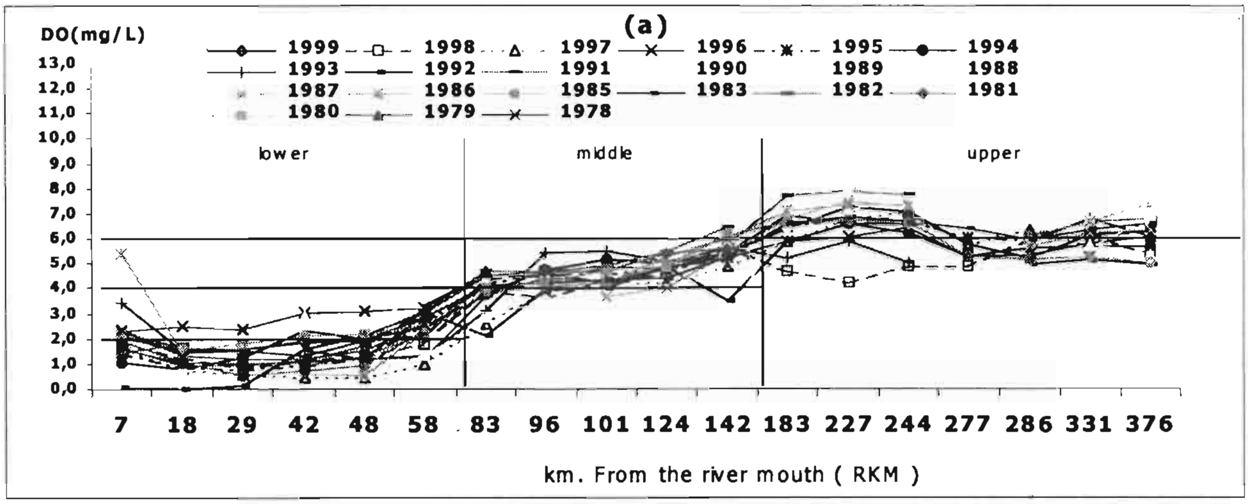
River Reaches	Tur.	DO	BOD	FCB	TCB	NH_3-N	TP	TS
Lower	24	80	10	75	71	56	7	31
Middle	36	6	2	40	36	2	0	0
Upper	26	1	2	36	37	1	1	0

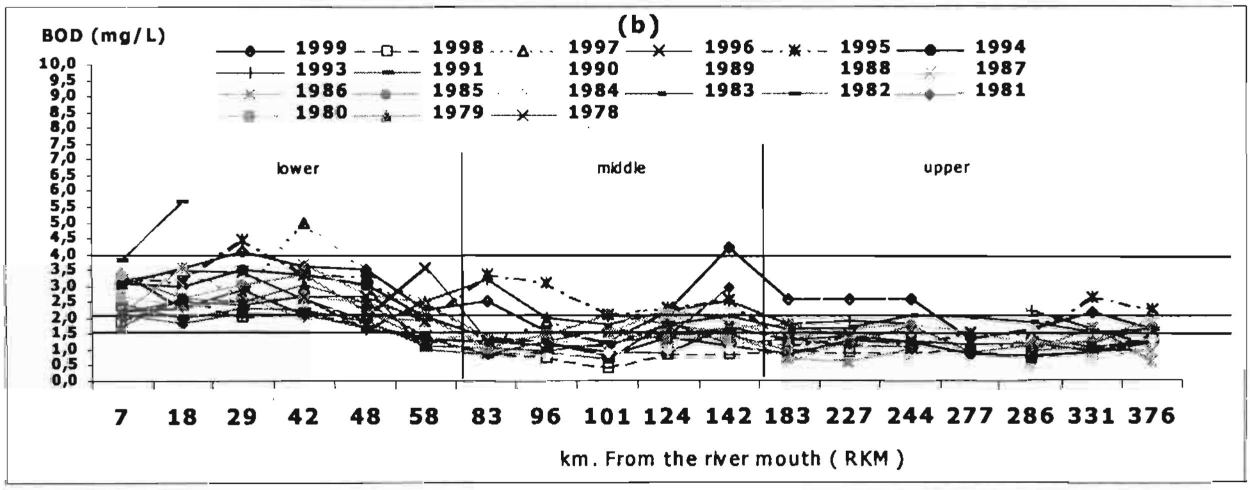
Water quality during 21 years (1978 – 1999) in the lower section has slightly sloped down trend of DO (Figure 4), slightly sloped up trend of BOD and extremely sloped up trend of TCB.

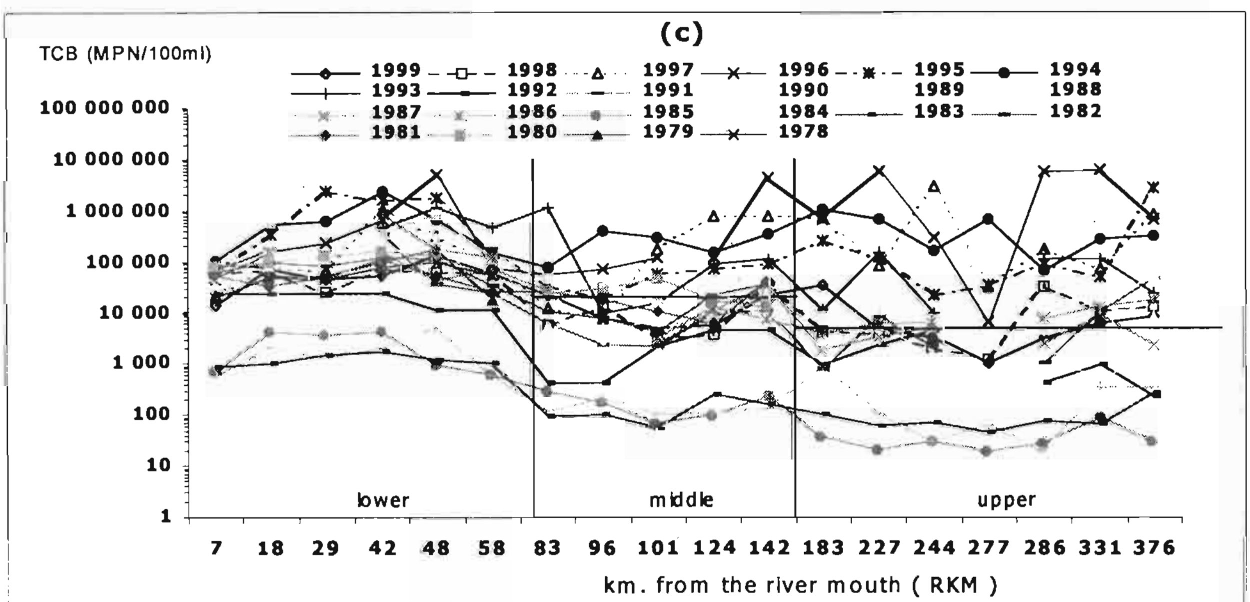
In the middle part, from Rama VI Bridge, Nonthaburi Province to Ayutthaya, the river was slightly polluted. The DO levels in most monitoring stations were slightly higher than the regulated value (not less than 4 mg/L), which were suitable for water consumption and agricultural uses. The average DO value was approximately 4.6 mg/L and the P20 value during the period was 3.9 mg/L. From Figure 2, DO values in this part were very moderately contaminated from Nonthaburi to Ayutthaya. The DO levels in almost all of the monitoring stations in year 2000 were not less than the DO standard level of the middle part of the Chao Phraya River (the observed DO values ranged from 1.0 to 2.9 mg/L). Pollution in term of average BOD was 1.5 mg/L and the P80 value was 1.9 mg/L. BOD values within this section did not exceed water quality standard (not more than 2.0 mg/L). The average TCB value was 80,000 MPN/100 mL and the P80 value was 22,000 MPN/100 mL, which was slightly higher than the regulated value (not more than 20,000 MPN/100 mL). Concentrations of TP, NH_3-N and NO_3-N in this section were averaged approximately 0.08, 0.10 and 0.63 mg/L, respectively. From table 3, FCB, TCB and turbidity are the major problem parameters by averaging 40, 36 and 36 % of most monitoring stations, respectively, during 1991 to 2000. The major contributors to pollution in this section were generated mainly from domestic and agricultural activities.

Consequently, the river water quality was in a less deteriorated state with normal DO value except in Amphoe Muang Nonthaburi, low BOD and slightly high FCB and TCB specifically in Amphoe Muang Ayutthaya. With compared to water quality since 1978, the trend of DO in this section is slightly sloped down, trend for BOD moderately slope up and TCB extremely slope up (Figure 4).

In the upper part of the river, from Amphoe Muang Ayutthaya to Amphoe Muang Nakhon Sawan, the river was less polluted. The average DO level in this section was 6.3 mg/L and the P20 value was 5.5 mg/L which was a little lower quality standard (not less than 6 mg/L). From Table 2, most DO values in this section were under the regulated standard value. The DO levels in almost all of the monitoring stations in year 2000 were higher level than the DO standard level (the observed DO values ranged from 4.0 to 7.9 mg/L) because of the dilution from flooding.


(a)
DO(mg/L)
1999 1998 1997 1996 1995 1994
1993 1992 1991 1990 1989 1988
1987 1986 1985 1983 1982 1981
1980 1979 1978
13,0 12,0 11,0 10,0 9,0 8,0 7,0 6,0 5,0 4,0 3,0 2,0 1,0 0,0
lower
middle
upper
7 18 29 42 48 58 83 96 101 124 142 183 227 244 277 286 331 376
km. From the river mouth (RKM)


(b)
BOD (mg/L)
1999 1998 1997 1996 1995 1994
1993 1991 1990 1989 1988 1987
1986 1985 1984 1983 1982 1981
1980 1979 1978
10,0 9,5 9,0 8,5 8,0 7,5 7,0 6,5 6,0 5,5 5,0 4,5 4,0 3,5 3,0 2,5 2,0 1,5 1,0 0,5 0,0
lower
middle
upper
7 18 29 42 48 58 83 96 101 124 142 183 227 244 277 286 331 376
km. From the river mouth (RKM)


(c)
TCB (MPN/100ml)
1999 1998 1997 1996 1995 1994
1993 1992 1991 1990 1989 1988
1987 1986 1985 1984 1983 1982
1981 1980 1979 1978
100 000 000
10 000 000
1 000 000
100 000
10 000
1 000
100
10
1
lower
middle
upper
7 18 29 42 48 58 83 96 101 124 142 183 227 244 277 286 331 376
km. from the river mouth (RKM)

The average BOD value in this section was 1.5 mg/L and the P80 was 1.8 mg/L. BOD values in this section did slightly exceed the regulated value (not more than 1.5 mg/L). The average TCB was 350,000 MPN/100mL and the P80 value was 35,000 MPN/100 mL with higher than the regulated standard (not more than 5,000 MPN/100 mL). Concentrations of TP, NH_3-N and NO_3-N in this section were averaged approximately 0.07, 0.08 and 0.52 mg/L, respectively. In the upper section of the Chao Phraya River, TCB, FCB and turbidity were the major problem parameters by averaging 37, 36 and 26 % of all monitoring stations during 1991 to 2000 (Table 3). The major contributors to pollutant generation in this section were mainly from domestic and agricultural activities.

I the upper part of the river, water quality was in a natural state, and most stations was slightly lower DO values, and higher BOD, FCB and TCB values than the regulated standard. The lowest DO values in this section were found to be 4.8 mg/L at Aumphor Muang Chainat. However, the BOD values in this section were higher than the surface water quality standard especially in the river flowing via large communities. TCB values mostly exceeded over the regulated value. with Compared to water quality during 21 years (1978 – 1999), trend of DO in this section slightly sloped down, while trend of BOD slightly sloped up and trend of TCB extremely sloped up (Figure 4).

In summary, the water quality of the Chao Phraya River was "moderately clean" in the upper part, " lightly polluted" in the middle part and " polluted" in the lower part. DO, BOD and FCB/TCB are major problems of water quality parameters. Low DO level, and high BOD and FCB/TCB were the most alarming water quality problems in the river. However, other parameters are needed to be considered such as nutrients from agricultural non-point source pollution.

2.4 Tha Chin river

The Tha Chin River has been subdivided into three sections: lower (RKM 0 to 82), middle (RKM 82 to 202) and upper (RKM 202 to 325) based on the river water quality standard and its classification. Water quality monitoring during the last decade (1984 – 1995) showed that water quality in the upper region were better than in the middle and lower parts of the river, respectively. The first three major polluted contributors in the Tha Chin River regarding the respective parameters (Figure 5) are low DO (30 %), high FCB and TCB (47 %) and high NH_3-N (15 %). Simachaya (1999) states that organic waste in term of BOD generation in the entire Tha Chin Basin are highest from industrial sector (33 %), followed by domestic sources (30 %), pig farms (23 %), fish and shrimp farms (12 %), and duck farms (2 %).

In the lower part, from the river mouth Samut Sakhon Province (RKM 0) to the Nakhon Chaisi District in the Nakhon Pathom Province (RKM 82), the river was seriously polluted with organic waste contamination. The most alarming water quality problem in this part was the low concentrations of dissolved oxygen (DO) during the dry period. DO levels almost every monitoring stations were lower than the regulated value of the established water quality standard for industrial use (not less than 2 mg/L). The average DO value in this section since 1982 was 1.2 mg/L and the P20 value during that time was 0.5 mg/L (Table 4). From figure 6, DO values in this part are very low especially from the river mouth to Nakhon Chaisi

District. The DO levels in most monitoring stations in year 2000 were lower than the regulated standard value (the observed DO values ranged from 0.0 to 0.9 mg/L). BOD levels in this section were mostly below the established water quality standard (not more than 4 mg/L). The average BOD value was 2.6 mg/L and the P80 value was 3.5 mg/L. TCB values were found as follows, the maximum as 24,000,000 MPN/100 mL, average as 350,000 MPN/100 mL and P80 as 170,000 MPN/100 mL. Concentrations of TP, NH_3-N and NO_3-N in this section were approximately 0.22, 0.68 and 0.85 mg/L, respectively. In the lower part of the Tha Chin River, DO, FCB, TCB, and NH_3-N were the major problem parameters by averaging 95, 69, 67 and 62 %, respectively, of all monitoring stations during 1991 - 2000 (Table 5). However, TS and BOD could be the potential problem's parameters in this section. The major contributors to water pollution in this section were generated mainly from domestic and industrial activities and pig farms.

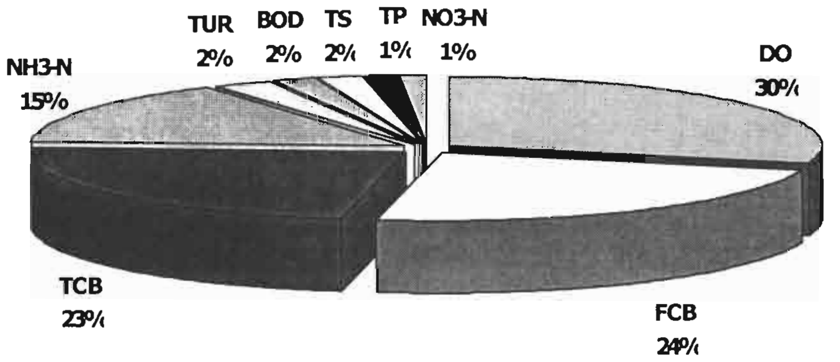


FIGURE 5 PROBLEM'S PARAMETERS IN THE THA CHIN RIVER 1991-2000

TABLE 4 THE MOST ALARMING WATER QUALITY PARAMETER OF THE THA CHIN RIVER 1982 - 1999

	DO		BOD		TCB	
River Reaches	Average	P20	Average	P80	Average	P80
Lower	1.2	0.5	2.6	3.5	350,000	170,000
Middle	2.5	1.2	2.4	3.0	700,000	220,000
Upper	5.2	4.4	1.8	2.1	650,000	120,000

TABLE 5 PERCENTAGE OF WATER – QUALITY PARAMETER PROBLEMS OF THE THA CHIN RIVER 1991-2000

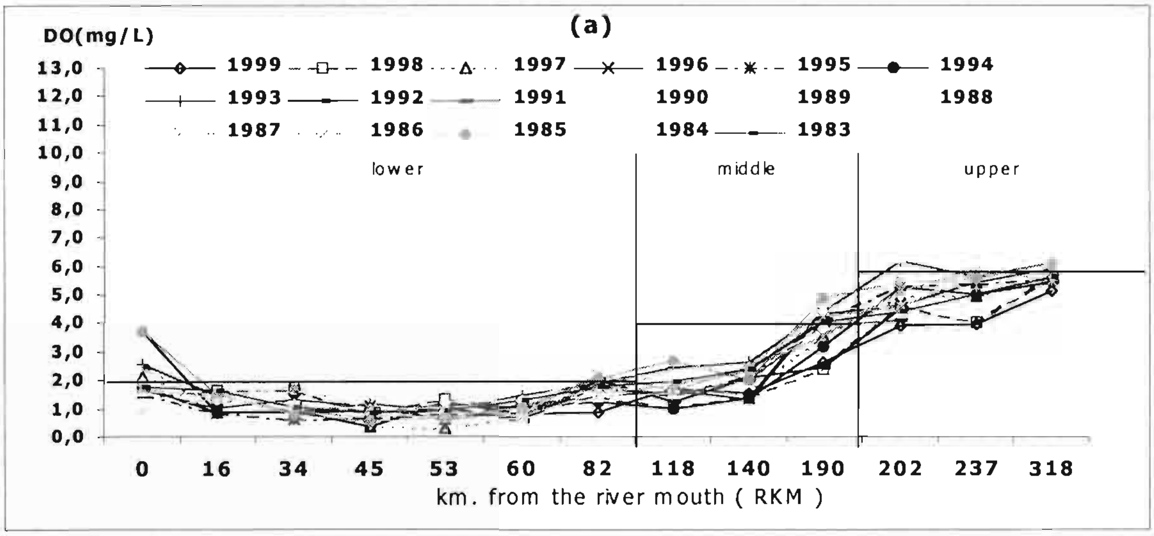
River Reaches	Tur.	DO	BOD	FCB	TCB	NH_3-N	TP	TS
Lower	0	95	6	69	67	62	5	11
Middle	4	73	5	49	49	23	1	0
Upper	28	3	3	45	43	3	0	0

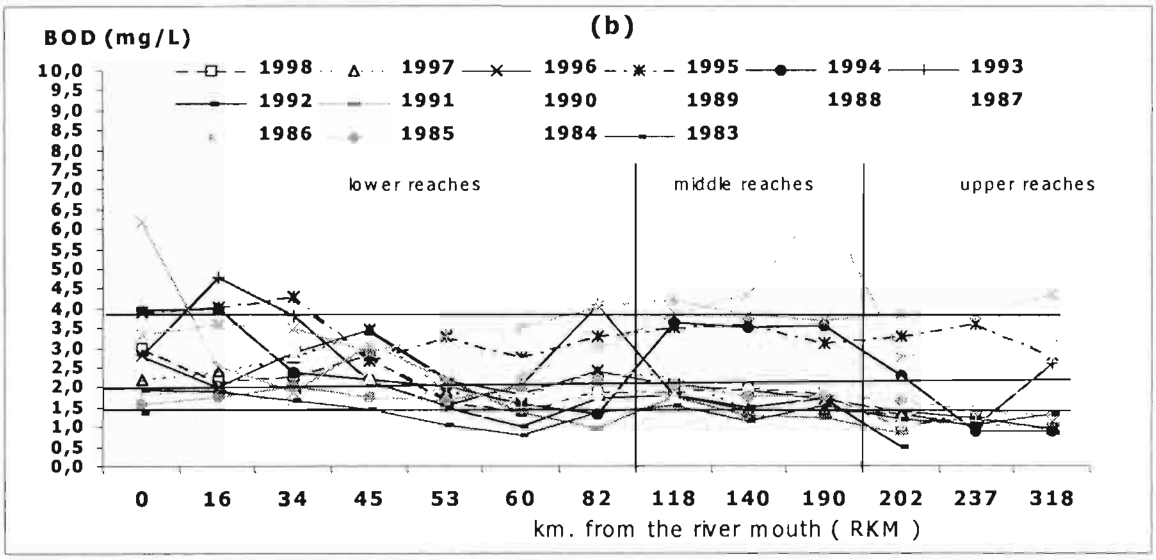
In the lower part, there were many canals in Nakhon Pathom and Samut Sakhon joining and delivering wastewater from domestic and industrial sources. Form Figure 7, water quality during 16 years (1982 – 1999) has trend of DO slightly sloped down and trend of BOD and TCB extremely sloped up.

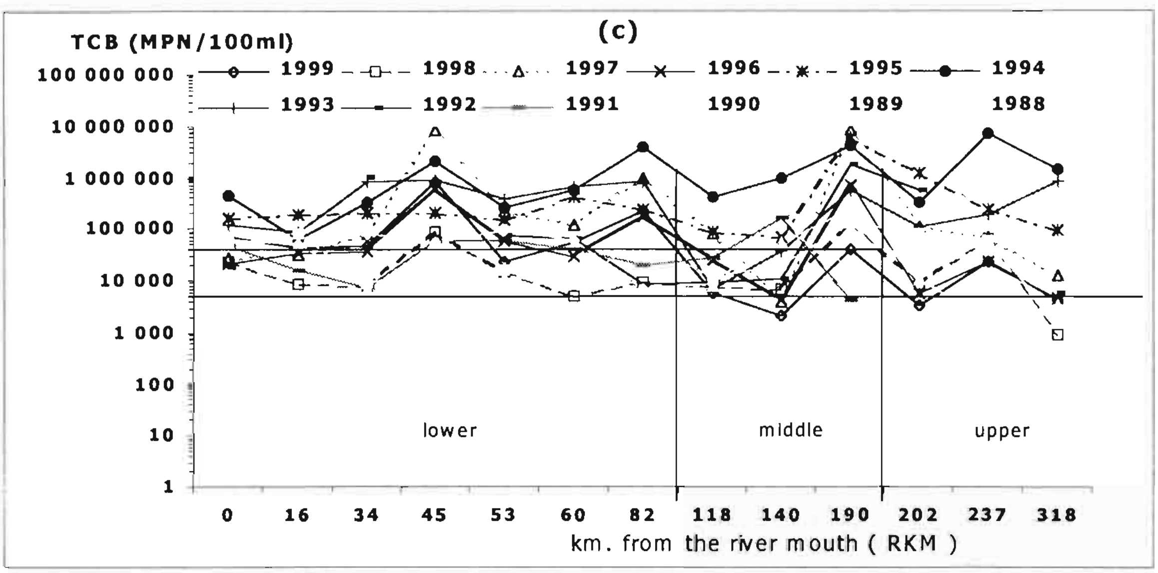
In the middle part, from Nakhon Chaisi District to the Phopraya Regulator in SuphanBuri Province the river was moderately polluted. The DO levels in almost all of the monitoring stations were lower than the regulated value for consumption and agricultural use (not less than 4 mg/L). The average DO value was 2.5 mg/L and the P20 value during that period was 1.2 mg/L. From Figure 6, DO values in this part was very seriously contaminated from domestic wastewater discharges between Nakhon Chaisi District and Muang Suphanburi. The DO levels of most monitoring stations in year 2000 were lower level than the DO standard level of Class 3 (the observed DO values ranged from 1.0 to 3.9 mg/L. Concentration of BOD was 2.4 mg/L and the P80 value was 3.0 mg/L. BOD values in this section did exceed water quality standard (not more than 2.0 mg/L). The average TCB was 700,000 MPN/100 mL and the P80 value was 220,000 MPN/100 mL, which was higher than Class 3 of the Surface Water Quality Standard (not more than 20,000 MPN/100 mL). Concentrations of TP, NH_3-N and NO_3-N in this section were averaged approximately 0.10, 0.31 and 0.50 mg/L, respectively. In the Tha Chin River, concentrations of DO, FCB and TCB were major problem parameters by averaging 73, 49 and 49%, respectively, of all monitoring stations during 1991 - 2000 (Table 5). Additionally, NH_3-N and turbidity could be the potential problem's parameters in this section. The major pollution sources in this sector were from domestic and agricultural activities.

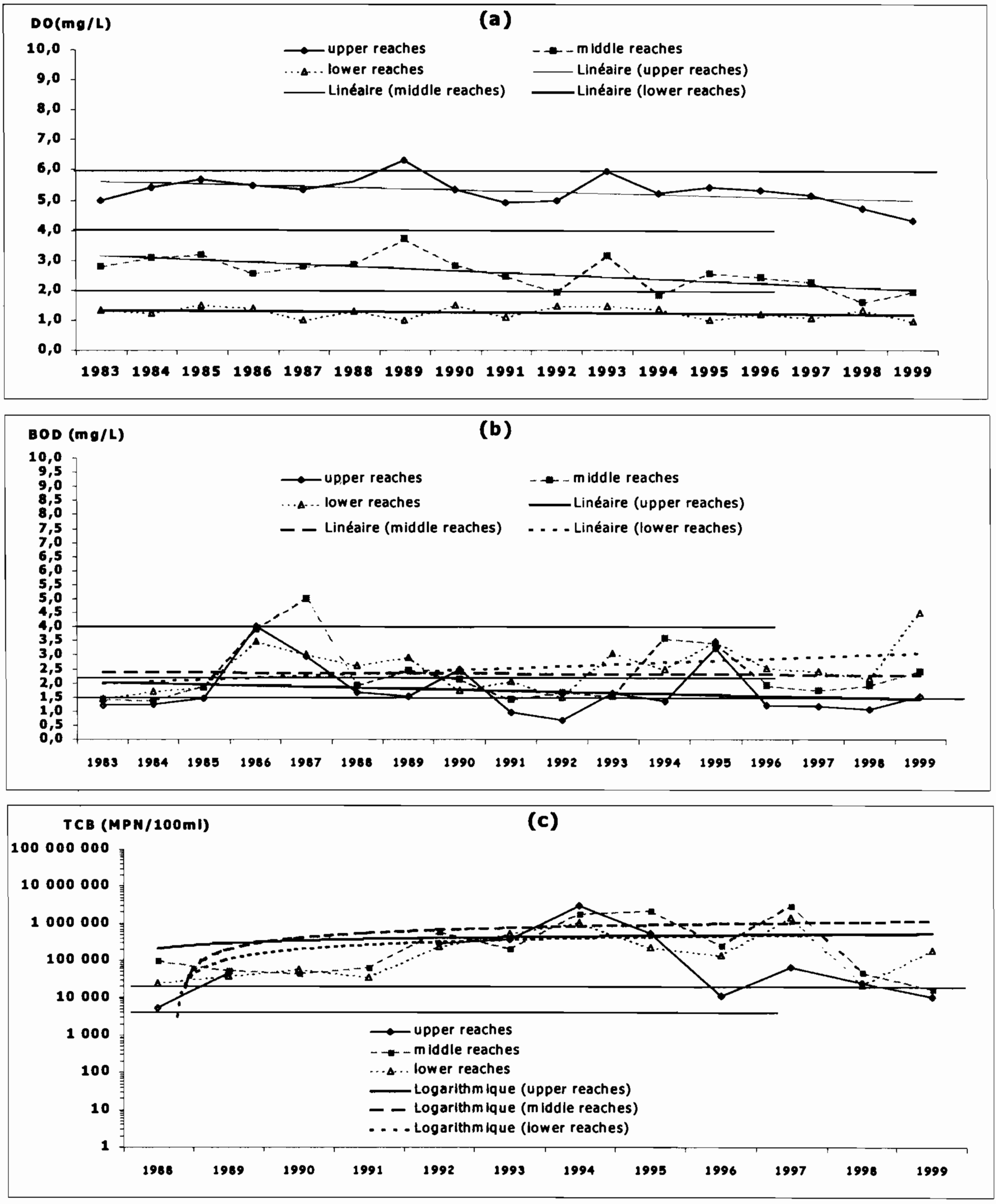
The middle part of the Tha Chin's water quality was in a moderately deteriorated state with low DO values specifically in Nakhon Pathom Province and high BOD and very high FCB/TCB especially in the river flowing in Nakhon Pathom Province. with Compared to water quality since 1982, the trend of DO in this section slightly sloped down, while the trend of BOD slightly sloped up and TCB extremely sloped up (Figure 7).

In the upper part of the river, from the Phopraya Regulator to the Polthep Regulator, the river is less polluted. The average DO level in almost all of this section was 5.2 mg/L and the P20 value was 4.4 mg/L lower than the water quality standard (not less than 6 mg/L). From Figure 6, DO values in this part is less contaminated. The DO levels in almost all of the monitoring stations in year 2000 were higher level than the DO standard level of the upper reaches of the Tha Chin River (the observed DO values ranged from 0.0 to 0.9 mg/L). The average BOD value in this section was 1.8 mg/L and the P80 value was 2.1 mg/L. BOD values in this section did exceed the regulated value (not more than 1.5 mg/L). The average TCB was 650,000 MPN/100mL and the P80 value was 120,000 MPN/100 mL (not more than 5,000 MPN/100 mL). Concentrations of TP, NH_3-N and NO_3-N in this section were averaged approximately 0.07, 0.10 and 0.88 mg/L, respectively. FCB, TCB, and turbidity are the major problem parameters by averaging 45, 43 and 28 % of monitoring stations during 1991 - 2000 (Table 5). The major contributors to pollution in this section were generated mainly from domestic and agricultural activities.


(a)
DO(mg/L)
1999 1998 1997 1996 1995 1994
1993 1992 1991 1990 1989 1988
1987 1986 1985 1984 1983
lower
middle
upper
13,0 12,0 11,0 10,0 9,0 8,0 7,0 6,0 5,0 4,0 3,0 2,0 1,0 0,0
0 16 34 45 53 60 82 118 140 190 202 237 318
km. from the river mouth (RKM)


(b)
BOD (mg/L)
1998 1997 1996 1995 1994 1993
1992 1991 1990 1989 1988 1987
1986 1985 1984 1983
lower reaches
middle reaches
upper reaches
10,0 9,5 9,0 8,5 8,0 7,5 7,0 6,5 6,0 5,5 5,0 4,5 4,0 3,5 3,0 2,5 2,0 1,5 1,0 0,5 0,0
0 16 34 45 53 60 82 118 140 190 202 237 318
km. from the river mouth (RKM)


(c)
TCB (MPN/100ml)
1999 1998 1997 1996 1995 1994
1993 1992 1991 1990 1989 1988
100 000 000
10 000 000
1 000 000
100 000
10 000
1 000
100
10
1
lower
middle
upper
0 16 34 45 53 60 82 118 140 190 202 237 318
km. from the river mouth (RKM)


(a)
DO(mg/L)
10,0
9,0
8,0
7,0
6,0
5,0
4,0
3,0
2,0
1,0
0,0
upper reaches
middle reaches
lower reaches
Linéaire (upper reaches)
Linéaire (middle reaches)
Linéaire (lower reaches)
1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999
(b)
BOD (mg/L)
10,0
9,5
9,0
8,5
8,0
7,5
7,0
6,5
6,0
5,5
5,0
4,5
4,0
3,5
3,0
2,5
2,0
1,5
1,0
0,5
0,0
upper reaches
middle reaches
lower reaches
Linéaire (upper reaches)
Linéaire (middle reaches)
Linéaire (lower reaches)
1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999
(c)
TCB (MPN/100ml)
100 000 000
10 000 000
1 000 000
100 000
10 000
1 000
100
10
1
upper reaches
middle reaches
lower reaches
Logarithmique (upper reaches)
Logarithmique (middle reaches)
Logarithmique (lower reaches)
1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999

In summary, the river water quality in the ThaChin River was in a natural state, and almost every stations in the upper reaches have slightly lower DO values, and higher BOD and TCB than the regulated standard. DO value in this section has the lowest value in Samchuk District within 4.8 mg/L of the P20 value. However, the BOD values this section were higher than the Surface Water Quality Standard in the river sections which large communities are located. On the other hand, the TCB values were mostly exceeded over the regulated value. When compared to water quality during 16 years (1982 – 1999), trend of DO in this section slightly sloped down, trend of BOD slightly sloped up and trend of TCB extremely sloped up (Figure 7).

During late April to early May 2000, water quality along the 150-kilometer length of the Tha Chin River from Song Phi Nong District in Suphan Buri Province, Nakhon Pathom Province, and down to Muang District in Samut Sakorn Province, was completely polluted. The watercolor became black with very bad smell. Concentrations of DO in the river measured during May 3-7, 2000 became zero. The water river quality became worse when it flowed through Nakhon Pathom and Samut Sakhon Provinces because of discharge of a large amount of wastewater from industries, communities, and pig farms. However, DO concentrations of the river have never been reached zero. Large number of fish and other aquatic organisms died after the mass of high polluted water flowed through. The effect of this disaster was investigated from the opportunity losses on water usage, water supply, and aquatic system. The aquatic ecosystem in the river and estuary was destroyed. The major pollution source of this disaster was from the discharged wastewater from Song Phi Nong Sub-delta (132,000 rai) because the paddy fields were flooded and decayed just before harvesting period (high carbohydrate content) (Pollution Control Department, 2000b).

In general, the water quality of the Tha Chin River is "clean" in the upper reaches, "moderately polluted" in the middle reaches and " polluted" in the lower one. DO, BOD and FCB/TCB are main parameters of the river water quality. Low DO level, and high BOD and FCB/TCB are the most alarming water quality problems in the river. However, other parameters are needed to consider as well as the three major parameters. Thus, use of all parameters has been increased to improve this paper in order to investigate the main effect from most activities in the Tha Chin River Basin.

2.5 Meklong River

The Meklong River is classified in class 3 of the Surface Water Quality Standard. There are 10 water-quality sampling stations in the river. Water quality monitoring results during the last decade (1984 – 1995) were to be fair and good water quality. The first three major polluted contributors in the Meklong River regarding the respective parameters (Figure 8) are high FCB and TCB (79 %), high TS (8 %) and high turbidity (6 %).

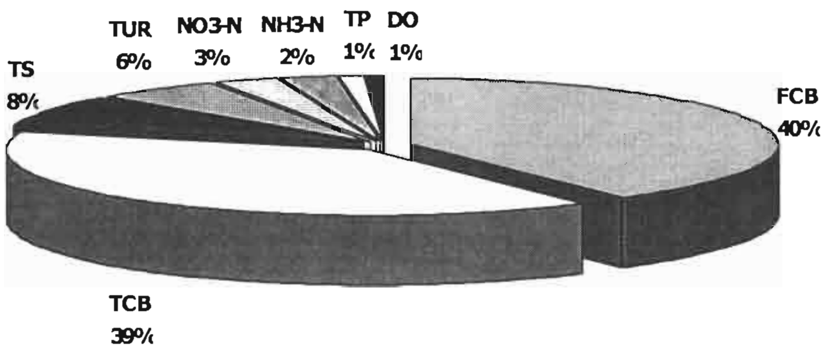
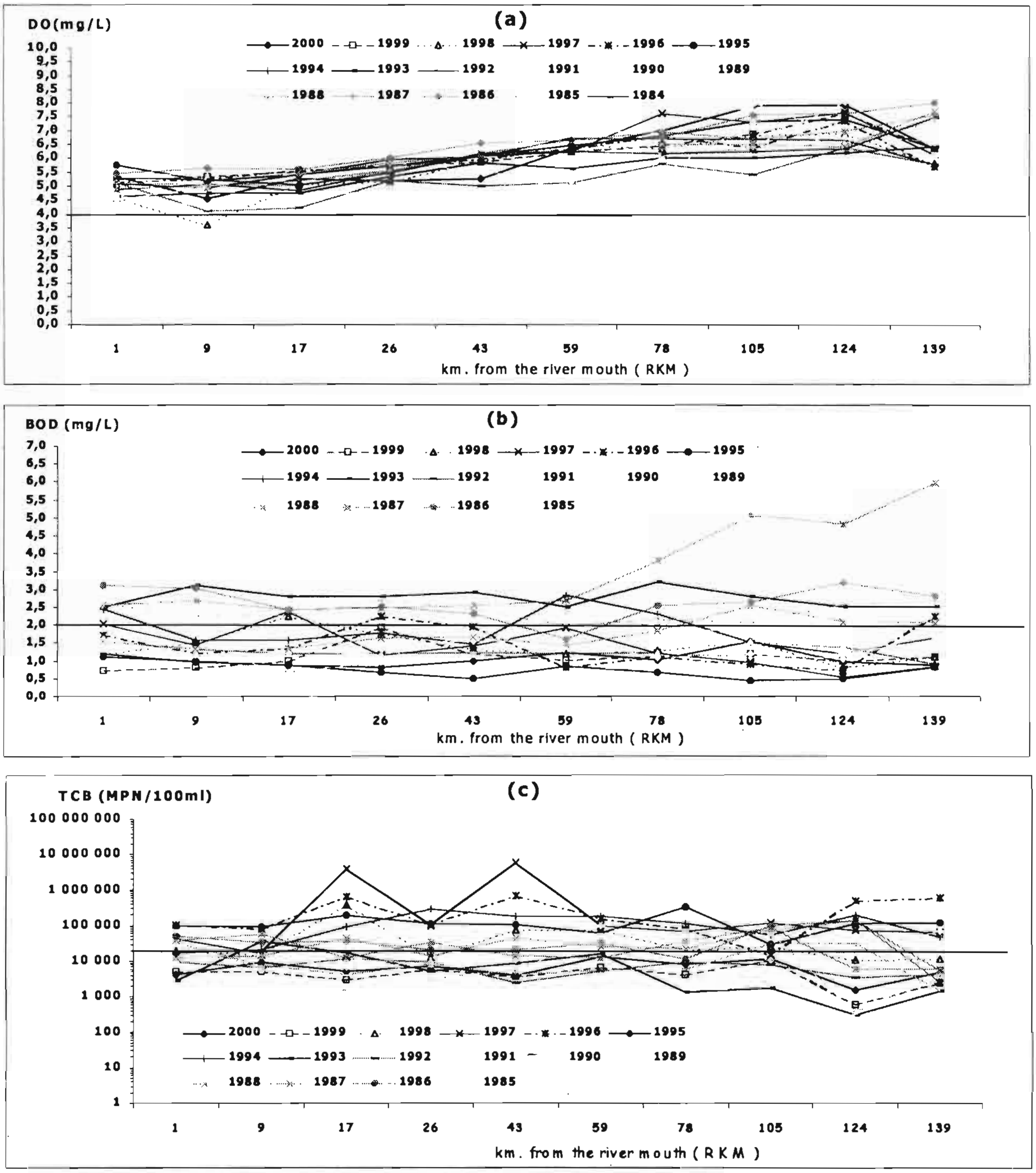


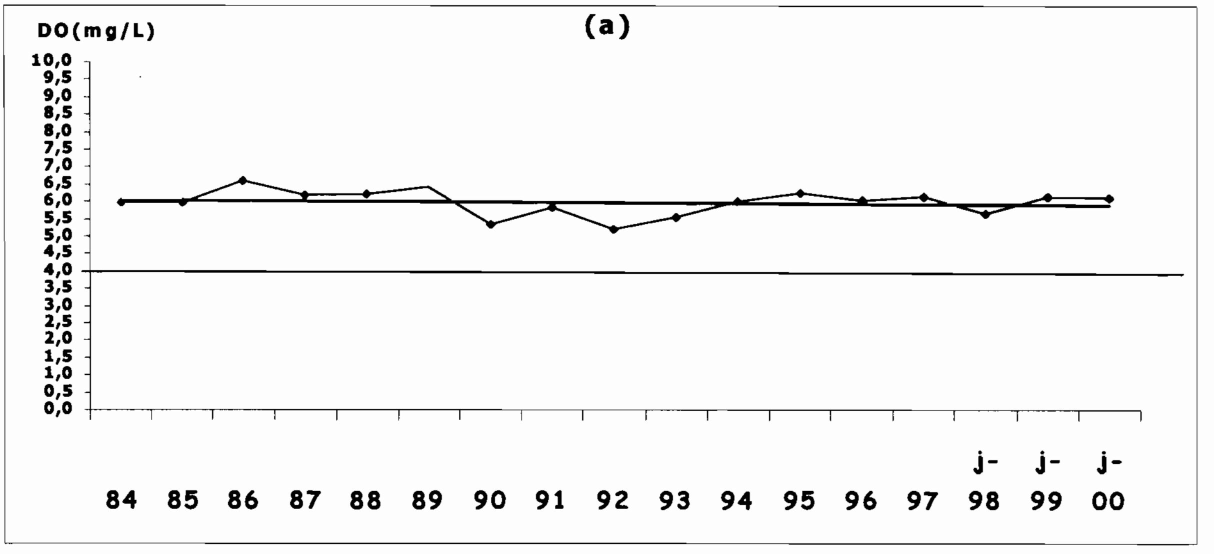
Figure 8 Problem's Parameters in the Meklong River 1992-2000

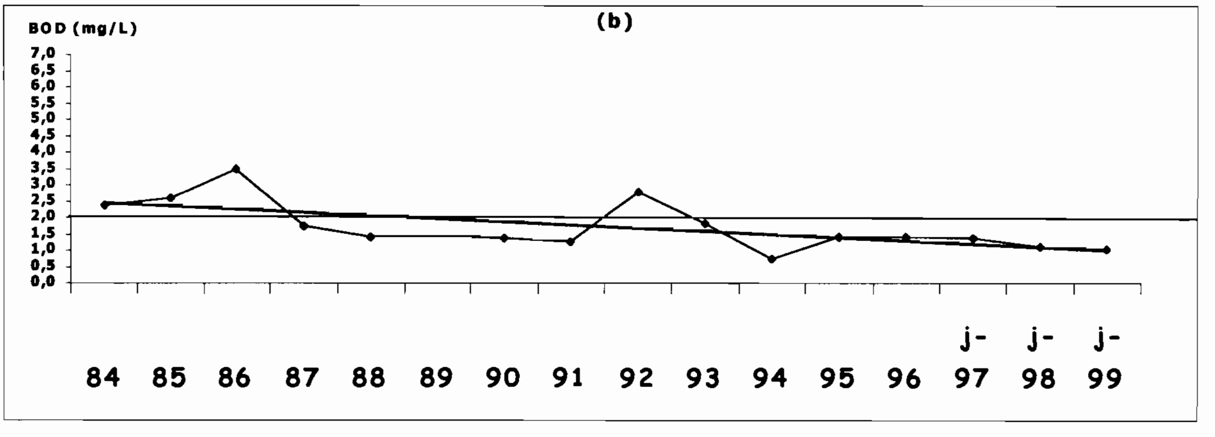
The Meklong River is less polluted. The most alarming water quality problem in this part is the low concentrations of dissolved oxygen (DO) during the dry period in certain years. However, DO levels almost every monitoring stations were higher than the regulated value in the established water quality standard for industrial use (not less than 4 mg/L). The average DO value in this section since 1978 to 1999 was 6.0 mg/L and the P20 value during those period of time was 5.1 mg/L (Table 6), which was within the Class 3 of the Surface Water Quality Standard. From Figure 9, most DO values in the river were higher than the standard value especialy from Dumnensaduk District, Rachaburi Province to Kanchanaburi Province. BOD levels in this section were mostly below established water quality standard (not more than 2 mg/L) with averaging 1.7 mg/L and the P80 value 2.3 mg/L. TCB values were found to be high with the maximum as 16,000,000 MPN/100 mL, average as 200,000 MPN/100 mL and P80 as 160,000 MPN/100 mL, which was higher than the standard value (not more than 20,000 MPN/100 mL). Concentrations of TP, NH_3-N and NO_3-N in the river were averaged 0.05, 0.14 and 0.31 mg/L, respectively. For the lower part of the Meklong River, FCB and TCB are the major problem parameter by averaging 44 and 43 % of all monitoring stations during 1991 to 2000 (Table 7). The major contributors to pollution in this section were generated mainly from domestic and industrial activities.

TABLE 6 THE MOST ALARMING WATER QUALITY PARAMETERS OF THE MEKLONG RIVER 1978 - 1999

	DO		BOD		TCB	
	Average	P20	Average	P80	Average	P80
River Reaches	6.0	5.1	1.7	2.3	200,000	160,000


(a)
DO(mg/L)
2000 1999 1998 1997 1996 1995
1994 1993 1992 1991 1990 1989
1988 1987 1986 1985 1984
10,0 9,5 9,0 8,5 8,0 7,5 7,0 6,5 6,0 5,5 5,0 4,5 4,0 3,5 3,0 2,5 2,0 1,5 1,0 0,5 0,0
1 9 17 26 43 59 78 105 124 139
km. from the river mouth (RKM)
(b)
BOD (mg/L)
2000 1999 1998 1997 1996 1995
1994 1993 1992 1991 1990 1989
1988 1987 1986 1985
7,0 6,5 6,0 5,5 5,0 4,5 4,0 3,5 3,0 2,5 2,0 1,5 1,0 0,5 0,0
1 9 17 26 43 59 78 105 124 139
km. from the river mouth (RKM)
(c)
TCB (MPN/100ml)
100 000 000
10 000 000
1 000 000
100 000
10 000
1 000
100
10
1
2000 1999 1998 1997 1996 1995
1994 1993 1992 1991 1990 1989
1988 1987 1986 1985
1 9 17 26 43 59 78 105 124 139
km. from the river mouth (R K M)


(a)
DO(mg/L)
10,0
9,5
9,0
8,5
8,0
7,5
7,0
6,5
6,0
5,5
5,0
4,5
4,0
3,5
3,0
2,5
2,0
1,5
1,0
0,5
0,0
84 85 86 87 88 89 90 91 92 93 94 95 96 97 j-98 j-99 j-00


(b)
BOD (mg/L)
7,0
6,5
6,0
5,5
5,0
4,5
4,0
3,5
3,0
2,5
2,0
1,5
1,0
0,5
0,0
84 85 86 87 88 89 90 91 92 93 94 95 96 j-97 j-98 j-99

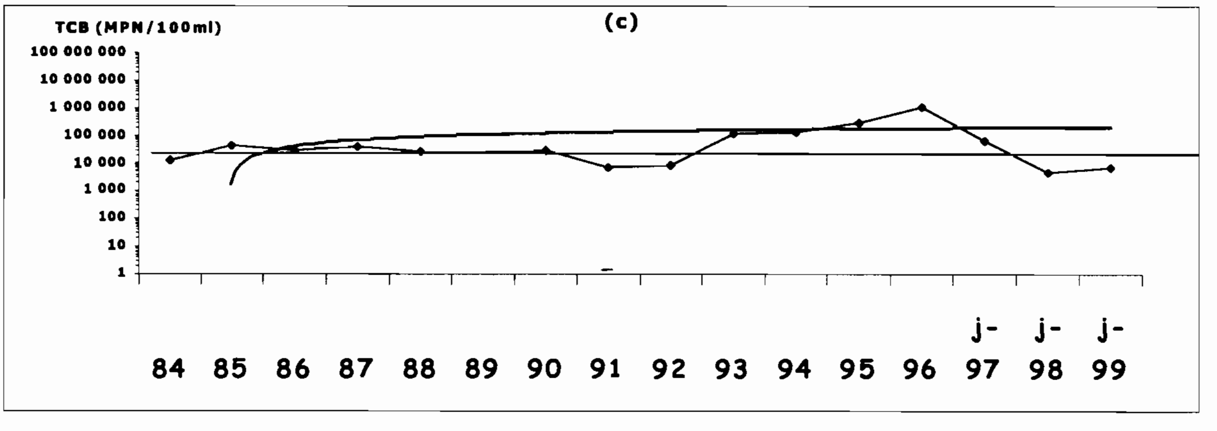

(c)
TCB (MPN/100ml)
100 000 000
10 000 000
1 000 000
100 000
10 000
1 000
100
10
1
84 85 86 87 88 89 90 91 92 93 94 95 96 j-97 j-98 j-99

TABLE 7 PERCENTAGE OF PROBLEMS OF EACH WATER QUALITY PARAMETER OF THE MEKLONG RIVER 1991-2000

	Tur	DO	BOD	FCB	TCB	NH_3-N	NO_3-N	TS
River Reaches	8	1	0	44	43	3	3	9

In summary, the Meklong River's water quality was still in good condition with high DO and low BOD values. However, some parts of the river especially in the urban areas, TCB and FCB were very high and sometimes higher that the value of the water quality standard. The river 's water quality during 14 years (1985 – 1999) has slightly sloped down trend of DO (Figure 10) and slightly sloped up trend of BOD and extremely sloped up trend of TCB.

3 Water quality management

As mentioned earlier, there are three major pollution sources: domestic, industrial, and agricultural wastewater. The contributions of waste loads from those sources are different from place to place. For examples, the major source of pollutant in the Chao Phraya River from domestic wastewater, while agricultural sources (especially pig farms) and industrial activities are major wastewater sources for the Tha Chin River. Various management approaches have been applied to tackle water pollution problems in the Chao Phraya Delta such as:

- Establish receiving water quality standards and classification based on existing beneficial uses and loading reduction policies
- Set up effluent standards for major pollution sources such as building, industry, pig farm, etc.
- Construct central treatment plants of major municipalities
- Monitor receiving water quality an effluent from point-source pollution
- Implement public awareness program
- Set up the restricted zone for protection the source of water supply (cabinet resolution) Such as limitation of industrial expansion especially that factories produce toxic substances and high organic matter discharges
- Set up Wastewater Management Authority for the region.

4 Conclusion

The most alarming water quality problem in the delta is the low concentrations of DO and high concentrations of coliform bacteria especially during the dry period. DO concentrations were found to be less than 1 mg/L and coliform bacteria were found in densities of up to 10 times the standard levels. It can be concluded that the pollution in the lower parts of the

Chao Phraya and Tha Chin Rivers has reached a critical status compared to the established water quality standards. However, water quality of Meklong River has been in good condition due to less amount of waste loading and high water quantity. Thus, the treatment of wastewater effluent to acceptable standards before discharging into receiving waters is highly required. In general, the first priority concern is the risk to human health and aquatic life. However, the importance of the waterbody for recreation, aesthetic, and economic purposes, and the fragility of any specific environments such as aquatic habitat and wetlands should also be concerned.

RECOMMENDATIONS

1. Since the water quality of the Chao Phraya Delta is becoming worse every year especially in the lower parts of the Chao Phraya and Tha Chin Rivers, appropriate investment in wastewater treatment facilities in these sections should be prioritized based upon assimilative capacity of receiving waters, budget availability, and prioritized projects within basin-wide approach. Simple wastewater system based on natural conditions are also being addressed such as wet land applications, stabilization ponds, and crop irrigation systems.

2. Waste minimization which is included wastewater recycle and reuse, should be applied in the delta for reducing waste and maintain water quantity in main streams especially for land application and agricultural fields. Some factories have used treated water in the cooling system. However, there is recently no enforcement of this aspect. Only campaign and reinforcement are practicing. The term of "cleaner production" encompasses all phase of production process and product life cycle should also be considered. As agriculture (mainly paddy fields) is a dominant land use in the delta and is thus an important source of water pollution, it is recommended that measure and policy of best management practices (BMPs) should be developed and applied as a tool for water quality management especially for non-point source pollution controls.

3. Database system for the delta should be developed such as geographic information system (GIS), water quality and quantity database, and development projects. The system should be made available for public.

4. Once water quality problems have been identified, it is necessary to develop targets for restoration especially the planning exercise in a basin-wide basis.

5. Water quality management planning should be developed regarding the information of community health risk potential, proximity to water supply sources, magnitude of the pollutant loading discharged to the receiving water, carrying capacity of the stream to absorb pollutants, water quality criteria, and distance of pollutant source from the stream.

6. In Thailand, there are more than 30 agencies within 8 different ministries that are directly and indirectly concerned with water quality and quantity. Thus, a national planning on water resources management should be developed under appropriate institutional and legal frameworks. Watershed committee in each basin or sub-basin should also be set up to handle and manage water resources in the basin.

REFERENCES

Pollution Control Department. 1997. Development of an Action Plan to Improve the Water Quality in the Central River Basin, Thailand. Ministry of Science, Technology and Environment

Pollution Control Department. 2000a. Water Quality Standards & Criteria in Thailand (in Thai). 4th ed., Ministry of Science, Technology and Environment.

Pollution Control Department. 2000b. Critical Water Pollution in the Tha Chin River (in Thai). Ministry of Science, Technology and Environment.

Simachaya, W. 1999. Integrated Approaches to Water Quality Management Using Geographic Information Systems and the WASP5 Simulation Model: Application to the Tha Chin River Basin, Thailand. Ph.D. Dissertation, School of Engineering, University of Guelph, Ontario, Canada, 409 pages

Simachaya, W. and Noikeang, P. 2000. State of Surface Water Quality in Thailand. Paper presented to the Seminar on Water Quality Management at Environmental Research and Training Center, Department of Environmental Quality Promotion.

Appendix

THE SURFACE WATER QUALITY STANDARD IN THAILAND

Parameter	Units	Statistic	Standard Value for Class***				
			1	2	3	4	5
1. Colour, Odour and Taste	-	-	N	N	N	N	-
2. Temperature	oC	-	N	N'	N'	N'	-
3. pH value	-	-	N	5-9	5-9	5-9	-
4. Dissolved Oxygen	mg/l	P20	N	6.0	4.0	2.0	-
5. BOD (5 days, 20 oC)	mg/l	P80	N	1.5	2.0	4.0	-
6. Coliform Bacteria							
- Total coliform	MPN/100ml	P80	N	5000	20000	-	-
- Fecal coliform	"	"	N	1000	4000	-	-
7. NO_3 -N	mg/l	Max. allowance	N	5.0			-
8. NH_3 -N	"	"	N	0.5			-
9. Phenols	"	"	N	0.005			-
10. Cu	"	"	N	0.1			-
11. Ni	"	"	N	0.1			-
12. Mn	"	"	N	1.0			-
13. Zn	"	"	N	1.0			-
14. Cd	"	"	N	0.005*, 0.05**			-
15. Cr (hexavalent)	"	"	N	0.05			-
16. Pb	"	"	N	0.05			-
17. Hg (total)	"	"	N	0.002			-
18. As	"	"	N	0.01			-
19. CN	"	"	N	0.005			-
20. Radioactivity							
- Gross α	Becqurel/l	"	N	0.1			-
- Gross β	"	"	N	1.0			-
21. Pesticides(total)	mg/l	Max. allowance	N	0.05			-
- DDT	μg/l	"	N	1.0			-
- α BHC	"	"	N	0.02			-
- Dieldrin	"	"	N	0.1			-
- Aldrin	"	"	N	0.1			-
- Heptachlor & Heptachlor Epoxide	"	"	N	0.2			-
- Endrin	"	"	N	none			-

Remark: P = Percentile value; N = naturally; N' = naturally but changing not more than 3 oC
* = when water hardness not more than 100 mg/l as CaCO3
** = when water hardness more than 100 mg/l as CaCO3
*** = Water Classification

Source: Pollution Control Department (2000a), National Environment Board Notification No.8 published in the Royal Goverment Gazette, vol. 111, No.16, dated February 4, B.E. 2537 (1994).

Benthic fauna and water quality in the Chao Phraya river, Thailand

Monchan Maketon[1], Rachadaporn Kittiworachet[2], Charuwan Somsiri[3] and Tippanan Ngamprayad[3]

Abstract *: The abundance and diversity of benthos were monitored at 14 sites along the length of the Chao Phraya River from January to December 1997. Forty six families were recorded in four phyla, namely the Annelida, Mollusca, Arthropoda and Chordata. The greatest number of families was twentyfour at the estuary, and the least number was five, at Amphoe Muang Singhaburi Singhaburi, Province. The peak density of all organisms was 6736 m^{-2} at Khet Phrakanong, Bangkok, during the rainy season. The lowest recorded density was 66 m^{-2} at Amphoe Muang Singhaburi Singhaburi, Province, and the average density across all sites was 1441 m^{-2}. The dominant group generally was the Annelida, especially the family Naididae. The highest indices of species diversity and evenness index were 2.08 and 0.79, respectively, at Amphoe Muang Pra Nakhon Sri Ayuthaya, Pra Nakhon Sri Ayuthaya Province, and the lowest values were 0.12 and 0.05, respectively, at Khet Phrakanong, Bangkok. These indices showed tendencies to indicate water quality in this study when considered concurrently with some others environmental factors.*

Water qualities were studied in many parameters. All BOD values from the upstream, middle and downstream were higher than Water quality standard value of class 2, class 3, and class 4 respectively, while most parameters were still in the range of water quality standard class 3. The calculated water quality index (WQI) was relatively high because Fecal-coliform bacteria (FCB) value was not included in the calculation. The indices indicated that the water qualities in the upstream and the middle were very good to fair instead of fair to poor, but the downstream qualities were poor at all sites.

[1] Department of Zoology, Faculty of Science, Kasetsart University, Bangkok, Thailand

[2] Ecology Group, Fisheries Environment Department, Division of Fisheries, Bangkok, Thailand

[3] Office of Atomic Energy for Peace, Division of Isotope Production, Bangkok, Thailand

1 Introduction

The Chao Phraya River is one of the most important main river in the central part of Thailand. Chao Phraya River covers an area of 10,270 Square kilometer, its well developed transportation infrastructure as well as a large number of pollution sources. The amount of biochemical oxygen demand (BOD) generated throughout the catchment approximately 595 tons/day. Physically the catchment is rather flat, its average slope only 1.1%. The average elevation throughout the basin is around 24 m. above mean sea level (AMSL). The river exhibits classic U-shaped channel that is characteristic of flood plain reaches of river. Typically, channel depths in the Chao Phraya River are around 15 m from top of the bank and have flat hydraulic gradients of around 0.01%. This suggests that in dry season the flow velocities are low, around 20 km/day or 0.2 m/s. Total length is 380 km. with fifteen provinces locatted along the Chao Phraya River. Nakhon Sawan province covers the largest area of the catchment, followed by Bangkok and Pathum Thani. The total 1996 population residing in the catchment were around 10.1 million (Pollution Control Department 1997). Several communities including people in the urban and suburban are using water from the river not only for municipal usage but also for industrial and agricultural purposes. Thus, the present water qualities are getting lower than the acceptable levels. The Department of Health (1996) has classified that 50 per cent of the problem occurred from the Fecal-coliform bacterias (FCB), 37.5 per cent from the Biochemical oxygen demand (BOD) and the Dissolved oxygen quantity (DO), 8.3 per cent from the ammonia-nitrate and nitrogen, and 4.2 per cent from heavy metals respectively. These problems might resulted from several factors, however, among other things, the dumping of untreated wastewater from the urban community seems to be a primary source. The secondary source would be the untreated wastewater from industry, since there were only 60 per cent of all industrial plants could treat their wastewater till met the standard criteria before releasing into the river (Water Quality Management 1997). Therefore, these problems cause direct effect to both water quality and aquatic ecology.

The studied for water qualities of the river have been done employing the abundance and diversity of benthic organisms as a mean. Due to the fact that, among the living fauna, benthos would be the least and slowest moving organisms (Photipitak 1988). In addition, the quantity and type of benthos will differ from one site to the other depends on the quality of water of such site. Thus, the information obtained from this study should be used for planning not only in fishery activity but also in water resource management in the future as well.

Therefore, the objective of this study consisted of several purposes, these include;

1. Study the type and quantity of the benthic fauna in the Chao Phraya River.

2. Compare the type and quantity of the benthic fauna among 14 sampling sites.

3. Study the dynamic, structure and influence of seasonal variation on the quantity of benthic fauna.

4. Study the indices of benthic fauna, including diversity, evenness, and similarity which could be used as a tool for water quality indication.

2 Materials and methods

2.1 Soil samples collection and benthos identification :

Ekman Grab was used for soil samples collection from the bottom of the river, three samples were collected from each site. Soil samples were passed through 35 mesh screen then kept the benthos in 5 per cent formalin solution for identification employing the procedure of Tudorancea et, al. (1979) and Washington (1984).

2.2 Species diversity index, evenness and similarity index calculation (Washington, 1984)

2.1) Species diversity index was calculated from the Shannon-Wiener Index

$$H' = -\sum_{i=1}^{s} (n_i/n) \ln (n_i/n)$$

2.2) Evenness was calculated from

$$E = H' / \ln s$$

where: H' = Species diversity
E = Evenness
S = Number of family
n = Total number of animal
ni = Number of each family

2.3) Similarity index was calculated from Juccard method

$$S' = 100 \; [nc / (ni + nj)]$$

where: S = Similarity index
ni = Total number of animal in first community
nj = Total number of animal in second community
nc = Sum of animal in smaller community (when compare between two communities)

2.3 Water samples collection and analyses :

- Water samples were collected from the middle depth of the river, then kept in the BOD bottles at 4OC. The BOD were measured follow the Winkler Method and the COD were measured follow the method of APHA, AWWA, and WPCF (1985).

- Measurement of water temperatures, pH, DO, salinity and transparency were performed immediately at each sites.
- Water quality index (WQI) was calculated from the formula, (Thongthummachat 1997)

$$WQI = n \sqrt{(TEMP)(pH)(DO)(BOD)(FCB)(NO3)(PO4)(TUR)(TS)}$$

2.4 Soil samples collection and organic matters analyses :

Ekman Grab was also used for soil samples collection, and the analyses for organic matters were done follow the Walkley-Black Method (Allison 1965).

2.5 Sampling sites :

Fourteen sites in the Chao Phraya River have been sampling, as shown in Figure 1, these include;

Site No. 1 Daechatiwong Bridge, Nakhon Sawan Province,
No. 2 The Chao Phraya Dam, Chai Nat Province,
No. 3 Amphoe Muang, Singhaburi Province,
No. 4 Krasattiyaram Temple, Phra Nakorn Sri Ayutthaya Province,
No. 5 Amphoe Bang Pa-in, Phra Nakorn Sri Ayutthaya Province,
No. 6 Amphoe Muang, Pathum Thani Province,
No. 7 Amphoe Pakkret, Nonthaburi Province,
No. 8 Piboon songkram ferry, Nonthaburi Province,
No. 9 Taevej ferry, Bangkok Province,
No. 10 Buddha Yodfa Bridge, Bangkok Province,
No. 11 Bangkok Bridge, Bangkok Province,
No. 12 Amphoe Phrakanong, Bangkok Province,
No. 13 Amphoe Phrapadang, Samut Prakarn Province, and
No. 14 The estuary of the river, Samut Prakarn Province.

All samples parameters were analyzed by the Fisheries Environmental Department.

2.6 Studying period :

From January to December 1997.

3 Results and discussion

3.1 Types and quantities of benthic fauna

Four benthos phyla were found namely Annelida, Mollusca, Arthropoda and Chordata and they were identified into 46 families. The average density from all sites was 1,441 per square meter. The average density of both the upstream and the central part of the river found 196 per square meter, and 2,686 per square meter was found in the downstream of the river as shown in Figure 2.

The lowest density and number of benthos found was at site No. 3 of Amphoe Muang, Singhaburi Province which were 66 per square meter and 5 families only. These parameters might related to the fact that there was poor organic matter in the soil and the soil type is mainly sand which not quite suitable for the growth of benthos (Lauhachinda 1985). The highest number of benthos found was at site No. 14 which is the estuary of the river, there were 24 families. The highest density of benthos was found at site No. 12 of Khet Phrakanong in Bangkok at the average of 6,736 per square meter as shown in Figure 3.

3.2 Dynamic structure and influence of seasonal variation of benthic fauna

The phyla Annelida seems to has the higest influence to the alteration of total benthic fauna since it was the dominant phyla found all year as shown in Figure 4. The most abundance families of the Annelida phyla are Naididae, Tubificidae, Nephtyidae, and Nereidae respectively (Figure 5-8), in Mollusca phyla are Mytilidae and Hydrobiidae and in Arthoproda phyla are Chironomidae (Figure 9-11).

The main structure of benthic fauna found was the Annelida group with the average of 90.03 per cent which might resulted from the rapid increasing population of the family Naididae, this family was found in every site all year long. The Mollusca, Arthropoda, and Chordata groups were found only 7.57, 2.39, and 0.01 per cent respectively as shown in Figure 12.

The high density of benthos was found in the rainy season which the highest was in September at the average of 2,256 per square meter and the least was found in February as shown in Figure 13.

3.3 Similarity index of benthic fauna

The similarity index of benthic fauna in every pair of sampling site was found to has an average of 20.03 per cent. This parameter might indicated that the similarity of benthic fauna were quite low in all sites along the river.

3.4 Diversity index and evenness index of benthic fauna

The highest species diversity index and evenness index were 2.08 and 0.79 at site No. 4 of Amphoe Muang, Pra Nakhon Sri Ayuthaya Province whereas the lowest were 0.12 and 0.05 respectively at site No. 12 of Khet Phrakanong. The diversity index and evenness of benthic fauna in the upstream and middle have higher average than the downstream of the river. The average diversity index of the river was 1.07 which indicated the poor quality of water

(Warren 1971). The evenness index average was 0.45 which indicated the poor distribution of benthic fauna in the river as shown in Figure 14.

3.5 Water quality

Water qualities were showed in Table 1, BOD values from the upstream, middle and downstream were higher than Water quality standard value of class 2, class 3, and class4, respectively, while most parameters were still in the range of water quality standard class 3. The calculated water quality index (WQI) was shown in Table 2, it was relatively high because Fecal-coliform bacteria (FCB) value was not included in the calculation. The indices indicated that the water qualities in the upstream and the middle were very good to fair instead of fair to poor, but the downstream qualities were poor at all sites.

Reference

Allison, L.F. 1965. Walkley and black methods, pp. 1372-1375. In C.A. Black (ed.)."Methods of Soil Analysis part2". Agronomy No. 9 Am. Soc. Agron., Maddison, Wisconsin.

APHA, AWWA and WPCF. 1985. Standard Methods for the Examination of Water and Wastewater. 16th ed., APHA. Inc., Washington, D.C. 1268p.

Department of Health 1996. Water Quality of Chao Phraya River Ministy of Plublic of Health. Bangkok. 31pps.

Lauhachinda, Nitaya. 1985. Ecology Buraphasan Bangkok. 289pps.

Mason, C.F. 1991. Biology of Fresh Water Pollution. John Wiley & Sons Inc., New York. 351p.

Pollution Control Department. 1997. Development of an Action Plan to Improve Water Quality in the Central River Basin, Thailand. Main Report, Thailand

Environment Foundation Montgomery Watson Asia Coastal Consultancy International Ply. Ltd.

Thongthummachat, Chanin. 1997. General Water Quality Index. J. of Pollution Control 1 : (2) : 8-11.

Tudorancea, C., R.H. Green and J. Huebner. 1979. Structure, dynamics and production of the benthic fauna in lake Manitoba. Hydrobiologia 64(1) : 59-95.

Warren, C.E. 1971. Biology and Water Pollution Control. W.B. Saunders Company, Philadelphia. 434p.

Washingtion, H.G. 1984. Diversity, biotic and similarity indices. A Review with Special Relevance to Aquatic Ecosytems 18(6) : 653-694.

Water Quality Management Division. 1997. Water Quality Classification and Water Quality Standard in Thailand. Department of Environmental Quality Promotion. Ministry of Science Technology and Environmental, Bangkok. 160pps.

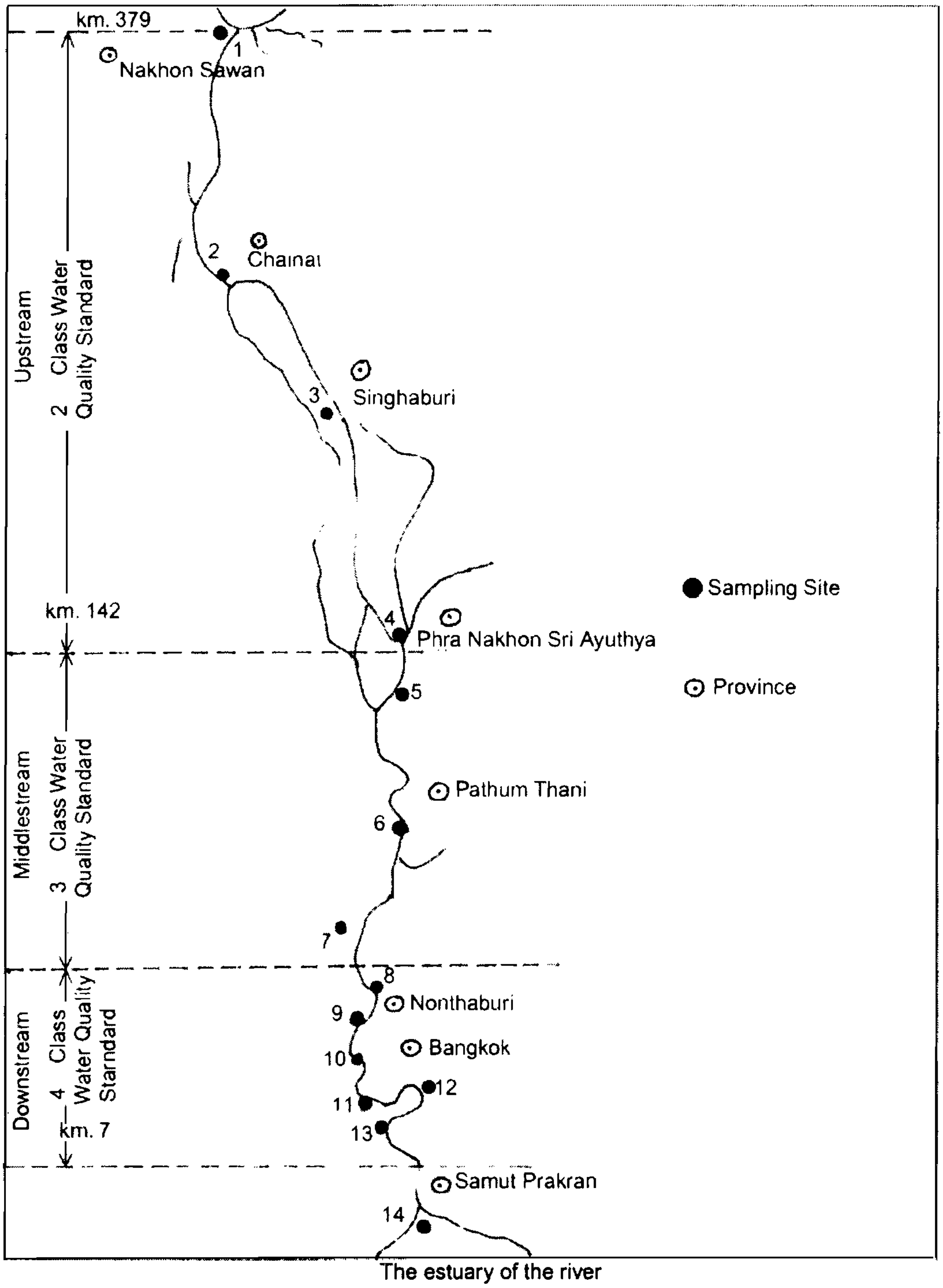


FIGURE 1 **MAP OF CHAO PHRAYA RIVER SHOWED 14 SAMPLING SITES.**

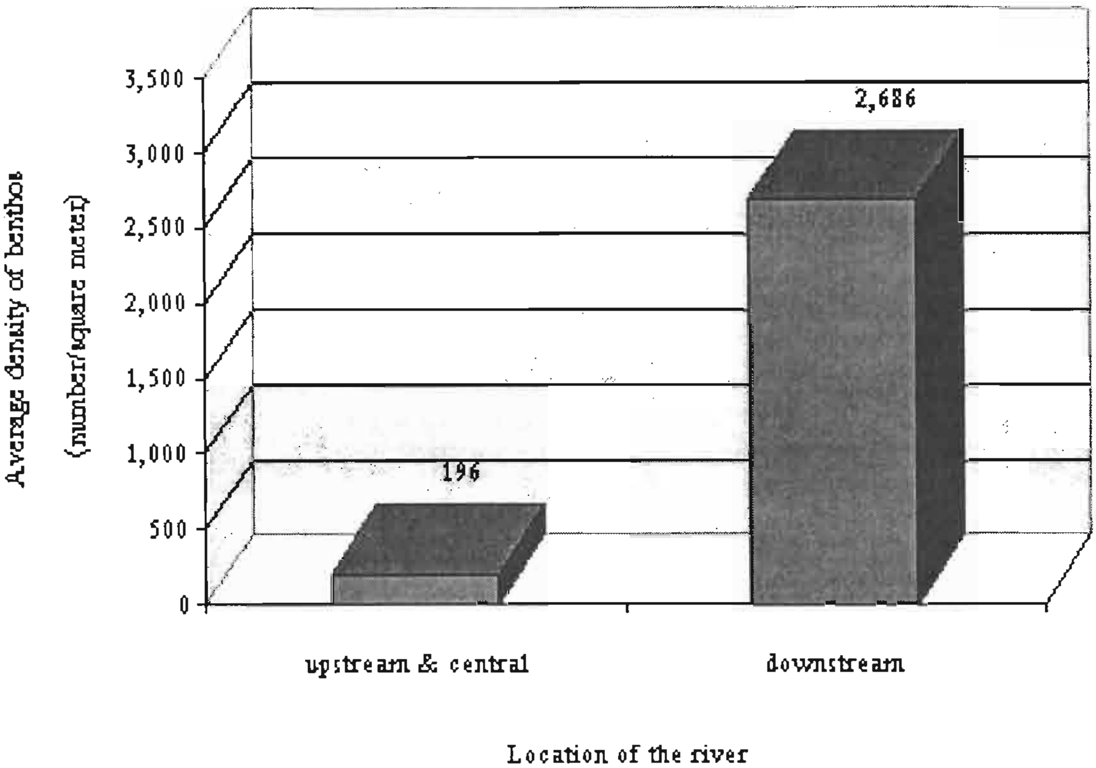


Figure 2 The average of the density of benthos from the upstream and the central part of the Chao Phraya River between January to December 1997.

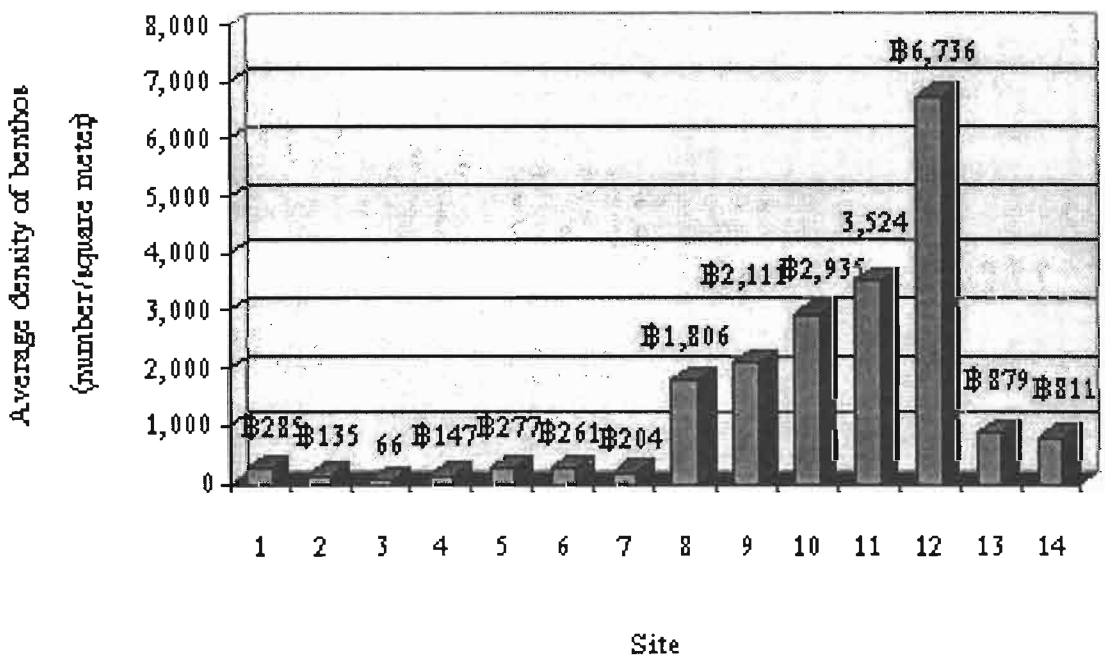


Figure 3 The average density of benthos from 14 sites of the Chao Phraya River between January to December 1997

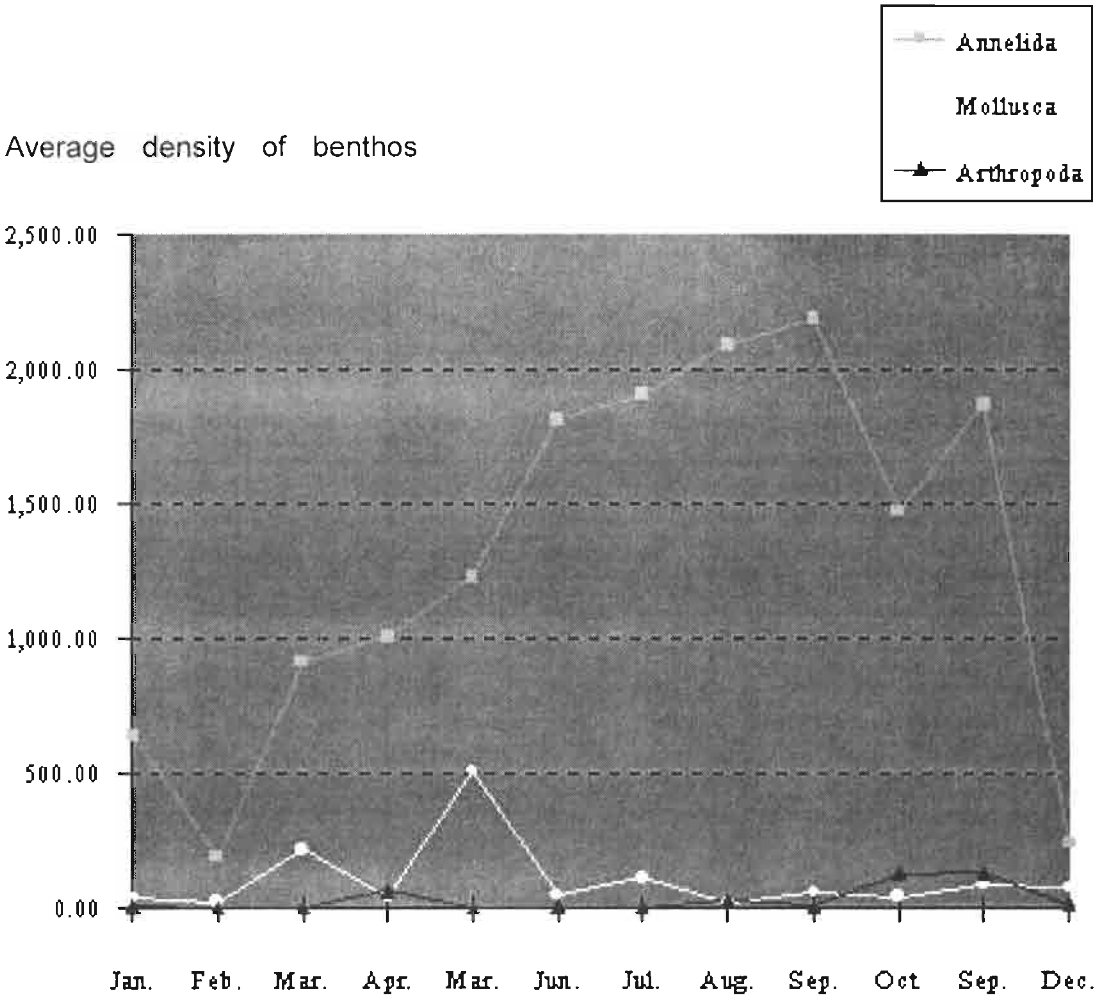


FIGURE 4 THE AVERAGE DENSITY OF 3 PHYLA OF BENTHOS IN THE CHAO PHRAYA RIVER FROM JANUARY TO DECEMBER 1997.

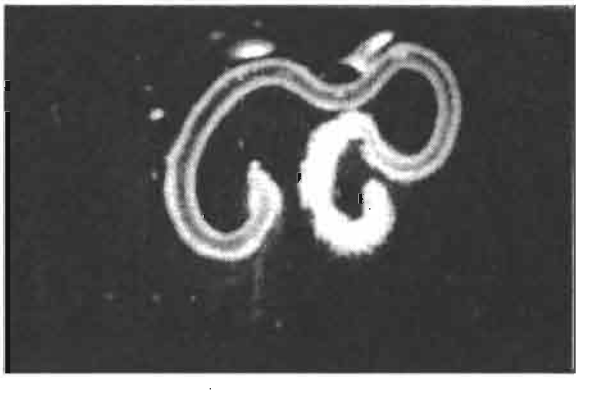


FIGURE 5 BENTHIC FAUNA, FAMILY NAIDIDAE FIGURE 6 BENTHIC FAUNA, FAMILY TUBIFICIDAE

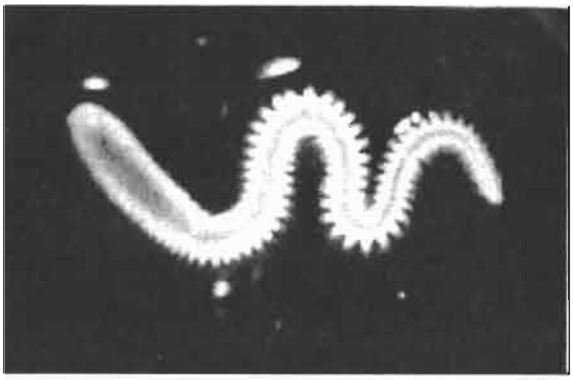


FIGURE 7 BENTHIC FAUNA, FAMILY NEPHTYIDAE

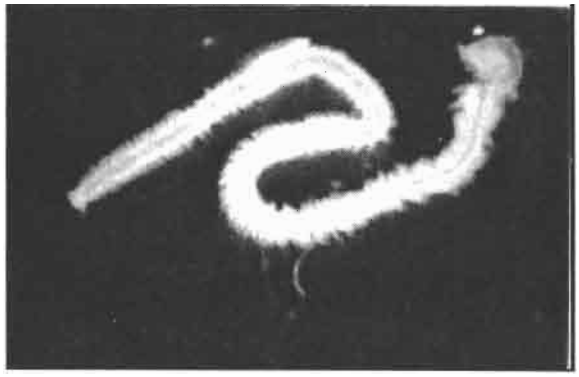


FIGURE 8 BENTHIC FAUNA, FAMILY NEREIDAE

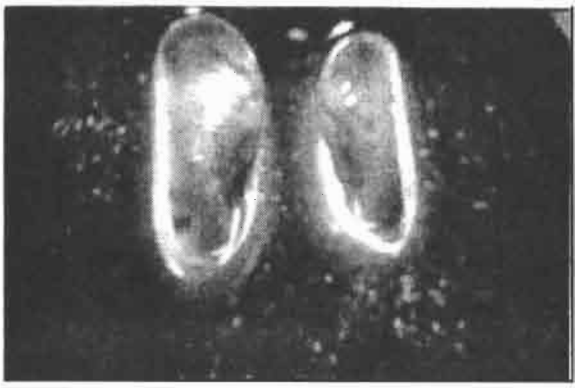


FIGURE 9 BENTHIC FAUNA, FAMILY MYTILIDAE

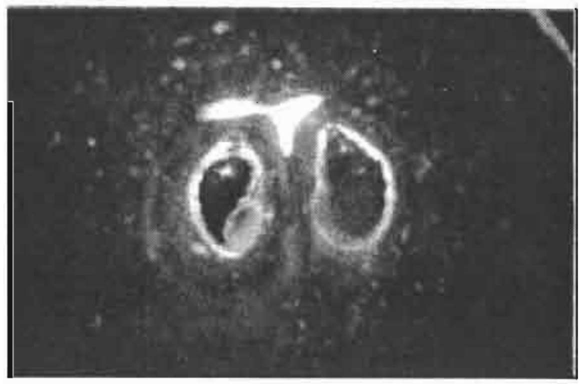


FIGURE 10 BENTHIC FAUNA, FAMILY HYDROBIIDAE

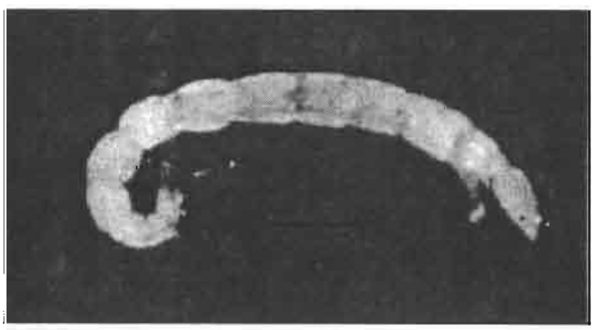


FIGURE 11 BENTHIC FAUNA, FAMILY CHIRONONAIDAE

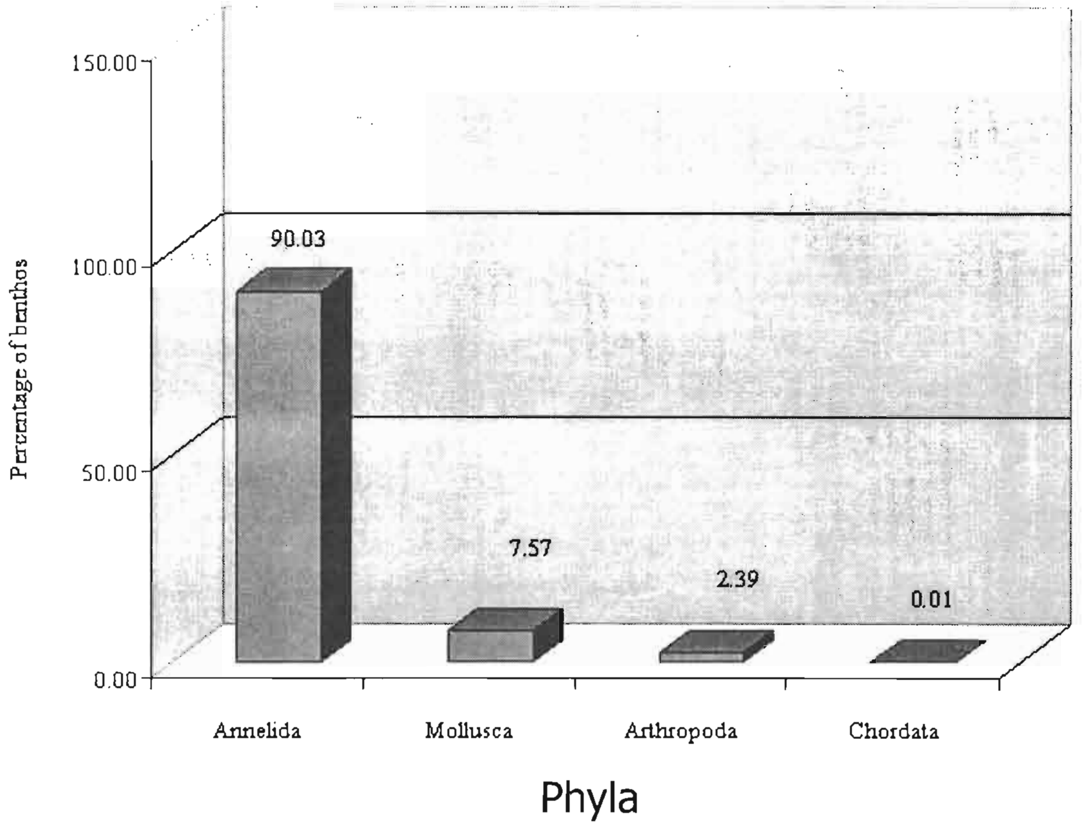


FIGURE 12 PERCENTAGE OF BENTHOS IN 4 PHYLA FOUND IN THE CHAO PHRAYA RIVER FROM JANUARY TO DECEMBER 1997.

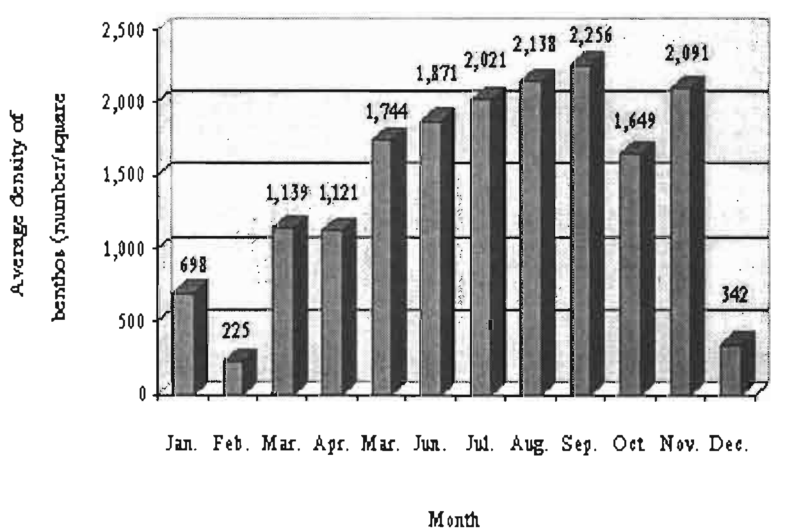


FIGURE 13 THE AVERAGE DENSITY OF BENTHOS FROM 14 SITES IN THE CHAO PHRAYA RIVER FROM JANUARY TO DECEMBER 1997.

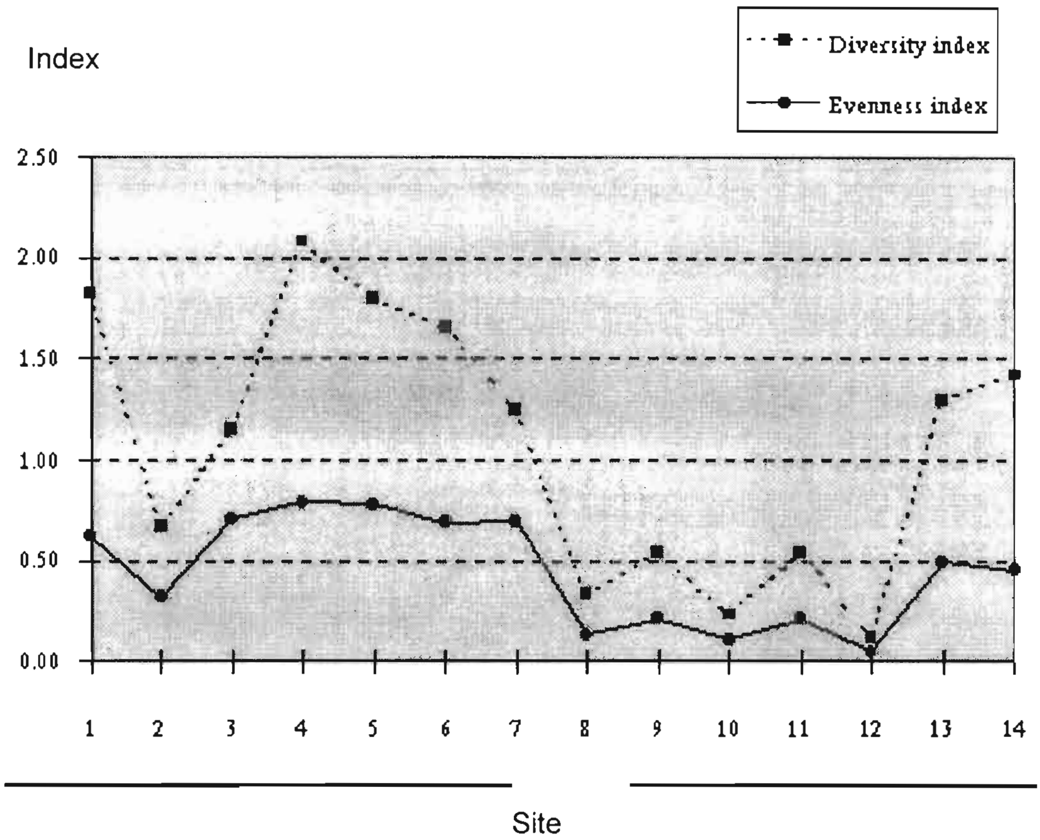


FIGURE 14 DIVERSITY INDEX AND EVENNESS INDEX OF BENTHOS FROM 14 SITES IN THE CHAO PHRAYA RIVER FROM JANUARY TO DECEMBER 1997.

Table 1 Average parameters of water qualities from 14 sites in the Chao Phraya River from January to December 1997.

Site \ Parameter	Ambient Temp. (° C)	Water Temp. (° C)	pH	Transparency (cm)	Salinity (ppt.)	TSS (mg/L)	DO (mg/L)	BOD (mg/L)	NO_3^- (mg/L)	PO_4^{3-} (mg/L)
1. Nakhon Sawan	32.3	29.8	7.43	23.3	0.00	81.17	7.46	2.55	0.16	0.40
2. Chai Nat	32.5	30.0	7.47	32.5	0.00	31.50	8.15	2.70	0.09	0.38
3. Singhaburi	31.8	30.1	7.63	28.8	0.00	42.17	8.08	2.88	0.15	0.38
4. Pra Nakhon Sri Ayuthaya	32.4	29.9	7.48	36.7	0.00	34.17	7.05	2.98	0.18	0.37
5. Bangpain	32.8	30.1	7.37	32.5	0.00	56.50	6.07	2.76	0.23	0.40
6. Pathum Thani	32.9	30.0	7.35	27.3	0.00	62.83	5.79	2.49	0.18	0.39
7. Pakkret	30.7	29.5	7.29	33.3	0.03	57.08	3.82	2.73	0.38	0.40
8. Piboon Songkram	30.4	29.7	7.30	45.2	0.05	62.67	2.41	2.73	0.53	0.54
9. Taevej	31.3	29.5	7.25	55.8	0.06	59.00	2.14	3.45	0.50	0.60
10. Buddha Yodfa Bridge	32.1	29.4	7.18	51.0	0.18	44.50	2.28	4.60	0.42	0.57
11. Bangkok Bridge	31.5	29.4	7.27	54.6	0.47	53.50	2.23	4.84	0.42	0.65
12. Phrakanong	32.7	29.6	7.30	43.6	3.18	58.83	1.46	5.23	0.40	0.77
13. Phrapadang	33.1	29.8	7.34	49.8	5.98	73.75	1.88	4.35	0.53	0.72
14. The estuary of the river	32.6	30.4	7.51	45.3	12.87	180.17	3.18	4.03	0.47	0.67

Table 2 Water quality index (WQI) from 14 sites in the Chao Phraya River from January to December 1997.

Site	WQI (Score)								Remark	
	WQI TOTAL	WQI min	pH	TS	BOD	DO	Nitrate	Phosphat e	DO saturate (mg/L)	Saturate (%)
1. Nakhon Sawan	80	45	93	85	76	99	97	45	7.6	98.2
2. Chai Nat	79	47	91	83	73	96	99	47	7.6	107.6
3. Singhaburi	79	47	90	85	72	97	97	47	7.6	106.3
4. Pra Nakhon Sri Ayuthaya	79	49	91	84	71	97	97	49	7.6	92.8
5. Bangpain	78	45	93	86	73	87	97	45	7.6	79.9
6. Pathum Thani	78	46	93	86	77	82	97	46	7.6	76.2
7. Pakkret	69	42	94	86	73	42	95	45	7.6	50.3
8. Piboon Songkram	57	22	94	86	73	22	94	28	7.6	31.7
9. Taevej	54	19	94	86	67	19	94	27	7.6	28.2
10.Buddha Yodfa Bridge	53	19	93	85	57	19	95	27	7.8	29.2
11. Bangkok Bridge	52	19	94	86	55	19	95	24	7.8	28.6
12. Phrakanong	47	13	94	86	54	13	95	20	7.6	19.2
13. Phrapadang	49	15	94	85	60	15	94	21	7.6	24.7
14. The estuary of the river	56	24	91	75	62	33	94	24	7.6	41.8

Environmental aspects of intensive agricultural practices: the case of the raised bed system

Roongnapa Korparditskul[1] and Roland Poss[2]

Abstract: *Poldered-fields have developed in the last century along the many canals that cross the lower part of the Chao Phraya delta near Bangkok. Each field, surrounded by a dike to protect the field from floods, is made of long beds around 2 meters in width separated by ditches. The level of water inside the plot is controlled by a pump, and the water of the ditches is used to water the crops. Very intensive systems using large amounts of fertilizers and pesticides have developed in these fields. Grape is the most intensive crop by the amount of pesticide applied.*

The objective of the study was to investigate the fate of fertilizers and pesticides applied to the fields. Therefore, the amount of nutrients and pesticides discharged from the fields into the canal were studied. Soils and water samples were collected and analyzed for physico-chemical properties, including pesticide contamination. The accumulation of elements in the soil profile was investigated in three different fields by taking soil samples to 50 cm depth.

The average mineral fertilization applied to grape was estimated to be 670 kg N, 300 kg P and 560 kg K year-1 ha soil-1, not to mention some organic manure. Insecticides and fungicides are usually applied in combination every 4 days. The most used pesticides are methomyl, chlorphenapyr, methamidophos, amitraz and copper oxychloride.

A regional survey showed that 28% of the water samples were contaminated, out of 148 samples taken along the canals. Further studies proved that monochrotophos and dimethoate, two widespread insecticides, were present at a concentration between 0.6 to 13.4 µg L-1. At these concentrations the pesticides are not a hazard to aquatic life and human health.

The discharge of nutrients in the canals was minimal both in suspension and in solution. Thus fertilizer overuse did not lead to pollution of the canals. Most applied elements accumulated in the soil profile, resulting in high values for P, K, Cu and Zn that can be detrimental to crop growth. Discontinuing P and K application for one year did not decrease grape yield. It should be possible to decrease fertilizer application without any decrease in yield, an important change for both farmer's profit and the environment.

Full paper not provided

[1] Kasetsart University, CSEAS, [2] IRD (Institut de Recherche pour le Développement)

The costs and benefits from utilizing fresh water for salinity intrusion for tangerine plantation in Bangmod area, Bangkok

Charit Tingsabadh and Wilawan Chaturongpalathipat[1]

Abstract: *Economic Evaluation of Salinity Control in the Chao Phraya River annual flow for salinity control accounts for just under 10% of the water allocation. Is this level optimal? The paper considers the case of salinity control for citrus orchards and production of potable water supply. The costs and benefits of salinity control are calculated and implications for water allocation are discussed.*

1 Introduction

1.1 Water problem in Thailand

Water is known to be vital in our life, mains used are in consumption and agriculture. It is also utilized in prevention of salinity intrusion, inland navigation and hydropower generation. Scarcity water, which is not only a national problem but also, extends the boundary to global problem. To use the water for every purpose has to consider in the utility that gets. Each purpose tries to maximize utility.

The agriculture is very important in the economic part of Thailand. The saline water is the major problem in agriculture part because the high salinity index of the water has direct impact on crop productivity. The salinity intrusion purpose is the third priority for water allocation. Especially in the dry season, the water is very scarce comparing to the other seasons. The plan of using water has to very concern about the utility and benefits that can get from that usage. Tangerine plantation is one of major part of economic plantation especially in the Bangmod area, Bangkok where is sensitive to saline water because it locates near the sea. The study of utilizing fresh water for salinity intrusion to maintain the Tangerine plantation has to consider about the opportunity costs of using for that purpose consisting of the maximum value of other purposes. In this study will concentrate on the opportunity costs by calculating the maximum value of domestic consumption purpose.

[1] Centre of Ecological Economics, Chulalongkorn University

1.2 Purpose of the study

To determine the costs and benefits of utilizing reserved fresh water for salinity Intrusion to maintain the Tangerine plantation in Bangmod area.

1.3 Scope of the study

In Bangmod area, where have soil characteristics and conditions that are suitable for Tangerine plantation and nowhere else can produce the good quality of Tangerine in Thailand. Now it confronts with the saline water, which affects the Tangerine productivity.

According to the water allocation planing by the Royal Irrigation Department, the water resources is allocated for 5 main purposes; Domestic consumption, Irrigated agriculture, Inland navigation, Salinity intrusion and Power generation. To use fresh water for salinity intrusion in the area of Tangerine plantation in Bangmod area, we have to concern about the opportunity costs that are forgone for other purposes as mentioned above.

To determine the cost, we will use the opportunity cost for domestic consumption by calculating the net profit of water, which represents the value of the water from the Metropolitan Waterworks Authority. The benefits of utilizing fresh water for salinity intrusion will be calculated in terms of the revenue from Tangerine productivity.

1.4 Method of study

1.4.1 Review previous literatures

1.4.2 Data collection

The salinity of the water from the Royal Irrigation Department (Water Operation Branch) from 1985 to 1995 (See Appendix 1).

The Tangerine productivity from the Ministry of Agriculture and Cooperatives from 1985 to 1995 (See Appendix 1).

The net profit of water which represents the opportunity cost of the water from Metropolitan Waterworks Authority from 1989 to 1998 (See Appendix 2).

1.4.3 Data analysis

The model from regression, used for this analysis is $Y = C(1)+C(2)*S_1+C(3)*S_1^2$

2 Review of literature

2.1 Tangerine productivity and salinity of water relationship

The water is one of the most important input for Tangerine plantation. The contamination of water is affected directly to their productivity such as the saline water will cause the water has high content of sodium salt measured by the salinity measurement. The salinity prevents their root system to absorb the water so their productivity is reduced when the level of salinity is higher their tolerance level. From now, there is no literature that shows the relationship between salinity and Tangerine productivity to find the optimum salinity level which tangerine can produce the maximum productivity and beyond this level, the productivity will be reduced by the effect of the high salinity level of the water.

2.2 Water used for salinity control

The Royal Irrigation Department, charged with responsibility to control the salinity in the river, has urged the Asian Institute of Technology to investigate the salinity conditions in the river under very low flow, and possibility revise the existing salinity intrusion model. This research was under the topic of "Salinity Intrusion during severe drought in the Chao Phraya River", December 1980.

The model consists of 2 portions: the tidal dynamics portion and the salt balance portion. The tidal dynamic portion is described by 2 equations namely:

Continuity $\partial H/\partial t + \partial Q/\partial x - q = 0$ ....(1)

Momentum $Q/\partial t + (Q/A)q - (Q^2/A^2)\ \partial A/\partial x + gA\partial H/\partial x + g(n^2Q|Q|/AR^{4/3} = 0$...(2)

The salt balance portion is described by the equation:

$\partial(AS)/\partial t = \partial(QS)\ \partial x + \partial(EA\partial S/\partial x)/\partial x$ ....(3)

where:

A	=	cross-sectional area
B	=	surface width of channel
E	=	longitudinal dispersion coefficient
g	=	gravitational acceleration
H	=	water surface elevation or stage above mean sea level
n	=	manning roughness coefficient
Q	=	instantaneous discharge
q	=	lateral inflow per unit length of channel
R	=	hydraulic radius
S	=	cross-sectional averaged salinity
t	=	time
x	=	distance along the river

From the equation (1), (2) and (3), there are many factors that affects the salinity level. The result from the AIT study and the actual observation from Water Operation Branch (WOB), we found that the actual observation is not related to the AIT formulation because the salinity level of the water is depended on the amount of rainfall, the amount of discharged water, the current of the water, the water level due to the sea level (fluctuated water level during the day) and the distance from the sea to that point. So the estimation of the salinity level of the water by calculating the water level, discharged water and others is very complex.

2.3 Water policy

According to The Royal Irrigation Department, its duty is charged with the responsibility to allocated the water with set criterion from "Water Resources Planning and Management of the Chao Phraya River basin, Thailand [2]. The allocation criterion of water release for various purposes has been adopted as practical guideline on priority basis as follows:

1. Top priority is given to the domestic consumption as it is considered essential for the living of the people .The water required for domestic use only accounted for about 7-8 percent of the total demand.

2. Water for irrigated agriculture to be made available during any dry spell or drought period in the early wet season in order to avoid damage to newly planted crops, and for dry season cropping. Water demand for irrigated agriculture is the highest among other users and equivalent to nearly 90 percent of the total demand.

3. Inland navigation. In some instance when the water level in certain stretches of waterways become low preventing passage of navigation of large shipment, it is then necessary to release extra water from the reservoir for a short period ot make passage of the navigation possible. Delay of large shipment could cause heavy damage to the concerned parties. During the low flow period, barge operators have also been requested to lower the carrying capacity of the barges to reduce water depth requested for passage of 2 meters draft.

4. Salinity intrusion. To prevent salinity intrusion into the Chao Phraya River near the river mouth causing damage to the fruit trees and orchards in the area surrounding Bangkok and to keep salt content below standard for production of potable water by the MWWA in the dry season, it is necessary to maintain the salinity at the Memorial bridge (48 kms from the river mouth) at not more than 2 ppt (part per thousand). During the low flow period, this problem has been well under control, but on the other hand, the water quality in the Chao Phraya River and canals around the city of Bangkok is below the allowable standard. This is a major problem has yet to be solved without further delay. To release additional water for water quality improvement, however, is not practical at present because the supply is still inadequate.

5. Hydropower generation. The hydropower plants normally operate for peak power generation in the evening to supplement the power generation from other power plants inter-connected to the national grid.

Water allocation planning in 1999 (January – June,1999)

Available water resources around 3,900 million cubic meters, which has to be managed for many activities during 6 months (dry spell). The water is allocated for these activities around 3,600 million cubic meters as follows:

Activities	Water allocated (million cubic meters)
Consumption (22 provinces)	700 (19.44%)
Agriculture encouraging	1,900 (52.78%)
Inland navigation	0
For Metropolitan Waterworks Authority	650 (18.06%)
Salinity intrusion	350 (9.72%)

3 Data analysis

3.1 Tangerine productivity and salinity level

The model represented the relationship between Tangerine productivity and salinity level is shown by the following model:

$$Y = C(1)+C(2)*S_1+C(3)*S_1^2$$

Where: Y = Tangerine productivity (kgs/rai/year)

S_1 = Salinity index of the water (g/l)

C = coefficient

From the regression result, the value of coefficient are

C(1)=2668.194, C(2)=195.0508, C(3)=-14.42594.

	Coefficient	Std.Error	t-Statistic	Prob.
C(1)	2668.194	295.9676	9.015155	0.0000
C(2)	195.0508	235.9956	0.826502	0.4325
C(3)	-14.452594	21.85292	-0.660955	0.5272

[2] The World Bank assignment for presentation in the workshop on water resources management policies, held on June 25-28,1991 in Washington D.C. by Messrs B.Badhanaphuti, T.Klaikayai, S.Thanopanuwat of Royal Irrigation Department and N.Hungspreug, Thammasart University, Bangkok, Thailand

R-squared	0.117405	Mean dependent var	2905.727
Adjusted R-squared	-0.103244	S.D. dependent var	533.4889
S.E. of regression	560.3524	Akaike info criterion	12.88413
Sum squared resid	2511958	Schwarz criterion	12.99265
Log likelihood	-83.47105	F-statistic	0.532088
Durbin-Watson stat	2.181950	Prob (F-statistic)	0.606802

Observed year	Actual	Fitted	Residual
1985	3000.00	2958.06	41.9394
1986	3000.00	2879.77	120.2290
1987	2800.00	2823.45	-23.4539
1988	2350.00	3141.24	-791.2360
1989	3200.00	2926.26	273.7430
1990	3200.00	2889.67	310.3260
1991	3200.00	2789.62	410.3820
1992	3460.00	3307.80	152.2040
1993	3076.00	3100.28	-24.2855
1994	1542.00	2560.83	-1018.8300
1995	3135.00	2586.02	548.9810

In 1988 and 1994, the result from regression shows difference between the model and the actual data. The reason is in both 2 years, the available water in the dam was less amount comparing to other years. Therefore in those years, the Tangerine productivity was not related to the salinity level.

The relationship between Tangerine productivity and salinity level is shown in Appendix 3. The optimum salinity level can be determined by differential the model

$$Y = 2668.194+195.0508*S_1-14.42594*S_1^2$$

which is $dY/dS = 195.0508-2(14.42594)* S_1 = 0$

so the optimum salinity level ($S_{optimum}$) is 6.76 g/l.

As The Royal Irrigation Department set up the level of salinity index at 2 g/l to maintain the crop productivity but for the Tangerine , it can endure the salinity up to 6.76 g/l.

3.2 Water requirement for salinity control

The optimum salinity level is 6.76 g/l (for Tangerine productivity) comparing to the standard from RID which is 2 g/l. Water used for salinity control will reduce from the water allocation plan from RID which is 350 million cubic meters.

To determine the amount of water required for salinity control is compared to the ratio of salinity level from RID (2 g/l) and optimum salinity level (6.76 g/l) which is represented by:

The ration of Soptimum/SRID = 6.76/2 = 3.38
where Soptimum = Optimum salinity level (g/l)
SRID = Salinity level (g/l) from RID

Since the model represented the relationship between the amount of water and salinity control is very complex, we will estimate the amount of water for salinity control by relating to the ration between the salinity level from RID and optimum salinity level for Tangerine. So the water used for salinity control at 6.76 g/l is less than the water allocation plan by 3.38 times.

The water used for salinity control at 6.76 g/l is 350 million m^3/3.38 = 103.55 million m^3

The water used reduces from plan equals to 350 – 103.55 = 246.45 million m^3

3.3 Cost-Benefit of salinity control

3.3.1 The cost of water for salinity control at 6.76 g/l.

= opportunity costs of water * 103.55 million m^3
= 1.87 Baht/m^3 * 103.55 million m^3
= 193.64 million Baht

3.3.2 The benefits from reducing the water used for salinity control at 6.76 g/l

= opportunity costs of water * 246.45 million m3
= 1.87 Baht/m3 * 246.45 million m3
= 460.86 million Baht

3.3.3 The benefits in terms of maximum productivity from salinity control at the optimum salinity level.

The productivity at the optimum salinity level is calculated by:

2668.194 + 195.0508*Soptimum – 14.42594*Soptimum2 = Y

2668.194 + 195.0508(6.76) – 14.42594*(6.76)2 = 3327.5066

The maximum productivity equals to 3327.5066 kgs/rai/year.

The current market price of Tangerine is around 30 Baht/kg.

The benefits from controlling salinity level at 6.76 g/l is

= 3327.5066 kgs/rai/year * 30 Baht/kg = 99825.20 Baht/rai/year.

4 Discussion and result

The cost of water allocated for salinity control can be determined by the opportunity cost of water which is forgone for other purposes such as for domestic consumption. The Metropolitan Waterworks Authority has responsibility for domestic consumption, therefore the opportunity cost of the water is the net profit.

To consider the current situation, the average salinity level of the water of April,1999 is 2.73 g/l (See Appendix 6). The amount of water used to control the salinity level at 6.76 g/l which maximizes the Tangerine productivity. The RID allocated the water for salinity intrusion can control the salinity level to be at 2.73 g/l.

The ratio between the optimum salinity level and the current situation equals to 6.76/2.73 = 2.47. Therefore the amount of water for salinity control is less than their plan by 2.47 times which is 350/2.47 = 141.70 million m^3 and the water used reduces from plan equal to 350 – 141.70 = 208.30 million m^3

4.1 The cost of water for salinity control at 6.76 g/l.

= opportunity cost of water * 141.70 million m3
= 1.87 Baht/ m3 * 141.70 million m3
= 264.98 million m3

4.2 The benefit from reducing the water used for salinity control at 6.76 g/l.

= opportunity cost of water * 208.30 million m3
= 1.87 Baht/ m3 * 208.30 million m3
= 389.52 million m3

But in this study, we can not calculate the amount of water controlled the salinity level of the water correctly because of the complexity of the relationship among the nature such as the maximum and minimum water level of the Chao Phraya River, the distance between the sea and the studied location. So the research to find the exact relationship between the amount of water for salinity control have to be studied more in the future.

5 Conclusion

This paper studies about the impact of saline water on Tangerine productivity and the costs and benefits of utilizing fresh water for salinity intrusion. The factors that effect on the Tangerine productivity are salinity level of the water, rainfall, the discharged water, the distance from the sea to that point (Bangmod area). The relationship between Tangerine productivity and salinity index of the water can be represented by the regression model by the equation of $Y = C(1)+C(2)*S_1+C(3)*S_1^2$

The optimum salinity level is 6.76 g/l which is different from the level from The RID ; 2g/l. From this point, we can reduce the amount of water for salinity intrusion from 350 million cubic meters to 103.55 million cubic meters which is different in the amount of 246.45 million cubic meters. For this different amount of water, we can allocate to other purposes such as for domestic consumption. The value of costs and benefits are summarized in the below table:

	Type of cost	Unit
1	Cost of allocated water for salinity intrusion(103.55 million cubic meters)	193.64 million Baht
	Type of benefit	Unit
1	Reduce the allocated water from RID water allocation plan	460.86 million Baht
2	Tangerine productivity	99825.20 Baht/rai/year (in Bangkok)

Appendix 1:

Table 1: The salinity index (g/l) from 1985 to 1995

Year	Salinity index (g/l)
1985	0.59
1986	0.41
1987	0.34
1988	2.38
1989	1.31
1990	1.34
1991	1.02
1992	6.10
1993	10.74
1994	0.49
1995	0.83

TABLE2: TANGERINE PRODUCTIVITY (KGS/RAI/YEAR) FROM 1985 TO 1995

Year	TangerineProductivity (kgs/rai/year)
1985	3,000
1986	3,000
1987	2,800
1988	2,350
1989	3,200
1990	3,200
1991	3,200
1992	3,460
1993	3,076
1994	1,542
1995	3,135

APPENDIX 2:THE OPERATION COSTS OF WATER FOR WATER CONSUMPTION AND BENEFITS

TABLE 3: STATISTICAL DATA OF THE LAST DECADE

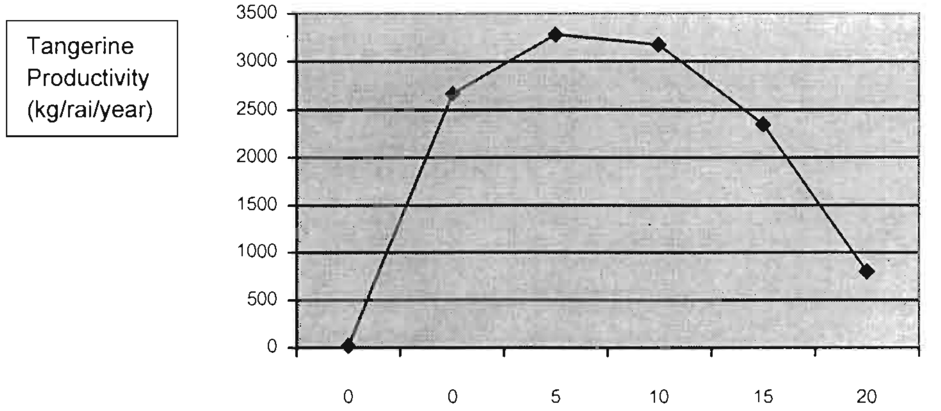
Descrip-tion	Unit	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Water Production	Mill. Cu.m.	934.3	1049.3	1109.2	1175.5	1224.9	1234.3	1405.2	1549.4	1632.8	1552.2
Water Sale	Mill. u.m.	628.2	718.7	781.3	823.4	836.1	816.1	870.3	911.2	944.8	914.8
Percent Sale	%	67.2	68.5	70.5	70.1	68.3	66.1	61.9	58.8	57.9	58.8
Customers	%	866673	949411	1027623	1090995	1139299	1194161	1241380	1289168	1341838	1369728
Employees	Number	5837	5732	5656	5618	5635	5742	5736	5684	5581	5432
Effective rate	Number	6.12	6.23	6.30	6.02	7.17	7.14	7.18	7.22	8.35	9.37
Cost per Unit sold	Baht/cu.m	5.34	5.19	5.23	5.19	5.38	5.84	7.08	7.33	7.55	8.96
Total Revenues	Mill. Baht	4531.5	5411.7	6128.5	6108.9	7051.2	7062.3	7516.8	7888.9	9037.3	9577.5
Total Expenses	Mill. Baht	3581.1	3976.0	4286.4	4439.2	4637.5	4931.3	6410.3	6936.2	7454.4	7513.5
Net Profit	Mill. Baht	950.4	1435.7	1842 1	1669.7	2413.7	2131.0	1106.5	952.7	1582.9	1182.7
Total Assets	Mill. Baht	19399.3	19846.5	21924.7	23748.4	26076.8	30800.0	33604.8	35999.2	40636.6	44280.4

TABLE 4: THE NET PROFIT (BAHT/CUBIC METER) AND AVERAGE VALUE FROM 1985 TO 1995

Year	Net profit (Baht/m3)
1989	1.51
1990	2.00
1991	2.36
1992	2.03
1993	2.89
1994	2.61
1995	1.27
1996	1.05
1997	1.68
1998	1.29
Average	1.87

The opportunity cost of using fresh water for salinity intrusion is 1.87 Baht per m^3

APPENDIX 3: THE RELATIONSHIP BETWEEN TANGERINE PRODUCTIVITY AND SALINITY LEVEL



Appendix4: Comparing table of water situation in large water reservoirs of The Royal Irrigation Department

Region	Usable		Available	Water	That	Can	Be	Used	
Reservoir	Volume (M m^3)	1997		1998			1999		
		(M m^3)	%available volume	(M m^3)	%Available Volume	(M m^3)	%Available Volume	Drainage(M m^3/day)	Accumulated drainage(m m^3)
North									
Bhumibol	9662.00	7217.00	74.69	4504.00	46.62	1283.00	13.28	8.52	137.13
Sirikit	6660.00	4537.00	68.12	3360.00	50.45	2282.00	34.26	12.61	206.11
Mae Ngad	243.00	186.00	76.54	195.00	80.25	82.00	33.74	0.47	5.61
Kew Lom	108.00	101.00	93.52	95.00	87.96	65.00	60.19	0.98	8.71
Mae Kaung	249.00	134.00	53.82	75.00	30.12	17.00	6.83	0.00	0.36
Total North	16922.00	12175.00	71.95	8229.00	48.63	3729.00	22.04	22.58	357.92
Northern East									
Lam Paw	1345.00	1048.00	77.92	903.00	67.14	451.00	33.53	0.48	7.54
Lam Ta Kong	297.00	290.00	97.64	138.00	46.46	81.00	27.27	0.26	4.34
Lam Pra	109.00	109.00	100.00	31.00	28.44	29.00	26.61	0.29	0.26
Paeng	477.00	338.00	70.86	361.00	75.68	149.00	31.24	0.88	15.10
Nam Oun	1854.00	1510.00	81.45	516.00	27.83	581.00	31.34	2.21	40.90
Ubonrat	1135.00	843.00	74.27	882.00	77.71	606.00	53.39	1.97	8.81
Sirinthon	144.00	125.00	86.81	42.00	29.17	69.00	47.92	0.04	4.18
Chulaporn	108.00	101.00	93.52	78.00	72.22	6.00	5.56	0.00	0.00
Hauw Kaew	118.00	65.00	55.08	55.00	46.61	42.00	35.59	0.00	0.00
Lam Nangrong	134.00	129.00	96.27	70.00	52.24	12.00	8.96	0.03	0.53
Moon Bon									
Total Northern East	5721.00	4558.00	79.67	3076.00	53.77	2026.00	35.41	6.13	81.66
West									
Kang	643.00	633.00	98.44	592.00	92.07	173.00	26.91	0.00	1.73
Krachan	7480.00	6523.00	87.21	4570.00	61.10	2453.00	32.97	4.30	128.75
Srinakarin	5848.00	3873.00	66.23	4834.003	82.66	1157.00	19.78	6.49	121.25
Koa Laem	385.00	384.00	99.74	65.00	94.81	95.00	24.68	0.26	0.26
Pranburi	200.00	203.00	101.50	43.00	21.50	147.00	73.50	0.02	1.98
Krasaew	152.00	148.00	97.37	27.00	17.76	59.00	38.32	0.26	2.42
TapSela									
Total West	14708.00	11764.00	79.98	10431.00	70.92	4084.00	27.77	11.33	256.39
East									
Bang Pra	102.00	89.00	87.25	48.00	47.06	42.00	41.18	0.13	1.83
Nong Koo	20.40	16.00	78.43	13.00	63.73	14.00	68.63	0.06	1.09
Mab Prochan	15.80	15.20	96.20	14.20	89.87	13.20	83.54	0.03	0.57
Dok Kray	69.50	65.00	93.53	65.00	93.53	61.00	87.77	0.23	3.35
Nong Plalai	151.20	141.50	93.58	127.50	84.33	144.50	95.57	0.22	4.24
Tatal East	358.90	326.70	91.03	267.70	74.59	274.70	76.54	0.67	11.08
South									
Rutchapropa	4287.00	2538.00	59.20	3006.00	70.12	2066.00	48.19	1.73	7.88
Bang Lang	1144.00	825.00	72.12	913.00	79.81	1063.00	92.92	4.76	40.25
Total South	5431.00	3363.00	61.92	3919.00	72.16	3129.00	57.61	6.49	48.13
Total Country	43140.90	32186.70	74.61	25922.70	60.09	13242.70	30.70	47.20	755.18

APPENDIX 5:

THE PLAN OF UTILIZING RESERVED WATER FROM BHUMIPOL AND SIRIKIT DAM IN DRY SPELL DURING JANUARY TO JUNE

Water usage activities		1993	1994	1995	1996	1997	1998	1999
Available water on Jan1		5357	2048	12733	14582	12107	8200	3900
1.Domestic consumption		550	700	1100	1800	1650	1600	550
- Above Nakorn Sawan		250	300	500	900	800	800	150
- Chao Phraya Project		300	400	600	900	850	800	400
2.Dry spell agriculture		2100	500	3300	4950	4200	3400	2050
- Out of irrigation system								150
- In irrigation system		2100	500	3300	4950	4200	3400	1900
3.Navigation		300	0	300	400	300	300	0
4.Authority Waterworks		650	550	700	750	750	750	650
5.Salinity Intrusion		400	250	600	600	500	450	350
Total 1-5	Plan	4000	2000	6000	8500	7400	6500	3600
	Actual	4610	1894	7216	9643	8556	6656	-
6.Second crop-rice (rai)	Plan	1.50	0	2080	3.50	3.30	2.70	1.90
	Actual	1.96	1.77	3.19	4.15	4.06	3.79-	

APPENDIX 6: SALINITY CONDITION OF CHAO PHRAYA RIVER IN APRIL,1999

Date	Samrong	BangNa	PraKaNong	Krung Thep Bridge	Memorial Bride	RID Samsen	Nonthaburi	RID Pak Kret
1	22.82	16.85	15.80	9.06	7.55	3.63	1.64	0.45
2	20.71	15.80	12.90	8.08	5.25	2.58	1.40	0.47
3	19.30	14.95	12.35	7.30	4.35	1.87	1.27	-
4	18.81	13.25	11.40	6.80	4.05	1.64	1.16	-
5	17.90	11.75	10.38	6.20	3.78	1.56	1.01	0.36
6	16.99	11.30	9.06	5.10	3.30	1.46	0.93	-
7	16.15	9.72	7.45	4.25	3.08	1.33	0.88	0.22
8	15.98	8.30	6.40	4.05	2.93	1.27	0.83	0.18
9	14.74	7.30	6.25	3.10	2.48	1.21	0.78	0.19
10	14.39	6.55	5.63	2.53	1.93	1.01	0.46	-
11	13.65	6.25	4.35	2.00	1.40	0.93	0.38	-
12	12.50	5.80	3.83	1.74	1.06	0.53	0.28	0.15
13	12.90	8.70	5.25	2.25	1.21	0.73	0.30	-
14	16.50	12.90	10.23	5.10	1.33	0.93	0.32	-
15	11.00	9.72	6.03	2.48	0.83	0.46	0.22	-
16	10.23	7.15	3.20	1.56	0.40	0.19	0.15	0.11

17	9.65	6.55	2.68	1.46	0.32	0.16	0.14	-
18	9.06	6.03	2.30	1.27	0.19	0.15	0.12	-
19	11.15	7.55	2.93	1.40	0.22	0.18	0.15	0.11
20	5.30	4.05	1.06	0.34	0.20	0.17	0.13	0.11
21	5.63	4.25	1.11	0.38	0.24	0.19	0.13	0.11
22	6.25	4.50	1.11	0.39	0.27	0.20	0.13	0.11
23	6.80	5.05	1.16	0.46	0.30	0.25	0.14	0.11
24	8.08	6.21	1.27	0.53	0.34	0.32	0.15	-
25	5.20	3.00	0.93	0.34	0.31	0.30	0.14	-
26	4.20	3.00	0.68	0.30	0.27	0.22	0.13	0.13
27	3.83	2.68	0.50	0.25	0.20	0.19	0.14	0.13
28	3.58	2.43	0.40	0.22	0.19	0.18	0.14	0.14
29	4.05	2.63	0.53	0.33	0.25	0.20	0.13	0.13

References

Frank Flatters, Theodore M,Horbulyk "Economic Perspectives on Water Conflicts in Thailand", TDRI Quarterly Review Vol.10 No.3, 1995.

Asian Institute of Technology, Final Report "Salinity Intrusion in the Chao Phraya and Mae Klong Rivers" March 1978

The Royal Irrigation Department, "Water Resources Planning and Management of the Chao Phraya River Basin, Thailand, 1991.

The Royal Irrigation Department, Water Allocation Planning in 1999".

Metropolitan Waterworks Authority, "Annual Report,1997".

An analytical supply response model of irrigable area project: A case study of the Chao Phraya river basin*

Sombat Sae-Hae[1]

Abstract: *Competition for water in the dry season has become more intense between upstream and downstream farmers, between agriculture and non-agricultural sector and even between government agencies. Objective of water resource management is to allocate the water resource in the efficient and equity manners. Approximately, 90% of the total water use in Thailand is used by the agricultural sector. The study's objective is to estimate the marginal value of irrigated water in the agricultural sector in the Chao Phraya River Basin. Methods used in the study are i) the estimation of a share equation (supply of crop) with the dependent variable being the area share of each subgroup (3 subgroups – rice, field crops and others) in the total area and ii) the estimation of a rice yield response function. Data used in the analysis was collected from the 16 irrigation projects in the basin. Results of the study showed that marginal value of irrigated water ranges from 0.19 to 1.42 bath per cubic meter. Wide range of these values may be explained by characteristics of the variables in the model. However, the model will be improved by treating more independent variables in order to obtain more precise outcome. Water resource management is usually more concerned with agricultural development. Technological change in agricultural production, e.g. machinery and early mature rice variety, have been considered as major factors that have led to increase cropping intensity. In addition, higher price of paddy induces some incentive to the Thai farmers to produce more paddy rice. Therefore, policies on agricultural production, trade and water allocation are necessary for increasing welfare of society.*

Water is an important input factor in agricultural production which need more water quantity than other economic sectors. The Chao Phraya Basin, including sub-basin in Northern; those are Ping, Wang, Yom, and Nan, is covering Northern and Central regions and being area that many conflict had occurred in dry season for long time, especially from Nakhon Sawan, where is mainly agricultural land, along through Bangkok, where is urban area. Therefore, the conflicts of both sectors have been occurred, especially in crisis of the dry season and

* This paper is a part of NRE/TDRI research funded by Thai Research Fund. The paper briefed from progress report in June 2000. Participants who are interested please follow up for completed paper after December, 2000.

[1] Thailand Development Research Institute (TDRI). The author would like to thank Dr.Ammar Siamwalla, Dr.Mingsarn Kao sa-ard, and DrAcharee Sattarasart at TDRI and Assoc.Prof.Somporn Isvilanonda at Faculty of Economics, Kasetsart University for their helps, their valuable comments and giving chance for contribution this paper.

stocking of water quantity in Bhumiphol Dam and Sirikit Dam totally under 6 billion cubic meter on January, 1st. For instance, during 1992 to1994 it was extremely dried period and only 2-3 billion cubic meter of water was available.

The mentioned conflict leads to the question how to allocate water resources for both economic sector and also for upstream and downstream area with equally and equity. According to efficiency managerial principle, things should be allocated to sectors that bring more economic added value first so that opportunity cost will not occur on them.

The main objective of the study is to estimate the marginal value of irrigated water in Chao Phraya basin by using production function regarding water resources as a input factor. And the out come would reflect policy in 2 points those are; (1) How many limited water resources should be allocated to Agricultural sector while compared with its economic value. And (2) How to add economic value of cultivated water. However the objective of this paper is to provide the estimation measurement conceptual framework of marginal value of irrigated water in agriculture sector for further study advantage.

This paper is divided into 3 sections, (1) theoretical framework, (2) the economic of marginal value of irrigated water (MVPw), and (3) conclusion.

1 Theoretical framework

1.1 Conceptual framework

The model used in this study is model for analysis of supply responding in irrigation area in the dry season that is the result of combination of output price, irrigated water factors, and other input factors together with fixed factor, those are land and capital which are constant in short-run period, and variable factor and receive output. This is under restriction that its price factor, substitute crop price factor, and non-agriculture commodities price factor determine production quantity and resources allocation. Furthermore, irrigated water quantity variable is an important factor for supply increasing in the dry season.

An important behavioral assumption on farmer's decision-making is based on farmer's aims to have maximize profit. And equation for maximize profit from agricultural output is shown as below.

$$\Pi = PQ - WV \qquad (1)$$

when Q and V are varies on production function, see equation (2);

$$Q = f(V, Z) \qquad (2)$$

Where Q is the vector of all the crop output
V is the vector of all the variable inputs
Z is the vector of other undefined variables
P is the vector of output prices
W is the vector of variables input prices

In maximize profit of firm there show of supply system equation thus as follow with equation (3),

$$Q = g(P, W, Z) \qquad (3)$$

The above structure of production is assumed that agricultural area is divided into 4 groups, consist of paddy field, field crop, fruit and tree, and vegetable. Supply equation of each group is nested to the others. Therefore the analysis of supply equation of each group have to be joint estimation with another crop supply in the structure. In addition, we assumed that production supply of each group is result from area and yield responding together.

Yield response function is as following equation (4);

$$Yi = Qi/Ai = h(Pi, W, Z) \qquad (4)$$

Where Yi is output i per area and Ai is cultivated area i

Equation (4), the correlation between yield and price variable, and irrigated water variable are positive. It means price variable and irrigated water variable increasing affected yield increasing. But other variables are negatively correlated with yield.

1.2 Econometric estimation

An important objective of production supply analysis of each crop is to estimate the elasticity of economic variable and irrigated water variable. In supply equation, we assumed that planned output is different from actual output. Because some input factors are not controlled by the farmers. This different output is used to construct farmer decision-making equation of 2 steps. At first step, farmer will make area using planning. The second step is to plan how to produce, which is upon planning of adding output per area unit (Behman, 1968; Evan and Bell, 1978; Isvilanonda and Poapongsakorn, 1995).

In farmer decision-making of area using, we assume that the planning for area using will upon price of output and input factors such as paddy and other crops price and labour cost is upon physical factors such as rainfall, irrigated water. All factors affect to change on supply curve as below.

$$sjt^* = aj + \Sigma_i aij.\ln Pit\text{-}1 + \Sigma_k akj.\ \ln Wkt + \Sigma_m amj.\ \ln Zmt + u1jt \qquad (5)$$

where sjt* is share of planned crop area by total area at time t
aij, akj, amj are coefficient of independent variable; u1jt is error term

By assuming that behavior of crop area follow as method in equation (6) (see Gudjarati, 1978 for more information).

$$sjt - sjt\text{-}1 = \Phi(sjt^* - sjt\text{-}1) \text{ and, } 0 < \Phi < 1 \qquad (6)$$

where j is crop area share we assumed 4 types, and t is year.

sjt and sjt-1 are actual area share of each crop by total cultivated area in year t and t-1 respectively. Equation (6) explains that the different of actual agricultural area (sjt) in year t and t-1 (sjt-1), is from adjustment of the difference between planned agriculture area in time t and actual agriculture area in time t-1. When we solved equation (5) and (6), it can be appeared in equation (7) that will be used in the estimation.

$$sjt = \alpha j + \Sigma_i \beta ij \ lnPt\text{-}1 + \Sigma_k \gamma kj \ lnWkt + \Sigma_m \omega mj \ lnZmt + \chi j \ sjt\text{-}1 + \eta 2jt \quad (7)$$

where j is 1,2,3,4 and t is time year.

In coefficient estimation of supply response equation, we estimate from system equation using pooling cross-section and time series data. Data used in the model was collected from the irrigation projects. Seemingly unrelated technique is used for coefficient estimation to reduce bias (Maddala, 1977) with following restrictions.

$$\Sigma \alpha j = 1 \quad (7.1)$$

$$\Sigma \beta ij + \Sigma \gamma kj = 0 \quad , \text{all i and k} \quad (7.2)$$

$$\Sigma \omega mj = 0 \quad , \text{all m} \quad (7.3)$$

$$\beta ij = \beta ji \quad , \text{all i and j} \quad (7.4)$$

From equation (7.1) to (7.3), summation of Sij equals to 1 for all cases, equation (7.4) is represented for symmetry requirement. In addition, by considering equation (7.2) and (7.4) share supply response equation is homogeneous degree zero to price variable (Siamwalla et al, 1990; Rosgrant and Kasryno, 1992).

For yield response equation and price factor and area physical, we assign equation as log-linear form which can be shown as equation (8).

$$Yjt = \delta j + \Sigma_h \Theta jh.Pht\text{-}1 + \Sigma_k \xi jk.Wt + \Sigma_m \rho jm.Zmt + vjt \quad (8)$$

In estimation of supply elasticity by price factor and related factor, we used to link area share (of crops those are paddy, field crop, vegetable, and fruit and tree) and yield together. The result is the total crop supply as following equation (9).

$$Qjt = sjt.Aj.Yjt, \quad (9)$$

Where Qjt is crop j output at time t. There calculated from j times crop j area.

From equation (7), (8), and (9), the coefficient received from estimation will be used to estimate elasticity of supply by economic factor and irrigated water variable. The elasticity of irrigated water (**ejQ$_{IR}$**) is derived from equation (10) as followings:

$$\mathbf{ejQ_{IR}} = \mathbf{ejY_{IR}} + \mathbf{ejA_{IR}} \quad (10)$$

Where **ejY$_{IR}$** represents elasticity of crop j when concerning of irrigated water. **ejA$_{IR}$** is elasticity of crop j area (in being as area share) concerning of irrigated water quantity.

1.3 Estimation model

From conceptual framework and econometric estimation, we can derive estimation model of price elasticity and marginal value of irrigated water (VMPx). The estimation have 2 steps, the first step is to estimate area response. The second step is to estimate yield response. The both steps will be linked together on irrigated water elasticity.

1.3.1 First Step : area response estimation

Dependent variable is share of crop area in each irrigation project which are divided into 3 type those are paddy area (s1), field crops and sugarcane area (s2), and other crops (s3), where s1 + s2 + s3 is equal to total crops area in the dry season. This study assume that paddy area share is our target, and field crop and sugarcane area share are substitute commodities and other crops area share is residual. There are 6 independent variables consist of paddy price, field crop price, vegetable price, irrigated water, agricultural labor wages, and fertilizer price. The model is ;

$$S1_{it}\ S2_{it} = f(PDDP_{t-1}, CRPP_{t-1}, FRTP_{t-1}, WU_{it}, LBP_t, FTZP_t)$$

Where $S1_{it}$ = Share of dry paddy area in irrigated area i at t

$S2_{it}$ = Share of field crops area in irrigated area i at t

$PDDP_{t-1}$ = Paddy Wholesale Price at time t-1 (baht per kg.)

$CRPP_{t-1}$ = Sugarcane Wholesale Price at time t-1 (baht per kg.)

$FRTP_{t-1}$ = Vegetable Wholesale Price at time t-1 (baht per kg.)

WU_{it} = Amount of Irrigated Water in Irrigation project i at time t (m3 in the dry season)

LBP_t = Agricultural Labor Wages at time t (unit : baht per day)

$FTZP_t$ = Fertilizer Wholesale Price on formulation 16-20-0 at time t (baht per ton)

From above equation, our hypothesis is that farmers will make-decision to increase allocated area for paddy by comparing with field crop area when they expected paddy price at time t-1 will be higher than field crop price. Irrigated water variable used for cultivation at time t is enough for demand in whole dry season. The both variables affect decision-making for paddy area allocation in positive direction. Meanwhile field crop price in last year (t-1) had been decreased comparing with paddy price. And input factor price, which are agricultural labor wages and fertilizer price, is not so expensive that farmer expected marginal profit would decline and not reach maximize profit. Field crop price variable and input price will affect in negative direction. The vegetable and fruit price variable in last year (t-1) will be price reference used for decision-making to longer change to fruit and vegetable cultivation or not, is upon the assumption that the area can be changed from paddy field to other crops by land physical is fixed.

The estimation method used for the model is system equations method which concerned with changing of other independent variables those are changed together. Estimation technique is Generalized Least Square (GLS) technique, the coefficient received from estimation of the log-form is elasticity of area response by irrigated water.

1.3.2 Second step : yield response estimation

Paddy yield of each project is a dependent variable. There are 4 independent variables consist of paddy price, irrigated water per area, agricultural labor wages, and fertilizer price. The model is ;

$$Yield_{it} = f(PDPI_{i,t-1}, WURAI_{it}, LBP_t, FTZP_t)$$

Where $Yield_{it}$ = Paddy yield in irrigation project i at time t (unit :kg per rai)

$PDDP_{t-1}$ = Paddy Wholesale Price at time t-1

$WURAI_{it}$ = Irrigated Water per area i at time t (unit : m3/ria)

LBP_t = Agricultural Labor Wages at time t
$FTZP_t$ = Fertilizer Wholesale Price on formulation 16-20-0 at time t (baht per ton)

The above model is under hypothesis that, after farmer made decision on allocating area for paddy, they aimed to get output to maximize profit. Thus, the motivation of production is high paddy price, as well as to receive input, water quantity, continuously. Then, the coefficient of both variables is positive direction, but the input, such as agricultural labor wages, fertilizer price which are production cost, is negative direction.

The estimation of this model used ordinary least square method (OLS).The received coefficient from the log-linear equation is elasticity. With this estimation, we will receive elasticity of paddy output per paddy price and per water quantity used in the project.

1.4 Data

Irrigation project area in the Chao Phraya river basin consists of 18 provinces,namely Chai Nat, Sing Buri, Ang Thong, Ayutthaya, Lop Buri, Saraburi, Nonthaburi, Pathum Thani, Nakorn Sawan, Suphan Buri Nakorn Pathom, Samutsakorn, Samutpakarn, Chachoengsao, and Bangkok. There are 26 large projects, 14 medium projects, and 119 small projects. Total project area is 8.855 million rai or 70.4 percent of the Chao Phraya river basin. The large scale project are covered 8.351 million rai or 94.3 of total irrigation area, irrigated area is 6.633 million rai or 74.9 percent of the large scale irrigation project. (Table 1)

The irrigation system for the Chao Phraya river basin is divided in 3 systems as its distribution; (1) Gravity irrigation system, the efficiency of this system is to irrigate around 62-82 percent in the dry season and 48-84 percent in the rainy season. This system is applied for 16 projects, comprise of i Polathep, ii Boromathad, iii Thabote, iv Samchuk, v Don Jedee, vi Pho Phaya, vii Chanasuth, viii Yangmanee, ix Phak Hai, x Manorom, xi Chong Kae, xii Khok Kateim, xiii Roeng Rang, xiv Maharat, xv Pasak Tai, and xvi Nakhonluang. Projects and irrigated area cover 4.545 and 4.082 million rai respectively.

(2) Conservation area irrigation system, is the system using natural canal as water storage and dispense water quantity fix to the shortage quantity. Agricultural land in irrigation system can be cultivated in all seasons. However, almost project's area characteristic are flood plain. Thus it has flooding problem. The efficiency of this system is to irrigate around 57-88 percent in the dry season and 50-84 percent in the rainy season. This system is applied for 8 projects, comprise of i Chao Ched-Bang yeehon, ii Phrayabanlue, iii Phrapimol, iv Pasicharoen, v Rangsit Nua, vi Rangsit Tai, vii Klong Dan,and viii Phra Ong Chai Ya Nuchit. Projects and irrigated area cover 3.807 and 2.551 million rai respectively. And (3) Pumping irrigation system cover 2 projects; i Bangbal and ii Wad Singh. Irrigation water is pumped and distributed by gravity system. Its efficiency is to irrigate around 72-89 percent in the rainy season.

This paper studied on the gravity irrigation system and pumping irrigation system. As we can measure water quantity used in the cultivation. We assumed that the whole cultivated area as if one area unit so the model can explain changing of area using for cultivation with changing of irrigated water quantity.

From above model in part 1.3, the study used pooling data for analysis. That is to join cross-section and time series data together. The data set is total 16 projects of irrigation area for 13 years, covering 1987 to 1999. Output price factor was Bangkok wholesale price during 1986 to 1998. Input factor price were agricultural labor wages in the central region. For fertilizer price formula 16-20-0 price during 1987 to 1999 was selected. The data was collected from Department of Economic Commerce and Office of Agricultural Economic)

2 The economic of marginal value of irrigated water (VMPx)

From the theoretical framework in section 3, the estimation of both model are received area response elasticity of irrigated water factor ($e_{a,w}$) and yield respond elasticity of irrigated water ($e_{y,w}$). Summation of both elasticity, is yield elasticity of irrigated water per area ($e_{q,w}$). By multipling the received elasticity with paddy yield (kilogram) and average paddy price (baht per kilogram) and divided by average irrigated water per area (cubic meter per rai). Equals marginal value of irrigated water (VMPx).

2.1 Model selection

The study estimated the estimation model in 2 forms as follows:

Model I, all output prices are wholesale prices of Bangkok market adjusted form to price index those are paddy price index, field crop price index (Cassava, Cotton, Ground nut, Mangbean, Soybean, Kenaf, Maize, Sugarcane, and Pineapple), vegetable price index (Tobacco, Chili, Shallot, Onion, Garlic, Cabbage), and fruit and tree price index (Rubber tree, Palm oil, Coconut, Longan, and Coffee). All price indexes are calculated by Divisia Price Index (DPI)[2] for 1986 to 1998 and fixed 1988 as base year. Labor wages,is nominal wages of central region deflate by consumer price index (CPI), adjusted by distance from Bangkok to Chai nat or Lop buri. For fertilizer price, we used Bangkok wholesale price deflated by GDP deflator adding by transportation cost from Bangkok to each province.

---

[2] DPI is price index that concerned rate of total commodities value changing at time t by calculate from sum of average commodity value i and commodity value i at time t multiply with rate of commodity price i changing at time t compared with commodity price i at time t-1 (see below equation). Which in economical thought, this method provide better meaning than Laspeyres Price Index and Paeches Price Index which are concerned comparing of commodities value at time t and commodities value at time t-1, and Fisher Price Index which is concerned changing of exponential price index. Divisia Price Index formulation is as below.

$$\log (D)t = (0.5) \sum_{i=1}^{I} (si + si,t-1) \log (pit / pi,t-1)$$

where sit = (pit * qit) / (pt * qt)

Dt is Divisia Price Index
sit is commodity value i at time t compared with commodity value of based year t
pit is commodity price i at time t where i=1,2,...,N and t=1,2,...,T
qit is commodity quantity i at time t, where i=1,2,...,N and t=1,2,...,T
pt is fixed commodity price at time t
qt is fixed commodity quantity at time t

Table 1 Irrigation Projects in the Chao Phaya River Basin (unit : rai)

Project	Provincial Area	Construction Started	Construction Finished	Project Area	Planed Irrigated Area	Actually Irrigated Area
1. Polathep	Chai Nat	2495	2506	103,000	96,300	96,300
2. Boromathad	Chai Nat, Suphan Buri, Sing Buri	2495	2506	405,000	365,000	365,000
3. Thabote	Chai Nat, Suphan Buri	2495	2506	218,356	196,400	196,520
4. Samchuk	Suphan Buri, Ang Thong	2478	2498	370,000	305,000	305,000
5. Don Jedee	Suphan Buri	2504	2507	164,652	146,000	148,129
6. Pho Phaya	Suphan Buri	2464	2476	415,938	370,000	370,000
7. Chanasuth	Sing Buri, Chai Nat, Suphan Buri, Ang Thong, Ayutthaya	2495	2506	527,000	448,200	474,300
8. Yangmanee	Ang Thong, Sing Buri, Ayutthaya	2495	2506	233,689	210,300	210,321
9. Phak Hai	Ayutthaya, Ang Thong, Suphan Buri	2495	2506	219,658	206,000	206,000
10. Bangbal	Ayutthaya, Ang Thong	2513	2526	160,000	137,000	137,000
11 Wad Singh	Chai Nat	Na.	Na.	Na.	Na.	Na.
12. Chao Ched	Ayutthaya, Suphan Buri	2482	2493	437,850	406,000	406,000
13. Phrayabanlue	Nonthaburi, Ayutthaya, Suphan Buri, Nakhon Pathom, Pathum Thani	2482	2493	420,000	358,650	350,000
14. Phrapimol	Nonthaburi, Nakhon Pathom	2482	2493	340,350	266,000	250,950
15. Pasicharoen	Nakhon Phathom, Bangkok, Samut Song Khram	2445	2450	202138	124,800	56,454
16. Manorom	Chai Nat, Nakhon Sawan, Sing Buri	2495	2505	285,104	268,000	262,681
17. Chong Kae	Nakhon Sawan, Sing Buri, Lop Buri	2496	2506	261,624	238,700	238,740
18. Khok Katiem	Lop Buri, Saraburi, Ayutthaya	2496	2506	228,300	205,500	205,470
19. Roeng Rang	Saraburi, Ayutthaya	2495	2506	203,781	179,000	179,000
20. Maharat	Sing Buri, Chai Nat, Lop Buri, Ang Thon, Ayutthaya	2495	2507	523,912	422,000	476,300
21. Pasak Tai	Ayutthaya, Saraburi	2464	2476	272,000	240,600	270,160
22. Nakhonluang	Ayutthaya	2503	2507	301,846	267,000	276,048
23. Rangsit Nua	Ayutthaya, Phatum Thani, Saraburi	2458	2467	445,500	454,000	359,775
24. Rangsit Tai	Phatum Thani, Bangkok	2464	2476	892,000	526,000	441,970
25. Klong Dan	Samut Prakan, Bangkok, Chachoengsao	2464	2476	559,000	525,000	409,757
26. Phra Ong Chai Ya Nuchit	Chachoengsao, Samut Prakan	2464	2476	511,000	510,000	510,000
Total Irrigated Area				8,350,698	7,471,450	6,632,523

Source : Royal Irrigation Department, and Kasetsart University and ORSTOM (1996).

Model II is derived from model I by using Bangkok nominal wholesale price information that formed to be constant price in 1988. We used the average price for whole year. Sugarcane price and cabbage price was selected for the field crops used vegetable price, repretively 16 dummy variable represent irrigation project in the Chao Phraya river basin.

The result of the study showed that overall testing for both model have significant and model II has higher significant and R2 than model I. Considering independent variable in modei I, only irrigated water variable has significant positive effect as expected. On the other hand, other variables have not significant effect. We can say that the result from model II is better than from model I. That is the coefficient of economic variable, irrigated water variable, and input factor variable are expected direction and significant at 0.01 percent. Consequently, we used the result of model II for interpretation.

2.2 The area study statistic

The irrigation project area in the Chao Phraya river basin covers 8.351 million rai there is irrigated area 79.4 percent of total irrigation project area and cultivated area in dry season 63.1 percent of total irrigated area. The studied area covers 54.4 percent of total irrigation project area in the Chao Phraya river basin or 4.544 million rai which is irrigated area 89.8 percent of studied project area and cultivated area in dry season 77.5 percent of studied irrigated area.

More than 70 percent of studied cultivated area in dry season is paddy field and the left area is field crops, vegetable and fruit, and other crops which are 15.6, 5.0, and 1.4 percent respectively. Growth rate of vegetable and fruit are increased more than 88.9 and 144.6 per annum. While paddy field growth rate is nearly constant (see table 2 and 3).

2.3 The result of area response and yield response

The estimation of area response equation by economic variable and irrigated water showed that the last price period (t-1) of paddy and sugarcane affect farmer's decision-making to allocate paddy area in the dry season with significant at 0.01. It means when paddy price rose up, farmers will also increase area for the paddy. When sugarcane price was relatively higher than paddy price, they will reduce paddy field and change to sugarcane. The price sensitivity of paddy and sugarcane are unequal and incomplete substitution.

The elasticity of paddy area response to paddy price factor and irrigated water factor is 0.515 and 0.17 ($e_{a,p}$ = 0.515 and $e_{a,w}$ = 0.170) respectively. It means, when paddy price or irrigated water increase by 1 percent, paddy field area in irrigated area will increase by 0.515 and 0.17 percent respectively. However, paddy price factor affected farmer decision-making more than irrigated water for allocation paddy area. Because in the Chao Phraya river basin, usually there are high risk for water resources scarcity in the dry season. Once paddy price rose up, farmers willingly take risk for paddy cultivation since they expected to get maximize profit even under uncertainty.

For 13 years ago, paddy yield have been increased from 600-700 kg. per rai during 1987-1989 to 700-800 kg. per rai in 1992. From the yield response estimation, the result showed that irrigated water factor affected the changing of paddy yield in the dry season at the significant of 0.01. The elasticity of paddy yield by irrigated water is 0.315 ($e_{y,w}$ = 0.315). It means, once irrigated water change by 1 percent, paddy yield will change by 0.315 percent.

Paddy price variable affected the increasing of paddy yield per area. Once farmers decided to produce paddy, its price will be an incentive for them to expect to maximum yield. However, paddy price factor is insignificantly.

2.4 The marginal value of irrigated water (VMPx)

The result of estimation in part 2.3, showed that the economic marginal value of irrigated water in the Chao Phraya river basin is range 0.192-1.436 baht per cubic meter that means farmers used 1 cubic meter irrigated water to produce on farm it will create economic return at range 0.192-1.436 baht. (table 8) However, how much received economic return more or less depending on the estimation model.

3 Conclusion

The preliminary result is not able to summarize completely about economic value of irrigated water. There is because the estimation on each variable is unexpected and insignificantly. However, we may conclude that economic value of irrigated water a cubic meter ranges between 0.192-1.436 baht.

The preliminary conclusion for policy making may be said that if government will restrict paddy area in the dry season in order to manage the limited water resources to have enough demand response in economic sector, the government has to use the economic value of irrigated water as an instrument to limit paddy area or to set compensation for the farmer's opportunity cost to stop paddy cultivation in the dry season.

TABLE 2 IRRIGATION PROJECT STATISTIC IN THE CHAO PHRAYA RIVER BASIN

Description	Chao Phraya river basin		
	Min.	Max.	Average
Irrigation project			
- Total Project area (million rai)		8.351	
- Total irrigated area million rai)		6.633	
- Total cultivated area (million rai)		5.267	
- Ratio of irrigated area and project area (%)		79.43	
- Ratio of cultivated area and irrigated area (%)		63.07	
Area Studied			
- Total project area (million rai)		4.544	
- Total irrigated area (million rai)		4.082	
- Total cultivated area (million rai)		3.520	
- Ratio irrigated area and project area (%)		89.83	
- Ratio cultivated area and irrigated area (%)		77.47	
Cultivated area share in area studied (%)			
- Paddy field	59.77	90.42	77.96
- Field crop	6.93	31.24	15.58
- Vegetable and fruit	0.91	8.88	5.05
- Other	0.66	2.23	1.42
Growth rate of cultivated area, during 1987 to 1999 (per annum)			
- Paddy field		14.23	
- Field crop		-32.73	
- Sugarcane		63.13	
- Vegetable		80.86	
- Fruit		144.56	
- Tree		26.53	
- Other		2.93	
- Average Growth rate		19.29	
Irrigated water per area (cubic meter / rai)		**1,519.69**	
Paddy Yield (kg. / rai)		**653**	

Source : calculated by the author

TABLE 3 CROP CULTIVATION AREA IN THE CHAO PHRAYA RAVER BASIN (UNIT : RAI)

Year	Paddy	Field crop	Vegetable	sugarcane	fruit	tree	Fish and other	Total
2530	2,472,745	96,219	55,334	55,447	198,621	34,901	199,035	3,112,302
2531	2,498,548	51,240	49,595	51,226	237,587	15,225	216,096	3,119,517
2532	2,769,481	44,635	52,152	61,276	218,586	15,745	234,468	3,396,343
2533	2,937,022	58,181	50,733	58,106	249,712	10,558	250,730	3,615,042
2534	1,775,698	84,752	35,919	157,743	239,240	7,524	139,804	2,440,680
2535	2,066,552	96,828	44,289	167,807	290,169	12,057	79,241	2,756,943
2536	1,870,834	77,373	49,479	183,325	296,017	12,581	159,689	2,649,298
2537	1,662,489	60,899	37,974	136,242	313,265	15,827	153,595	2,380,291
2538	2,460,405	53,016	37,174	191,570	343,197	13,764	123,414	3,222,540
2539	3,560,670	28,235	45,213	214,789	366,654	26,211	167,253	4,409,025
2540	3,444,669	23,619	43,022	192,231	380,351	10,880	76,461	4,171,233
2541	3,196,927	31,395	42,237	164,047	359,099	12,216	137,460	3,943,381
2542	2,701,470	37,744	32,777	165,093	383,065	22,466	198,725	3,541,340
2530-33	2,669,449	62,569	51,954	56,514	226,127	19,107	225,082	3,310,801
2534-37	1,843,893	79,963	41,915	161,279	284,673	11,997	133,082	2,556,803
2538-40	3,155,248	34,957	41,803	199,530	363,401	16,952	122,376	3,934,266
2541-42	2,949,199	34,570	37,507	164,570	371,082	17,341	168,093	3,742,361

Source : Royal Irrigation Department

Table 4 Area response estimation in model I

	OLS		GLS	
	Coeff.	t-test	coeff.	t-test
No. Obs.	204			
Constant	-1.454	-1.100	-2.847	-2.895
LWPDDI	0.072	0.378	-0.085	-0.526
LWCRPI	0.260	1.392	0.183	1.632
LWFRTI	-0.053	-0.508	-0.084	-2.831
LWU	0.043	3.096	0.045	3.252
LFTZP	0.159	1.045	0.319	2.774
adj. R-square	0.112		0.105	
Chi-square	-		2.529	
F-test	6.140		5.750	
DW. Stat.	0.992		1.028	
Paddy Share	0.695		0.695	
e (p,w)	X		x	
e (a,w)	0.062		0.065	

Remark LWPDDI is log of paddy wholesale price index
LWCRPI is log of wholesale price index of field crop group
LWFRTI is log of wholesale price index of fruit and tree group
LWU is log of irrigated water
LFTZP is log of fertilizer wholesale price

Source: estimated by the author

Table 5 Yield response estimation in model II

	OLS	
	coeff.	t-test
No. of Obs.	204	
Constant	-3.264	-0.577
LWPDDI	0.339	0.395
LWURAI	-0.018	-0.201
CHPYW	0.390	1.898
LFTZP	1.092	1.688
adj. R-square	0.054	
F-test	3.920	

Remark LWPDDI is log of paddy wholesale price index
LWU is log of irrigated water
CHPYW is dummy of the West of Chao Phraya river basin bank
LFTZP is log of fertilizer wholesale price

Source : estimated by the author

Table 6 Area response estimation in model 2

	OLS		GLS	
	coeff.	t-test	coeff.	t-test
No. of obs.	221			
PDDP	0.054	4.629	0.052	4.668
SGCP	0.531	2.184	-0.049	-5.349
LVGTP	-0.024	-2.197	0.006	2.188
LWU	0.134	6.620	0.119	6.113
LFTZP1	-0.256	-4.543	-0.216	-4.979
D1	0.422	4.986	0.397	4.701
D2	0.403	4.781	0.373	4.437
D3	-0.004	-0.041	-0.006	-0.066
D4	0.113	1.312	0.010	1.117
D5	0.277	3.169	0.265	3.029
D6	-0.056	-0.558	-0.046	-0.466
D7	-0.178	-1.876	-0.176	-1.860
D8	0.019	0.214	0.003	0.035
D9	0.363	3.970	0.307	3.393
D10	0.434	4.676	0.375	4.096
D11	0.034	0.915	0.081	0.887
D12	0.149	1.770	0.118	1.406
D13	-0.019	-0.214	-0.028	-0.312
D14	-0.212	-2.427	-0.225	-2.580
D15	-0.116	-1.302	-0.125	-1.412
D16	-0.193	-2.175	-0.203	-2.284
Adj. R-square	0.392		0.320	
Chi-square	-		28.340	
F-test	8.090		6.160	
DW. Stat.	1.638		1.479	
Paddy Share	0.696		0.696	
E (p,w)	x		x	
E (a,w)	0.192		0.170	

Remark PDDP is paddy wholesale price deflated by GDP non-agricultural deflator
SGC is sugarcane wholesale price deflated by GDP non-agricultural deflator
LVGC is log of cabbage wholesale price deflated by GDP non-agricultural deflator
LWU is log of irrigated water
LFTZP1 is log of fertilizer wholesale price deflated by GDP agricultural deflator
D1,.,D16 is dummy of 16 irrigation projects

Source : estimated by the author

Table 7 Yield response estimation in model 2

	OLS	
	Coeff.	t-test
No. of obs.	221	
LFPDDP1	0.409	0.948
LWURAI	0.315	4.976
LLBP1	0.433	1.688
D1	1.632	3.741
D2	1.862	4.220
D3	1.447	3.320
D4	1.414	3.244
D5	1.734	3.960
D6	1.189	2.684
D7	1.410	3.232
D8	1.283	2.918
D9	1.848	4.158
D10	-0.415	-0.939
D11	1.117	2.533
D12	0.274	0.629
D13	0.815	1.825
D14	0.130	0.289
D15	1.199	2.738
D16	0.636	1.445
Adj. R-square	0.134	
F-test	2.890	

Remark LPDDP1 is log of paddy wholesale price deflated by GDP non-agricultural deflator
LWURAI is log of irrigated water per area
LLBP1 is log of agricultural labor wages deflated by GDP agricultural deflator
D1,.,D16 is dummy of 16 irrigation projects

Source : estimated the author

Table 8 Marginal value of irrigated water in Chao Phraya river basin

	e (a,w)	e (y,w)	e (q.w)	VMPx
Model 1				
OLS	0.062	-	0.062	0.1835
GLS	0.065	-	0.065	0.1924
Model 2				
OLS	0.192	0.315	0.507	1.501
GLS	0.170	0.315	0.485	1.4356

Remark Assumption for calculation the marginal value of irrigated water in Chao Phraya river basin: paddy yield 653 kg./rai, irrigated water per area 1,520 m3/rai, and paddy wholesale price 6.89 baht/kg.

Source : calculated by the author

References

The Resources Engineering Consultant Company Limited. (1994). The Project of data study and Development Potential of Chao Phaya Basin. main report, November 1994.

Somporn Isvilanonda. (1999). An Analysis of Sugarcane Production Supply. Journal of Economic Kasetsart University. Vol. 6, no. 3. (in Thai)

Suphat Viratdhanapong et al. (1999). The Farmer's Paddy Product (Central Region and North-Eastern Region). Agricultural Economic Document no. 2/2543, Section of Agricultural Economic Research, Office of Agricultural Economic. (in Thai)

AIT. (1994). Study of Potential Development of water resources in the Mea Klong river basin. Volume I : Main Report. April 1994.

Behrman, J. R. (1968) Supply Response in Underdeveloped Agriculture: A Case of Four major Annual Crops in Thailand 1937-1968, Amsterdam, Netherlands: North Holland Publishing

Evans, S. and Bell, T.M. (1978). How Cotton Acreage, Yield, and Production Respond to Price Changes, Agricultural Economic Research, vol. 30, no. 3.

Gujarati, D. (1978). Basic Econometrics, New York: McGraw-Hill Book Company.

Isvilanonda, S. and Poapongsakorn, N. (1995). Rice Supply and Demand in Thailand: The Future Outlook, Sectoral Economic Program, Thailand Development Research Institute, Bangkok, Thailand

Maddala, G. S. (1977). Econometrics, New York: McGraw-Hill Book Company

Rosgrant, M. W. and Kasryno, F. (1992). Supply Response with Endogenous Technology: Food Crops in Indonesia, A Paper Presented at the Workshop on Production and Policy Implications of Medium and Long Term Rice Supply and Demand 25-27 March, at the International Rice Research Institute, Philippines.

Sayrs, L.W. 1989. Pooled Time Series Analysis Series : Quantitative Application in the Social Sciences. A SAGE University Paper 70

Siamwalla, A., Setboonsarng, S., and Patamasiriwat, D. (1990). The Response of Thai Agriculture to World Economy, Thailand Development Institute, Bangkok, Thailand.

The drainage improvement and rural development in the delta with emphasis on the case studies in Rangsit Tai and Bang Ban areas

Yoshihiko Ogino [1]

Abstract: *Most of the countries in South and Southeast Asia have generally a typical bi-seasonal monsoon climate such as Thailand where a year is divided into two seasons of dry winter season and wet summer season. Low lying lands and delta areas of major rivers become heavily waterlogging and inundation during the monsoon rainy season in every year. In the past, this waterlogging condition on the land during monsoon season was generally not a major constraint as rice is cultivated mostly in wet season using flood by rain-fed irrigation. In dry season, if water is available, farmer wants to plant rice as second crop by river-fed irrigation. Increasing yield, introduction of more sensitive varieties, improvement of workable condition of farm machinery and demands for more crop diversification have changed this situation and made better waterlogging control.*

The need for improvement of drainage condition is most urgent in these areas in the recent days. Agricultural development in these areas has reached the stage at which the present inadequate drainage conditions have become the main constraint.

The Asian monsoon, which is characterized as high temperature and rainfall, provides them favorite condition to grow rice. South, South East and East Asian Region extending from west coast India to Japan covers about 15 % of the world land surface and the population of this region is more than 50 % of the world. The population density is roughly six times that of rest of the world. The population of South and South East is predominately rice farming agriculture. Rice is still staple food crop of 80 % of population in this region.

Water is however the most serious constraint for rural development and agricultural food production today here. Little and too much water for the people living there, to fight against and to abandon water and lands, and flood and drought are continuously repeated every year. Adequate water management by farmers themselves seems to be beyond their capacity.

River taming followed by drainage construction in some areas has been carried out and agricultural drainage projects will be needed in these areas in near future. Drainage project of paddy based farming system in humid tropics is a new challenge of the world, which needs technological and financial assistance from the developed countries.

Full paper not provided

[1] Osaka Prefectural University

Operational flood forecasting for Chao Phraya river Delta

Sutat Weesakul[1] and Supot Thammasittirong[2]

ABSTRACT: *The flood forecasting model was developed and improved to be used as operational model for Chao Phraya delta. This study applies AIT River Network model to forecast the flood by input the forecasted upstream boundary, which is the daily discharge at the tail of Chao Phraya Dam, and downstream boundary, which is tidal level at Fort Chula. Not only the model that will provide flood forecast but also both boundaries should be good forecasted. At the upstream boundary, the non-dimensional shape of unique flood hydrograph was formulated and proposed. The three empirical formulae for forecasting peak discharge, time base and dimensionless shape of hydrograph were derived. Good agreements between observed and forecasted daily discharge were obtained with the error ± 10% or ± 300 cms. For the downstream boundary, the conventional harmonic analysis was applied. The optimum length of tidal record and number of tidal constituents were found to be 30 days with 4 constituents which provide the least root meant square with the error ± 20% or ± 0.20-0.30 m. Finally the model was applied to forecast the daily maximum water levels of 1980, 1983 and 1995 flood with one month in advance. The results of flood forecasting show the acceptable agreements between the observed and forecasted water levels with the average errors of about ± 20 cm. in the river and ± 15 cm. in the flood plain.*

1 Introduction

The Chao Phraya Delta is one of the most important deltas in the Central Part of Thailand. Many times in the past the delta have been flooded and these floods result in extensive damage to economic and social condition, especially at the lower reach of the Chao Phraya river. Natural flooding in this area is mainly due to high tide in the Gulf of Thailand, high discharge from the north, local rainfall and inflow from the surrounding area. The tide in the Chao Phraya River is highest from November to December while peak flow in the Chao Phraya River from the north normally passes the Chao Phraya Dam in Mid-October and reaches Bangkok in November. Therefore, water levels in the lower reach of the Chao Phraya River due to the combined effect of tide and river flow from the north are highest at the beginning of November. To reduce the damage and protect the city from flooding, flood forecasting is one of the important tools used for this purpose.

[1] Visiting Faculty, Water Engineering and Management Program, Asian Institute of Technology, P.O. Box 4, Klong Luang 12120, Phatumthani, Thailand

[2] Graduate Student, Water Engineering and Management Program, Asian Institute of Technology, P.O. Box 4, Klong Luang 12120, Phatumthani, Thailand

Mathematical models of Chao Phraya River basin flood forecasting were developed by Tingsanchali and Arbhabhirama in 1978 and the models were improved to study the flooding conditions and the effect of the Chao Phraya 2 division channel by Tingsanchali and Vongvisessomjai in 1986. In 1999, JICA carried out the Master plan study on integrated plan for flood mitigation in Chao Phraya River basin using Mike11 model. However none of the model is used in operational level due to lack of real time boundary condition.

The Asian Institute of Technology (AIT) River Network Model, a combination of the River Model and Cell-Link Model developed by Suppataratarn (1990), was used to simulate flow in both the river and the floodplain. This model is appropriate for simulating flow in detaic areas such as the Chao Phraya delta in Thailand. In this study the model is applied for operational flood forecasting in the Chao Phraya delta.

2 Study area

The study area is the Chao Phraya River basin, covered an area of 151,757 km^2 as shown in Figure 1. The basin is divided into ten subbasin as shown in Table 1 which subbasins 1 to 9 are used as the input data for the upstream discharge forecasting and subbasin 10 is the Chao Phraya delta. The delta is characterized by a flat and low lying broad deposited surface. The major drainage systems of the plain are the Chao Phraya River and its tributaries, i.e. the Thachin, the Noi, and the Lopburi rivers. The plain also receives water from the Pasak River in the northeast, the Bangpakong River in the east and the Maeklong River in the west. In Chainat Province, which is the apex of the delta, waters of the Chao Phraya River can be diverted by the Chao Phraya dam into a number of main water courses, consisting of regulated natural rivers and manmade irrigation canals. Figure 2 shows the detail of the Chao Phraya delta.

Table 1 List of names and area of the subbasin

SubBasin	Name of Sub-basin	Area (km^2)
1	Bhumibol Dam Basin	26,386
2	Wang River Basin	11,708
3	Ping River Residual Basin	9,632
4	Yom River Basin	24,720
5	Sirikit Dam Basin	13,130
6	Nan River Residual Basin	20,227
7	Chainat Residual Basin	5,084
8	Pasak River Basin	15,206
9	Some Parts of Chao Phraya River Basin	6,664
10	Chao Phraya Delta	19,000
	Total	**151,757**

3 Theoretical considerations

3.1 Flood forecasting model

The River Network Model is applied to use for flood forecasting in the Chao Phraya delta by input the forecasted upstream and downstream boundary. The model was a combination of the River model and the Cell-Link model (quasi two-dimensional model) which represent the characteristic of flow over riverbank in the floodplain. The River model for describing flow in the river channel was formulated using one-dimensional unsteady flow of de SAINT VENANT equations. The Cell-Link model describing the flow in floodplains was based on the diffusion model as proposed by ZANOBETTI and LORGERE (1970). The detail of governing equations and the numerical formulations is in SUPPATARATARN (1990).

3.1.1 Physical layout and schematization of model

River reaches are subdivided into small reaches while the flood plains are subdivided into cells. Flows between cell and cell or cell and river reach are through links, which represent canals, weirs or siphons. The physical layout of the model is shown in Figure 3 while the schematization is shown in Figure 4. There are 126 grids in the River model and 139 cells in the Cell and Link model. The maximum, average and minimum values of lengths between grids are 17.0, 9.3 and 2.0 km while those of cell are 470, 137 and 13 km^2 respectively

3.1.2 Data

- *Observed data*: The observed data are topographic data and some of hydrologic data. The topographic data are the main river cross-section and berm section data, ground elevations, canal sections and dike levels. The hydrologic data are initial water levels in cell, initial water levels and initial discharges at grids, rainfall and evapotranspirations.

- *Forecasted boundaries*: The forecasted boundaries are discharges at upstream boundary at Chao Phraya dam (Station C13) and tidal level at downstream boundary at Fort Chula as shown in Figure 4.

3.2 Forecasting of discharge hydrograph at the tail of Chao Phraya Dam (Station C13)

Chao Phraya Dam is a large barrage dam, locates on the Chao Phraya River at Chainat Province. The upper part of Chao Phraya Dam, the Chao Phraya River system consist of four principle tributaries; Ping, Wang, Yom and Nan rivers, all originating in the northern highland. The Wang and Yom rivers join the Ping and Nan rivers in the middle basin, respectively. Then, the Ping and Nan rivers join to from the Chao Phraya River at Nakhon Sawan Province, which flows down to the lower basin through the Chao Phraya Dam.

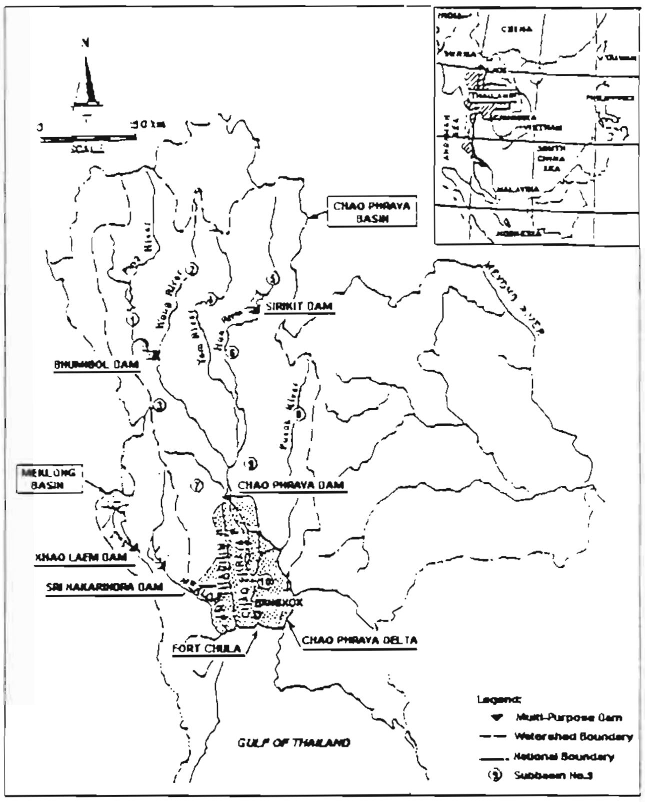


Figure 1. The Chao Phraya River Basin

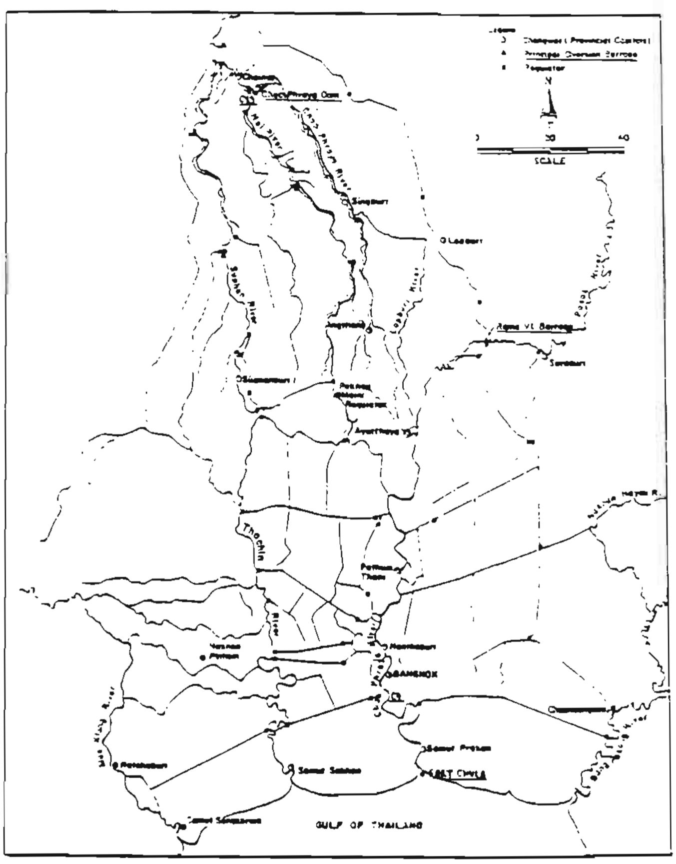


Figure 2. The Chao Phraya Delta

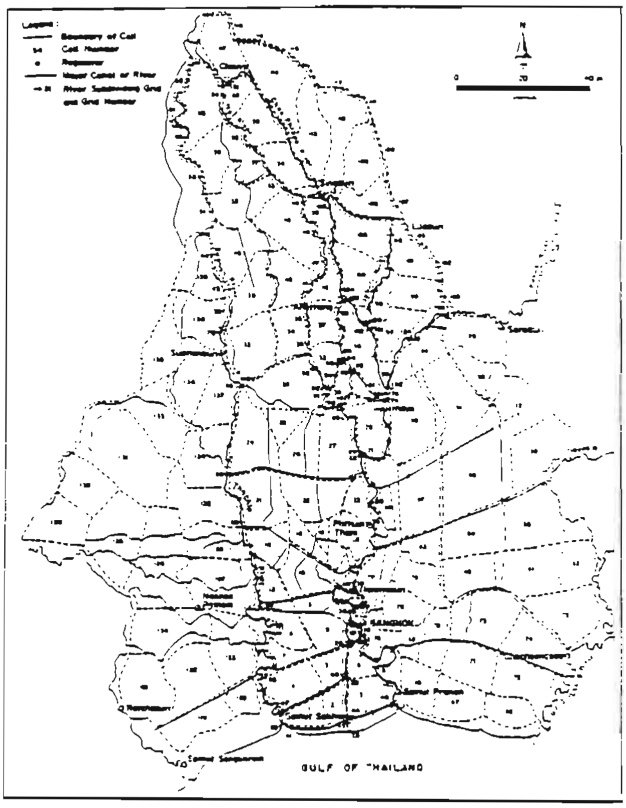


Figure 3. Physical Layout of the River Network Model for the Chao Phraya Delta (Suppataratarn, 1990)

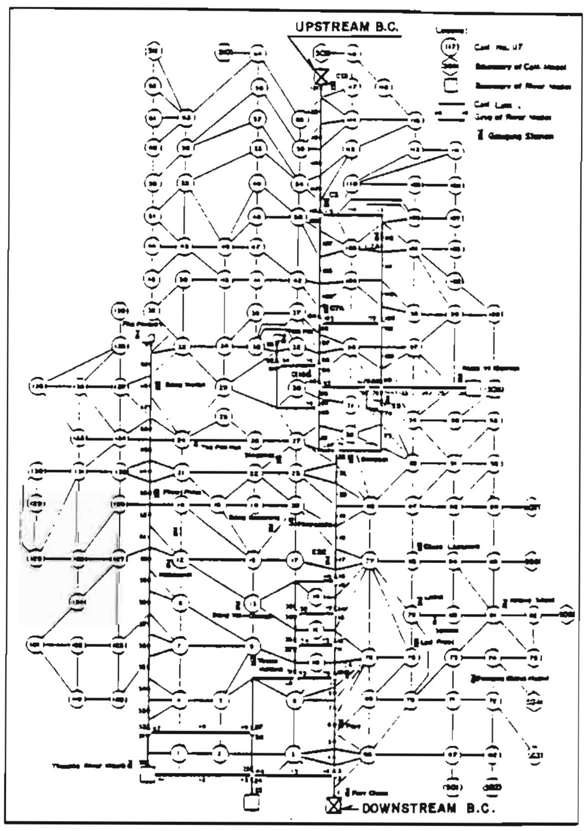


Figure 4. Schematization of the River Network Model for the Chao Phraya Delta (Suppataratarn, 1990)

Due to the complicate characteristics of upstream river system, the hydrograph in the upstream catchment of Chao Phraya dam can be formulated using hydrograph characteristics and hydrological parameters. However, it may not suitable to apply for flood forecasting since the rainfall is unknown in advance. Therefore the simplified model will be studied to use for forecasting.

From the study, it found that the discharge hydrograph at C13 as shown in Figure 5 is related with the volume of waters from upstream catchment area. Therefore the discharge hydrograph forecasting models are formulated by considering simple relationship between previous rainfall data and volume of discharge from reservoirs in the study area & discharge hydrograph at C13.

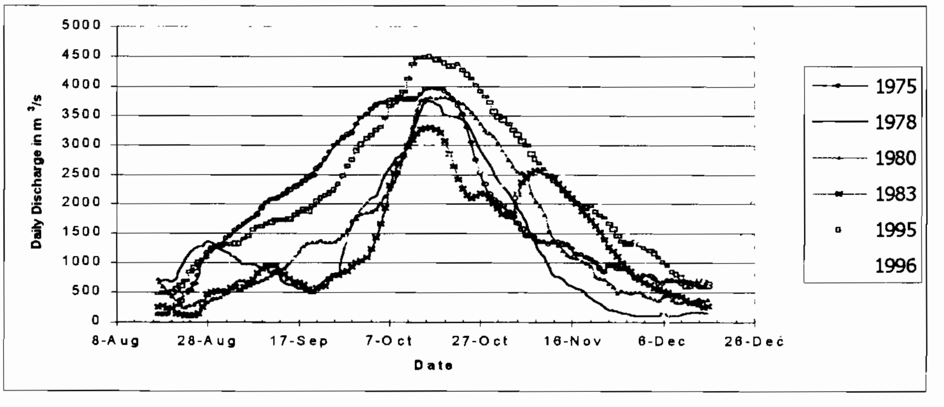


Figure 5. Daily Discharge Hydrograph at C13

The empirical formulae of forecast the upstream discharge hydrograph at the tail of Chao Phraya Dam, station C13 are formulated using multiple regression model by considering relationship between the characteristics of upstream river system and discharge hydrograph at upstream boundary.

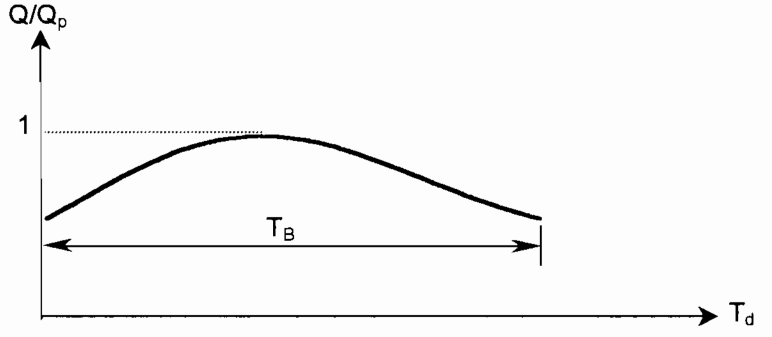
3.3 Required Data

Flooding record that will be used in the study are 9 years which are 1975, 1978, 1980,1983, 1985, 1988, 1994, 1995 and 1996. The peak of all flood were more than 2,500 m^3/s. The required data of each flood events are the following:

Rainfall: Rainfall data that were used in this study are daily rainfall of 76 rainfall stations. The distribution of the selected rainfall stations into various subbasins is done by using Thiessen polygon method.

Reservoir: There are two major dams, which located in the study area; one is Bhumibol Dam and the other is Sirikit Dam. Both of them are storage dams, which are under the operation of Electricity Generating Authority of Thailand. The required data is daily released discharge.

Discharge Hydrograph: The past recorded daily discharges at the tail of Chao Phraya Dam (C13) are used in the study. These data are provided every year by RID in "Thailand Hydrological Yearbook".



Peak Discharge Forecasting

$$Q'_p = -448 + 0.0989R_{f1A} + 0.0823R_{f1B} + 0.0153R_{f2A} + 0.0863R_{f2B} + 0.1360R_{f3A} \quad (1)$$

where

Q'_p = peak discharge forecasted at station C13 (m^3/s)

R_{f1A} = cumulative volume of rainfall and released discharge from reservoirs during 1July to 15 July (mcm)

R_{f1B} = cumulative volume of rainfall and released discharge from reservoirs during 16 July to 31 July (mcm)

R_{f2A} = cumulative volume of rainfall and released discharge from reservoirs during 1 August to 15 August (mcm)

R_{f2B} = cumulative volume of rainfall and released discharge from reservoirs during 16 August to 31 August (mcm)

R_{f3A} = cumulative volume of rainfall and released discharge from reservoirs during 1 September to 15 September (mcm)

Time Base Forecasting

$$T'_B = 960 - 0.0305R_{f1} - 0.0639R_{f2} - 0.0131R_{f3} + 7.8052E\text{-}07(R_{f1})^2 + 1.6657E\text{-}06(R_{f2})^2 + 6.4996E\text{-}07(R_{f3})^2 \quad (2)$$

where

T'_B = time base forecasted of hydrograph at station C13

R_{f1} = cumulative volume of rainfall and released discharge from reservoirs during 1 July to 31 July

R_{f2} = cumulative volume of rainfall and released discharge from reservoirs during 1 August to 31 August

R_{f3} = cumulative volume of rainfall and released discharge from reservoirs during 1 September to 15 September

Normalized Hydrograph

$$Q/Q_p = -15.698(T')^6 + 33.311(T')^5 - 7.391(T')^4 - 25.144(T')^3 + 16.433(T')^2 - 1.5206(T') + 0.4609 \quad (3)$$

where

T' = T_d/T_B

T_d = Time of Discharge Forecasting by the model (d = 1, 2, ..., T_B days)

T_B = Time Base of hydrograph (days)

Q/Q_p = Shape of Hydrograph at day *d*

Figure 6. Non-Dimensional Discharge Hydrograph

3.4 Model formulation

There are three parts for discharge hydrograph forecasting. Those are peak discharge (Q_p), time base of hydrograph (T_B) and shape of hydrograph (Q/Q_p) as shown in Figure 6. The combination of upstream rainfall and released discharge from dam are combined in different ways in order to obtain the best fit of non-dimensional discharge hydrograph. Finally equations (1), (2) and (3) using 15 days interval rainfall and water volume released from Bhumipol and Sirikit dam are found to be the best for discharge hydrograph forecasting at station C13. Details of other equations can be found in THAMMASITTIRONG (2000).

3.5 Result of discharge hydrograph forecasting at C13

By substitute $Q_p^{'}$ from Eq.(1) and $T_B^{'}$ from Eq. (2) into Eq. (3), the forecasted discharge at station C13 can be determined. The comparisons of the forecasted and observed discharge hydrograph at station C13 in 1975, 1978, 1980, 1983 , 1988, 1994, 1995 and 1996 are shown Figure 7. It was found that the accuracy of forecasting is about 90% or ± 300 m^3/s. and it can forecast the date of peak discharge occurring within 9 to 26 days in advance with an error of ± 5 days. This procedure can be used to forecast the maximum discharge at C13 which is useful to assess the possible worse flood condition.

3.6 Forecasting of water level at downstream boundary

The water level fluctuation in the Gulf of Thailand depends on the astronomical factor and physiography of the region, while the meteorological factor is considered to produce only minor effects.

The characteristics of the water level variation at Fort Chula is analyzed from previous records of hourly tides at Fort Chula by using harmonic analysis and are then incorporated into the Harmonic Model to generate the water level fluctuation at any desired period of time to be used as the downstream boundary condition of the River Network Model.

The harmonic model is used to forecast the downstream water level at Fort Chula and the suitable number of constituents and the tidal record length that used as input of the model are determined to obtain the best tidal forecasting in the next 7 days.

3.7 Harmonic model

The relative motion of the earth, moon and sun causes periodic tide producing forces. The period of each constituent can be determined form astronomical studies. The harmonic analysis expresses the tide as a composition of a number of simple harmonic constituents. The tidal variation, denoted by $\eta_r(t)$, at a particular location and time, t, can be expressed as the sum of the effects of various constituents as

$$\eta_r(t) = a_0 + \sum_{i=1}^{N} a_i \sin\left[\frac{2\pi t}{T_i} + \delta_i\right] \quad (4)$$

In Eq. 4, a_0 is the mean sea level, N is the total number of constituents, while a_i, δ_i and T_i are the amplitude, phase and period of the i^{th} constituent. The values of a_0, a_i, δ_i can be determined for each corresponding values of T_i using the information obtained from tidal records at Fort Chula.

Applying known values of a_0, a_i, δ_i, and T_i, the hourly sea level fluctuation at Fort Chula can be generated at any future time. The detailed description of harmonic analysis is given by AIT (1978).

3.8 Result of Analysis

There are three types of methods that used to measure the efficiency of the model, the first is Maximum Error, the second is Mean Absolute Deviation (MAD) and the last is Root Mean Square Error (RMSE).

In this section, the number of constituents and the tidal record length will be determined to obtain the best tidal forecasting in the next 7 days. The number of harmonic constituents varies from 4 to 8 constituents and the record length varies from 7 to 60 days. Figure 8 shows the comparison of root mean square error of harmonic analysis vary with various sets of record length and number of constituents in September 1995.

From the study, it is found that the suitable record length of data is 30 days and the suitable number of constituents is 4 constituents (M_2, S_2, K_1 and O_1 with periods of 12.4206, 12.0000, 23.9346 and 25.1894 hr, respectively). This model can forecast hourly tidal level for next 7 to 30 days ahead with an error of $\pm$0.20-0.30 m

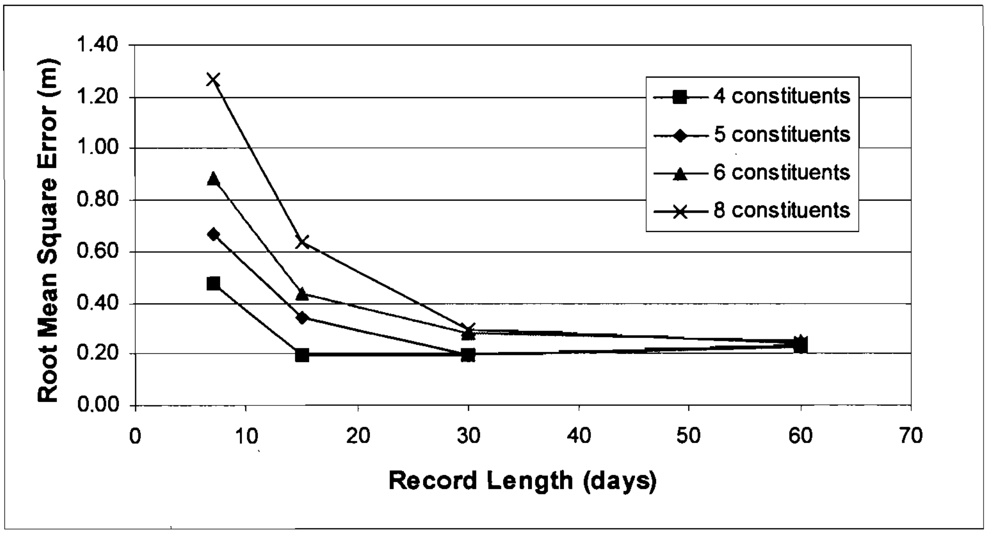


Figure 8. Comparison of the Root Mean Square Error of Harmonic Analysis at Fort Chula in September 1995

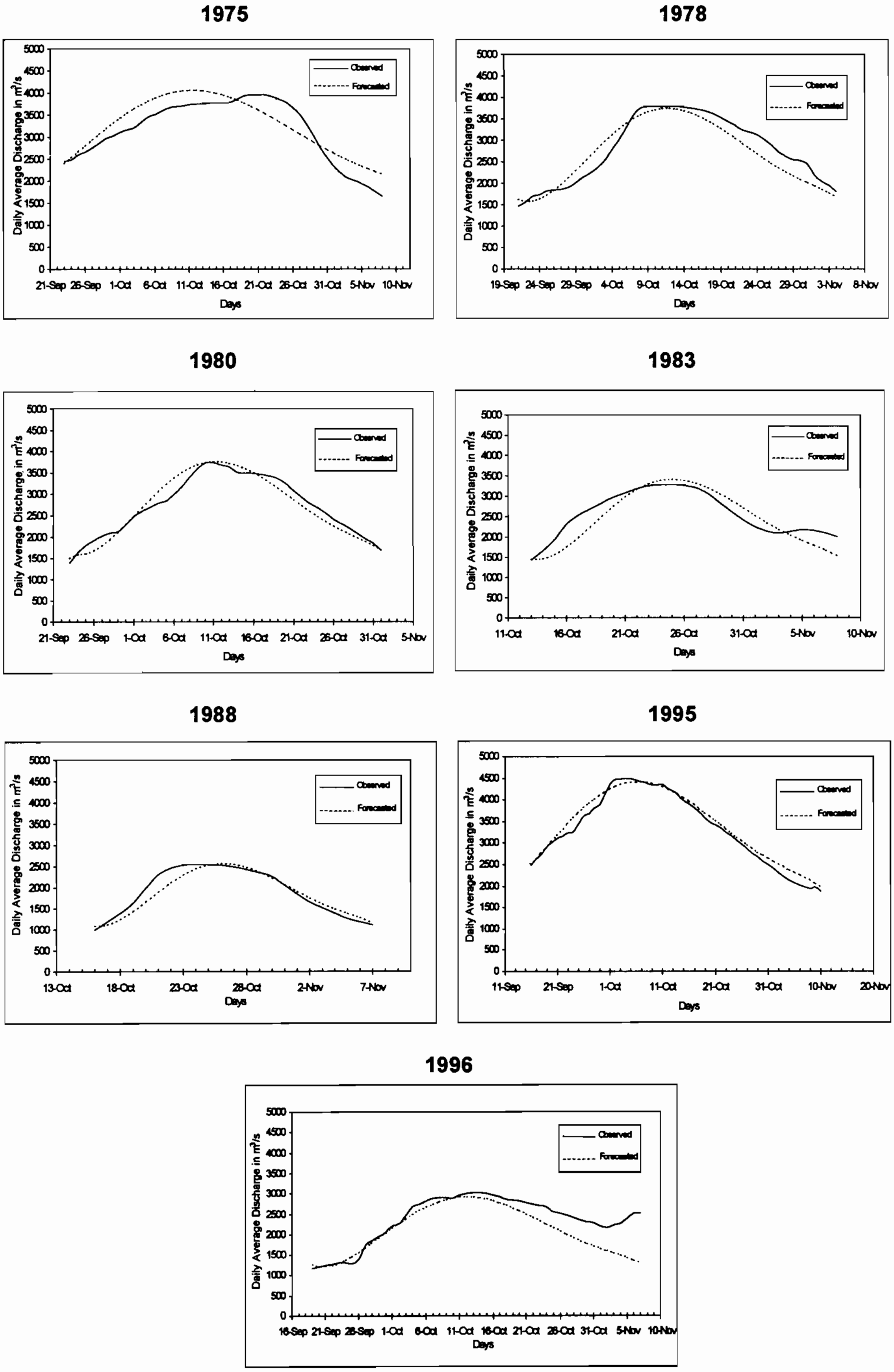


Figure 7. Comparison of Observed and Forecasted Discharge Hydrograph at C13

4 Application and results

Flood Forecasting in the Chao Phraya River Delta

The River Network Model is applied to use for flood forecasting in the Chao Phraya River Delta by input the forecasted upstream and downstream boundary condition.The upstream boundary is the released discharge hydrograph at the tail of Chao Phraya Dam and the downstream boundary is the water level at Fort Chula. The model is used to forecast three severe flood events in 1980, 1983 and 1995.

Result of Forecasting

The results of forecasting will be compared with the observed data. The daily maximum water level hydrographs in three area namely, the river stations, the eastern floodplain stations and the western floodplain stations is used to examine the capability of flood forecasting model. In each flood events, the results of forecasting for 7 days ahead are considered in order to prepare flood protection measures.

Table 2. Root Mean Square Error between the observed and forecasted maximum water level at various stations.

Station Names	Root Mean Square Error (m)		
	1980 Flood	**1983 Flood**	**1995 Flood**
River Stations			
Bangkok Port	0.15	0.14	0.23
Memorial Bridge, C4	0.23	0.10	0.18
RID Pak Kret, C22	0.18	0.15	0.08
Bang Sai	0.12	0.06	0.09
Ayutthaya, S5	0.08	0.06	0.10
Bangban, C15	0.33	0.35	-
Angthong, C7A	0.30	0.27	0.56
Lopburi, L2A	0.12	0.09	0.09
Singburi, C3	0.19	0.33	0.55
West Bank Floodplain Stations			
Bang Yai-Chimpli	0.05	0.08	0.30
Tail of Tawee Wattana	0.04	0.17	0.33
East Bank Floodplain Stations			
Chula Longkorn	0.05	0.04	0.03
Samwa	0.02	0.04	0.05
Ladprao	0.06	0.04	-

The comparison of the observed maximum water level and the forecasted result of some selected station of 1995 flood are showed in Figure 9 and Table 2. shows the root mean square error between the observed water level and the forecasted result at some selected locations in river and floodplain stations of 1980, 1983 and 1995 flood.

Figures 10 to 12 show the comparison of travel time of the observed and forecasted maximum water level from Chao Phraya Dam to different stations along the Chao Phraya River in 1980, 1983 and 1995 Flood respectively. It was found that floods in 1980 and 1995 show overestimate (faster) of travel time while that in 1983 shows underestimate (slower). It is difficult to have precise forecasting of flood travel time using maximum water level since its peak is rather flat for 1-2 weeks as shown in Figure 9.

5 Conclusions

1. The upstream discharge forecasting model could forecast discharge hydrograph at the Tail of Chao Phraya Dam (Station C13) with the error of ± 10% or ± 300 cms. by input the record rainfall and released discharge from reservoirs. The harmonic model could forecast the tidal level at downstream boundary (Fort Chula) with the error ± 20% or ± 0.20-0.30 m. by input the record water level using 30 days record length and 4 constituents. The combined results of both could be used for flood warning and flood control for cites along the Chao Phraya River, especially Bangkok which the full capacity of the water receiving is about 2,500 m^3/s and is high effected from tide at the river mouth.
2. The AIT River Network Model could be used for flood forecasting by input the forecasted upstream and downstream boundary. The formulated model for the Chao Phraya delta area could well forecast the flood flow conditions in 1980, 1983 and 1995 using almost the same parameters except the topographic conditions and gate operations which were based on the actual conditions. The forecasting results are generally good enough. The average error of forecasting is about ± 20 cm. in the river and ± 15 cm. in the flood plain. However, in 1995 flood the error of forecasting is quite high when compared with the 1980 and 1983 flood and should be adjusted for further study.
3. The results of this study could be used for optimizing the effectiveness of flood control measured to protect the city from flooding and minimizing the damage as the following:
    - Forecast the upstream discharge hydrograph at the Tail of Chao Phraya Dam: To estimate peak discharge and date of occurrence and used them for operating the barrage height along the river and operating the reservoirs.
    - Forecast the downstream tidal level at Fort Chula: To estimate tidal effect and avoided the combined effect of tide and river flow from the upstream by controlling the released discharge from reservoirs and operating gates.
    - Flood forecasting: To use the results of water level forecasting for flood warning and flood control in the cites.

References

JAPAN INTERNATIONAL COOPERATION AGENCY. (1999), The Study on Integrated Plan for Flood Mitigation in Chao Phraya River Basin, Summary and Main Report, Royal Irrigation Department Kingdom of Thailand.

Suppataratarn, P. (1990), Modeling of River Networks, Dissertation No. WA 90-2, Asian Institute of Technology, Bangkok, Thailand.

Thammasittirong, S. (2000), Operational Flood Forecasting for Chao Phraya River Basin, Master Thesis No. WM-99-23, Asian Institute of Technology, Bangkok, Thailand.

Tingsanchali, T. (1974), Flood Plain Modeling, Dissertation No.11, Asian Institute of Technology, Bangkok, Thailand.

Tingsanchali, T. and Arbhabhirama, A. (1978), Hydrodynamic Models of the Chao Phraya River System, Research Report No. 81, Asian Institute of Technology, Bangkok, Thailand.

Tingsanchali, T. and Vongvisessomjai, S. (1986), Bangkok Flood Protection, Chao Phraya 2, Appendix AIT-Part, Research Report No. 186 Feasibility Report Conducted for Bangkok Metropolitan Administration, the Kingdom of Thailand.

Zanobetti, D., Lorgere, H., Preissman, A. and Cunge, J.A. (1970), Mekong Delta Mathematical Model Program Construction, Journal of Waterways to Harbours Division, Proceeding of the ASCE, Vol. 96, No. WW2.

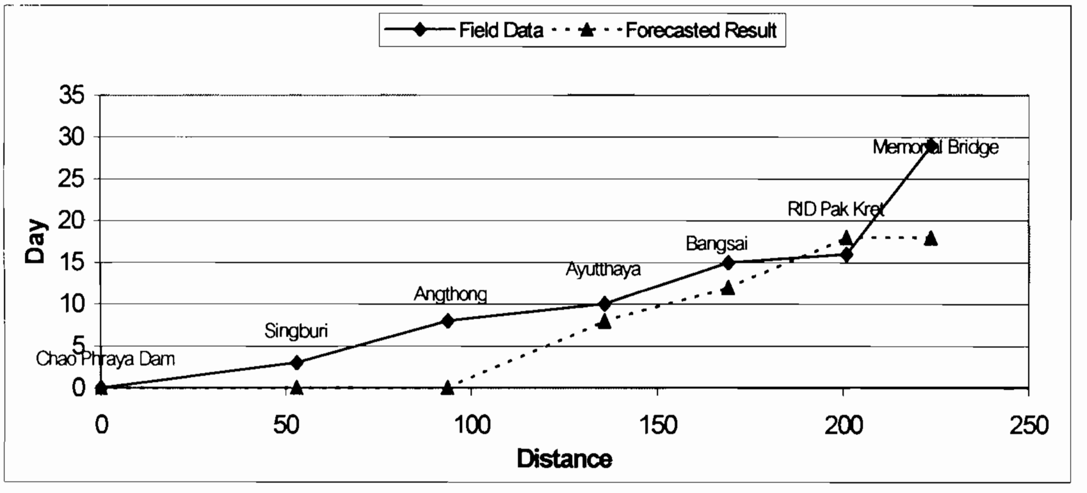


Figure 10. Comparison of Travel Time of Maximum Water Level from Chao Phraya Dam to Different Stations along River in 1980 Flood

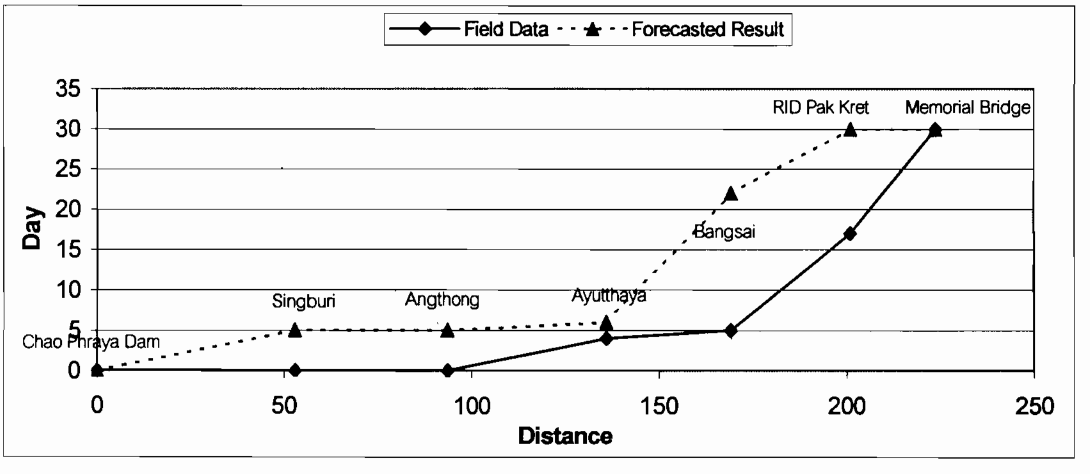


Figure 11. Comparison of Travel Time of Maximum Water Level from Chao Phraya Dam to Different Stations along River in 1983 Flood

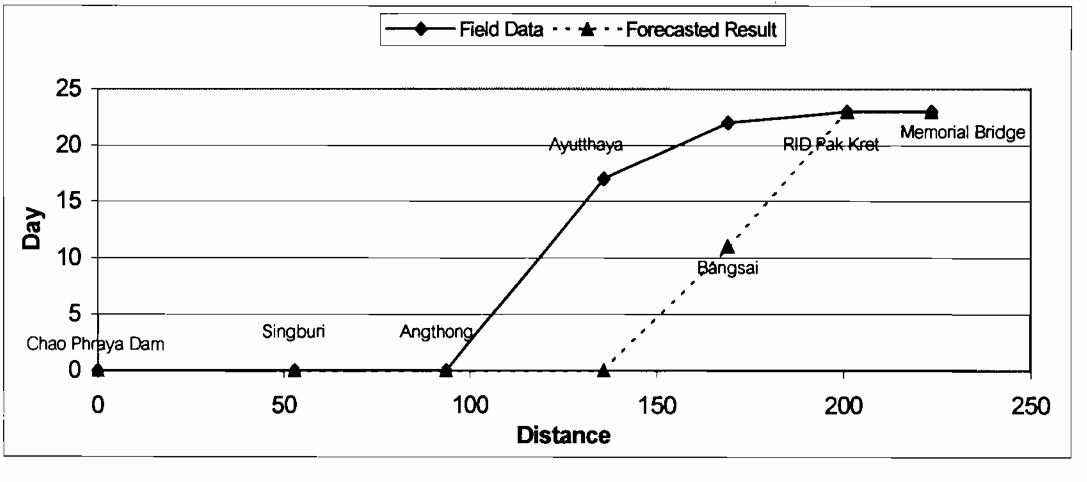


Figure 12. Comparison of Travel Time of Maximum Water Level from Chao Phraya Dam to Different Stations along River in 1995 Flood

Forecasting model of Chao Phraya river flood levels at Bangkok

Tawatchai Tingsanchali[1]

Abstract: *Hourly flood forecasting is necessary in coastal rivers and estuaries for the purposes of flood control and mitigation. The water level is greatly affected by the movement of the tidal waves that continually fluctuate and by the upland flood discharge. The interference of the tidal backwater with the upstream flow of the river increases flood stages that enlarge flood plain inundation areas and increase potential flood damages.*

A neural network model with a back-propagation algorithm (BP) is applied for forecasting hourly water levels in the Chao Phraya River at Bangkok Memorial Bridge (Station C4) which is located about 48 km from the river mouth. The considered river reach is from the river mouth at Fort Chula (km 1) to Bang Sai (km 112). The river flow is mainly influenced by the effects of the upstream discharge at Bang Sai, the tide levels at Fort Chula. The neural network model is calibrated and verified based on the observed hourly flood level data during high stages in 1998. The accuracy of flood forecast is evaluated by using a statistical performance index and is found to be very satisfactory. The results of this study encourage further applications of the neural network model for hourly tidal discharge forecasting in the Chao Phraya river and in other rivers under different topographical and flow characteristics.

1 Introduction

The Chao Phraya River Basin is the largest basin in Thailand. Rising among the northern mountains of the country, it flows through fertile rice fields and the Bangkok Plain, then pours into the Gulf of Thailand. Its catchment basin is about 163,000 km^2, which is almost 1/3 of the area of the whole country. Approximately 50% of the drainage area of the Chao Phraya River Basin lies in the hills and mountains, with the remaining half in the flat alluvial plains of the Central Valley. The average yearly rainfall is about 1,200 mm in the northern region and 1,350 mm in the Central Valley. The peak is in September and 85% of the total flood volume is attained in the months of May to October during the Southwest Monsoon. The months of November through April are dry months with less than 15 % of rain. The basin, particularly the delta in the downstream reach, has been the focus of much agricultural production and urban development. However, recurrent floods have inflicted serious damage to the basin,

[1] Professor, Water Engineering and Management Program,, School of civil engineering, Asian Institute of Technology, P.O. box 4 Klong Luang, Pathum Thani, Thailand 12120,

particularly the delta area. Formulation of a flood forecasting system is therefore necessary in order to cope up with flood damage problems.

Many flat areas with coastal rivers are centers of development, high-density communities and developed economy such as Bangkok, the capital of Thailand. The Bangkok Memorial Bridge is situated about 48 km from the mouth of the Chao Phraya River. In Bangkok, frequent flooding is usually caused by the combined effects of high discharges of the Chao Phraya River from the north, high tides at the river mouth and heavy rainfall in the city. The present study is limited to the flood levels in the tidal reach of the Chao Phraya River from Fort Chula (km 1) near the Chao Phraya river mouth up to Bang Sai gaging station (km 112) (see Figure 1).

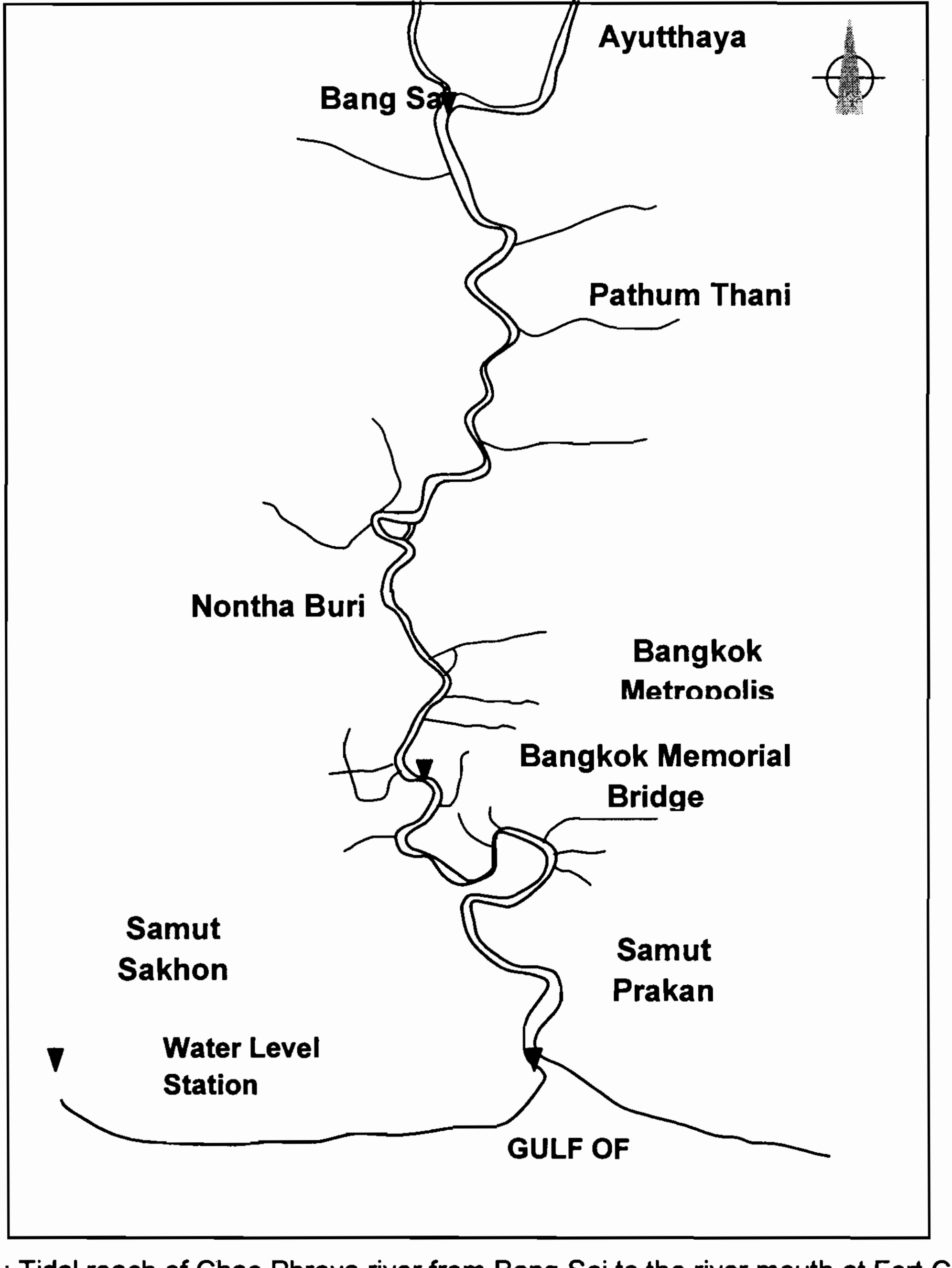


Figure 1: Tidal reach of Chao Phraya river from Bang Sai to the river mouth at Fort Chula

Hourly streamflow forecasting in tidal rivers has been carried out using various models such as the use of unsteady flow models by Tingsanchali (1982 and 1996) and JICA(1988 and 1998). Recently, neural networks have been successfully applied to hydrology for rainfall forecasting in space and time (French et al., 1992) and for river flow prediction (Karunanithi et al., 1994 and Tingsanchali and Gautam, 2000). A well known method of supervised learning of neural networks called Back-Propagation (BP) (Rumelhart et al., 1986 and 1988) has been found effective in flood forecasting problems (Zhu and Fujita, 1994; Tingsanchali and Gautam, 2000). The main objective of this study is to develop a neural network model for forecasting hourly flood water levels of the Chao Phraya River at Bangkok Memorial Bridge.

2 Neural network model structure

Artificial Neural Networks (ANNs) are being used increasingly to predict and forecast water resources variables. Based on the consideration of the hydrological processes (Dooge, 1974) divides hydrological models into three categories- physically based distributed models, lumped conceptual models and black box models. Neural Network models which inherently involves mapping of input and output vectors can be considered as a black box model. Such black box models can be considered of little significance in enhancing the understanding of hydrological and hydraulic processes, nevertheless, in operational hydrology their usefulness can be paramount. The excessive requirement of field data in the case of physically based distributed models and the large number of parameters and subsequent difficulty in calibration in the case of lumped conceptual models render such models less suitable in operational flood forecasting use. This is the reason why simple black box or storage based models found to be used extensively as flood forecast models.

Several algorithms of neural network model exist. However, back propagation which belongs to supervised learning algorithm that performs a gradient descent search in weights space using generalized delta rule is often reported in applications (Minn and Halls, 1986). Back Propagation (BP) networks were developed by Rumelhart and McClelland (1986 and 1988) for learning associations between input and output patterns using more than a single layer perception, which overcomes some limitations of a single-layer perception (no hidden layer). A three layer feed forward neural network model is shown in Figure 2. Any BP network is based on a supervised learning technique that compares the actual output from output units to the target or specified output and then readjust the weights backward in the network. The same input is presented to the network in the next iteration, so the actual output will be closer to the target output.

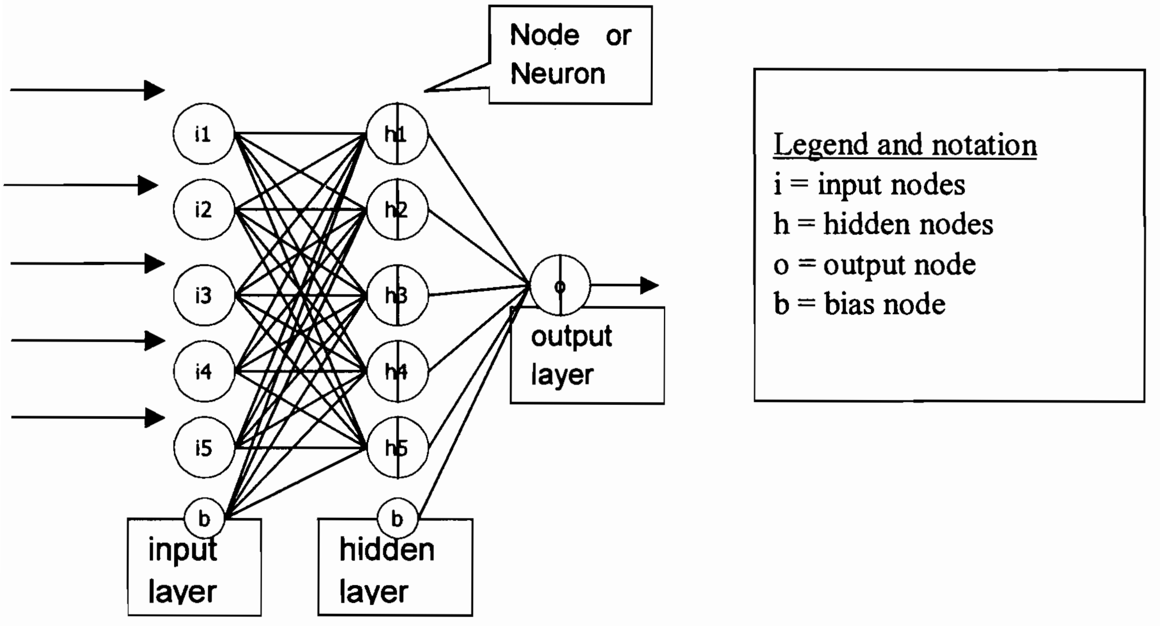


Figure 2 A typical three layer neural network model

3 General Structure of Neuron

A node or neuron of a hidden layer is characterized by two functional activities, namely,

- Activation in which all the weighted inputs are summed up yielding what is known as activation of the neuron
- Transfer in which the activation of the neuron is transferred into outputs with the aid of appropriate type of functions such as logistics, linear and step functions.

One of the basic requirements of the BP training is that the transfer function be continuous and differentiable. The sigmoid logistic non-linear function which fulfills the above requirement and which has a simple derivative making the implementation of algorithm easier (Minn and Halls, 1996) is often used. The sigmoid function has the value ranging between 0 to 1. The logistic function, which is a commonly used transfer function in NN, transforms the weighted input into an output. The characteristic of the sigmoid function can be graphically illustrated in Figure 3.

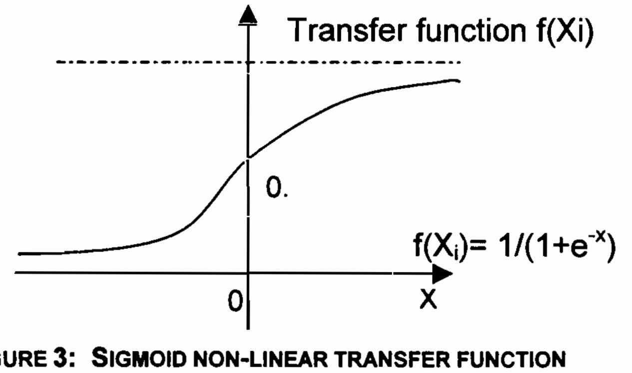


FIGURE 3: SIGMOID NON-LINEAR TRANSFER FUNCTION

The standard back propagation training algorithm is as followed

1. Initialize all weights and bias factors to small random values.
2. Forward pass: Present input vector $(I_1, I_{2,...,} I_{no})$ and specify the desired output $(t_1, t_{2,...,} t_{n1})$
3. For layer m = 1,2,...,l:

According to Figure 4, we can compute $N_{j,m}$,the activation of neuron j in layer m

a.

$$N_{j,m} = \sum_{i=1}^{n_{m-1}} W_{ji,m} \cdot O_{i,m-1} + \theta_{j,m} \tag{1}$$

where $O_{i,0} = I_i$

t_j = target value of neuron j in output layer

$O_{j,m}$ = output of neuron j in layer m

$\theta_{j,m}$ = bias value for neuron j in layer m

$W_{ji,m}$ = synaptic weight between node j in layer m and node i in layer m-1

n_m = number of neuron in layer m

b. Compute the output $O_{j,m}$ of the j^{th} unit in the layer m

$$O_{j,m} = \frac{1}{1+e^{-N_{j,m}}}; j = 1,2,...,n_m \tag{2}$$

4. Compute the final output $(O_{1,1}, O_{2,1}, ..., O_{n1,1})$ and compared with the desired output $(t_1, t_{2,...} t_{n1})$. If the difference is acceptable, the process is terminated and the system has learned. Otherwise, continue to next step. When the number of epochs is reached while the difference is not acceptable, the convergence is not attained. One should try with a new set of initial values, or even modify the structure of the network.

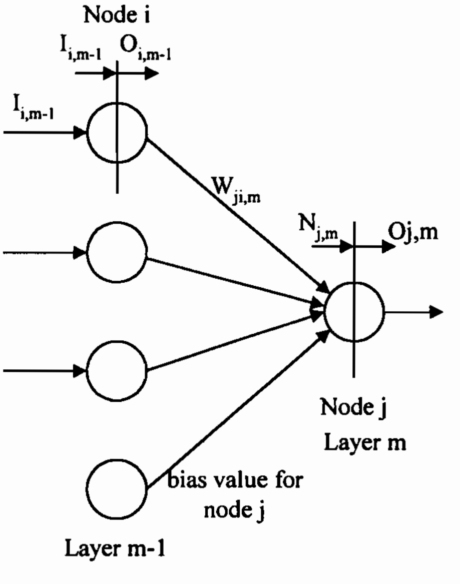


Figure 4 Transfer of inputs of layer m-1 to a nodal output of layer m

5. Backpass: For layer m = l, l-1, l-2, ..., 1

Let $\delta_{j,m}$ = the value of δ for neuron j in layer m

a. We can compute the following

For output layer m $\delta_{j,m} = O_{j,m}(1-O_{j,m})(t_j - O_{j,m});$ (3a)

For hidden layer m $\delta_{j,m} = O_{j,m}(1 - O_{j,m})\sum_{k=1}^{n_{m+1}} W_{kj,m+1}\delta_{k,m+1}$ (3b)

b. Compute the weight increments:

$$\Delta W_{ji,m}(n+1) = \eta \cdot \delta_{j,m} \cdot O_{i,m+1} + \alpha \cdot \Delta W_{ji,m}(n) \quad (4)$$

where η = learning parameter

α = momentum constant

$\Delta W_{ji,m}(n)$ = weight change between node j in layer m and node i at n iteration

$\Delta W_{ji,m}(n+1)$ = weight change between node j in layer m and node i at n+1iteration

$O_{i,m-1}$ = $I_{i,m}$

n = number of iteration (n = 1,2,3,...)

c. Compute the new values of the weights:

$$W_{ji,m}(n+1) = W_{ji,m}(n) + \Delta W_{ji,m}(n+1) \quad (5)$$

where

$W_{ji,m}(n)$ = weight value between node j in layer m and node i at n iteration

$W_{ji,m}(n+1)$= weight value between node j in layer m and node i at n+1 iteration

6. Go to step 2.

In a neural network architecture, the output node represents the water levels and discharges to be forecasted. The hidden nodes, which are the internal part of the system, enable to learn the non-linear relationship between the output and input. The parameters on which the forecast value depends with some function represent the input nodes. The training time is directly dependent on the size of the network, the larger the network size, the longer the training time. The training process depends on number of input units, number of hidden units and convergence criteria. To make the problem simple, an architecture with three layers is used, i.e, input layer, hidden layer and output layer. The small number of hidden nodes may not able to train the network and a very large number of hidden nodes pose difficulty to the training but may also weaken the effective learning strength of the networks. Therefore the determination of the hidden layers and nodes is made by the trial and error process depending on the condition of the problem. The basic way in which back propagation is trained is that a set of input and output patterns is given in the training phase of back propagation. The system transfers the input to output based on initially randomly selected weights using the defined activation function. The system output is then compared with training set output and the difference between these two is what to be minimized in the so called "training phase" which is identical to "calibration" of the conceptual models.

The weights leading into the output node and weights leading to the hidden nodes are adjusted backward so that the correction in error is propagated backward in an iterative process until the system converges after a predefined acceptable limit. The network is then said to be trained.

4 Model application

The input data of the BPNN model are the observed hourly upstream water levels at Bang Sai, the observed hourly downstream water levels at Fort Chula. The hourly measured water level data at Station C4 were used as the target water levels in the BPNN model calibration and verification for forecasting the water levels at this station. During high flood periods, it was found that the effect of local inflows to the river is very small compared to the river discharges and hence can be neglected.

By considering the data in 1998, the calibration (training) and verification (testing) of the model is carried out for the flood level data at Station C4. The highest flood water level in October 1998 is used in the model training to assure that the calibrated parameters of the model can really represent the highest flow condition. The flood data in August 1998 is used in the model testing

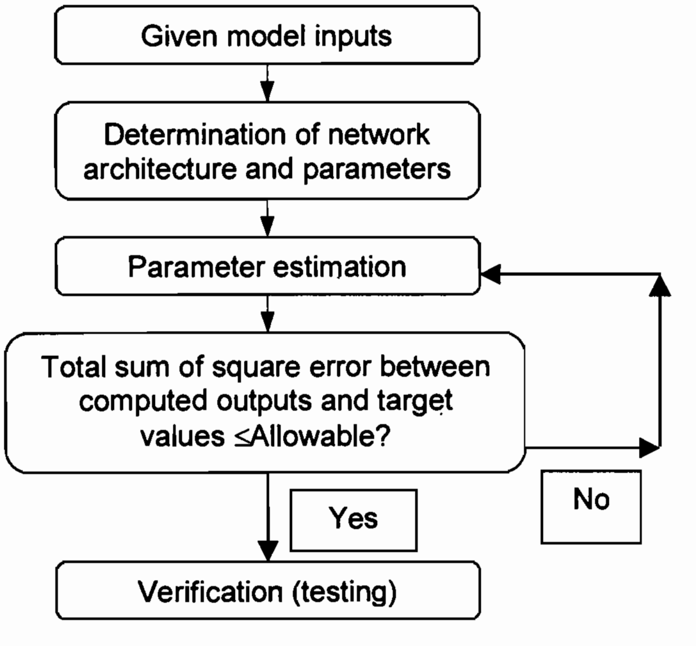


Figure 5 Steps in training and testing NN model

The data used consist of two sets: one for training and the other for testing the model.. As the BPNN Model uses Logistic Activation Function on which its output lies in the interval [0,1] (Figure 3) , the original data is linearly transformed to the interval [0.05,0.95] before inputting to the network. Interval [0.05,0.95] is chosen instead of interval [0,1] because Logistic Activation Function is an asymptotic function, so it neither reaches the value 0 nor 1.

4.1 Input data processing

Let a and A are the minimum and maximum values of the data series respectively; then an actual value X_t is transformed to the interval [0.05,0.95] using the formula:

$$X_t' = \frac{0.9(X_t - a)}{A - a} + 0.05 \qquad (6)$$

where X_t is the actual value, a is the minimum value, A is the maximum value and X_t' is the transform value

4.2 Output data processing

Once the most suitable network is found, the output results from the neural network are transformed back into their original value by the equation:

$$X_t = \frac{(A - a)(X_t' - 0.05)}{0.9} + a \qquad (7)$$

The model is trained starting with some small randomly generated weights. After the predefined target error of 0.05 for 90% of all patterns is reached, the training process is stopped and the weights are saved. These weights and the same NN architecture of the model are utilized in the verification (testing) phase. The momentum parameter β was fixed at 0.5 while the learning parameter η was varied from 0.2 to 0.03 at the final stage.

5 Results and discussions

Two network architectures were tried. One is a three layer network with five input nodes, five hidden nodes and one output node. Another is with ten input nodes, five hidden nodes and one output node. It is found that the latter network yields a better accuracy than the first one and the computation time is within acceptable limit. Therefore the second network (10-5-1) as shown in Figure 6 is selected in this study for forecasting hourly water levels and discharges and is also shown in Table 1.

TABLE 1 FUNCTIONAL RELATIONSHIPS FOR ONE-HOUR AHEAD FORECASTING HOURLY WATER LEVELS AND DISCHARGES

Case	Functional Relationship	Network Architecture
Water level	W'(t+1)=f[B(t),B(t-1),F(t),F(t-1),U(t),U(t-1),D(t),D(t-1),W(t),W(t-1)]	10-5-1
Discharge	Q'(t+1)=f[B(t),B(t-1),F(t),F(t-1),U(t),U(t-1),D(t),D(t-1),Q(t),Q(t-1)]	10-5-1

5.1 Water level and discharge forecasting by the BPNN model

The formulation of hourly water level or discharge forecasting is simple as the output expressed is functionally dependent on the hourly observed input data which are the observed hourly water levels at Bangsai, Bangkok Memorial Bridge (Station C4) and Fort Chula.

The BPNN model was used for water level and discharge forecasting at Station C4. For one-hour ahead, the model parameters are set for training procedures for various study cases. The target error of 0.05 is set for all study cases. The value of learning parameter is equal to 0.02 while the momentum rate is equal to 0.95.

Model Performance

The NN model performance was evaluated both qualitatively by the visual comparison of the simulated and observed hydrographs and quantitatively using the performance statistical index namely the Model Efficiency (EI) (Nash and Sutcliffe, 1970). The model efficiency is given by,

$$EI = \frac{SR}{ST} \tag{8}$$

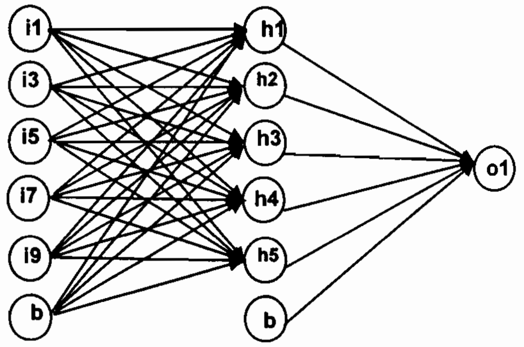
$$SR = ST - SE \tag{9}$$

$$ST = \sum_{i=1}^{N} (Q_i - \overline{Q})^2 \tag{10}$$

$$SE = \sum_{i=1}^{N} (Q_i - F_i)^2 \tag{11}$$

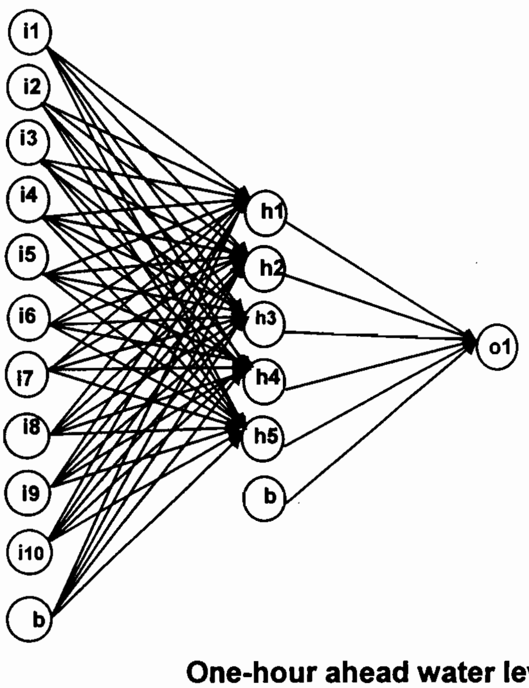
where, SR is the variation explained by the model, ST is the total variation of the discharge in training stage, SE is the sum of square of the differences between the forecasted data F and the observed data Q, subscript i refers to time i, $\overline{Q}$ is the mean value of observed value, $\overline{Q} = \frac{1}{N}\sum_{i=1}^{N} Q_i$, N is the number of data points.

By varying the time sets of the input nodes of the BPNN model for training the networks, the present and past one-hour data give more accuracy than only the present input data. The differences of EI values between two cases are significant therefore the present and past one-hour data were defined as the input nodes. The results of forecasting hourly water levels and discharges are shown in Figure 7. The past data of more than one hour are not used as the additional input node in this study because the increase in the computational time and the efficiency index is not significant. The efficiency index is found to range from 95.1 to 98.9 for model training and testing. The model performance is found to be satisfactory.



One-hour ahead water level forecasting BPNN(5-5-1)

Legend and Notation
i1= B(t)
i2= B(t-1)
i3= F(t)
i4= F(t-1)
i5= U(t)
i6= U(t-1)
i7= D(t)
i8= D(t-1)
i9= W(t)
i10=W(t-1)
i11=Q(t)
i12=Q(t-1)
o1=W'(t+1)
or =Q'(t+1)
i= input node
b= bias nodes
h= hidden nodes
o= output nodes
B= water level at Bang Sai
F= water level at Fort Chula
U= upstream local inflow
D= downstream local inflow
W=water level at Station C4
W'=forecasted water level at Station C4
Q= observed discharge at Station C4
Q'=forecasted discharge at Station C4
t= 1 hour time step, present time t



One-hour ahead water level forecasting BPNN(10-5-1)

FIGURE 6 NETWORK ARCHITECTURES FOR FORECASTING OF HOURLY FLOOD WATER LEVELS OR DISCHARGES

Tingsanchali,T. and Gautam, M.R. 2000. Application of Tank, NAM, ARMA and Neural network models to flood forecasting. *Journal of Hydrological Processes*, John Wiley and Sons Publisher, U.K. 26 pages. (in press)

Zhu, M.L.and Fujita, M. 1994. Comparison between fuzzy reasoning and neural networks methods to forecast runoff discharge. *Journal of Hydroscience and Hydraulic Engineering*, Vol.12, No. 2, 131-141.

Flood management in Chao Phraya River basin

Siripong Hungspreug, Wirat Khao-uppatum, Suwit Thanopanuwat[1]

Abstract: *The Chao Phraya Rivers and her tributaries, have played a major role in the nation's history from the periods of Sukhothai to Ayutthaya and Bangkok at present. Their existence was critical to the growth of the Kingdom of Thailand and fostered the development of major cities, including the capital city. In Ayutthaya Period, Thai people wisely used a long inundation during flood time in the Delta as the natural barriers against her country's enemy. The floodplains of these rivers also provide some of the most productive farmland and continually contribute to the economic growth of the country. The high level of investment in the infrastructure for flood reduction were constructed to minimize the annual risk. But naturally, in the Chao Phraya Delta, flood has continuously been experienced every year due to hydrometeorological and geographical condition.*

The flood of 1995 demonstrated that people and their properties in the floodplains of Chao Phraya River basin were at risk. Excessive rainfall and related runoff inundated nearly 15,000 sq.km. of floodplains and caused major damages to agricultural land and communities along the river. The inundation nearly exceeded 16 billion cu.m., dike breaching and over-topping occurred at almost every reach of the rivers. However, the extensive inundation considerably relieved the urban areas located further downstream, like Bangkok and its satellites, from a serious disaster. Overall damages were extensive with about 72 billion Baht and a large amount of unquantifiable impacts on the health and well-being of the population. The Royal Irrigation Department thus initiated a formulation of an integrated strategy plan of flood mitigation in the Chao Phraya River Basin in an inter-agency cooperation manner during December 1996 and August 1999. The plan was formulated with structural and nonstructural measures covering the use of the floodplain by preservation of present natural retarding effect ; assurance of safety level of major cities, enhancement of safety level in agricultural area, and an institutional arrangement for implementation of measures.

[1] Siripong Hungspreug is Director of Office of Budget Programming and Project Planning; Wirat Khao-uppatham is Director of office of Hydrology and Water Management; and Suwit Thanopanuwat is an expert on Water Resources Development Planning, all of Thailand's Royal Irrigation Department.

1 Flood management in Chao Phraya river basin

1.1 Chao Phraya river basin

The Chao Phraya River Basin as shown in Figure 1 is Thailand's largest and most important geographical unit in terms of land and water resources development. It is located in the north and central regions of the country and occupies about 35 percent of the country's total area. About 20 million people (30 percent of the population) reside in the basin in which more than 70 percent are farmers. Rice is the main crop in both irrigated and rainfed areas of the basin.

Average annual rainfall in the basin ranges from 1,000 to 1,400 mm. The climate is dominated by the Southwest monsoon, which occurs between May and October. About 90 percent of annual rainfall occurs during this period, causing heavy floods. The scarcity of rain between November and April makes agricultural conditions unfavourable. On average, the total volume of available water is estimated at 31,300 million cu.m. per year.

1.2 Characteristics of the basin's upper and lower reaches

The river basin can be characterized geographically into upper and lower basins. The upper basin is mountainous, with 40 percent forest cover and 41 percent cultivated land. Traditionally, agriculture has been practiced in the river valleys. Shifting cultivation has caused soil degradation and erosion in some areas and has changed the hydrological regime. The lower basin (the river's delta) is the floodplain and is well suited to rice cultivation. After irrigation water became available in the 1970s, farmers in the lower basin switched from growing floating rice to cultivating higher-yielding varieties.

Among the basin's major infrastructure, the Chao Phraya barrage irrigates an area of about 1.2 million ha in the lower part of the river basin to increase wet season rice production. The multipurpose Bhumibol and Sirikit dams are located upstream of the barrage. Their construction enabled provision of water to 400,000 ha of dry-season cropping in the lower part of the river basin. Hydropower from these dams has become a major source of electrical energy for Thailand.

Flood protection is important in the lower part of the river basin because of the risk of large-scale damage to public and private property. Dikes were constructed downstream of the Chao Phraya barrage to prevent the inundation of cultivated land from small flood. Residential area were also protected by dikes and polder system at a higher safety level, together with a number of pumping stations, especially in the downstream-most of the river, Bangkok and vicinities.

The Chao Phraya River is the principal source of water for domestic and industrial uses in the basin. The major user is the Bangkok Metropolitan Water Work Authority (MWWA), with an annual requirement of about 1,100 million m^3. This amount has been supplemented with groundwater. The MWWA intends to terminate the use of groundwater and replace it with transferring water from the Mea Klong basin. Presently, less than 10 percent of water use in Bangkok comes from groundwater.

2 Floodplain management

From history of the country, the capital of Thailand in each era is always located in the floodplain of Chao Phraya River Basin in the bank of the river and its tributary. Thai people in the former time were accustomed with river flood and developed the way of living in this vast floodplain and had wisely used a long inundation during flood time in the Delta as the natural weapons against her country's enemy. Until recently, from 1970, when a modern water resources development scheme were constructed and significantly improve the living condition, enhance economic activities through better regulation of water and reduction of flood in the delta.

Though efforts have been made to mitigate flood damage in the Chao Phraya River Basin through the construction of dams, reservoirs, dikes and pump stations, flooding problem still persists due to the increase of flood discharge as a result of deforestation, expansion of farmlands and urban areas, etc., in line with the economic growth.

The flood damage potential is increasing due to rapid urbanization and land development in downstream areas, particularly, the Bangkok metropolitan area and other municipalities along the Chao Phraya River. A disastrous flood occurred in October 1995, resulting in the extensive damage to properties and loss of human lives.

2.1 Causes of floods

The causes of floods, in general, may come from two main sources: nature and human intervention, as follows:

2.1.1 Natural causes

The main natural causes are overbank flow of the rivers, heavy rainfalls and tides.

Overbank flow : Floods in Thailand are also generally caused by overflow from the rivers, which results in widespread flooding. During the peak flood in 1995, the flow in the Chao Phraya River passing through Bangkok metropolis to the Gulf of Thailand was much higher than the capacity of the Chao Phraya River and caused severe flooding in the Chao Phraya Delta and Bangkok metropolis.

Heavy rainfall : Heavy local rainfall is usually the main cause of inland floods, as it often exceeds the drainage capacity of the local areas or streams. For example, several tropical cyclones passed through Thailand and caused heavy rains in 1995, including the depression storm "Lois".

Influence of tides : Tidal fluctuation at the river mouth has often affected the drainage of river floods into the Gulf of Thailand. This effect prolongs the period of flooding, especially in the coastal provinces of the Chao Phraya River basin, Samut Prakan, Bangkok metropolis and Samut Sakhon.

2.1.2 Man-made causes

The most common man-made causes in Thailand are deforestation, uncoordinated urban development, over-abstraction of groundwater, and destruction of flood embankments.

Deforestation : This is the most significant man-made cause that increases flood peak from rainfall and reduces the lag time between rainfall and run-off. In a deforested area, surface run-off and peak flood discharge tend to be higher, since there are no trees to obstruct the flow. Moreover, the rapid run-off will increase erosion of soil surface particles, resulting in higher turbidity and more serious sedimentation. This results in reducing function of the river and water sources.

Uncoordinated development : In urban development, most of the surface areas are covered with houses, roads or paved surface having lower water absorption and rainfall tends to convert almost immediately into run-off flowing into the drainage system. This phenomenon is in contrast to that in rural areas, where rainfall can be retained by vegetation cover and absorbed by soil. Many kind of development in delta area have related to creating higher flood risk for example protection of urban and high-value farm will reduce space of flood inundation accordingly such as orchards, aquaculture, etc. Construction of roads and railways will also obstruct flow especially for inland flow. Housing construction in public areas along river or canal banks is another example of action that reduces the stream cross-section and thus its flow capacity. Uncontrolled dumping of sewage and garbage may obstruct the flow and cause siltation in the drainage streams. As a consequence, uncoordinated development in many parts of the country has resulted in decrease in drainage efficiency both inland and river courses.

Destruction of flood embankments : There have been cases in which inhabitants living in areas outside the protection of flood embankments destroyed those embankments in the hope of reducing the flood-water level in their areas. Protection of these embankments was difficult, although there are government agencies responsible for the maintenance and monitoring of the embankments. These events resulted in abrupt flooding of the protected residential areas.

Over-abstraction of groundwater : Pumping of groundwater is one of the main causes for land subsidence, which has resulted in deeper flooding and longer waterlogging. The government agencies concerned are trying to limit the pumping of groundwater and this effort has been emphasized in the Bangkok metropolitan Area.

2.2 An overview of past floods and developments

2.2.1 Past flood damage

Floods continue to cause annual damage in the Chao Phraya River Basin, as summarized in table below. It may be noted that the flood damage was estimated based mainly on the value of property damage and did not include the cost of lost production and other forms of economic loss. The trend towards higher flood damage reflects a number of factors, including the higher value of property and the ongoing development of property more vulnerable to floods.

PAST FLOOD DAMAGE IN THE CHAO PHRAYA RIVER BASIN (MILLION OF BAHT)

Year	1978	1979	1980	1981	1982	1983
Damage	21.0	3.2	1,549	314.3	224.1	1,104

Year	1984	1985	1986	1987	1988	1998
Damage	323.3	350.3	628.4	832.6	21.0	3.2

Year	1990	1991	1992	1993	1994	1995
Damage	1,549	314.3	224.1	2,181.6	45.9	11,858

2.2.2 Major change in the flooding regime

Changes in the flooding regime in the Chao Phraya River basin reflect not only changes in each factor causing flood but also in the interaction among them. While riverine flooding caused by the overbank flow of the main river discharge remains an important cause for major flooding and flood damage, the coinciding of floodwaves from the tributaries, urban floods and high tides appear to have become more frequent and are thus an increasingly threatening factor. In order to give an overall picture of the flooding regime in the lower Chao Phraya River basin, the most important causes of flooding in the three most severe floods during the past 60 years are briefly summarized in following table.

As Chao Phraya delta is the highest economic growth area of the country, the high level of investment in the infrastructure, with the extensive development of natural resources over the years in the basin, have led to a complex change in the flooding regime. This change is also effected by the complexity in water resources management. Apart from the construction of various storage reservoirs in the upper part of the basin, the following measures have been implemented:

Main features of the major floods in the lower Chao Phraya River basin

		1942	1983	1995
Human Intervention	Forest cover[a]	166,000 km^2	106,000 km^2	92,000 km^2
	Area denuded	--	60,000 km^2	74,000 km^2
	Reservoir capacity	Nil	23,000 million m^3	24,000 million m^3
	Flood protection	2,230 km^2	12,900 km^2	14,400 km^2
	Urban area[b]	51 km^2	389 km^2	528 km^2
Natural Causes	Rainfall upstream	Exceptionally Heavy	Unusually heavy (Sep.to Nov.)	Unusually heavy to Exceptionally heavy
	Rainfall in Bangkok	Normal	Unusually heavy (Aug.to Nov.)	Normal to unusually Heavy
	Tides	Normal spring tide with additional seasonal effects	Normal spring tide with additional seasonal effects	Normal spring tide with additional seasonal effects

[a] Northern and central regions of Thailand.
[b] Bangkok area only.

2.2.3 Summary of past development

Overbank flow protection scheme : The dykes were constructed along both sides of the Chao Phraya River banks from Nakhon Sawan down in to Bangkok under the supervision of the Royal Irrigation Department. Nowadays, these dykes of 300 km length are used as highways. The regulators were installed at the confluence of the tributaries to control backwater flow from the Chao Phraya River. However, the dykes are incomplete in some part, such as on the western side of Bangkok for which the Bangsai-Bangkok Highway is being temporarily used as a part of the dykes.

Flood control schemes for major municipal areas : There are seven major municipalities situated along the Chao Phraya River: Nakhon Sawan, Chai Nat, Singha Buri, Ang Thong, Ayutthaya, Patum Thani and Nonthaburi. The Public Works Department (PWD) plans to provide flood protection to these cities by polder systems, which consist of retaining walls, embankments, regulators and pumping stations.

Flood control schemes for Bangkok and vicinity : The master plan for flood protection in this area was launched in 1984. The first scheme was finished in 1995. According to that scheme, 1,500 km^2 will be protected from floods. The scheme consists of several initiatives of His Majesty the King, such as a 74-km dyke, starting from the Rangsit Canal down toward the sea at Samut Prakan, and 20 pumping stations along the Chao Phraya River with a total of 30 million m^3/day. The construction of regulators and drainage systems in Nonthaburi and Samut Prakan is part of the scheme. According to the work plan of the Bangkok Metropolitan Administration (BMA), a permanent concrete floodwall with a total length of 80 km along the

Chao Phraya River will be constructed within the next five years together with increasing the drainage capacity up to 65 million m^3/day.

Flood control schemes of agricultural area : The Royal Irrigation Department (RID) has established a flood protection and drainage for the agricultural area in the lowor Chao Phraya basin. Dykes have been constructed along the Bang Pakong River in the east, Tha Chin River in the west and also the Chao Phraya River, to provide flood protection to an agricultural area of 5,000 km^2. More than 50 regulators and pumping station with a capacity of 50 million m^3/day were constructed.

2.2.4 Evaluation of the current flood control situation

An evaluation of the current situation of flood control in the basin is summarized below:

The upstream reservoirs have markedly helped regulate the flow regime. For a flood of the magnitude of that of 1995, corresponding to a 25-year flood, the flood peak at Nakhon Sawan, will be reduced by 1,000 m^3/s, or over 20 per cent of the natural flood. It may be noted that the capacity of these reservoirs in flow regulation is also important in reducing the volume of the floodwaves travelling down to the Bangkok region during the critical period.

The development and protection of large areas in the lower Chao Phraya basin, especially for agriculture and urban development, have greatly reduced the natural capacity of the basin in dispersing and reducing the floodwaves when passing through this area.

The confinement of the river to its main channel in Bangkok, although not complete, has led to an increase in the flood-water level resulting from an increase in the outflow to the sea. This fact has consequently required an increase in the level of protection against the river floods.

3 The 1995 Flood

The depression storm "Lois" in 1995 caused heavy rainfall in the north. Spillage of the Sirikit Dam and high discharges of the Nan, Yom and Chao Phraya rivers inundated large areas in the Phrae, Sukhothai, Phitsanulok, Phichit and Nakhon Sawan provinces as well as all other provinces along the Cho Phraya River downstream of Nakhon Sawan as shown in Figure 2. Bangkok and vicinity suffered from the flood for more than two months. However, the city core of Bangkok was saved by the flood protection system that had been constructed in 1984. The flood in 1995 was considered a severe flooding event affecting the entire country.

The main causes of flooding are low flow capacities river channels. The present river channel capacities are between 3,000 and 4,000 m^3/s in the stretch near Nakhon Sawan, about 1,300 m^3/s in the upstream near Ayutthaya, about 2,900 m^3/s in the downstream near Ayutthaya, and about 3,600 m^3/s at Bangkok as shown in Figure 3. The flow capacity decreases toward the downstream, this implies that spillage from the river channel gradually occurs in the upstream when a large scale flood occurs; hence, spillage do not concentrate in the downstream. This situation contributes to alleviation of flood damages to Bangkok, while the spilled water is widely retained in the agricultural area in a manner of inundation for 2-3 months. Huge inundation took place over 15,000 sq.km. Most of the floodwater was generated in the Nan and Yom river basins. Firstly, the floodwater originated in the upper basin then flowed down along the Nan and Yom rivers, repeating collection of tributaries' runoff water and spillage by overtopping and dike breaching. The total water volume which swelled to 31 billion m^3 at Nakhon Sawan then entered the delta areas and spilled over the river banks to the adjoining flood plains caused inundation to nearly 16 billion m^3. The contribution of local rainfall to the inundation in the Lower Central Plain, namely the Higher and Lower deltas, was not significant. The estimated flow capacity near Bangkok was about 3,600 m^3/s, or at its maximum capacity.

Besides the natural causes, it is pointed out the several causes of human intervention activities such as land use in flood risk areas, development of upstream, operation of flow control facilities such as dams, and coordination among agencies concerned on flood management are with the increase in flood damage.

3.1 Flood damage condition

When floods strike, people try to protect their assets or mitigate flood damage by taking countermeasures. Since inundation comes up slowly, people can determine when the flood comes and have enough time to take countermeasures. Inundation level comes up several centimeters per day, and it took 20 to 30 days from the beginning of the inundation to reach the highest level in the case of Ayutthaya in 1995. The flood information is frequently broadcast on radio and TV. People make efforts to move their assets such as furniture and television to the second floor or an upper place like a shelf or desk in most cases. Shop owners construct protection walls made of cement.

Large factories are located around municipalities or sanitary cities in general. Most of these factories have their own dikes for protection against floods. They usually have large amounts of assets such as facilities, machinery, relatively protected against floods. However, once these are submerged, the damage amount becomes very large.

People have developed the wisdom of providing flood countermeasures through their experiences. However, they cannot prevent or mitigate big floods and, actually, much damage has been inflicted.

It is difficult to estimate the overall flood damage. Theoretically, it is divided into two categories, tangible damage and intangible damage. The latter, which includes negative psychological impact such as fear, depression and health, etc., cannot quantify in monetary terms. Only tangible damage is further considered into two categories: direct damage and indirect damage. Direct damage is measurable and often referred to as the damage. Indirect damage is not physical but subsequent negative effect on economic activities. Sales loss, for instance, is a typical indirect damage due to business suspension in a shop forced to close by inundation. Direct damage also includes loss of tourism and expenses for diseases and so on. Under the foregoing circumstances, estimation of flood damage in the 1995 flood amounts to about 72 billion baht. It was also estimated the future condition (20 year) when land use will be changed toward more urbanization, the magnitude of 1995 flood will increase damage to 164 billion baht, as demonstrated in Figure 3.

3.2 Royal flood management initiatives and ongoing flood mitigation project by agencies concerned

His Majesty the King has shown great concern for flooding in regions outside Bangkok by suggesting various methodologies to suit local conditions and to conform with the availability of government officials and budgetary constraints.

The low-lying flat terrain of Bangkok causes floodwaters to drain from the area slowly Many canals have a small gradient while others are silted or filled up. Weeds and other items block the flow of water. There are some of the factors why Bangkok and the surrounding area have been subject to heavy flooding for many years. His Majesty has devised a flood management system for Bangkok which he calls Kaem Ling (Monkey's Cheeks). The concept is to temporary storing water in some places at high tide and drain out at low tide.

Together with the Royal-initiated Projects, the agencies responsible for flood mitigation and drainage works have made serious efforts under the following projects:

- Heightening of flood barrier at Bangkok Metropolitan Area by BMA
- Provision of polder system together with the improvement of drainage system by PWD
- River improvement and drainage system improvement by RID
- Loop-cut at Bangkok Port and construction of multipurpose dams by RID
- Monkey's cheeks projects on the coastal area both east and west of Chao Phraya estuary by BMA and RID

Through these projects, the flood protection level in major urban areas is, in general, expected to increase. However, protection works in the upstream sometimes bring about adverse influences to the downstream: i.e., the protection level in Bangkok is expected to decrease due to the construction of polder in Pathum Thani and Nonthaburi. For the agricultural areas it is expected that the present low protection level against floods is maintained in the future.

4 Formulation of Master Plan

4.1 Basic concept for the formulation of master plan

- According to the past flood occurrence, flood conditions in the Chao Phraya River Basin is featured with the existence of extensive inundation areas, which play an important role to retain flood discharge flowing into the Chao Phraya River, resulting in the mitigation of flood damage in the downstream. In this connection, the flood mitigation plan is formulated putting emphasis on preservation of the natural retarding effect. The concept is a global one for flood mitigation through the provision of nonstructural measures and also corresponds to the monkey cheek concept.

- On the other hand, the Chao Phraya River basin, especially the Chao Phraya Delta, tends to be developed continuously in the future, even in such natural retarding area, which results in the decrease of retarding effect causing the increase of flood discharge to the downstream. To minimize the influence due to decrease of retarding effect, suitable measures for comprehensive flood mitigation including structural and nonstructural measures are introduced.

- Flood mitigation measures are also classified according to the flood, i.e., basin-wide flood or local inland water. The Master Plan is formulated by putting emphasis on flood mitigation measures for basin-wide flood. As for local inland water, the conceivable measures for drainage system improvement is examined for agricultural areas as well as the prioritization for implementation of improvement works.

- The flood prone areas in the basin are mainly composed of urban and agricultural areas. Among them, the urban areas will take priority for flood protection because their social and economic impacts are considered much higher than the agricultural areas. Urban areas like Bangkok, Ayutthaya, Nakhon Sawan and others are to be protected by effective measures against bigger scale floods.

- The agricultural areas play an important role as retarding area during big scale floods, and this role should be preserved. On the other hand, for small-scale floods, the present flood damage condition should be improved, providing suitable measures within the allowable extent that will not cause adverse influence to the other areas.

- Flood damage conditions are influenced by nonstructural such as control of land and groundwater extraction, and such influence would finally affect the effectiveness of structural measures. In this connection, the selection of an optimum measure is made through a comparative study on alternatives, considering the most effective combination of structural and nonstructural measures.

- Although the purpose of the Master Plan is flood mitigation, it is also important to consider the shortage of municipal water supply in the dry season. The multipurpose use of the proposed flood mitigation measures is thus examined, especially for irrigation and municipal water supply.

4.2 Measures of the Master Plan

The Master Plan is formulated with 2018 as the target year. In general, several measures consisting of structural and nonstructural ones are considered to cope with the flooding problems, as shown in Figure 4. Specific measures as follows are required to deal with the above-said issues in the Chao Phraya river basin.

4.2.1 Preservation of present natural retarding effect and minimization of Increase of flood damage

To maintain the present natural retarding effect and to minimize the increase of flood damage, nonstructural measures, especially land use control and guidance, are essential. For the realization of land use control and guidance, flood risk maps as shown in Figure 5 are provided, so that all agencies concerned can prepare the development plan based on these maps considering the influence of development. Also, people who are going to development the land are forewarned through publication of the flood risk maps.

4.2.2 Assurance of safety level against flood at Bangkok and urban areas

To assure the safety level of urban areas against floods, nonstructural measures such as the modification of reservoir operation rule, flood forecasting, flood fighting and land use control and guidance are considered, while ring levee with drainage system improvement is applied as the structural measure.

To assure the safety level of a 100-year return period at Bangkok, the following alternatives are proposed in combination with the ring levee provided by PWD, as shown in Figure 6.

- Alternative 1, Partial Protection of Pathum Thani and Nonthaburi
- Alternative 2-1, Heightening of Flood Barrier
- Alternative 2-2, Diversion Channel

4.2.3 Enhancement of Safety Level against Flood in Agricultural Areas

To enhance the safety level against flood in agricultural areas, nonstructural measures such as the modification of reservoir operation rule, flood forecasting, flood fighting and land use control and guidance, etc., are proposed. On the other hand, the following structural measures are proposed for flood mitigation in agricultural areas: (a) river improvement; and (b) distribution and drainage systems improvement.

The protection level of agricultural areas in the downstream of Chai Nat could be enhanced to a 10-year return period by a combination of the above measures.

4.2.4 Institutional Arrangement for Implementation of Measures

In principle, the existing agencies concerned will handle these measures under their own responsibilities. To smoothly implement these measures, however, it is necessary to set up a new organization, the River Basin Committee, as the coordination agency among the agencies concerned, because such an organization does not exist at present in the Thai government.

4.3 Economic evaluation of the Master Plan

The cost, benefit and economic viability of the measures proposed in the three (3) alternatives are evaluated in monetary term as shown below.

Alter-native	Project Component	Cost (mil. Baht)	Economic Benefit (mil. Baht)	Economic Viability		
				EIRR*	B-C	B/C
Alt. 1	Modification of Dam Operation Rule; Distribution and drainage systems improvement; River Improvement and others, but with partial protection of Pathum Thani and Nonthaburi	6,907 as initial cost and 464 as annual cost	3,268/year	21.1%	5,875	2.4
Alt. 2-1	Alternative 1 plus Heightening of Flood barrier and full protection of Patum Thani, Nonthaburi and Bangkok	8,400 as initial cost and 476 as annual cost	4,838/year	24.0%	9,014	2.9
Alt. 2-2	Alternative 1 plus Flood Diversion, Upgrading of river improvement, and Full protection of Patum Thani, Nonthaburi and Bangkok	39,896 as initial cost and 671 as annual cost	6,300/year	12.0%	1,427	1.1

4.3.1 Comparison of Alternative Measures

The alternative measures have individual advantages and disadvantages. The major issues are mainly the following:

(1) Alternative 1 (Partial Protection of Pathum Thani and Nonthaburi)

From the technical point of view, this is slightly better than "do nothing" since it limits the protection area and is not effective to mitigate flood damage in a wide area. From the economical and environmental points of view, the construction of this alternative may not have serious issues. However, from the social point of view, inhabitants will not accept the delineation of protected and not protected areas within the same administrative area.

(2) Alternative 2-1 (Heightening of Flood Barrier at Bangkok)

From the technical point of view, this is a measure to absorb the adverse influence of increase of flood discharge at Bangkok due to protection of Pathum Thani and Nonthaburi. This alternative may enhance the protection level in the upstream area to a certain extent. From the economical point of view, this alternative may not have serious issues. However, from the social and environmental points of view, it will cause serious issues due to the construction of a 'high' barrier between inside and outside of the riparian area. The barrier may affect daily activities of so many people concerned, who are using infrastructures and facilities provided for business activities.

(3) Alternative 2-2 (Construction of Diversion Channel)

From the technical point of view, this is an only alternative that can provide opportunity for enhancement of protection level in upstream area, while satisfactory protect downstream area. From the economical and social points of view, this alternative will require an enormous investment as well as a number of house evacuation and land acquisition. On the other hand, the diversion channel can be multi-purposely used as large-scale infrastructure for regional development such as transportation, land and town planning, etc.

4.3.2 Selection of alternative measures

Though the Master Plan of 1999 had proposed the three alternatives, it had not selected or suggested the most suitable one. It is recommended that all concerned in the nation is necessary to use this study results for further discussions in order to select the most acceptable alternatives. During January to October 2000, Crown Property Bureau supported a technical program through Office of National Water Resources Committee by organizing an inter-agency working group for synthesizing the frame work of integrated water management program in Chao Phraya River. The working group on flood resulted in selection of alternative 2-2 (construction of Diversion Channel) as the most suitable alternative for further implementation. The main reasons are; it has a basin-wide effective not only benefit Bangkok but also agricultural land upstream; and it improves hydraulic condition of lower delta in sustainable manner.

The project will bring about many intangible benefits such as the stabilization of people's living condition, decrease of waterborne diseases, increase of work opportunities, and so on. Among the alternatives, the diversion channel can be used for water resources development purposes.

4.3.3 Environmental consideration

The Forest area was reduced from 166,000 km^2 in 1942 to 106,000 km^2 in 1983 and to 92,000 km^2 in 1995. Such deforestation influences flood occurrence through the reduction of water conservation effect, resulting in the increase of peak flood discharge. Wetlands in low-lying area also effected by siltation and encroachment for farmland. The loss of wetland and upland cover and modification of the landscape throughout the basin over the last 50 years significantly increased runoff. However, in condition of large scale flood, the heavy and long duration of rainfall over the upper part of basin creates saturated condition on forest and land, produce high rate of runoff. Although upland watershed treatment and restoration of upland and low-lying wetland can possibly reduce flood stages in more frequent floods (5 years or less) , it is questionable whether they would have significantly altered the 1995 conditions.

5 Conclusion

The Master Plan of integrated flood damages mitigation in the Chao Phraya River Basin has been formulated in accordance with the "Monkey Cheeks" concept for preservation of the present retarding effect and, also, with the introduction of suitable flood mitigation measures. To realize the Master Plan, several projects have been selected for urgent implementation. It is concluded that flood mitigation in the context of the Master Plan is essential for development of the basin and the country as whole, and the implementation of selected projects is the most effective means to achieve the safety level of 100-yr for urban areas and 10-25 yr for agriculture land.

It is necessary to note that floods are natural phenomena; mankind tries to overcome these problems by numerous measures and most of the time forgets the fact that water needs space. Once an area has been protected from flooding, it will automatically exacerbate the flood problem in another area. Basinwide planning is necessary for effective flood management, and changes in land use and expansion of the community are the great hindrances. A good land-use planning procedure and good enforcement of water-related laws are a must. Floods can be prevented, controlled or avoided only to a certain degree, It has to be realized that at present all kinds of measures applied for the benefits of flood control can be effective only at a certain magnitude of flood.

The 1995 flood was a significant hydrometeorological event. In some areas it represented an unusual event, however, it was just another of the many that have been seen before and will be seen again. The flood magnitude of 1995 is less than 1942 resulted partly from construction of reservoirs during 1960's and 1970's. For Over 30 years the people in delta has learned that effective flood plain management can reduce vulnerability to damages and create a balance among natural and human uses of flood plains and their related watersheds to meet both social and environmental goals. Damages in 1995 was estimated at 72 billion Baht and expected to increase to 164 billion Baht in future land use. The country can no longer afford such costs, economical and socially. The Master Plan and Follow-up activity provide a solution for flood plain management in this delta. The government, at all levels, all businesses and all citizens must take the actions required to do so by sharing responsibility and accountability.

References

Crown Property Bureau. 2000. Framework for Integrated Water Management and Development in Chao Phraya River Basin. Report prepared for seminar during 4-5 August 2000. (Thai version)

CTI Engineering International Co., Ltd. and INA corporation. 1999. The Study on Intrgrated Plan For Flood Mitigation in Chao Phraya River Basin. Japan International Cooperation Agency (JICA); Royal Irrigation Department, Thailand.

Economic and Social Commission for Asia and the Pacific. 1999. Regional cooperation in the Twenty-first Century on Flood Control and Management in Asia and the Pacific. United Nations. New York

Report of the Interagency Floodplain Management Review Committee to the Administration Floodplain Management Task Force. 1994. Sharing the Challenge : Floodplain Management into the 21st century. Washington, DC.

Royal Development Project Board; Department of Technical and Economic Cooperation; United Nations Development Programme. 1997. Concepts and Theories of His Majesty the King on Development. Bangkok. Thailand.

Vadhanaphuti, Boonyok; Klaikayai, Thanom; Thanopanuwat, Suwit and Hungspreug, Natha.1991. Water Resources Planning and Management of Thailand's Chao Phraya River Basin. World Bank Technical Paper No.175.

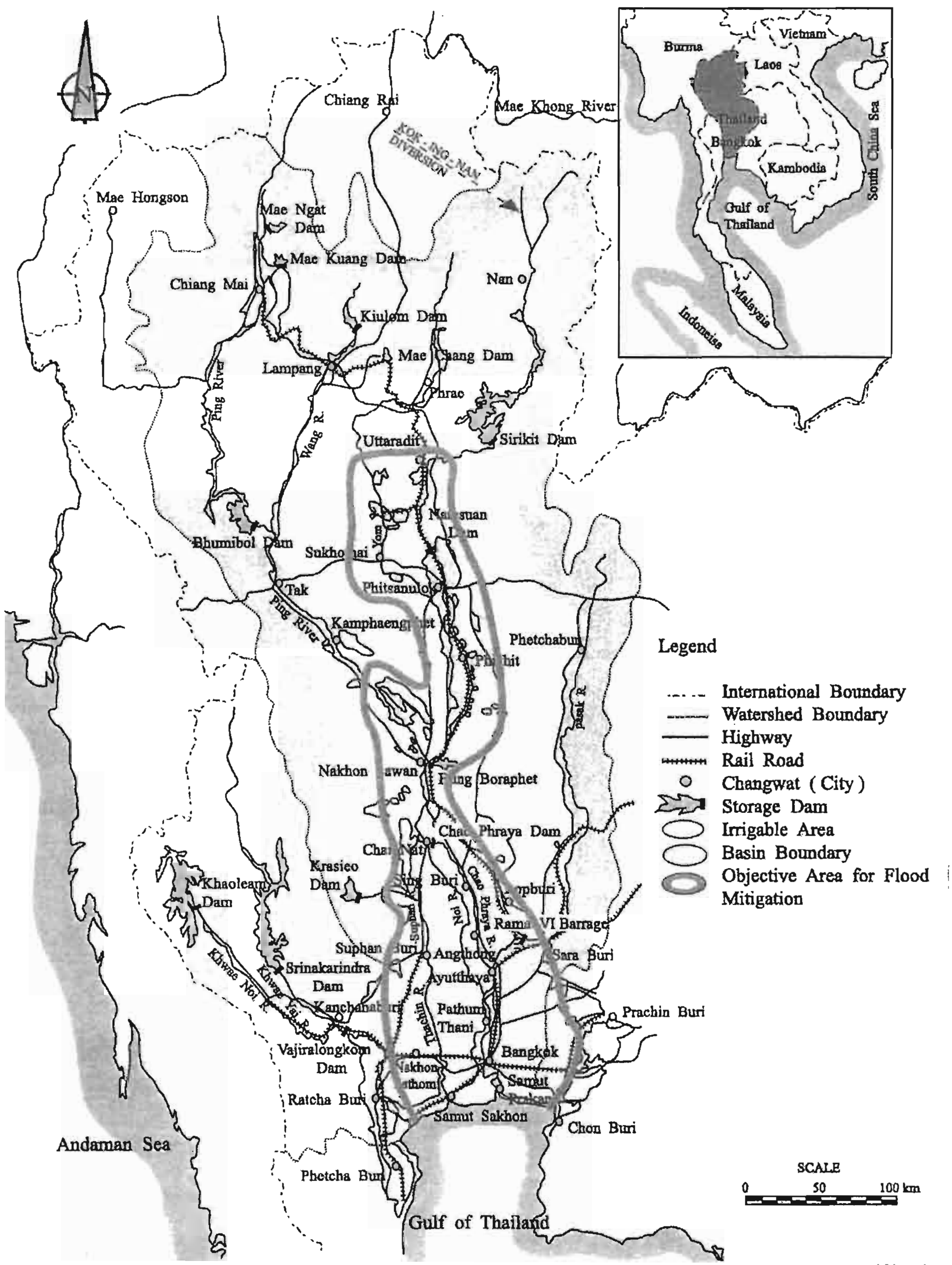


Fig.1 GENERAL MAP

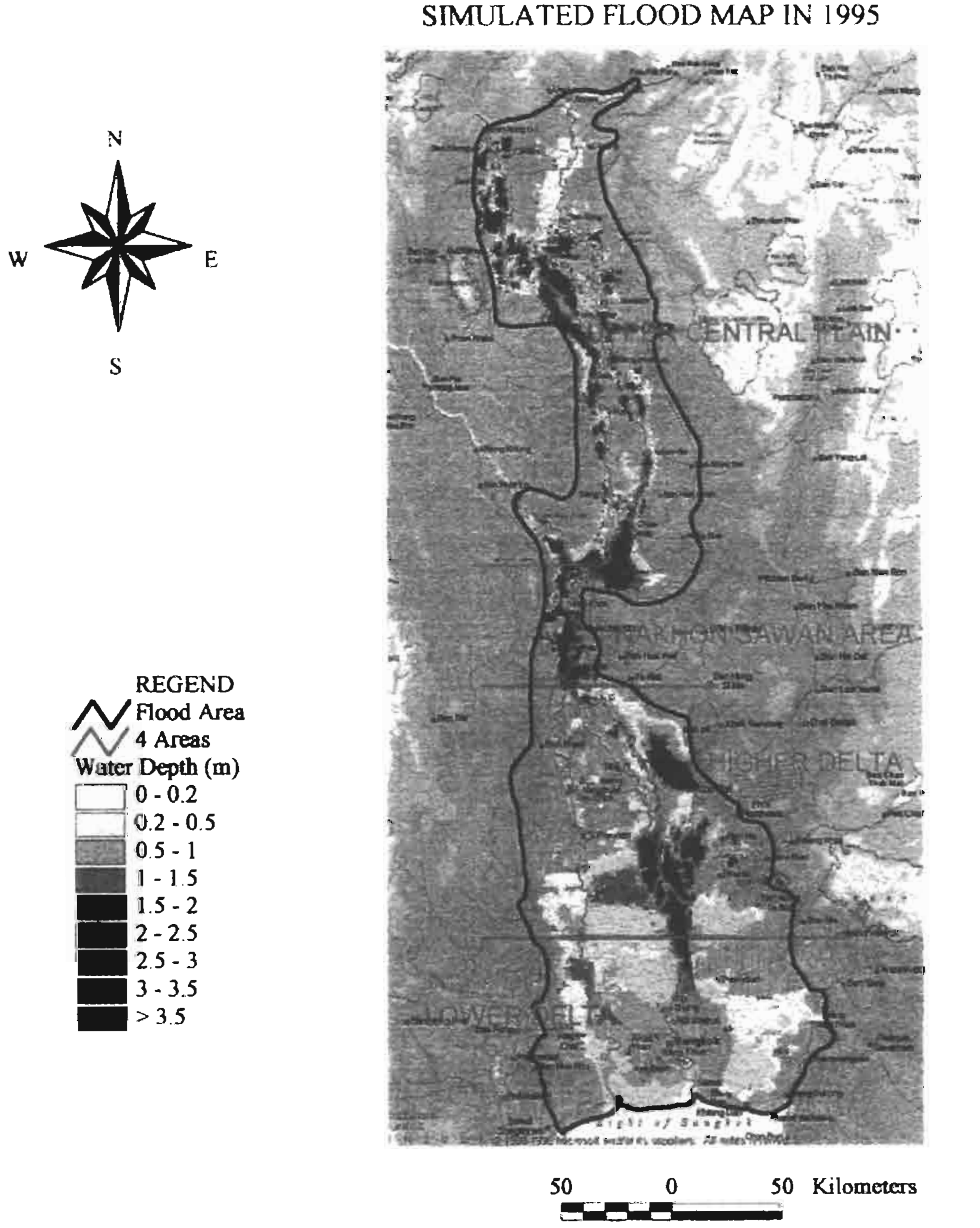
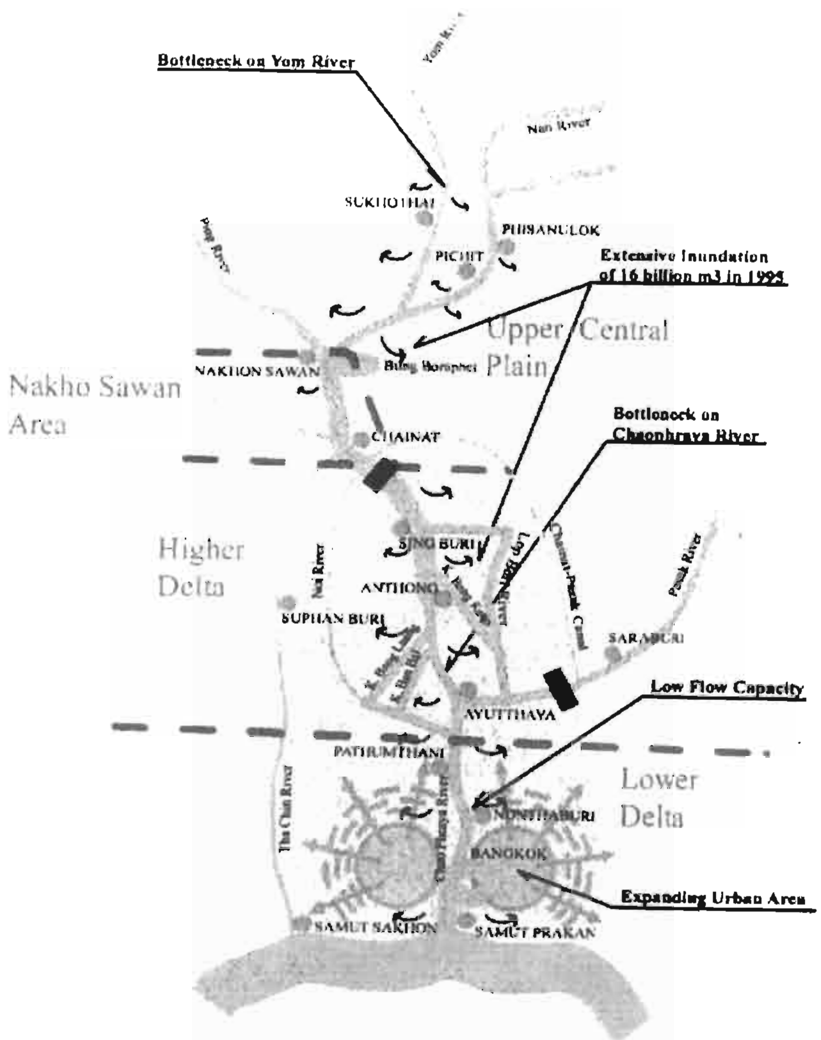


Fig.2 ESTIMATED INUNDATION MAP



River and Flooding Condition

Area	River	Stretch	Flow Capacity (m^3/s)	Inundation Volume in 1995
Upper Central Plain	Nan	Phisanulok to Chao Phraya River	1,000 to 2,000	5 billion m^3
	Yom	Sukhothai to Nan River	50 to 1,100	
Nakhon Sawan Area	Chao Phraya	Nakhon Sawan to Chainat	2,500 to 4,500	1 billion m^3
Higher Delta	Chao Phraya	Chainat to Ayutthaya	4,200 to 1,300	7 billion m^3
Lower Delta	Chao Phraya	below Ayutthaya	2,900 to 3,200	3 billion m^3
	Chao Phraya	BMA Flood Barrier *	3,600	

*: On-going Project

Flood Damage in 1995 Flood

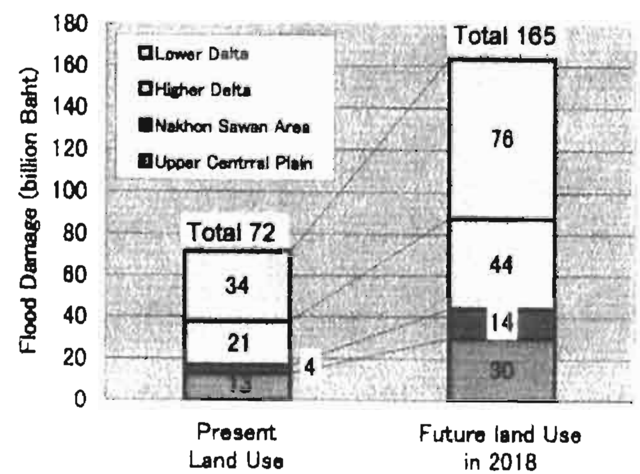


Fig.3 PRESENT FLOODING SITUATION

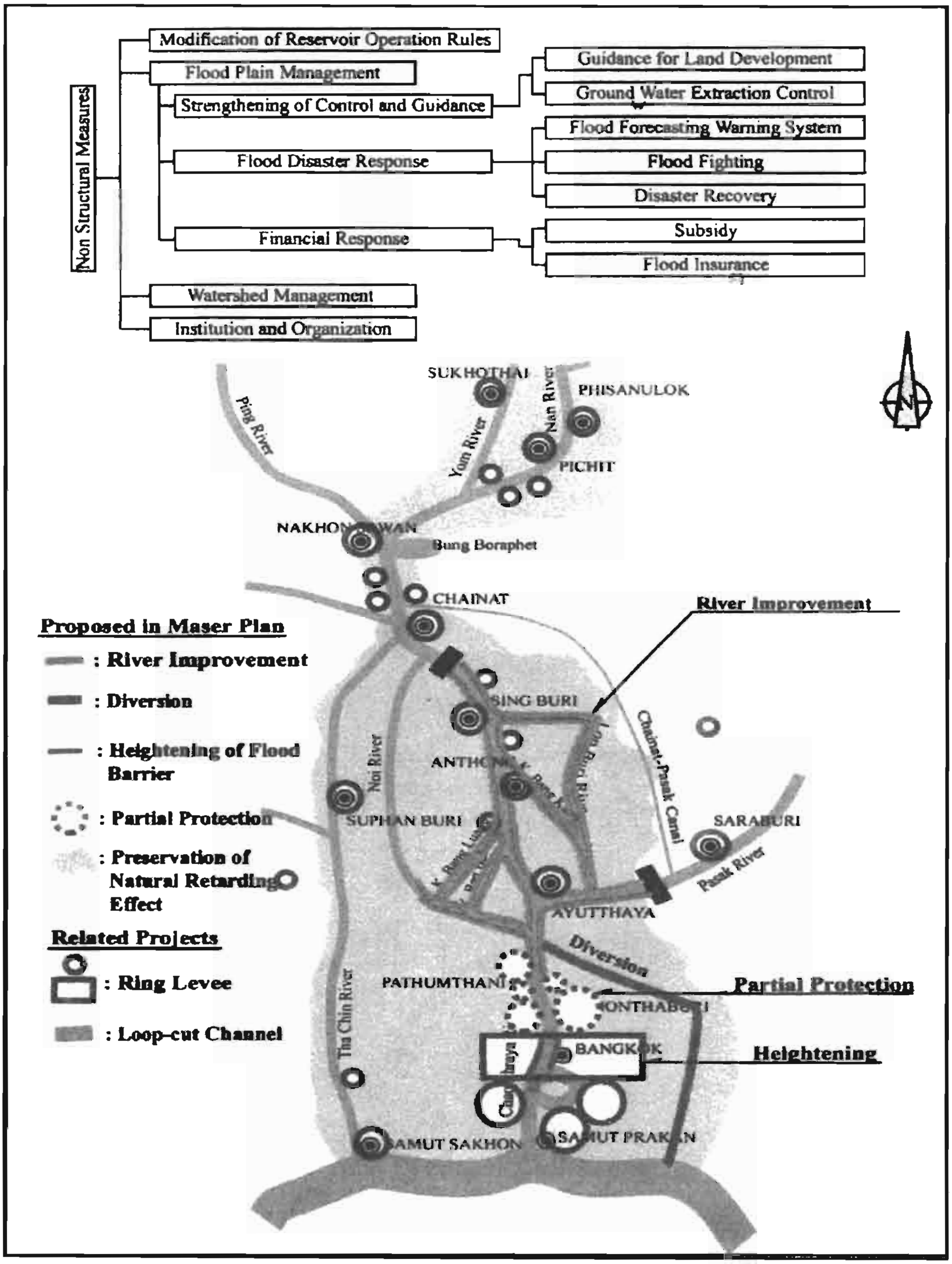


Fig.4 MAJOR PROPOSED MEASURES

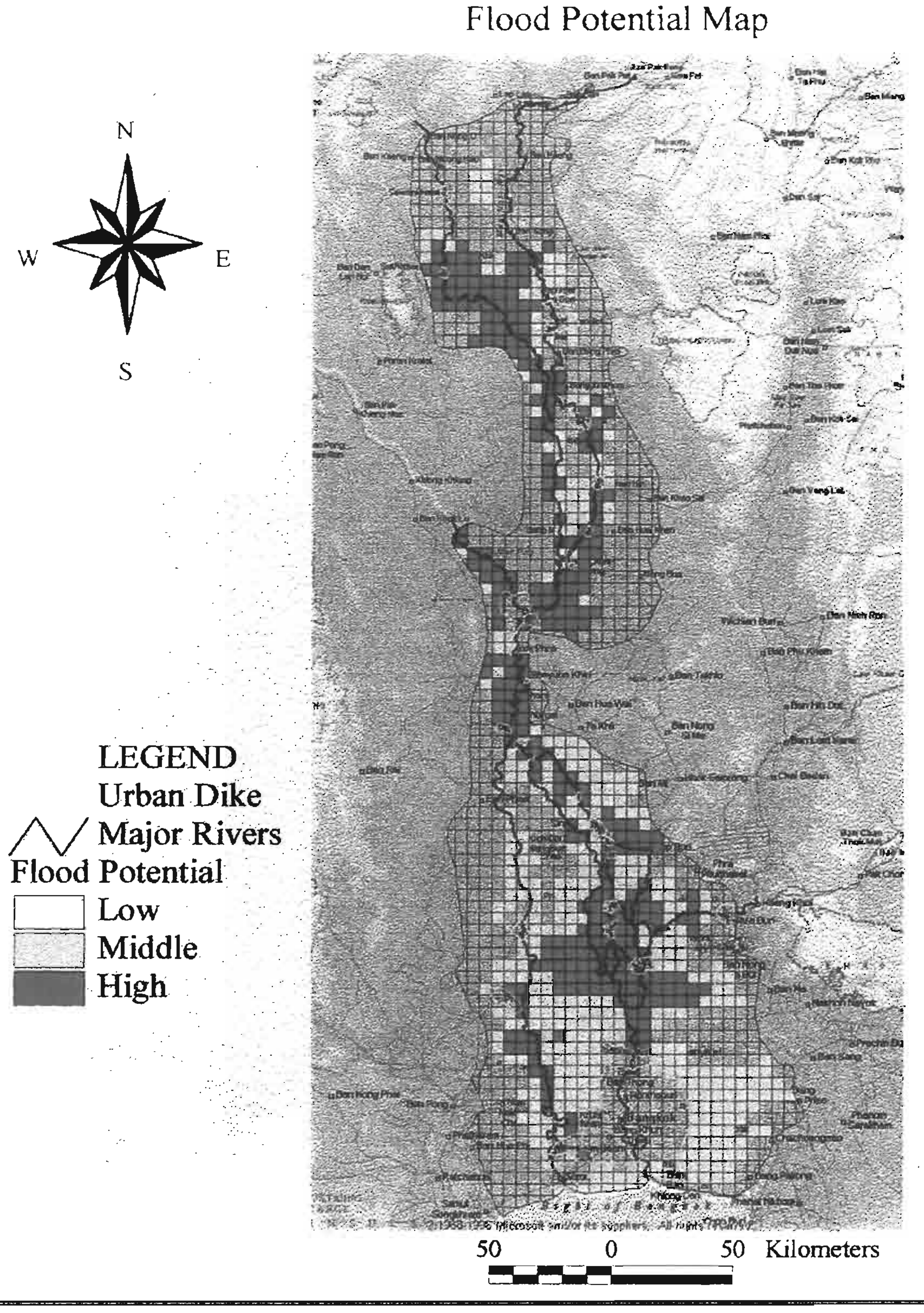


Fig.5 FLOOD POTENTIAL MAP

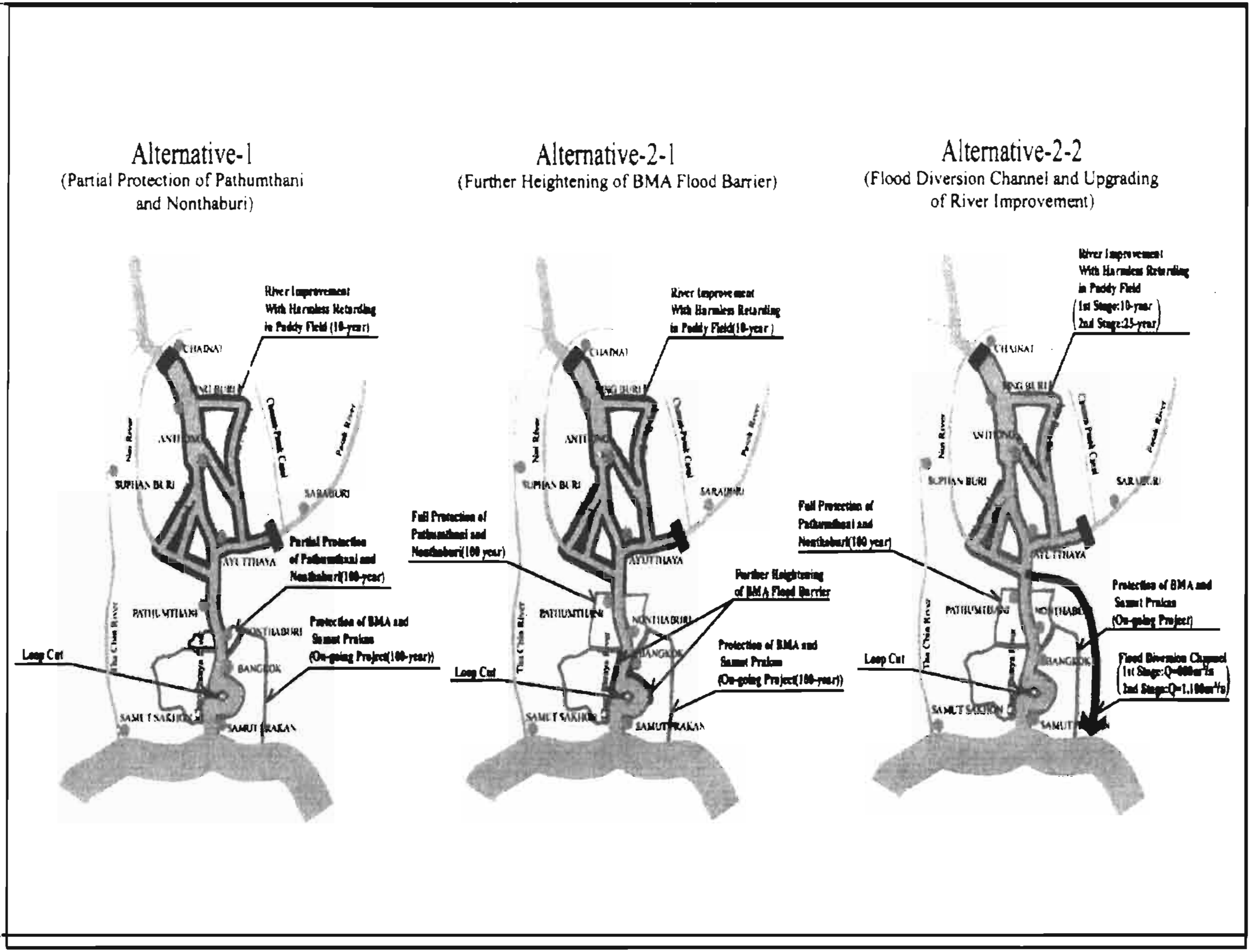


Fig.6 ALTERNATIVES

Flood-risk map in the Chao Phraya Delta

Thanawat Jarupongsakul[1], Sunya Saraphirome[2], Rasame Suwanweerakamton[3] and Chaiyuth Sukhsri [4]

Abstract: *Geographic information system (GIS), Remote sensing (RS), and Global positioning system (GPS) provide a broad range of tools for determining areas affected by floods and identifying floods-prone areas. Satellite images taken during the period of 1987-1997 provide an effective means of mapping the extent of the flood affected areas. Spatial data stored in the digital database of the GIS such as a digital elevation model (DEM), meteorological and hydrological data can be used to analys the flood-risk map of the study area. The GIS database may also contain agricultural, socio-economic, communication, population and infrastructural data. This can be used, in conjunction with the flooding data, for evacuating strategy, rehabilitation planning or damage assessment. Flood-risk maps can be prepared for flooding of different magnitudes, for example 10, 25, 50, and 100 years of return periods. Combined together they produce a flood risk map which delineates zones inundated by each of the above floods. Superimposed on topographic maps of the scale 1 : 50,000 , they permit an estimate of depth of flooding at specific locations by subtracting ground elevation from water surface elevation.*

Human intervention affecting flooding in the lower central plain of Thailand has taken place to a significant level over the past 40 years. The effects of the loss of natural retention and overbank storage in the lower Chao Phraya valley has been to increase the severity of downstream flooding, especially by increasing the frequency of 10 years flood return period about 50% and 25 years flood return period about 15%. The trends in ongoing development in the basin and improved and extended protection of large areas from flooding by dikes will lead to more severe flooding conditions in the future.

บทคัดย่อ

การศึกษาโดยใช้ระบบสารสนเทศทางภูมิศาสตร์ (GIS) ข้อมูลระยะไกลจากภาพถ่ายดาวเทียม (RS) และเครื่องมือหาพิกัดทางภูมิศาสตร์ (GPS) มาช่วยในการวิเคราะห์หาพื้นที่ถูกน้ำท่วมและหาพื้นที่เสี่ยงภัยน้ำท่วมนั้น นับได้ว่าเป็นวิธีการที่มีประสิทธิภาพอย่างยิ่ง โดยเฉพาะการศึกษานี้มีการใช้ภาพถ่ายดาวเทียมตั้งแต่ปี พ.ศ. 2530-2540 ซึ่งนับได้ว่าข้อมูลพื้นที่น้ำท่วมที่ได้มีความน่าเชื่อถือได้ที่นำไปใช้ได้ ข้อมูลเชิงพื้นที่ประเภทต่าง ๆ ได้ถูกจัดเก็บโดยระบบสารสนเทศทางภูมิศาสตร์ (GIS) ตัวอย่างเช่น ข้อมูลรูปแบบจำลอง

[1] Department of Geology, Chulalongkorn University, Bangkok, Thailand
[2] Geological Survey Division, Department of Mineral Resource, Bangkok, Thailand
[3] Computer Center, Khon Kaen University, Khon Kaen, Thailand
4 Mekong River Commission, Phnom Phenh, Combodia

ของค่าระดับความสูง ข้อมูลทางอุตุนิยมวิทยา และข้อมูลทางอุทกวิทยา ได้ถูกจัดเก็บในระบบฐานข้อมูลเดียวกันเพื่อใช้ในการวิเคราะห์เพื่อประกอบกับข้อมูลภาพถ่ายดาวเทียมในการจัดทำแผนที่พื้นที่เสี่ยงภัยน้ำท่วมของพื้นที่ศึกษา ฐานข้อมูลที่อยู่ในระบบสารสนเทศทางภูมิศาสตร์ (GIS) ยังสามารถบ่งบอกถึง ข้อมูลทางการเกษตรกรรม สภาพเศรษฐกิจสังคม เส้นทางคมนาคม ประชากร และข้อมูลสาธารณูปโภคในพื้นที่ ซึ่งสามารถใช้เป็นข้อมูลประกอบกับข้อมูลน้ำท่วมเพื่อช่วยในการวางแผนอพยพผู้คน การวางแผนการตั้งถิ่นฐานใหม่ หรือการประเมินความเสียหายของการเกิดน้ำท่วมแต่ละครั้งได้ แผนที่เสี่ยงภัยที่ได้จากการศึกษาจะอยู่ในรูปแบบของระดับความรุนแรงของน้ำท่วมที่ขนาดต่าง ๆ กัน ขนาดความรุนแรงของน้ำท่วมจะแปรผกผันตามโอกาสที่จะเกิดน้ำท่วมอีกครั้งในระดับนั้น ๆ เช่น ขนาดความรุนแรงที่คาบอุบัติซ้ำ 10 ปี, 25 ปี, 50 ปี, และ 100 ปี เป็นต้น ข้อมูลความเสี่ยงภัยของน้ำท่วมที่มีขนาดความรุนแรงที่มีคาบอุบัติซ้ำ ต่าง ๆ กัน จะถูกซ้อนทับแสดงบนแผนที่ภูมิประเทศมาตราส่วน 1 : 50,000 ซึ่งจะมีความสะดวกแก่หน่วยงานต่าง ๆ ที่นำไปใช้ต่อไป

ในระยะเวลา 40 ปีที่ผ่านมา พฤติกรรมของมนุษย์ที่อาศัยอยู่ในลุ่มน้ำเจ้าพระยาตอนล่างทำให้เกิดผลกระทบต่อการเกิดอุทกภัยอย่างมาก ผลกระทบของการสูญเสียพื้นที่ลุ่มต่ำและพื้นที่เก็บกักน้ำริมตลิ่งที่มีอยู่ตามธรรมชาติในบริเวณนี้ ได้เพิ่มความรุนแรงของน้ำท่วมบริเวณท้ายแม่น้ำ โดยเฉพาะทำให้จำนวนครั้งของน้ำท่วมที่มีขนาดความรุนแรงที่คาบอุบัติซ้ำ 10 ปี เพิ่มขึ้น 50% และน้ำท่วมที่ขนาดความรุนแรงที่มีคาบอุบัติซ้ำ 25 ปี เพิ่มขึ้น 15% แนวโน้มในการพัฒนาลุ่มน้ำอย่างไม่หยุดยั้ง และการปรับปรุงการป้องกันน้ำท่วมสำหรับพื้นที่ขนาดใหญ่โดยคันกั้นนั้น จะนำไปสู่การเกิดปัญหาน้ำท่วมที่มีขนาดความรุนแรงเพิ่มขึ้นในอนาคต.

คำนำ

น้ำท่วมในลุ่มแม่น้ำเจ้าพระยาตอนล่าง รวมทั้งพื้นที่กรุงเทพมหานคร ซึ่งมักจะเกิดจากหลายสาเหตุหรือสาเหตุใด ๆ ดังต่อไปนี้ 1) ฝนตกหนักในพื้นที่รับน้ำทางตอนบนของลุ่มน้ำ, 2) ฝนตกหนักในบริเวณพื้นที่, 3) ลักษณะทางธรณีสัณฐานของพื้นที่, 4) น้ำทะเลหนุน, และ 5) กิจกรรมต่าง ๆ ของมนุษย์ ดังนั้นการเกิดน้ำท่วมจึงเป็นปรากฏการณ์ธรรมชาติและบางส่วนมีสาเหตุจากกิจกรรมมนุษย์ การเปลี่ยนแปลงการใช้ที่ดิน และการขยายตัวของพื้นที่ชุมชนเมือง ปัญหาแผ่นดินทรุดของกรุงเทพ มหานครและปริมณฑล ปัญหาการระบายน้ำของชุมชนเมือง ตลอดจนการเพิ่มพื้นที่เกษตรกรรมทำให้สูญเสียพื้นที่ลุ่มต่ำ และพื้นที่เก็บกักน้ำริมตลิ่งที่มีอยู่ตามธรรมชาติ เป็นผลทำให้แนวโน้มความรุนแรงของน้ำท่วมเพิ่มขึ้นในบริเวณลุ่มแม่น้ำภาคกลางตอนล่าง น้ำท่วมที่เกิดขึ้นในปี 2538 เป็นตัวอย่างที่เห็นได้ชัดเจน พบว่า ความเสียหายอันเกิดจากน้ำท่วมได้แผ่ขยายครอบคลุมพื้นที่เป็นบริเวณกว้าง ก่อให้เกิดผลกระทบต่อชีวิตและทรัพย์สินเป็นจำนวนมาก ดังนั้นเหตุการณ์น้ำท่วมในปี 2538 ทำให้คณะผู้วิจัยสนใจศึกษาวิจัยพื้นที่เสี่ยงภัยน้ำท่วมใน

บริเวณที่ราบภาคกลางตอนล่าง โดยนำเอากรณีน้ำท่วมครั้งนั้นมาศึกษาเปรียบเทียบกับข้อมูลการเกิดน้ำท่วมในอดีตและใช้ข้อมูลภาพถ่ายดาวเทียมตั้งแต่ปี 2530-2540 ประกอบกับข้อมูลต่าง ๆ ของพื้นที่ อาทิเช่น ข้อมูลอุตุนิยมวิทยา ข้อมูลอุทกวิทยา เป็นต้น และมีการนำเอาเทคโนโลยีสมัยใหม่ทางด้านระบบสารสนเทศทางภูมิศาสตร์ (GIS) และเครื่องหาพิกัดทางภูมิศาสตร์ (GPS) มาช่วยในการศึกษาครั้งนี้

ขั้นตอนการศึกษาวิจัย

การศึกษาวิจัยครั้งนี้ได้ใช้ระบบสารสนเทศทางภูมิศาสตร์ (GIS) ข้อมูลระยะไกล จากภาพถ่ายดาวเทียม (RS) ตั้งแต่ปี 2530-2540 และเครื่องหาพิกัดทางภูมิศาสตร์ (GPS) มาช่วยในการวิเคราะห์ หาพื้นที่ถูกน้ำท่วม รายละเอียดดังแสดงในรูปที่ 1 การจัดทำแผนที่พื้นที่เสี่ยงภัยน้ำท่วมของพื้นที่ศึกษา ได้มาจากการวิเคราะห์ข้อมูลดาวเทียวด้วยระบบคอมพิวเตอร์ (Digital processing) โดยใช้ซอฟแวร์ EASI/PACE (PCI) ข้อมูลภาพถ่ายดาวเทียมที่นำมาใช้ในการวิเคราะห์พื้นที่น้ำท่วมครั้งนี้สามารถแบ่งออกเป็น 2 ชุด ข้อมูลชุดแรกใช้สำหรับการวิเคราะห์แผนที่ธรณีสัณฐานน้ำท่วม (Flood Geomorphology) โดยใช้กรณีศึกษาของน้ำท่วมปี 2538 ข้อมูลดาวเทียมที่ใช้มีทั้งหมดมี 4 ช่วงเวลา คือ 1) ช่วงที่มีระดับน้ำท่วมสูงสุด (ตุลาคม 2538) 2) ช่วงหลังน้ำท่วม (ธันวาคม 2538) 3) ช่วงก่อนหน้าแล้ง (กุมภาพันธ์ 2537) และ 4) ช่วงหน้าแล้ง (เมษายน 2537) ข้อมูลทั้ง 4 ช่วงจะถูกนำไปวิเคราะห์ด้วยคอมพิวเตอร์โดยมีการปรับแก้เชิงเรขาคณิต (Geometric correction) เป็นการปรับค่าพิกัดจุดภาพให้มีความถูกต้องตามระบบพิกัดอ้างอิง ซึ่งใช้แผนที่ภูมิประเทศ กรมแผนที่ทหาร มาตราส่วน 1:50,000 ระบบพิกัด กริด ยู.ที.เอ็ม (UTM : Universal Transverse Mercator) ภาพทั้งหมดที่ถูกปรับแก้พิกัดถูกต้อง (Corrected image) แล้วจะนำไปทำค่าดัชนีพืชพรรณผลต่างแบบนอร์แมลไลซ์ (Normalized difference vegetation index : NDVI) ข้อมูลดาวเทียมทั้ง 4 ช่วงที่ทำค่าดัชนีพืชพรรณเรียบร้อยแล้ว ถูกนำไปวิเคราะห์ข้อมูลเพื่อการจำแนกลักษณะธรณีสัณฐานวิทยาน้ำท่วม โดยวิธีจำแนกแบบไม่ควบคุม (Unsupervised classification) ด้วยการแบ่งกลุ่มประเภทข้อมูลแบบ K-means clustering ผลที่ได้จะถูกนำไปเปรียบเทียบกับแผนที่ธรณีสัณฐานวิทยา มาตราส่วน 1:250,000 (Ohkura et., al. 1989: Somboon, 1990) และมีการตรวจสอบความถูกต้องของข้อมูลในภาคสนาม แผนที่ธรณีสัณฐานวิทยา น้ำท่วมที่ได้จากการศึกษาสามารถจำแนกลักษณะภูมิลักษณะน้ำท่วม (Flood Landform) ออกเป็นพื้นที่ลุ่มต่ำหลังแม่น้ำ (Back Swamp) เป็น 4 ระดับ คันดินตามธรรมชาติปัจจุบัน (Recent Natural Levee) คันดินธรรมชาติเก่า (Old Natural Levee) และทางแม่น้ำเก่า (Old River Channel) ซึ่งจะเป็นข้อมูลพื้นฐานสำหรับใช้วิเคราะห์หาพื้นที่เสี่ยงภัยน้ำท่วมต่อไป

ข้อมูลดาวเทียมของทุกปี ตั้งแต่ปี พ.ศ. 2530-2540 ในช่วงเวลาที่น้ำท่วมประมาณเดือนกันยายนถึงตุลาคม ได้ถูกนำไปวิเคราะห์ด้วยซอฟแวร์ EASI/PACE (PCI) โดยการปรับแก้ค่าพิกัดภูมิศาสตร์ ทำค่าดัชนีพืชพรรณ แล้วนำไปวิเคราะห์โดยใช้ช่วงคลื่น 5, 4, 2 และค่าดัชนีพืชพรรณร่วมกัน ผลที่ได้เป็นแผนที่น้ำท่วมในปีต่าง ๆ ตั้งแต่ปี พ.ศ. 2530-2540 ข้อมูลที่ได้ทั้งหมดจะถูกนำไปวิเคราะห์ขั้นสุดท้ายร่วมกับข้อมูลทางด้าน

อุตุนิยมวิทยา ข้อมูลอุทกวิทยาโดยเฉพาะนำไปเชื่อมโยงกับความรุนแรงของน้ำท่วมที่เกิดขึ้นในแต่ละปี เปรียบเทียบกับข้อมูลความสัมพันธ์ระหว่างอัตราการไหลของน้ำและระดับน้ำในแต่ละสถานีน้ำท่าของพื้นที่ศึกษา ผลการศึกษาขั้นสุดท้าย หลังจากมีการตรวจสอบในภาคสนามเพื่อความถูกต้องของข้อมูลมากยิ่งขึ้น แผนที่พื้นที่เสี่ยงภัยน้ำท่วมที่ได้จากการศึกษาในครั้งนี้มีด้วยกัน 4 ระดับ ตามค่าอุบัติซ้ำของน้ำท่วมที่ระดับต่าง ๆ กัน คือ คาบอุบัติซ้ำ 10 ปี, 25 ปี, 50 ปี และ 100 ปี ผลลัพธ์ที่ได้จะถูกนำไปวิเคราะห์ร่วมกับข้อมูลที่ถูกจัดเก็บในระบบสารสนเทศภูมิศาสตร์ต่อไป

การวิเคราะห์ข้อมูลอุตุนิยมวิทยา

สภาพภูมิอากาศของพื้นที่ศึกษาอยู่ในเขตมรสุมเขตร้อนชื้นฤดูฝนจะเริ่มตั้งแต่เดือนพฤษภาคม จนถึงเดือนตุลาคม ปริมาณฝนตกประมาณ 80% ของเฉลี่ยทั้งปีจะตกในฤดูฝนซึ่งมีปริมาณเฉลี่ยประมาณ 1000-1400 มม./ปี เดือนกันยายนถึงเดือนตุลาคมของทุกปีจะมีฝนตกหนักเพราะอิทธิพลของมรสุมและพายุไต้ฝุ่น จึงเป็นสาเหตุสำคัญทำให้เกิดน้ำท่วมเป็นประจำเพราะน้ำจากทางลุ่มน้ำตอนเหนือไหลมาถึงพื้นที่ศึกษา หากมีพายุหรือมรสุมตกในช่วงนั้นก็ทำให้เกิดน้ำท่วมมีความเสียหายมากขึ้น ในการศึกษาครั้งนี้ได้มีการนำข้อมูลด้านอุตุนิยมวิทยาป้อนเข้าสู่ระบบคอมพิวเตอร์ ซึ่งมีทั้งค่าพิกัดของสถานีวัดอุตุนิยมวิทยา ทั้งหมด 203 สถานีที่อยู่ในพื้นที่ศึกษาและอีก 198 สถานีที่อยู่นอกพื้นที่ศึกษา ดังรูปที่ 2 ค่าอุณหภูมิและปริมาณฝนตกเฉลี่ยรายเดือนในคาบ 40 ปีและข้อมูลรายวันของปี พ.ศ. 2538 ซึ่งข้อมูลทั้งหมดได้รับการอนุเคราะห์จากกรมอุตุนิยมวิทยาและกรมชลประทาน ผลการวิเคราะห์การกระจายตัวของปริมาณฝนตกเฉลี่ยในคาบ 40 ปี โดยใช้โปรแกรมระบบสารสนเทศทางภูมิศาสตร์ด้วยซอฟแวร์ SPANS ดังรูปที่ 3 รูปที่ 4 กราฟแสดงปริมาณฝนตกเฉลี่ยรายวันของพื้นที่ศึกษาตั้งแต่เดือนเมษายน 2538 จนถึง เดือนมีนาคม 2539 ผลการวิเคราะห์กรณีศึกษาน้ำท่วมของปี 2538 พบว่า ในบริเวณพื้นที่ภาคกลางตอนล่างเริ่มมีฝนตกประมาณกลางเดือนพฤษภาคม 2538 และมีฝนตกตลอดจนถึงเดือนเดือนตุลาคม โดยมีฝนตกหนักต่อเนื่องในช่วงเดือนสิงหาคมถึงเดือนกันยายน ปริมาณฝนตกหนักที่สุดวัดได้ 243 มิลลิเมตร ที่สถานีวัดน้ำฝน อ. เมือง จ. สมุทรสาคร วันที่ 13 กันยายน 2538 ทำให้เกิดน้ำท่วมขังในหลายพื้นที่ของที่ราบภาคกลางตอนล่าง นอกจากนี้ยังมีการวิเคราะห์สภาพปริมาณฝนตกของวันที่ของวันที่นำเอาข้อมูลภาพดาวเทียมที่มาใช้วิเคราะห์สภาพน้ำท่วม ปี พ.ศ. 2538 ดังในรูปที่ 5 พบว่า ในวันที่ 12 ตุลาคม พ.ศ. 2538 มีฝนตกหนักเป็นบางพื้นที่โดยเฉพาะจังหวัดอยุธยา อ่างทอง และนครนายก รูปที่ 6 จะถูกนำไปวิเคราะห์เทียบกับแผนที่พื้นที่เสี่ยงภัยน้ำท่วมที่ได้ วัตถุประสงค์เพื่อการตรวจสอบว่าแผนที่พื้นที่เสี่ยงภัยน้ำท่วมที่ได้จากการวิเคราะห์ภาพถ่ายดาวเทียมของน้ำท่วม ปี พ.ศ. 2538 เป็นสภาพน้ำท่วมที่เกิดจากการล้นฝั่งอย่างเดียวหรือไม่ บางครั้งสภาพน้ำท่วมในพื้นที่ศึกษาอาจจะเกิดจากสาเหตุมีฝนตกติดต่อกันหลายวัน ดังนั้นรูปที่ 6 เป็นการวิเคราะห์ปริมาณฝนตกก่อน 3 วันและ 7 วัน ตาม

ลำดับ เพื่อประโยชน์ในการตรวจสอบว่าสภาพน้ำท่วม ที่ปรากฏในภาพถ่ายดาวเทียมเกิดจากมีฝนตกหนักในพื้นที่ได้ชัดเจนยิ่งขึ้น

การวิเคราะห์ข้อมูลอุทกวิทยา

สภาพการไหลของแม่น้ำในพื้นที่ลุ่มแม่น้ำเจ้าพระยาตอนล่าง พบว่ามีการเปลี่ยนแปลงขึ้นอยู่กับปริมาณฝนที่ตกลงมา ทั้งในพื้นที่ศึกษาและบริเวณต้นน้ำเหนือเขื่อนต่าง ๆ ปริมาณการไหลของแม่น้ำเริ่มเพิ่มขึ้นตั้งแต่เดือนเมษายนและมีปริมาณมากที่สุดประมาณเดือนกันยายนและเดือนตุลาคมของทุกปี ในการศึกษาครั้งนี้ได้มีการนำเข้าข้อมูลด้านอุทกวิทยาป้อนเข้าสู่ระบบคอมพิวเตอร์ รูปที่ 7 แสดงตำแหน่งของสถานีวัดน้ำท่าในพื้นที่ศึกษาทั้งหมดจำนวน 47 สถานี และนอกพื้นที่ศึกษาอีกจำนวน 56 สถานี ข้อมูลระดับน้ำและปริมาณการไหลของแต่ละสถานี ได้ถูกป้อนเข้าสู่ระบบคอมพิวเตอร์ ซึ่งประกอบด้วยค่าระดับน้ำสูงสุดรายปี และระดับน้ำรายวันของกรณีศึกษาน้ำท่วมปี พ.ศ. 2538 นอกจากนี้บางสถานียังมีการเก็บข้อมูลเกี่ยวกับลักษณะลำน้ำ (River profile) กราฟแสดงความสัมพันธ์ระหว่างระดับน้ำ กับปริมาณการไหลขอลแม่น้ำ (Rating curve) ของแต่ละสถานี และกราฟความสัมพันธ์เทียบคาบเกิดซ้ำของอัตราการไหลของแม่น้ำ (Frequency of Annual Peak Discharge)

สถานีวัดน้ำท่าหลักที่นำมาใช้วิเคราะห์ครั้งนี้มีทั้งหมด 9 แห่ง ได้แก่ C.13, C.3, C.28, C.7a, S.5, C.31, C.22, C.12 และ C.4 รูปที่ 8 แสดงตำแหน่งของสถานีวัดน้ำท่าดังกล่าวพร้อมทั้งภาพตัดขวางของลำน้ำเจ้าพระยา ณ จุดที่การวัดระดับน้ำ ข้อมูลระดับน้ำรายวันของสถานีวัดน้ำท่าทั้ง 9 แห่ง ตั้งแต่วันที่ 1 เมษายน พ.ศ. 2538 จนถึง 31 มีนาคม พ.ศ. 2539 ได้มีการแสดงไว้ในรูปที่ 9 จากการวิเคราะห์ระดับน้ำรายวันและภาพตัดขวางของลำน้ำเจ้าพระยาแต่ละจุดพบว่าน้ำเริ่มท่วมล้นฝั่งที่จังหวัดสิงห์บุรี (C.3) และจังหวัดอ่างทอง (C.28, C.7A) ประมาณวันที่ 13-15 กันยายน พ.ศ. 2538 ส่วนที่จังหวัดอยุธยา (S.5) น้ำเริ่มล้นฝั่งประมาณวันที่ 19-20 กันยายน พ.ศ. 2538 และที่อำเภอปากเกร็ด (C.22) น้ำท่วมล้นฝั่งประมาณวันที่ 25-29 ตุลาคม พ.ศ.2538 ดังนั้นการวิเคราะห์แผนที่พื้นที่เสี่ยงภัยน้ำท่วมของปี พ.ศ. 2538 เราจึงเลือกใช้ภาพถ่ายดาวเทียมวันที่ 12 ตุลาคม พ.ศ. 2538 มาใช้ในการศึกษา เพราะค่าระดับน้ำของทุกสถานีวัดน้ำท่าทั้ง 9 แห่ง อยู่ในระดับสูงสุด จึงเหมาะสมในการนำภาพถ่ายในช่วงนั้นมาศึกษาสภาพน้ำท่วมในปี พ.ศ. 2538 แผนที่พื้นที่เสี่ยงภัยน้ำท่วมของปีพ.ศ. 2538 ที่ได้จากการวิเคราะห์ด้วยซอฟแวร์ EASI/PACE ผลที่ได้จะถูกนำไปเปรียบเทียบกับความรุนแรงของคาบอุบัติซ้ำของน้ำท่วมปีพ.ศ. 2538 ของสถานี C.3, C.28, C.7A, และ S.5 แผนที่เสี่ยงภยน้ำท่วมที่ได้จึงเป็นค่าเฉลี่ยของความรุนแรงที่ได้จากการเปรียบเทียบค่าอุบัติซ้ำของอัตราการไหลของแม่น้ำ (Frequency of Annual Peak Discharge) และกราฟความสัมพันธ์ระหว่างอัตราการไหลของแม่น้ำและระดับน้ำ (Rating Curve)ดังรูปที่ 10 ของแต่ละสถานีแสดงให้เห็นถึงพื้นที่ที่มีความเสี่ยงมาก เสี่ยงปานกลาง และ

เสี่ยงต่ำตามลำดับ ของน้ำท่วมปี พ.ศ. 2538 ซึ่งสามารถเทียบเคียงได้กับความรุนแรงน้ำท่วมที่มีค่าอุบัติซ้ำ 50 ปี

การวิเคราะห์พื้นที่น้ำท่วมและจัดทำแผนที่พื้นที่เสี่ยงภัยน้ำท่วม

เพื่อความเข้าใจเกี่ยวกับน้ำท่วมในพื้นที่ศึกษาจึงมีการศึกษาน้ำท่วมในอดีตโดยเฉพาะ ปี พ.ศ. 2485, ปี 2521 ปี 2523, ปี 2526, และ ปี 2539, เปรียบเทียบกับข้อมูลที่ได้จากการวิเคราะห์ทางด้านอุตุนิยมวิทยาและอุทกวิทยาของพื้นที่ สภาพพื้นที่น้ำท่วมในอดีตมีดังต่อไปนี้ :

น้ำท่วมปี 2485

ในพื้นที่ศึกษาพบว่าน้ำท่วมครั้งที่รุนแรงที่สุดเท่าที่มีการบันทึกไว้น่าจะเป็นน้ำท่วมปี พ.ศ. 2485 ข้อมูลระดับน้ำที่สะพานพุทธยอดฟ้าจุฬาโลก มีระดับน้ำถึง 2.25 เมตร ซึ่งเป็นค่าที่สูงสุดของสถานีวัดน้ำนี้ และที่สถานีวัดน้ำที่จังหวัดนครสวรรค์ (C.2) มีระดับน้ำสูงกว่าน้ำท่วมปี พ.ศ. 2538 ถึง 1.5 เมตร อย่างไรก็ตามข้อมูลที่ได้จากการวัดในอดีตอาจจะมีความถูกต้องไม่มากนัก แต่น่าจะเป็นข้อมูลที่สำคัญเพราะนอกจากจะเป็นน้ำท่วมครั้งใหญ่ที่สุดเท่าที่มีในบันทึกแล้ว เรายังพบว่าสภาพลุ่มแม่น้ำเจ้าพระยาในปี พ.ศ. 2485 ยังเป็นธรรมชาติมากที่สุด บริเวณต้นน้ำยังไม่มีการสร้าง เขื่อน ๆ ใด และระบบป้องกันน้ำท่วมก็ยังไม่มี ดังนั้นข้อมูลน้ำท่วมในปีนี้ จึงควรศึกษาอ้างอิงเปรียบเทียบกับข้อมูลน้ำท่วมในปีต่อ ๆ ไป

น้ำท่วมปี 2521

มีฝนตกหนักบริเวณต้นน้ำบริเวณลุ่มแม่น้ำเจ้าพระยาตอนบน โดยเฉพาะในลุ่มน้ำสาขาแม่น้ำน่าน ลุ่มน้ำสาขาแม่น้ำยม ลุ่มน้ำสาขาแม่น้ำปิง และลุ่มน้ำสาขาแม่น้ำป่าสัก ที่สถานีวัดน้ำที่จังหวัดนครสวรรค์ (C.2) และจังหวัดชัยนาท (C.13) มีปริมาณการไหลสูงสุดที่ 3,500 ลบ. เมตร/วินาที และ 3,800 ลบ. เมตร/วินาที ตามลำดับ สถานีวัดน้ำที่จังหวัดอ่างทอง วัดปริมาณการไหลสูงสุดได้ 2,900 ลบ. เมตร/วินาที มีฝกตกหนักบริเวณพื้นที่คลองชัยนาท-ป่าสัก แม่น้ำลพบุรี ทำให้เกิดน้ำท่วมในบริเวณนี้เป็นเวลานาน กรุงเทพมหานครมีน้ำปกติ ไม่พบความเสียหายที่เกิดจากน้ำท่วม มีน้ำท่วมล้นฝั่งหลายบริเวณตั้งแต่จังหวัดชัยนาท ถึงจังหวัดพระนครศรีอยุธยา

น้ำท่วมปี 2523

มีน้ำท่วมหลายพื้นที่สาเหตุมาจากฝนตกหนักในพื้นที่นั้น ๆ และน้ำล้นฝั่งในบางแห่ง น้ำท่วมปี พ.ศ. 2523 พบว่าที่บริเวณจังหวัดนครสวรรค์มีอัตราการไหลของน้ำในแม่น้ำเจ้าพระยาประมาณ 4,400 ลบ. เมตร/วินาที และที่จังหวัดชัยนาทวัดได้ 3,800 ลบ. เมตร/วินาที พบว่าน้ำท่วมหนักบริเวณริมแม่น้ำเจ้าพระยาทั้งสองฝั่งตั้งแต่จังหวัดชัยนาทถึงจังหวัดอยุธยา ดังรูปที่ 5.11 น้ำท่วมครั้งนี้ได้ทำความเสียหายให้แก่พื้นที่เกษตรกรรมและพื้นที่อยู่อาศัย ตั้งแต่จังหวัดนครสวรรค์ ชัยนาท สิงห์บุรี อ่างทองและอยุธยา

น้ำท่วมปี 2526

พื้นที่กรุงเทพมหานคร ได้รับความเสียหายอย่างมากจากน้ำท่วมครั้งนี้ และในเวลาต่อมาจึงได้เกิดโครงการป้องกันน้ำท่วมทั้งฝั่งตะวันออกและฝั่งตะวันตกของแม่น้ำเจ้าพระยา สาเหตุของน้ำท่วมครั้งนี้เกิดจากปริมาณฝนตกอย่างหนักบริเวณต้นน้ำของลุ่มน้ำเจ้าพระยาตอนบนในราวเดือนกันยายนถึงเดือนพฤศจิกายน ปริมาณน้ำที่สถานีวัดน้ำที่จังหวัดชัยนาทวัดได้ 3,400 ลบ. เมตร/วินาที ในเดือนตุลาคมและพฤศจิกายน ปริมาณน้ำจากลุ่มน้ำสาขาสะแกกรังประมาณ 2,300 ลบ. เมตร/วินาที ได้ไหลสู่แม่น้ำเจ้าพระยาบริเวณลุ่มเจ้าพระยาตอนล่างมีฝนตกหนักในราวเดือนสิงหาคม ประมาณ 434 ม.ม. (ค่าเฉลี่ยประมาณ 170 ม.ม.) ทำให้เกิดน้ำท่วมหลายแห่ง และปริมาณฝนตกรวมตั้งแต่เดือนกันยายนถึงพฤศจิกายน สูงถึง 405 ม.ม. (ค่าเฉลี่ยประมาณ 215 ม.ม.) ทำให้ระดับน้ำที่สะพานพุทธยอดฟ้าฯ สูงถึง 2.04 เมตรในเดือนพฤศจิกายน มีผลทำให้พื้นที่ทั่วไปของกรุงเทพมหานครมีน้ำท่วมขัง

น้ำท่วมปี 2539

สาเหตุน้ำท่วมครั้งนี้เกิดจากมีปริมาณฝนตกหนักเฉพาะในหลายพื้นที่และน้ำล้นฝั่งในหลายแห่งดังรูปที่ 11 ความรุนแรงของน้ำท่วมปี 2539 นับได้ว่าไม่รุนแรง สังเกตได้จากปริมาณน้ำที่สถานีวัดน้ำที่จังหวัดนครสวรรค์ วัดได้แค่ 3,000 ลบ. เมตร/วินาที มีฝนตกหนักบริเวณพื้นที่ตะวันตกของแม่น้ำท่าจีน ทำให้ต้องมีการปล่อยน้ำจากเขื่อนกระเสียว จึงมีน้ำท่วมในหลายพื้นที่ของจังหวัดสุพรรณบุรี

วิเคราะห์แผนที่พื้นที่เสี่ยงภัยกรณีศึกษาน้ำท่วมปี พ.ศ. 2538

การวิเคราะห์และจัดทำแผนที่พื้นที่เสี่ยงภัยน้ำท่วมในพื้นที่ศึกษา ได้นำเอากรณีน้ำท่วมปี พ.ศ. 2538 มาเป็นกรณีศึกษาและวิเคราะห์อย่างละเอียด โดยนำมาเปรียบเทียบกับข้อมูลการเกิดน้ำท่วมปี พ.ศ. 248, ปี 2521 ปี 2523, ปี 2526, และ ปี 2539

น้ำท่วมปี พ.ศ. 2538 นับได้ว่ามีความรุนแรงครั้งหนึ่ง พื้นที่ถูกผลกระทบคาดว่ามีประมาณ 20,000 ตารางกิโลเมตร ตั้งแต่บริเวณต้นน้ำลุ่มแม่น้ำเจ้าพระยาตอนบน โดยเฉพาะบริเวณลุ่มน้ำสาขายมและน่าน จนถึงพื้นที่บริเวณที่ราบภาคกลางตอนล่าง เป็นที่น่าสังเกตว่าน้ำท่วมปี พ.ศ. 2538 มีผลกระทบต่อพื้นที่กรุงเทพมหานครเพียงบางจุดเท่านั้นและไม่รุนแรงนัก เมื่อเปรียบเทียบกับพื้นที่รอบนอกจากการประเมินความเสียหายที่มีต่อสาธารณูปโภค เช่น การซ่อมถนน สะพานและอื่น ๆ พบว่า มีความเสียหายถึง 6.4 พันล้านบาท ส่วนความเสียหายต่อเกษตรกรรม บ้านเรือน อุตสาหกรรมและอื่นๆ ไม่ทราบตัวเลขที่แน่นอนได้

สาเหตุของน้ำท่วมปี พ.ศ. 2538 เกิดจากพายุตกหนักตั้งแต่เดือนกรกฎาคม จนถึงเดือนกันยายนโดยเฉพาะในเดือนสิงหาคม บริเวณลุ่มน้ำสาขาน่านและป่าสักมีฝนตกลงมาหนักถึง 450 ม.ม. และ 345 ม.ม. ตามลำดับ ทำให้มีปริมาณน้ำที่สถานีวัดน้ำจังหวัดนครสวรรค์สูงถึง 4,800 ลบ.เมตร/วินาที ที่สถานีวัดน้ำจังหวัดชัยนาทวัดได้ 4,500 ลบ.เมตร/วินาที และสถานีวัดน้ำจังหวัดอ่างทองวัดได้ 2,700 ลบ. เมตร/

วินาที ทำให้น้ำล้นฝั่งตั้งแต่จังหวัดชัยนาทจนถึงจังหวัดอยุธยาพื้นที่น้ำท่วมครอบคลุมพื้นที่ส่วนใหญ่ของที่ราบภาคกลางตอนล่าง

แผนที่พื้นที่เสี่ยงภัยน้ำท่วมในพื้นที่ศึกษา

การศึกษาวิจัยครั้งนี้ได้มีการจัดทำแผนที่พื้นที่เสี่ยงภัยน้ำท่วมทั้งหมด 4 ระดับความรุนแรงตามค่าอุบัติซ้ำคือ 10 ปี, 25 ปี, 50 ปี, และ 100 ปี ซึ่งรายละเอียดของแผนที่พื้นที่เสี่ยงภัยน้ำท่วมได้มีการตรวจสอบระดับน้ำท่วมที่ปรากฏในสนาม ได้แก่ ข้อมูลที่วัดในสนาม ข้อมูลเก่าที่มีการบันทึกไว้และข้อมูลที่ได้จากการสอบถาม รูปที่ 12 แสดงข้อมูลการวัดระดับน้ำท่วมในสนามโดยใช้ระดับน้ำที่ปรากฏอยู่ เช่น ระดับน้ำจากเสาไฟฟ้า ระดับน้ำจากต้นไมยราบยักษ์ ระดับน้ำจากต้นข้างฟางลอยและระดับน้ำจากต้นโสน เป็นต้น

รูปที่ 13 แสดงแผนที่พื้นที่เสี่ยงภัยน้ำท่วมที่มีคาบอุบัติซ้ำ 10 ปี พบว่าน้ำท่วมที่มีระดับความรุนแรงขนาดนี้สามารถทำให้พื้นที่ในบริเวณที่ราบภาคกลางตอนล่างมีระดับความเสี่ยงต่อการถูกน้ำท่วมได้ 3 ระดับดังนี้ พื้นที่ที่มีความเสี่ยงสูง (High risk) ซึ่งจะมีระดับน้ำท่วมประมาณ 150-200 เซนติเมตร พื้นที่ส่วนใหญ่อยู่ในเขตอ่างทอง อยุธยา ปทุมธานี และบริเวณชายฝั่งทะเล คิดเป็นพื้นที่ประมาณ 40.30 ตารางกิโลเมตร พื้นที่ที่มีความเสี่ยงปานกลาง (Medium risk) ซึ่งจะมีระดับน้ำท่วมประมาณ 80-150 เซนติเมตร พื้นที่ส่วนใหญ่กระจายเป็นพื้นที่กว้างในเขตจังหวัดสุพรรณบุรี อ่างทอง อยุธยา ปทุมธานี และบริเวณชายฝั่งทะเลคิดเป็นพื้นที่ประมาณ 2,104.73 ตารางกิโลเมตร พื้นที่ที่มีความเสี่ยงต่ำ (Low risk) ซึ่งจะมีระดับน้ำท่วมน้อยกว่า 80 เซนติเมตร พื้นที่ส่วนใหญ่กระจายทั่วไปในบริเวณที่ราบภาคกลางตอนล่าง คิดเป็นพื้นที่ทั้งหมด 4,013.66 ตารางกิโลเมตร โดยคิดเป็นพื้นที่เสี่ยงภัยน้ำท่วมทั้งสิ้น 6,158.69 ตารางกิโลเมตร

รูปที่ 14 แสดงแผนที่พื้นที่เสี่ยงภัยน้ำท่วมที่มีคาบอุบัติซ้ำ 25 ปี พบว่าน้ำท่วมที่มีระดับความรุนแรง ขนาดนี้สามารถทำให้พื้นที่ในบริเวณที่ราบภาคกลางตอนล่างมีระดับความเสี่ยงต่อการถูกน้ำท่วมได้ 3 ระดับดังนี้ พื้นที่ที่มีความเสี่ยงสูง (High risk) ซึ่งจะมีระดับน้ำท่วมประมาณ 200-250 เซนติเมตร พื้นที่ส่วนใหญ่อยู่ในเขตฝั่งตะวันตกของแม่น้ำเจ้าพระยาแถบจังหวัดสุพรรณบุรี อ่างทอง อยุธยา ปทุมธานี และบริเวณชายฝั่งทะเล คิดเป็นพื้นที่ประมาณ 2,145.04 ตารางกิโลเมตร พื้นที่ที่มีความเสี่ยงปานกลาง (Medium risk) ซึ่งจะมีระดับน้ำท่วมประมาณ 100-200 เซนติเมตร พื้นที่ส่วนใหญ่อยู่ในเขตจังหวัดสิงห์บุรี อ่างทอง อยุธยา ปทุมธานี และจังหวัดฉะเชิงเทรา คิดเป็นพื้นที่ประมาณ 4,290.60 ตารางกิโลเมตร พื้นที่ที่มีความเสี่ยงต่ำ (Low risk) ซึ่งจะมีระดับน้ำท่วมน้อยกว่า 100 เซนติเมตร พื้นที่ส่วนใหญ่กระจายทั่วไปคิดเป็นพื้นที่ทั้งหมด 3,121.16 ตารางกิโลเมตร โดยคิดเป็นพื้นที่เสี่ยงภัยน้ำท่วมทั้งสิ้น 9,556.80 ตารางกิโลเมตร

รูปที่ 15 แสดงแผนที่พื้นที่เสี่ยงภัยน้ำท่วมที่มีคาบอุบัติซ้ำ 50 ปี พบว่าน้ำท่วมที่มีระดับความรุนแรงขนาดนี้สามารถทำให้พื้นที่ในบริเวณที่ราบภาคกลางตอนล่าง มีระดับความเสี่ยงต่อการถูกน้ำท่วมได้ 3 ระดับดังนี้ พื้นที่ที่มีความเสี่ยงสูง (High risk) ซึ่งจะมีระดับน้ำท่วมโดยเฉลี่ยมากกว่า 250 เซนติเมตร พื้นที่

ส่วนใหญ่อยู่ในแถบฝั่งตะวันตกของแม่น้ำเจ้าพระยาแถบจังหวัดสุพรรณบุรี อ่างทอง อยุธยา และปทุมธานี และฝั่งตะวันออกของแม่น้ำเจ้าพระยาแถบจังหวัดสิงห์บุรี อ่างทอง อยุธยา และปทุมธานี นนทบุรี คิดเป็นพื้นที่ทั้งหมด 2,805.05 ตารางกิโลเมตร พื้นที่ที่มีความเสี่ยงปานกลาง (Medium risk) ซึ่งจะมีระดับน้ำท่วมประมาณ 100-250 เซนติเมตร พื้นที่ส่วนใหญ่อยู่ในแถบจังหวัดสิงห์บุรี อ่างทอง อยุธยา ปทุมธานี นนทบุรี และกรุงเทพมหานคร คิดเป็นพื้นที่ทั้งหมดประมาณ 3,937.55 ตารางกิโลเมตร พื้นที่ที่มีความเสี่ยงต่ำ (Low risk) ซึ่งจะมีระดับน้ำท่วมโดยเฉลี่ยน้อยกว่า 100 เซนติเมตร พื้นที่ส่วนใหญ่กระจายทั่วไปคิดเป็นพื้นที่ทั้งหมด 2,814.20 ตารางกิโลเมตร โดยคิดเป็นพื้นที่เสี่ยงภัยน้ำท่วมทั้งสิ้น 9,556.80 ตารางกิโลเมตร

รูปที่ 16 แสดงแผนที่พื้นที่เสี่ยงภัยน้ำท่วมที่มีคาบอุบัติซ้ำ 100 ปี พบว่าน้ำท่วมที่มีระดับความรุนแรงขนาดนี้สามารถทำให้พื้นที่ในบริเวณที่ราบภาคกลางตอนล่าง มีระดับความเสี่ยงต่อการถูกน้ำท่วมได้ 3 ระดับดังนี้ พื้นที่ที่มีความเสี่ยงสูง (High risk) ซึ่งจะมีระดับน้ำท่วมโดยเฉลี่ยมากกว่า 300 เซนติเมตร พื้นที่ส่วนใหญ่อยู่ในแถบจังหวัดสิงห์บุรี อ่างทอง อยุธยา สุพรรณบุรี ปทุมธานี นนทบุรี กรุงเทพมหานคร ฉะเชิงเทรา และพื้นที่แถบชายฝั่งทะเล คิดเป็นพื้นที่ทั้งหมด 6,592.23 ตารางกิโลเมตร พื้นที่ที่มีความเสี่ยงปานกลาง (Medium risk) ซึ่งจะมีระดับน้ำท่วมประมาณ 150-300 เซนติเมตร พื้นที่ส่วนใหญ่อยู่ในแถบจังหวัดอยุธยา ปทุมธานี นครนายก ฉะเชิงเทรา ราชบุรี และนครปฐม คิดเป็นพื้นที่ทั้งหมดประมาณ 6,605.95 ตารางกิโลเมตร พื้นที่ที่มีความเสี่ยงต่ำ (Low risk) ซึ่งจะมีระดับน้ำท่วมโดยเฉลี่ยน้อยกว่า 150 เซนติเมตร พื้นที่ส่วนใหญ่กระจายทั่วไปคิดเป็นพื้นที่ทั้งหมด 6,845.14 ตารางกิโลเมตร โดยคิดเป็นพื้นที่เสี่ยงภัยน้ำท่วมทั้งสิ้น 20,043.32 ตารางกิโลเมตร

แบบจำลอง 3 มิติของสภาพน้ำท่วม

ข้อมูลระดับความสูงของพื้นที่ศึกษาที่ได้จากข้อมูลแผนที่ภูมิประเทศของกรมแผนที่ทหาร มาตราส่วน 1:50,000 ได้ถูกนำเข้าสู่ระบบสารสนเทศภูมิศาสตร์ และได้ถูกนำไปวิเคราะห์ทำแบบจำลองความสูงของพื้นที่ (Digital Elevation Model : DEM) โดยใช้ซอฟแวร์ EASI/PACE ข้อมูลที่ได้จะถูกนำไปซ้อนทับโดยข้อมูลภาพดาวเทียมหรือแผนที่พื้นที่เสี่ยงภัยน้ำท่วม เราสามารถใช้โปรแกรม Fly ในซอฟแวร์ EASI/PACE เพื่อทำแบบจำลอง 3 มิติของสภาพน้ำท่วมในพื้นที่ศึกษาสามารถเคลื่อนที่ได้เหมือนกับการถ่ายภาพจากที่สูงโดยเครื่องบินดังรูปที่ 17 ข้อมูลแบบจำลอง 3 มิติของสภาพน้ำท่วมสามารถนำไปประยุกต์ใช้กับการตรวจการณ์สภาพน้ำท่วมได้ หากเราสามารถได้ภาพดาวเทียมจากสถานีภาคพื้นที่ดินได้โดยตรงและส่งข้อมูลมาวิเคราะห์ เราก็สามารถตรวจการสภาพน้ำท่วมได้ทันทีทันใดเหมือนนั่งดูอยู่บนเครื่องบิน ซึ่งช่วยให้เราเข้าใจสภาพน้ำท่วมได้ดียิ่งขึ้นและยังช่วยให้การวิเคราะห์คาดการณ์น้ำท่วม (Flood Forecasting) และการเตือนภัยน้ำท่วม (Flood Warning) ได้ถูกต้องแม่นยำยิ่งขึ้น

สรุปและวิจารณ์

แผนที่พื้นที่เสี่ยงภัยที่จัดทำขึ้นในการศึกษาครั้งนี้สามารถนำไปใช้เป็นเครื่องมือในการเตือนภัยให้กับประชาชนที่อาศัยอยู่ในบริเวณพื้นที่ที่เสี่ยงภัยได้ตระหนักถึงอันตรายและเตรียมพร้อมที่จะเผชิญสถานการณ์ภัยพิบัติเพื่อประโยชน์ในการลดความสูญเสียที่จะเกิดขึ้น และเป็นข้อมูลให้กับหน่วยงานต่าง ๆ ที่เกี่ยวข้องในการจัดทำแผนรองรับเพื่อป้องกันและบรรเทาความเสียหายอันจะเกิดขึ้นในอนาคต นอกจากนี้แผนที่พื้นที่เสี่ยงภัยน้ำท่วมยังเป็นข้อมูลพื้นฐานให้หน่วยงานทั้งของภาครัฐและภาคเอกชนสามารถนำไปใช้เป็นเครื่องมือในการวางแผนในระดับต่าง ๆ ได้แก่ วางแผนการใช้ที่ดินทางการเกษตร การวางแผนผังเมือง การวางแผนจัดเก็บภาษีน้ำท่วม การวางแผนการดำเนินงานก่อสร้างโครงสร้างพื้นที่ราบทางกายภาพต่าง ๆ เช่น ถนน ทางรถไฟ และคันคลองชลประทาน เพื่อเป็นการป้องกันไม่ให้มีการก่อสร้างที่อยู่อาศัย โรงงานอุตสาหกรรมหรือทำเกษตรกรรมในพื้นที่ที่มีความเสี่ยงต่อการเกิดภัยธรรมชาติสูง

แผนที่พื้นที่เสี่ยงภัยน้ำท่วม มาตราส่วน 1:50,000 ที่ได้จากการศึกษาครั้งนี้ สามารถนำไปใช้ประโยชน์ในการกำหนดมาตรฐานการออกแบบระบบระบายน้ำ การควบคุมการใช้ที่ดิน การวางผังเมือง การจัดเก็บภาษีน้ำท่วมทั้งในชุมชนเมืองและชนบท การกำหนดมาตรฐานการประกันภัยน้ำท่วม รวมทั้งข้อเสนอแนะแนวทางการบริหารจัดการลุ่มน้ำอย่างยั่งยืนโดยเฉพาะการป้องกันน้ำท่วม ที่มีขนาดความรุนแรงมากขึ้น จำเป็นต้องใช้มาตรการบริหารจัดการลุ่มน้ำท่วม (Floodplain Management) ซึ่งจำเป็นต้องอาศัยแผนที่พื้นที่เสี่ยงภัยเป็นข้อมูลพื้นฐานเป็นหลัก อย่างไรก็ตามแผนที่พื้นที่เสี่ยงภัยที่ได้จากการศึกษานี้คงต้องมีการเก็บข้อมูลเพิ่มเติม เพื่อการปรับปรุงให้มีความทันสมัยมากยิ่งขึ้นโดยเฉพาะ ควรจะมีการจัดทำแผนที่เสี่ยงภัยน้ำท่วมในมาตราส่วนขั้นรายละเอียดมากยิ่งขึ้น เช่น 1:4,000 หรือ 1:5,000 เป็นต้น

<u>กิตติกรรมประกาศ</u>

งานวิจัยชุดนี้มิอาจดำเนินการสำเร็จลุล่วงได้ หากไม่ได้รับการสนับสนุนเงินทุนวิจัย จากสำนักงานกองทุนสนับสนุนการวิจัย (สกว.) ขอขอบพระคุณนักวิจัยและผู้ช่วยวิจัยทุกคนที่ช่วยให้งานดำเนินงานออกมาตามเป้าหมายและภาควิชาธรณีวิทยา คณะวิทยาศาสตร์ จุฬาลงกรณ์มหาวิทยาลัยที่ให้ใช้สถานที่ห้องปฏิบัติการวิจัย เพื่อใช้ในการศึกษาวิจัยในครั้งนี้

เอกสารอ้างอิง

ESCAP. 1991. Manual and Guidelines for comprehensive flood Loss prevention and Management, United Nations Development Programme. 92p.

JICA. 1998. The study on integrated plan for flood mitigation on Chao Phraya River Basin (Interem Report) CTI Engineering Co., Ltd. and INA Corporation.

Ohkura, H., Haruyama, S., Oya, M., Vibulsresth, S., Simking, R., and Suwanwerakamtorn, R. 1989. A Geomorphological Survey Map of the Central Plain of Thailand Sholwing Classification of Flood-indundated Areas. In: Research Notes of the National Research Center for Disaster Prevention No.83. National Research Center for Disaster Prevention, Japan

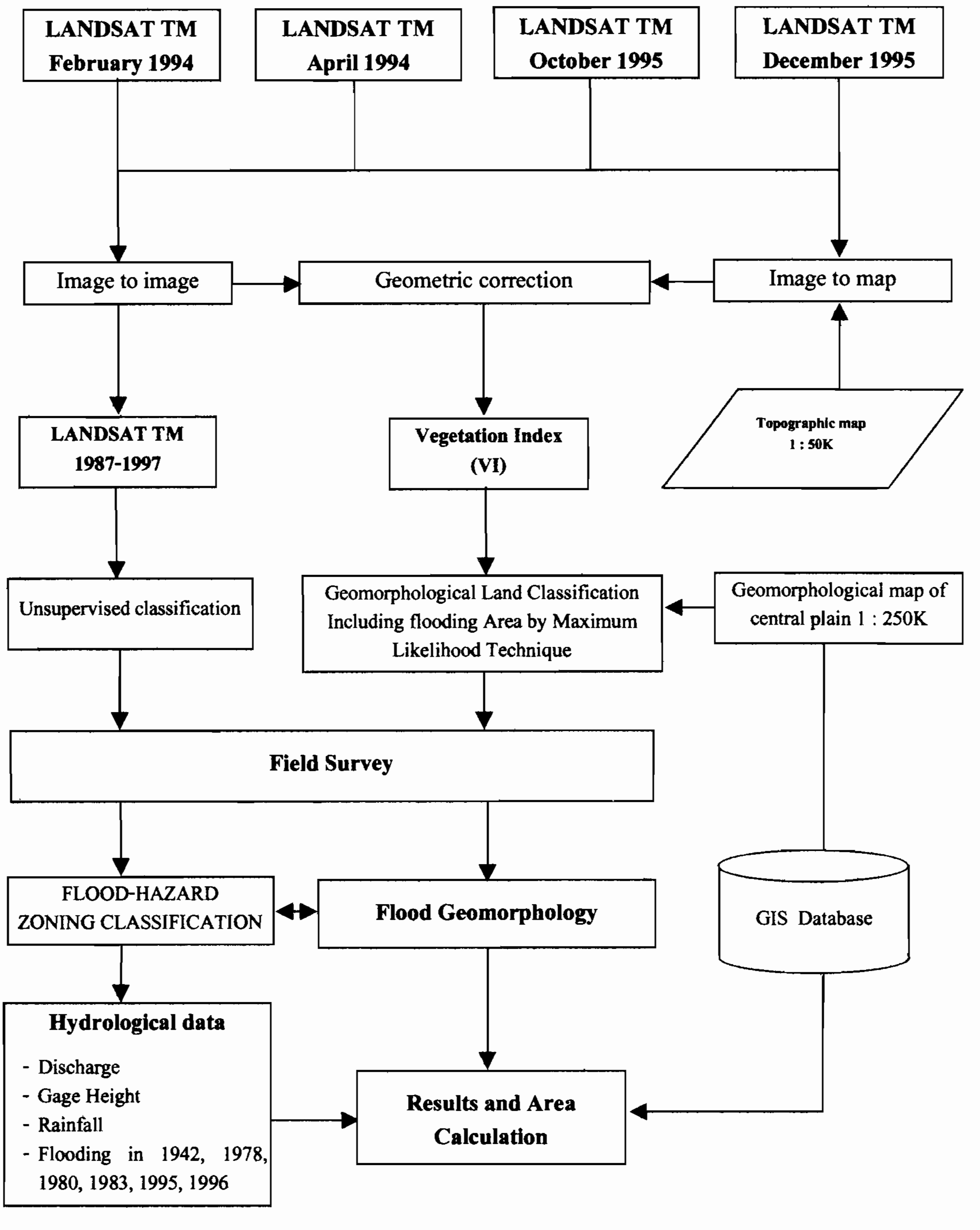
Somboon, J.R.P. 1990. Geomorphology of The Chao Phraya Delta. Unpublished Ph.D. dissertation, Kyoto University

สำนักงานคณะกรรมการพัฒนาเศรษฐกิจและสังคมแห่งชาติ 2540 การจัดการสาธารณภัยในภาคใต้ของประเทศไทย คณะทรัพยากรธรรมชาติ มหาวิทยาลัยสงขลานครินทร์, 461น.

สำนักนโยบายและแผนสิ่งแวดล้อม 2539 รายงานฉบับสมบูรณ์โครงการศึกาเพื่อกำหนดพื้นที่ที่เสี่ยงต่อการเกิดอุทกภัยและภัยธรรมชาติ ในเขตลุ่มน้ำภาคตะวันออกเฉียงเหนือ คณะวนศาสตร์ มหาวิทยาลัยเกษตรศาสตร์, 380น.

สำนักนโยบายและแผนสิ่งแวดล้อม 2540 รายงานฉบับสมบูรณ์โครงการศึกาเพื่อกำหนดพื้นที่ที่เสี่ยงต่อการเกิดอุทกภัยและภัยธรรมชาติ (ในเขตลุ่มน้ำภาคตะวันออกและภาคตะวันตก) บริษัท บรี ดิเวลลอปเมนท์ คอนซัลแตนท์ จำกัด, 318น.

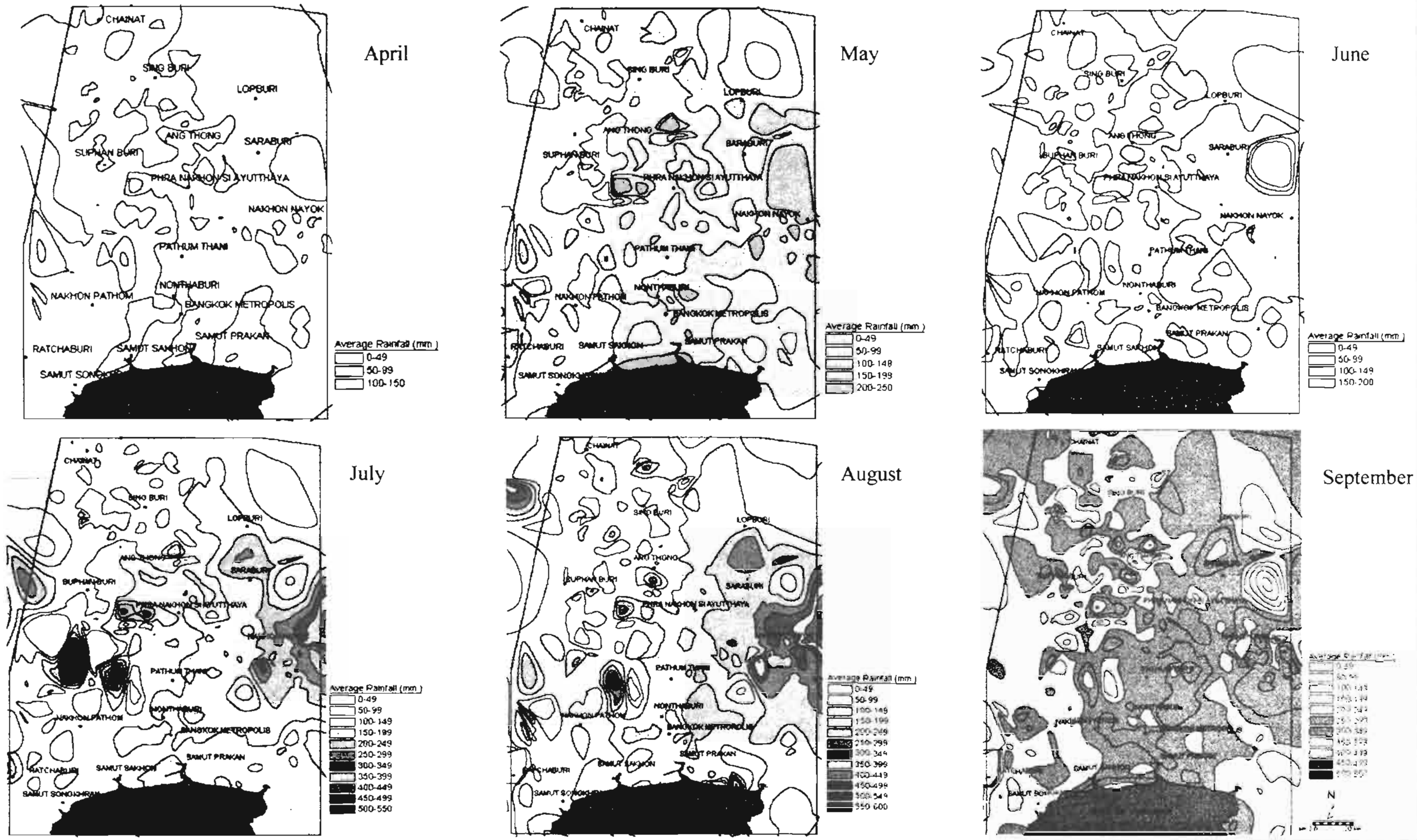
สำนักนโยบายและแผนสิ่งแวดล้อม 2542 รายงานฉบับสมบูรณ์โครงการศึกาเพื่อกำหนดพื้นที่ที่เสี่ยงต่อการเกิดอุทกภัยและภัยธรรมชาติ (ในเขตลุ่มน้ำภาคกลาง) สถาบันวิจัยวิทยาศาสตร์และเทคโนโลยีแห่งประเทศไทย, 505น.



TRF PROJECT/ Geomorphology Aspects Affecting the Occurrence of Floods and Influencing the Drainage in the Lower Central Plain, Thailand

Center for Disaster and Land Information Studies
Department of Geology, Chulalongkorn University

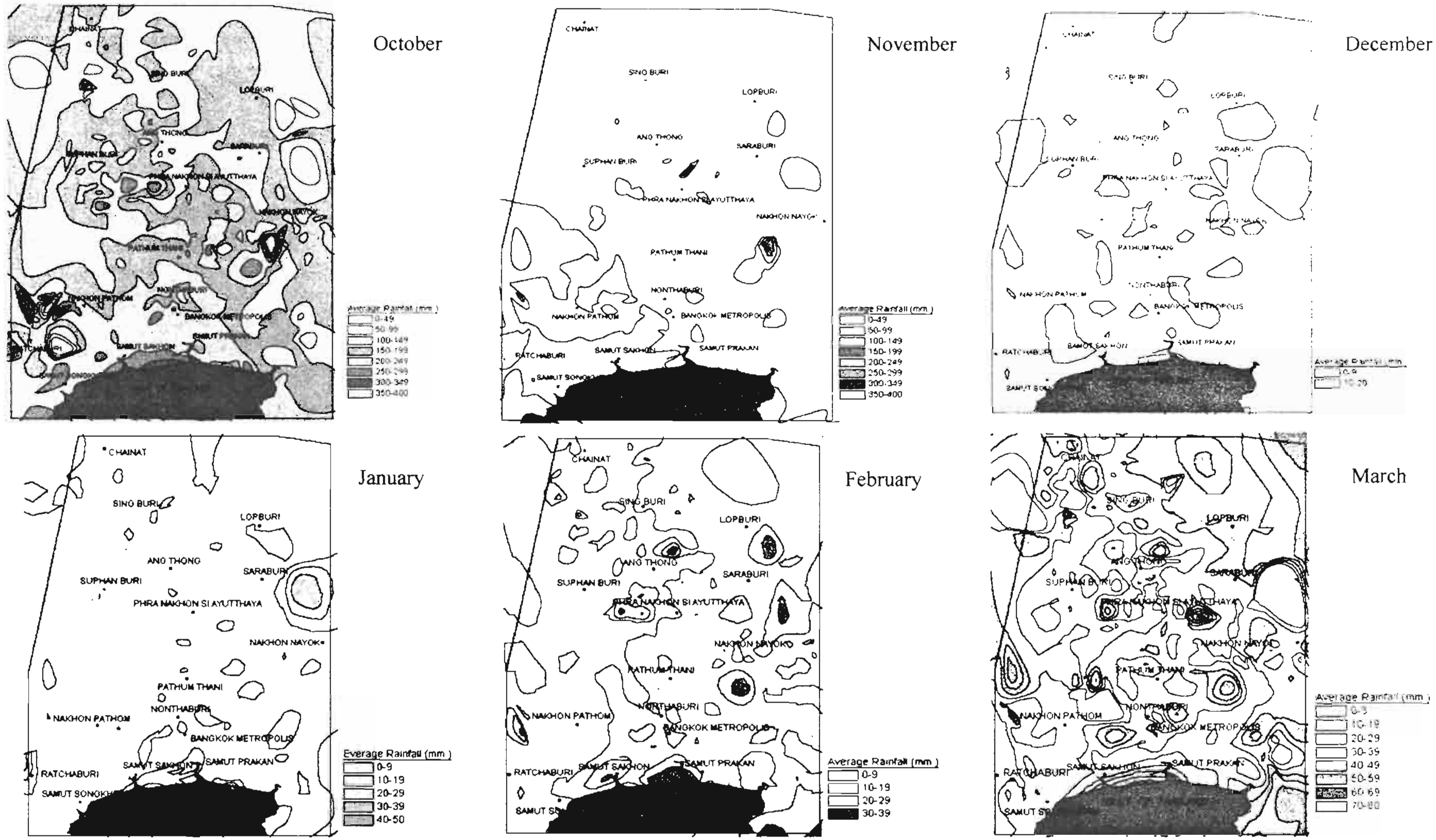
รูปที่ 1
ขั้นตอนการวิเคราะห์แผนที่พื้นที่เสี่ยงภัยน้ำท่วม ในพื้นที่ศึกษา



TRF PROJECT/ Geomorphology Aspects Affecting the Occurrence of Floods and Influencing the Drainage in the Lower Central Plain, Thailand

Center for Disaster and Land Information Studies
Department of Geology, Chulalongkorn University

รูปที่ 3
การกระจายตัวของปริมาณน้ำฝนรายเดือนเฉลี่ย ในคาบ 40 ปี บริเวณพื้นที่ศึกษา

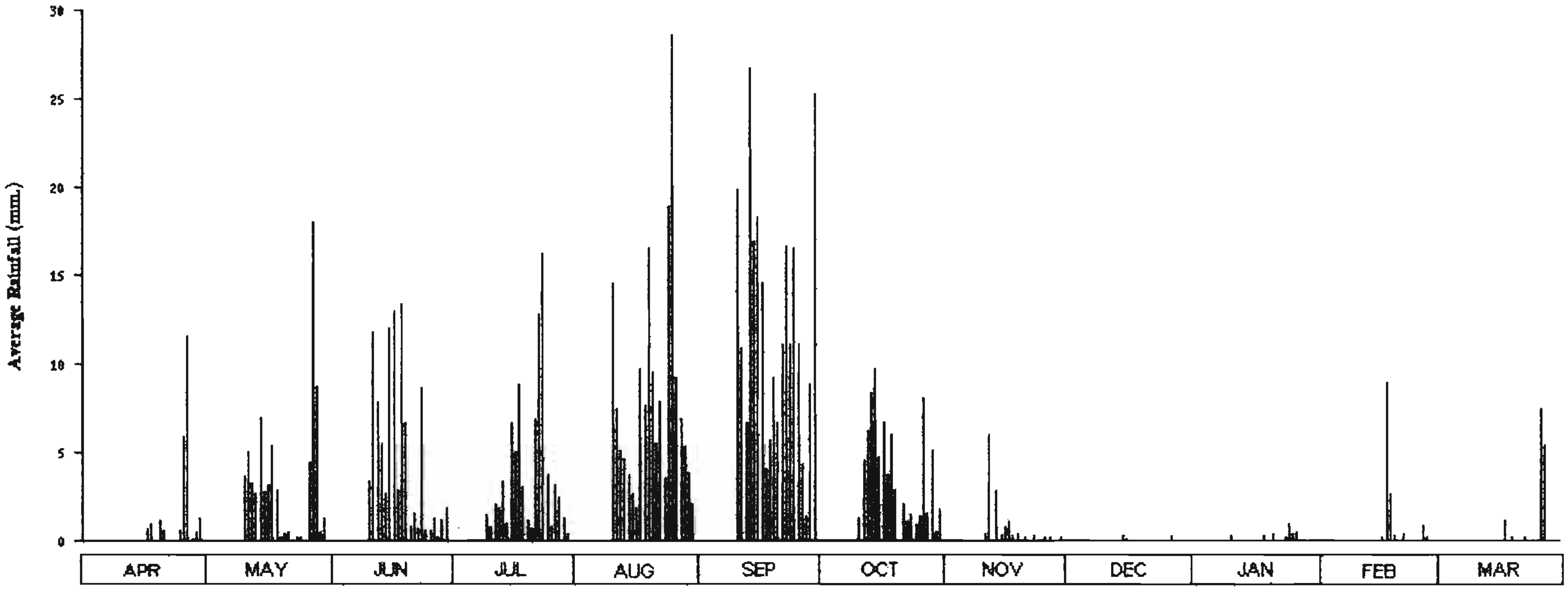


TRF PROJECT/ Geomorphology Aspects Affecting the Occurrence of Floods and Influencing the Drainage in the Lower Central Plain, Thailand

Center for Disaster and Land Information Studies
Department of Geology, Chulalongkorn University

รูปที่ 3 (ต่อ)
การกระจายตัวของปริมาณน้ำฝนรายเดือนเฉลี่ย ในคาบ 40 ปี บริเวณพื้นที่ศึกษา

Average Daily Rainfall Year, 1995 (April1, 1995 to March 31, 1996)

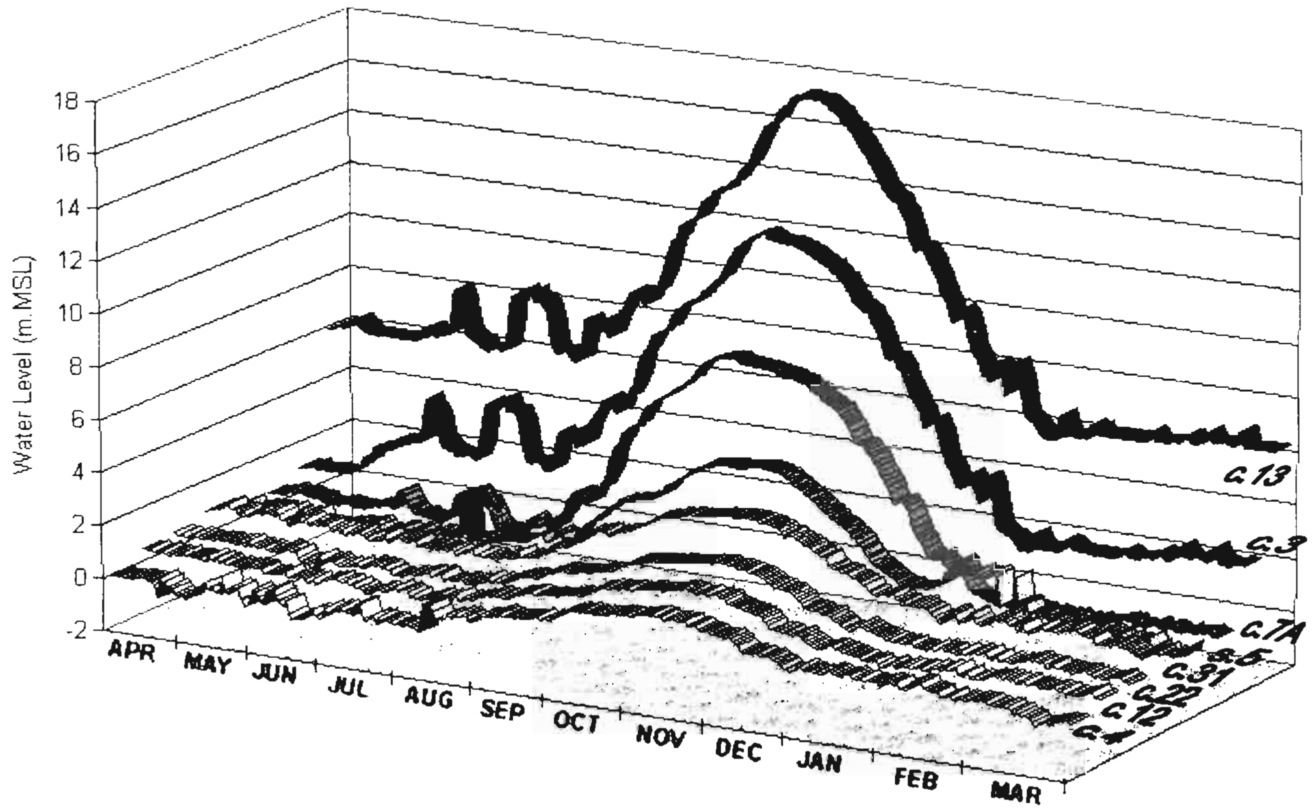


TRF PROJECT/ Geomorphology Aspects Affecting the Occurrence of Floods and Influencing the Drainage in the Lower Central Plain, Thailand

Center for Disaster and Land Information Studies
Department of Geology, Chulalongkorn University

รูปที่ 4
กราฟแสดงปริมาณฝนเฉลี่ยรายวันของพื้นที่ศึกษา ตั้งแต่เดือนเมษายน 2538–มีนาคม 2539

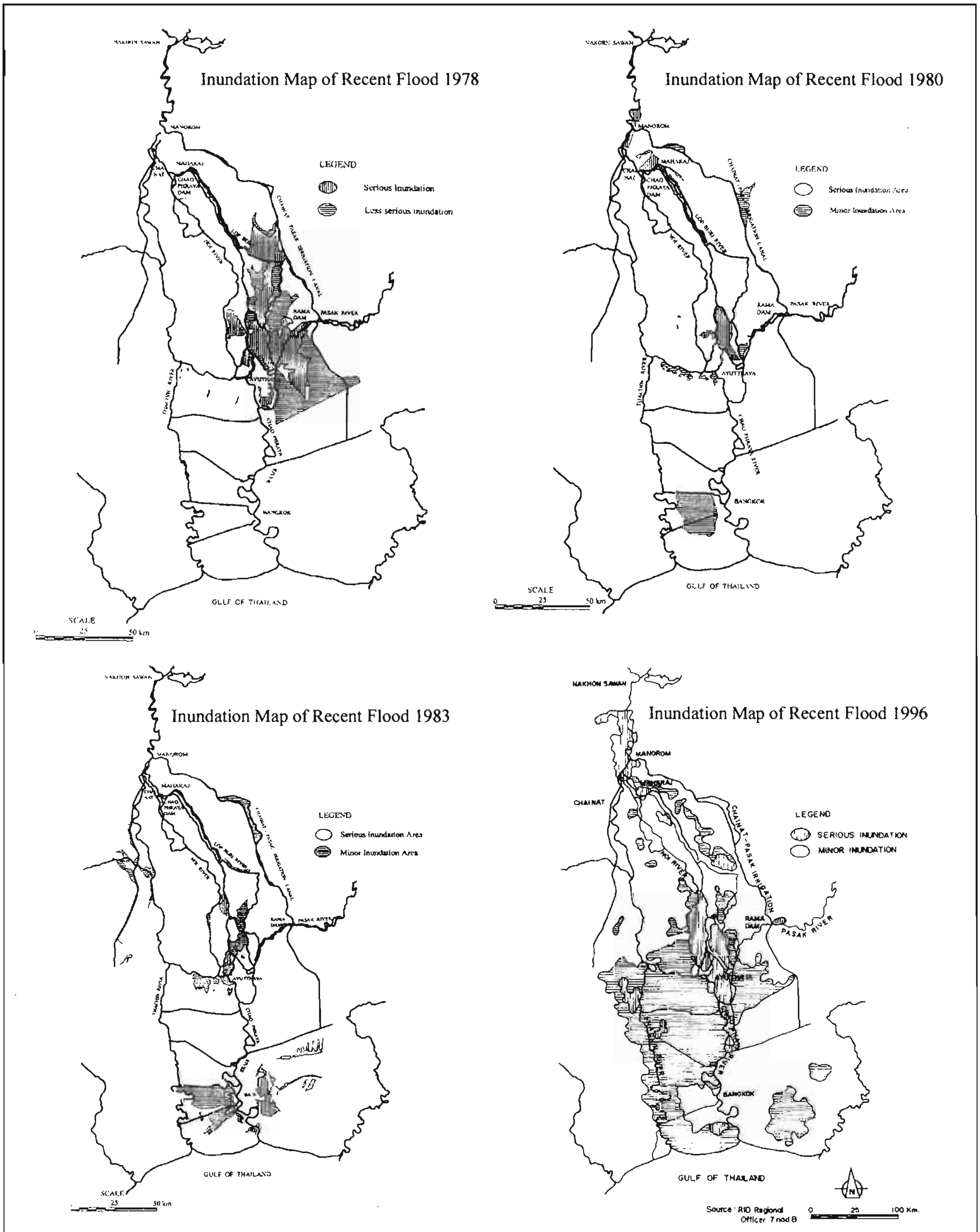
Maximum Gage Height In Water Year April1, 1995 to March 31, 1996
of Chao Phraya River



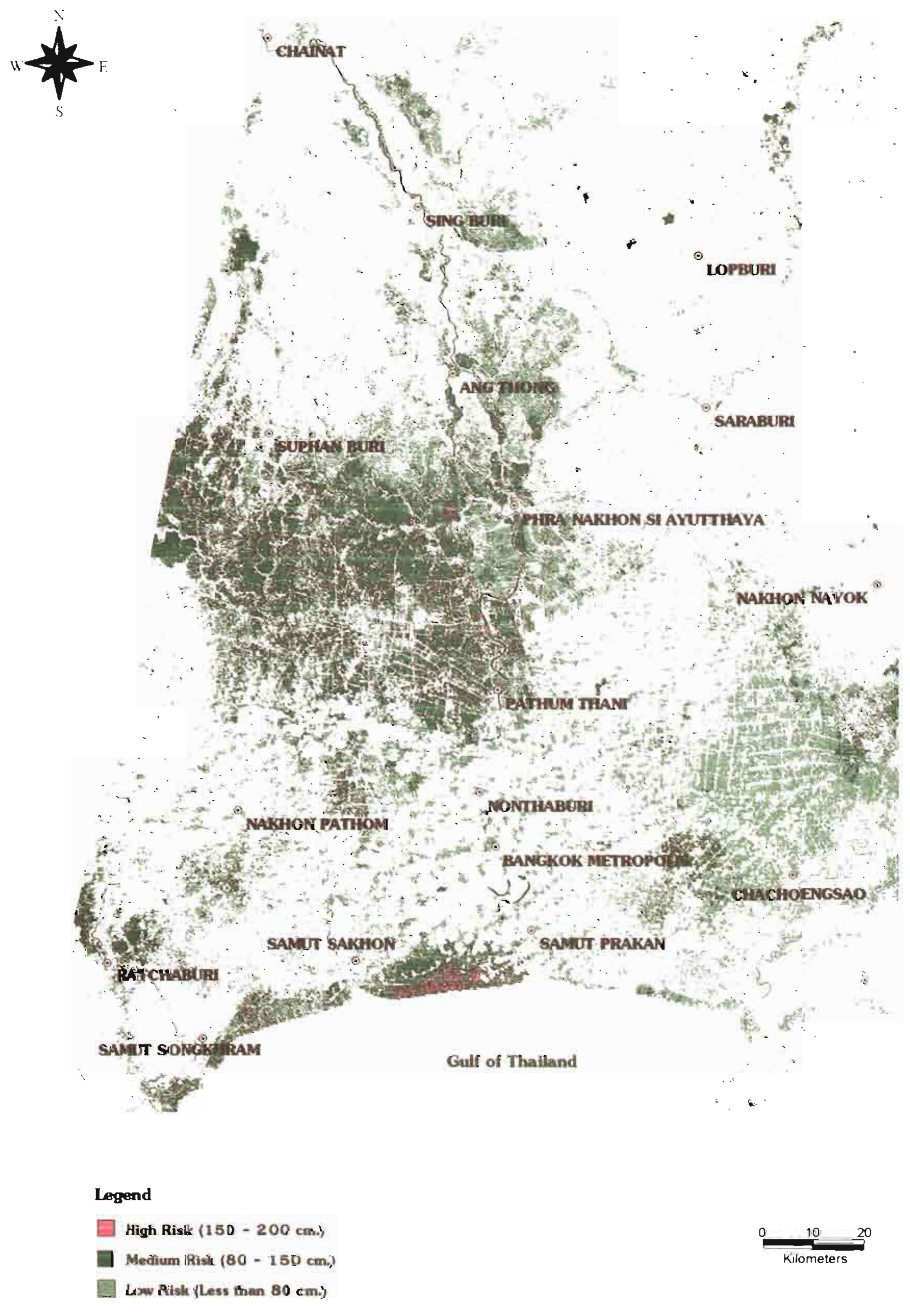
TRF PROJECT/ Geomorphology Aspects Affecting
the Occurrence of Floods and Influencing
the Drainage in the Lower Central Plain, Thailand

Center for Disaster and Land Information Studies
Department of Geology, Chulalongkorn University

รูปที่ 9
ข้อมูลระดับน้ำรายวันของสถานีวัดน้ำท่าหลักทั้ง 8 แห่ง
ตั้งแต่เดือน เมษายน 2538-มีนาคม 2539



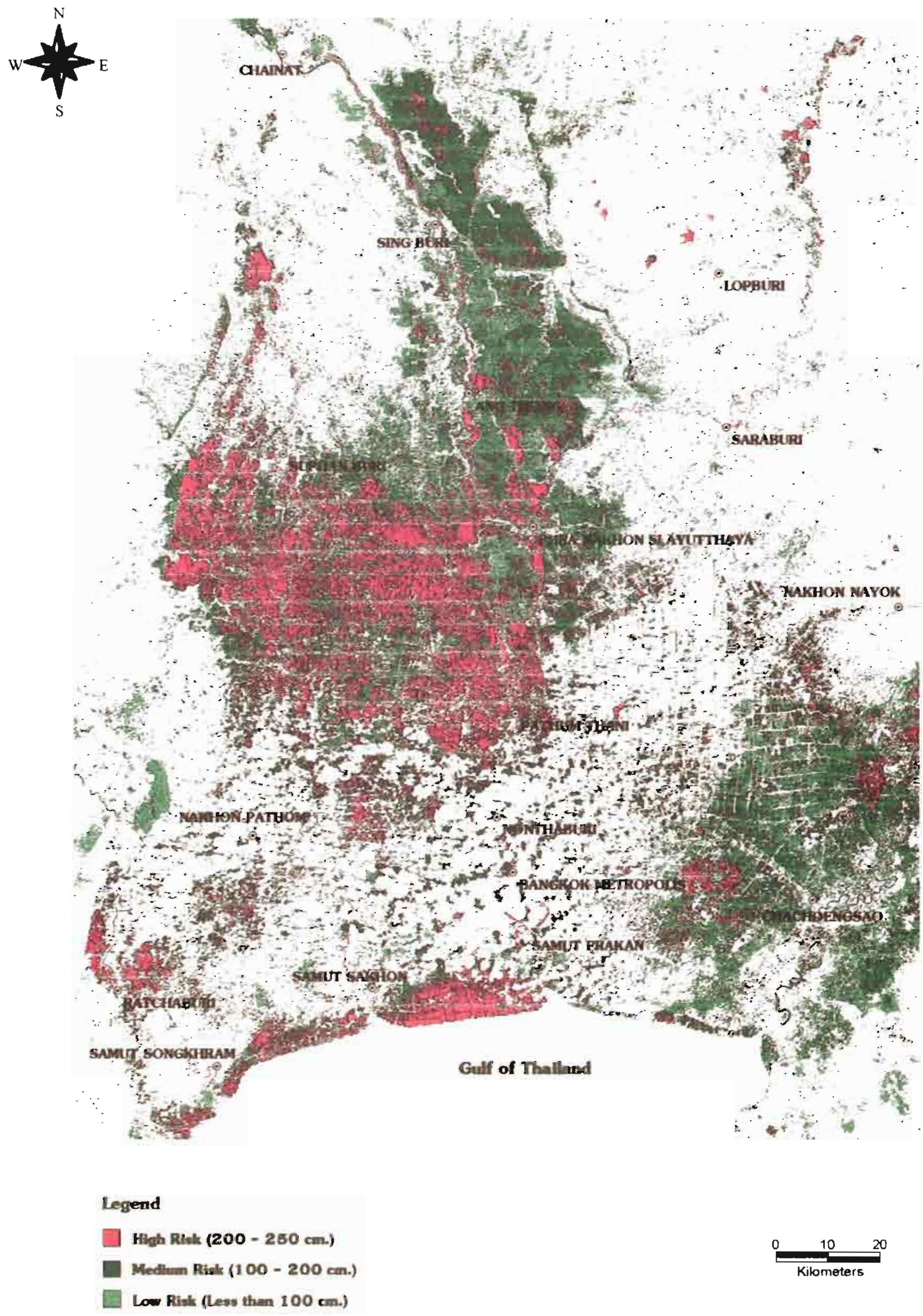
TRF PROJECT/ Geomorphology Aspects Affecting the Occurrence of Floods and Influencing the Drainage in the Lower Central Plain, Thailand	**รูปที่ 11** **พื้นที่ที่ได้รับความเสียหายจากน้ำท่วมปี พ.ศ.2521 พ.ศ.2523 พ.ศ.2526 และ พ.ศ.2539 (อ้างอิงจาก JICA, 1998)**
Center for Disaster and Land Information Studies **Department of Geology, Chulalongkorn University**	



TRF PROJECT/ Geomorphological Aspects Affecting the Occurrence of Floods and Influencing the Drainage in the Lower Central Plain, Thailand

Center for Disaster and Land Information Studies
Department of Geology, Chulalongkorn University

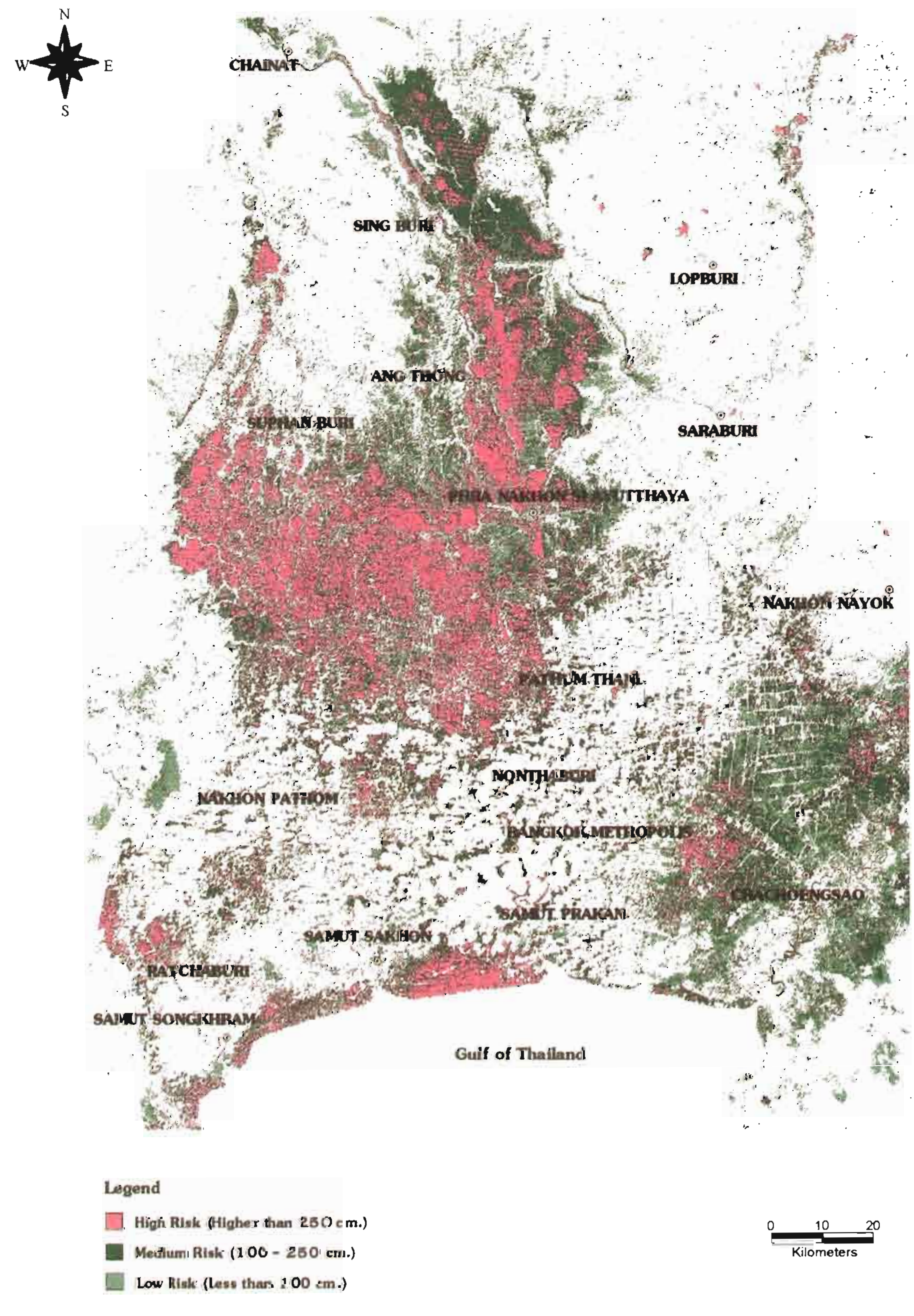
รูปที่ 13
แผนที่เสี่ยงน้ำท่วมที่มีคาบอุบัติซ้ำ 10 ปี



TRF PROJECT/ Geomorphological Aspects Affecting the Occurrence of Floods and Influencing the Drainage in the Lower Central Plain, Thailand

Center for Disaster and Land Information Studies
Department of Geology, Chulalongkorn University

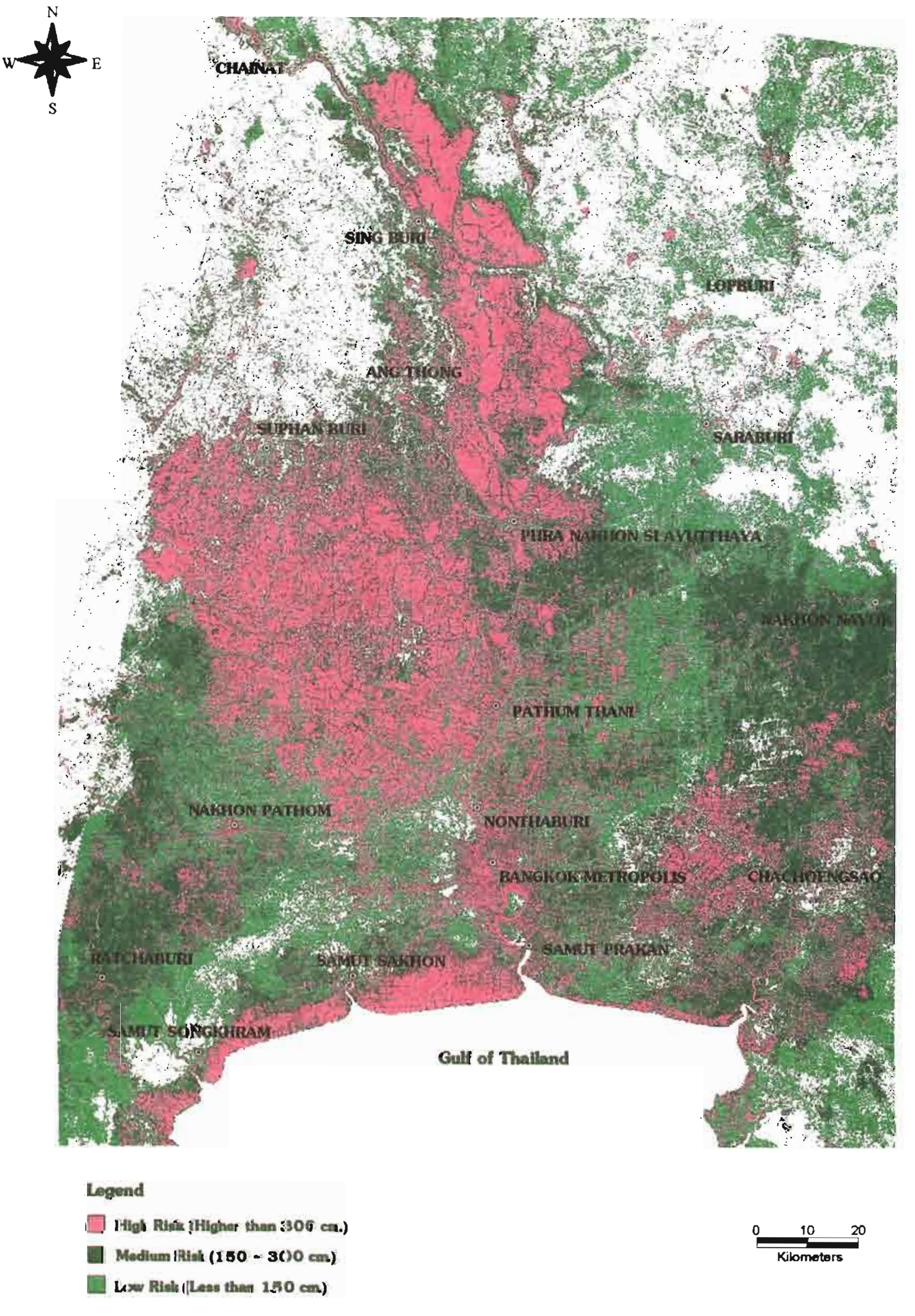
รูปที่ 14
แผนที่เสี่ยงน้ำท่วมที่มีคาบอุบัติซ้ำ 25 ปี



TRF PROJECT/ Geomorphological Aspects Affecting the Occurrence of Floods and Influencing the Drainage in the Lower Central Plain, Thailand

Center for Disaster and Land Information Studies
Department of Geology, Chulalongkorn University

รูปที่ 15
แผนที่เสี่ยงน้ำท่วมที่มีคาบอุบัติซ้ำ 50 ปี



TRF PROJECT/ Geomorphological Aspects Affecting the Occurrence of Floods and Influencing the Drainage in the Lower Central Plain, Thailand

Center for Disaster and Land Information Studies
Department of Geology, Chulalongkorn University

รูปที่ 16
แผนที่เสี่ยงน้ำท่วมที่มีคาบอุบัติซ้ำ 100 ปี

Flood management and flood prone rice systems in the Chao Phraya delta

Chatchom Chompadist[1], Francois Molle[2] and Sripen Durongdet[3]

ระบบการปลูกข้าวในพื้นที่น้ำท่วมขังและการจัดการน้ำท่วมในที่ราบลุ่มเจ้าพระยา

ชัชชม ชมประดิษฐ์, ฟรังซัว โมล, ศรีเพ็ญ ดุรงค์เดช

Abstract: *A total of 300,000 ha in the Chao Phraya delta are still cropped with deep-water and floating rice varieties. The paper describes the specific patterns of water management required by such systems and provides information on current varieties and cropping techniques used. A water balance of the delta in the wet season is achieved, in order to discuss the role of the flood prone area in flood mitigation. It is shown how collected data can be used to monitor how much data is stored and where there is still buffering capacity. Last, the paper shows different possible paths of evolution of these areas in order to intensify production and farmers' incomes.*

บทคัดย่อ

ในที่ราบลุ่มแม่น้ำเจ้าพระยายังคงมีพื้นที่ประมาณ 1,875,000 ไร่ (300,000 ha) ที่ยังคงปลูกข้าวพันธุ์พื้นเมืองที่เป็นข้าวทนน้ำลึกและข้าวขึ้นน้ำ (ฟางลอย) ผลงานวิจัยนี้อธิบายถึงรูปแบบเฉพาะของการจัดการน้ำในพื้นที่ดังกล่าวนี้ และรวมถึงสารสนเทศของพันธุ์ข้าว และวิธีการที่ใช้ปลูกข้าวอยู่ในปัจจุบัน

แสดงการทำสมดุลของน้ำในที่ราบลุ่มแม่น้ำเจ้าพระยาในฤดูฝน เพื่อพิจารณาหน้าที่ของพื้นที่ที่เป็นที่ลุ่มน้ำขังนี้ช่วยบรรเทาอุทกภัย ซึ่งแสดงให้เห็นว่าข้อมูลที่ได้บันทึกอยู่นั้น สามารถนำมาใช้ติดตามถึง ปริมาณน้ำที่เก็บขังอยู่ และยังมีที่ไหนที่ยังมีศักยภาพรับน้ำเพิ่มได้อีก

[1] Royal Irrigation Department, Bangkok

[2] IRD (Institut de Recherche pour le Développement), Kasetsart University

[3] Department of Geography, Kasetsart University

สุดท้ายในรายงานนี้ แสดงให้ทราบถึงความเปลี่ยนแปลงที่ปรากฏให้เห็น แนวทางที่เป็นไปได้ ต่าง ๆ เพื่อที่จะทำให้ผลผลิตและรายได้เพิ่มขึ้นในพื้นที่เหล่านั้น

ระบบการปลูกข้าวในพื้นที่น้ำท่วมขังและการจัดการน้ำท่วมในที่ราบลุ่มเจ้าพระยา

คำนำ

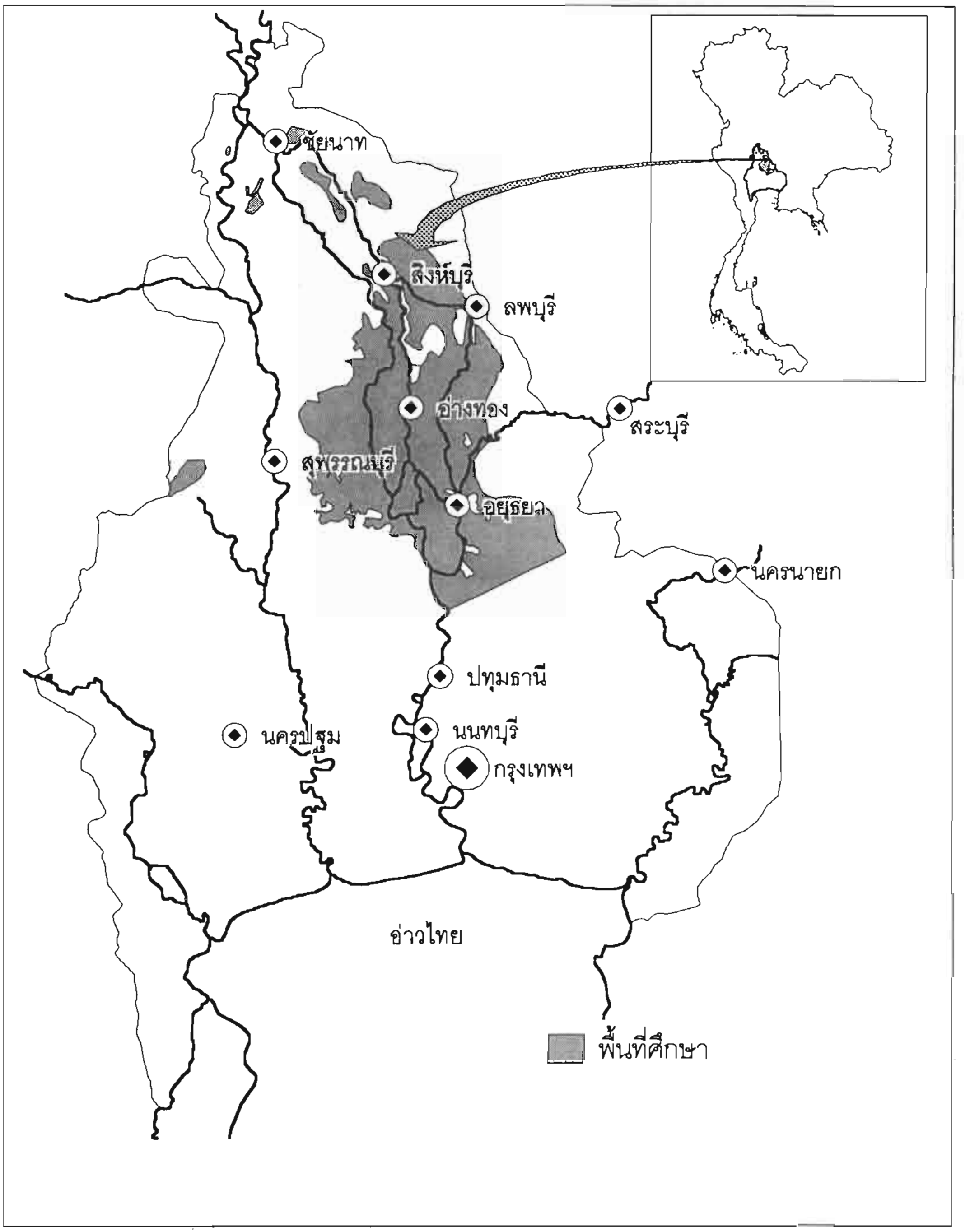
สภาพอุทกวิทยาตามธรรมชาติ ในเขตที่ราบดินดอนสามเหลี่ยมแม่น้ำเจ้าพระยาได้เปลี่ยนแปลงไปมากในช่วงคริสตศตวรรษที่ผ่านมานี้ อันเป็นผลเนื่องมาจากการดำเนินงานพัฒนาระบบชลประทานระยะต่างๆของโครงการชลประทานเจ้าพระยาใหญ่รวมทั้งการก่อสร้างเขื่อนขนาดใหญ่สองแห่งในตอนบนของลุ่มน้ำเจ้าพระยา(เขื่อนภูมิพลที่ก่อสร้างแล้วเสร็จในปีค.ศ.1968และเขื่อนสิริกิติ์ที่ก่อสร้างแล้วเสร็จในปี ค.ศ.1976) การพัฒนาระบบชลประทานสมัยใหม่เอื้ออำนวยการยอมรับและการแพร่ขยายพันธุ์ข้าวลูกผสมที่ให้ผลผลิตสูง(HYVs)ในเขตพื้นที่นี้เกือบทั้งหมด การปรับปรุงพัฒนาระบบระบายน้ำเริ่มค่อยๆมีความสำคัญมากขึ้นตั้งแต่ช่วงปลายคริสตทศวรรษที่ 60 นี้

แต่อย่างไรก็ตาม ในเขตที่ราบภาคกลางซึ่งมีพื้นที่หลายแห่งเป็นที่ลุ่มต่ำ ระบายน้ำไม่ดีหรือน้ำท่วมขัง ยังคงมีการเพาะปลูกข้าวพันธุ์พื้นเมือง(TV)รวมทั้งข้าวพันธุ์ทนน้ำลึก(DWR-เหมาะสมสำหรับระดับน้ำลึกระหว่าง 50-100 เซนติเมตร)และข้าวพันธุ์ขึ้นน้ำหรือข้าวพันธุ์ฟางลอย(FR-สามารถปรับตัวได้ในระดับน้ำลึกระหว่าง 100-350 เซนติเมตรและมีความสามารถยืดปล้องยาวอย่างรวดเร็ว) พื้นที่ที่ปลูกข้าวพันธุ์พื้นเมืองมีอยู่ประมาณ 400,000 เฮกตาร์(2,500,000 ไร่) โดยมากกว่าครึ่งหนึ่งตั้งอยู่ในเขตพื้นที่ราบลุ่มของแม่น้ำเจ้าพระยาและแม่น้ำลพบุรี(ภาพที่ 1) ซึ่งมีพื้นที่ปลูกข้าวพันธุ์พื้นเมืองรวมกันทั้งหมดถึง 300,000 เฮกตาร์(ประมาณ 2,000,000 ไร่)

ในปัจจุบันการเกิดภาวะ "น้ำท่วมขัง" มิได้เกิดจากน้ำไหลท่วมล้นตลิ่งของแม่น้ำดังแต่ก่อนเท่านั้นแต่ดูเหมือนว่า อาทิเช่น สถานะการณ์ในพื้นที่แม่น้ำสายหลักต่างๆ -พื้นที่ร่องน้ำระหว่างคันดิน- แสดงให้เห็นอย่างชัดเจน(หรืออย่างน้อยอาจจะแสดง)พื้นที่ภายในซึ่งมีการระบายไม่สมบูรณ์เต็มที่ พื้นที่เหล่านี้ถูกป้องกันน้ำท่วมจากแม่น้ำโดยคันดิน แต่ในอีกด้านหนึ่งไม่สามารถระบายน้ำที่มาจากแหล่งต่างๆและที่สะสมอยู่ภายในออกไปได้ ด้วยเหตุนั้น การแก้ไขปัญหาที่ช่วยให้การเพาะปลูกข้าวในพื้นที่น้ำท่วมขังนี้ยังคงปฏิบัติต่อไปได้จึงเลือกใช้วิธีการควบคุม ซึ่งประกอบด้วย อัตราการเพิ่มสูงขึ้นของน้ำ ระดับน้ำท่วมขังสูงสุด และความยาวนานของน้ำท่วมขัง

ข้อสังเกตเพิ่มเติมด้วยเหมือนกัน ในขณะที่มีการศึกษาวิจัยจำนวนมากและในบางครั้งซ้ำซ้อนกันเกี่ยวกับการชลประทานและการแพร่กระจายน้ำในเขตที่ราบดินดอนสามเหลี่ยมของแม่น้ำเจ้าพระยา เกือบทั้งหมดไม่มีข้อมูลที่เป็นประโยชน์เกี่ยวกับการควบคุมระบายน้ำและระบบการเพาะปลูกข้าวในพื้นที่น้ำท่วม

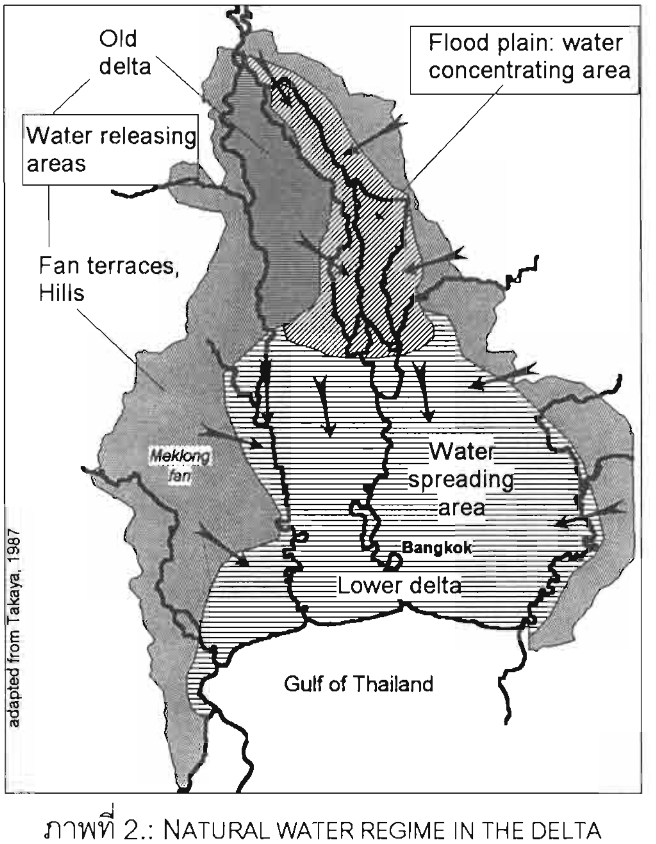
ขัง ดังนั้นรายงานวิจัยชิ้นนี้จึงเสนอการวิเคราะห์อย่างลึกซึ้งในเขตพื้นที่นี้เกี่ยวกับ ด้านการเพาะปลูกข้าว - คุณลักษณะของข้าวและแนวโน้ม- และด้านการจัดการน้ำ ซึ่งประกอบด้วยข้อมูลที่มีแหล่งกำเนิดมาจากการสำรวจภาคสนาม(ประมาณ 900 จุดสำรวจ โดย 1 ใน 3 เป็นวิธีการแบบสอบถามอย่างละเอียด) ภาพถ่ายด้วยดาวเทียม ระบบสารสนเทศทางภูมิศาสตร์(GIS) แบบจำลองระดับความสูงเชิงตัวเลขของพื้นที่ (DEM-digital elevation model) และข้อมูลเกี่ยวกับน้ำของกรมชลประทาน



ภาพที่ 1. พื้นที่ศึกษา

สภาพน้ำท่วมในสมัยก่อน

เราสมมุติฐานว่าอะไรเป็นสภาพน้ำท่วมในสมัยก่อนในสามเหลี่ยมปากแม่น้ำเจ้าพระยา น้ำป่าที่มีต้นกำเนิดจากพื้นที่ตอนบนของสามเหลี่ยมปากแม่น้ำ และลำน้ำสาขาที่ไหลรวมเข้ามาเพิ่มปริมาณการไหลของแม่น้ำเจ้าพระยาในทุ่งรับน้ำท่วมของสามเหลี่ยมปากแม่น้ำ (ภาพที่ 2) ด้วยระดับน้ำที่สูงขึ้นของทางน้ำหลัก (ลำคลองต่างๆในทุ่ง) คลองระบายในทุ่งถูกปิดกั้นในบางจุด น้ำจึงเออไหลย้อนกลับไป หรือแม้แต่ช่องระหว่างสันดอนริมฝั่งแม่น้ำไหลเข้าไปท่วมในทุ่ง ข้าวขึ้นน้ำถูกหว่านในทุ่งราบน้ำท่วมนี้ในช่วงต้นฤดูฝน เมื่อพื้นที่ได้รับน้ำท่วม ข้าวจะยืดปล้องยาวตามน้ำ ความเสี่ยงเกิดขึ้นจากความไม่แน่นอนและระดับน้ำที่ขึ้น ๆ ลง ๆ ของน้ำที่ท่วม ความลึกและช่วงเวลา ในบางปีน้ำจะแห้งเร็วเกินไปก่อนที่ข้าวจะสุก บางปีน้ำจะมาเร็วและท่วมสูงขึ้นอย่างรวดเร็วเกินกว่าที่ข้าวจะสามารถยืดปล้องตามได้ และน้ำจะไหลบ่าท่วมลงไปถึงพื้นที่สามเหลี่ยมปากแม่น้ำตอนล่าง ซึ่งเป็นที่ราบและกว้างใหญ่ทำให้น้ำแผ่กระจายออกและลดความแรงลง น้ำท่วมในตอนล่างของสามเหลี่ยมปากแม่น้ำไม่ท่วมสูงมาก (อย่างมากไม่เกิน 1 เมตร) ประการแรกเป็นเพราะทุ่งราบกว้างมากพอที่จะกระจายน้ำออกไป ประการที่สองเพราะทุ่งราบน้ำท่วมตอนบนเป็นที่รองรับน้ำท่วมด่านแรก หรือ เป็นพื้นที่ชะลอและช่วยบรรเทาน้ำท่วม (van der Heide, 1903)



ภาพที่ 2.: NATURAL WATER REGIME IN THE DELTA

วัตถุประสงค์

เพื่ออธิบายหน่วยระบายน้ำในทุ่งราบน้ำท่วมของดินดอนสามเหลี่ยมปากแม่น้ำเจ้าพระยา แสดงคุณลักษณะ รูปแบบการควบคุมน้ำ

1. แสดงระบบการปลูกข้าวพันธุ์พื้นเมือง เทคนิกที่ใช้ พันธุ์ข้าว
2. แสดงรูปแบบการจัดการน้ำในพื้นที่น้ำท่วมขัง การติดตามและจัดการน้ำท่วมเพื่อบรรเทาอุกทกภัย
3. แสดงให้เห็นวิวัฒนาการของการปลูกข้าว รูปแบบที่ปรากฏให้เห็นมากเพิ่มขึ้น
4. การทำหน้าที่ / การจัดการน้ำของพื้นที่น้ำท่วมขัง

ลักษณะโดยทั่วไปของหน่วยระบายน้ำ ("box")

ถึงแม้ว่าพื้นที่เหล่านี้ ได้ถูกจัดให้เป็นพื้นที่อยู่ในเขตพื้นที่ส่งน้ำชลประทานแบบส่งด้วยแรงโน้มถ่วง (gravity) ทุ่งราบน้ำท่วมเกือบทั้งหมดอาศัยน้ำท่วมและการควบคุมน้ำในคลองระบาย ถ้าน้ำไหลล้นคันดินดังที่เกิดขึ้นในปีพิเศษ ตลอดเวลาที่น้ำท่วมไม่ได้เกิดจากการที่น้ำไหลล้นฝั่งออกมา อย่างที่คนทั่วไปเชื่อว่าเป็นดังนั้น น้ำที่ท่วมขังอยู่เป็นการควบคุมให้เกิดขึ้น โดยประกอบกันขึ้นด้วย คันดินที่สร้างขึ้นล้อมรอบพื้นที่และประตูน้ำในคลองระบาย เกิดขึ้นเป็นหน่วยระบายน้ำหนึ่ง ๆ และสิ่งที่สำคัญที่สุดคือการควบคุมประตูระบายน้ำที่ระบายน้ำออกไปสู่แม่น้ำสายหลัก

หน่วยระบายน้ำ สามารถอธิบายในลักษณะคล้ายกล่อง "box" ด้วยส่วนประกอบต่าง ๆ (ภาพที่ 3)

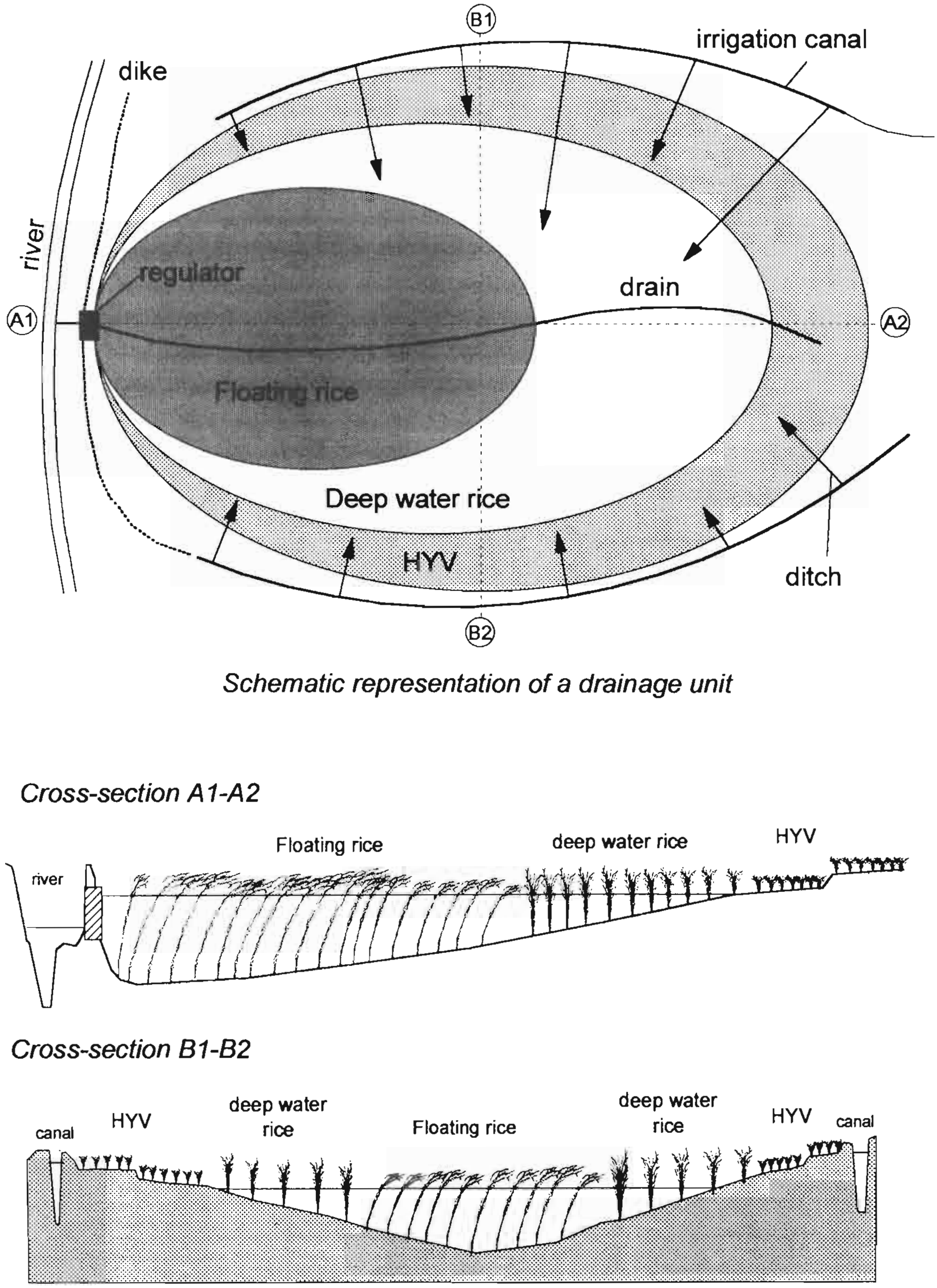
- มีคันดินล้อมรอบบางส่วนหรือทั้งหมดของขอบเขตพื้นที่

มีระบบระบายน้ำภายใน เพื่อรวบรวมน้ำผิวดินภายให้ไหลออกสู่ลำน้ำสายหลัก

- มีประตูน้ำ 1 แห่ง หรือหลายแห่ง ควบคุมการไหลเข้า-ออก ของน้ำภายในหน่วยระบายน้ำ กับแม่น้ำที่อยู่ด้านนอกคันดิน

ประตูน้ำและคันดินนี้มีวัตถุประสงค์หลายอย่าง

- เพื่อยกระดับน้ำเข้าไปสู่พื้นที่ที่เป็นที่ดอน ซึ่งในบางพื้นที่น้ำชลประทานไปไม่ถึงเพราะขาดระบบแพร่กระจายน้ำ
- เพื่อช่วยพยุงให้ข้าวพันธุ์ที่มีอายุปานกลาง หรือข้าวที่มีอายุยาว ให้มีน้ำหล่อเลี้ยงไปจนถึงสิ้นปี (เมื่อน้ำลดระดับลงอย่างรวดเร็ว)
- เพื่อควบคุมระดับน้ำในพื้นที่น้ำท่วมขัง โดยป้องกันระดับน้ำที่สูงกว่าทางด้านท้ายน้ำจากแม่น้ำไหลย้อนกลับเข้ามาในพื้นที่
- เพื่อช่วยเก็บน้ำไว้ในคลองระบายสำหรับใช้ในฤดูแล้ง



ภาพที่ 3. : SCHEMATIC REPRESENTATION OF A DRAINAGE UNIT ("BOX")

อธิบายการจัดการน้ำ (การควบคุมการระบายน้ำ)

หน่วยระบายน้ำหนึ่งๆ "box" มักจะประกอบขึ้นด้วยพื้นที่เป็นหลัก 2 พื้นที่ คือ 1-พื้นที่ส่วนที่เป็นที่ดอน ซึ่งมีระบบระบายน้ำและระบบส่งน้ำชลประทานด้วยคลอง (มักจะเป็นพื้นที่อยู่ตามริมตะพักแม่น้ำหรือลำน้ำเดิมตามธรรมชาติ ซึ่งได้กลายมาเป็นคลองส่งน้ำ) และ 2-พื้นที่ส่วนที่เป็นที่ต่ำ ซึ่งระดับน้ำที่ท่วมขังอยู่ได้ด้วยการเก็บกักของประตูน้ำ

ขณะที่พื้นที่ส่วนบนสามารถกล่าวได้ว่าเป็นพื้นที่ที่สามารถรับน้ำชลประทานด้วยวิธีแรงโนม้ถ้วงของโลก สำหรับส่วนที่ต่ำพูดได้ว่าน้ำที่ท่วมขังอยู่ก็ด้วยระบบการควบคุมของประตูระบายน้ำ พื้นที่ส่วนแรกจะปลูกข้าวพันธุ์ส่งเสริมให้ผลผลิตสูง High Yield Varieties (HYV) และข้าวทนน้ำลึก Deep Water Rice (DWR) ขณะที่พื้นที่ส่วนหลังจะปลูกข้าวทนน้ำลึก ด้วยกันกับข้าวขึ้นน้ำ floating rice (FR) ในพื้นที่ลุ่มต่ำสามารถมองเห็นการแบ่งเขตพื้นที่ได้จากรูปตัดตามขวาง ของภาพที่ 3

การควบคุมสภาพทางอุทกวิทยาโดยทั่วไป ที่ควบคุมโดยประตูระบายน้ำ สามารถอธิบายโดยย่อได้ดังต่อไปนี้ (ภาพที่ 4)

1. ช่วงเริ่มต้นของฤดูฝน ประตูน้ำจะถูกปิดเพื่อเก็บน้ำแต่ก็ไม่มาก หน่วยระบายน้ำและการปลูกข้าวด้วยวิธีหว่านแห้งอาศัยน้ำฝน ช่วงนี้ไปสิ้นสุดประมาณปลายเดือนกรกฎาคม

2. เมื่อฝนเริ่มตกและการส่งน้ำชลประทานเพิ่มมากขึ้น ในช่วงนี้ประตูน้ำยังคงปิดอยู่เพื่อเก็บรักษาน้ำจากน้ำฝน และป้องกันน้ำท้วมที่ไม่ได้ควบคุมที่อาจจะเกิดขึ้นได้จากแม่น้ำ ในปีน้ำน้อย อย่างไรก็ตามการเปิดประตูเพื่อรับน้ำเข้ามาจากแม่น้ำเข้ามาในหน่วยระบายน้ำเพื่อเพิ่มระดับภายในกรณีที่มีน้ำในแม่น้ำมาก ตัวอย่างเช่น เกิดมีฝนตกหนัก ประตูน้ำจำเป็นต้องเปิดออกเพื่อระบายน้ำส่วนเกินออกไป ส่วนนี้เป็นไปได้ อย่างไรก็ตามจะลดลงตลอดช่วงฤดูฝน เพราะว่าระดับในแม่น้ำเพิ่มสูงขึ้นจนกระทั่ง เดือนตุลาคม-พฤศจิกายน และทำให้ระดับน้ำในแม่น้ำสูงขึ้น

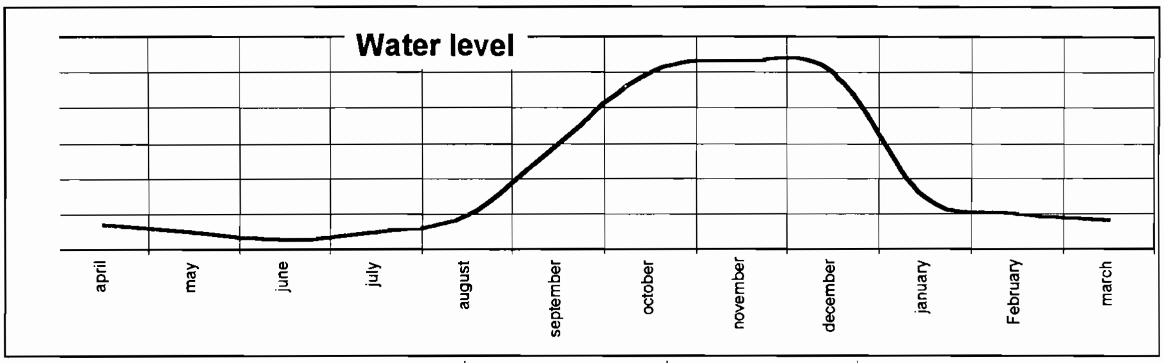
3. ในกรณีที่ไม่สามารถระบายน้ำออกได้เพราะระดับน้ำภายนอกสูงกว่าภายใน ก็ไม่สามารถทำอะไรได้ เพียงแต่หวังว่าระดับน้ำภายในจะมีอัตราเพิ่มขึ้นไม่รุนแรงและไม่สูงมากเกินไป ถ้ามีอัตราเพิ่มขึ้นอย่างเร็ว แล้วข้าวพันธุ์ทนน้ำลึกจะอยู่ในอันตราย ถ้าอัตราเพิ่มขึ้นของระดับน้ำมากกว่า 10 เซนติเมตร/วัน แล้วแม้แต่ข้าวขึ้นน้ำจะเสียหายบางส่วน

4. ในกรณีที่ ทั้งน้ำผิวดินภายในและระดับน้ำในแม่น้ำภายนอกต่ำ ที่จะช่วยยกระดับน้ำในหน่วยระบายน้ำให้สูงขึ้นได้ระดับที่ต้องการ จะเป็นเหตุให้พื้นที่ปลูกข้าวที่อยู่ในที่ดอน ตามขอบเนินของพื้นที่น้ำท่วม ได้รับความเสียหายจากการขาดน้ำ

5. ในบางครั้งก่อนที่ข้าวจะสุก ประตูน้ำจะต้องเปิดเพื่อระบายน้ำออกจากพื้นที่และสามารถเกี่ยวข้าวได้ วันที่เปิดประตูและอัตราการระบายน้ำออก ขึ้นอยู่กับสภาพของแต่ละหน่วยระบายน้ำ โดยส่วนมากประตูระบายน้ำจะเปิดเพื่อระบายน้ำออกในราวเดือนธันวาคม

6. หลังจากพื้นที่ทั้งหมดได้ระบายน้ำออกและเก็บเกี่ยวเรียบร้อยแล้ว ประตูน้ำจะปิดลงอีกครั้งเพื่อเก็บรักษาน้ำไว้ใช้ในฤดูแล้ง สำหรับการปลูกพืชฤดูแล้งตามริมคลองระบายน้ำ ซึ่งเกษตรกรที่อยู่ริมฝั่งบางคนต้องใช้เครื่องสูบน้ำนำน้ำเข้าสู่แปลงที่อยู่ติดคลอง

Phases of box management

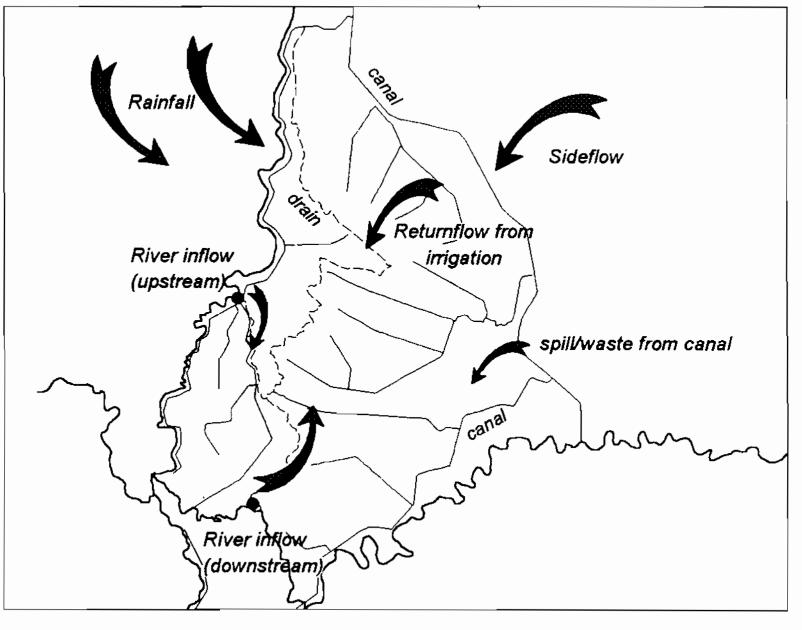


Crop establishment	Filling-up	Regulation	Drainage
Regulator closed to retain water for the dry-season. Rice broadcasting under rainfed conditions. Rice may be lost in low-lying areas in case of heavy rainfall, in high land if dry spells (re-sowing necessary)	Regulator closed. water accumulates in the box (rainfall, irrigation, river, sideflows..). Open to drain if excess water; increase artificial inflow if not enough water. Optimum level may not be reached	Regulator closed. water level regulated at the optimal level Open to drain if excess water; increase artificial inflow if not enough water. Overload if drainage to the river impossible	Regulator opened to drain the box. Date of box opening and drainage rate adapted to rice varieties in the box High water levels in the river may hinder box drainage

ภาพที่ 4.

จุดที่สำคัญมาก ตามที่ได้นำเสนอ คือการที่รู้ว่า เมื่อไรและน้ำจากที่ไหนมาเติมให้หน่วยระบายน้ำ น้ำจากหลาย ๆ แหล่ง ทั้งที่ควบคุมได้ และควบคุมไม่ได้ สนับสนุนกันเติมน้ำเข้ามาให้หน่วยระบายน้ำ (ภาพที่ 5)

1. น้ำฝน
2. น้ำที่มาจากแม่น้ำโดยผ่านเข้ามาทางประตูน้ำ ในกรณีนี้เป็นไปได้เพียงกรณีที่ระดับน้ำในแม่น้ำสูงเพียงพอ ซึ่งโดยทั่วไปกรณีนี้เกิดไม่บ่อยนัก
3. มาจากน้ำเหลือใช้ส่วนเกิน ของการใช้จากน้ำชลประทานและระบายลงสู่ระบบระบายน้ำ น้ำส่วนนี้โดยปกติมักจะได้รับค่อนข้างช้า (มักจะก่อนเดือนสิงหาคม)
4. น้ำที่ได้รับโดยตรงจากคลองชลประทานสายหลัก (น้ำที่ส่งมามากเกินในคลองซอย หรือ ส่งเข้ามาให้ลงคลองระบาย (ทางทิ้งน้ำ))
5. น้ำที่มาจากพื้นที่ที่อยู่ติดกัน (side-flows) หน่วยระบายน้ำ 3 หน่วยที่อยู่ทางด้านทิศตะวันออกรับน้ำจากส่วนนี้มาก



ภาพที่ 5.: DIFFERENT TYPES OF (POSSIBLE) INFLOW IN A DRAINAGE BOX

ในบางปีที่น้ำน้อย ผลรวมของน้ำทั้งหมดที่เติมเข้ามาในหน่วยระบายน้ำอาจจะไม่เพียงพอที่จะใช้ในหน่วยระบายน้ำ ในทางตรงกันข้าม ในปีที่น้ำมาก (หรือปีปกติ สำหรับบางหน่วยระบายน้ำ) ประตูระบายน้ำมักจะต้องเปิดเพื่อระบายน้ำออก เพื่อลดระดับน้ำที่เพิ่มสูงอยู่บ่อย ๆ ในปีที่มีน้ำมากจริง ๆ การสะสมของน้ำเกินกว่าระดับความต้องการ ขณะที่ไม่สามารถระบายน้ำออกไปได้เพราะว่าน้ำในแม่น้ำมีระดับสูง

กว่าภายใน หน่วยระบายน้ำต้องตกอยู่ในสภาพที่มีระดับน้ำสูงเกินกว่าความต้องการชั่วขณะซึ่งสามารถเป็นอันตรายกับข้าวได้ (โดยเฉพาะข้าวพันธุ์ HYV หรือ DWR)

หน่วยระบายน้ำที่สำคัญในทุ่งราบน้ำท่วมของแม่น้ำเจ้าพระยา

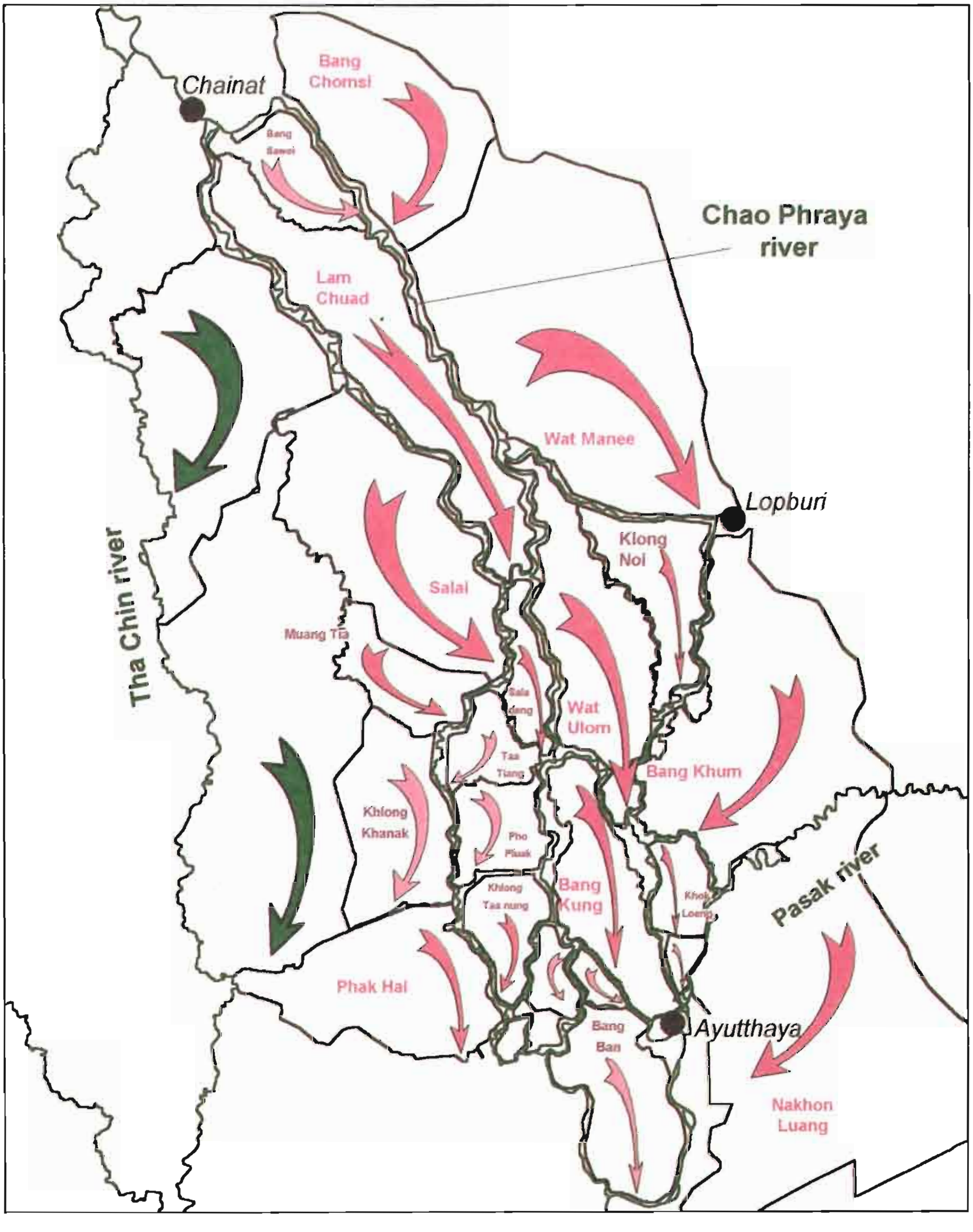
หน่วยระบายน้ำขนาดใหญ่ของสามเหลี่ยมปากแม่น้ำเจ้าพระยามีทั้งสิ้น 18 หน่วย (โดยไม่พิจารณาหน่วยระบายน้ำที่ระบายน้ำออกสู่แม่น้ำท่าจีน) และอีก 7 หน่วย ที่เป็นหน่วยระบายน้ำอิสระขนาดเล็ก ตามที่แสดงในภาพที่ 6 โดยบางหน่วยข้างในยังประกอบด้วยหน่วยระบายน้ำย่อย ๆ จำนวนมาก โดยมีประตูน้ำกั้นลดหลั่นกันไปตามระดับภูมิประเทศ[4]

เราสามารถแยกให้เห็นชัด ของหน่วยระบายน้ำ 4 หน่วยที่อยู่ด้านข้างฝั่งตะวันออก (ตั้งชื่อตามชื่อประตูน้ำ) บางโฉมศรี, วัดมณี, บางกุ่ม, และนครหลวง[5] หน่วยระบายน้ำเหล่านี้เป็นหน่วยที่ติดต่อกับแม่น้ำเจ้าพระยาและแม่น้ำลพบุรีทางฝั่งตะวันตก ขณะที่ระดับคอย ๆ สูงขึ้นทางทิศตะวันออกของแต่ละหน่วย ตำแหน่งเฉพาะของหน่วยระบายน้ำเหล่านี้คือเป็นพื้นที่เชื่อมต่อระหว่างพื้นที่ดอนสูงกับพื้นที่สามเหลี่ยมปากแม่น้ำ หมายความว่าหน่วยระบายน้ำเหล่านี้ต้องได้รับน้ำที่มาจากด้านนอก(side flows)บ้าง จากพื้นที่ราบสูงที่อยู่ติดกัน น้ำจากภายนอกนี้ถูกขวางกั้นไว้หรือไม่ก็ผันลงสู่คลองชัยนาท-ป่าสัก (ตามขอบเขตของพื้นที่ชลประทานทางด้านฝั่งตะวันออก) หรือผ่านทางช่องระบายน้ำลอดใต้คลอง เข้าสู่พื้นที่ชลประทาน ทางด้านฝั่งตะวันตก หน่วยระบายน้ำสาหร่าย และม่วงเตี้ย มีลักษณะพื้นที่คล้ายกันแต่ไม่มีการรับน้ำที่มาจากพื้นที่ภายนอกที่อยู่ติดกัน (side flows)

ในตอนกลางของพื้นที่ราบน้ำท่วม หน่วยระบายน้ำลำชวด, ศาลาแดง, วัดอุโลม, คลองน้อย และบางกุ้ง ในทำนองเดียวกันกับหน่วยระบายน้ำเล็ก ๆ ที่เป็นอิสระ สามารถที่จะพิจารณาว่าเป็นหน่วยระบายน้ำที่อยู่ชั้นใน คันดินที่สมบูรณ์ ในบางพื้นที่เป็นเหมือน “เกาะอยู่ภายใน”

[4] ลูกศรสีแดงแสดงหน่วยระบายน้ำหลักที่มีข้อมูลด้านอุทกวิทยา ส่วนลูกศรสีน้ำเงินเป็นหน่วยระบายน้ำที่ไม่พิจารณาเนื่องจากมีระบายน้ำออกไปทางด้านฝั่งตะวันตก (แม่น้ำท่าจีน)

[5] โครงการนครหลวงมีประตูระบายน้ำหลักตามริมฝั่งแม่น้ำเจ้าพระยา 4 ประตู คือ ปตร.ข้าวเม่า บ้านโพธิ์ บ้านหว่า และคลองจิก ซึ่งไม่ได้ใช้อธิบายละเอียดสำหรับหน่วยระบายน้ำนี้



ภาพที่ 6.: MAIN DRAINAGE UNITS (OR "DRAINAGE BOXES") OF THE FLOOD-PRONE AREA

ตารางที่ 1 : หน่วยระบายน้ำหลัก และคุณลักษณะ

Box	Area (km2) (1)	Elevation (upper 5 %) (m MSL) (2)	Elevation (lower 5 %) (m MSL) (3)	Overall "depth" (m) (2)-(3)	Slope index (1)/(2)-(3)	Regul-ation depth (m MSL)	Max. water average depth (m)	Out regulators (main/sec.)	Inner regulators, weirs or pipes
Wat Manee	751	11.4	6	5.4	139	7.5	2.8	3 main	18
Bang Khum	453	7.4	3.0	4.4	103	4.5	3.2	3main/3sec.	12
Salai	360	10	5.4	4.6	78	6.5	2.7	1 main	2
Bang Ban	160	2.7	1.1	1.6		(2.0)	1.3	2 main/1 sec	0
Phak Hai	342	2.5	1.7	.8	428	3.1	2.4	6	0
Lam Chuad	315	13.1	7	6.1	52	8.4	2.5	1 main	4
Wat Ulom	222	8.0	3.0	5.0	44	4.5	3.1	1 main	25
Bang Kung	152	5.0	2.0	3.0	51	4.2	3.4	1 main/2 ?	4
Khlong Noi	119	7.2	4.0	3.2	37	5.4	3.0	1 main	3
Muang Tia	89	7.5	4.9	2.6	34	5.75	1.45	1 main	1
Khlong Taa nung	69	3.5	2.0	1.5	46	3.6	2.1	1main/3sec.	2
Sala Deng	50	6.8	3.8	3.0	17	5.4	4	1 main	0?

ระบบการปลูกข้าว(Rice systems)

ข้อมูลที่มีคุณค่าได้รับจากการสำรวจในพื้นที่เพาะปลูก 300,000 เฮกตาร์ ซึ่งมีการปลูกข้าวพันธ์ทนน้ำลึกและข้าวพันธ์ขึ้นน้ำ โดยมีจุดสำรวจทั้งสิ้น 900 จุดสำรวจ ลักษณะสำคัญของระบบการปลูกข้าวในเขตพื้นนี้สามารถกล่าวโดยสรุปได้ ดังนี้

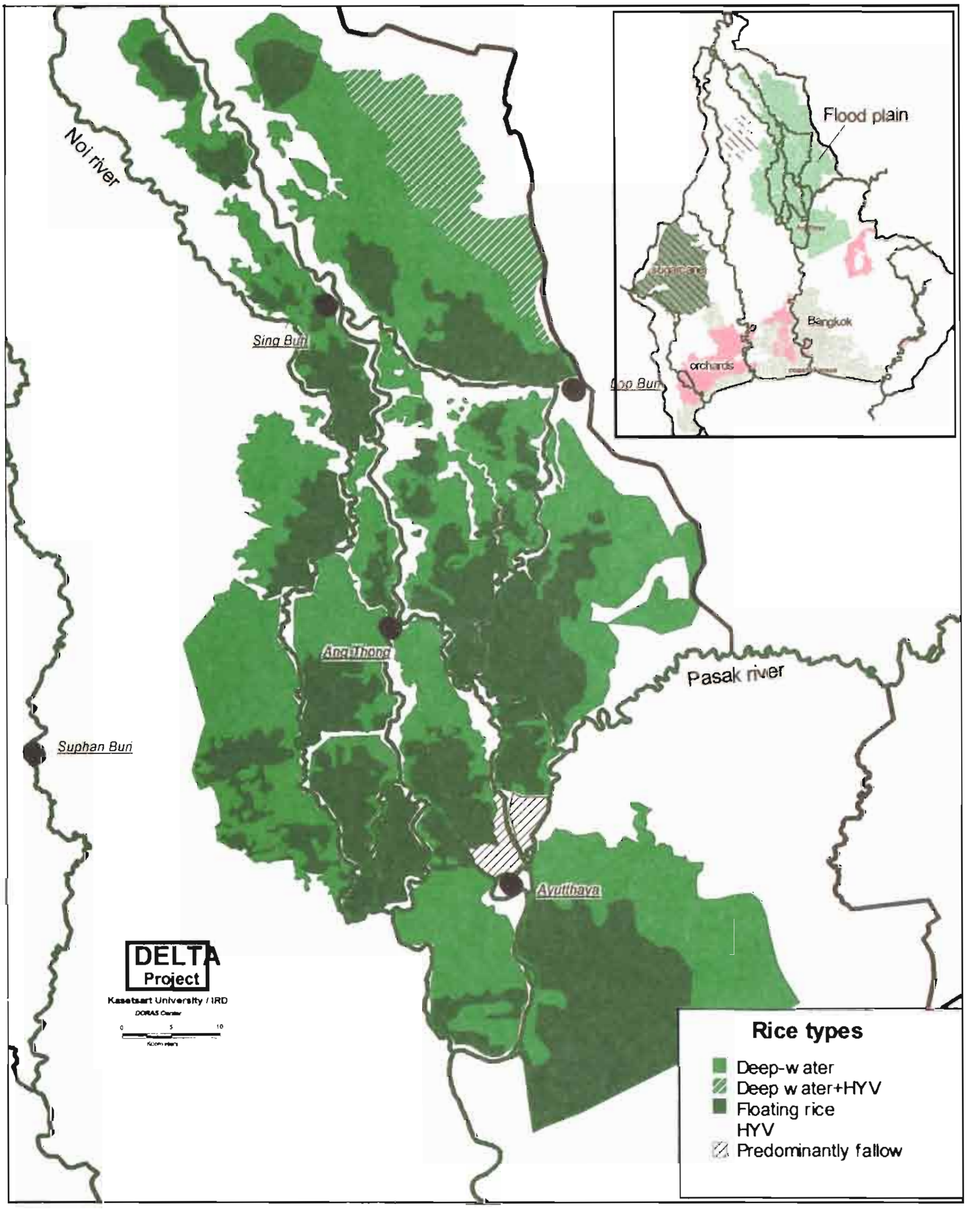
- มีการควบคุมน้ำค่อนข้างดี และการลดความเสี่ยงสามารถทำได้โดยการพัฒนาปรับปรุงที่ดินและมีวิธีการควบคุมน้ำ
- ผลผลิตที่ของข้าวพันธุ์พื้นเมืองได้ประมาณ 60% ของผลผลิตที่ได้รับจากข้าวพันธุ์ลูกผสม
- มีการทดแทนความอุดมสมบูรณ์ตามธรรมชาติด้วยปุ๋ยเคมี ร้อยละ 72 ของแปลงปลูกข้าวพันธุ์พื้นเมืองได้รับปุ๋ยเคมี (ปริมาณเฉลี่ย 32 กิโลกรัม/ไร่ เมื่อมีการใส่ปุ๋ย)

- โดยทั่วไปขาดแคลนโครงสร้างการทำฟาร์ม และ/หรือตั้งอยู่ห่างไกลจากคลองชลประทาน
- มีการทำนาปีละ2ครั้งน้อยหรือไม่สม่ำเสมอ บางส่วนขึ้นอยู่ปัจจัยที่กล่าวถึงข้างต้น แต่แนวโน้มความสม่ำเสมอมีเพิ่มมากขึ้นรวมทั้งมีการลงทุนอย่างชัดเจนในการปรับปรุงแปลงนา แนวโน้มเหล่านี้ถูกส่งเสริมจากประสบการณ์ที่ได้รับการจัดสรรน้ำอย่างสูงใน 3 ปีที่ผ่านมา
- มีแนวโน้มการเก็บเกี่ยวข้าวด้วยเครื่องจักรกลเพิ่มมากขึ้น โดยร้อยละ 72 ของแปลงนามีการใช้รถเกี่ยวข้าว
- ลดความหลากหลายของพันธุ์ข้าวที่ใช้ปลูกในพื้นที่ พบว่าพันธุ์ข้าวหลัก 6 พันธุ์มีเนื้อที่เพาะปลูกร้อยละ 58 ของพื้นที่ปลูกข้าวพันธุ์พื้นเมือง และเมื่อเพิ่มต่อมาอีก 17 พันธุ์หลักมีเนื้อที่เพาะปลูกร้อยละ 82 ของพื้นที่ปลูกข้าวทั้งหมด
- จากการศึกษาวิจัยนี้มี 60 พันธุ์ที่ใช้ปลูกอยู่ในปัจจุบัน ในขณะที่ชาวนากล่าวถึง 80 พันธุ์เมื่อมีการสอบถามเกี่ยวกับการเพาะปลูกข้าวในอดีต ฉะนั้นจากทั้งหมดมีสูญหายไป 43 พันธุ์(ไม่พบในการสำรวจ)
- มีข้าวที่เป็นพันธุ์แนะนำปรากฏอยู่ไม่มากนัก

ปัจจัยสำคัญที่เป็นข้อจำกัดของผลผลิตน่าจะเป็นความเสี่ยงต่อการเสียหายซึ่งมีอยู่มากมายในช่วงเวลาเพาะปลูกข้าวภายใต้สภาพที่อาศัยน้ำฝน นอกจากการเพิ่มขยายการชลประทานแล้ว มีวิธีการเพียงเล็กน้อยที่สามารถลดความเสี่ยงต่อการเสียหายอันมีเหตุมาจากฝนทิ้งช่วง

พิจารณาเกี่ยวกับเทคนิคการเพาะปลูก จากการสำรวจแสดงให้เห็นว่าไม่มีความสัมพันธ์ระหว่างการใช้ข้าวพันธุ์พื้นเมืองกับการเพาะปลูกด้วยวิธีหว่านแห้ง ข้าวพันธุ์ทนน้ำลึกและในบางครั้งข้าวพันธุ์ขึ้นน้ำนั้นต่างก็ใช้วิธีการเพาะปลูกทั้งวิธีหว่านแห้งและวิธีหว่านน้ำตม โดยกรณีหลังนั้นพบอยู่ในเขตพื้นที่ ซึ่งมีระบบชลประทานแต่การระบายน้ำไม่ดีเพียงพอ (ความเสี่ยงต่อน้ำท่วมจึงเลือกใช้ข้าวพันธุ์พื้นเมือง) และเมื่อพื้นที่แปลงนาถูกใช้ทำนาปรังฤดูแล้ง (เพาะปลูกข้าวพันธุ์ลูกผสมที่ให้ผลผลิตสูงด้วยวิธีหว่านน้ำตม)

ไม่ปรากฏให้เห็นการเพาะปลูกข้าวด้วยวิธีปักดำ เริ่มเกิดขึ้นในคริสตทศวรรษที่80และไม่พบเห็นอีกเลยตั้งแต่ช่วงต้นคริสตทศวรรษที่90 สิ่งนี้เป็นจุดสำคัญด้วยเหมือนกันคือ : ทำให้การจัดการน้ำง่ายขึ้นและขจัดปัญหาหลักเกี่ยวกับแรงงานและการวางแผนกิจกรรมฟาร์ม ปัญหาหลักสุดท้ายคือ การเก็บเกี่ยว : ในปัจจุบันได้มีการใช้เครื่องจักรกล



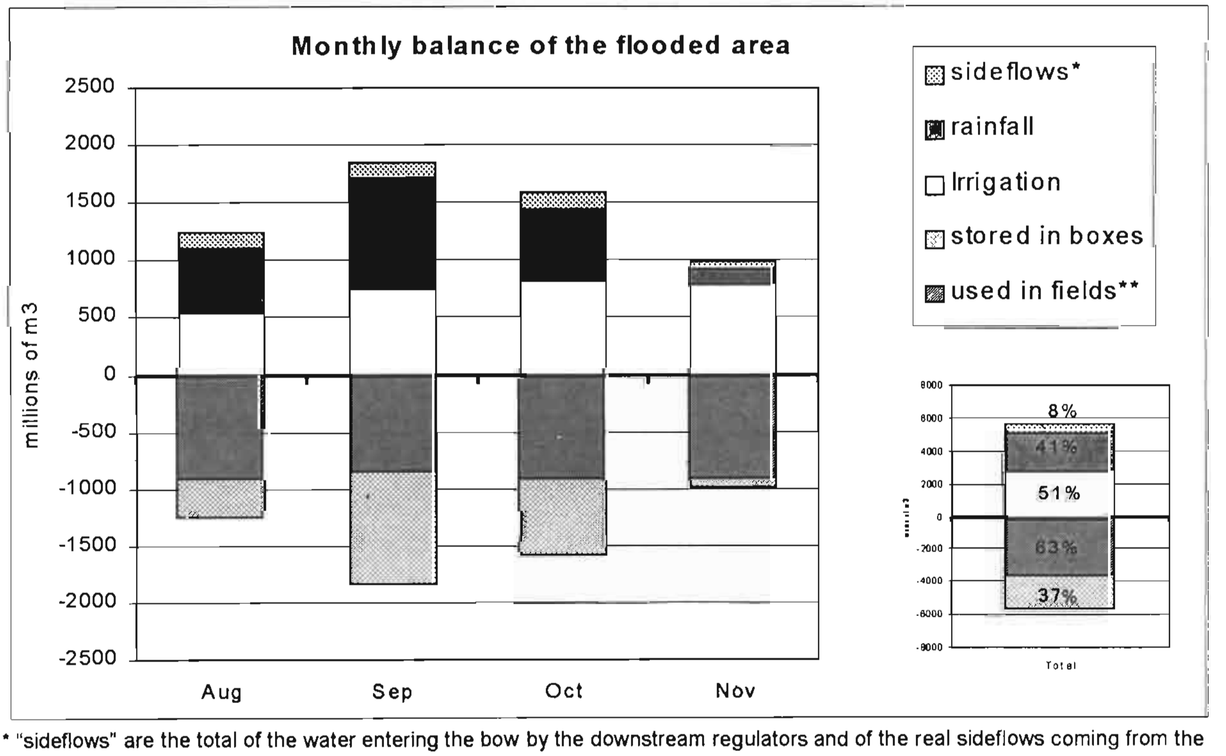
ภาพที่ 7.: DISTRIBUTION OF MAIN RICE TYPES IN THE FLOOD PLAIN

พื้นที่น้ำท่วมขังและการจัดการน้ำท่วม

การวิเคราะห์สภาพทางอุทกวิทยาของหน่วยระบายน้ำหลัก โดยประมาณค่าจากน้ำที่ไหลเข้ามาจากแหล่งต่างๆ ค่าโดยเฉลี่ยของน้ำที่ไหลเข้ามาในพื้นที่น้ำท่วมขัง (น้ำฝน, น้ำจากระบบชลประทาน, น้ำที่ไหลเข้ามาจากพื้นที่ที่อยู่ติดกัน และน้ำที่ไหลเข้ามาจากแม่น้ำ) สามารถที่จะทำการเปรียบเทียบ สำหรับแต่ละเดือน กับความต้องการของพืชตามทฤษฎีและความสูญเสียที่เกิดจากการซึมลงไปในดิน และด้วยปริมาณน้ำใช้การที่เก็บไว้ในหน่วยระบายน้ำทั้งหมด จำแนกโดยรายเดือนแสดงให้เห็นว่าฝนเป็นน้ำที่ไหลเข้ามากกว่ามาจากแหล่งอื่นในช่วง 2 เดือนแรก น้ำส่วนใหญ่ถูกใช้ในแปลงนา** ในเดือนสิงหาคมและพฤศจิกายน ด้วยเหตุนี้การเพิ่มน้ำเข้ามาในหน่วยระบายน้ำส่วนใหญ่ในระหว่างเดือนกันยายน และตุลาคม (ภาพที่ 8)

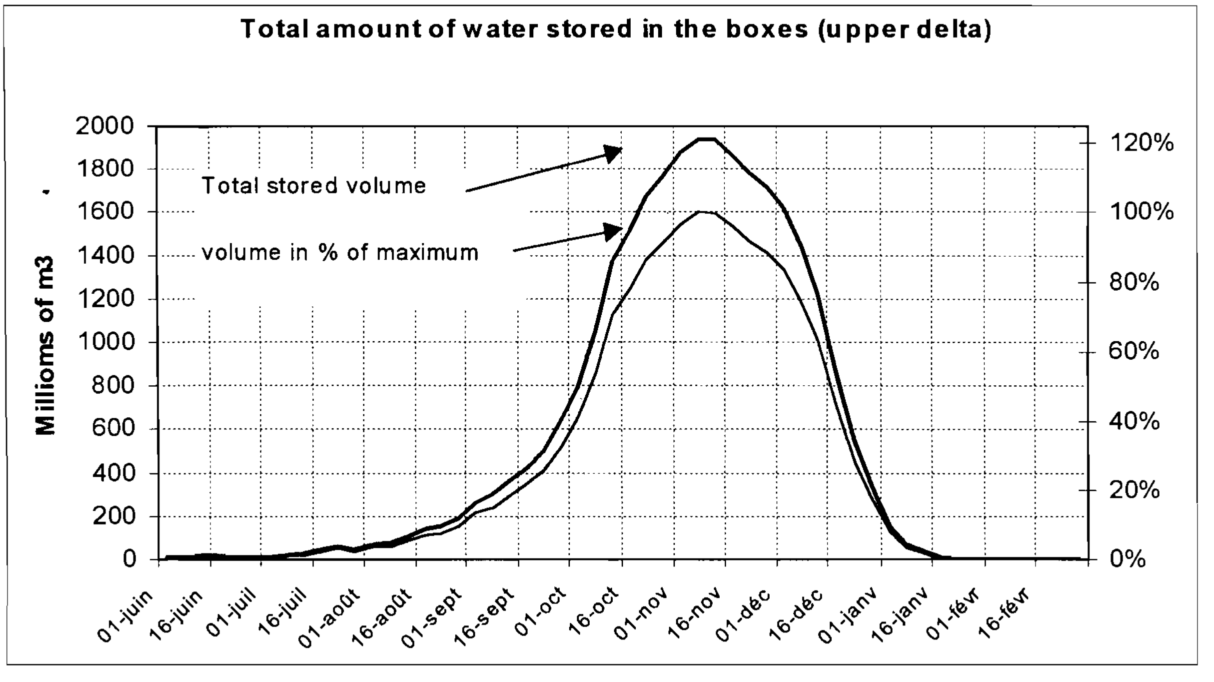
จากทั้งหมด คิดเป็น 51% ของน้ำที่ไหลเข้ามาทั้งหมด (ระหว่างเดือนสิงหาคม และเดือนพฤศจิกายน) รับมาจากคลองชลประทาน 41% รับมาโดยตรงจากฝนและน้ำผิวดินภายใน 8% มาจาก sideflows* คิดเป็นปริมาตรทั้งหมด 5.5 พันล้านลูกบาศก์เมตร โดยที่ 2 พันล้านลูกบาศก์เมตร ถูกใช้เพื่อเติมน้ำเต็มให้กับหน่วยระบายน้ำ ขณะที่นอกนั้น 3.5 พันล้านลูกบาศก์เมตร ถูกใช้โดยพืชและสูญเสียจากการซึมลงดิน

ภาพที่ 8.: MONTHLY WATER BALANCE



* "sideflows" are the total of the water entering the bow by the downstream regulators and of the real sideflows coming from the non irrigated area on the east.
** "used in fields" is the total of crop use and percolation

ถ้าเรารวมเวลาที่ใช้ในการเก็บน้ำเข้ามาในแต่ละหน่วยระบายน้ำ เราได้ประเมินน้ำทั้งหมดที่เก็บเอาไว้ในทุ่งราบน้ำท่วม (ภาพที่ 9) สารสนเทศที่สำคัญอย่างหนึ่งที่ได้มาจากกราฟนี้คือ ค่าที่แสดงให้ทราบว่ายังมีความจุเหลือสำหรับเก็บน้ำในแต่ละวันที่แสดง วันที่ 1 ตุลาคม ความจุทั้งหมดถูกใช้ไปเพียง 40% ขณะที่สิ้นเดือนของเดือนเดียวกันความจุของหน่วยระบายน้ำถูกใช้ทั้งหมด (97%) ***นี้แสดงว่าถัดจากวันนี้ไป พื้นที่รับน้ำ(buffer area) สามารถที่จะช่วยรับปริมาตรน้ำได้เพียงโดยต้องรับน้ำเข้าไว้ด้วยการเกินพิกัดความจุ*** กล่าวได้ว่าโดยระดับน้ำในหน่วยระบายน้ำจะต้องสูงกว่าการควบคุมโดยปกติ



ภาพที่ 9.: EVOLUTION OF THE WATER STOCK IN THE FLOOD PLAIN

วิธีเพิ่มความจุเก็บกักเป็น 2 เท่า

เราได้ทราบก่อนหน้านี้แล้วว่าผลรวมของความจุของ 18 หน่วยระบายน้ำหลักเท่ากับ 2 พันล้านลูกบาศก์เมตร ค่า (มากที่สุด) ที่สามารถรับไว้ได้ประมาณต้นเดือนพฤศจิกายน เมื่อระดับน้ำในหน่วยระบายน้ำทั้งหมดถึงระดับเก็บกักที่ต้องการ ปริมาตรของน้ำที่เก็บสะสมไว้ของพื้นที่ศึกษาค่อนข้างจะสูงและควรจะเปรียบเทียบกับความจุของพื้นที่ตอนล่าง (lower delta) ไม่มีข้อมูลที่ถูกต้องสำหรับพื้นที่ตอนล่าง เหตุผลหนึ่งที่พื้นที่ฝั่งตะวันออก (West Bank) ถูกน้ำท่วมด้วยความรุนแรงต่างๆ ขึ้นอยู่กับปี ในบางครั้งพื้นที่ถูกน้ำท่วมจนถึงเดือนธันวาคม หรือในทางกลับกันเหมือนในปีพ.ศ.2541 แทบจะไม่มีน้ำเก็บในท้องทุ่งเลย ใน

ปัจจุบันพื้นที่ฝั่งตะวันออก (East Bank) การที่มีน้ำท่วมและเก็บกับน้ำไว้ ลดน้อยลงไปมาก ในปีปกติ ขนาดคามจุของ East bank ขึ้นอยู่กับความจุของระบบแพร่กระจายน้ำที่ที่เชื่อมโยงอยู่ทั่วไป

ความจุของระบบแพร่กระจายน้ำในทุ่งฝั่งตะวันตกประเมินได้ประมาณ 80 ล้านลูกบาศก์เมตร (TEAM et al. 1992) ตัวเลขนี้ไม่ชัดเจนเนื่องจากความลึกน้ำที่พิจารณาคิดจากค่าความจุเต็มที่ แต่เราทดลองใช้ค่าประเมินที่ 150 ล้านลูกบาศก์เมตร เป็นค่าพิกัดสูงสุด[6] ถ้าเราพิจารณาว่าพื้นที่ซึ่งถูกน้ำท่วมประมาณ 1,500 ตารางกิโลเมตร (เกือบทั้งหมดของโครงการฯพระยาบรรลือ และเจ้าเจ็ดบางยี่หน) และค่าเฉลี่ยความลึกไม่น่าจะเกิน 50 เซนติเมตร ได้ค่าโดยประมาณหยาบ ๆ ที่ 750 ล้านลูกบาศก์เมตร (โดยไม่พิจารณาความสูญเสียจากการซึม) จากทั้งหมดเราพอจะคาดคะเนได้ว่ามีน้ำเก็บกักอยู่ในทุ่งฝั่งตะวันตกในปีปกติไม่มากไปกว่า 1 พันล้านลูกบาศก์เมตร หรือน้อยกว่า 50% ของปริมาตรเก็บกักในพื้นที่ตอนบน (upper delta) ซึ่งตรงกันกับการศึกษาของ JICA ซึ่งพบว่ามีน้ำท่วมขังอยู่ 1.3 พันล้านลูกบาศก์เมตรในช่วงน้ำท่วมปีพ.ศ.2539 ในปี พ.ศ.2538 มีน้ำท่วมขังอยู่ถึง 2.5 พันล้านลูกบาศก์เมตร แต่นี้ตรงกับน้ำท่วมกรณีพิเศษ (มีน้ำท่วมขังอยู่ในทุ่งตอนบน (upper delta) ในช่วงเวลาเดียวกันประมาณ 7 พันล้านลูกบาศก์เมตร ความจุนี้จะลดลงเนื่องด้วยคันกันน้ำที่จังหวัดปทุมธานีและนนทบุรี

ผลกระทบของการรับน้ำเกินพิกัด

ความจุประมาณ 2 พันล้านลูกบาศก์เมตรซึ่งคำนวณจากน้ำปีปกติ ซึ่งควบคุมน้ำอยู่ในระดับได้สำเร็จโดยไม่มีน้ำมากเกิน ในกรณีของน้ำท่วมอย่างรุนแรง มันเป็นไปได้/ไม่สามารถหลีกเลี่ยง ที่จะผันน้ำส่วนเกินบางส่วนลงไปสู่คลองระบายน้ำและคลองชลประทาน ซึ่งสุดท้ายทำให้หน่วยระบายน้ำต้องรับน้ำเกิดพิกัด

แบบจำลองระดับความสูงเชิงตัวเลข (digital elevation model - DEM) ทำให้ประเมินความจุสำหรับ การเพิ่มระดับน้ำในหน่วยระบายน้ำต่าง ๆ (ตารางที่ 2) แสดงว่าการรับน้ำเกินพิกัดนำมาซึ่งการเพิ่มความจุของพื้นที่รับน้ำ (buffer area) สำหรับการเพิ่มขึ้นทั้งหมด 25 เซนติเมตร ปริมาตรเก็บกักเพิ่มขึ้น 43% คิดเป็นความจุเพิ่มขึ้น 0.8 พันล้านลูกบาศก์เมตร สำหรับ 50 เซนติเมตร ปริมาตรเก็บกักเพิ่มขึ้น 95% และปริมาตรเก็บกักเพิ่มขึ้น 1.85 พันล้านลูกบาศก์เมตร[7]

---

[6] ซึ่งรวมความจุที่มากเพิ่มขึ้น ด้วยความจุของคลองในทุ่ง

[7] ตัวเลขนี้ได้ปรับแก้เล็กน้อย ตามที่ได้ปรากฏในรายงานวิจัย Molle et al. (1999)

ตารางที่ 2: ESTIMATION OF THE INCREASE OF THE STORAGE CAPACITY THROUGH OVERLOADING

Storage level	Average year	+ 10 cm	+ 25 cm	+ 50 cm
Storage capacity (billion m3)	2.03	2.32 (+18 %)	2.82 (+43 %)	3.85 (+95 %)

ความเป็นไปได้ของการจัดการน้ำท่วมโดยให้ buffer area รับน้ำเกินพิกัด

จากข้อมูลข้างบน มันชัดเจนว่าพื้นที่รับน้ำ (buffer area) ในตอนเหนือของสามเหลี่ยมปากแม่น้ำ เมื่อคิดถึงค่าโดยเฉลี่ยและยอมให้เพิ่มพิกัดได้ในกรณีที่มีความต้อง ความคิดในการจัดการน้ำท่วมควรพิจารณาระดับน้ำในแต่ละหน่วยระบายน้ำหลัก เพื่อที่จะประเมินได้ว่าที่ไหนระดับน้ำสามารถเพิ่มสูงได้โดยทำให้เกิดความเสียหายน้อยที่สุด นี้เป็นไปได้อย่างยิ่งด้วยข้อมูลที่มีอยู่แล้ว เพราะว่าการบันทึกค่าระดับน้ำได้เก็บไว้แล้วเกือบทุกหน่วยระบายน้ำ

ปัญหาสำคัญที่ไม่ทราบ ซึ่งต้องวิจัยต่อไป คือการประเมินระดับของความอ่อนไหว (degree of sensitivity) ของแต่ละหน่วยระบายน้ำที่จะต้องรับน้ำเกินพิกัด อีกนัยหนึ่งอะไรทำให้พืชเสียหาย, บ้านและสิ่งก่อสร้าง สามารถคาดการณ์ได้จากระดับการรับน้ำเกินพิกัดที่จะผันเข้าไปในหน่วยระบายน้ำ มันเป็นการยากที่ประมาณการแต่เชื่อได้ว่าไม่รุนแรงมาก พูดได้ว่าน้อยกว่าหรือเท่ากับ 50 เซนติเมตร ความเสียหายเกือบทั้งหมดเกิดขึ้นกับข้าว สำหรับที่อยู่อาศัยและสิ่งก่อสร้างอื่น ๆ ซึ่งทั้งสองอย่างนี้ปลูกหรือตั้งอยู่สูงกว่าหรือเคยชินต่อสภาพอุทกภัยแล้ว เราจะดูกับปัญหานี้ในหัวข้อต่อไป

ถ้าให้หน่วยระบายน้ำ (box) รับน้ำสูงกว่าพิกัดโดยไม่มีปัญหากับ box ยังต้องดูก่อนว่าจะทำได้โดยวิธีใดให้ประสบผลสำเร็จ ซึ่งขึ้นอยู่กับสภาพที่มีอยู่ของ (1) ทางระบายน้ำล้นในคลองสายใหญ่ (2) ประตูระบายสามารถรับน้ำจากแม่น้ำจากจุดใดจุดหนึ่งของขอบเขต box ที่อยู่ด้านเหนือน้ำ (3) ความจุคลองชลประทาน นอกจากข้อแก้ไขที่เป็นไปได้ตามนี้แล้ว ยังมีวิธีที่เป็นไปได้โดยเปิดประตูบายด้ายท้ายน้ำเพื่อให้น้ำจากแม่น้ำไหลย้อนเข้ามา (ในกรณีของน้ำท่วม ระดับน้ำในแม่น้ำมักจะสูงกว่าใน box)

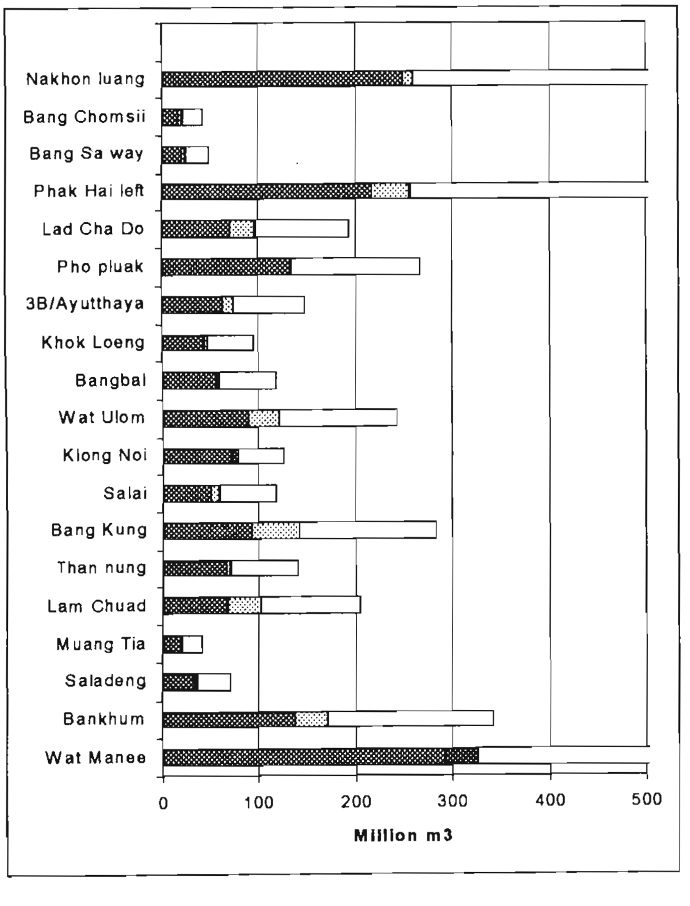
การสร้างกระดานติดตามน้ำท่วม

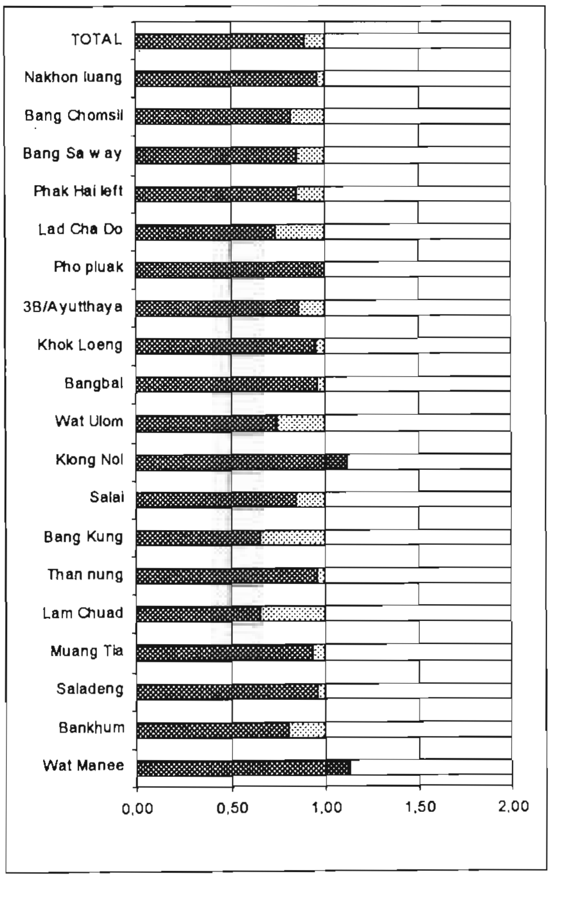
เพื่อสะดวกแก่การมองเห็นสภาพน้ำใน box เชิงพื้นที่ สามารถมองเห็นภาพจากแผนที่พื้นฐานแสดงสภาพระดับน้ำในหน่วยระบายน้ำหลัก สีสามารถช่วยแสดงสถานะของแต่ละหน่วยระบายน้ำที่สัมพันธ์กับระดับน้ำปกติ และชี้ให้เห็นยังมีหน่วยระบายน้ำใดที่ยังเหลือความจุรับน้ำได้อีก หรือควรจะผันน้ำเข้าไปที่ไหน ตารางคำนวณที่เชื่อมโยงกันสามารถแสดงผลรวมน้ำที่เก็บกัก และแสดงว่ายังที่เหลือรับเพิ่มอีกเท่าไร ภาพที่ 10 แสดงตัวอย่างสมมุติของเครื่องมือที่สร้างขึ้น ปรากฏตามที่แสดงด้านล่างนี้

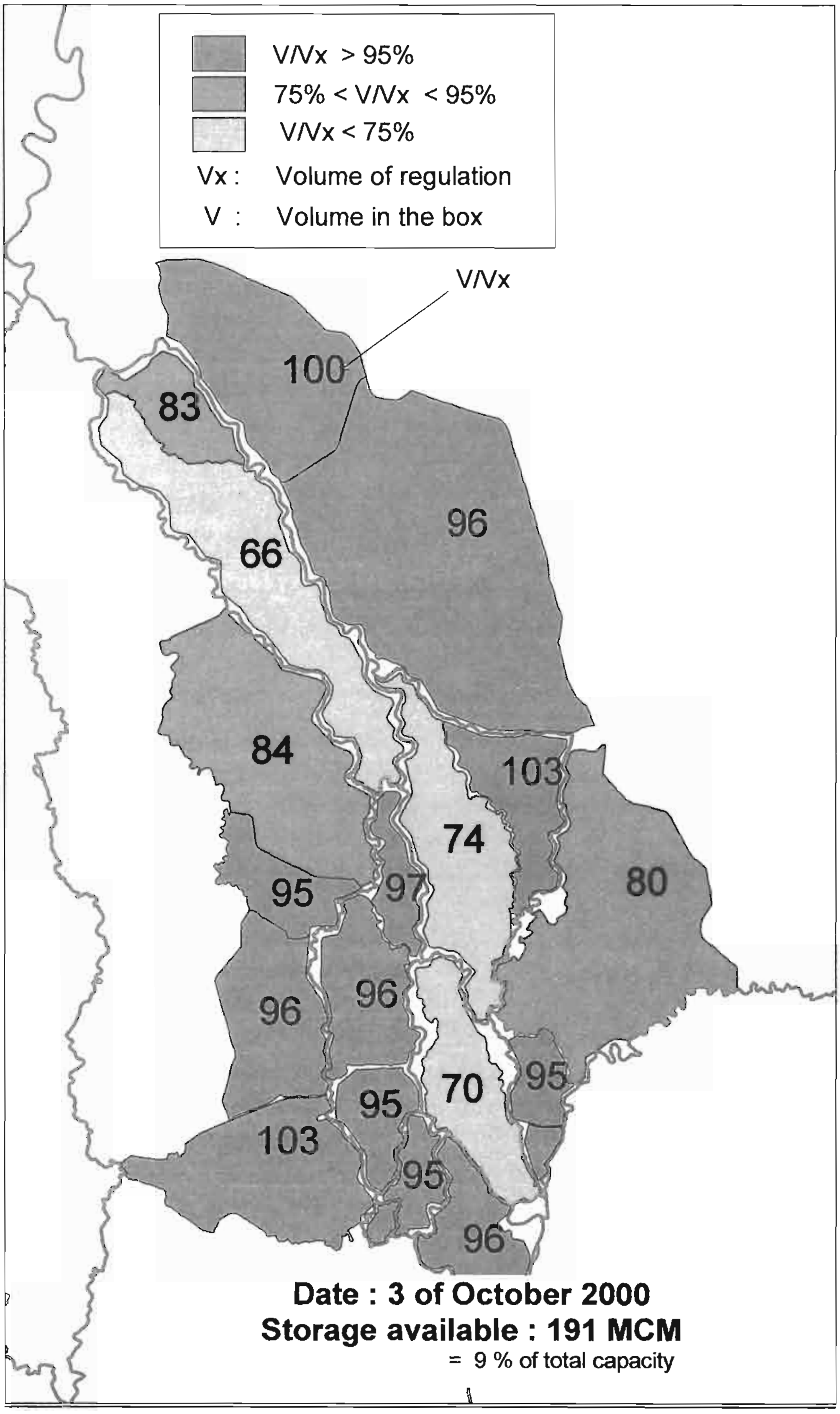
ภาพที่ 10.: EXAMPLE OF "DASHBOARD" FOR THE MONITORING OF THE FLOODED AREA (CHARTS AND MAP)

Box	Hx	Vx	H actual	V actual	Slack	in %Vx
Wat Manee	7,5	259	7,61	292	-33	113
Bankhum	4,5	171	4,28	137	33	80
Saladeng	5,4	35	5,35	34	1	96
Muang Tia	5,75	20	5,71	18	1	94
Lam Chuad	8,4	102	8,05	67	35	66
Than nung	3,5	70	3,46	67	3	96
Bang Kung	3,6	141	3,23	93	48	66
Salai	6,5	59	6,37	50	9	85
Klong Noi	5,4	63	5,50	70	-8	112
Wat Ulom	4,5	121	4,22	90	31	74
Bangbal	2	59	1,98	56	2	96
Khok Loeng	4	47	3,96	44	2	95
3B/Ayutthaya	3,5	74	3,30	63	10	86
Pho pluak	4	133	4,00	133	0	100
Lad Cha Do	3,6	96	3,40	72	25	74
Phak Hai left	3,1	255	3,02	217	38	85
Bang Sa way	12,2	24	12,11	20	3	86
Bang Chomsii	10,2	21	10,11	17	4	82
Nakhon luang	2,75	260	2,73	249	11	96
TOTAL		**2009**	**98**	**1791**	**217**	**89**

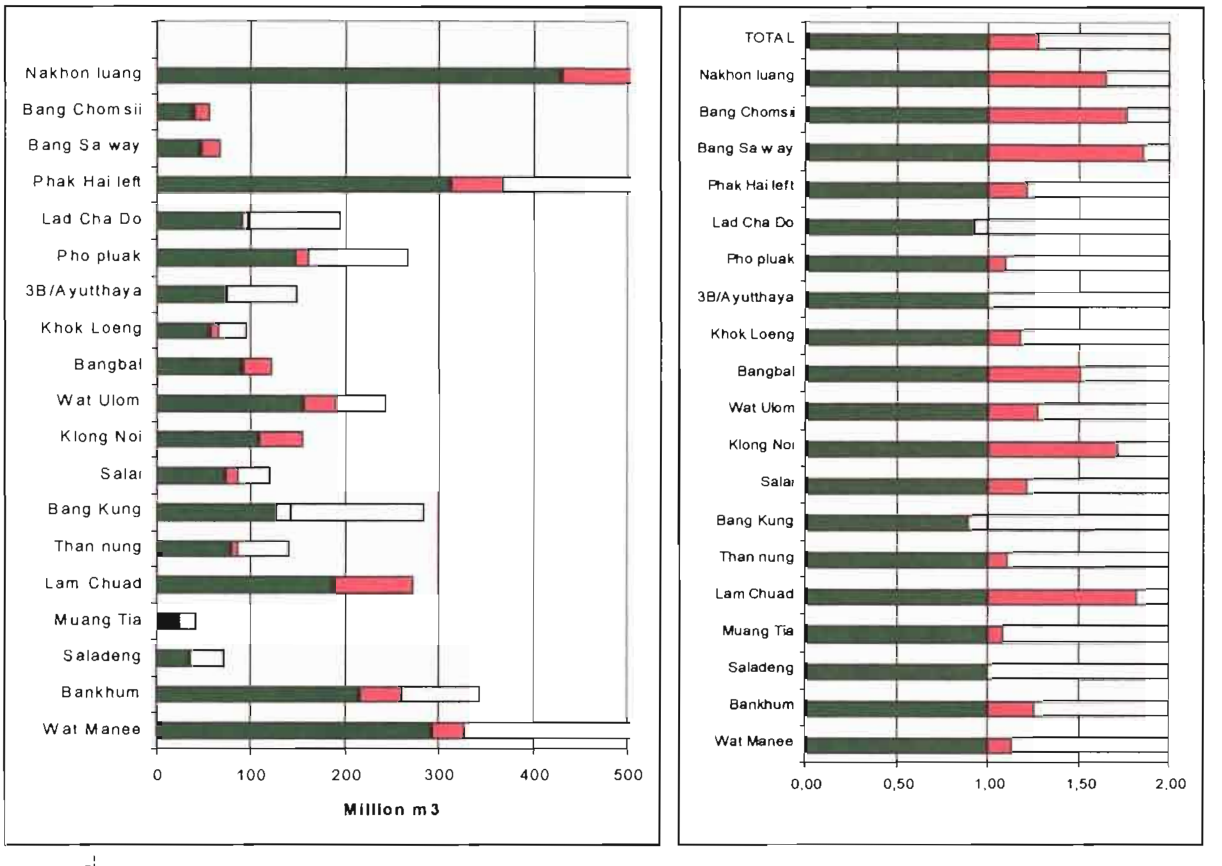
MONITORING BOX STATUS: FILLING RATE, IN ABSOLUTE AND RELATIVE TERMS (PER BOX)







ภาพที่ 11.: FLOOD MONITORING AND MANAGEMENT - CHAO PHRAYA DELTA (MAP)



ภาพที่ 12.: EXAMPLE OF DASHBOARD IN CASE OF HIGH FLOOD (MONITORING OF OVERLOAD)

ความยากของการประเมินปริมาณน้ำที่จะสามารถเก็บใน box เพราะ box ภายในที่มีประตูลดหลั่นเป็นช่วงๆ ตามความลาดเทของภูมิประเทศ "cascade boxes" ซึ่งเป็น box ที่ซับซ้อนมีการแบ่ง box ภายใน box ย่อยอยู่ต่อเนื่องกัน ตัวอย่างเช่นใน วัดอุโลม box ระดับน้ำที่ด้านท้าย box ไม่ได้แสดงให้ทราบถึงสถานะของน้ำใน box ย่อยที่อยู่ด้านเหนือน้ำ ในกรณีของน้ำท่วม อย่างไรก็ตาม การขึ้นของระดับน้ำจะทำให้ box ที่อยู่ภายในระหว่างกลางหายไป การติดตามสามารถปรับปรุงโดยพิจารณาระดับน้ำที่ประตูน้ำหลักต่าง ๆ ที่อยู่ต่อเนื่องกัน ซึ่งหมายถึงต้องเก็บข้อมูลเพิ่มในช่วงเวลาที่วิกฤต

กระดานติดตามน้ำท่วม "dashboard" แสดงสถานะของแต่ box (เป็นเปอร์เซ็นต์ของปริมาตรเก็บกักจริงต่อความจุเต็มที่ ไม่ได้พิจารณาค่าเกินพิกัด) และแสดงทางด้านซ้ายเป็นปริมาตร (ในหน่วยพันล้านลูกบาศก์เมตร) ซึ่งยังคงเก็บได้อีก ซึ่งทำให้ผู้จัดการน้ำรู้ทันทีว่าพื้นที่ใดน้ำต้อง/สามารถที่รับน้ำได้ ในทำนองเดียวกันรู้ว่า box ใดเต็มที่แล้ว เพื่อลดอัตราการระบายน้ำที่เข้ามาโดยระบบชลประทาน

ระบบเดียวกันนี้สามารถนำไปใช้กับสภาพปกติ โดยเฉพาะเมื่อมีอัตราน้ำมากจนเป็นอันตรายสามารถบังคับให้ไปสู่หน่วยระบายน้ำที่ยังคงมีที่เก็บน้ำเหลืออยู่ (โดยส่วนมากในเดือนกันยายน หรือ

ตุลาคม) หรือ ในกรณีที่มีน้ำท่วมรุนแรง เพื่อติดตามหน่วยระบายน้ำให้รับน้ำเกินพิกัด และเลือกตัดสินใจดีที่สุด (โดยส่วนมากในอย่างช้าในเดือนตุลาคม และพฤศจิกายน) มันต้องเน้น อย่างไรก็ตามยังมีอีกระดับหนึ่งซึ่งการจัดน้ำน้ำท่วมจะเป็นได้เพียงบางส่วนและเป็นไปได้ชั่วคราว เมื่อได้สภาพเหมือนดังที่ประสบในปี พ.ศ.2538 คันดินอาจจะถูกเจาะ ทางน้ำทั้งหมดต้องรับน้ำเกินพิกัดและเป็นไปไม่ได้ที่จะจัดการได้ต่อไป

การประเมินความเสียหาย, ราคาและประโยชน์ที่ได้รับ

ขีดความเสียหายต่อข้าวจากการได้รับน้ำเกินพิกัดสามารถที่ประมาณการได้จากลำดับพื้นที่ที่ปลูกข้าว พันธุ์ส่งเสริมให้ผลผลิตสูง (HYV) ข้าวทนน้ำลึก และข้าวขึ้นน้ำในแต่ละ box (ดูภาคผนวก) มันยากที่ต้องพิจารณาถึงสวนผลไม้ยกร่อง (อย่างไรก็ตามมีไม่มากนักในพื้นที่น้ำท่วม) คิดในด้านบวกได้ว่าเป็นพื้นที่ปลูกข้าวขึ้นน้ำ 42% ซึ่งได้รับผลกระทบไม่มาก ถ้าเรามั่นใจว่าจะทำให้ระดับน้ำเพิ่มขึ้นน้อยกว่าวันละ 5-8 เซ็นติเมตรต่อวัน

เพื่อให้เกิดความเป็นธรรมกับชาวนาผู้ซึ่งอยู่ในพื้นที่ที่ถูกเลือกเป็นพื้นที่เก็บน้ำ จะต้องได้รับค่าชดเชย ชาวนาจะได้รับค่าเสียหายโดยใช้พื้นที่เป็นฐาน ผลผลิตเฉลี่ย และราคาข้าวตามจริง ถ้าเราพิจารณาว่าผลผลิตเฉลี่ยทั้งหมดเป็น 50 ถัง/ไร่ (สำหรับข้าวทุกชนิดที่ปลูกในพื้นที่) ราคาข้าวเป็น 4,500 บาท/ตัน[8] และความเสียหายเป็นครึ่งหนึ่งของ 1,250,000 ไร่ ของพื้นที่ในทุ่งราบน้ำท่วมที่ปลูกข้าว[9] เราได้เพดานอยู่ที่ 1.4 พันล้านบาท ในกรณีความเสียหายรวมถึงการปลูกข้าวและกระทบถึงสิ่งปลูกสร้าง ค่านี้มากเกินกว่า

นี้สามารถเปรียบเทียบกับความเสียหายต่อสิ่งปลูกสร้างของรัฐที่ 32 พันล้านบาทสำหรับปี 2539 (72 พันล้านบาท ในปีพ.ศ.2538) (JICA, 1999, ซึ่งไม่ได้พิจารณาผลกระทบทางด้านเศรษฐกิจ) ถึงแม้เราพิจารณาเพียงค่าโดยประมาณครึ่งหนึ่งของความเสียหายที่เกิดขึ้นในพื้นที่ตอนล่าง (lower delta) สัดส่วนค่าความเสียหายยังคงอยู่ที่ 1/10 เป็นไปได้อย่างมากว่าจะเกิดความเสียหายไม่มากต่อพื้นที่รับน้ำที่ถูกกำหนดของเรา ในปีที่สามารถควบคุมน้ำท่วมได้โดยให้ boxes รับน้ำเกินพิกัด ไม่น่าจะมากกว่า 500 ล้านบาท ถึงแม้ว่าเป็นการยากที่จะประเมินความถี่ของน้ำท่วมที่จัดการได้และไม่ได้ นี้เปรียบเทียบประโยชน์กับการควบคุมน้ำท่วมวิธีอื่น (ตัวอย่างเช่น อย่างต่ำที่สุด 9 พันล้านบาท สำหรับการบรรเทาอุทกภัย โดยการ

---

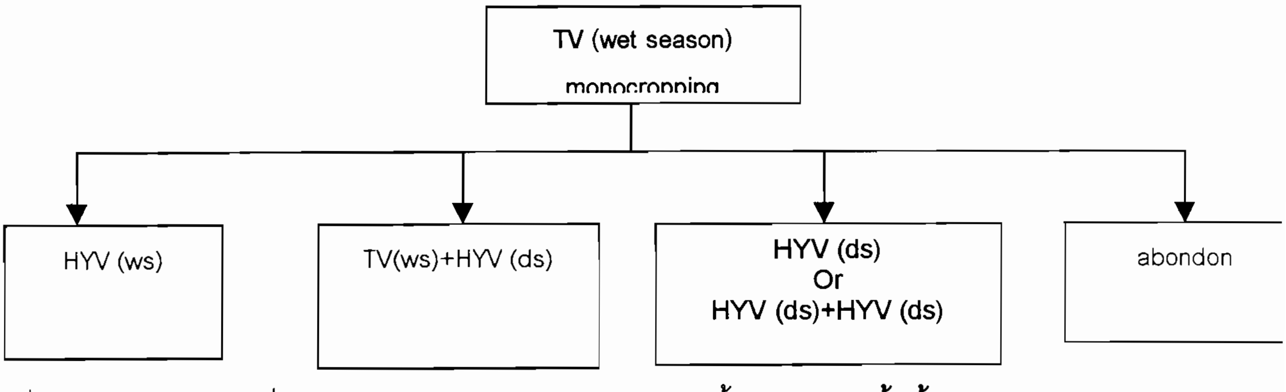
[8] ด้วยเหมือนกันการพิจารณานี้ เกษตรกรเหล่านั้นจะไม่มีค่าใช้จ่ายสำหรับการเก็บเกี่ยวและการขนย้าย (ประมาณ 450 บาท/ไร่)

[9] พื้นที่ทั้งหมดคือ 1,875,000 ไร่ สมมุติว่าพื้นที่ปลูกข้าวประมาณ 2 ใน 3 ของพื้นที่ทั้งหมด ความเสียหายเกิดขึ้นครึ่งหนึ่งของพื้นที่อย่างไม่น่าเป็นไปได้ ดังนั้นเป็นการประมาณอย่างต่ำ เพราะว่าข้าวขึ้นน้ำมีความสามารถยืดปล้อง และเพราะว่าแม้ว่าในปี 2538 เปอร์เซ็นต์ความเสียหายก็มีไม่ถึง

ประมาณของ JICA, 42 พันล้านบาทสำหรับทางผันน้ำ อยุธยา-ฝั่งตะวันออก-ทะเล)[10] ใน 3 ทศวรรษสุดท้ายนี้แนะนำอย่างโดยประมาณว่า 2 ปีจาก 3 ปี จะไม่เป็นการยากในการจัดการอัตราการไหลสูงสุดในฤดูฝน โดยปราศจากการใช้ให้ boxes รับน้ำเกินพิกัด หนึ่งปีจาก 3 ปี ระบบต้องถูกกระตุ้นแต่ปราศจากความจำเป็นต่อวิธีให้ความสำคัญของความเสียหาย

ปรับปรุงการจัดการน้ำของ boxes โดยติดตามอย่างใกล้ชิดว่า ที่ไหนน้ำควรจะถูกผันไป โดยมีผลกระทบทางบวก ถึงแม้ว่ายากที่จะประเมินในเชิงปริมาณ ต่อขอบเขตความเสียในบางปี และจะต้องปรับปรุงการจัดการระดับน้ำใน box ด้วยเหมือนกัน (ช่วงเวลาและอัตราการขึ้นของระดับน้ำตามความต้องการของข้าว)

ถึงแม้หลักเบื้องตนการจ่ายค่าชดเชยเป็นที่ต้องการ มันต้องถูกบันทึกว่ามันจะมีเงื่อนไขว่าความรับผิดชอบทั้งหมดต่อพืชซึ่งได้รับความเสียหายจากน้ำท่วม จะต้องได้รับการสนับสนุนจากรัฐบาล นี้ไม่ใช้กรณีในปัจจุบัน ซึ่งเกษตรกรต่อสู้กับการขาดการไม่เอาใจใส่ ของทั้งน้ำท่วมที่กลับกลายเป็นรุนแรงเพราะว่าธรรมชาติ หรือเพราะว่าการขาดการจัดการ ในปีพ.ศ.2538 เป็นตัวอย่างแสดงว่าพืชที่ได้รับความเสียหายได้ถูกบันทึก แต่ค่าชดเชยความเสียหายไม่ได้ให้คืนแก่เกษตรกร[11] อันตรายของระบบ หรือราคาของมัน คือ ยอมให้เกิดความเสียหายบางส่วนโดยตั้งใจต่อพื้นที่ปลูกข้าวเพื่อที่จะสงวนพื้นที่ด้านท้ายน้ำ รัฐบาลจะต้องชดเชยความเสียหายต่อเกษตรกรสำหรับสิ่งนี้ ต่อไปความเสียหายทั้งหมดที่จะเกิดขึ้นในอนาคตจะถูกใส่ความว่าเกิดจากมัน เพราะว่าเป็นไปไม่ได้ที่จะพิสูจน์ หรือเป็นน้ำท่วมอย่างจงใจหรือไม่ ดังนั้นมีจุดสำคัญที่ต้องพิจารณาและการตัดสินใจของทางด้านการเมืองที่จะทำ ก่อนที่จะพิจารณาขั้นนี้



ภาพที่ 13.การวิวัฒนาการที่เป็นไปได้สำหรับระบบการปลูกข้าวทนน้ำลึกและข้าวขึ้นน้ำในทุ่งราบภาคกลาง

[10] หนึ่งบาทของเงินที่ใช้ซ่อมความเสียหาย กับหนึ่งบาทของค่าชดเชยความเสียหายแก่เกษตรกรไม่เท่ากันเพราะว่าอย่างหลังมีค่าทางด้านปกป้องสังคมสูงกว่า ขณะที่เกษตรกรอยู่ในสภาวะราคาข้าวตกต่ำ

[11] หรือเป็นเพียงทางอ้อม (ให้เมล็ดพันธุ์ฟรี, เพิ่มปริมาณน้ำให้ในฤดูแล้งต่อมา ฯลฯ)

การเปลี่ยนแปลงและภาพที่ปรากฏชัดมากขึ้น

การวิวัฒนาการสังเกตุเห็นได้และสามารถพยากรณ์สำหรับอนาคตได้ แรงผลักดันหลักอาจเป็นผลประโยชน์ตอบแทนต่ำของการเพาะปลูกข้าวพันธุ์พื้นเมือง ในระยะยาวชาวนาจะถูกบังคับให้เข้าไปหาแนวทางอย่างใดอย่างหนึ่ง การเพาะปลูกข้าวแบบปราณีต หรือการปลูกแบบหลากหลายผสมผสาน หรือละทิ้งจากการเกษตร ในรายงานฉบับนี้ได้แสดงให้เห็นตัวอย่างของแนวโน้มข้างต้นเหล่านี้ จำแนกข้อได้เปรียบ ขีดจำกัด และข้อบังคับต่างๆ

1. วิวัฒนาการอย่างที่หนึ่งอาจเป็นไปได้ในพื้นที่ที่ซึ่งสามารถกำหนดสภาวะน้ำให้เหมาะสมได้ แล้วเปลี่ยนเป็นข้าวพันธุ์ลูกผสมที่ให้ผลผลิตสูงแทนที่ข้าวพันธุ์พื้นเมือง มีความเป็นไปได้ในเขตพื้นที่ที่เหมือนกับโครงการชลประทานบรมธาตุและที่อำเภอท่าวุ้ง และสามารถแพร่ขยายพื้นที่ออกไปในหน่วยระบายน้ำลำชวดหรือหน่วยระบายน้ำดอนตูม หรือสามารถทำได้เขตที่ดินดอนสูงของแต่ละหน่วยระบายน้ำด้วยการลดระดับน้ำให้ค่อนข้างต่ำลงในบางหน่วยระบายน้ำ

   เขตพื้นที่กำลังมีการปรับเปลี่ยนทางฝั่งตะวันออกของแม่น้ำเจ้าพระยาซึ่งแต่ก่อนเพาะปลูกข้าวด้วยวิธีปักดำ ยังคงมีการใช้ข้าวพันธุ์ทนน้ำลึกถึงแม้ว่าไม่มีความเสี่ยงต่อน้ำท่วมขังหรือมีเพียงเล็กน้อยและมีการชลประทานแล้ว ยังคงเหลืออยู่เป็นหนึ่งในกรณีที่หาได้ยาก ที่ซึ่งมีการปลูกข้าวพันธุ์พื้นเมืองภายใต้สภาพการชลประทานของทวีปเอเชีย และควรมีการค้นคว้าอย่างละเอียดลึกซึ้งต่อไปในเขตพื้นที่นี้เพื่อให้ทราบได้ว่าอะไรเป็นสาเหตุให้สถานการณ์เช่นนี้ยังคงมีอยู่

2. วิวัฒนาการอย่างที่สองเป็นการเพิ่มพื้นที่เพาะปลูกข้าวในฤดูแล้งให้มีมากขึ้น แนวทางแก้ไขประการแรกที่สุดโดยผันน้ำจากแม่น้ำโขงหรือแม่น้ำสาละวินเพื่อเพิ่มปริมาณน้ำที่สามารถใช้ประโยชน์ได้ในเขื่อนต่างๆ การปรับปรุงที่อาจจะต้องตามมาด้วยเหมือนกัน 1) การปรับปรุงตารางเวลาการส่งน้ำและการแพร่กระจายน้ำ 2) แหล่งน้ำที่สอง ได้แก่ บ่อบาดาล, น้ำที่เหลือค้างในคูคลองระบาย สระน้ำที่ขุดกระจัดกระจายในที่ลุ่มต่ำ ถึงแม้ในปัจจุบันจะอยู่ภายใต้ข้อจำกัดหลายประการ พื้นที่ซึ่งเพาะปลูกข้าวพันธุ์พื้นเมืองสมควรที่จะให้ได้รับความเป็นธรรมมากกว่านี้และไม่คำนึงถึงอย่างไร้ระเบียบแบบแผนในพื้นที่เหล่านี้ ในขณะนี้ส่วนมากของเงื่อนไขในการเพาะปลูกข้าวนาปรังฤดูแล้งและความยั่งยืนของการทำฟาร์มขึ้นอยู่กับความถี่ของการเพาะปลูกข้าวนาปรังฤดูแล้งเป็นอย่างยิ่ง

3. วิวัฒนาการอย่างที่สามเป็นการละทิ้งการเพาะปลูกข้าวในฤดูฝนและเริ่มการเพาะปลูกข้าวนาปรังฤดูแล้งเมื่อสิ้นสุดฤดูฝนโดยเร็วที่สุดเท่าที่จะเป็นได้ ขึ้นอยู่กับแหล่งน้ำในท้องถิ่นที่สามารถใช้ประโยชน์ได้ การเพาะปลูกข้าว 2 ครั้งสามารถทำได้ในบางฤดูแล้ง ถ้าหน่วยระบายน้ำทั้งหมดปฏิบัติตามแนวทางนี้แล้ว ก็ไม่มีข้อจำกัดอะไรอีกสำหรับการเก็บกักและปล่อยน้ำตามรูปแบบเดิม : การลดน้อยลงของน้ำท่วมขังต้องให้เป็นไปตามสภาวการณ์ธรรมชาติซึ่งเอื้ออำนวยในการพาะปลูกข้าวนาปรังฤดูแล้งได้อย่างรวดเร็ว มีโอกาศที่เอื้ออำนวยให้โครงการชลประทานผักไห่ดำเนินการเปลี่ยนแปลงตามอย่างเขตพื้นที่ทางฝั่งตะวันตกของแม่น้ำเจ้าพระยาได้ทำมาเมื่อ 20 ปีที่แล้ว

4. วิวัฒนาการอย่างสุดท้ายที่สังเกตุเห็นได้คือ การละทิ้งการเพาะปลูกข้าวและ/หรือการเกษตร การเคลื่อนย้ายนี้เห็นได้มากที่สุดในพื้นที่ที่ซึ่งสภาพนิเวศการเกษตรที่ไม่เอื้ออำนวยต่อการเปลี่ยนแปลงอย่างหนึ่งอย่างใดข้างต้นนี้ และที่ซึ่งใกล้ถนนใหญ่หรือเขตอุตสาหกรรมหรือเมืองใหญ่(อยุธยา กรุงเทพมหานคร) ซึ่งทำให้เกิดโอกาสของแรงงานและกระตุ้นอย่างยิ่งให้การถือครองที่ดินเปลี่ยนไปเป็นของนักเก็งกำไรและของนักค้าที่ดิน

สรุป

แม้จะเพิ่มกฎระเบียบและควบคุมน้ำผ่านคลอง คันดิน และประตูระบายน้ำ พื้นที่น้ำราบน้ำท่วมของสามเหลี่ยมปากแม่น้ำเจ้าพระยายังคงมีคุณสมบัติเป็นพื้นที่รองรับน้ำ (buffer area) ด้วยความจุ 2 พันล้านลูกบาศก์เมตร ปริมาตรเกือบทั้งหมดนี้มาจากฝนที่ตกภายในหรือน้ำที่นำมาจากแม่น้ำเจ้าพระยาผ่านมาทางคลองชลประทาน ขณะที่ปริมาตรเก็บกักมากที่สุดตามต้องการอยู่ในราววันที่ 1 พฤศจิกายน มีความจุเหลือที่จะสามารถรับน้ำเข้าไปได้อีกโดยต้องรับเกินพิกัดของหน่วยระบายน้ำ สำหรับการเพิ่มระดับอย่างที่ละน้อยขึ้นอีก 50 เซนติเมตร พบว่าความจุจะเพิ่มจากเดิมเป็น 2 เท่า

การติดตามหน่วยระบายน้ำ(box)และความจุเก็บกักสามารถทำได้สำเร็จ โดยใช้งบประมาณน้อยมาก และใช้ข้อมูลที่เก็บเป็นประจำอยู่แล้วของกรมชลประทาน โดยต้องเพิ่มจุดเก็บข้อมูลอีก 4-5 จุดในเวลาที่เกิดน้ำท่วม กระดานติดตามน้ำท่วม (monitoring dashboard) สามารถติดตั้งได้โดยง่าย และระดับน้ำที่เก็บบันทึกอยู่แล้วแปลงให้อยู่ในค่าของความจุใช้การ และนำแสดงออกทางแผนที่ ในเวลาที่เกิดวิกฤตกระดานติดตามน้ำท่วมสามารถใช้เพื่อเตือนล่วงหน้าของการรับน้ำเกินพิกัดของหน่วยระบายน้ำ

การใช้ทุ่งราบน้ำท่วม เป็นพื้นที่รับน้ำเพื่อบรรเทาน้ำท่วมในทุ่งราบตอนล่าง (lower delta) และโดยเฉพาะในเขตพื้นที่กรุงเทพฯ ต้องไปด้วยกันกับระบบของค่าชดเชยแก่เกษตรกรผู้ซึ่งข้าวจะได้รับความเสียหาย คิดเป็นส่วนของมูลค่าที่น้อยอย่างมากเมื่อเปรียบเทียบกับการบรรเทาอุทกภัยด้วยวิธีอื่น และผลของความเสียหาย

ขั้นตอนการสนับสนุนโดยที่ละน้อย ของระบบการติดตามประกอบด้วย

- เพิ่มจุดติดตามระดับน้ำให้สมบูรณ์ในบาง boxes (นี้หมายถึงการเพิ่มแถบวัดระดับน้ำ ในหน่วยของความสูงเมื่อเทียบกับน้ำทะเลปานกลาง (เมตร รทก.) ในบาง sub-boxes) และรายงานระดับน้ำรายวันให้ศูนย์ในเวลาที่เกิดน้ำท่วม (โดยวิทยุสื่อสาร)
- สำหรับแต่ละ box ควรจะทำบัญชีรายชื่ออย่างถูกต้อง ของทางน้ำทั้งหมดซึ่งสามารถใช้เป็นทางนำน้ำเข้ามาสู่ box (ทางรับน้ำป่าจากคลองชลประทานสายใหญ่, คลองชลประทานอื่น ๆ, ลำน้ำธรรมชาติ หรือคลองระบายที่เชื่อมต่อกับระบบของแม่น้ำ, และอื่น ๆ)
- ถึงแม้การเพิ่มระดับน้ำโดยพอประมาณดูเหมือนว่าไม่ทำให้เกิดความเสียหาย การประชุมกับผู้นำท้องถิ่น กำนัน/ผู้ใหญ่บ้าน ในแต่ละ box สามารถช่วยประมาณความเสียหายที่จะเกิดขึ้นได้สำหรับระดับน้ำ

ต่าง ๆ จากประสบการณ์ที่ผ่านมาและทำบัญชีรายการทรัพย์สินที่จะเกิดความเสียหาย ดัชนีความอ่อนไหวสิ่งแรกที่สามารถได้จากตารางภาคผนวกซึ่งแสดงสัดส่วนของข้าวขึ้นน้ำในแต่ละ box

- ถ้า boxes ถูกใช้สำหรับให้รับน้ำเกินพิกัดด้วยเหตุอันควร เกษตรกรและท้องถิ่นนั้นควรจะได้รับทราบและทราบถึงการดำเนินการบางอย่าง สำหรับการกำหนดล่วงหน้าของค่าชดเชยความเสียหายที่จะเกิดขึ้น (ถึงแม้ว่าจะไม่ค่อยได้รับการสนับสนุน)

References

JICA (1999) The study on integrated plan for flood mitigation in Chao Phraya river basin, 2 volumes.

Molle, Francois; S. Durongdej; C. Chompadist; A. Joannon and Y. Limsawad. 1999. Improvement of rice cultivation and water management in the flooded area of the Central Plain of Thailand : a zoning of rice varieties by using remote sensing imagery, Kasetsart University, DORAS Center, Research Report n°5, submitted to NRCT, Bangkok, pp. 155.

Molle, Francois; C. Chompadist. 2000. "Kaem ling" Project and flood prone areas : how to double the monkey's cheeks, Kasetsart University, DORAS Center, pp. 23.

Takaya, Y.; 1987. Agricultural development of a tropical delta : a study of the Chao Phraya delta, Monographs of the Center for Southeast Asian Studies, Kyoto University, University of Hawaii Press, Honolulu, 269 p.

Van der Heide J.H.; 1903; General report on Irrigation and Drainage in the lower Menam valley, Ministry of Agriculture, 149 p.

Annexe: Rice types, by Box

Box	Total area (ha)	Floating rice (%)	DW (%)	HYV (%)
Ayu1	3073	100	0	0
Ayu2	1323	100	0	0
Ayu3	902	100	0	0
Ban Praek	581	100	0	0
Bang Ban north	1870	80	20	0
Kok Loeng	4819	80	20	0
Klong Taanung	6903	73	27	0
Pho pluak	7612	71	29	0
Bang Chomsi	5535	57	43	0
Lam Chuad	16109	53	47	0
Nakhon Luang	55687	51	49	0
Bang Saway	4098	50	50	0
Bang Kung	13289	46	54	0
Wat Ulom	21595	45	41	14
Salai	14123	40	60	0
Bang Khum	34776	38	56	6
Saladang	4783	33	67	0
Klong Noi	11629	30	48	22
Wat Manee	42083	29	61	10
Phak Hai	9570	28	72	0
Lat chado	17263	18	82	0
Bang Ban	15957	17	83	0
Taa Tiang	5568	0	100	0

Proposal for enhancing flood retarding capacity in the Chao Phraya Delta

Naritaka Kubo and Chikayo Hotta[1]

Abstract: *Floating rice areas spreading north of Ayutthaya have been playing important roles for downstream areas of the Chao Phraya River until now. During the rainy season, they received flooding water to decrease the flow rate of the Chao Phraya River, which mitigated flood damage against Bangkok metropolitan area. During the dry season, they released stored water, which irrigated vast downstream paddy field areas. However, nowadays the area used for high yield rice's cultivation is rapidly increasing instead of the floating rice area. As the results, in these areas, an excessive water that was not recognized as a flood when people grew floating rice became considered as a flood. Moreover, because of the increase of vehicles and road networks, flood mitigation becomes more and more important even in rural areas. Considering these situations, we proposed following several development projects, which may be beneficial to floating rice areas and also may contribute to the downstream rural and urban areas. (1) Constructing regulating reservoirs for rice cultivation during the rainy season. (2) Raising roads and residential sites to avoid submergence. (3) Releasing water to increase retarding capacity during rainy season. Concerning to these projects, we examined their effectiveness for the water resource's development and for the flood mitigation.*

1 Introduction

More than thirty years has passed since two big reservoirs (the Phumiphol dam and the Sirikit dam) were constructed in two major tributaries of the Chao Phraya River. They have greatly contributed to the Thai society in the fields of irrigation, municipal water supply, power generation, and flood control. Recently, however, water shortage becomes tangible in several areas because of rapid economic development, increase of irrigated area, and the change of hydrological conditions in the upper regions. As two reservoirs have vast downstream areas often hit by heavy rainfalls, two reservoirs cannot control floods perfectly. Moreover, flood damages become more and more serious than ever before, because the Bangkok outskirts' areas have been urbanized and industrialized.

Vast paddy field areas over the Chao Phraya Delta have high productivity, and play an important role to mitigate floods by storing rainfall water and releasing it slowly. Especially,

[1] Dept. of Environmental & Agricultural Engineering, Faculty of Agriculture, Tokyo University of Agriculture & Technology

floating/deep water rice can tolerate deep water, and paddy field for which shows high retarding capacity. The released water after floods can be also used to irrigate downstream areas during the dry season. However, this retarding capacity is now decreasing gradually due to the spread of high yield varieties and the urbanization. The high yield varieties are replacing the floating rice, and require proper water management. It means that excessive water must be drained directly to the outside canals or rivers, which leads to water shortage during the dry season.

After the big flood in 1995, the King Phumipol proposed the "Monkey Cheek Project", where a part of flooded water should be stored temporarily in numerous small reservoirs or ponds to cut down the peak discharge. With accordance to this idea, we will propose "Enhancing Retarding Capacity Project". In this project we will show the way to strengthen the retarding and reserving water functions inherent to the floating rice paddy fields, without constructing huge dams or release canals that are commonly used to prevent floods.

2 Flood retarding function of paddy fields in old delta

Agricultures, in the Southeast Asian countries, have developed since old times adapting themselves to surrounding water environments. It means that crop varieties and the timing for seeding or harvesting are subject to the environment. It is also quite different from the concept of the large-scale land improvement project, in which environment is tried to change suitable to modern agriculture. As water environment became controllable to some extent by such projects, many farmers in the Chao Phraya Delta are replacing the floating rice to the high yield varieties. As the result, the area of floating rice reduced half during this decade.

TABLE 1 CHANGE OF FLOATING RICE AREAS IN THE DELTA

Year	1976	1986	1995	1996
Area (1000ha)	180	228	173	114

The floating rice can grow following the ponding depth, and becomes sometimes more than several meters. Paddy field area of the floating rice is usually surrounded by high dikes, which are usually used as roads. It can store a considerable amount of water, and this function is called "retarding function" of the floating rice area. Assuming that the average ponding depth is 2 meters, we can estimate that about 2.28 billions m^3 of retarding capacity was lost during this decade. In other words, if the high yield varieties take the place of the floating rice and its allowable depth is 30 cm, 1.9 billions m^3 of water is released without being reused during the rainy season. This may be one of the reasons why drought becomes serious in recent years.

Floating rice cultivation is as follows. Paddy soil is plowed during April and May. Seeding follows the plowing after half month. At that time, paddy field is not flooded but the soil is a little bit softened. Because the yield is subject to the amount of seed, 20 to 30 kg of seeds are sowed per rai. Ponding begins at the end of August or at the beginning of September, when flooded water flows into the floating rice area. According to the increase of water depth after September, the rice crop also grows rapidly becoming 2 to 3 meters long. Farmers cannot do anything while the deep water, because the fertilizer application and weeding have no meanings. Harvest time is around December when all water flows out, and only ears of lying rice plants are reaped with a sickle. The yield is about 2 kg/ha, which is one third of that of the high yield variety.

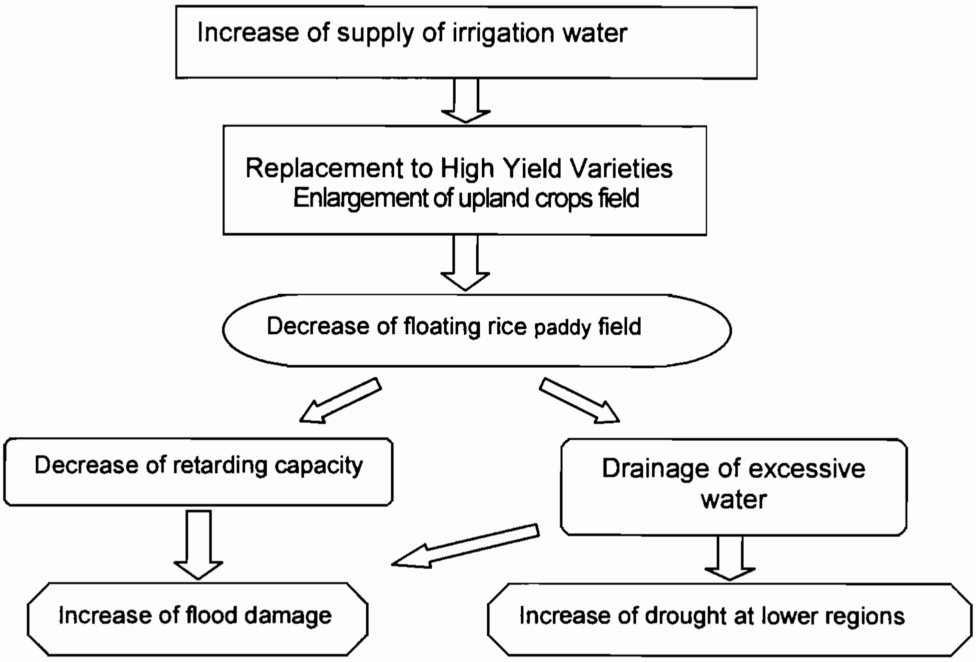


FIG. 1 PROCESS OF PROBLEMS CAUSED BY DECREASE OF FLOATING RICE AREAS

Paddy field cultivation in the old Delta and its hydrological conditions are as follows. The Great Chao Phraya project aimed at a major water resources' development to supply irrigation water during rainy season, and both irrigation and drainage channels were arranged at that time. This project also enabled farmers to grow paddy crops during the dry season. Many farmers came to grow the high yield varieties, and the high yield varieties are now planted around 66% of the total area in the old Delta. On the other hand, the floating rice and the deep water rice are naturally driven away in the changing environment, and their planted area is decreasing rapidly.

TABLE 2 PROJECTION OF AREA AND SHARE OF RICE VARIETIES IN THE OLD DELTA

Land Use	Annual Growth (%)	Present (1998)		Future (2005)		Future (2018)	
		Area (km^2)	Share (%)	Area (km^2)	Share (%)	Area (km^2)	Share (%)
Rice	-0.4	9,133	100.0	8,684	100.0	8,336	100.0
1) HYV	0.3	6,038	66.1	6,183	71.2	6,703	80.4
2) General	0.0	0	0.0	0	0.0	0	0.0
3) Deep Water	-3.0	2,539	27.8	2,051	23.6	1,339	16.1
4) Floating	-3.0	556	6.1	449	5.2	293	3.5

TABLE 3 COMPARISON BETWEEN LOCAL VARIETIES AND HIGH YIELD VARIETIES

	Local varieties	High yield varieties
Yield	Deep water rice:300-400 kg/rai Floating rice:200-300 kg/rai	About 600kg/rai
Water supply	Rain fed, gravity irrigation	Irrigation
Growing season	Deep water rice: 7,8-12 Floating rice: 5,6-12,1	6-11(rainy season) 12-5(dry season)
Fertilizer, chemicals, Herbicide	No need	Need large quantities
Growing speed	Fast	Slow
Photosensitivity	Sensitive	No-sensitive
Stem length	Deep water rice: 1,2m Floating rice: 2,3m	40,50cm

3 Enhancing retarding capacity project

We propose our project under following three assumptions. The first assumption is that they will not construct a large-scale release canal in future, which washes flood away directly to the sea, because it may cause a severe water shortage during the dry season. We also assume that a large part of flooded water must be stored within the Delta at the end of the rainy season consequently. The second assumption is that high yield varieties will replace floating rice in almost all areas, and that the floating rice cultivation will continue in a very limited area. Table 2 shows the projection of the rice cultivation areas in future. We can see that the area of the floating rice will reduce rapidly, and its share will be only 3.5% of the total paddy field area after 18 years. The reasons may be that the yield of the floating rice is low and agricultural mechanization is difficult for the floating rice cultivation. The third assumption is that the living standard will be improved more in future and the importance of protecting houses, buildings and roads from floods will increase remarkably. Namely, rural living styles are urbanized, and the submergence of houses and roads is recognized as a disaster. People are requiring counter measures to prevent damages by a flood having the same scale with that in 1995. Above three assumptions seem to be realistic at least in future in many areas in the Delta.

We expect following four effects by this project. The first effect is that farmers can mechanize their farming, and that they can grow high yield varieties three times in two years through drainage improvement and acquirement of irrigation water. The second effect is that houses and roads are free from floods, and floods do not disturb daily lives of people. Floods are not avoidable, but damages by floods are expected to be avoidable. The third effect is that damages against downstream urban areas of the Chao Phraya River, especially Bangkok metropolitan area, are mitigated in the flood season. The fourth effect is that much irrigation water is supplied to the downstream agricultural areas in the dry season.

Above four effects of our project may look too admirable. Our project, however, is not such that as produces something from nothing, but it merely changes water distribution temporally and spatially. You can see that this project is feasible by checking the annual water budget in the Delta, which will be shown later. Advantage of this project, we expect, is that results come out in accordance with the rate of the project achievement. In such a project as construction of a dam, the result comes out when the project is fully accomplished.

The outline of this project is as follows. This project consists of two parts. One is concerned in construction, and another is in the practice. First, the construction part is explained.

Surrounding dike and dividing dike: A former floating rice area, which is a unit of the retarding area, is divided into two parts with same conditions by a surrounding dike and a dividing dike. As dikes are also sites for houses and roads, they must be raised and not to be inundated against a big flood. From the worst record of the past floods, the height of dikes is decided.

Regulating reservoir: Several regulating reservoirs are constructed within the former floating rice area. Several swamps may exist in the area. In such a case, sites for ponds may be acquired from such swamps. The regulating reservoir should be big enough to store water for the paddy rice in the rainy season, and to provide soil material for the dike construction.

Channel networks: Irrigation and drainage channels are also arranged properly.

Pumping station: Pumping station is constructed to lift water in the regulating reservoir for the irrigation or for the drainage.

Water gates: Several gates are constructed to regulate the inflow from outside, the outflow from inside, and the water exchange between two parts divided by dividing dike.

Next, the practice is explained.

(1). The unit consists of two blocks, i.e., A block and B block, and two blocks exchange their roles each other every year. The paddy rice is grown three times in two years. When the A block is used for the rice cultivation twice (rainy and dry) in a year, the B block is used only one time (rainy), and vice versa.

(2). When the A block is used for the dry season paddy rice (from December to March), the B block reserves flood water and supply irrigation water to the A block.

(3). In the B block the rainy season cultivation (from April to September) begins when remaining water is fully drained before the end of February. On the other hand, in the A block the rainy season cultivation (from May to August) also begins after harvesting the dry season crops. Irrigation water for the both blocks is supplied from regulating reservoirs, rainfall, and drained water from the upper regions.

(4). During the flood season, flooded water is stored in both blocks. However, if a flood comes earlier and the harvesting is not completed in the A block, the B block exclusively stores flooded water.

(5). At the end of the flood season, the B block is drained actively and the dry season cultivation begins in December.

The above cultivation cycle is applied to an average-sized flood. However, if a small-sized or large-sized flood comes, the practice may be modified as follows.

In case of the small-sized flood, the B block reserves a small amount of water and cropping area in the A block is reduced. In case of the large-sized flood, the A block is flooded for longer time. As the result, the dry season cultivation delays in the A block and no crops can be grown in the rainy season. If next flood comes earlier, the A block guards the B block where rainy season rice is grown.

4 Feasibility of the project

The above project will not work effectively if it is practiced only in one project, because a flood occurs in a large area. Not a small number of this kind of projects can multiply their individual effects. However, if the project is applied for many areas, it will lose concreteness and may become very abstractive because each area has its own properties. Therefore, we choose one floating rice area for which this project is considered most suitable, and examine the feasibility of this project.

Table 4 shows deep water and floating rice cultivation areas, and Figures 3 and 4 show flooded areas and floating rice areas, respectively. We can find several overlapping areas from above two figures. They are Ayuttaya, Ang Thong, Lop Buri, and etc. Among them, we select Lop Buri area as the site for the pilot project.

The proposed site is a floating rice area of about 3,000 ha located northwest of Lop Buri city and surrounded by Lop Buri River and Chai Nat-Pasak Canal. North of this area, there are three irrigation districts irrigated by three secondary canals of Chai Nat-Pasak Canal. They are CPK16, 17, and 18, and about 7 mm/day of water is supplied to their command districts in the rainy season. Table 5 shows commanded areas and supplied flows by three canals.

TABLE 4 CULTIVATED AREAS OF DEEP WATER RICE AND FLOATING RICE (1992/1993)

Provinces	Cultivated Area(ha)		Total
	WD<100cm	WD>100cm	
Ayutthaya	33,328	64,123	97,451
Nhkorn Sawan	59,527	11,593	71,120
Phichit	52,136	13,859	65,995
Nhkorn Nhyok	17,686	25,875	43,561
Ang Thong	12,326	29,037	41,363
Lop Buri	12,793	21,325	34,118
Phitsanulok	21,049	8,598	29,647
Prachin Buri	5,796	16,243	22,039

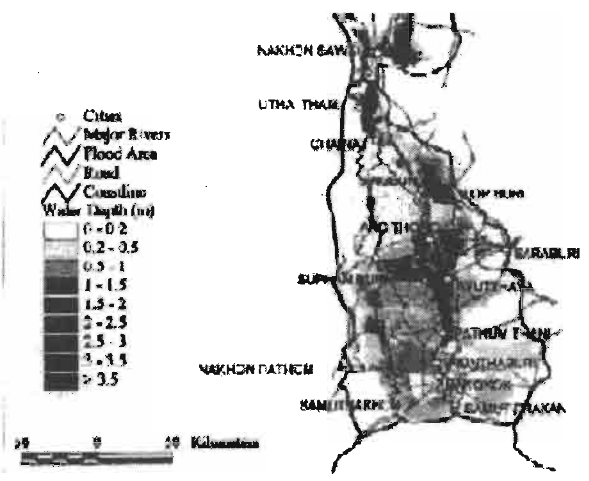


FIG. 2 INUNDATION MAP OF FLOOD IN1995

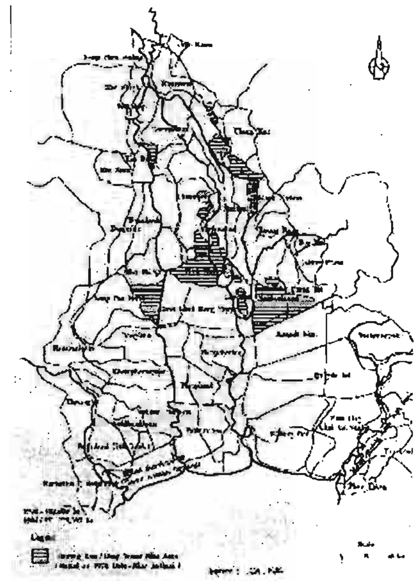


FIG. 3 DEEP WATER/FLOATING RICE CULTIVATION IN 1989

TABLE 5 AREAS AND FLOWS OF THREE SECONDARY CANALS

Secondary canal	Area (ha)	Flow (m^3/s) in rainy season
CPK 16R	10,920	8.873
CPK 17R	2,440	1.983
CPK 18R	6,740	5.551

Figure 4 shows precipitation data for average, flood, and drought years. The average year's precipitation is calculated by averaging precipitation data of 11 years, i.e., '80-'87, '89, '90, and '93. The flood and drought years are 1983 and 1993, respectively.

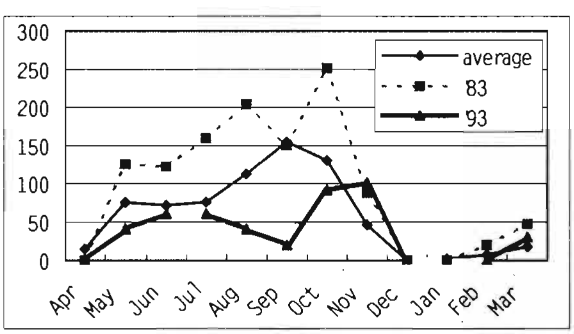


FIG.4 PRECIPITATION AT LOPBURI (MM/MONTH)

In this report, we show only a rough estimate of soil and water budgets when this project is practiced. Detailed simulations of soil and water budgets are now being calculated, but their results are not yet matured to report. As for the soil budget, 15,000,000 m^3 volume of soil is produced if regulating reservoirs are constructed, of which the area is 300 ha and the depth is 5 m. The area of 300 ha is 10 percent of the project area. When this volume of soil is used for the dike construction, the length of the dike becomes 150 km if the cross sectional area of the dike is 100 m^2 (5 m*20 m). As the total length of the surrounding dike and dividing dike is about 50km, the remaining soil may be used to raise the ground level of houses and buildings. From the viewpoint of the soil budget, the volume of 15,000,000 m^3 is large enough to enforce the dikes.

As for the water budget, we estimate the water requirement for the dry and rainy seasons. In the dry season, only the A block is used for cropping and the B block supplies irrigation water. If the total water requirement is 2,000 mm in the A block, the B block can supply water if its ponding depth is more than 2m. The depth of 2m is not so deep because floating rice areas are usually inundated by 2 to 3 m depth. Therefore, irrigation water will be fully supplied in the dry season.

During the rainy season both blocks must be irrigated. The irrigation water is available from regulating reservoirs, rainfall, and unused and drained water coming from northern areas irrigated by Chai Nat-Pasak canal. The regulating reservoirs can supply about 15,000,000 m^3 of water because reservoirs are not used during the dry season. The rainfall also supply about 7,000,000 m^3, because the total rainfall from April to September is about 240 mm from Fig.4 and the catchment area is 3,000 ha. The unused and drained water from the irrigated area having 20,000 ha is estimated about 12,000,000 m^3. This amount of water is derived from irrigation water plus rainfall minus evapotranspiration. As the Chai Nat-Pasak canal supplies irrigation water about 7mm/day during June and July, the total supplied water is 84,000,000 m^3. The total rainfall from April to July is estimated about 48,000,000 m^3, and the evapotranspiration during the same period is 120,000,000 m^3 if the daily evapotranspiration is 5 mm/day. As the result, the total available water is about 34,000,000 m^3. If the total water requirement during the rainy season is 1,550 mm, about 2,200 ha, i.e., 70 percent of the project area, can be irrigated.

Above examination of soil and water budgets indicates that this project is feasible if small amount of supplemental water is supplied from the Chai Nat-Pasak canal. However, we cannot conclude whether this project is economically feasible or not because we did not calculate the BC ratio of this project. It may not be so difficult to calculate the costs for land purchase, for construction of dikes, regulating reservoirs and pumping stations, and for pump operation. However, it will be very difficult to estimate the benefits of flood mitigation in downstream areas or no inundation of the project site.

5 Conclusion

The rice cultivation and water management in the Delta are now changing rapidly requiring an adequate water resource's distribution and suitable land use. At the same time, life styles in rural areas are also changed, and came to show discrepancy with the hydrological environment. In the proposed project, considering the hydrological properties in the Delta, we sought the way people and agriculture in the Delta can adapt themselves to the new water environment. Through the examination of this time, we could get the conclusion that the project is physically feasible, but there remain many problems to be solved and examined until its realization. We are now making more detailed analysis by use of hydrological simulations.

Bancha Kwanyuen[1]

Abstract: *The availability of water in the Chao Phraya delta in the dry season is much dependent upon run-off into the Bhumipol and Sirikit dams, and in particular on rainfall. This paper analyses the change of rainfall trend for all river basins in the north of Thailand. These basins comprise of Salawin, Kok, Ping, Wang, Yom, and Nan river basins. Analyses include tendency of both sub-basin and main system for each basin. Forty-seven years of annual rainfall between 1951 to 1997 from reliable rainfall stations were used in the calculation. The series of annual rainfalls and their moving average values were analyzed by two approaches: trend of rainfall and the shift in rainfall quantities. The analyses were carried out using hypothesis testing and the T-test. Results from previous study using annual rainfall data up to 1991 that showed tendency of rainfall recession and downward shift in annual rainfall for many basins are also compared. Results from both studies showed that rainfall recession existed in Kok, Ping and Nan basins. The moving average technique proved to be valuable method in removing the effect of cycle for annual rainfall. In addition, there was no change in both annual and monthly temperature and no relation between change of rainfall and temperature seemed to exist.*

1 Introduction

Rainfall is a major factor for planning and management of irrigation project and agricultural production such as reservoir operation, irrigation area, and irrigation water requirement. The rainfall change especially the reduction in annual rainfall may have a great effect on the effectiveness and accuracy on planning of irrigation project. In all regions of Thailand, the majority of population relies largely on agricultural sector including the north region. Moreover, the river basins in the north namely, Ping, Wang, Yom, and Nan contribute water supply for both north and central regions. Therefore, the change or reduction in rainfall may have a great effect on the country economy since the Chao Phraya basin which is the most productive for rice cultivation in the country receives most of its water from Bhumibol and Sirikit Dams especially for the dry season.

A research conducted at Asian Institute of Technology more than 10 years ago using rainfall record of about 50 years indicated that there was no change in rainfall structure for Thailand. However, in the last two decade it was observed that the drought had occurred more often than the past. Few publications showed the evident and proved statistically about the

[1] Department of Irrigation Engineering, Faculty of Engineering, Kasetsart University, Thailand

tendency of rainfall and its distribution. Akkanwanich (1995) studied the distribution and trend of drought in northeast Thailand. The author classified the drought condition for the most sensitive area into 4 zones i.e. Chaiyapum, Khonkaen, Nakhonratchasima and Loei Provinces and the wet area in Nakhonphanom and Nongkhai Provinces. Furthermore, the record from 40 rainfall stations had shown that the rainfall recession was about 2.47 mm/year. Kwanyuen (1998) reported the decrease of annual rainfall ranging from 2 to 6 mm/year in the central plain river basins from 86 rainfall stations. Moreover, rainfall distribution expressed in term of number of rainy day and rainfall intensity were also slightly change in some areas. Kwanyuen (2000) demonstrated a slightly reduction of annual rainfall and annual number of rainy day in the northeast region using data from 126 rainfalls during 1952-1998. These rainfall recessions occur mostly in the western part of the region range from 1 to 4 mm/year.

The change of in quantity and distribution of annual rainfall will directly effect the availability of water. Therefore, it is important to know whether there is a reduction in rainfall quantity so the information can be used for adjusting the planning and management of irrigation project and water resources related issues. This study analyzes the tendency of rainfall from 101 rainfall stations in Salawin basin, Kok basin, Ping basin, Wang basin, Yom basin, and Nan basin (see Figure 1) and each basin comprises of 19, 12, 25, 9, 15, and 21 rainfall stations, respectively. Result from this study will be compared with the previous analysis using data during 1952 to 1991. In addition, the analyses also extend to relation between the change of annual rainfall and pattern of rainfall distribution.

2 Characteristics of river basins and climatic conditions

The north of Thailand consists of 6 river basins: Salawin, Kok, Ping, Wang, Yom, and Nan basins. It also includes a part of Khong basin that will be excluded from this study. The total drainage areas are approximately 17920, 7895, 33898, 10790, 23615, and 34330 square kilometers, respectively. The basins are in the tropical monsoon zone subjected to the southwest monsoon during May to October and subjected to the tropical cyclonic storm from South China Sea during the end of rainy season between September and October. The annual rainfall of Salawin and Kok basins varies between 1000 and 2000 mm/year and the average annual rainfall is about 1100 to 1600 mm/year. The annual rainfall of Ping, Wang, Yom, and Nan basins is slightly lower between 700 and 1600 mm/year with the average annual rainfall of 900 to 1400 mm/year. Due to its location in tropical latitude, temperature is uniform throughout the year with very little seasonal variation around the mean of 28 °C. The average temperature at the hottest month (April) is about 32 °C and the average temperature at the coldest month (December) is about 25 °C.

3 Methodology

In this study, the trend of rainfall and its distribution are investigated and the results of data from 1952-1991 and 1951-1997 are compared. The procedures to analyze these data are similar in each basin and sub-basin and may be summarized as follows:

1. The rainfall stations and their records are investigated to select the rainfall stations that have long and rather complete records that are appropriate for the analyses. Forty-seven years of record from 1951 to 1997 are used in the study. In case of rainfall records at some stations have missing values or short records, these data are estimated by transferring information from nearby stations with complete or large records. The method is based on simple linear regression model, which is the most commonly used model for transferring hydrological information between stations. In this study, the hydrological model, HEC4 was used as a tool to estimated the required values.
2. The second step is to estimate the annual equivalent uniform depth using Thiessen Polygon method that is suitable for the topography of study area which can be classified as plain and mountain area with non-uniform rain gauge station.
3. The next step is to test influences about slope whether the regression lines ($y=\alpha+\beta x$) of the annual rainfall of real data have a zero slope. The T-test is applied for this case since the data have standard normal distribution. The hypothesis is two ways test (H0: $\beta = 0$; H1: $\beta \neq 0$) at .05 significant level. Then the test for shift or change in mean value is implemented using F-test with the hypothesis H0: $\mu_1 = \mu_2$; H1: $\mu_1 \neq \mu_2$ at .05 significant level. In order to select the critical year, data are divided into two groups and tested repeatedly from 1971 to 1982. For example, the first comparison is between annual rainfalls of 1951-1970 and 1971-1997 and the twelfth or the last comparison is between annual rainfalls of 1952-1981 and 1982-1997.
4. The results of annual rainfall of the real data of 1952-1991 from the previous study (Kanchanalekha, 1997) are compared to the result in this study.
5. Then the annual rainfalls evaluated by moving average method at 3, 4, 5, 6, 7, and 8 years are generated from the raw rainfall data.
6. The moving average data are tested for the tendency of data and shift in mean value with similar procedures as in step 3.
7. Finally, the changes in annual and monthly temperature are investigated. Then the changes in rainfall distribution according to the number of rainy day and rainfall intensity are investigated according to the boundary of province area rather than the boundary of basin area.

4 Results of the study

4.1 Trend of annual rainfall

FroThe analyses from previous study using data from 1952 to 1991 show that there are mixed result of constant and recession trend of these basins. Similarly, there are also mixed results of constant and downward shift in annual rainfall. The results of last study and this study are presented together in table1. For Salawin, Ping, Yom and Nan basins, the tendencies are the same for both sets of data. For Kok and Wang basins, the tendencies are mixed between constant and recession depending on the variation of data. Nevertheless, the result from long record (1951-1997) may be better representation. Therefore, primary observations are that the trend for annual rainfall of Salawin, Wang and Yom basins is constant, there is a recession trend on annual rainfall of Kok, Ping and Nan basins, and finally a downward shift in mean value occurs at Kok and Yom basins.

m the analyses of real annual rainfall data for the whole basin using data from 1951 to 1997, there is no change in annual rainfall for Salawin, Wang and Yom basins. But there are relatively moderate recession trends for Ping and Nan basins and significant decrease trend in Kok basin. Considering the shift in mean value, there is no shift for Salawin, Ping, Wang, and Nan basins. Nevertheless, there is a downward shift for Kok and Yom basins. Figure 2 shows the recession tendency of annual rainfall for Kok basin.

Figure 2 Trend for annual rainfall of Kok basin

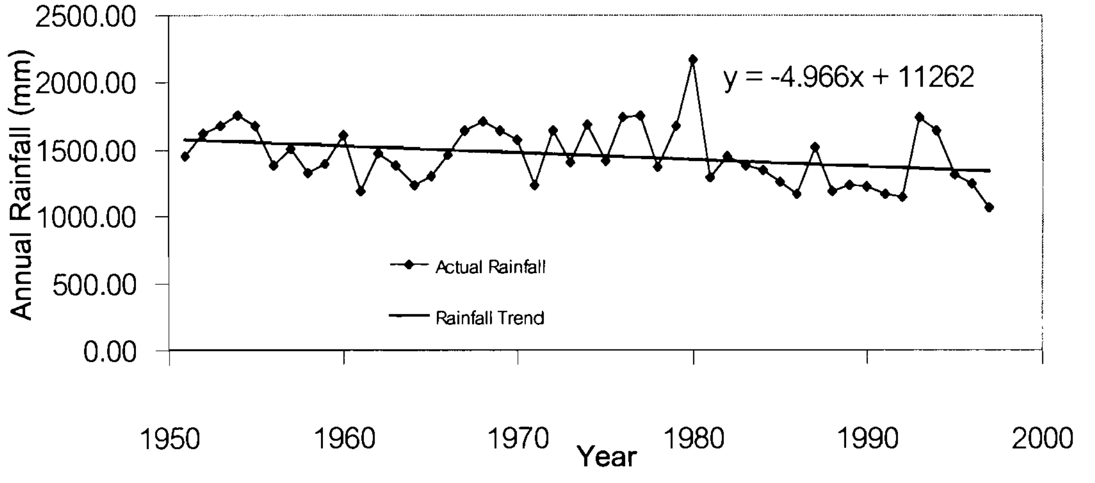


Table 1 Summary result for annual rainfall tendency of the whole basin

Basin	Previous (1952-1991)		Present (1951-1997)	
	Rainfall Trend	Shift in Mean	Rainfall Trend	Shift in Mean
Salawin	Constant	No	Constant	No
Kok	Constant	Downward	Recession (5.53)*	Downward
Ping	Recession (2.82)*	Downward	Recession (2.84)*	No
Wang	Recession (3.71)*	Downward	Constant	No
Yom	Constant	Downward	Constant	Downward
Nan	Recession (3.03)*	No	Recession (2.42)*	No

Note : * ( ) Rainfall recession in mm/year

By using moving average technique, six new data sets are generated from the original annual rainfall for 3, 4, 5, 6, 7 and 8 years moving average. Then these data are evaluated on the annual rainfall tendency and shift in mean value using the same procedure applied for the original annual rainfall. Results from the analyses are summarized in table 2 and 3.

Table 2 Summary results on tendency of moving average data of annual rainfall

Basin	Real Data	MA-3	MA-4	MA-5	MA-6	MA-7	MA-8
Salawin	C	C	C	C	C	R (0.92)	R (0.91)
Kok	R (5.53)	R (4.65)	R (4.45)	R (4.40)	R (4.45)	R (4.31)	R (4.16)
Ping	R (2.84)	R (1.76)	R (1.57)	R (1.43)	R (1.39)	R (1.14)	C
Wang	C	C	C	C	C	C	C
Yom	C	R (1.67)	R (1.52)	R (1.51)	R (1.69)	R (1.79)	R (1.87)
Nan	R (2.42)	R (1.79)	R (1.71)	R (1.89)	R (2.18)	R (2.33)	R (2.47)

Note : MA = Moving Average, C = Constant, R (x) = Recession in x mm/year

Table 3 Summary results on shift in mean of moving average data of annual rainfall

Basin	Real Data	MA-3	MA-4	MA-5	MA-6	MA-7	MA-8
Salawin	No	Yes	Yes	Yes	Yes	Yes	Yes
Kok	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ping	No	No	Yes	Yes	Yes	Yes	Yes
Wang	No	No	No	Yes	Yes	Yes	No
Yom	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Nan	No	Yes	Yes	Yes	Yes	Yes	Yes

From the analyses on tendency of moving average data for the main basin, it is found that generally the moving average data will give similar result to the real data e.g. Kok, Ping, Wang, and Nan basins. However, for Salawin and Yom basins, the tendency may be identified using moving average technique. The reason is that the moving average method can remove or reduce the effect on the cycle of the data. From the analyses on shift in mean of moving average data for the main basin, it is also found that normally the moving average data will give same result to the real data e.g. Kok and Yom basins. Nevertheless, for Salawin, Ping and Nan basins, the shift in mean can be identified using moving average technique by the same reason.

Most of the basins are relatively large, therefore they are divided into sub-basin and data from these smaller areas are also analyzed. For Salawin basin located in the northwest of the region that consists of 17 small sub-basins, the tendency for sub-basins are constant for all sub-basins. For Kok basin, the smallest basin located in the north of the region that consists of 4 small sub-basins, the tendency is generally the same as the main basin. In detail, there are relatively large decrease in annual rainfall ranging from 5 to 8 mm/year in 3 sub-basins and constant for only 1 sub-basin. For Ping basin, a large basin located in the western part of the region that consists of 16 sub-basins, although the main basin has a recession in annual rainfall but the majority of sub-basins have no change in annual rainfall. In detail, the upper and lower parts (10 sub-basins)have constant rainfall, the middle part has a recession trend about 3 to 4 mm/year. For Wang basin, a small basin located in the middle of the region that consists of 7 sub-basins, all of them have a constant tendency. For Yom basin located in the southern part of the region that consists of 9 sub-basins, most of them have a constant tendency except one basin that has a small recession of 3 mm/year. For Nan basin, a large basin located in the east region that consists of 15 sub-basins, even though the main basin has a recession trend but most of the sub-basins have a constant tendency except Kwai Noi sub-basin that has a small recession of 2.5 mm/year. The area of sub-basins and results from the analyses of some selected basins such as Kok, Wang and Yom basins are presented in table 4.

Table 4 Summary data and results for sub-basins of Kok, Wang and Yom basins

Basin	Sub-basin	Area (km^2)	Rainfall Trend	Shift in Mean
Kok	1. Nam Kok	2770	Recession 7 mm	Yes
	2. Mae Fang	1945	Constant	No
	3. Mae Laos	2640	Recession 6 mm	Yes
	4. Mae Saruay	540	Recession 8 mm	Yes
Wang	1. Upper Wang	1687	Constant	No
	2. Mae Sai	743	Constant	No
	3. Nam Tui	801	Constant	No
	4. Middle Wang	2132	Constant	No
	5. Nam Jang	1600	Constant	No
	6. Nam Tum	738	Constant	No
	7. Lower Wang	3090	Constant	No
Yom	1. Upper Yom	2029	Constant	No
	2. Nam Duan	1945	Constant	No
	3. Nam Ngaw	1800	Constant	No
	4. Middle Yom	2588	Constant	No
	5. Mae Kammee	571	Constant	No
	6. Mae Ha	507	Constant	No
	7. Lower Yom	11287	Recession 3 mm	No
	8. Huai Mae Sin	610	Constant	No
	9. Mae Mok	2279	Constant	No

In general, there is no shift in mean annual rainfall for majority of the sub-basins of Salawin, Ping, Wang, Yom, and Nan basins. However, there is a significant downward shift in mean annual rainfall for most sub-basins of Kok basin. In addition, it is found that the results of moving average analyses for sub-basins are similar to the ones from the real annual rainfall data but the shift can be identified easier by the moving average as shown in the example of Yom basin in table 5.

Table 5 Results on tendency of moving average data of sub-basin of Yom basin

Yom Basin	Rainfall Trend (mm/year)							Shift in Mean
	Real	MA-3	MA-4	MA-5	MA-6	MA-7	MA-8	
Main Basin	C	R-2	R-2	R-2	R-2	R-2	R-2	Yes
1. Upper Yom	C	C	C	C	C	C	C	No
2. Nam Duan	C	C	C	C	C	C	C	No
3. Nam Ngaw	C	C	C	C	C	C	C	No
4. Middle Yom	C	C	C	C	C	C	C	No
5. Mae Kammee	C	C	C	C	C	C	C	No
6. Mae Ha	C	C	C	C	C	C	R-2	No
7. Lower Yom	R-3	R-3	R-2	R-2	R-2	R-3	R-3	No
8. Huai Mae Sin	C	C	C	C	C	C	C	No
9. Mae Mok	C	C	C	C	C	C	R-1	No

Note : MA = Moving Average, C = Constant, R = Recession

4.2 Trend of temperature

The analyses of temperature change and rainfall distribution for the basin are implemented only in some representative provinces as follows: Chiang Mai for Salawin basin; Chiang Rai for Kok basin; Chiang Mai and Lampoon for Ping basin; Lampang for Wang basin; Phrae and Phayao for Yom basin; and Nan and Pitsanulok for Nan basin.

The results show that monthly temperature is mostly constant for every month of all provinces. For annual temperature, there are mixed results of constant, decrease and increase trends for all basins. Nevertheless, these changes seem to be insignificant and there is no correlation between rainfall and temperature. It may conclude that a small change of annual temperature may be a periodic phenomenal or temporary change rather than a true trend.

4.3 Rainfall distribution

In this study, rainfall distribution is expressed in term of number of rainy day and its density distribution. Results show that the annual number of rainy day is constant for the majority of 6 provinces and slightly increase for the other 2 provinces. These changes are rather insignificant and there is no correlation between annual rainfall and number of rainy day. However, the monthly number of rainy day is varied among constant, decrease and increase as shown in table 6. In case of density distribution, there is no sign of change in rainfall pattern since the numbers of rainy day for all intensities are very much stable.

Table 6 Trend in monthly number of rainy day for basin in the north

Province	Annual	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Chiang Mai	C	C	I	I	C	C	C	C	C	C	C	C	C
Chiang Rai	I	C	C	C	I	I	C	I	C	C	C	I	C
Lampoon	C	C	C	I	D	C	D	D	I	D	I	D	D
Lampang	C	C	C	C	C	C	D	C	C	D	C	C	C
Phrae	I	C	C	C	C	I	C	I	C	C	I	C	C
Phayao	C	C	I	I	D	D	I	I	I	D	I	C	D
Nan	C	C	C	C	C	I	D	C	C	D	C	C	C
Pitsanulok	C	C	C	D	C	C	C	C	C	D	I	C	C

Note : C= Constant, I = Increase, D =Decrease

5 Discussion

The analyses of rainfall change for the north of Thailand use rainfall data from 1951 to 1997 from rain gauge stations that their locations distribute through out the basin command area. Real annual rainfall data and their moving average data of 3, 4, 5, 6, 7, and 8 years are analyzed for all basins and sub-basins to identify trend of annual rainfall and shift in mean value. In addition, results using data during 1952-1991 from previous study and results using data during 1951-1997 from this study are compared. Finally, the analyses of temperature change and rainfall distribution employ the data based on provincial area according to the same system used by the Meteorological Department. The important characteristics of the main river basins and sub-basins may be summarized as follows:

For Salawin basin, there is no change in annual rainfall of the main basin and sub-basins. The shift in mean is not exist for the main basin but downward shift occurs in some sub-basins.

For Kok basin, there is a strong recession in annual rainfall for both main basin and sub-basin. These areas with recession cover about 75 percent of the total area of the basin. The downward shift in mean also occurs in the same area as the recession.

For Ping basin, there is a recession in annual rainfall of the main basin but the recession on the sub-basin occurs only at the middle part of the basin. The upper and lower parts of the basin have stable tendency. The downward shift only occurs in some sub-basins in the middle part of basin.

For Wang and Yom basins, there is no recession in annual rainfall for the main basin and sub-basins except a small recession in lower Yom sub-basin. The downward shift only exists in the main basin of the river.

Finally, for Nan basin, there is a recession in the main basin and Kwai Noi sub-basin. The downward shift occurs only in three sub-basins at the upper part of the basin.

Overall, a strong recession in annual rainfall may be observed in Kok basin and a small recession can also be observed in Ping and Nan basins. The conclusion from both data sets (1952-1991 and 1951-1997) are slightly different so the result from this study that has a more complete and longer record may be a better representation of the basin characteristics.

In most cases, results from the real annual data and the moving average data indicate similar tendency with a small variation of value. However, the moving average data may be a better representative in many cases since this technique can remove the cycle effect out from the data.

From the analyses, there is no sign of change for annual and monthly temperatures and structure of rainfall intensity. Therefore, the relation between the change of rainfall and temperature may not exist. In addition, there is no relation between the annual number of rainy day and the amount of annual rainfall.

6 Conclusions and recommendations

Some important conclusions that can be summarized from this study are as follows:

1. There is an evident of annual rainfall recession in some river basins of the north region especially Kok, Ping and Nan basins. This recession is relatively strong in Kok basin. Downward shift is also noticed in the area of strong recession but it need to be proved whether there is a shift alone or there is a combination of recession and shift.

2. Results from the real value of annual rainfall and the moving average data are slightly different. Therefore, periodic or cycle of annual rainfall may exist and can partially remove by moving average technique.

3. Both annual and monthly temperature has stable tendency. Therefore, there may be no relation between rainfall recession and temperature change.

4. Rainfall distribution has no change and the reason for rainfall recession still have to be investigated.

The recession of annual rainfall in the north of Thailand is an important factor for availability of water supply for the north and central regions that must be considered in design, planning, operation, and management of water resources project. The future study should consider these changes in order to receive more accurate solutions of existing and new irrigation projects.

References

Akkanwanich, K. 1995. Distribution and trend analysis of drought in northeast Thailand, Thesis, Chulalongkorn University, 291 p.

Kanchanalekha, K. 1997. Analysis of climate change in northern and northeastern of Thailand, Kasetsart University, 313 p.

Kwanyuen, B. 2000. Analysis of annual rainfall change in the northeast of Thailand by moving average method. Third regional symposium on infrastructure development in civil engineering, December 4-6, 2000, Tokyo.

Kwanyuen, B.; Cherdchanpipat, N. and Satoh, M. 1998. Analysis of climate change in central plain of Thailand. Workshop on sustainable development of agricultural infrastructure and organization management of Chao Phraya and Mae Klong basins, October 30, 1998. Bangkok. p. 85-97.

Saipanich, W. 1998. Analysis of influence factors on rainfall change in northern and northeastern of Thailand, Kasetsart University, 346 p.

Dry-season water allocation in the Chao Phraya basin: what is at stake and how to gain in efficiency and equity[1]

François Molle[2], Chatchom Chompadit[3], Jesda Keawkulaya[4]

Abstract: *The Chao Phraya basin has long been a water-deficit basin. Water stored in the Bhumipol and Sirikit dams only allow the irrigation of half of the delta, in average. The share of water available for agriculture in the delta is declining because of higher water abstraction both within the upper reaches of the basin and in Bangkok Metropolitan Area. The question of where, to whom, when and how this scarce resource is allocated is therefore of paramount importance.*

The paper first reviews the sectoral and spatial pattern of allocation in the last 25 years and assesses the efficiency and the equity of this allocation. It subsequently investigates all the options offered to increase management efficiency and proposes some guideline for achieving higher equity and more even sustainability of farming systems. This includes technical, socio-institutional and economic issues.

1 Introduction

The Chao Phraya basin makes up one third of Thailand's territory, encompasses the great majority of irrigated areas and also includes Bangkok Metropolitan Area. The basin can be conveniently divided in three sections (Figure 1). The *upper basin* (the catchment area of Bhumipol and Sirikit dams), the *middle basin* (downstream of the dams, down to Nakhon Sawan), and the lower part (or the *delta*). The yearly inflow into the dams has been declining because of deforestation, decreasing precipitation (Bancha, *this conference*) and growing water abstraction in the upper basin, from 11 to 9 billion m3 during the last thirty years (Molle et al. 2000). In the middle reach, both medium and large scale RID projects and group irrigation based on pumping along the river (fostered by the Department of Energy Promotion). In the delta, 1 million ha can potentially be irrigated (with a high potential for triple cropping), while BMA's demand has risen from .36 million m3/day in 1979 to

[1] This papers presents a few points drawn from the report: Molle, François; Chompadist, Chatchom; Srijantr, T. and Jesda Keawkulaya. 2000. Dry-season water allocation and management in the Chao Phraya basin. Research Report submitted to the EU, draft, Bangkok, 235 p.

[2] Researcher at IRD (Institut de Recherche pour le Développement), working at Kasetsart University: odoras@ku.ac.th

[3] Royal Irrigation Department, Bangkok

[4] Kasetsart University, Department of Irrigation Engineering

approximately 7.5 million m3/day in 2000 (which includes an approximate 3 Mm3/day from underground water). A twenty one fold increase in twenty two years...

During the dry season, all water users within the middle and lower reaches of the basin rely, by and large, on water delivered by the Bhumipol and Sirikit dams. Declining inflows and growing non-agricultural use makes a despairingly simple equation: water resources for agriculture are deemed to decrease substantially, with a drastic impact on the sustainability of farming in the irrigated areas of the basin. A wide range of solutions have been proposed, debated or opposed by the different stakeholders concerned by the issue. These include:

Increase of supply: This is the preferred option of government agencies which have been engaged in water resources development in the past (RID, EGAT,..). The main solutions are the building of additional dams, the transbasin diversion of water from the Salaween and Mekong rivers, the tapping of more aquifers.

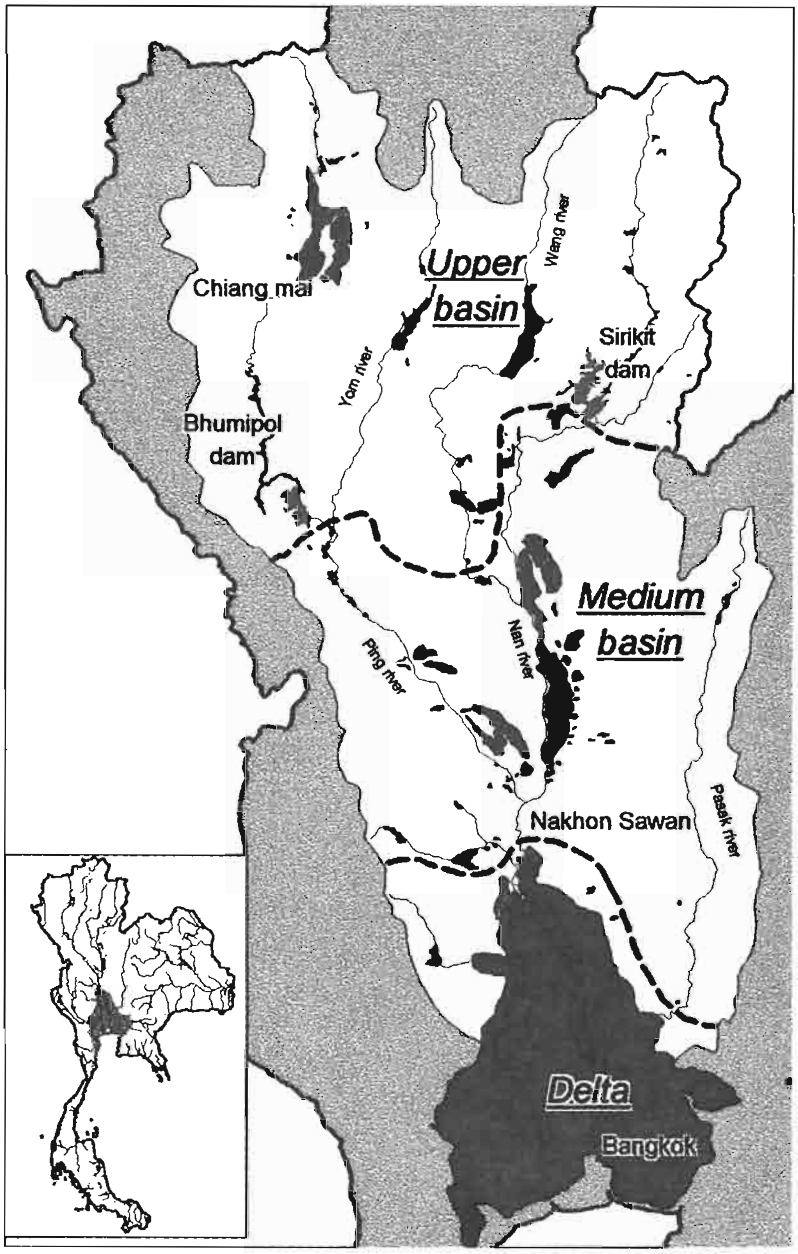
Improvement of overall management: Improved knowledge of hydrologic conditions, better co-ordination, better timing and assessment of water releases, reduction of water released by the dams and flowing to the sea in excess of the discharge needed to control seawater intrusion, etc. Institutional and administrative reforms are also needed to create a Basin Agency which should be responsible for the allocation and monitoring of water supply, for the control of the development of water use, and for enforcing legislation.

Water saving and upgrading efficiency of use: All users may potentially use water in smaller quantities *and* with fewer losses. Irrigators should adopt water saving farm practices and crops with lower water requirements. They should associate in order to adopt patterns of water distribution believed to reduce waste and increase equity. Loss by infiltration in canals could be cut by lining them. Urban tap water networks should be improved to reduce leakage. Industries should adopt water saving innovations and recycling of the water which quality has deteriorated to the point that it cannot be used anymore (a sink in the system).

Economic incentives: In parallel, or as a complement, policies aimed at introducing economic incentives should contribute to water saving ("user-pay principle"), water quality protection ("polluter-pay principle") and to an economically more efficient allocation of water among users (water rights, water markets). Far-reaching administrative and legal reforms are pre-requisite to these options.

All these options have pros and cons, contenders and opponents. The present paper is not intended to address all these options. A first part examines projections of water use and stresses the impact on agriculture in the dry-season. Past records of water allocation in the last 25 years are then assessed and patterns of spatial inequity are emphasised. Attention will then be turned to the allocation and distribution processes, and several improvements are proposed in order to increase efficiency and equity.

FIGURE 1: LAYOUT OF THE CHAO PHRAYA BASIN AND ITS THREE SUB-DIVISIONS



2 Mid and long term perspective on water use in the basin

We must first establish a prospective view on how the pattern of water use is likely to evolve in the near future. All the projections presented below are based on orders of magnitude and average (or median) values; they represent likely trends, and disregard yearly fluctuations.

2.1 Supply side

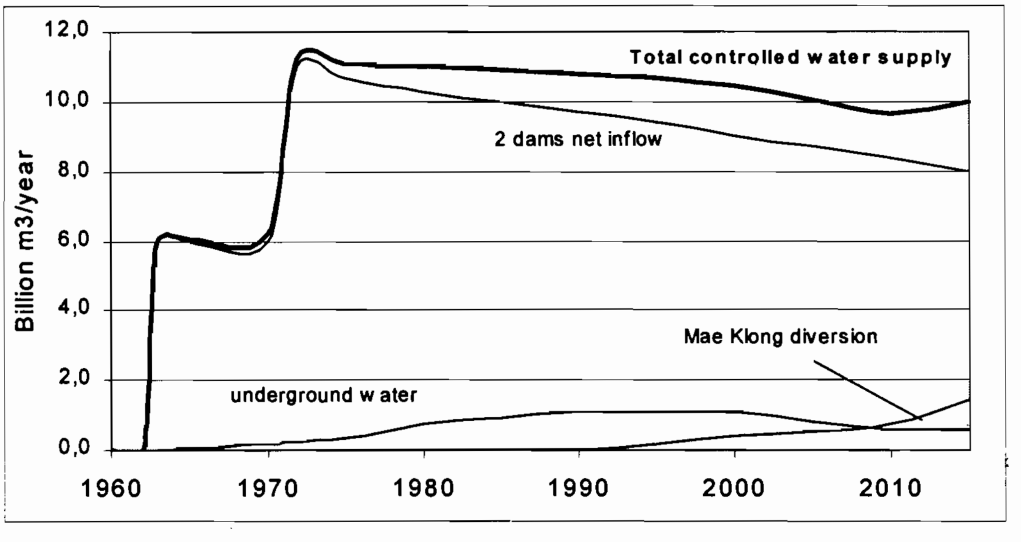
On the supply side, there is little data on how the inflow into the two dams is going to evolve but both the absolute increase of water abstraction in the upper part of the basin and the declining rainfall climatic trend do not allow the slightest hope that supply will increase. In the northern region, the irrigated area is reported to have increased 47% between 1980 and 1989 (ESCAP, 1981). It is estimated that the two dams yearly net inflow (evaporation discounted) has decreased from 11 to 9 Bm3 in the last 28 years and that it will drop another 1 Bm3 in the next 15 years (Molle et al. 2000).

Water diverted from the Mae Klong basin is already reaching Thon Buri in limited amounts (.4 Bm3/year) but the discharge is phased to reach 23 cms in 2010 and a maximum of 45 cms in 2017, in accordance with the gradual development of water treatment units.

There is no reliable data on the exact volume extracted from the aquifer in BMA. Estimates from JICA, ten years ago, amounted to 2.9 Mm3/day and TDRI (1990) concluded that they are probably around 3 million m^3/day (=3 Mm3/day). Bangkok and the surrounding provinces are now believed to use 1.5 million cubic metres out of 2.5 of water pumped from underground aquifers each year (Bangkok Post, 1999). Given (a) that the price differential between piped water and groundwater has not been bridged in the last ten years; (b) that the industrial sector has dramatically expanded, and (c) the admitted unrecorded pumping, there is little likelihood that these amounts may have decreased during this period. Therefore, our calculations are made considering an actual pumping rate of 3 Mm3/day. It is also estimated that the capacity of Bangkok aquifers to supply ground water is about 1 Mm3/day, but that extraction should be less than this capacity in order to prevent land subsidence (Bangkok Post, 1999).

Figure 2 shows that the estimated amount and variation of the different sources of water. Overall, the average total controlled water supply in the basin (from dams, underground water and diversion from the Mae Klong) is going to decrease under 10 Bm3 (with a slight temporary rebound in 2015 due to the full capacity of the diversion from Mae Klong but further decline in the long term).

FIGURE 2: TRENDS IN TOTAL AVERAGE SUPPLY TO THE CHAO PHRAYA BASIN (MIDDLE AND LOWER REACH)



2.2 Demand side

On the demand side, it is assumed that water uses and dams releases in the wet season will not vary significantly. Agriculture will continue to be supplemented with irrigation at similar rates and the impact of the growth of other uses will be marginal because of their magnitude and of the contribution of uncontrolled side-flows. The focus is therefore on the water remaining for dry-season cropping, while the production potential of the irrigated agricultural sector will remain largely above the share of water which is likely to be apportioned to it.

A growing and little elastic demand is governed by the growth of cities and industries. TDRI's projections in (TDRI, 1990) were based on a water demand in BMA projected to grow at 9% per year for residential and 10% for services but the crisis has probably levelled of these numbers. We will consider here different hypotheses of growth from a current value of 7.5 Mm3/day, including 3 M from aquifers. The obvious unsustainable nature of groundwater overdraft means that, sooner or later, the water supplied by the aquifer will have to be drawn from superficial water (Sethaputra et al. 1990). If we consider that at least half of the estimated 3 Mm3/day underground water contribution will have to be transferred to superficial supplies, this means that another 0.55 Bm3 must be supplied yearly by the river system (Chao Phraya and Mae Klong). In other words, Bangkok area is on the way to move from a negligible or secondary user to a main one. Even though, fortunately, a large part of Bangkok needs will be supplied by sideflows, the burden on the reservoirs is still estimated at around half of the total need in superficial water[5].

2.3 Balancing demand and supply

Assuming that the wet season commands an average dams release of 5 Bm3 (as seen from historical series) and that this value will change little in the mid-term (see earlier comment), we may now use the projections on overall supply to deduce both the amount of water available in the dry-season and the share remaining for agriculture after other priority uses are satisfied.

The trend in water requirements for BMA is here estimated for a growth ratio of 5%/year. This demand will be partly met by underground water, Mae Klong diversion and by the Chao Phraya river. Salinity control (water lost to the sea), is attributed a floor value of .5 Bm3 for the dry season. The increase of supply from the Mae Klong and the decrease by half of underground water (passed over to superficial water[6]) are also taken into account. *The average controlled water (dams) which will be available for irrigation and other uses in the delta and middle basin in the dry season will undergo a cut of 15% (from 5.1 to 4.4 Bm3) in the next 15 years*. For yearly growth rates of 3% and 7%, these cuts will be 4 and 30 Bm3 respectively. The decrease will be extremely sensitive to the growth of non-agricultural use

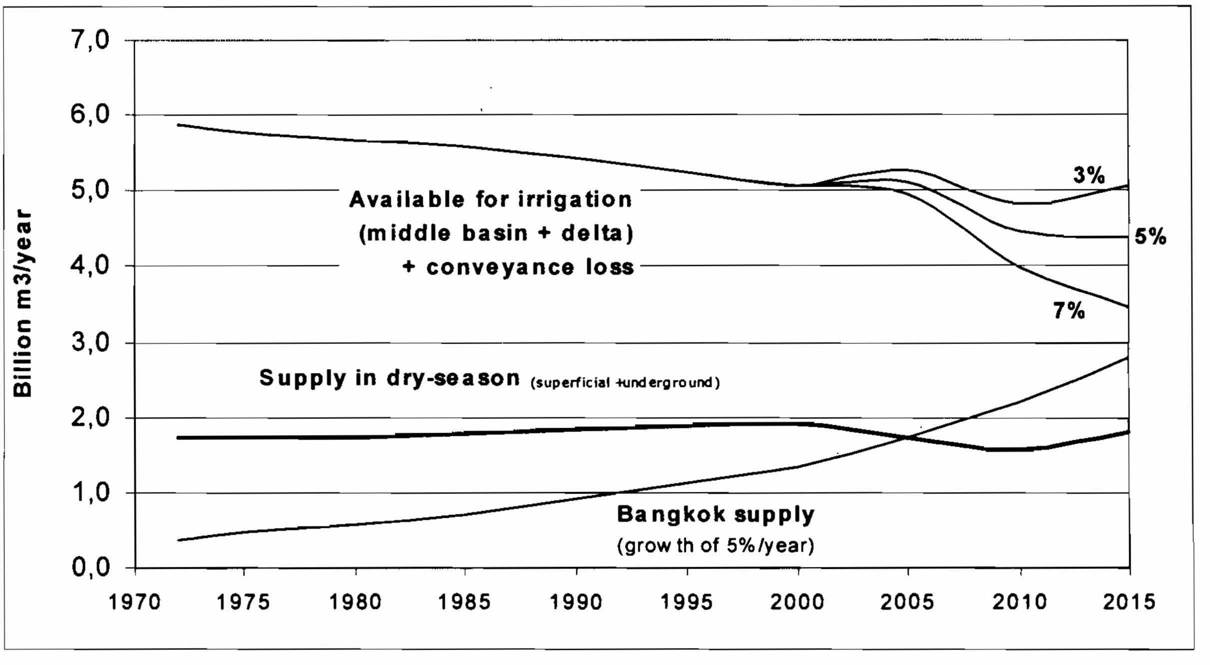
[5] During the month of January, abundant water is coming from the drainage of the floodplain. Dams are contributing mostly in the February-June period, and in some periods of the wet season in some years.

[6] This also means, in passing, that BMA will have to upgrade its capacity to distribute superficial water.

which is now more problematic to assess than before the crisis: using the rates adopted by TDRI in the 1990 study, the cut would be 54%... It is worth noting again that the situation is significantly smoothened by the rising inflow from the Mae Klong basin scheduled over the next decade, without which the drop would be far more critical.

The general picture in the 15 years ahead is therefore one of a significant reduction of the water available for the agricultural sector, which will turn drastic if demand growth returns to pre-crisis levels.

FIGURE 3: EVOLUTION OF THE AVERAGE TOTAL CONTROLLED WATER SUPPLY IN THE BASIN



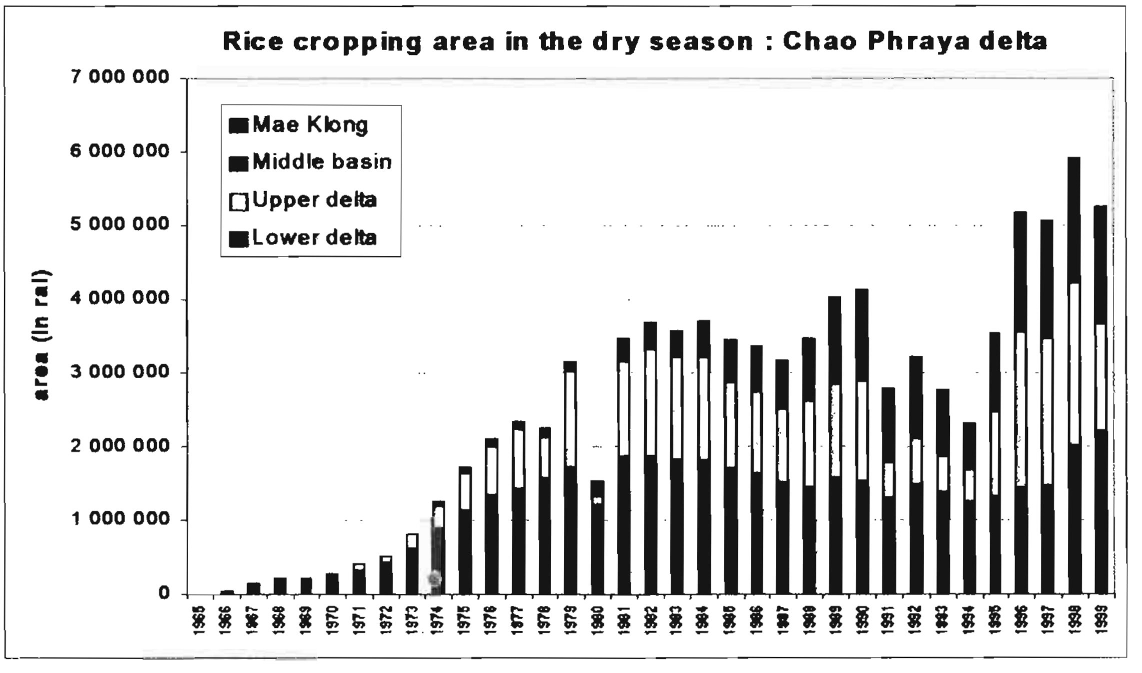
3 Historical patterns of spatial allocation (1977-1999)

3.1 The growth of dry-season cropping

A first surge of double cropping (72,000 rai) was observed in the year 1971 in the upper delta; this was concomitant to the advent of High Yield Varieties (HYVs). A second hike occurred in 1973, further to the beginning of the operation of the Sirikit dam and the threshold of 2 million rai was reached in 1976 ; only three years later, the rice area amounted to 3 million rai (a little less than 500,000 ha), a value which can be taken as an average for the 20 ensuing years. During this period, the upper delta accounted for an average of 45% of the DS rice area, against 55% for the lower delta. Figure 4 also presents the rice area corresponding to the Mae Klong area. From this figure pops up the evidence of a notable difference between the upper and lower parts of the delta: while the later, with an average value of 1.8 millions rai, remains rather stable (although showing a gradual decline due to the encroachment of urban areas), the share of the upper delta is rather hectic. The all times record occurred in 1998, after three consecutive years in which the share of the upper delta exceeded that of the lower delta to reach 2 millions rai. This came along with a surge of triple cropping, amounting to roughly 1 million rai in 1998 and 1999.

To put it short, the lower delta is advantaged in years of shortage, as water is delivered to this area in priority, in order to ensure environmental sustainability, transportation and to control saline intrusions. With water filling up the extensive and dense network of channels of this flat area, there is little scope for farmers to refrain from pumping and for officers to prevent them to do so. In years of abundant water, large supplies are derived to all main waterways branching off the Chao Phraya river in Chai Nat, and the upper delta can extract water first.

FIGURE 4: EVOLUTION OF THE AREA CROPPED WITH RICE IN THE DRY-SEASON



3.2 Cropping intensity

These cropping areas can be translated in terms of cropping intensities. Calculations are based on the data collected and published by RID at the Project level. These data are not deprived of errors[7]. However, apart from being the only data available, their quality can be

[7] Several reservations must however be made. Data for the lower delta seem less reliable because the density of field staff is much lower (no zonemen) and no map is available to really determine the cropping area. The assessment of cropping intensity is also obscured by the fact that cropping calendars are shifted and that the distinction between wet and dry season is not always clear-cut. Some areas may grow only a DS crop and no WS crop, distorting the calculation of the potential rice area. This is responsible for some imprecision in the West Bank, notably Chao Chet and Phrayabanlue Projects and also affects Pho Phya project (which southern tip is on the same hydrological regime as the West Bank) and Phak Hai Project (which in the last 10 years has undergone a drastic shift from WS floating rice mono-cropping towards dry-season HYV rice cropping). What is the potential rice area is not always precisely known. Taking the (running) maximum rice area cultivated over 3 years is not always correct because there might be some fallow land. In Chao Chet Bang Yeehon Project, for example, the

considered reasonably good, particularly when one acknowledges the difficulty of the task of recording land use data (see Molle et al. 1998).

Several types of cropping intensity indices can be calculated (Table 1). The average *rice cropping intensity* is the ratio between the dry-season + wet season rice areas and the estimated potential rice area. Considering the upper and lower delta, aggregated figures give indices of 1.34 and 1.44 respectively, with an average for the delta of 1.38. Cropping intensity can also be computed considering adding field crops (FC) to the wet+dry season rice area. This entails an average increment of the indice of 0.02 for the upper delta. It can also be computed by considering the total non-rice area under cultivation, including fruit trees, year-round vegetable production, sugar cane and aquaculture (Tot). The average indices [DS rice + WS rice + FC + 2*Tot]/[Potential irrigated area], or the *Total cropping intensity*[8], is given in Table 1. It reveals that for the period running from 1981 to 1999, the total cropping intensity has been 1.40 for the upper delta and 1.51 for the lower delta (average 1.45). The same indices, calculated for the last 5 years, yields overall values of 1.57 and 1.70. In conclusion, the upper delta appears to have around 40% of its irrigated area cropped during the dry season, with a rather high elasticity in case of abundant water supply, while the lower delta is roughly half cultivated in the dry season. This last value, however, is strongly influenced by the inclusion of Pasak Tai and Nakhon Luang Projects in the East Bank, both with very low cropping intensity. It is further pulled downward by values of DS rice area for the Rangsit Tai projects which are believed to be underrated. If we account for these two factors and restrict ourselves to the lower East Bank (Rice CI 1.50), combined with the West Bank (Rice CI of 1.70), we find a more realistic cropping intensity of 1.60 for the lower delta, and around 1.80 for the last 5 years. The total crop intensity index is at 1.65 for the lower delta (1981-1999). The temporal variation of the delta rice cropping intensity is given in Figure 5.

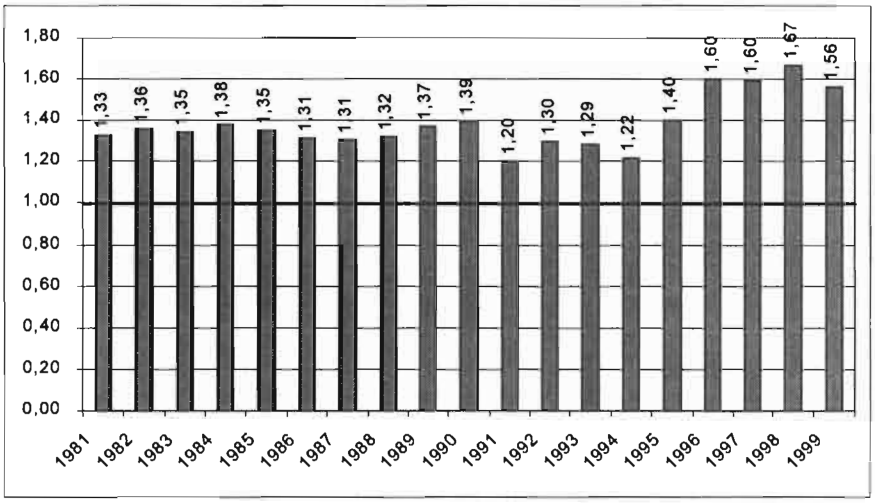
TABLE 1: CROPPING INTENSITY INDEXES

	Rice cropping intensity	Rice + Fc crop. Intensity	Total cropping intensity	Rice cropping intensity	Total cropping intensity
Period	1981-1999			1995-99	
Upper delta	1,34	1,36	1,40	1,52	1,57
Lower delta	1,44	1.45	1,51	1,63	1,70
Total delta	1,38	1,40	1,45	1,57	1,63

official irrigated area is 406.000 rai but the maximum rice area is 310.000 rai. The difference includes non-rice crops, fallow land, and areas changed to built-up. Triple cropping (only recorded since 1998 but much older) also makes things more difficult.

[8] Note that perennial crops are multiplied by two. This is because the cropping intensity indexes considered here are relative to a seasonal rice crop, not to absolute soil occupancy along the year. Full rice double cropping gives an indice of 2, whereas a soil occupancy index would be close to 0.65. Perennial crops are supposed to be equivalent to two crops of rice.

FIGURE 5: AVERAGE RICE CROPPING INTENSITY FOR THE DELTA (1980-199)



3.3 Spatial patterns of dry-season cropping

The contrast mentioned earlier regarding the upper and the lower deltas is likely to be sharpened when observing the smaller scale of the Project level. This readily defines a spatial heterogeneity, both year by year and on the average over 20 years, which translates in terms of *(in)equity*. The quality of the access to water is governed by several factors, including physical, technical and political, which contribute to shaping the spatial pattern of water allocation.

The first index considered here:

CI1= [*(DSrice + WSrice + F.Crops + 2*Perenials)/agricultural potential cropping area*]

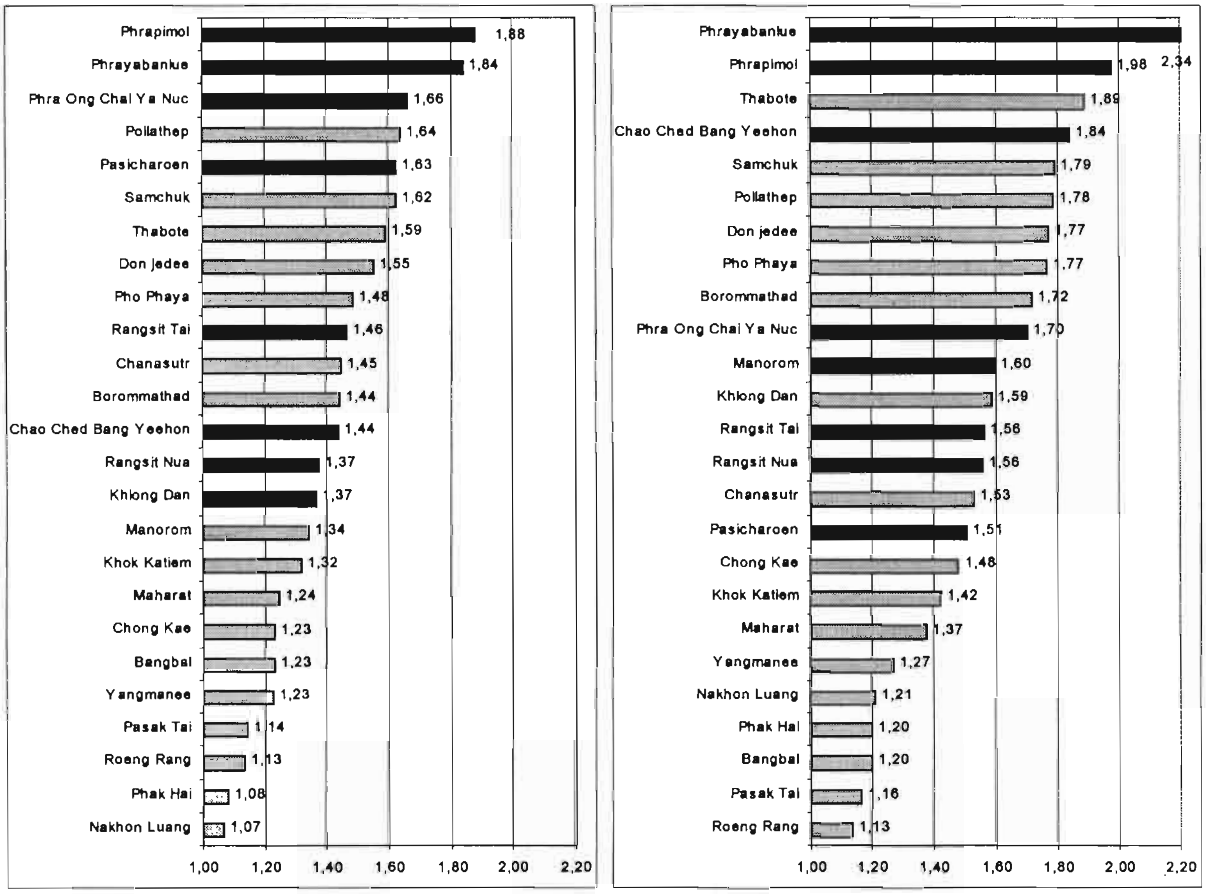
is indicative of the effective benefit drawn from DS cropping (or irrigation) by a given project with its specific constraints ; it includes all crops and takes the *agricultural potential cropping area for one season* as a unit. Figure 7 displays the spatial variation of CI1 both for the 1981-1999 period and the 1995-1999 period. The west of the delta appears to be characterised by much higher indices than the east (especially upper east). The pattern was changed in the last 5 years (with an increase of the cropping intensity in the lower delta) but, while all indices are on the rise, the central and eastern upper-delta still do not reap the full benefice of irrigation.

The Project total cropping intensities just shown are partly biased by the fact that the rice area in the dry-season has been implicitly compared with the *potential rice area in the wet season:* this does not take into account the fact that some projects encompass floating rice areas which are deprived of on-farm infrastructures (ditch, levelling, bunding) and which, therefore, are not candidate to DS cropping.

CI2 = [1+*(DS rice + F.Crops)/potential rice area in the dry-season*], compares *rice cropping intensities* on the *sole* area which can, technically, achieve double-cropping: this serves as a formal index of spatial equity[9].

The values of CI2 by Project are displayed in Figure 6. Inequalities regarding Projects[10] partly deprived of on-farm infrastructures have been reduced but the sheer contrast have not disappeared. For the last 5 year period[11], the magnitude is raised but the order is slightly modified. The spatial patterns of inequity in cropping intensity evidenced remain whatever variation of the index is considered.

FIGURE 6: CI2, RICE+FIELD CROPS INTENSITY INDEX (1981-1999 AND 1995-1999)



[9] This indice, however, creates difficulties for projects which are not fully cropped in the wet season (upper west bank, Phak Hai, Phophya). It is therefore applied only to the projects which do have restrictions of on-farm infrastructure.

[10] Namely: Maharat, Yangmanee, Roeng Rang, Kok Katiem, Pasak Tai, Nakhon Luang, and to a much lesser extend Chanasutr, Borommathad, Chong Kae, Bang Bal.

[11] The indice is only for rice (Field crops non included)

TABLE 2: CROPPING INTENSITY INDEXES, BY PROJECT

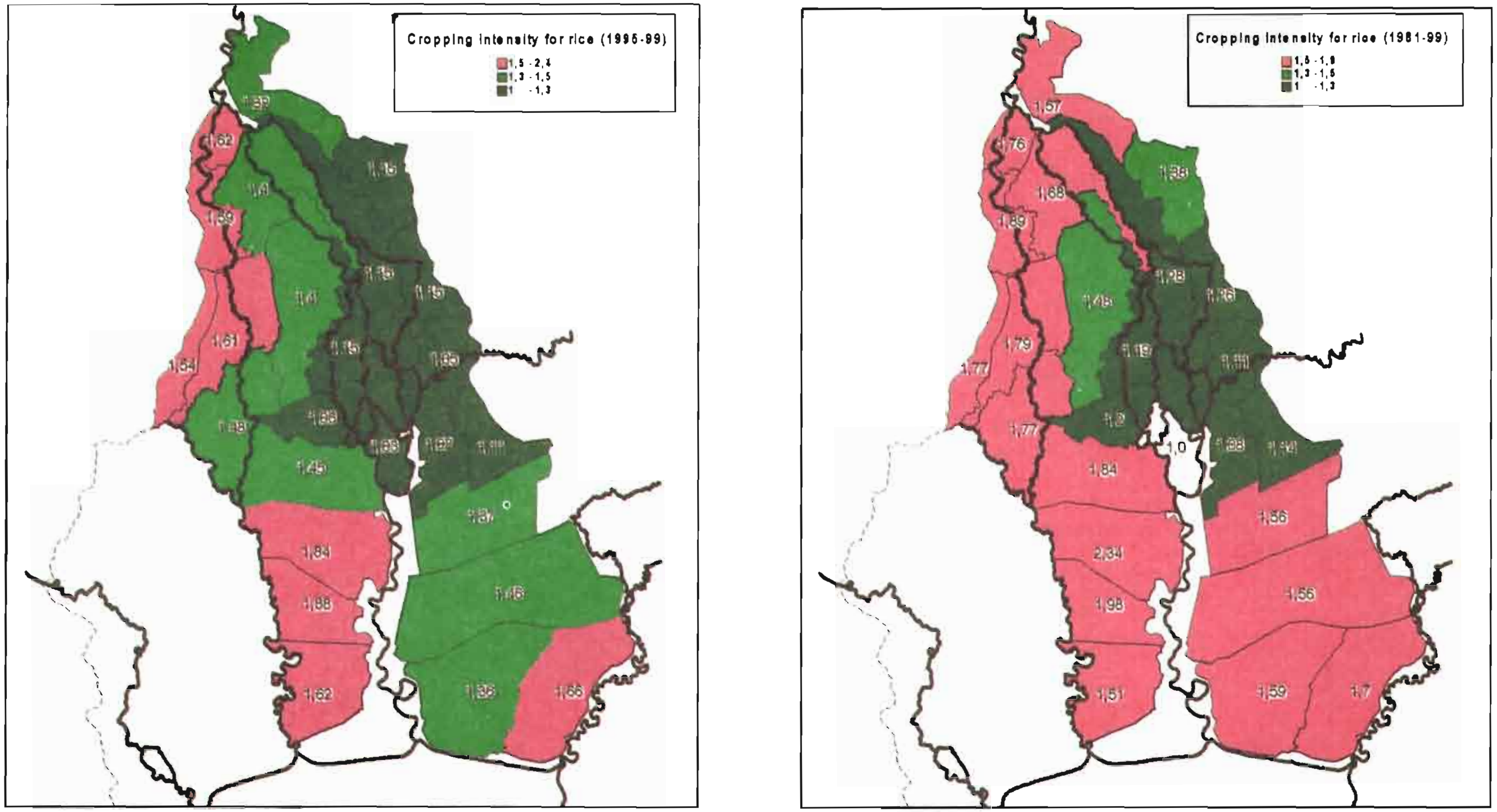
Project	Rice CI	Rice + FC CI	Total CI	Rice CI	Total CI	Rice + FC correct CI	Rice correct CI	%of area with no on-farm
Period	1981-99			1995-99		1995-99	1995-99	%
Borommathad	1,40	1,42	1,40	1,64	1,68	1,44	1,72	5
Chanasutr	1,40	1,40	1,36	1,38	1,48	1,45	1,53	10
Chong Kae	1,15	1,19	1,18	1,38	1,38	1,23	1,48	20
Don jedee	1,54	1,55	1,51	1,66	1,77	1,55	1,77	0
Khok Katiem	1,15	1,19	1,18	1,27	1,26	1,32	1,42	39
Maharat	1,15	1,18	1,18	1,29	1,28	1,24	1,37	25
Manorom	1,32	1,33	1,32	1,55	1,57	1,34	1,60	5
Pho Phaya	1,48	1,48	1,46	1,71	1,77	1,48	1,77	0
Pollathep	1,62	1,62	1,61	1,75	1,76	1,64	1,78	3
Roeng Rang	1,05	1,11	1,10	1,15	1,11	1,13	1,13	15
Samchuk	1,61	1,62	1,52	1,63	1,79	1,62	1,79	0
Thabote	1,59	1,59	1,56	1,81	1,89	1,59	1,89	0
Yangmanee	1,15	1,16	1,15	1,17	1,19	1,23	1,27	30
Nakhon Luang	1,02	1,03	1,03	1,08	1,08	1,07	1,21	60
Pasak Tai	1,11	1,12	1,11	1,13	1,14	1,14	1,16	15
Phak Hai	1,06	1,08	1,08	1,20	1,20	1,18	1,45	55
Bangbal	1,03	1,06	1,05	1,06	1,05	1,23	1,20	75
Chao Ched Bang Yeehon	1,45	1,44	1,41	1,75	1,84	1,44	1,84	0
Khlong Dan	1,36	1,37	1,29	1,49	1,59	1,37	1,59	0
Pasicharoen	1,62	1,63	1,32	1,16	1,51	1,63	1,51	0
Phra Ong Chai Ya Nuc	1,66	1,66	1,59	1,60	1,70	1,66	1,70	0
Phrapimol	1,88	1,88	1,74	1,79	1,98	1,88	1,98	0
Phrayabanlue	1,84	1,84	1,76	2,20	2,34	1,84	2,34	0
Rangsit Nua	1,37	1,37	1,23	1,24	1,56	1,37	1,56	0
Rangsit Tai	1,46	1,46	1,44	1,51	1,56	1,46	1,56	0
TOTAL upper delta	**1,34**	**1,36**	**1,33**	**1,48**	**1,52**			
TOTAL lower delta	**1,44**	**1,45**	**1,38**	**1,53**	**1,63**			
TOTAL	**1,38**	**1,40**	**1,36**	**1,50**	**1,57**			

3.4 Water supply and cropping area

Water supply (the sum of irrigation and *effective rainfall*) can be compared with the total cropping area in order to derive standards of water use and to evidence differences between Projects or variations over time. The upper delta has been divided in 12 hydraulic units[12]; in the lower delta, water balances are precarious. There is a significant inflow, both by gravity and by pumping, into the West Bank from the Tha Chin river (which receives water from the Mae Klong system) and unknown flows from/to the Chao Phraya River. The East Bank receives less water from its bordering rivers. The inflow from Bang Pakong is discontinued in late January and is partly substituted by pumping.

[12] The Roeng Rang and Kok Katiem projects can be separated for aspects of rice cropping but must be pooled for water balance: they thus form the RR+KK section.

FIGURE 7: SPATIAL RICE CROPPING INTENSITY (1981-1999 AND 1995-1999)



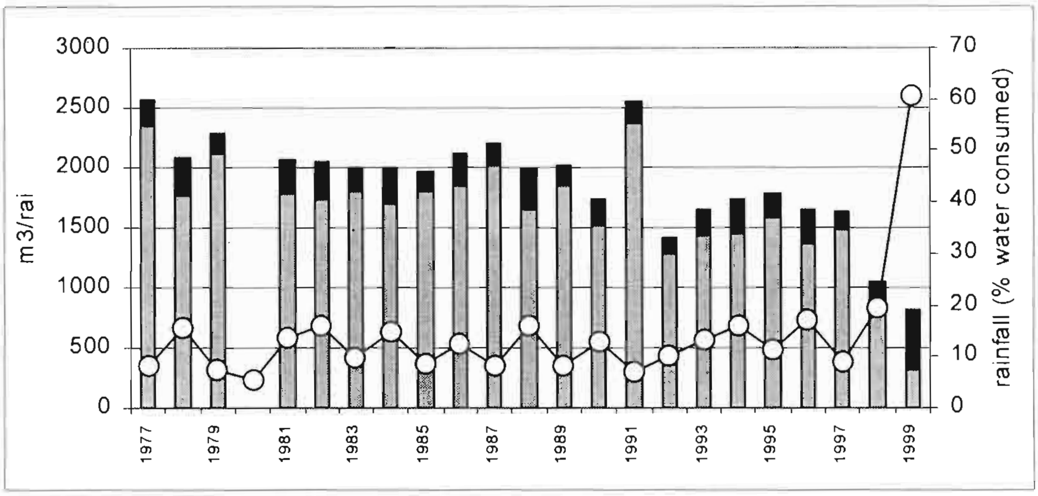
Water balances can be achieved for hydraulic units which have records of inflows and outflows. Inflows are recorded five times a day at all the main regulators of the distribution network. Return flows to the drainage systems are unfortunately unknown. There are a few reasons to believe that these are not of any significant magnitude in the dry season: at the plot level, the great majority of farmers have to pump water from the ditch and they are eagerly combating any loss out of their plot of a scarce water. At the Project level, many of the main and secondary drains are equipped with regulators in order to better retain water in the dry season (they capture superficial and sub-superficial run-off), and little water is passed on to downstream areas. Return flows remain much probably under the 10% threshold. The delta may also get some inflow from adjacent upland areas in case of heavy rainfall. The sections and months concerned have been discarded.

Several possible sources of error impair the accuracy of the estimation of both water supply and cropping areas[13] but estimates of overall seasonal consumption can nevertheless be attempted. Figure 8 shows that (the year 1999 excluded) the average of irrigation water use in the upper delta is 1700 m^3/rai and that there is a declining trend over the years. This decline can be explained by: 1) An increased water use efficiency at the plot level, fostered by the growing pressure on the water resource and by the growing use of individual pumping at the plot level (which strongly encourages water savings); 2) an increased use of shallow tube-wells; 3) a trend towards shifting cropping calendars earlier in the rainy season. This very significantly decreases water use for land preparation (see more on that in § 5). It also shifts an increasing part of the crop cycle out of the January-June period and consequently underestimates the water effectively used by this crop; 4) a growing use of shorter duration rice varieties, especially in triple cropping areas.

The anomaly observed for the year 1999 is mostly due to the fact that most farmers, knowing about planned water restrictions, still wanted to benefit from high rice prices and started their dry-season crop very early, in the October-December period. Considering rainfall raises the total amount of water received by a rai of rice-equivalent to 1929 m^3. These values should be slightly incremented to account for the area cropped out of the January-June reference period.

[13] : inaccurate hydraulic formulas, or the use of the latter in situations where their precision is not ensured; pumps providing unrecorded inflows; errors of reading (gauge), recording (in books) and, in some cases, ad-hoc over or underreporting. To simplify the water balance, we have expressed the cropping area in terms of *rice-equivalent*. In what follows, coefficients of 0.4 for field crops/vegetables, 0.7 for sugar cane, and 1 for orchards and aquaculture have been used. Another difficulty is linked to our limited knowledge of cropping calendars in the dry-season. While we consider the amount of water delivered during the first six months of the year (January-June), calendars – including staggering - may sometimes be shorter, while in other instances they may start before January or end later than June. The impossibility to specify this point over two decades has led us to simplify the water balance, at the expense of some accuracy. We will compare the total cropping areas by *section* (based on RID reports, by Projects) and the amount of water supplied (irrigation + effective rainfall) over the January-June period. Also unknown is the share of water distributed by the irrigation network which is used for domestic purposes (other than agriculture). It has been assumed that this non-agricultural use amounted to between 5 and 10% in the upper delta, and 15% in the southern delta (golf courts, etc).

FIGURE 8: AVERAGE IRRIGATION WATER CONSUMPTION PER RAI IN THE DRY SEASON (1977-99)



Over the 1977-1999 period 11.64 million ha (72.7 million rai) of *rice-equivalent* have been cropped in the whole delta during the dry-season. The corresponding irrigation water supply[14] amounted to 86 billion m^3. The overall estimated effective rainfall is 16 billion m^3. This gives an overall average of 1180 m^3/rai, or 1400 m^3/rai including rainfall. These values should be corrected by a factor of 1.15-1.25, according to the year, to account for the area partly cropped out of the January-June reference period. *This gives an average consumption of water per rai around 1600 m3, or 10,000 m3/ha, with a significant spatial variability and a slight temporal decline, from which 15% is provided by rainfall.*

A similar analysis can also be made for each hydraulic unit. It can be shown that water consumption varies widely (between 1,500 and 3,000 m3/rai), in part because some sub-areas have an unknown and non recorded part of supply from other sources (notably tube wells), head or tail-end location, higher conveyance loss, and difference in cropping calendar.

4 Present planning and allocation

4.1 Control of water use in the basin

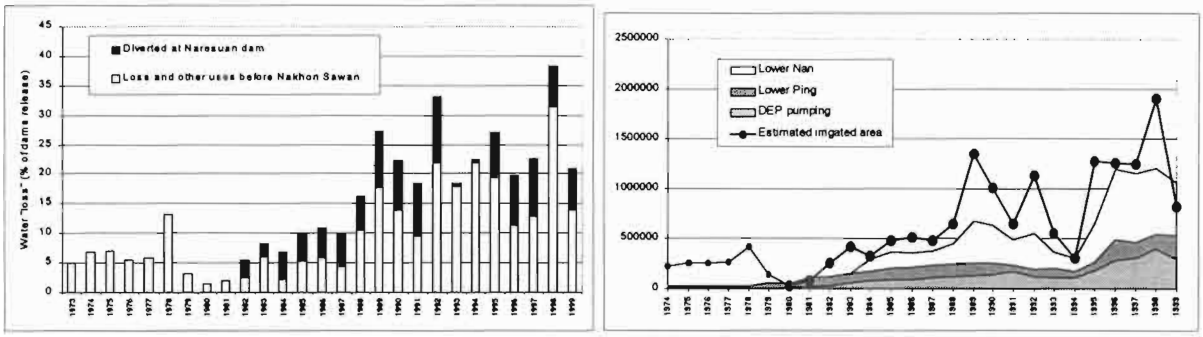
One of the main constraints to both planning and management is the growing share of uncontrolled water abstraction in the rivers, between the dams and Chai Nat. This includes approximately 300 groups of farmers using pumps implemented by the Department of Energy Promotion and RID mid-scale projects.

A quantitative estimation of how much water is withdrawn from the rivers before they reach Chai Nat, at the apex of the delta can be made by considering the water balance between

[14] plus contributions from the Bang Pakong and Tha Chin rivers and from tube-wells (mostly in the northern part of the upper delta). Over a long period, however, shallow aquifers can be considered to be greatly replenished by irrigation; therefore they correspond to recycling within the basin, not to additional supply from outside the system.

the dams releases and the flow at Nakhon Sawan, a few kilometers before Chai Nat, during the driest period: February-March-April. During these three months sideflows are extremely limited. All are dubbed here "water loss", with reference to the delta[15]. Figure 9 shows that while water abstraction in the *middle basin* was only around 5% of the dams releases in the 70's, it has now increased to, say, 25%, with a peak of 38% in 1998 ! This includes "controlled" uptake by RID in Phitsanulok project (since 1982), as indicated in the figure, and in the Lower Ping area (since 1990), but also accounts for the growth of scattered private pumps. The figure (right) also provides an estimate of the growth of the cropping area in the medium basin.

FIGURE 9: COMPARISON OF THE 2 DAMS RELEASE AND THE AMOUNT OF WATER REACHING CHAINAT (FEB. TO APRIL)



A similar phenomena of semi-controlled water abstraction is also developing on the margins of the delta proper. On the Western side, along the Makham-Uthong canal, these areas are now estimated at 80.000 rai. Large ditches branching from the main canal have been dug as far as several kilometres and several pumping units can be observed along the canal (many of them belonging to RID). In the Chong Kaew Project, on the east, fruit growers have installed very powerful pumps along Chai Nat-Pasak canal and even sell water to some other farmers ! In the lower delta, uncontrolled abstraction from golf-courses, real estates, etc. is also wide spread. These examples show that there is at present a growing loss of control on water use in the basin (who, when, how much), partly provoked by the uncoordinated initiatives of various Department, which make proper management increasingly problematic.

4.2 Formal pre-season planning

In 1981, the Cabinet appointed the Dry Season Cropping Promotion Committee chaired by the Ministry of Agriculture to prepare an annual plan, objectives and promoting measures for dry-season cropping. A sub-committee was appointed to collect relevant data and, each year, prepare a plan. After acceptation of the plan, users and agencies would know the plan for dams release and operate accordingly (Binnies, 1997). During the 1991-1994 drought

[15] This does not mean that the delta should necessarily be favoured. However, if we consider that it infrastructures are the oldest and that irrigation had been planned based on the available water resources, it is also legitimate to reckon that later schemes have in fact been built based on the same water resource and that they depleted the initial share of the delta. This has to be questioned on the ground of elementary economic logic.

period, it proved impossible to manage the system according to the plan and the committee ended its work. However the sub-committee continues to meet yearly in order to achieve some co-ordination between agencies.

Normally, at the end of the year (November), the sub-committee (or working group), with representatives from the various Ministries involved (MOAC, DOAE, RID, EGAT, DEP, etc.) is convened with the aim to examine the situation for the whole country and to define the national policy for the coming dry-season. Data are presented by several technical Offices and a preliminary target is set up for the dry season area cultivation. The policy is mostly based on the projection of the active water storage for the 1st of January presented by EGAT. On its side, RID (regional offices) has consulted the Provincial agricultural services and comes out with a crude pre-repartition of the area by Province, with areas broken down according to crops (rice, field crops, trees) and water status (irrigated/non irrigated). Some other aspects are discussed and may also be taken into consideration (this year the Office of Agricultural Economics warned that rice prices were declining and that the planting area should be controlled; in 1996 and 1997, supplies were increased to compensate for the flood damage undergone during the preceding wet season, etc.). The share of water which can be pumped by DEP pumping stations along the river is also specified. These recommendations are further endorsed and made official by the Dry Season Committee, of which the minister of the Ministry of Agriculture and Co-operative (MOAC) is chairman.

The principal figure presented to the meeting is the assessment of the available water for the next dry season (projection of the water stock on the 1st of January). This Available Volume, or *active storage*, (hereafter called AV) is expressed in billion m^3 and generally varies between 5 and 15 billions m^3, but happened to be as low as 3.6 billion in 1980 and 2 billion m^3 in 1992. From the available volume AV (which gives an indication of whether the coming dry-season is to be considered "dry", "normal" or "wet"), a Target Volume (TV) of water release for the January-June period is issued. TV is only a part of AV because of the need of inter-annual regulation and the risk to lack water in the early rainy season, when requirements sometimes offset natural flows or precipitations. There is, however, no definite standard on how much water must be kept at the end of the dry-season, but 2-3 billion m^3 is a minimum basis. The value of TV is transformed in cropping area, following a thumb rule of 1,600 m^3/rai. This Target Area (hereafter TA) is expressed in *rai* and generally varies between 2 to 3.5 million rai.

The relationships between AV, TV and TA are grounded on past experience and are approximately based on the following rules (RID, *pers. com.*):

Active storage AV > 10 Bm3, released plan TV = 6.5-7.5 Bm3; for paddy area TA= 3.1 – 3.3 M.rai
Active storage AV = 7.5-10 Bm3, released plan TV = 6 Bm3; for paddy area TA ≈ 3.0 M.rai
Active storage AV = 5-7.5 Bm3, released plan TV = 4 Bm3; for paddy area TA ≈ 2.0 M.rai
Active storage AV < 5 Bm3, released plan for domestic use and other constraints only.

The global release target TV is subsequently distributed among the various water uses within the basin, namely domestic use, BMA, transportation, control of salinity intrusion, irrigation, with the latter broken down by IRD Region. A weekly calendar of water release is prepared by the regional offices, with the constraint that the total of the weekly releases equate the amount allocated to each of them for the 6 months. Each region also specifies the weekly releases for each of the main canals included in it, together with the cropping area targets for each Project.

Projects are requested to draw maps of target areas, considering areas with possible loss in the rainy season (flood, grasshoppers, etc), to plan the use of RID's mobile pumping stations and to set a weekly calendar for water supply in all the main canals in the Project. All these activities, however, have little or no impact on the already planned schedule and on real water distribution. In parallel, each Project organises meetings at the *zone*[16] level in order to inform farmers about the cropping area allocated to their zone. This is generally done together with the gate keepers, zonemen and sub-district extensionists. Rather than the figure itself, farmers first give attention to the overall policy adopted: "*it is prohibited to plant*", "*there is little water this year*" or "*this year, water is good*" form the basic "*hearsay scale*" on which farmers rely in order to decide to engage in cropping or not. The cropping area announced is also taken as an indication but it is considered together with further advice from officers which qualifies the risk. Project Officers tend to be conservative on the latter as a *protective measure against a possible drastic water shortage lying beyond their control.* They commit themselves to ensure water supply for a limited area, but at the same time may suggest that a larger cropping area is likely to be possible.

4.3 Plan revisions and operational real-time adjustments

In some instances however, peculiar conditions may call for the revision of the whole plan. This generally occurs at the beginning of the season, in January or early February. Two instances of adjustments in the planned weekly calendar have recently occurred (and are probably representative of the two main causes of plan revision): discrepancies between technical and political criteria of target setting (1999); severe mismatch between the planned schedule and effective crop progress (2000).

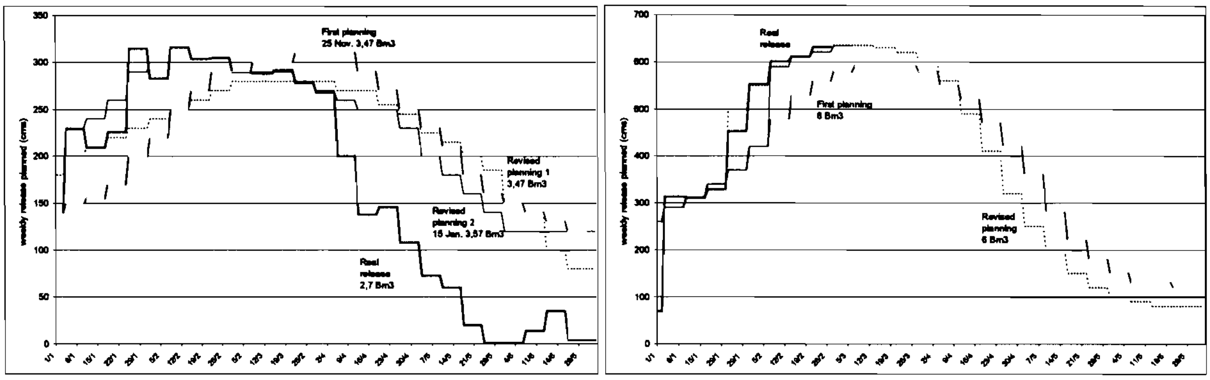
In summary, the allocation process can be typified as supply-driven, guided by experience rather than by clear-cut technical parameters, somewhat flexible rather than rigidly pre-determined. It focuses on the allocation at macro level, with little control on the day-to-day fluctuations experienced at the lower levels but with a concern not to stray too much from the weekly planning, as a way to ensure that the total water released at the end of June do not differ from the overall target by more than, say, 15%. Water supply at lower levels (laterals) is very loosely defined and uncertain.

After the setting of weekly dams release targets, first at the onset of the season, then with possible – although rare – in-season adjustments, RID officers focus their attention upon day-to-day water management. Although EGAT happens to release water amounts very close to those requested (more on this later), irrigation managers have to cope with three kinds of uncontrolled perturbations: pumping irrigation in the *middle basin*; hectic cropping

[16] A sub-unit of a Project (approximately 1000-1500 ha)

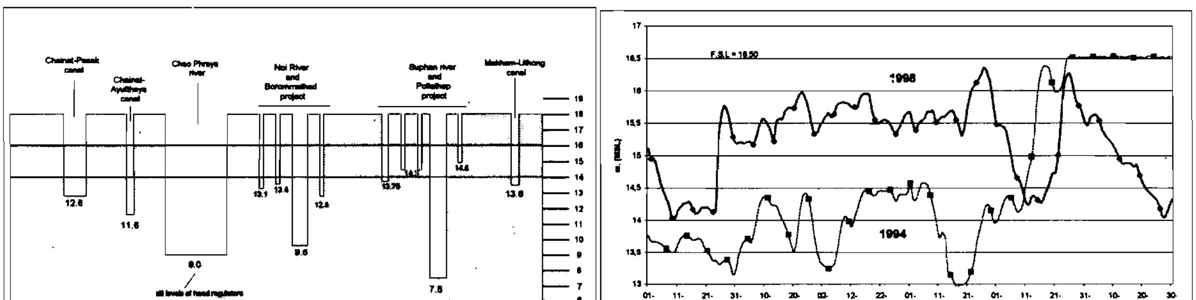
calendar; climatic events. The first perturbation, and partly the third (possible sideflows in May and June), impact on the discharge eventually reaching Chai Nat dam.

FIGURE 10: PLANNING REVISION IN THE DRY-SEASON 1999 AND 2000



An irregular inflow at Chai Nat translates into fluctuations of the water level upstream of the dam. This further disrupts the discharge of all the regulators which control the waterways branching off the Chao Phraya river, upstream of Chai Nat dam, most especially in those which sill level is high. Figure 11 shows that rivers have no problems to get water when the level drops but that most canals do. The main reasons for such fluctuations are the uncontrolled water use in the middle basin and the decrease in dam releases during the week end. As the demand for energy diminishes (many factories and offices close), EGAT reduces releases accordingly. This effect takes approximately 5 days to materialise in Chai Nat dam. In order to limit this phenomena, EGAT has agreed to maintain daily releases during the week end over 60% of the average value for the week considered. Nevertheless, disruptions are still perceptible and resented by RID officers[17].

FIGURE 11: WATERWAYS SILL LEVELS AT CHAINAT (IN M MSL) AND FLUCTUATIONS OF THE WATER LEVEL



Daily data for the dry-seasons of the years 1994 (dry) to 1998 (wet) are used here to show the extent of these fluctuations upstream of Chai Nat dam: 1994 sticks out as very problematic year in which virtually no irrigation water was supplied and the water level

[17] It appears that the lower releases on week-ends are somewhat dampened on the way. If we look at the daily dam releases for each of the weeks of the 1998 dry-season, we find that in fact there are slumps on Sundays. On the average over the 26 weeks, the decrease is 61% of the week average, that is almost exactly the value agreed upon. However, 5 weeks have Sunday releases under 55%, with 3 of them under 50% of the week average.

remained below 14.50 m MSL, this is 2 meters below 16,5 m, the full-supply design level used in the wet-season. In "normal" dry-seasons, the level is generally fluctuating between 15.5 and 16.0 m. Other years also show significant fluctuations and difficulties to ensure a proper level, especially during January and February.

4.4 Management and adjustments at the Project level

In normal situations, Project managers ensure/adopt a continuous flow to all their laterals. If the policy is to follow a year-by-year rotation in which half of the Project only is supposed to grow rice, then the flow to the other half is maintained low, but rarely cut, at least in the head reach. How these limited flows are compatible with classical earth canals equipped with sluice gated regulators and designed to provide gravity flows to laterals at the full supply level is not readily obvious to the observer. In fact, situations vary according to topographical features but the most common case is that of farmers compensating for the lack of gravity flow to their FTOs (Farm Turn Out) by using individual pumping devices. *If operational constraints experienced by RID have forced farmers to develop their pumping capacity, it is all the more true that this – in return – has discouraged whatever regulation improvements RID would have otherwise been pushed to achieve.* Rotational arrangements are part of the paraphernalia but as their implementation entails significant transaction costs, RID officers understandingly prefer the actual *statu quo* according to which their role is to ensure water in the canal, even at the bottom of it, while farmers have implicitly integrated the fact that they will need pumping devices to access water.

The development of the individual pumping capacity has been paramount in easing water management in the dry-season and in providing farmers with the flexibility to easily access any pounding or flowing water. On the negative side, it is equivalent to substituting managerial exigencies for increased monetary costs (pumping equipment and operation), which burden is borne by the farmers. A more subtle negative aspect of this process has also been the strengthening of a pervasive individualistic conception of gaining access to water. Although collective arrangements are sometimes necessary and implemented, there is ample evidence that individual pumping has implicitly reinforced the acceptance that locational advantages necessarily translate into a privileged access to water: head enders can pump water as soon as it appears, in total independence from a possible collective rotational arrangement or other efforts aimed at raising the water level in the canal or increasing equity.

The way, in a context of rather high uncertainty, supply and demand adjust to one another is not obvious and cannot be easily reduced to the classic distinction between a demand-driven process (supply is adjusted to a given demand) and a supply-driven one (inflows are fixed and known in advance and the irrigated area is calculated accordingly). A careful analysis shows that it may in fact be a blend of both, with a delicate and fluctuating dosage of ingredients.

Let us schematised the objectives, constraints, risks and trump cards of the main two parts concerned. Farmers, unless rice prices be really depressed, usually attempt to grow a dry-season rice area as large as possible, two times or more if possible. They must evaluate the risk of doing so according to information given by RID and media. By starting their crop massively and/or by resorting to secondary water sources, they will force RID to supply their crops until the end of the cycle. In case of drastic shortage, they may request local politicians to intervene in order to get an extra supply.

On their side, RID officers both want to serve their farmers and minimise risk. In some instances the second aspect may override the first one and officers are likely to adopt strategies aimed at limiting the expansion of the cropping area. In some instances, they are seen opening middle reach check regulators, allegedly to provide consumption water to downstream areas, but in reality to prevent upstream areas to grow too large an area, which would dramatically increase the risk of future shortage. For officers, shortage means farmers' unrest, political interventions and hierarchical superiors possibly asking for explanations, all things which must be avoided as much as possible. Their margin of flexibility lies in a certain degree of slack in water allocation: they may sometimes allocate poorly reported extra water supplies through releases into drains, by setting pumps along the rivers or by treating them as "*upaphok-boriphok*" (domestic consumption) water. Under-reporting may also occur in times of tighter quota monitoring. An important protective measure is to commit to a low standard target area, in order to transfer risk-taking onto farmers, while giving *off-record* indications on how much risk should be reasonably taken. This is why RID officers are reluctant to plan large areas, even in their demand channelled to the Regional Office.

This system is served by the implicit philosophy conveyed by the development of individual pumping. By fostering the acceptance that farmers along the canal do gain privileged access to water, it chokes claims of greater equity, with their cohort of demanding measures, and fits RID's concern to control the expansion of the cropping area: if the *first-pumping-first-served* principle is endorsed, then any water flow in the laterals will swiftly translate into a green "glove pattern" rice area. The width and the length of each "finger" depends on the flow itself, the roughness of the canal, topography and the pumping capacity of the farmers along its banks.

Should this be seen in a negative fashion ? Does not, after all, pumping lead to a very efficient water use at the plot level and ensure that even limited flows are fully made use of ? It may also be ideally adapted to a water supply characterised by its irregularity and sometimes, uncertainty. However positive these aspects may be, this is achieved at the expense of equity, which will be touched upon later.

4.5 Total water release during the dry season: decision-making

The total amount of water to be released by the dams during the six month period running from January to June is the key parameter of the allocation process and of the inter-annual dam management. In normal years, this amount is usually around 6 or 7 billion m^3. The year 1996 set a record close to 10 billion, while two years of crisis have received less than 4 billion m^3 (1980 and 1994).

4.5.1 What technical guideline for the determination of the Target Volume ?

It stands to reason that the determination of the target volume(TV), that is the total amount of water to be released during the January-June period, is a direct measure of the risk perceived and accepted. This risk is dependent upon the "intensity" of the demand (farmers and political pressure). If a low value of TV is chosen, then there will be enough water to regulate whatever situation may arise in the coming months. On the contrary, if most of the available water is released, we run the risk that water requirements will be high during the next wet-season, which generally goes together with a low run-off into the dams.

Uncertainty remains about how much water will have to be used in the following wet season. On average, monthly sideflows are higher than corresponding monthly requirements and most of the inflow in the dams can be stored. Statistically, however, "dry" months occur frequently and dam water must be released to supplement both rainfall and sideflows. In all cases the dams water balance in the rainy season will be positive but the net stock gain, 4.7 Bm3 in a median year, may be as low as 1.5 Bm3 one year out of ten. In the next dry season, however, dams release will have to amount *at least* to a floor value of 2-2.5 Bm3. Therefore, there is a risk of having an overall yearly deficit of at least 1 Bm3 (or more if releases in the dry-season happen to be higher than the floor value).

Risk will be lowered if the carry-over stock kept at the end of the dry-season (floor value FV) is increased. It appears that at the moment there is no agreed upon value which should not be trespassed. It therefore gives way to conflicting interpretations between the farmers/politicians, who tend to see immediate benefit, and project managers, who are afraid of the major disrupting consequences of a possible drastic shortage or of a dam emptying.

How the target volume TV translates into cropping area is another "quiz". As the relationship is poorly known, it is difficult to estimate a realistic target area TA: consequently it is difficult to follow a decision-making allocation process based on cropping area.

Figure 12 shows the theoretical relationships between the available water and cropping areas, as estimated by Acres (1979) and, more recently, by Pal & Panya (2000). The difference between the two curves in an interesting indication of the initial under-evaluation of the cropping area; the figure also shows the observed historical values. The years 1975 and 1976, with cropping areas much under the potential, are indicative of an early development of dry-season cropping. The years 1999 and 2000, on the other hand, have yielded extremely high cropping areas. This reflects, among other factors, a sharpening of the trend to advance cropping calendars (therefore an increasing part of the rice area is started before the 1st of January), a better registration of triple cropping and possibly an increase in the use of 3 month cycle rice varieties. Discrepancies also account for errors in reporting and for the fact that the water eventually released during the dry season may differ from the "sustainable" values assumed in the models.

To analyse what has been the effective allocation in the past, it is interesting to first examine how the active storage volume on the 1st of January and the 1st of July relate to the amount of water effectively released during the dry-season. We may consider the magnitude of the drawdown of the dams active storage between the 1st of January and the 1st of July (this also considers dams inflow). displays the corresponding values classified by magnitude and also shows the initial and final stored volumes. The lower figure shows these drawdowns classified according to the final volume (1st of July). The years 1974, 1975 and 1976 stand at the extreme right. In those years, Sirikit dam had just been set into operation and water demand in the dry-season was still limited. It is less clear why, for example, the year 1986 only sees a release of 5 Bm3, while almost 8 Bm3 are still available at the end of the dry-season; or why the year 1983 starts with more than 10 Bm3 but releases so much water that only 1.4 Bm3 remains 6 months later, incurring in some high risk.

FIGURE 12: GUIDELINES FOR SEASONAL ALLOCATION, AND OBSERVED VALUES

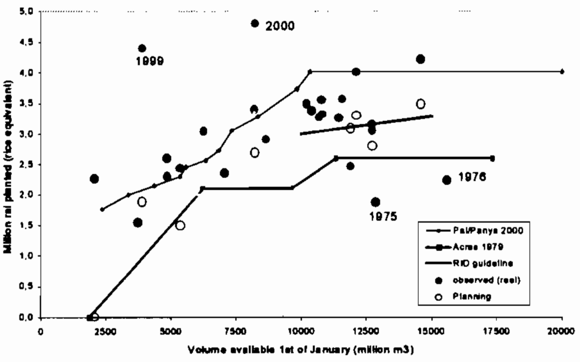
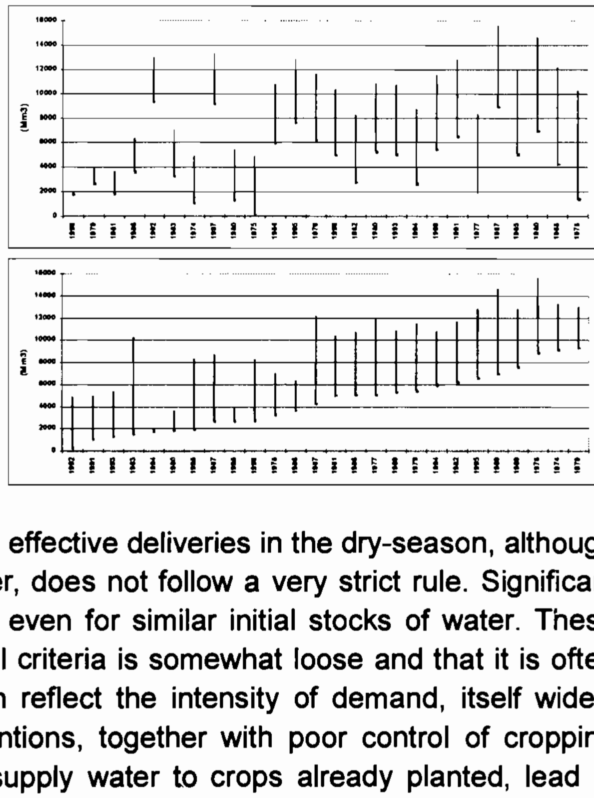


FIGURE 13: ACTIVE STORAGE DRAWDOWN BETWEEN THE 1ST OF JANUARY AND JULY, CLASSIFIED ACCORDING TO THE MAGNITUDE OF DRAWDOWN AND TO THE FINAL ACTIVE STORAGE



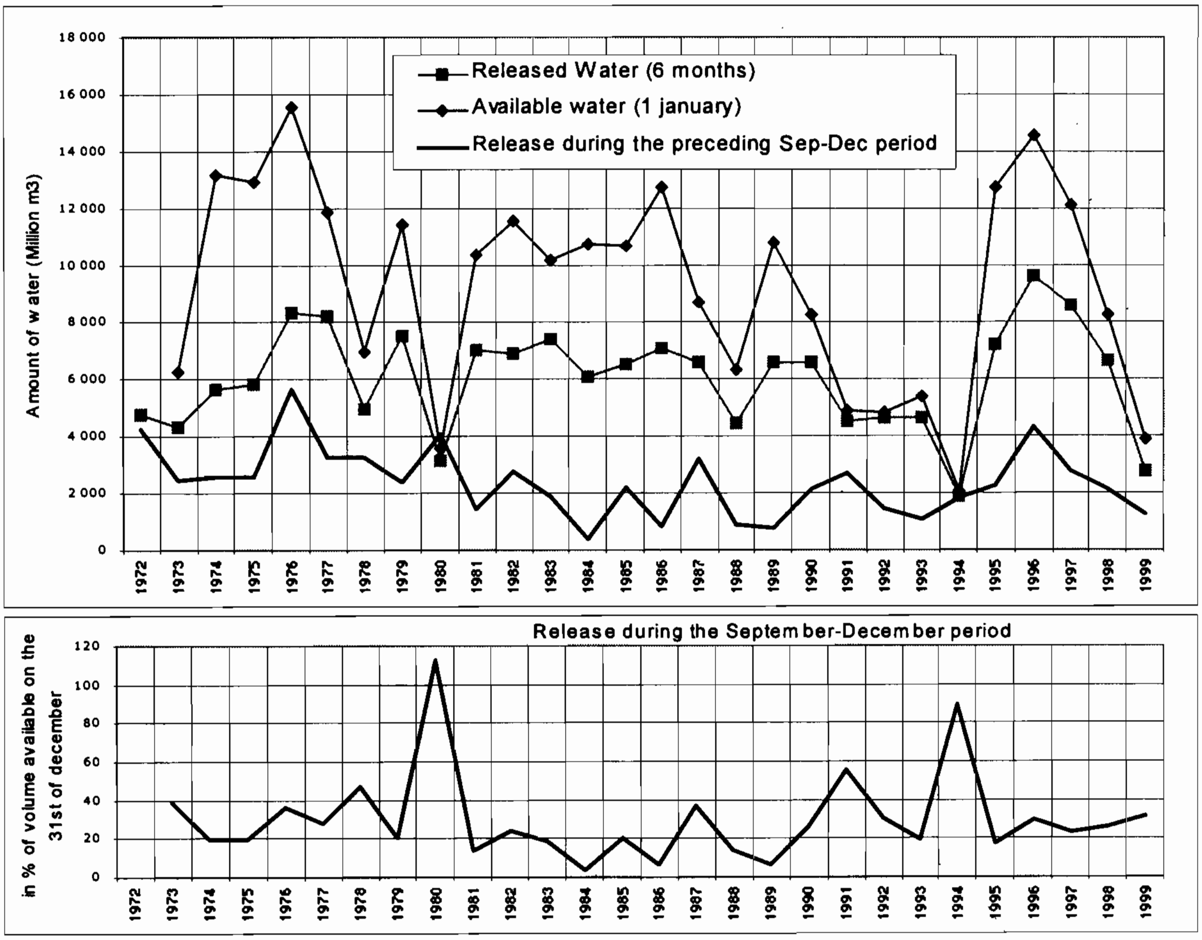
From all these observations, it follows that the effective deliveries in the dry-season, although widely governed by the available stored water, does not follow a very strict rule. Significant variations are evidenced between the years, even for similar initial stocks of water. These can be attributed to the fact that the technical criteria is somewhat loose and that it is often challenged by more political decisions which reflect the intensity of demand, itself widely correlated to the price of rice. Such interventions, together with poor control of cropping calendars, which sometimes forces RID to supply water to crops already planted, lead in some instances to very high levels of risk for the ensuing seasons.

Figure 14 shows that the available water (over the dead storage volume) is in most years significantly higher than the amount of water released. This mirrors the will of interanual regulation and/or the limits of the diversion capacity. The lower (thicker) curve compares these first two values with the total amount of water released during the end of the rainy season (September to December). It shows that the 1980 crisis was partly generated by the undue release of 4 billion m^3 during these four months. This was also the case in 1991 and in 1994, as highlighted by the lower part of the figure which expresses the amount of water released in percentage of the remaining water on the first of January.

From all these observations, it follows that the effective deliveries in the dry-season, although widely governed by the available stored water, does not follow a very strict rule. Significant

variations are evidenced between the years, even for similar initial stocks of water. These can be attributed to the fact that the technical criteria is somewhat loose and that it is often challenged by more political decisions which reflect the intensity of demand, itself widely correlated to the price of rice. Such interventions, together with poor control of cropping calendars, which sometimes forces RID to supply water to crops already planted, lead in some instances to very high levels of risk for the ensuing seasons.

FIGURE 14: SEASONAL RELEASE COMPARED WITH AVAILABLE WATER (1972-1999)



There are several difficulties in determining the most opportune amount of water to be released in the dry-season. One aspect is whether the dams release (and the cropping area) is allowed to take totally different values every year, depending on the stock, or whether it is preferable to have a constant average target, from which will be departed only in exceptional years (very low active storage). Although this problem is classical, there are very few, if any, examples of policy favouring stability/equity instead of instability/efficiency.

5 Improving equity and efficiency in allocation and management

5.1 Dams management

5.1.1 Dams releases vs. downstream requirements

The logics of dam management for irrigation and energy generation are different in some respects but not totally antagonist. RID wants water to be delivered in the dry-season AND in the rainy season – most especially the months of July, August and September - , when and if the rainfall pattern entails specific requirements. These requirements will depend on local rainfall but, above all, on the amount of side-flows generated in the basin downstream of the dams and upstream of the main irrigated areas. Contrarily to common wisdom, this latter requirement is by no mean small and, should sideflows be insufficient, large amounts of water will have to be released by the dams during this period. In years of abundant runoff, water releases are also commanded by concerns of flood control and dam safety. Ideally, water should be stored during the rainy season as much as possible, and released during drier months.

EGAT, on the other hand, is managing a wide diversity of energy generation plants, the largest part of which is thermal based, with hydropower making approximately 8% of the total. All the sources are not equivalent in terms of cost and flexibility. Hydropower generation is most especially appreciated for the facility of switching it on and off at will, which is not conveniently feasible with thermal plants. It is therefore used to cope with peak demands (generally during three periods in a given day: 9 to 11:00 a.m; 14:00 to 16:00, and 18:00 to 20:30) and with outages or emergency shut-down of thermal plants. These are rather common (weekly occurrences) and the dam turbines are frequently solicited to "fill up the blanks".

Should we fail to consider this aspect of scheduling and flexibility, we would readily get to the conclusion that the dams should be managed according to RID's logic: in fact, except for a negligible share of water going through the spillways, the amount of water going through the turbines remains basically unchanged in the long run, as all of it (minus the loss) is sooner or later eventually released. The total amount of power generated is therefore unchanged, but for slight differences in the average head in the turbine[18].

The comparison of the weekly water demands formulated each week to EGAT by RID with effective release show that, during the dry season (and for the last six years data) there is a rather close match between the two. EGAT is therefore following by and large the schedule agreed upon. More generally, we can try to estimate the effective mismatch between dam

[18] keeping more water in the rainy season leads to a higher average water stock and corresponding head in the generators. On the other hand, loss by evaporation is increased, as the water body exposed to the sun is larger. On the whole, energy gains or loss derived from changes in management are at best of the second order and, in any case, not significant enough to govern, or even influence, the policy and schedule of water allocation and release.

releases and water use by looking at whether water is released in excess at Chai Nat dam (that is to say *in excess of* downstream minimum requirements for Bangkok and salinity control, in other words lost to the sea), *independently* of the planned values. This is unlikely to happen in the dry season, as the available water is eagerly awaited by farmers along the canals, but, rather, during the rainy season. Such possible water losses, however, may be both controlled or uncontrolled. The different situations can be broken down in 6 cases:

Situation 1: In the dry season, the system is supply oriented. A given amount of water is released by the two dams (D), based on the stored volume. Irrigation (here including all water uses along canals: Ir) adapts to the water supply and vice versa, but with much less elasticity in the second case. No water is lost at Chai Nat[19].

Situation 2: if, in the situation, just described, water is released at Chai Nat in excess of a given minimum threshold (rather generously chosen here as 80 cms), then the difference is computed as a *controlled* water loss (to the sea) for the system. This is shown in red (case 1).

Situation 3: in the March-June period approximately (the later part of the dry season and early rainy season), some significant natural sideflows may occur in case of rainfall. If there is a situation of water shortage, then sideflows are added and incorporated to the deliveries. In other cases, this water may be considered to reduce dam deliveries[20]. This can happen either because the manager wants to keep the overall supply at the same level (giving more could trigger more planting in the dry season) or because the demand is already satisfied (complement irrigation in the early wet season).

Situation 4: Because, for some reason, deliveries have not been reduced, the inflow at Chai Nat is found to be exceeding demand (or the level of supply that RID wants to maintain to avoid overcropping). In that case, water must be passed on to the Chao Phraya river, resulting in *controlled* loss (case 2).

Situation 5: In the rainy season, sideflows may amount to huge discharges which exceed the needs and/or the diversion capacity at Chai Nat. The excess water is passed on to the Chao Phraya river as an *uncontrolled* loss.

Situation 6: if, in such a situation, water is released from the dams, this release will accrue to the excess water and will not be used. If water is released because of dam safety reasons and/or because of the will to limit the probability of unproductive spill (no energy generated), then these releases are not considered as lost. If this is not the case, all amounts released *in excess* of the minimum requirements for ecological preservation and domestic use downstream of the two dams (1-2 million m3/day/dam) are considered as *controlled* loss (case 3).

Other situations: Without records of forced outages of EGAT's plants and of how much water had to be released to cope with them, it is not possible to estimate how much of these losses must be attributed to these emergency cases. Controlled releases triggered by a situation in which possible future non-productive spill must be avoided - the water level in one of the dams is above the upper rule curve - can be estimated based on the monthly values of this curve. This situation can be shown to be quite rare: it occurred only once, in 1975, for the Bhumipol dam (together with some spill) and four times for the Sirikit dam (in 1974, 1975, 1981 and 1995).

[19] In fact, there is often insufficient release at Chai Nat dam, sometimes provoking damage by salinity intrusion.

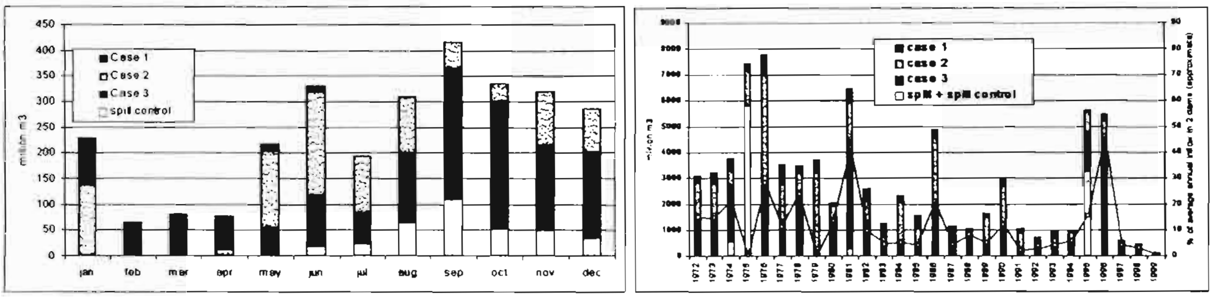
[20] Especially if the deliveries in the first part of the dry-season have exceeded target values.

This description may imperfectly represent all the possible situations but it nevertheless allows a categorisation of the different types of loss and an evaluation of their respective shares within the overall *loss*. These can be tentatively estimated based on monthly values of the water balance in the basin.

Figure 15 provides the monthly averages of the three kinds of loss, together with releases motivated by spill-control, for the 1972-1999 period. As expected, losses corresponding to case 1 concentrate in the first five months of the year. Case 2 losses dominate in the June-August period, while Case 3 losses are paramount in the September-December period. These losses are quite considerable in quantitative terms, especially in the rainy season. The figure also reveals a complementary picture of the yearly total loss along the 1972-1999 period. We can observe: 1) a striking variability of the yearly total water loss; 2) a decline of the total loss, suggesting that a decreasing inflow paralleled by a growing demand have fostered a stricter management of the dams; 3) that the decline affects the three types of loss.

In quantitative terms, the total average yearly loss amounts to 2.9 billion m^3, or 30% of the average inflow in the two dams, including releases for spill control together with effective spill which amount to 350 million m^3). Case 1 is rather limited in magnitude (291 million m^3), while Case 2 and Case 3 losses have similar magnitudes (1.06 and 1.12 billion m^3 per year on average).

FIGURE 15: WATER RELEASE AT CHAI NAT IN EXCESS OF REQUIREMENTS: THEORETICAL LOSS (AVERAGE MONTHLY VALUES AND YEARLY VALUES)



As noticed earlier, the year 1996 sticks out as an horrendous counter-example of the improved management, in terms of loss reduction, observed in the 1990s. More than 4 Bm3 have been dumped to the sea. It can be observed that 1.3 Bm3 have been released from the dams in August, out of which 1.1 Bm3 was lost to the sea[21]. What must also be emphasised, however, is that many significant releases observed from April to September, despite the occurrence of some rainfall, are in general motivated by irrigation requirements and are not, as often claimed by outsiders, released for the sole objective of energy generation[22].

[21] The water level in Sirikit was quite high (between 145 and 149 m) but had not reached the spill level (150.5 m). It is believed that the 700 million m3 releases were a psychological consequence of the exceptional 1995 flood.

[22] This approach, however, probably overestimate water losses. By considering monthly values, we ignore both the errors due to not considering carryover from one month to another (the water released the last five days of a given month is used downstream the following month) and the more significant constraints of real day-to-day management: the lagtime corresponding to adjusting releases to uncontrolled factors, including rainfall.

5.1.2 Dissociating energy generation and other use

At the completion of the Sirikit dam in 1972, hydropower generation accounted for almost one third of the total electricity produced in Thailand. Therefore, the rules and patterns of dam management were designed with the objective to maximise energy generation. In addition, supply was in excess of demand and EGAT was enjoying a significant degree of "slack" which could be managed according to specific energy-generation requirements. This situation can still be found in the Mae Klong (Satoh et al. 1999; Kositsakulchai et al. 1999) but the situation in the Chao Phraya river basin is now clearly the opposite one. Yet, because of the early orientation of dam management for energy generation and because of the flexibility offered by the dams to compensate for forced outages of thermal power plants, EGAT has continued to enjoy a certain liberty in managing the dams. We have seen earlier that this margin of flexibility has been drastically reduced in the last 10 years. As water is getting scarcer in the basin and conflicting interest arise, resources and their management come under growing scrutiny.

Several elements suggest that it is now possible to adopt a management of dams based on downstream requirement and not energy generation. 1) A first element is that hydropower has undergone a dramatic decline in relative importance as a source of energy for Thailand. From one third of the national production in the early seventies, it now amounts to only 8% of it, and Bhumipol and Sirikit dams eventually represent only 4% of the national production; 2) there is an overcapacity inherited from both the economic crisis and overrated projections considered in the past (Watershed, 1999); 3) More flexible production with other dams (Laos) or gaz turbine is or will soon be available (Independent Power Producers, Ratchaburi Plant), which may offer most of the peak generation facility now provided by the dams. Giving priority to downstream use will of course little alters the amount of energy produced (water will still flow through the turbines) but will push EGAT to solve problems of plant outage by using the overcapacity and not water from the dams, and answering to peak demand with other dams or gaz turbines. Indeed it will be a recognition of the changes occurred in both the power generation and water use sectors, and of the adjustments already made.

Other aspects of dam management should also receive attention. Dams release must be responsive to variations in demand, in particular to those due to hydrologic events. Rainfall and natural sideflows in the basin must be detected in real time, translated in projection of inflow and dams releases must be attuned accordingly. The upper rule curve of the dams must be revised in order to maximise the final stored volume rather than the total energy generated. It must investigated whether tapping the dead volume of the Sirikit dam (only justified to raise the head for energy generation) could be recognised as a normal procedure and not as dramatic event.

5.2 Reconsidering cropping calendars

Until the end of the 80's, most of the dry-season rice cropping and corresponding water supply were scheduled from February onward. Only the Chachoengsao Province on the East and the West Bank had different calendars (Kasetsart University and ORSTOM 1996): the former would start dry-season cropping as early as late October, in order to complete it before February, when water gets salty in the Bang Pakong river. The later would attune its calendar to the flood duration and perform one crop before and/or[23] one after. In a year of average flood, that is little water is stored in the West bank, which acts as a buffer, the area with earlier crop establishment (late October) is located in the middle-east of the West Bank (both higher land and better poldered area). As water recedes, rice is established, with the lower/later parts located along the Tha Chin river. All calendars are delayed in case of significant flood.

In the upper delta, the dry-season traditionally began in February, but the most distant sub-areas may start their crop as late as May. *The last decade has witnessed a gradual and complete deregulation of the theoretical scheduling*. This trend has been particularly obvious in the West of the upper delta (Don Chedi, Samchok, Phophya[24]). It has been fostered by the uncertainty as whether (late) deliveries would eventually come and/or be sufficient for a crop of rice. Rather than waiting until late into the season, many chose to start their dry-season crop in continuation of the wet-season one. Such a shift, in the footsteps of the West bank, soon proved much advantageous. Farmers would capitalise on the residual field wetness to cut the drastic peak need of water at land preparation time (between 250 and 300 mm in dry soils conditions). They would also not only benefit from rather abundant water remaining in the waterways until the end of December but also force RID to maintain some supply to sustain their crops during the period in which it should theoretically be suspended. While this shift could have prompted a smooth and acknowledged adjustment of the water schedule, a difficulty arose because of year-to-year variations, as the intensity of demand is linked to the price of rice and its timing to whether the wet season preceding crop has been late (sometimes delayed by a late preceding dry season crop) and, for the lower delta and Song Phi Nong area, when water will recede.

The use of shallow wells (at least for one part of the cycle), has also contributed to deregulating calendars. Farmers with very high cropping intensity acknowledge that they don't even refer any more to conventional seasons (*na-pii, na-prang*). Mention is made of *na-pleng* (the third crop) but others admit that they just don't know what growing-season they follow.

This gain in flexibility has undoubtedly been one of the main factor responsible for the records of cropping-areas observed in the last dry-seasons. Nevertheless, it also blurred all the landmarks used hitherto for allocating water in the dry-season. This calls for the necessity to first recognise these changes, then to incorporate them into the definition of a more flexible and rational allocation process.

The choice of cropping calendars entails wide differences in absolute water requirements. It must therefore be investigated how these have been fixed in the past and whether the logic

---

[23] Some parts of the West Bank have long been growing only one wet-season or dry-season crop ; the generalisation of double (or triple cropping) is rather recent and has been mostly allowed by the construction of pumping stations along the Tha Chin River.

[24] The southern tip of the Project (along Song Phinong river) follows a calendar close to the West Bank. Early supplies channelled through the main canals may have allowed upstream farmers to benefit from this water and shift calendars.

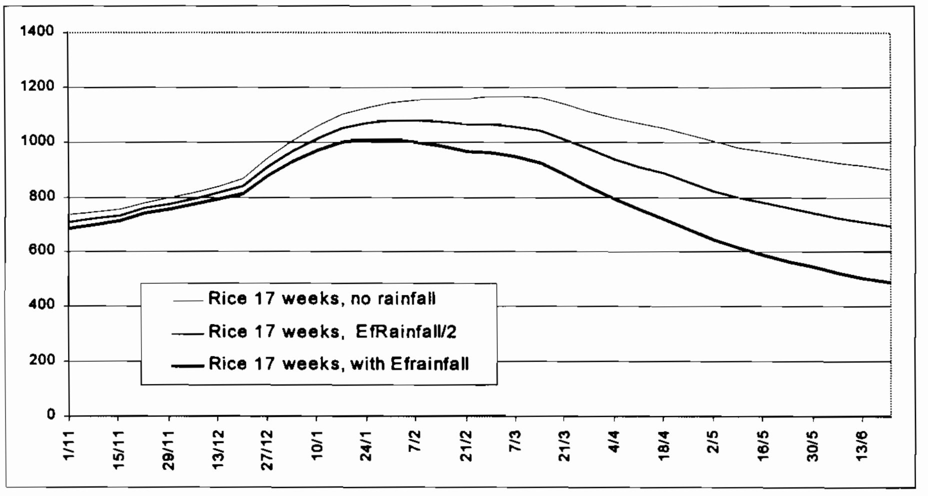
which governed this choice is still relevant under changed conditions. When dry-season cropping developed on a large scale in the mid seventies, the dry-season calendar was determined based on several constraints, including: the necessity to stop operation for maintenance purposes; the need to avoid the drainage of irrigated land into lower lands which are harvested in January; the dry land conditions demanded, in some projects, at the time of sugar cane harvest (in particular to allow trucks to enter the plots); widespread plot-to-plot system requiring co-ordination between farmers and calling for a collective, regular and predictable start of the season; the use of transplanting, also requiring predictability (nursery). For these reasons, water supplies were scheduled to start around the beginning of February, with little staggering. A first exception to this rule was the shift of calendars observed in the West Bank.

Spreading calendars over the November-July period almost doubles the time available to grow a second crop (and allow some farmers to grow three crops over the whole year). This clearly offsets part of the hydraulic constraint of the network, as implied by its limited flow capacity. A second important point to be emphasised here is *the impact of calendar shifting on crop water use*. As climatic conditions (precipitations and ET) vary along the year, the water needs of a given rice crop of, say, 17 weeks, also vary.

In addition to this, the water requirements for land preparation also vary according to time. Land preparation, as practised for rice crops established with transplanting or with the wet broadcasting technique, includes soaking land, ploughing, puddling, levelling and draining water out before sowing. This agricultural operations, depending on the soil characteristics and its initial wetness, can take as much as 300 mm of water. In some types of clays which give way to large cracks when they dry (as observed in some parts of the eastern part of the delta), this amount can even be of greater magnitude. This is considerable, when one remembers that the rest of the cycle will request between 850 and 1,100 mm. If land is already soaked or wet at the time of land preparation, a significant amount of water can therefore be saved. As for rainfall, a crop grown later in the season will statistically benefit more from rainfall than if it is grown early in the year. Regarding ET, evapotranspiration will be at its maximum during March-April, resulting on higher water needs during this period.

We can try to overlay – and aggregate – these different factors in order to see how the overall water requirements vary *with* the date of crop establishment. Figure 17 speaks for itself and shows the dramatic variability of crop water requirement with the date of planting (percolation rates are taken at 1 mm/day). A short duration rice of 13 weeks consumes around 1,350 m^3 when planted in early February but less than 900 if planted before new year. A common variety of 17 weeks receiving average effective rainfall, will require more than 1,500 m^3, if planted in early February. Approximately 30% of the total water is saved for an early planting on the 1st of November, 15% for mid-December. Water savings can be all the higher for a very late planting, with a high variation according to rainfall.

FIGURE 16: VARIATION OF WATER USE FOR ONE CROP OF RICE, ACCORDING TO THE DATE OF PLANTING



5.3 Demand management

When considering improvement of efficiency, one generally thinks about avoiding loss in the canals (lining) or at the plot level (use of water by farmers). The first point is a question of civil engineering and will not be touched here. Common wisdom assumes (because the price paid for water is small or nil) that water waste in irrigation is widespread and that large amounts could be saved and redistributed. As many observers who propose the introduction of economic tools keep harping on, "since water is not appropriately priced, it is used inefficiently, and consumers have no incentive to economise" (Christensen and Boon-Long, 1994)[25]. This argument runs counters to reality. Let us first turn to the evidence that farmers are getting the lion's share of Thailand's water resources and pitifully squander it. What comes to the fore, when one looks at the process of water allocation, is that farmers are not getting a larger share through some kind of privilege or preferential treatment but, rather, that they are eventually attributed *the water which is left* (if any). Their "right" is limited to what is not allocated to other needs and they fully bear the consequence of its unpredictable and fluctuating nature. It is incorrect to state that farmers are wasting water just because their share of water is by far the largest. It is so only *as far as* other sectors have not raised their demand to more significant levels, and *because* the government has, in the past, developed infrastructures to allow a productive use of water in irrigated areas.

[25] This seems to be taken as indisputable evidence. See, for example, declarations of a high-ranking officer "Water should be priced in order to increase the efficiency of its use in the farm sector" (The Nation. 2000. April 21); "Agricultural experts agree that water-pricing measures would help improve efficiency in water use among farmers" (The Nation, 1999 Feb. 17); the Director of the National Water Resources Committee director: "In reality water is scarce, and the only mechanism to save water and encourage efficient use is to give it a price" (The Nation, 2000. April 23); the resident advisor for the ADB in Thailand: "International best practices suggest that efficiency in water management can be improved considerably through imposition of nominal water user fees" (Bangkok Post 2000, June 11). This echoes an endless list of similar outright statements: "if water is cheap, it will be wasted" (The Economist, 1992); "Currently, most farmers don't have to pay for irrigation water and, thus, have little incentive to conserve water or to use it efficiently on high-value crops. As a result, irrigation efficiency is under 30%" (TDRI, 1990), etc.

A second assumed evidence which must be put under scrutiny is whether farmers are using water efficiently. Based on common knowledge that efficiency in large state-run irrigated schemes is often found as low as 30 or 40%, there is a tendency to stick to this overall vision without questioning it any further[26]. The first point which needs to be emphasised is that such situations are often found in water systems, common in monsoon Asia, which are not closed (i.e which have by and large resources in excess of demand and out of which some usable water supply is left). The second type of systems are *closed* systems. There has been recently wide recognition of the fact that focusing on relatively low water efficiency at the on-farm or secondary levels could be totally misleading (Keller et al., 1996). Many systems, and river deltas typically account for the most significant of them, *eventually display extremely high overall efficiency*. More generally, what has often escaped the attention of many commentators is that such systems have not been passive in front the growing water scarcity. On the contrary, they have been extremely responsive to it in recent times and have gradually developed flexible ways to access water in all places *where it can be found*. Nowadays, no conventional gravity systems is functioning as it has been designed to. Individual pumping capacity has developed in order to tap water in canals, drains, ponds or aquifer and there are often few unused return flows.

The Chao Phraya delta in the dry season provides the most illustrative example of such a closed system. The first point is that most of the return flow from fields or canals is reused downstream. Favourable specific locations where double cropping is well established are often found along drains, most of which have been gated in order to retain superficial and to capture sub-superficial flows. Pumping in drains is often more reliable than depending on canal water. If we consider the efficiency of irrigation at the macro level, we must reckon that the only waste water is the water which eventually flows out of the delta system, that is to say flows to the sea. As this flow is hardly sufficient to control pollution and salinity intrusion in the rivers mouth (in the dry season), it follows that no or only negligible water is lost. The second component of water loss is the infiltration. It occurs that such a loss is channelled either to shallow aquifers or to deep aquifers: in the first case, it is tapped again trough tube wells or soon returns to the drainage system where it is reused. In the second case it reaches aquifers which flow to the Bangkok area where they are notoriously over-exploited, resulting in land subsidence and horrendous costs in upgrading flood protection and in flood damages[27]. We may therefore venture to state that *infiltration losses in the delta are not sufficient* to offset the depletion of the aquifers. On the whole, if we except losses by evaporation in waterways, which cannot be avoided, we may contend, somewhat provocatively, that the macro-efficiency of the delta is 100% (or more if we consider the depletion of both shallow aquifers (in some years of limited irrigation supply) and Bangkok's aquifer).

---

[26] "Currently, most farmers don't have to pay for irrigation water and, thus, have little incentive to conserve water or to use it efficiently on high-value crops. As a result, irrigation efficiency is under 30%. Urban consumers and commercial and industrial users pay only nominal water fees that do not reflect the marginal cost of supply" (TDRI, 1991). If 70% of the water delivered to irrigation areas is assumed to be lost, it should also be shown where does such an amount of water disappear to !

[27] It is estimated that the damages of the 1995 flood amounted to 50 billion baht, that is 2 billion US $!

Even when we examine carefully plot irrigation, it is hard to find the decried pattern of wasteful practices. The main reason is that most farmers access water through pumping. This is true for all the farmers located in the lower delta (in this so called flat *conservation area,* water is integrally and individually pumped from a dense network of waterways) and for an approximate 60 % of the farmers in the upper delta. Altogether, it follows that approximately 80% of farmers are resorting to pumping, the great majority using low-lift axial pumps. It follows that because of the costs incurred by these water lifting operations, there is little likelihood that farmers may be squandering water. Estimates of water use in the delta given earlier have also shown that efficiency is rather high. Considering all this evidence, it appears that harking back to this erroneous picture of the farmer as a wasteful villain is altogether thoroughly flawed, unfair[28] and at least misleading.

A corollary of this situation is that, in contravention to official declarations, most farmers *do not get water free*. It goes without saying that these investments in pumps, motors and gazoline are not negligible. It has been shown that these pumping costs, because of very long application times caused by poor land levelling, may even be as high as discouraging sugar-cane growers to apply the adequate amount of water, despite water being available in the adjacent ditch (Srijantr and Molle, 1999). It must therefore be acknowledged that *farmers do pay to use water in the dry-season*, partly in consequence of the failure to supply them with gravity water. It follows that the argument that farmers tend to ignore the value of water is significantly weakened.

A further aspect of the irrelevance of water pricing for achieving water savings in our context is that, as it has long been recognised (Moore, 1989), there is no way to apply some volumetric pricing in gravity low-land rice small irrigation. Therefore, there is no incentive for farmers to save water, even if they pay for it. Even if we decide to define a pragmatic water charge for whatever motivation, there are other drastic obstacles to its definition in medium and large scale gravity schemes. The *quality of the access to water in most large scale schemes of Thailand* is so varied that it is very hazardous to define a single fee *per area unit* under such circumstances. Big differences exist between head and tail-enders and this variability cannot be assessed once for all: the access to water depends upon the overall amount of water distributed in the different canals, itself a yearly vagary. It will be impossible to charge someone who was obliged to pump water from a distant drain up to his plot (sometimes in several successive steps) the same fee than a farmer getting water by gravity at the head of the canal.

A water fee would then be an additional tax and must therefore be considered *within the wider overall context of national taxation.* Asserting that farmers in the Central Plain have never paid for the irrigation system or for water use may be acceptable literally and in a narrow sense: if we consider, however, the revenues siphoned off from rice cultivation by the State through the mechanism of the rice premium between 1952 and 1984, it becomes clear that rice-farmers have indirectly paid back more than it can ever be dreamt of levying through a water fee. The discussion may also include whether cost recovery concerns state investments or operational recurrent costs. It is surprising to see that the former has been

[28] Charoenmuang (1994) reports that in some conflicts in the Mae Taeng Canal Project (Northern Region), "villagers urged city dwellers and government agencies to economise on water consumption".

publicly supported by donors. Even in the United States, Postel (1992) reports that 4 millions ha of the West are supplied "at greatly subsidised prices" by The Federal Bureau of Reclamation (see also Anderson and Snyder, 1997). Irrigators of the California's huge Central Valley Project have repaid only 4% of its capital cost.

In brief, it appears that: 1) there is a significant gap between theoretical economic values of water and farmers' ability to pay; 2) that it is extremely hazardous to define a fee based on the area irrigated in the situations in which the quality of access to water is extremely heterogeneous; 3) that a fee high enough to offset collection costs would, in the actual context of fluctuating rice prices, raise the economic risk attached to farming; 4) that no water saving can be expected from a flat water fee; 5) that the alleged situation of water waste at the farm level is a fallacy; 6) that it is incorrect to state that farmers have never paid for infrastructures or water delivery, as state-recovery was achieved through export taxation; 7) that an additional tax is to be considered *within the wider overall context of national taxation,* where taxes, subsidies and State investments eventually define the reproducibility of economic activities and shape the patterns of shift from the agricultural sector to non-agricultural sectors.

5.3.1 Shift towards low-consumption crops

Another possibility to achieve water conservation is to induce a shift away from rice to field-crops, which consume approximately 40% of the amount of water needed for rice. This, ideally, would allow more farmers to benefit from a second crop in the dry season. Such a shift could be boosted by differential taxes, fixed according to the kind of crop.

Evidence of dynamics of diversification in the delta (Kasetsart University and ORSTOM, 1996) show that farmers display great responsiveness to market changes and opportunities (a point definitely evidenced by the recent spectacular development of inland shrimp farming: see Szuster and Flaherty, *this conference*). Good transportation and communications allow marketing channels to perform rather efficiently. The main weak point remains the risk attached to the higher volatility of field crops prices, which discourage farmers from shifting significantly to non-rice crops. As long as the economic environment of field crop production remains uncertain[29], there is little scope to push farmers to adopt such crops or to sustain criticism on their growing rice, as many have incurred in losses by growing field crops (either by will or suggestion from extension services). Inducing shifts in cropping patterns to achieve water saving by means of differential taxes is believed to be unrealistic while such risk remains.

In addition, there are several other constraints (agro-ecology: heavy soil with little drainage, not favourable to growing field crops; labour and capital requirements, skill-learning, development of proper marketing channels, etc.), which condition the process of diversification and it is doubtful that, in addition to public policies aimed at fostering it, its

[29] It can be argued that rice marketing is also uncertain. However, the political sensitivity of rice production is such that there are limits which cannot be easily trespassed. In contrast, no one really matters if the price of chili (a very intensive cash crop with heavy capital investment) swings from 30 to 2 baht/kg in one year and scattered growers have little means to voice their distress and limit their loss.

pace may be increased beyond what is already observed. Contrary to common rhetoric, farmers do not need to have their water priced to shift to other productions. They will increasingly do so if uncertainty on water and prices is lowered. They have time and over shown dramatic responsiveness to constraints on other production factors, such as labour for example, and have already sufficiently experienced the scarcity of water to adapt their cropping patterns, should conditions be favourable[30].

5.3.2 Linking water management, institutional reforms and economic incentives

It has been shown that the rationale to establish water fees for the purpose of water saving or for cost-recovery is rather weak and based on a poor knowledge of field reality. In particular, water supply at present is far from resembling a "service", with its requirements of quality and certainty. The quality of "service" is linked to the whole "water chain", with all its technical and institutional aspects at various levels. It has also be shown how the farmers (and RID's field staff) strategies have adapted to this context of uncertainty. No collective action can be undertaken under the prevailing conditions. This takes us to imagine scenarios in which the potentially powerful linkages between water pricing (by group), institutional reforms and water management improvement could be activated (Small and Carruthers, 1991). An intermediate solution would be to ensure a water supply at the lateral level (defined as a sort of "right" to be negotiated), and to have farmers' organisations managing this supply at lower levels.

What would be expected is that binding farmers together by granting them a collective right could be a way to "force" them to act collectively in order to (a) achieve greater efficiency/equity within the command area of their canal; (b) to constitute a bargaining power to obtain from RID the water supply they are entitled to; (c) to internally solve the problem of differentiated qualities of access to water and define individual charges accordingly; (d) to instil some formalised notion of water right which could later be conducive to some form of tradability; (e) to constitute autonomous bodies which could later take over a part of the managerial tasks attributed to RID and could further federate at the Project or basin level; (f) to foster, in return, a corresponding improved performance on RID's (and EGAT's) part. The potential benefits are so sweeping that one may be tempted to gloss over the prerequisites to such moves.

We must first investigate what is meant by "improved performance", what are the constraints experienced by these agencies, those which mat lie beyond their reach, and those which offer significant margin for progress. At the other extremity, it must be analysed whether farmers are able or willing to respond as expected.

It has been shown earlier that there are crucial constraints on the improvement of the quality of water delivery in the dry season: a more stable hydraulic regime requires the automation of the main gates at Chai Nat dam, operational procedures to dampen the effect of reduced dams releases during the week-ends, higher responsiveness to hydrologic events, additional weirs and structures in the canals to raise water levels, etc. On an institutional level, it still

[30] The spectacular endogenous spread of sprinklers in vegetable production observed in the Mae Klong area shows that farmers are not opposed to investing and adopting water saving devices.

remains to define how the set of drastic changes needed can be brought into the system with the acceptation and participation of both farmers and agencies. The costs of establishing such a policy, defining sound hydraulic units, involving farmers in the conception phase, co-ordinating uses at the basin level and reducing political interference, controlling and applying penalties on unauthorised abstraction, setting a system in which collected fees are used locally, in particular to pay RID's staff, giving farmers a say in how much water is allocated, where and when, etc. are obviously huge. These changes must also be phased, as an eventual success will be conditional on their concomitant establishment.

All these measures translate in crucial exigencies addressed to the Thai institutional and political setting. Management rules, rights and control must be defined at all the level of the river basin, which challenges the actual definition of roles. The current institutional deadlock includes the sheer inadequacy of current laws with the problems experienced; the confuse definition and scattered attribution of roles and power to the different ministries and strata of the government; and a context of political interventionism and laxity in law enforcement (see more details in Molle, 2000).

6 Conclusions and prospects

There is little doubt that the short-term evolution of the demand/supply balance of water in the Chao Phraya basin demands drastic responses both at the technical and institutional levels. Access to water in the dry season is paramount in defining the sustainability and reproducibility of agricultural households, but the water available is going to decline 15% in the next 15 years (for a growth of Bangkok's needs of 5% per year). The analysis of water allocation in the past 25 years shows: 1) an average cropping intensity of 1.45 in the delta, with a growth in the past 5 years; 2) spatial patterns of inequity; 3) a growing de-regulation of cropping patterns and a further weakening of policy criteria for allocating waters; 4) a system of allocation based on experience but without clear decision making criteria, which increases the risk entailed by political interference in allocation.

Several aspects of dry-season water management have been emphasised. It has been shown in particular that the overall efficiency was quite high, and that the management of the dams was nowadays more neatly attuned to the downstream demand. It was advocated that the evolution of the energy generation sector (small and declining share of Sirikit and Bhumipol dam) should be incorporated in the management policy and that dams should now be formally managed in order to limit or avoid releases lost to the sea (in particular in the rainy season). It was also shown how the definition of cropping calendars impacted on the amount of water used and it is recommended to spread these calendars as much as possible over the October-June period. This means that the schedules must be desaggregated by main canal, allowing more areas to start dry season cropping just after harvesting the wet season crop.

While it is common to hear about conflicts for water within the basin, it is of paramount importance to realise that there is no real competition in terms of allocation among users. This would happen if their respective water shares were subject to weighed reductions in case of shortage, and if these weighing coefficients were a matter of debate and negotiation.

Rather, it appears that the different uses are ranked by priority and that the possibility to reduce allocation for 1) Bangkok, 2) salinity intrusion, 3) pollution dilution and 4) transportation is very limited. In fact, it is agriculture which bears the brunt of the pressure on water resources: not only does its share – defined as the *remaining* available water – decreases over the years, this decrease also entails that this remaining part is increasingly subject to interannual variability. These fact are obscured by the dominant common wisdom that agriculture is indirectly responsible for shortages because of its alleged low efficiency of use. On the whole, it appears that the elasticity of the different water allocations are in sharp contrast and that the agricultural sector is eventually the one which must adapt to changes.

It appeared that the objective of achieving *water saving* through some kind of water pricing is at best illusory, as farmers in the dry-season eventually use only the water which is left, do it rather efficiently, often indirectly pay for that, and have already experienced water scarcity. *Attributing the responsibility of water shortage to poor efficiency is the most widespread and misleading misconception.* Should irrigation gain 10% in efficiency, this would not diffuse any crisis but only raise by the same amount the area that will be irrigated (still well under the overall potential demand). Shortages and crises are not due to an hypothetical low efficiency but to the allocation policy and its impact on dams water stocks. This lack of strong technical criteria in managing dams and in allocating water to irrigation, and the way they are being challenged by political interventions and farmers' uncontrolled planting[31], are conducive to drastic shortages and incur in escalating risks. This does not dismiss the fact that efficiency gains are desirable in that they allow the benefits of water use to be spread to a larger number of users. But it draws our attention on the inconsistency of the commonly stated relationship between efficiency and water shortage. Admittedly, "water is far too important to its users to be the basis for socioeconomic experiments" (Perry et al. 1997). In this regard, the stance that "markets should be given a chance", only because centralised administration has shown its limits, appears a bit short.

It was also advocated that economic incentives would fail and/or would be meaningless unless they are considered as a "binding element" within a much larger reform in which farmers would participate both in decisions of allocation and in water management at the secondary and tertiary levels. Such a scenario not only means drastic technical and institutional reforms, but also that all of them be phased and backed by a strong political will.

In other words, what is at stake is the proper management of the transition from a status of common-pool resource in sparsely populated agricultural areas to one of a collective and participative management in a more complex world, respectful of basic equity and efficiency standards.

[31] The hopelessness of officials is apparent in public declarations: The Deputy Agriculture Minister reports in early 1998 that "plantations in Nakhon Sawan, Tak and Kamphaeng Phet had increased to more than 670,000 rai from a target of 190,000" (Bangkok Post, 1999, January 13), while the RID director admits that "things are out of control", with 330,000 rai under cultivation, against a limit set at 90,000 rai (The Nation; 1999 Jan 8). "Our major concern is that we have no effective measures to control the use of water by rice growers. The only thing we can do is ask for their cooperation to cut down rice cultivation".

Acknowledgements

This paper is a preliminary version of a study carried out within the research project "Water Management, Land Development and Economic Diversification in Southeast Asian Deltas" funded by the European Union (INCO-DC).

References

ACRES (1979) Chao Phraya - Meklong basin study, Phase 1 - Main report + annexes.

Anderson, T. L. and Pamela S. Snyder (1997) Priming the invisible pump, Political Economy Research Center, 20 p.

Bangkok Post, 1999. B5bn sought to stem land subsidence, 24/1/1999

Binnies & Partners et al. 1997. Chao Phraya Basin water management strategy (main report and annexes).

Charoenmuang, Tanet (1994) The governance of water allocation problems in Thailand, four case studies from the upper Northern Region, in TDRI (1994), Water conflicts, pp 53-86.

Christensen, Scott R. and Arreya Boon-Long (1994) Institutional problems in Thai water management, TDRI, 54 p.

ESCAP. 1991. Assessment of water resources and water demand by user sectors in Thailand, 99 p.

Kaosa-ard, Mingsarn and Nisakorn Kositrat (1993) Economic instruments for water resources management in Thailand, presented at the Workshop of the use of economic instruments in environmental policies, Paris.

Kasetsart University, ORSTOM, 1996. Identification of agricultural and irrigation patterns in the Central Plain of Thailand : prospects for agricultural research and development, 220 p., DORAS Project, Bangkok

Keller, Andrew, Keller, Jack and David Seckler (1996) Integrated water resources systems: theory and policy implications, Research Report 3, IWMI, Colombo.

Kositsakulchai, Ekasit ; Kumnuansilp, U. ; Molle, F. and Pierre Chevallier (1999) Analysis of water and power management of the Mae Klong River basin : a regional management analysis within a national scope, Kasetsart Journal of Engineering. 21 p.

Molle F.; Chompadist C.; Sopaphun P. 1998. Beyond the Farm-Turn-Out : on-farm development dynamics in the Kamphaengsaen Irrigation Project, Thailand, Irrigation and Drainage Systems, Volume 12, no 4, pp. 341-358.

Molle, F. (forthcoming) Social and economic patterns of landlord-tenant relationships in the Chao Phraya Delta, Thailand: an historical perspective, submitted to The Journal of Rural Studies.

Molle, François; Chompadist, Chatchom; Srijantr, T. and Jesda Keawkulaya. 2000. Dry-season water allocation and management in the Chao Phraya basin. Research Report submitted to the EU, draft, Bangkok, 235 p.

Molle, François. 2000. Water Pricing in Thailand: theory and practice. Kasetsart University, DORAS Center, Research Report n°7, 60 p.

Molle, Francois; S. Durongdej; C. Chompadist; A. Joannon and Y. Limsawad. 1999. Improvement of rice cultivation and water management in the flooded area of the Central Plain of Thailand : a zoning of rice varieties by using remote sensing imagery Kasetsart University, DORAS Center, Research Report n°5, submitted to NRCT, Bangkok, pp. 155.

Molle, François; Srijantr, Thippawan. 1999. Agrarian change and the land system in the Chao Phraya Delta, DORAS Project, Kasetsart University, Bangkok, Research Report n°6, 191 p.

Moore, M. 1989. The fruits and fallacies of neoliberalism: the case of irrigation policy, World Development, Vol. 17, No.11, pp. 1733-1750.

Perry, C.J.; Rock, M. and David Seckler (1997) Water as an economic good: a solution, or a problem ?, Research Report 14, IWMI, Colombo, 17 p.

Postel, Sandra (1992) The last Oasis: facing water scarcity, New York: Norton and Co.

Prechawit, Chaiwat. 2000. How to transform the work of water management and maintenance in the year 2000, in "Chuchat day 2543", Royal Irrigation Department, pp. 28-33 (in Thai)

Satoh, Masayoshi; et al. 1999. Reservoir operation principles for stable water supply in the Mae Klong River basin, Proceedings of the Workshop on Sustainable Management of the Mae Klong River basin, p. 13.Bangkok Post, 1997. Call for water price increase to ease worsening shortages, 12/10/1997

Sethaputra, Sacha; Panayotou, Theodore; Wangwacharakul, Vute. 1990. Water resources: shortage amidst abundance, TDRI Quarterly Review 5:3, p. 12-19.

Srijantr, Thippawal, Molle, F. and C. Chompadist (1999) Profitability and yield gap of sugar cane cultivation in the Mae Klong region, Kasetsart Journal of Agricultural Economics.

TDRI. 1990. Water shortages: managing demand to expand supply, 101 p.

Watershed, 1998. People' s forum on ecology. Special issue on water: a source of life or a resource for development ?, Nov. 1998., 68 p.

Wongbandit, Amnat (1997) Legal Aspects, Annexe G of the report "Chao Phraya basin water resources management strategy, Binnies et al. (1997), 74 p.

Water balance analysis of irrigation management for the preparation of dry season rice in the Chao Phraya Delta: the case of the Khok Katiem and Roeng Rang Irrigation Projects

Fujiki Tomohisa[1], Satoh Masayoshi[2], Lersak Lewtakulpaiboon[3] and Watchara Suiadee[3]

Abstract: *The purpose of this paper is to clarify how the irrigation for paddy preparation is efficiently performed during the dry season when the available water resources are limited. A catchment basin of approximately 23,000 ha, which is included in the project area of Khok Katiem or Roeng Rang, is settled as the survey site. The water input and output in the survey area have been measured and the progress in the paddy preparation have been observed from January to March. The water balance, associated with the progress in the paddy preparation, suggests that the unexpected and unstable irrigation water supply leads to inefficient water use. It concludes the strong need for water management improvement.*

1 Introduction

During the dry season in the Chao Phraya Delta, water resources totally depend on the water left in the Bumipol and Sirikit Reservoirs at the end of the rainy season, so it is important to use the limited water resources as efficiently as possible. Since the irrigation water for dry season rice occupies approximately 70% of the whole water demand during the dry season, it should be discussed as to whether the irrigation water is used efficiently or not.

This paper focuses on the water use and the water balance in an irrigated area during the preparation period from February to March, during which a large amount of water is intensively used. It analyzes the inflow and outflow in a survey area to make clear how efficiently the irrigation water is used based on the survey of both water balance and the development of land preparation.

[1] Doctoral Program in Agricultural Sciences, University of Tsukuba, (1-1-1 Tennodai, Tsukuba, Ibaraki, 305-8572, Japan)

[2] Institute of Agricultural and Forest Engineering, University of Tsukuba, (1-1-1 Tennodai, Tsukuba, Ibaraki, 305-8572, Japan)

[3] *College of Irrigation, Royal Irrigation Department,* (Tivanont Rd., Pakkred, Nonthaburi 11120, Thailand)

2 Method of survey

2.1 Outline of survey area

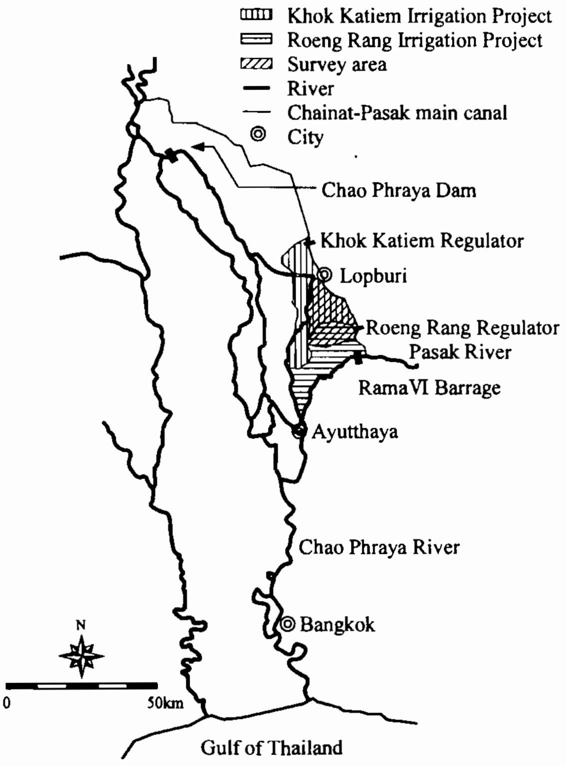


Fig. 1 Location of survey area in Chao Phraya

Yai

and

A drainage basin of the Roeng Rang stream was chosen as the survey site which includes a part of the beneficiary area of Khok Katiem and Roeng Rang Irrigation Projects (Fig. 1). Both projects are located along the Chainat-Pasak main canal. The whole survey area is approximately 23,200 ha.

Three lateral canals of 21R, 22R and 23R feed water to this area (Fig. 2). They take water from the Chainat-Pasak main canal through the intake gate. A short canal of 22R-1 without an intake gate was constructed to supplement 22R and joins 22R a short distance from its intake. The 21R, 22R and 22R-1 belong to the Khok Katiem Irrigation Project, and 23R belongs to the Roeng Rang Irrigation Project. The flow capacity of 21R, 22R and 23R is 3.44 m^3/s, 1.48 m^3/s and 2.92 m^3/s, irrigating the beneficiary area of 4,200 ha, 1,800 ha and 3,600 ha, respectively. This total area excludes the deep-water rice area which is located downstream of the lateral canal in the southwest part of the survey area.

In addition to the three lateral canals, there are 22 irrigation ditches, which take water directly from the Chainat-Pasak main canal. All of them have no intake gate installed. Each of them irrigates a small area along the main canal, totaling to 2,700 ha.

Most of the drainage water from this survey area, except a part of the command area of 2L-21R and 23R, gathers at the Jaksaa through the Roeng Rang Yai drainage canal. The outflow of the survey area can be observed at Jaksaa.

2.2 Water balance

2.2.1 Inflow and outflow

Water is supplied to the survey area through the following canals; three lateral canals of 21R, 22R including 22R-1 and 23R, 22 direct irrigation ditches and three drainage canals. As for the outflow, water is discharged out of the survey area through the following ways; 1R-21R lateral canal, the command area at the right bank of 2L-21R and at the left bank of 23R, and the Roeng Rang Yai drainage canal.

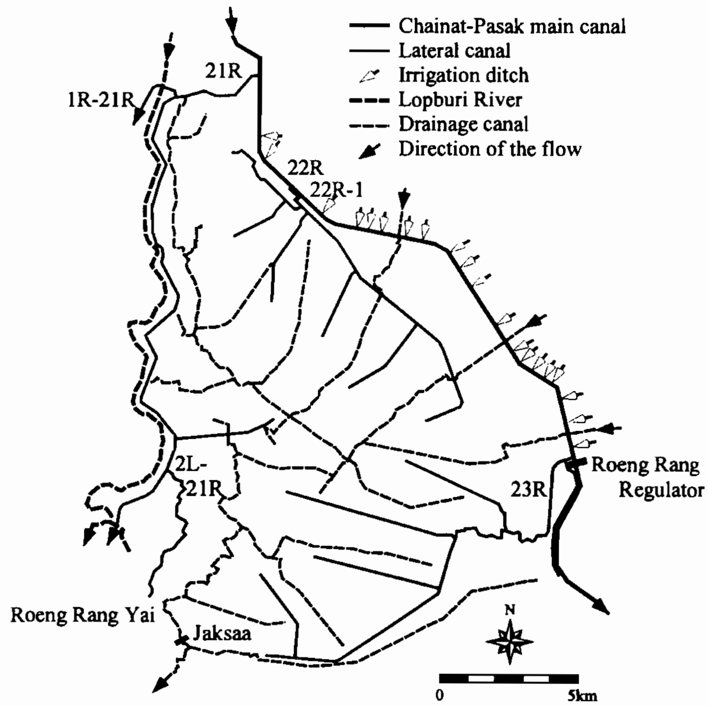


FIG. 2 LAYOUT OF SURVEY AREA

The inflow is estimated by subtracting the discharges in 1R-21R and the water distributed to the left bank of 23R and to the right bank of 2L-21R from the total discharge of supplied water to the survey area. The outflow is the discharge from the Roeng Rang Yai drainage canal at Jaksaa.

2.2.2 Calculation of discharge

The discharge in 21R, 22R and 23R was observed by each Project office every day and was used for the analysis. The discharge in other canals was calculated using discharge-stage relations. The water levels in the drainage canal at Jaksaa, in the main canal at 22R-1 and in the main canal upstream from the Roeng Rang regulator were recorded daily. The measurement of discharge in the related canals including 22 direct irrigation ditches was performed 5 times during the preparation of dry season rice. Based on the results, discharge-stage curves for the drainage canal at Jaksaa, 22R-1 and 22 direct irrigation ditches were developed.

The distributed water to the command area at the right bank of 2L-21R and at the left bank of 23R is estimated as the discharge in 2L-21R and 23R multiplied by the ratio of the command area of the right bank and left bank in the command area of each lateral canal.
The discharge in 1R-21R and 2L-21R was estimated based on the ratio of the measured discharge to the discharge of 21R during the preparation season. The discharge in the three drainage canals was estimated based on the measured discharge during the survey period.

2.3 Progress in rice planting

The authors recorded the area planted with dry season rice every two weeks over the survey area to identify the time the dry season rice was planted. For the area already planted at the survey site, the planting time was judged by the height or state of the rice plant.

3 Results and discussion

3.1 Water balance

Figure 3 shows the inflow and outflow in the survey area during the preparation of dry season rice, from the end of January to the end of March. It is obvious that both the inflow and the outflow are sharply fluctuating. Figure 4 shows the breakdown of inflow. The discharge in 22 irrigation direct ditches fluctuates more than that in the three lateral canals. This indicates that the discharge in 22 irrigation ditches is strongly subjected to the change in water level at the main canal since they have no intake gates.

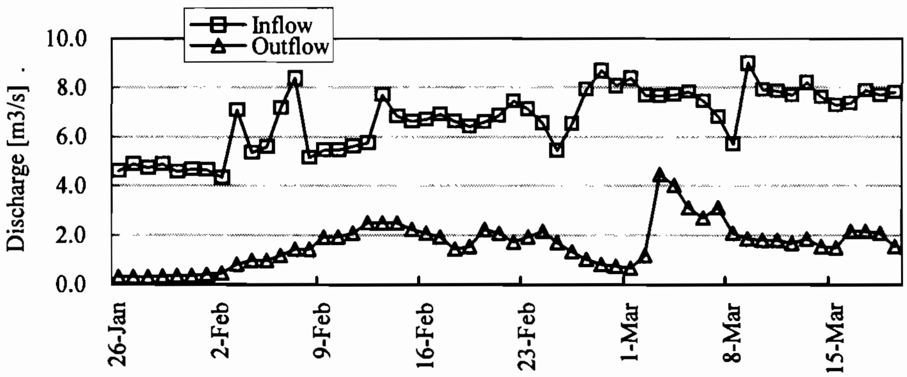


FIG. 3 INFLOW AND OUTFLOW FROM THE SURVEY AREA

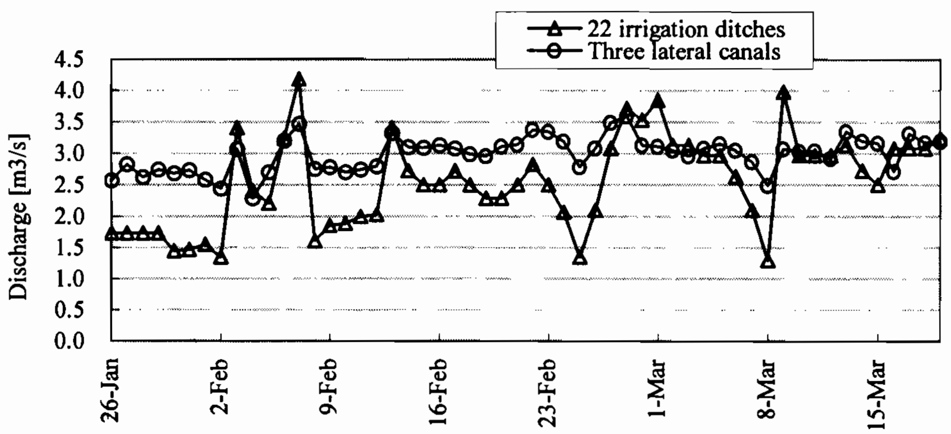


FIG. 4 BREAKDOWN OF INFLOW INTO THE SURVEY AREA

Figure 5 shows the intake intensity, which is the discharge divided by each command area. The total command area of 22 irrigation ditches and the three lateral canals are 2,738 ha and 9,640 ha, respectively. The intake intensity in 22 irrigation ditches is much higher and more widely fluctuating than that of the three lateral canals. The share of irrigation water in these direct ditches is substantial in spite of the small capacity in each ditch. The problem is that the intake for the ditches can not be controlled, while the lateral canals are properly controlled by the intake gates.

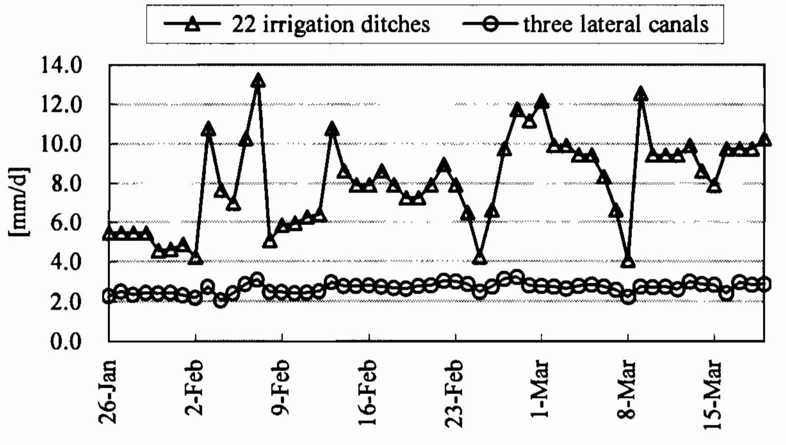


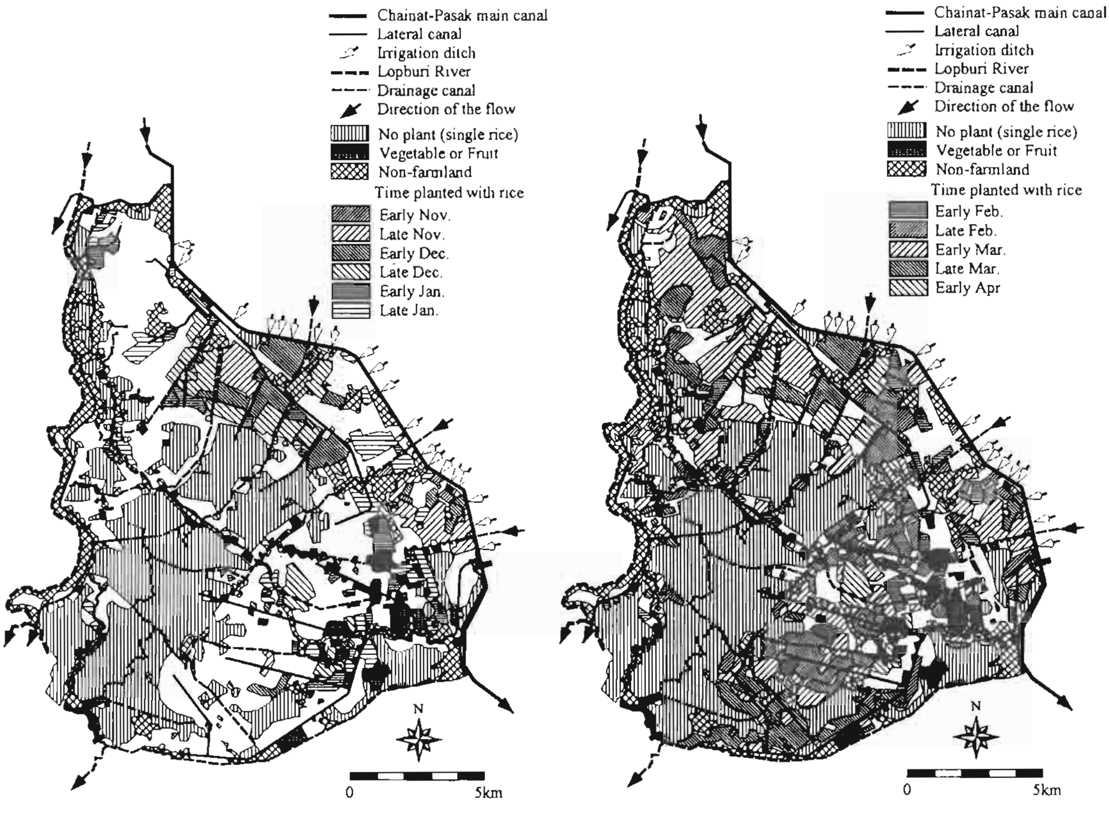
FIG. 5 INTAKE INTENSITY IN 22 IRRIGATION DITCHES AND THREE LATERAL CANALS

3.2 Progress in planting of dry season rice

The areas planted with dry season rice for each period of a half of a month are shown in Fig. 6. It is seen that rice was planted near the main canal before the dry season irrigation started, and the rice was planted there twice during the dry season. The area of the second-dry-season-rice reached 24% of the total area that was planted with rice during the dry season. The land use in the survey area is shown in Table 1. Most of the "No plant" area occupying about 30% of the whole survey area is the area used for deep-water rice that is planted once a year during the rainy season.

TABLE 1 LAND USE IN THE SURVEY AREA

	Rice-planted-area	No plant (single rice)	Vegetable or Fruit	Non-farmland	Total
Area [ha]	13,275	6,563	873	2,472	23,183
[%]	57	28	4	11	100



(As of late January, 2000) (As of early April, 2000)

Fig. 6 The classification of the rice-planted-area for each period of a half of a month

Figure 7 shows the transition of the rice-planted-area for each period of a half of a month. Rice planting proceeded rather constantly before late February and became most intensive in early March. Figure 8 shows the Rice-growing-area classified by the time of planting. Figure 8 gives a good explanation of the second-dry-season-rice. For example, if the rice was planted in late November, it would be harvested in early March and the area would soon be replanted with the second-dry-season-rice in late March.

The inflow and outflow in the survey area, shown in Fig. 3, seem to coincide with each other at the time lag of 4 days (Fig. 9). The fluctuation of outflow may be mainly caused by the fluctuation in the inflow through 22 irrigation ditches. However, the inflow pattern during the preparation season does not coincide with the progress pattern of rice planting. This means that the water intake was not well controlled according to the water demand for land preparation. It resulted in ineffective water distribution because the unexpected and sudden increase in the delivered water could not be effectively used by the farmers and it was discharged out of the project area.

FIG. 7 TRANSITION OF THE RICE-PLANTED-AREA FOR EACH PERIOD OF A HALF OF A MONTH

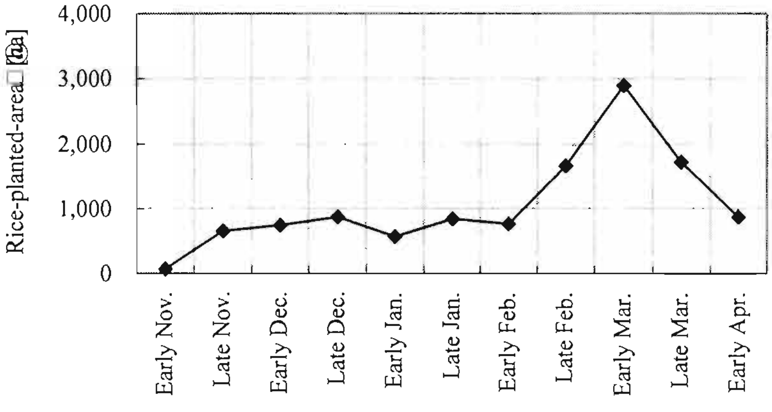
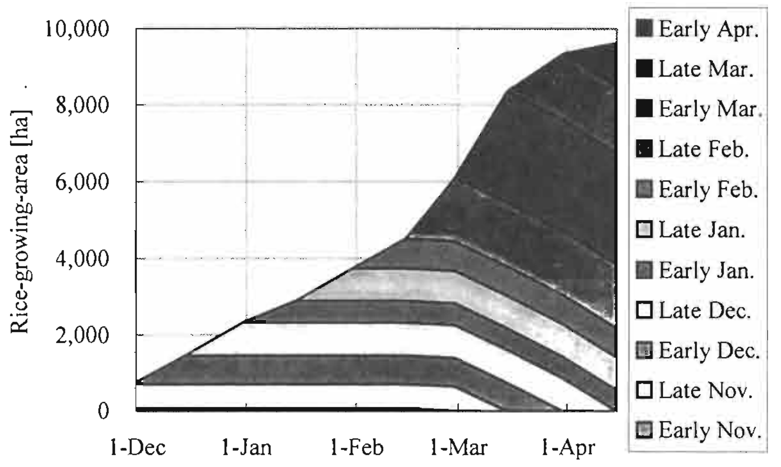


FIG. 8 RICE-GROWING-AREA BY THE TIME OF PLANTING



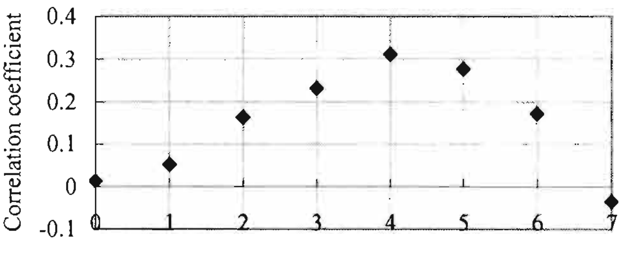


FIG. 9 CORRELATION BETWEEN INFLOW AND OUTFLOW

3.3 Water requirement for the preparation of dry season rice

The water requirement for the preparation of dry season rice in this area is designed at 274.5mm. The authors calculated the actual value based on the field survey mentioned above and the result of the calculation is shown in Table 2.

Total inflow and total outflow are calculated as the total inflow and total outflow from February to March, respectively. According to the Penman method, evapo-transpiration at the Khok Katiem project area for February and March is 152 and 177 mm/month, respectively. Total Evapo-Transpiration in the survey area is calculated by multiplying this value by the rice-growing-area. The stored water in the area is calculated by subtracting the total outflow and total evapo-transpiration from the total inflow. Dividing it by the rice-planted-area from February to March gives the water requirement for preparation.

The result of 120 mm is less than half of the designed value. This result may be informative for the improvement of water management in the irrigation system in the future. One of the reasons why the water requirement was small was that 24% of the planted area during this period was prepared just after the harvest of the first-dry season-rice, when the paddy soil was still wet.

TABLE 2 WATER BALANCE IN THE SURVEY AREA DURING THE PREPARATION OF DRY SEASON RICE, FROM FEBRUARY TO MARCH

Total inflow	[MCM]	36.4
Total outflow	[MCM]	9.6
Estimated Evapo-Transpiration	[MCM]	18.3
Stored water	[MCM]	8.4
Rice-planted-area from Feb. to Mar.	[ha]	7,046
Water requirement for preparation	[mm]	120

4 Conclusions

1) There are a lot of ditches without gates that take irrigation water directly from the main canal. The intake intensity in these ditches is very high and fluctuates sharply because of it being affected by the water level in the main canal. The share of irrigation water in the ditches is large enough to make the water intake unsteady, thus resulting in the difficulty in controlling the water distribution in the main canal.

2) Outflow was also sharply fluctuating. This indicates that the water supply didn't suit the water demand for the preparation of dry season rice.

3) The water requirement for preparation was estimated at 120mm, which was less than half of the designed value. This may contribute to the better understanding of the water use in the project areas.

Acknowledgements

The authors express their gratitude to Mr. Chaiyaporn THUMPAKDEE, the chief of the administrative division of the Khok Katiem Irrigation Project, Mr. Papat PATUMWAT, the chief of the water allocation division of the Roeng Rang Irrigation Project, for their valuable and extensive help.

References

Chaiwat, P. (1995): Water management in the Chao Phraya River Basin, Proceedings Of Tokyo Symposium On Sustainable Agriculture And Ruraldevelopment-Agriculture for Our planet-, The Japanese Institute of Irrigation and Drainage, p.268

Kasetsart University and ORSTOM. (1996): Agricultural and Irrigation Patterns in the Central Plain of Thailand, Preliminary analysis and prospects for Agricultural Development, Bangkok, Thailand, DORAS Project, p.67

Water management in the upper East Bank of the Chao Phraya Delta

Piphat Sathianpantarit[1], Anusak Mujalinvimuti[1], Phonchai Klinkhachorn[1], Athaporn Punyachom[1], Somnuk Jirasirisopon[1], Yoshito Yuyama[2]

Abstract: *Chao Phraya Delta of Thailand is one of greatest rice granary in Asian monsoon area. Its farming and water management has changed drastically by the Greater Chao Phraya Project. Recently, water shortage has become more serious by the decrease of runoff discharge upstream and increase in water demand. New modernized water management system corresponding to various changes is actually sought for.*

This paper reviewed present situation, recent change of background, difficulties and existing problems on water management in the Chao Phraya Delta. Then, the importance of paddy field for natural resources conservation was referred. Finally, the strategies for more appropriate water management were discussed. The decision support system for water operation under preparation was also introduced. Main focus was given to the upper east bank of the delta.
It is essential to achieve stable water supply in dry season. Examples of strategies considered in this paper are as follows:
To construct regulating ponds.
To increase the number of monitoring on water operation and hydrology and improve accuracy.

1. *To promote the networking of information on water management, so as to find the common benefit among RID organizations and /or water users.*
2. *To develop and use decision support system for water operation.*
3. *To prepare some benefit for contribution of saving irrigation water.*
4. *To promote participatory irrigation management cooperated by farmers' group.*
5. *To examine crop calendar by locations for increasing the reuse opportunity of water.*

It is difficult to evaluate the reasonableness of water allocation planning and practical water operation perfectly. Therefore, to have information in common and share the thinking process among RID and other authorities concerned are important to seek for more appropriate water management and bring up human resources.

[1] Royal Irrigation Department

[2] JICA Expert of Water Management, MWMS Project (RID-DOAE-JICA)

1 Introduction

Chao Phraya Delta of Thailand is one of greatest rice granary in Asian monsoon area. Its farming and water management has changed drastically by the Greater Chao Phraya Project (van Beek, 1995). The original purpose of the project was supplementary irrigation in rainy season. At present, its function reached to irrigation in dry season and domestic water supply.

Recently, water shortage (Chaiwat, 1994, Roongrueng et al., 1996, Sanyu et al., 1999) has become more serious by the decrease of runoff discharge upstream and increase in water demand. The rice price hovered around low level. Under such circumstances, now is a turning point of paddy farming. New modernized water management system corresponding to the change is actually sought for.

In this paper, present situation, recent change of background, difficulties and existing problems on water management in the Chao Phraya Delta are reviewed. Then, the importance of paddy field for natural resources conservation is referred. Finally, the strategies for more appropriate water management are discussed. Main focus is given on the upper east bank of the delta.

2 Outline of the upper east bank of the Chao Phraya Delta

The Chao Phraya River basin has a catchment area of 162,000 km^2 including 1.4 million ha of the low-lying delta area. Main water resources in the basin are the Bhumiphol reservoir dam with storage capacity of 13,500 MCM (million cubic meter) and the Sirikit reservoir dam with storage capacity of 9,500 MCM. The Pasak reservoir dam with storage capacity of 960 MCM has just completed in 1999. The Chao Phraya diversion dam in the Chao Phraya River at Chainat enables to allocate water for the delta area. Location of main water operation facilities is shown in Figure 1. The area marked by diagonal line shows the upper east bank of the Chao Phraya Delta.

Total area of the upper east bank of the Chao Phraya Delta is 244,000 ha including 218,000 ha of irrigated area. The area is located in a part of Chai Nat, Nakhon Sawan, Lop Buri, Saraburi, Sing Buri, Ang Thon and Phra Nakhon Si Ayutthaya provinces. They get water resources from rainfall and the Chao Phraya River. Figure 2 shows main water operation facilities in the upper east bank of the delta and surrounding area. The Chainat-Pasak canal and Chainat-Ayutthaya canal are used to convey water from the Chao Phyara River throughout the Manorom regulator and the Maharaj regulator respectively. The maximum flow capacity of the Chainat Pasak canal is 210 m^3/s and that of the Chinat-Ayutthaya canal is 75 m^3/s. Those facilities were constructed under the Great Chao Phraya Project along with lateral distribution canal system and drainage system.

The land elevation in the irrigated area changes between 1 m and 19 m above mean sea level (MSL). Annual rainfall in the area changes between 1000mm and 1,600mm. Figure 3 shows the average monthly rainfall at Lopburi. Figure 4 shows the trend of annual rainfall. Rainy season starts from middle of April and ends late in October. At the beginning stage of the rainy season, it rains locally and within short period. Non-rain days sometimes continue for quite a long period. The runoff ratio is difficult to calculate. However, it is estimated between 15 and 30% (Atthaporn, 1999). Tidal effect sometimes comes to Ang Thong. This area often suffers from water shortage and flooding. Therefore, water operation is essential for the prosperity of the area.

3 Present situation of water management

The Royal Irrigation Department (RID) is main organization to carry out water management. The east bank of the Chao Phraya delta is under the control of Regional Irrigation Office No.8 (RIO-8). There are five Operation and Maintenance (O/M) Project offices in the upper east bank of the delta, namely Manorom, Chong Khae, Khok Krathiam, Roeng Rang and Maharaj O/M projects. Their responsibilities are planning of water resources allocation, daily water operation including monitoring, flood protection and so on.

Figure 5 shows the organizations and flow of information on water management. Within RID, content of information in instructing direction is water allocation and facility operation at main water operation facilities. Content of information in reporting direction are daily rainfall, water level, discharge and condition of facility operation and weekly cultivation condition under the control of O/M Project offices. Table 1 shows example of data sheet at Khok Krathiam O/M Project. Information is prepared by hand writing. Facility operation at tertiary canal level is out of reporting.

In terms of field data, zonemen and facility operators who belong to O/M Project Office collect most data. Data are reported to O/M Project Office by way of water master or directly. Facility operators are consisted of gate operator who is generally called gate tender, pump operator and canal operator who is generally called canal keeper. For example, there are two Water Master offices and sixteen Zonenman offices in Khok Krathiam O/M Project.

In the delta area, some O/M Project offices send their reports to both RID Head Office and their RIO, and others send them only to their RIO according to data communication conditions. Communication media used for information exchange are oral communication, voice radio communication, telephone, fax and so on. In the upper east bank of the delta, each O/M Project Office sends daily report to RIO-8, then RIO-8 sends them to RID Head Office. They usually use fax. According to the surprise inspection between on 15 December 1999 and 5 October 2000 for 13 times in total, 95% information arrived at RID H.O. on that day or within one-day delay.

Recently, RID is shifting the authority of daily water allocation from Head Office to RIO under the control. In normal water condition, RID Head Office orders only water operation at the Chao Phraya diversion dam and total water allocation for each RIO command area. RIO-8 determines water operation at main regulators such as Manorom, Chong Khae, Khok Krathiam, Roeng Rang and Maharaj regulators. RIO-8 also pays attention to main drainage regulators. Lateral and tertiary canal level is under the responsibility of each O/M Project.

RID Head Office estimates total water requirement based on collected information and makes water operation plan. Then, RID proposes the plan of release discharge from upstream reservoir dams weekly to Electricity Generating Authority of Thailand (EGAT). The primary purpose of dam operation by EGAT is hydroelectric power generation. However, released water from dams is basically used effectively in most cases. If the water levels at the dams become higher than the designed upper rule curve, EGAT has to release excess water for protecting dams and flood mitigation.

Water allocation in dry season (RID, 1998) is very important problems to prevent water conflict. Many regulations are done among organizations concerned including RID. The discussion starts from October of the previous year to determine water allocation between January and June (hereafter called WM dry season). The period of actual dry season and WM dry season is different. RID, EGAT and other related organizations collect information and estimate remaining water storage volume as of 1st January in main dams and reservoirs. After understanding available water resources in the six months, water allocation planning is discussed. It is generally understood that about 6,600 MCM is needed in WM dry season for irrigation, domestic and industry consumption, navigation, salinity control (Chaiwat, 1995). Of them, water supply for Bangkok is about 700 MCM. Domestic and industry consumption, salinity control, navigation in the delta area are 700 MCM, 600 MCM and 300 MCM respectively. The priority of water allocation changes year by year. The priority of irrigation becomes the last in case of serious water shortage. The allocated water resources for irrigation determines cultivation planning in WM dry season. General criteria are as follows:

1) When the remaining active storage volume at dams as of 1st January is more than 8,000 MCM, target cultivation area is recommended 480,000 ha.
2) When the remaining active storage volume at dams as of 1st January is between 5,000 MCM and 8,000 MCM, target cultivation area is recommended between 320,000 ha and 480,000 ha.
3) When the remaining active storage volume at dams as of 1st January is less than 5,000 MCM, cultivation planning will be canceled.
4) For the WM dry season of 2000, new methodology to determine the total release discharge from upstream dams was adopted. The inflow and demand of water for the following three years were estimated, then the most stable water supply planning was chosen.

The following priority was adopted to determine the location of cultivation area in WM dry season of 1998:

1) First priority: to allocate water for the paddy field where wet season's cultivation in 1997 was impossible.
2) Second priority: to allocate water for the farmer who had damage by violent natural calamity in 1997.
3) Third priority: to allocate water for the farmer who is planned to receive irrigation water in WM dry season of 1998 based on rotational rule.
4) The last priority: to allocate water for farmer who wants to cultivate for increase of income.

The followings are procedures within RID to determine the location of cultivation:

1) At first, RID Head Office informs RIOs about amount of available water resources between January and June and the plan of total amount of water allocated for each RIO.
2) RIO selects the command area where irrigation water is supplied based on rotation rule. The area is selected by lateral canal basis.
3) RIO informs the results to O/M Project offices.
4) O/M Project offices discuss with farmers and arrange the plan of cultivation area and daily water distribution.
5) O/M Project office make daily water allocation plan and report to RIO.
6) RIO arranges the collected information from O/M Project offices and reports to RID Head Office.

RID makes not only planning but also monitoring and report. Table 2 shows the comparison between planning and result in recent years. There are other water resource from the Maeklong River basin and the Pasak reservoir dam. In 2000, water transfer from the Maeklong river basin to the Tha Chin River was planned 1,000 MCM and actually 420 MCM were transferred. In terms of the Pasak reservoir dam, 534 MCM was planned to release, and actually 753 MCM was released. Table 3 shows the planning of water allocation for the upper east bank of the delta in WM dry season of 2000. RID and EGAT try to keep the planed water operation at dams and main regulators, namely release discharge from dams and intake from main regulators. However, those have to be modified by the influence of rainfall and unexpected water demand. Figure 6 shows the comparison between planning and results of intake discharge from the Manorom regulator. The planning of intake was 1,046 MCM. In case of WM dry season of 2000, the rain started earlier than normal season. The water level at the Sirikit reservoir dam became near to the upper rule curve from middle of May. EGAT released more water than the plan because of high demand of electricity. That caused the increase in discharge at the Chainat-Pasak canal. As a result of it, the practical intake became 1,666 MCM. In terms of total RIO-8 area, although the planning of water use was 1,735 MCM, but they actually received 2,387 MCM. The plan of the cultivated area in RIO-8 command area was 115,000 ha. The practical cultivation area became 197,000 ha that was almost maximum potential in dry season.

In the delta area, rice cultivation more than five times per two years is possible now where water condition is good. Historically, the rice cultivation in dry season started only about 30 years ago. In those days, farmers could get irrigation water every two years by rotation. It was new trial. Before that, only one crop in a year was possible. The rice cultivation area increased rapidly, but soon came to the limit because of available water resources and existing function of irrigation facilities (Virat, 1992, Water Operation Branch, 1999). The flow capacity of the system under the Great Chao Phraya Project is equivalent to about 7 mm/d for supplementary irrigation supply. It can meet about 60% of water requirement of paddy farming. After unsuccessful regulation of cultivated area with farmers, some farmers started rice cultivation by their own will. Farmers could cultivate rice any time they like if they can get water, because non-photosensitive variety was developed. It collapsed the order of water operation at on-farm level in some areas.

Some O/M Project areas shifted main rice cultivation from rainy season to dry season after the Greater Chao Phraya Project, because farmers there want to escape from flood disaster. Average crop intensity of dry season in the delta area is 30-40 %(Sanyu et al., 1999). There is much difference by locations as shown in Figure 7. The ratio of the upper east bank is relatively low. When we think about equality among O/M projects, we need to understand crop intensity throughout the year and historical background. However, to make a persuasive water allocation rule considering both priority and preference is not so easy.

Recent change of background on water management in the delta area can be summarized as follows:

- Amount of rainfall in the upstream of the Chao Phraya River basin tends to decrease. It causes the decrease of inflow discharge into the reservoir dams.
- Intake discharge at upstream of the delta area increased so much. It decreased the discharge at the Chao Phraya diversion dam where most irrigation water is delivered throughout main regulators. Figure 8 shows the change of discharge at Nakhon Sawan and Chainat in the Chao Phraya River. (The Nakhon Sawan point is about 94 km upstream or 50 km north of the Chao Phraya diversion dam, and the Chainat point is just downstream of the diversion dam.)
- Besides supplementary irrigation in rainy season, water allocation for domestic and industrial use, and flood control have been requested.
- Rice cropping calendar became different even within command area of some thousand ha.
- Situation of over cropping continues as shown in Table 2.
- Many gates or regulators have been constructed at the end of lateral canals, main drainage canals even in the gravity irrigation system area as well as the Lopburi river. Those increase the function of storing water in the area.
- Farmers tend to have their own pumps and ponds.
- Because floating rice area and deep water rice area decreased, it became difficult to convey excess flooding water into paddy fields.
- The Pasak reservoir dam contributes mitigation of water shortage and flood especially in the lower east bank of the delta.

4 Difficulties and problems of water management

Many researches and international cooperation projects have been implemented, and many proposals were given on water management. Their contribution is great. But, RID still has the following difficulties on practical water management in the delta area:

1. Water travelling time from upstream dams to the fields needs much time as long as 1-3 weeks.
2. Arrival discharge at the Chao Phraya diversion dam changes by the fluctuation of release discharge from upstream dams, because EGAT saves the release on holidays. Figure 9

shows the comparison between total release discharge from upstream dams (Bhumipol and Sirikit reservoir dams) and discharge at Nakhon Sawan in the Chao Phraya River.

3. It is difficult to estimate runoff discharge (side flow) from rainfall information accurately.
4. Much water is consumed in the upstream of the delta area beyond the control of RID. Sometimes, only half of released water from dams arrives at the Chao Phraya diversion dam. Other departments have installed many pumps there and regulation of water allocation at planning stage is not enough even now. This phenomenon can be estimated during WM dry season in Figure 9.
5. There is no regulating pond that enables released water from upstream dams to use more effectively during unexpected rainfall.
6. Water level in the main irrigation canal sometimes has to be kept high to send water for some lateral canals that intake sill elevations are relatively high compared with standard of minimum water level as shown in Figure 10. In such cases, not only discharge but also water level becomes important indicator for water operation.
7. It is difficult to use local rainfall more effectively under the present monitoring system and the number of staff.
8. Cooperation of farmers on maintenance of on-farm facility and keeping cultivation plan in dry season is not enough. Someone sometimes breaks on-farm facilities at lateral and tertiary canals.
9. When farmers start planting after small rain at the beginning of rainy season, but rain does not continues, a young rice plant would wither and die if irrigation water is not enough supplied. This weather condition is called dry spell. Farmers strongly ask irrigation water even though their paddy fields are out of irrigation schedule.
10. A third person sometimes gives pressure to RID on water allocation.

On the other hand, RID needs to resolve the following problems:

1. Accurate measurement of discharge at main regulators.
2. Frequent renewal of data on canal network and O/M facilities.
3. Close connection among O/M Project offices, RIOs and RID Head Office on inputting collected data into computers and their usage.
4. To make well-grounded water operation process with scientific analysis.

Promotion of digitizing and networking will contribute to save time and personnel expenses in total. It makes the preparation of input data for analysis easy. Existing software such as AISP (Acres Irrigation Support Package)(ACRES, 1982, Choolit, 1999, Pal Consultant Co. Ltd. et al., 1999) should be used more widely. Establishment of information processing environment will be first step. On the other hand, to keep balance between experience and analysis is also important.

5 Function of paddy fields for natural resources conservation

Paddy farming in Asia monsoon area is strongly connected with rural social system. Good management of paddy field is essential for not only food production but also natural resources conservation. Paddy farming including related water management has been playing following important roles and function (Yuyama et al., 1996, Yuyama, 1999):

1) Flood mitigation as retarding basin
2) Water resources for downstream area as regulating pond
3) Water quality and ecosystem conservation
4) Protection of soil erosion
5) Production of oxygen
6) Provision for recreational opportunity

One of characteristics in the Chao Phraya Delta is floating rice farming. It can be summarized as low input and low yield but sustainable farming. Cultivated floating rice area decreased from 228,000 ha in 1987 to 114,000 ha in 1997(CTI et al., 1999). The storage volume in the floating rice area in 1997 can be estimated 2,750 MCM by assuming that water depth is 2.5 meter. The volume would be almost as same as standing water in remaining paddy fields in rainy season if the water depth were assumed 0.3 meter. For reference, inundated volume in the flood of 1995 was estimated 15,900 MCM (CTI et al., 1999). Without paddy fields, to protect metropolitan Bangkok from flooding is impossible. The distribution of the floating rice area is shown in Figure 11. Floating rice area in the upper east bank of the delta in 1998 was 52,400 ha. Table 4 shows detail condition. Unit of floating rice area is from some thousand to ten thousand ha. Each unit has drainage regulator to control water level. The weight of artificial control of water increased even in floating rice area. Recently, newly constructed big roads function as embankment.

Floating rice can grow flexibly corresponding to irregular increase of water level. It grows just like rice grown in a dry field with weed at the beginning stage. Then, the stem increases between 2 m and 10 m according to water condition. It takes 7-9 months from planting to harvest. The harvest starts from December or January after the standing water is drained.

Released water from the floating rice area can also contribute to decrease salinity concentration at downstream area. EC (Electrical conductivity) in the irrigation and drainage canals of the upper east bank of the delta ranged between 15 and 30 mS/m. Those values are equivalent to TDS (Total dissolved solids) of 100-200 mg/L. Comparing from the EC standard for irrigation of 200 mS/m, measured values were relatively very low.

There is economic analysis to find suitable land use in terms of water consumption (Paul Consultant Co. Ltd. et. al, 1999, Apichart, 2000). Rice production came to low position under the indicator of the profit per specific water consumption (Baht/m^3). However, when we discuss about land use change from paddy field to other usage, we need to consider the sustainability of activity and potential function of paddy farming. Otherwise, one countermeasure might cause negative impact to another problem. Performance of water use in paddy farming differs by the level of spatial scale and time, because water consumption of paddy field is different by the growing stage and drained water can often be reused at downstream area. Return flow is actually difficult to estimate. Therefore, such kind of economic analysis should make clear of prerequisite conditions for the analysis.

6 Strategy for more appropriate water management

6.1 General Strategies

Recently, we need much regulation and time to construct large-scale dams or inter-basin water conveyance canals. On the other hand, we need to develop water resources to correspond increasing demands. More efforts have to be done at O/M side, too. To save irrigation water in rainy season is essential to achieve stable water supply in dry season. To promote crop diversification in dry season will also contribute to it. More close communication between supply side and demand side is needed. Field monitoring and analysis (Chalong, 1991, V.V.N. Murty et al., 1991, Pushpa et al., 1993, Apichai et al., 1994, Chatchai et al., 1993) should be emphasized for the delta level water allocation planning and operation.

Examples of strategies/countermeasures for more appropriate water management are as follows:

1) To construct regulating ponds.
2) To increase the density of check gate, field turn out (FTO), canal and road.
3) To increase the number of monitoring on water operation and hydrology and improve accuracy.
4) To promote the networking of information (Kobayashi et. al, 1994) on water management, so as to find the common benefit among RID organizations and/or water users.
5) To develop and use decision support system for water operation containing feedback of experience, databases, and analyses. Effective use of existing software (Choolit, 1999, Yoshino et al., 1997, Hayase et al., 1996) and databases is important.
6) To improve rules and regulations on water allocation including preparation of some benefit for contribution of saving irrigation water.
7) To establish technology and economic basis for promoting crop diversification in dry season more widely.
8) To strengthen a campaign of water saving for supplementary supply of irrigation water in rainy season.
9) To promote participatory irrigation management (PIM) cooperated by farmers' groups.
10) To examine dam operation rule curves with EGAT after reviewing proposed ideas (Sanyu et
11) al., 1999, CTI et al., 1999, Horikawa, 1997).

12) To strengthen training courses that can contribute practical water operation.

13) To strengthen integrated watershed management in NWRC (National Water Resources Committee).

14) To examine crop calendars by locations for increasing reuse of water.

15) To examine automatic control type regulator when renewal is discussed.

Any one of them is not easy to implement. However, they are considered unavoidable problems. In terms of 1), many spatial levels of ponds can be considered. Purposes are peak cut of discharge during flood, storage of for early dry season or emergency, and minimizing travelling time lag of water between supply and demand (buffer function). In terms of 3) and 4), great progress is expected by the improvement of information technology. However, organization of maintenance team and renewal plan of facility and equipment are needed in advance especially for telemetering system. Information on drainage (Francois et al., 1997) will be more important for conservation of water resources. In terms of 7), the strengthening of drainage standard is needed, because vegetables are not so strong against inundation as paddy. In terms of 12), effort has already started to cope with flood, water shortage and environmental conservation. In terms of 13), more effective use of released water from the floating rice area should be discussed. Reuse of irrigation water will contribute water quality conservation (Yuyama et al., 1999).

Main information on water management and hydrology is opened to the public at homepage of RID (http://www.rid.go.th). RID organized the Office of Hydrology and Water Management in 1997. Collected data can be used more effectively and practically. To have information and process on water management in common will also contribute to have ownership and bring up capable person. Research achievements (Kasetsart University and ORSTOM,1996, http://www.ku.ac.th/delta) are helpful to reconfirm existing condition and to pick up alternative countermeasures.

6.2 Proposal of decision support system for water operation in the upper east bank of Chao Phraya delta

The purpose of the system is to achieve more appropriate and fair water management. To monitor existing condition accurately and share summarized information in common is essential. The decision-maker and all responsible persons will be able to get latest summarized information easily. The target O/M Project is Manorom, Chong Khae, Khok Krathiam, Roeng Rang and Maharaj. To learn from the past trend, daily data from 1994 will be input. The concepts of the system are as follows:

1) Contribution to practical water operation throughout the year
2) Combination of monitoring, analysis and experience (improvement of man-machine interface)
3) Common ownership of water management process among RID Head Office, RIO-8 and five O/M Project offices (including establishment of information networking)
4) Seeking for stable water supply by water saving at every spatial and temporal levels

5) Effective use of existing software
6) Effective use of existing hydrological and water management databases and their strengthen in function
7) Input of daily information at lateral canal level and above
8) Paying more attention to drainage system

The system will be designed by Windows basis and connected with existing hydrological and water management databases. The support by Geographical Information System (GIS) and Remote Sensing (RS) technology will be helpful. The system is consisted of four sub-systems of monitoring, database, analysis, and reference information as shown in Table 5. Plan of data communication networking is arranged in Figure 12. Needed daily information on hydrology and water management is shown in Table 6.

7 Conclusion

Farming and water management in the Chao Phraya Delta is changing rapidly now. Corresponding to changes in background, re-allocation of water resources, rehabilitation of aged facilities, construction of facility and examination of its operation for crop diversification, and promotion of PIM are actually sought for (Charoon et al., 1993, Siripong, 1997). In the eighth Agricultural Development Plan (MOAC, 1998), three strategies of 1) strengthening international competitiveness, 2) natural resources conservation and sustainable agricultural development, and 3) human resources and farmers organization development, were stated.

Modern technology and Thai custom need to be mixed well to search for sustainable agricultural system including water management and marketing. Not only preference in economics but also future prosperity in the delta area has to be discussed among all necessary stakeholders.

In this paper, present situation and problems of water management in the delta area was reviewed. Water operation seemed to become more complicated and difficult than before to satisfy new requirement. Many challenges are needed for stable supply of water in dry season.

In terms of the upper east bank of the delta, they received the benefit by the Greater Chao Phraya Project so much. The area has great potential of development and alternative possibilities (NESDB, 1990). It is up to national policy and agriculture policy. The development of the area has great impact on water use, flood fighting and water quality environment to the lower east bank of the delta including Bangkok.

It is difficult to evaluate the reasonableness of water allocation planning and practical water operation perfectly. Even when water operation is suitable in total, small complains will come from many water users. Every process of water operation can not be automatic. Therefore, we need decision support system as tool of man-machine interface or expert system to promote water management with accountability. To have information in common and share the thinking process among RID and other authorities concerned are important to seek for more appropriate water management and bring up human resources.

References

ACRES. 1982. Chao Phraya - Meklong Basin Study Phase 2 and 3.

Apichai,Wathanayomnaporn; Kiyoshi,Horii; Noriharu,Usuki and Hideaki,Yamamoto. 1994. Improved On-Farm Water Management in the Sam Chuk Project in Thailand. Report of the Expert Consultation of the Asian Network on Irrigation/Water Management, JICA & RAPA of FAO, pp.68-78.

Apichart,Anukulamrphai. 2000. Water Resources and Irrigation Development in Thailand. Proc. of 16th Foreign Affairs Lecture on the Agricultural Infrastructure Improvement and Rural Development in Southeast Asia, JSIDRE&JIID&ADCA, pp.1-13.

Atthaporn,Buddhapalit. 1999. Water Information System and Flood Disaster in Thailand. Proc. of IDNDR Symposium on Mitigation of Water-related Disaster, Nagoya, pp.51-61.

Chaiwat,Prechawit. 1994. Irrigation/Water Management in Thailand- Focusing on 1994 Drought-. Report of the Expert Consultation of the Asian Network on Irrigation/Water Management, JICA & RAPA of FAO, pp.50-55.

Chaiwat,Prechawit. 1995. Water Management in the Chao Phraya River Basin. Proc. of Tokyo Symposium on Sustainable Agriculture and Rural Development, pp.261-272.

Chalong,Kirdpitugsa and Chaiwat,Kayankarnnavy. 1991. Field Monitoring of Water Use for Wet Season Rice. Proc. of 8th Afro-Asian Regional Conference of ICID, Bangkok, B15, pp.150-166.

Charoon,Kamolratana and Chao,Watanakarn. 1993. Modernization of Irrigation Systems in Thailand. Trans. of 15th ICID Congress, The Hague, Q.44-R.59, pp.777-788.

Chatchai,Boonlue; Hector, M. Malano. 1993. Relation between Crop Diversification and Operational Flexibility in the THUP SALAO Irrigation System, Thailand. Trans. of 15th ICID Congress, The Hague, Q.44-R.37, pp.483-499.

Choolit,Vatcharasinthu.1999. Basin Operation Model (AISP)- Case Study:Chao Phraya Delta-. Panya Consultants Co.,Ltd.

CTI Engineering Co., Ltd. and INA Corporation. 1999. The Study on Integrated Plan for Flood Mitigation in Chao Phraya River Basin. Final Main Report, RID, JICA.

Hayase,Y.; Koseki,K.; Wisan,W. and Attaporn,B. 1996. Development of Hydrological Information System in the Chao Phraya River Basin. Proc. of International Conference on Water Resources & Environment Research, Vol.1, pp.611-618.

Horikawa,N. 1997. Operation Analysis of Multi-Purpose Reservoirs in the Chao Phraya River Basin. JARQ, 31(2), pp.125-132.

Kasetsart University and ORSTOM. 1996. Agricultural and Irrigation Patterns in the Central Plain of Thailand. DORAS Project.

Kobayashi,T.; Supot,Promnaret; Usuki,N. and Horii,K. 1994. A Model Water Management Information Network System in the Central Plain of Thailand. Report of the Expert Consultation of the Asian Network on Irrigation/Water Management, JICA & RAPA of FAO, pp.56-67.

MOAC. 1998. Agricultural Development Plan in the 8th National Economics and Social Development Plan (1997-2001). (in Thai)

Molle, François; Jesda,Keawkulaya; Sutin,Glunbud and Nicolas Wiel. 1997. Drainage Management and Agricultural Change in Deltaic Regions -the case of the Chao Phraya delta, Thailand-. Proc. of 7th ICID International Drainage Workshop, Vol.3, pp. M3-1-15.

NESDB. 1990. Upper Central Region Study, JICA.

Pal Consultant Co. Ltd. and Panya Consultant Co. Ltd. 1999. Water Management in Chao Phraya Delta. RID. (in Thai)

Pushpa,Raj,Onta; Phattaporn,Mekpruksawong and Rainer,Loof. 1993. Impact of the Spatial Distribution of Rainfall on Irrigation Water Demand. Trans. of 15th ICID Congress, The Hague,Q.44-R.68, pp.885-897.

RID. 1998. Planning to Support Farmer in Dry Season of 1998. (in Thai)

RID. 1998. Report on Farmer Support in Dry Season of 1998. (in Thai)

Roongrueng,Chulajata; Charoon,Kamolratana; Siripong,Hungspreug and Natha,Hungspreug. 1996. Master Planning of Water Resources Development in Thailand (1994-2006). Trans. of 16th ICID Congress, Cairo, Q.47, R.1.05, pp.55-67.

Sanyu Consultants Inc. and Nippon Koei Co., Ltd. 1999. The Study on the Kok-Ing-Nan Water Diversion Project in the Kingdom of Thailand. Final Main Report, RID, JICA.

Siripong,Hungspreug. 1997. Modernization of Irrigation Schemes in Thailand. Water Report, FAO, pp.237-245.

Van Beek, Steve. 1995. The Chao Phya River in Transition, Oxford University Press, pp.121-147.

Virat,Khao-Uppatum. 1992. Irrigation/Water Management for Sustainable Agricultural Development in Thailand. Report of the Expert Consultation of the Asian Network on Irrigation/Water Management, JICA & RAPA of FAO, pp.173-190.

V.V.N. Murty; S. Kaewrueng; A. Sarwar and M. Akram. 1991. Assessing Demand Patterns at the Tertiary Levels of Large Irrigation Systems. Proc. of 8th Afro-Asian Regional Conference of ICID, Bangkok, B21, pp.228-236.

Water Operation Branch. 1999. Water Management for Rice Production in Thailand. Third Country Training Course Textbook, RID, 29p.

Yoshino,H.; Usuki,N.; Chaiwat,Prechawit; Eriguchi,H. and Yamamoto,H. 1997. Study on Optimal Gate Operation Method in a Long Open Channel. JARQ, 31(1), pp.21-28.

Yuyama,Y.; Yoshino,H. and Kitamura,Y. 1996. Impact of Paddy Fields on Mitigation of Flood Damage. Proc. of 6th ICID Drainage Workshop, Slovenia, pp.272-280.

Yuyama,Y. 1999. The Impact of Agriculture on Water Quality and its Improvement Methodology in Japan. Regional Workshop on Water Quality Management and Control of Water Pollution, FAO, Bangkok, 19p.

Yuyama,Y.; Miyamoto,K. and Ono,K. 1999. Influence of Drought on Paddy Farming and Water Quality. Trans. of 17th ICID International Congress, Q.48, R.5.04, pp.193-202.

Tables and figures (order by appearance)

Table 1 Example of O/M information

Facility Information	Max. Water level of prevoius day Upstream (1)	Downstream (2)	Average discharge of previous day (3)	Upstream of regulator or pump (4)	Downstream of regulator or pump (5)	No. of operating gate or pump (6)	Duration of gate opening or pump operation (7)	Length of gate opening x number (8)	Discharge (9)	Rainfall (Station code) (10)
	(m. mean sea level)		(m³/s)	(m. mean sea level)		(machine)	(hour)	(m.)	(m³/s)	
Distribution canal										
1. Khok Krathiam Regulator	10.82	9.45	69.29	10.68	9.40	4	24	0.70x4	68.21	(CPK 27)
2. Intake 18R	10.82	10.78	1.26	10.68	10.64	1	24	1.00x1	1.20	
3. Intake 19R	9.37	-	-	9.32	-	1	24	together 18R		(CPK 16) -
4. Intake 20R	9.21	-	-	9.16	-	1	24	close	-	(CPK 17) -
5. Intake 21R	8.77	8.73	3.00	8.73	8.69	2	24	1.20x2	3.00	(LOP 1) -
										(LOP 2) -
										(LOP 3) -
										~~(LOP 4)~~
										(LOP 5) -
										(LOP 6) -
										(LOP 7) -
6. Intake 22R	8.65	-	-	8.61	-	2	24	close	-	(CPK 33) -
										(CPK 18) -
Drainage canal										
1. Reg. Wat Manee Chonrakan	**Accept**			4.50	3.20	3	24	1.00x1	-	
2. Siphon Lopburi				3.08	-	-	-	-	-	
3. Reg. Klong Ta Mek				2.77	2.45	3	24	close	-	
4. Reg. Klong Noi	(Mr. Sompong Bangtakul)			2.96	3.04	1	24	close	-	
5. Reg. Krathum	O & M Project Engineer,			2.48	0.80	1	24	close	-	
6. Siphon km. 92+200 *	Khok Krathiam Project			-	-	1	24	close	-	*Refer to km. of
7. Waste way km. 95+615 *				9.10	-	3	24	close	-	Chainat-Pasak
8. Siphon km. 109+068 *				-	-	1	24	close	-	Canal

Remark : Values in (4), (5), (6), (8), (9) are observed at 6:00 a.m.

Table 2 Planning and practical water allocation in the Chao Phraya River Basin

(MCM)

		1993	1994	1995	1996	1997	1998	1999	2000
Active Storage on 1st January		5,357	2,048	12,733	14,582	12,107	8,239	3,879	11,930
1. Consumption for domestic & Industry		550	700	1,100	1,800	1,650	1,600	550	(1,600)
-North of Nakorn Sawan		250	300	500	900	800	800	150	(800)
-Great Chao Phraya Project		300	400	600	900	850	800	400	(800)
2. Dry season cultivation		2,100	500	3,300	4,950	4,200	3,400	2,050	(3,000)
3. Navigation		300	0	300	400	300	300	0	300
4. MWA		650	550	700	750	750	750	650	750
5. Salinity Control		400	250	600	600	500	450	350	350
Sum of 1-5	Plan	4,000	2,000	6,000	8,500	7,400	6,500	3,600	6,000
	Actual	4,610	1,894	7,216	9,643	8,556	6,656	2,575	6,500
6.Paddy field area (million rai)	Plan	1.50	0	2.80	3.50	3.30	2.70	1.90	3.10
	Actual	1.96	1.77	3.19	4.15	4.06	3.79	3.49	4.42

1) Water allocation plan in dry season between January and June was arranged. Side flow is not taken into account.
2) Active storage is effective storage at both Bhumibol and Sirikit reservoir dams.
3) MWA: Metropolitan Waterworks Authority
4) Paddy field area is sum of irrigated area. (1.0 rai = 0.16 ha)
5) RID changed the format of planning from 2000. The values inside ( )in 2000 were assumed to fit the format of previous years.

TABLE 3 PLANNING OF WATER ALLOCATION IN WM DRY SEASON 0F 2000(MCM)

	Manorom	Chong Khae	Khok Krathiam	Roeng Rang	Maharaj
Rice	80	115	100	30	147
Vegetable	0	14	8	12	15
Fruit	2	7	4	1	0
Fish pond	1	2	1	2	0
Domestic use	12	1	17	5	0
Sum	95	145	130	50	162

TABLE 4 CONDITION OF FLOATING RICE AREA IN THE UPPER EAST BANK OF THE DELTA (1998)

O/M Project	Area (ha)	Maximum water level (m.MSL)	Remarks
Chong Khae	720	+1.20	
Khok Krathiam	18,076	+5.95	Average water level
Roeng Rang	4,480	+6.00	Bang Khum regulator area
	4,320	+5.00	Khor Lerng regulator area
Maharaj	480	+10.20	Left bank of Chainat-Ayutthaya canal area (km. 21-26)
	7,234	+8.03	Chainat Pasak main drainage canal No.3 area (km. 18-27)
	10,298	+5.50	2L-8L lateral canal area
	6,785	+4.16	End of Chainat-Ayutthaya canal area

TABLE 5 : PLAN OF CONSTITUTION OF SUB-SYSTEM

<Monitoring>	**<Database>**
Storage and release of reservoir/dam Rainfall Water level Discharge Salinity Cropping area and soil moisture Inundation condition Operational condition of facilities	River and canal network Hydrological database Water management database Facility database V~h curve at block level Basic material to calculate water Requirement by respective crop List of important reports and papers
<Analysis>	**<Reference information>**
Water requirement analysis Runoff analysis Calculation of discharge at regulator, gate, pump etc. Flow analysis (non-uniform flow, Unsteady flow) Water balance analysis AISP, WASAM, MIKE Basin, MIKE 11 etc.	Flow of information on water operation Organization and responsible persons related to water operation Plan of cropping Plan of water allocation Weather forecast Arrangement of problems (past, present and expected) Alternative ideas for countermeasure or trouble solution Question and Answer

TABLE 6 : NEEDED DAILY INFORMATION ON HYDROLOGY AND WATER MANAGEMENT

	Storage Volume	Water level	Discharge	Salinity	Operation
<Reservoir dam>					
Bhumiphol	O	O	O		
Sirikit	O	O	O		
Pasak	O	O	O		
<Chao Phraya river>					
Nakhon Sawan (C2)	-	O	O		
Chao Phraya Diversion Dam	-	O*	O		O
(C13)	-	O			
Singburi (C3)	-	O	O		
Ang Thong (C7A)	-	O			
Bangsai (C29)	-	O		O	
RID Pakkret (C22)	-	O		O	
RID H.O. (C12)	-	O		O	
Memorial Bridge (C4)	-	□			
River mouth					
<Pasak river>					
Ban Muang Nua(S9)		O	O		
Kaeng Khoi(S2)		O	O		
Rama VI Diversion Dam (S 26)		O*	O		O
Panchama Thirat Uthit Hospital(S5)		O			
<Lopburi river>					
Singburi regulator		O*	O		O
Siphon Lopburi(L2A)		O*	O		
Lopburi regulator		O*	O		O
<Chainat Pasak Canal>					
Manorom regulator		O*	O		O
Chong Khae regulator		O*	O		O
Khok krathiam regulator		O*	O		O
Roeng Rang regulator		O*	O		O
<Chainat Ayutthaya Canal>					
Maharaj regulator		O*	O		O
Ban Tuk regulator		O*	O		O
Bang Chom Sri Siphon		O*	O		O
<Drainage regulator>					
Bang Kharm (Chong Kae)		O*	O		O
Wat Manee(Khok Krathiam)		O*	O		O
Klong Ta Mek(Khok Krathiam)		O*	O		O
Bang Chom Sri (Maharaj)		O*	O		O
Ban Rai (Maharaj)		O*	O		O
Kao Chang (Maharaj)		O*	O		O
Bang Khung (Maharaj)		O*	O		O
<O/M>					
Monorom O/M Project area		O	O		O
Chong Khae O/M Project area		O	O		O
Khok Krathiam O/M Project area		O	O		O
Roeng Rang O/M Project area		O	O		O
Maharaj O/M Project area		O	O		O

Remark-1: O* means monitoring at both upstream and downstream. □ means estimated tidal level.
Remark-2: O/M information includes water level and discharge at intake of lateral canals, drainage canals, etc as exemplified in Table 1.)

A. Reservoir Dam
   (1) Bhumiphol Dam Storage volume (m^3) Effective storage volume (m^3) Water level (m) Released discharge (m^3/d)
   (2) Sirikit Dam Storage volume (m^3) Effective storage volume (m^3) Water level (m) Released discharge (m^3/d)
   (3) Pasak Dam Storage volume (m^3) Effective storage volume (m^3) Water level (m) Released discharge (m^3/d)

B. Chao Phraya river
   (1) Nakhon Sawan (C2) Water level, discharge
   (2) Chao Phraya Diversion Dam (C13) Water level(upstream and downstream), released discharge, operational condition
   (3) Singburi (C3) Water level
   (4) Ang Thong (C7A) Water level, discharge
   (5) Bangsai (C29) Water level
   (6) RID Pakkret (C22) Water level, salinity
   (7) RID H.O. (C12) Water level, salinity
   (8) Memorial Bridge (C4) Water level, salinity

C. Pasak river
   Ban Muang Nua(S9) Water level, discharge
   (1) Kaeng Khoi(S2) Water level, discharge
   (2) Rama VI Diversion Dam (S 26) Water Level (upstream and downstream), release discharge, operational condition
   (3) Panchama Thirat Uthit Hospital(S5) Water level

D. Lopburi river
   (1) Singburi regulator Water Level (upstream and downstream), release discharge, operational condition
   (2) Siphon Lopburi(L2A) Water level, discharge
   (3) Lopburi regulator Water Level (upstream and downstream), release discharge, operational condition

E. Chainat Pasak Canal
   (1) Manorom regulator Water Level (upstream and downstream), release discharge, operational condition
   (2) Chong Khae regulator Water Level (upstream and downstream), release discharge, operational condition
   (3) Khok krathiam regulator Water Level (upstream and downstream), release discharge, operational condition
   (4) Roeng Rang regulator Water Level (upstream and downstream), release discharge, operational condition

F. Chainat Ayutthaya Canal
   (1) Maharaj regulator Water Level (upstream and downstream), release discharge, operational condition
   (2) Ban Tuk regulator Water Level (upstream and downstream), release discharge, operational condition
   (3) Bang Chom Sri Siphon Water Level (upstream and downstream), release discharge, operational condition

G. Drainage system
   Water Level (upstream and downstream), release discharge, operational condition
   (1) Bang Kharm regulator(Chong Kae)
   (2) Wat Manee regulator(Khok Krathiam)
   (3) Klong Ta Mek regulator(Khok Krathiam)
   (4) Bang Chom Sri regulator(Maharaj)
   (5) Ban Rai regulator(Maharaj)
   (6) Kao Chang regulator(Maharaj)
   (7) Bang Kung regulator(Maharaj)

H. Rainfall
   Information from Hydrology Center 5 and O/M Project offices

I. O/M Information
   Water level and discharge at intake of lateral canal, water level and discharge at drainage canal, operational condition (There are overlapping information with other items.)
   (1) Monorom O/M Project area
   (2) Chong Khae O/M Project area
   (3) Khok Krathiam O/M Project area
   (4) Roeng Rang O/M Project area
   (5) Maharaj O/M Project area

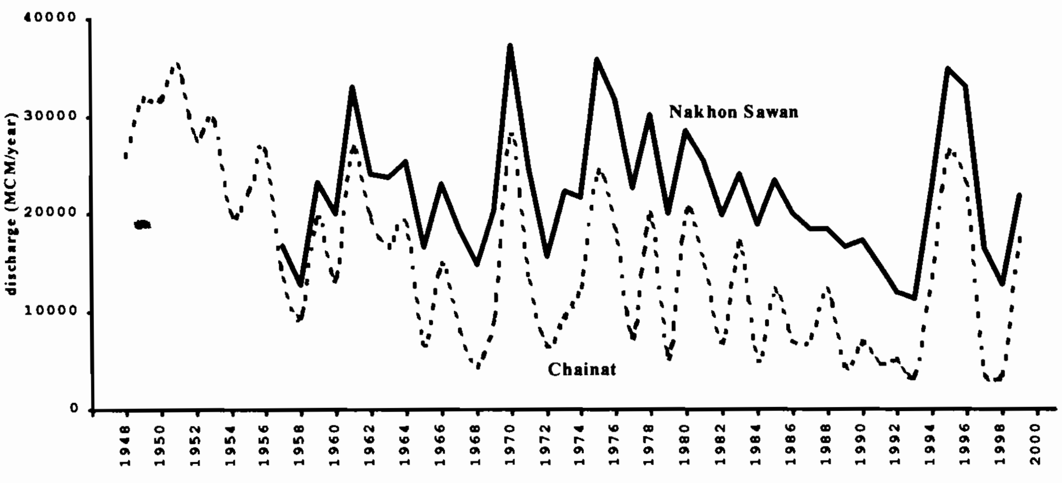


Figure 8 Changes of annual discharge at Nakhon Sawan and Chainat in the Chao Phraya River

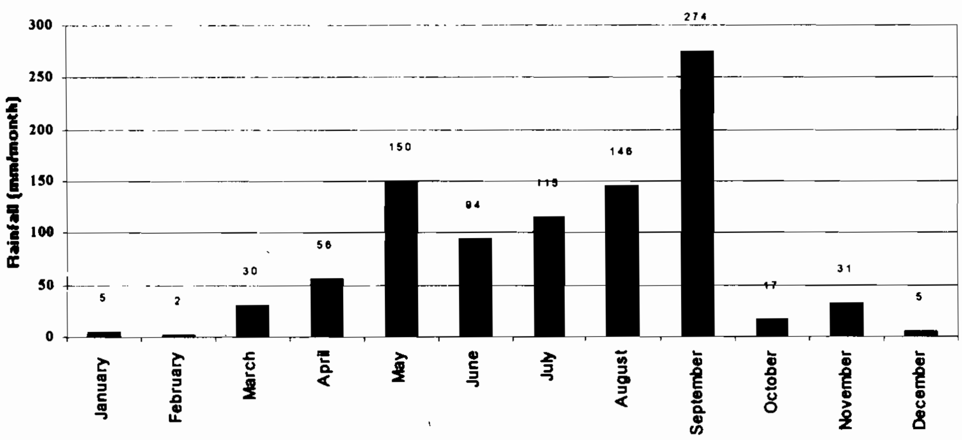


Figure 3 Monthly Rainfall at Lopburi between 1989 and 1998

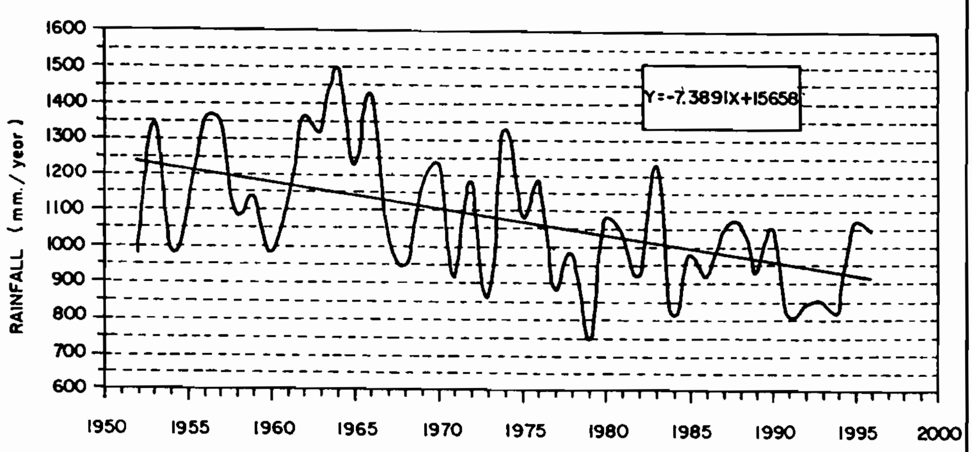


Fig. 4

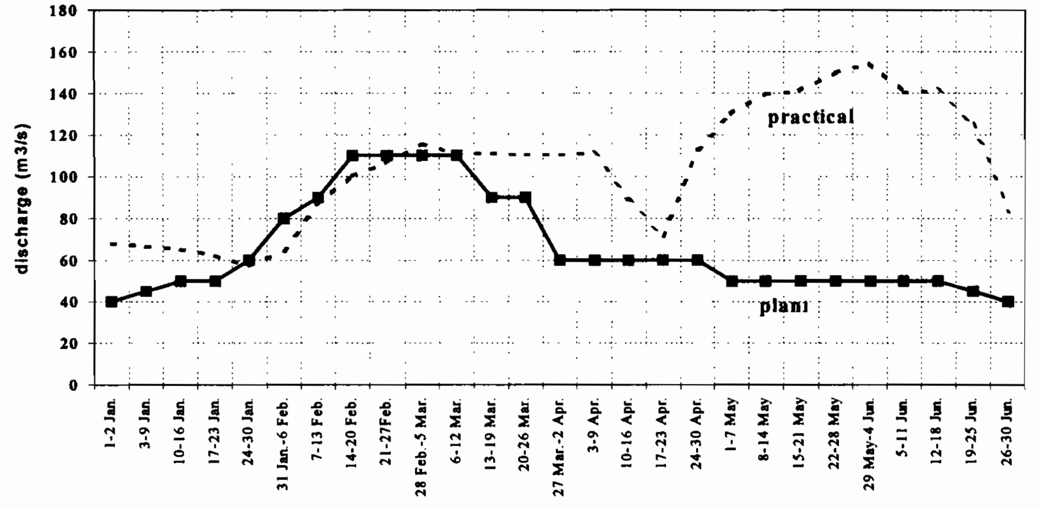


Figure 6 Planning and practical intake discharge from the Manorom regulator

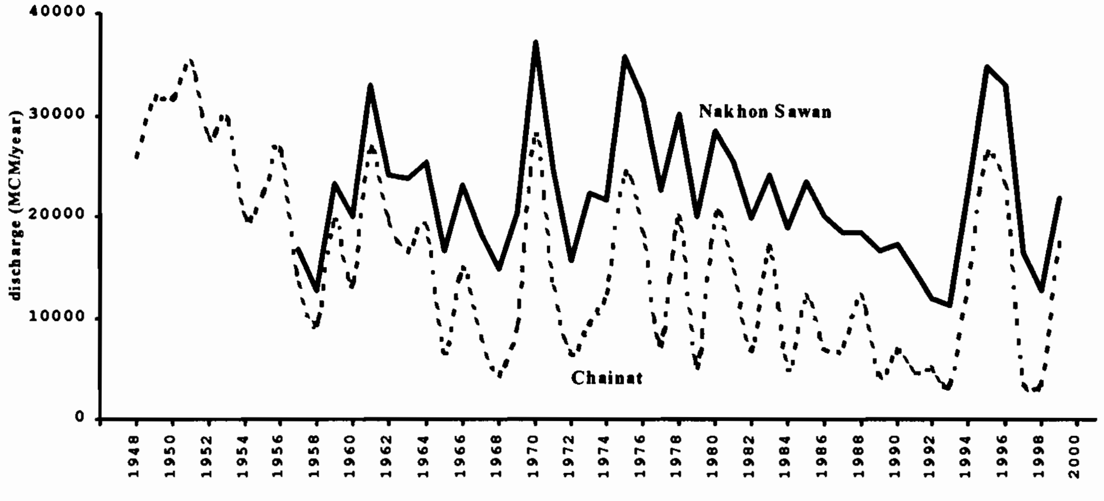


Figure 8 Changes of annual discharge at Nakhon Sawan and Chainat in the Chao Phraya River

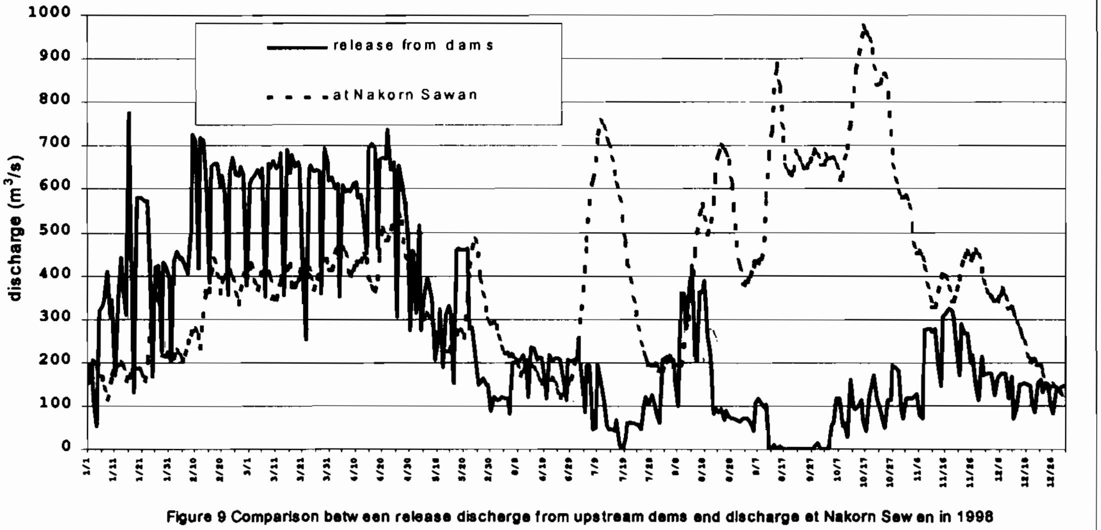


Figure 9 Comparison between release discharge from upstream dams and discharge at Nakorn Sawan in 1998

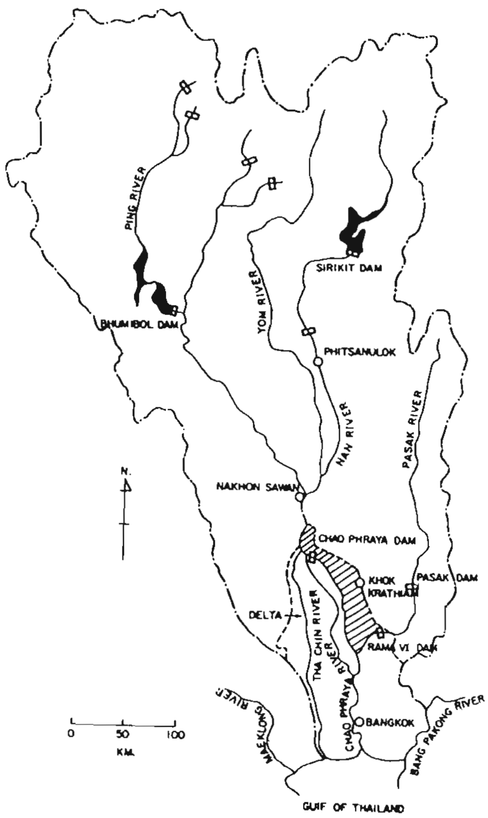


Fig 1

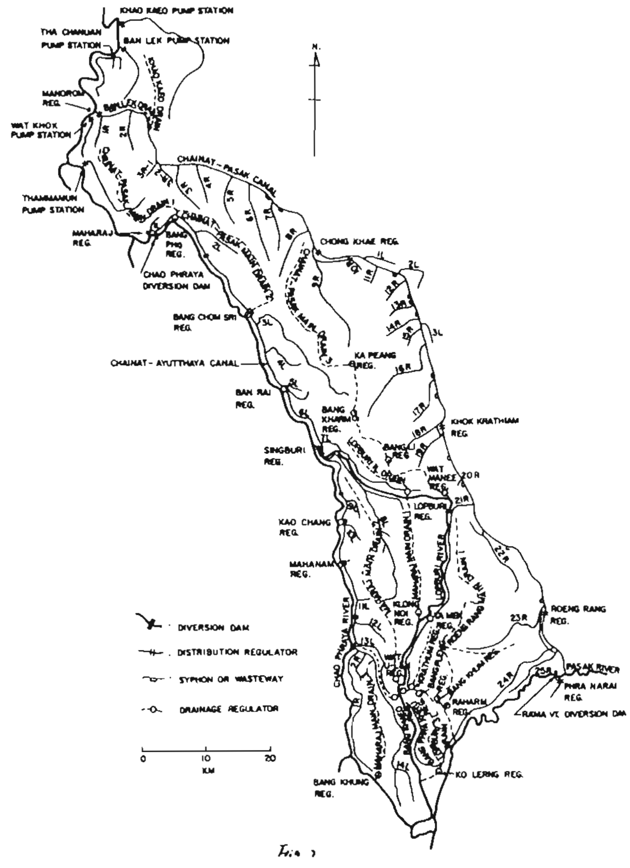


Fig. 2

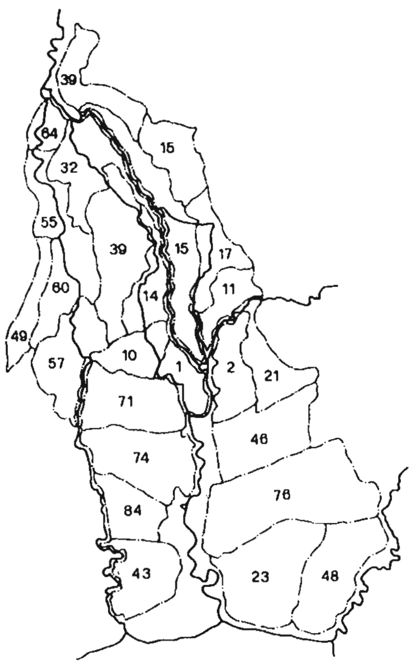


Fig. 7

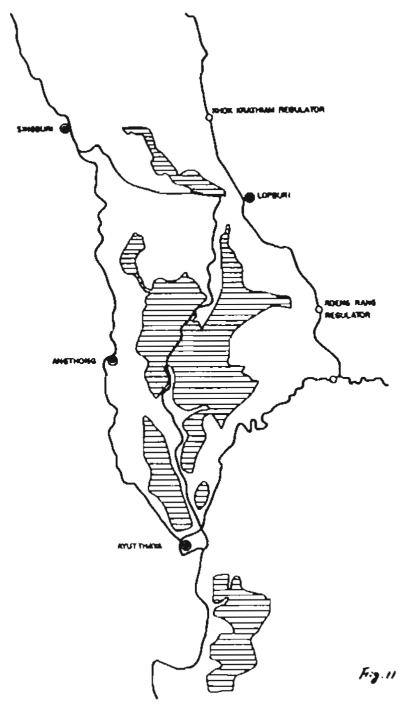
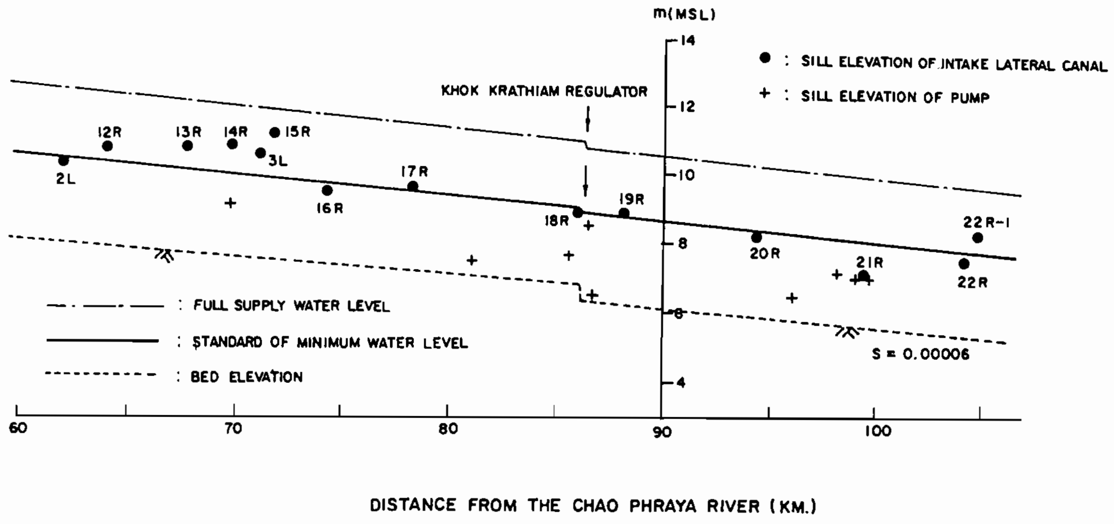


Fig 11



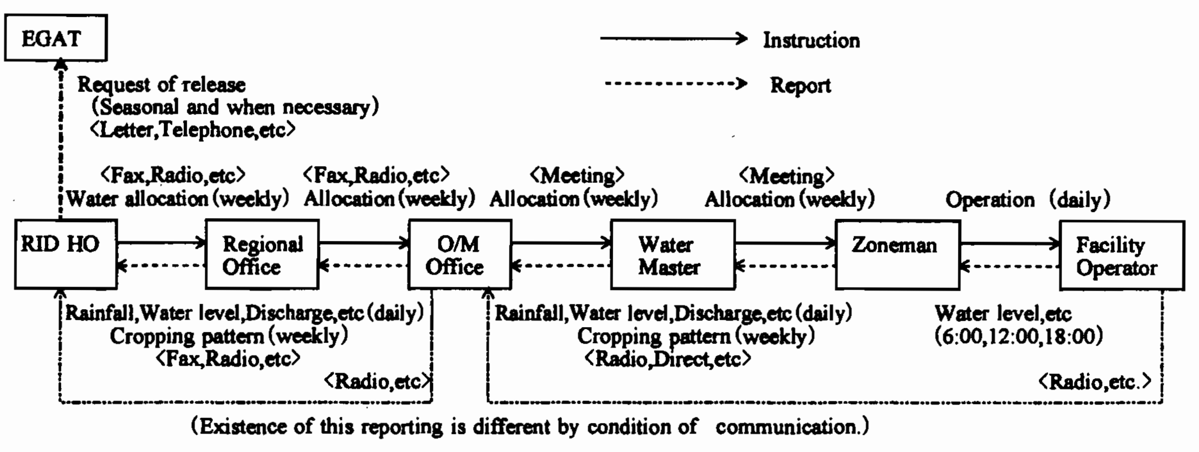


Figure 5 Flow of Information for Water Management

TABLE 2: PLANNING AND PRACTICAL WATER ALLOCATION IN THE CHAO PHRAYA RIVER BASIN

(MCM)

		1993	1994	1995	1996	1997	1998	1999	2000
Active Storage on 1st January		5,357	2,048	12,733	14,582	12,107	8,239	3,879	11,930
1. Consumption for domestic & Industry		550	700	1,100	1,800	1,650	1,600	550	(1,600)
-North of Nakorn Sawan		250	300	500	900	800	800	150	(800)
-Great Chao Phraya Project		300	400	600	900	850	800	400	(800)
2. Dry season cultivation		2,100	500	3,300	4,950	4,200	3,400	2,050	(3,000)
3. Navigation		300	0	300	400	300	300	0	300
4. MWA		650	550	700	750	750	750	650	750
5. Salinity Control		400	250	600	600	500	450	350	350
Sum of 1-5	Plan	4,000	2,000	6,000	8,500	7,400	6,500	3,600	6,000
	Actual	4,610	1,894	7,216	9,643	8,556	6,656	2,575	6,500
6.Paddy field area (million rai)	Plan	1.50	0	2.80	3.50	3.30	2.70	1.90	3.10
	Actual	1.96	1.77	3.19	4.15	4.06	3.79	3.49	4.42

1) Water allocation plan in dry season between January and June was arranged. Side flow is not taken into account.
2) Active storage is effective storage at both Bhumibol and Sirikit reservoir dams.
3) MWA: Metropolitan Waterworks Authority
4) Paddy field area is sum of irrigated area. (1.0 rai = 0.16 ha)
5) RID changed the format of planning from 2000. The values inside ( )in 2000 were assumed to fit the format of previous years.

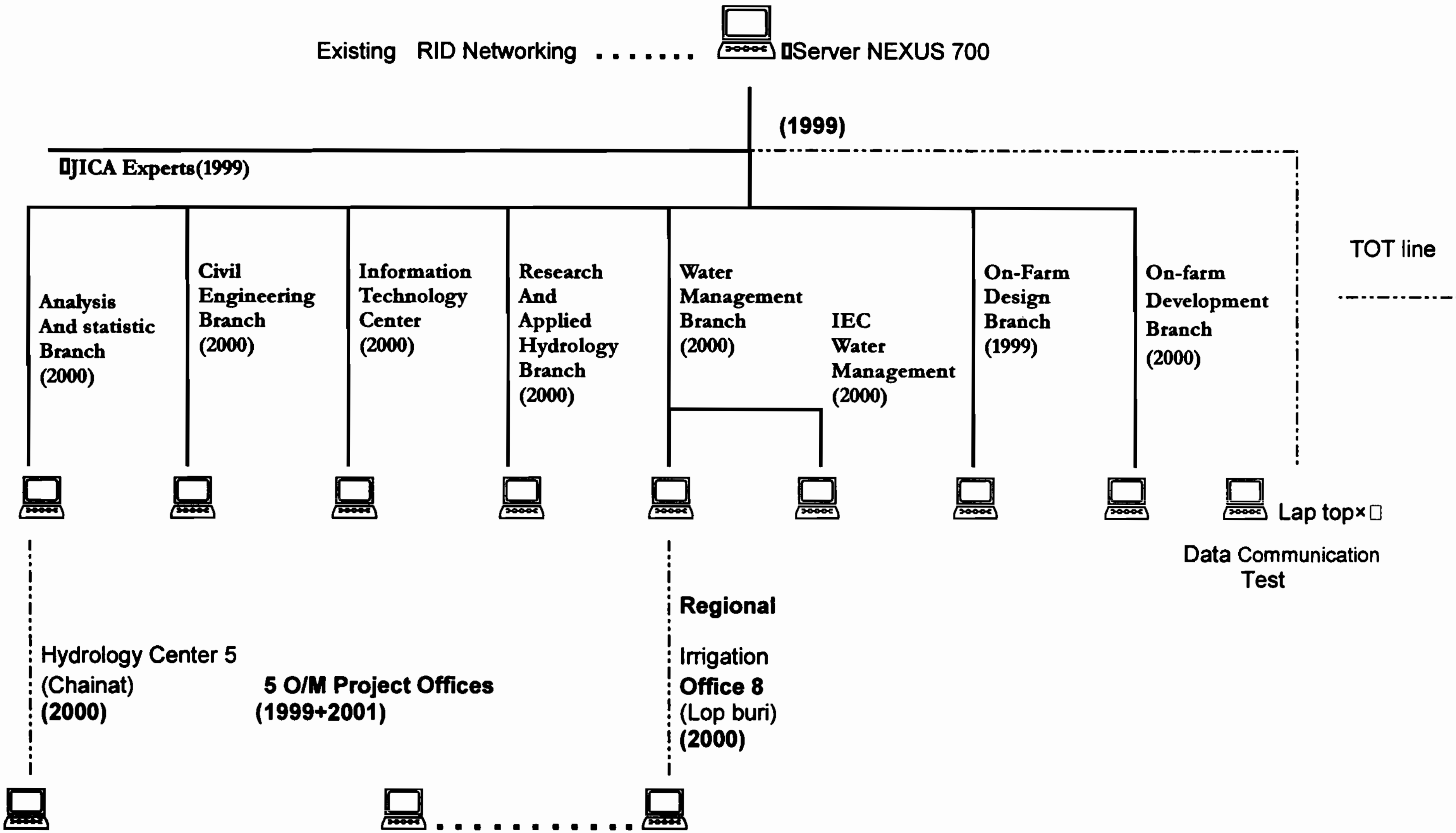


Figure 12: Plan of data communication networking

Operation principles of multipurpose reservoirs for stable water supply in the Mae Klong river basin

Ayumi Kawabata[1],Masayoshi Satoh[2], Varawood Vudhivanich and Nimit Cherdchanpipat[3]

Abstract: *The purpose of this study is to propose a reservoir operation principle in the Mae Klong River Basin so that water users can have a more stable water supply giving no adverse influence on hydropower generation. The authors analyze the operation records of water resource systems for the last thirteen years. It clarifies that substantial amounts of water released from multipurpose dams for power generation was followed by water shortage problems. A new operation rule, which includes two seasonal storage lines (an upper and a lower storage line), is proposed. The upper storage line is to prevent water from spilling during the flood season, while the lower line is to keep water for downstream water uses. A simulation of the reservoir's operation shows the effectiveness of the proposed principles.*

Key words: reservoir operation, operation rule, stable water supply, hydropower generation

1 Introduction

The Mae Klong river has two main tributaries, the Khwai Yai and Khai Noi, in which the multipurpose reservoirs, Srinagarind (SRN) and Khao Laem (KHL) are constructed, respectively. Just downstream from the junction of the tributaries, there is the Vajiralongkorn (VJ) diversion dam, from which water is supplied to the "Greater Mae Klong River Irrigation Project". These three hydraulic facilities have joined to control water in the basin since 1985, resulting in more availability of the water resources. With its relatively abundant water resources, the basin has been transferring water to the Bangkok Metropolitan area since 1995, and it is expected to supply more water in the future. The storage in these reservoirs, however, decreased to almost nothing during the dry seasons of 1993 and 1994, when the water use sectors downstream experienced a severe water shortage. These upstream reservoirs are year-to-year carry over reservoirs whose storage is greatly effected by the reservoir operation in the previous years. To properly understand the state of the water

[1] Doctoral Program in Agricultural Sciences, University of Tsukuba, Tsukuba, Ibaraki, 305-8572 Japan

[2] Institute of Agricultural Engineering, University of Tsukuba, Tsukuba, Ibaraki, 305-8572 Japan

[3] Faculty of Engineering, Kasetsart University, Kamphaengsaen Campus, Nakhon Pathom, 73140 Thailand

resources in this basin, hydrological and water demand conditions for continuous years should be discussed. The objectives of this study are to clarify how the water released from reservoirs has effectively been used by water users based on the water management records, and to propose a new reservoir operation principle for more effective water use in the basin.

2 Requests to reservoir operation from different sectors

To set up the operation principle, we must first consider the requests from different sectors, the hydropower generation sector and the water use sector including irrigation, municipalities, navigation, environment, etc. For the power generation sector, in the long run, it is desirable to release as much water as possible without letting the water level decrease very much. The share of hydropower generation in the total electricity consumption in Thailand is as much as 9 % (EGAT), so generating a lot of hydropower may also lead to a reduction in the consumption of fossil fuels such as natural gas, bunker oil or lignite, so the total production of hydropower is important. Also in the short term, the release of storage water, in such cases of regulating the capacity of hydropower generation to meet the peak load for each day, is needed. On the other hand, other water sectors including the irrigation sector request mainly stableness in the water resources management. This is a small request for the reservoir operation.

In Japan, this difference causes a conflicting relationship between the hydropower sector and the other sectors. Introducing the concept of seasonal storage requirements (SSR) generally solves this problem. In the operation of reservoirs adopting SSR, operation priority is placed on water use sectors when the water level is less than the SSR set for each reservoir.

This method can be applied to the reservoir operation in the Mae Klong river basin. The problem is the effect on the power generation. In fact, this method, when applied to Japan, puts a limitation on power generation. However, the flow regimes and the reservoir capacities are quite different in the two countries. It may be worth studying in the future.

3 Analysis of the release from the Vajiralongkorn dam

3.1 Outline of the basin water management

The record of reservoir operation at SRN and KHL up to December 1999 are presented in Figs. 1 and 2, where all the data are monthly. The inflows here indicate the net inflow (Real inflow - Evaporation from reservoir surface). Fig. 3. shows the release from the VJ dam. From these figures, we know that;

a. There has been no spilled water at SRN, while only some at KHL. This means that most of the water is released from the storage dams through power generating turbines.

b. There is a large variance in the rainy season inflow from year to year. There have been especially big inflows from 1995- 1997, which are apparently different from the inflow pattern during previous years.

c. Although the floods at SRN and KHL occurred almost in the same years, they do not always occur simultaneously. This may be because of the different rainfall sources in the SRN and KHL basins (1998, Sugiyama et al).

d. The water storage in the reservoirs largely decreased when the rainy season inflow was low for two successive years.

e. The downstream release from VJ has usually been larger than 50 CMS, which is the minimum requirement to prevent seawater intrusion in the estuary of the river (AIT, 1994).

3.2 Method of Analysis

3.2.1 "Savable Water"

There are two sources of surplus release from VJ, where water is released more than 50 CMS. One is the release from SRN and KHL, and the other is the side flow occurring between the storage dams and the VJ diversion dam. Of these, the side flow is not controllable because it is a natural discharge from the downstream area of the storage dams. However, the surplus originating from the release of the storage dams has a possibility of being saved in the reservoirs.

The authors define "Savable Water" (SW) as the portion of the discharge from the storage dams that can be decreased within the fulfillment of the minimum requirement for the downstream area of VJ. SW defined in this way is not the water that can really be saved in the reservoirs, but the water that has a technical possibility of being saved. Saving water is possible only when there is enough room in the reservoirs. Here, release requirement for hydropower generation is included in SW.

3.2.2. Identification of Savable Water

To make the situation clear, the Mae Klong river basin is divided into four blocks as shown in Figure 4. Area I consist of the catchment areas of SRN and KHL. Area □ covers all the area from where drainage water goes to the Mae Klong river upstream of VJ, including the irrigated areas. Area □ is made up of VJ and the Mae Klong irrigation projects.

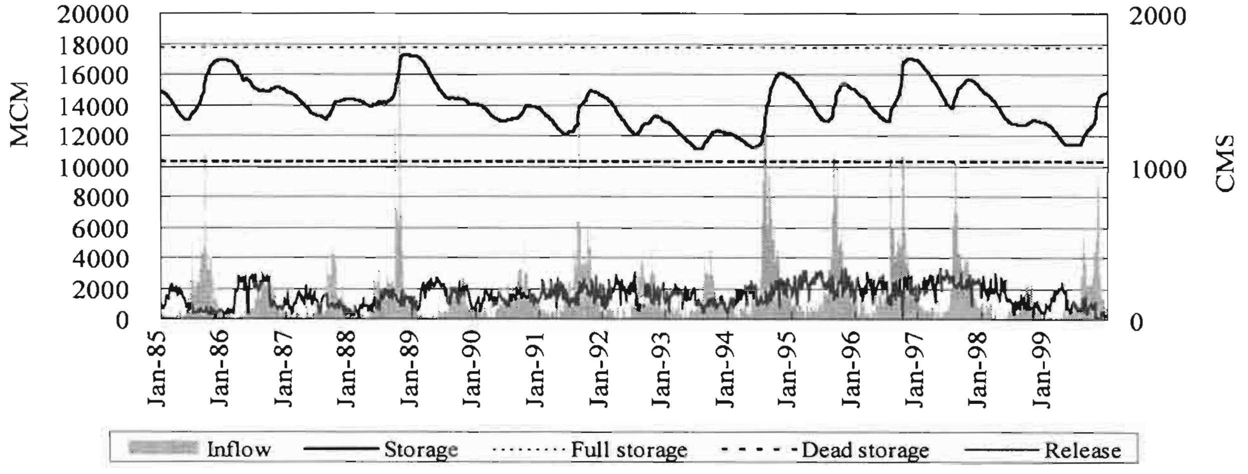


Fig. 1. Reservoir Operation Record (SRN)

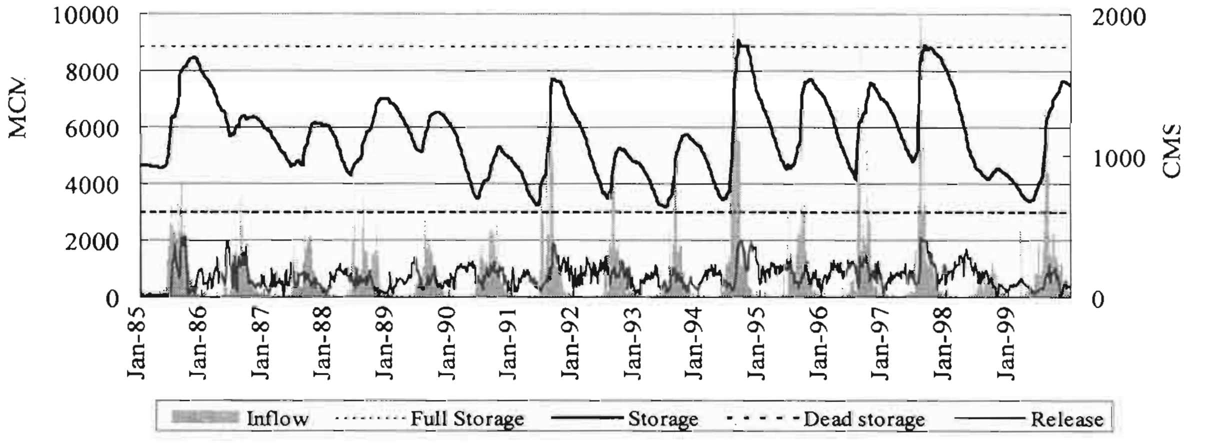


Fig. 2. Reservoir Operation Record (KHL)

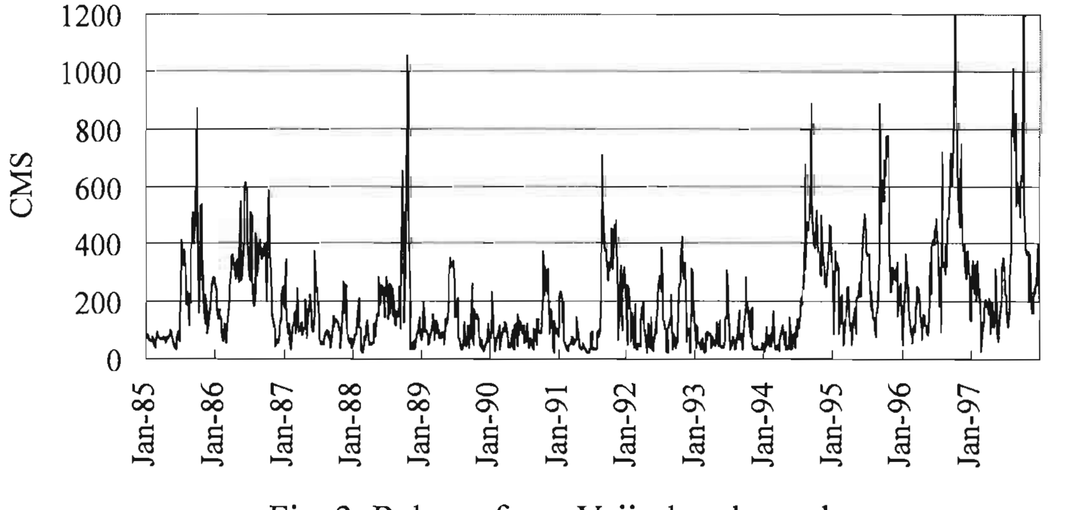


Fig. 3. Release from Vajiralongkorn dam

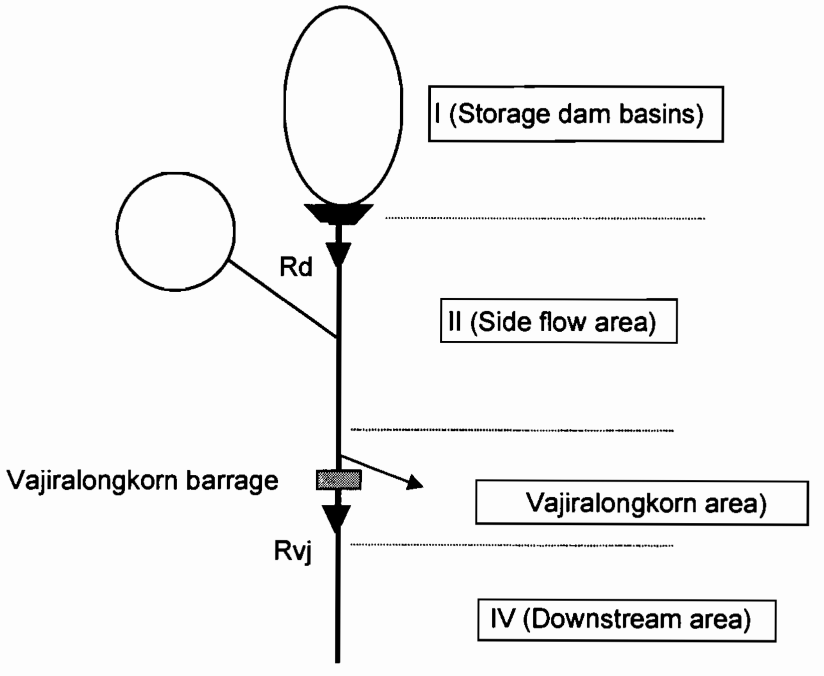


Fig. 4. Modeling of the Mae Klong River Basin

When the release from VJ exceeds 50 CMS, the surplus water at VJ is calculated as,

$Svj = Rvj - 50,$

where *Rvj* is released from VJ. If the surplus release at VJ and the release from the storage dams occur simultaneously, *SW* can be calculated by the following formula;

$SW = Min\ (Svj,\ Rd),$

where *Rd* is the sum of the release from SRN and KHL. In this case, it is simply understood that *Rd* – *SW* means the necessary release (NR) for water use sectors from the reservoirs.

3.3 Results of Analysis

The savable water identification is performed using historical data for the unit time of 5 days. The result for a part of the studied period is shown in Fig. 5, where the contribution of the side flow to the surplus release from VJ is presented for 1991- 1997. The contribution of the savable water and the side flow is summarized in Table 1, showing that 86 percent of the surplus is the result of the release from the reservoirs.

The main part of the surplus originated from the side flow during the flood season of the rainy years. The surplus release from the side flow was small during the dry years such as in 1992 to 1994. Its occurrence, of course, is dependent on the water requirement upstream of VJ as well as on the rainfall in the region. Fig. 5 indicates that the water requirement is high enough to utilize all the discharge from the side flow area during the dry seasons.

This savable water was not efficient for water use sectors and was used only for hydropower generation. The important point here is that this water existed before the dry seasons in 1993 and 1994, which caused a severe water shortage. There must be surplus water that is equivalent to the total amount of the SW because the total discharge is larger than the total water requirement in the basin. There is a possibility of avoiding water shortage by properly distributing the surplus water over the year or successive years. The question is how to distribute the surplus water under the condition that there should not be a water shortage for water use sectors or spilling water that is not used for power generation.

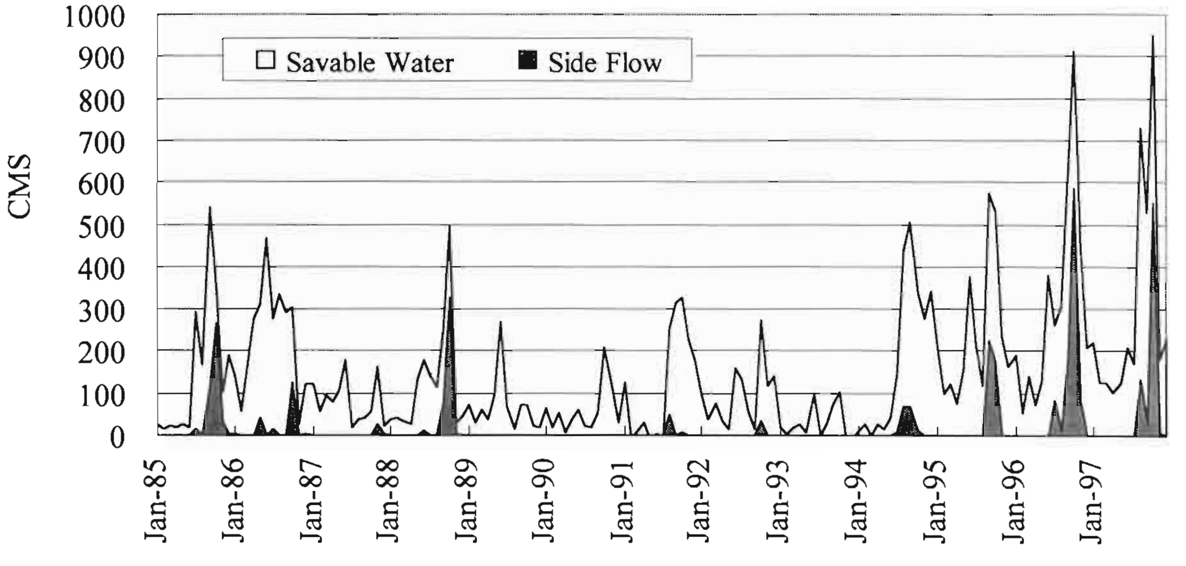


Fig. 5. Contribution of Side Flow in Surplus Release from VJ

Table 1. Origin of Surplus Release from VJ. (MCM)

Side Flow	8859	(14)
Reservoir Release	54414	(86)
Total	63273	(100)

Total volume during 1985-1997

4 New principle for reservoir operation

4.1 Proposal of Operation Principles

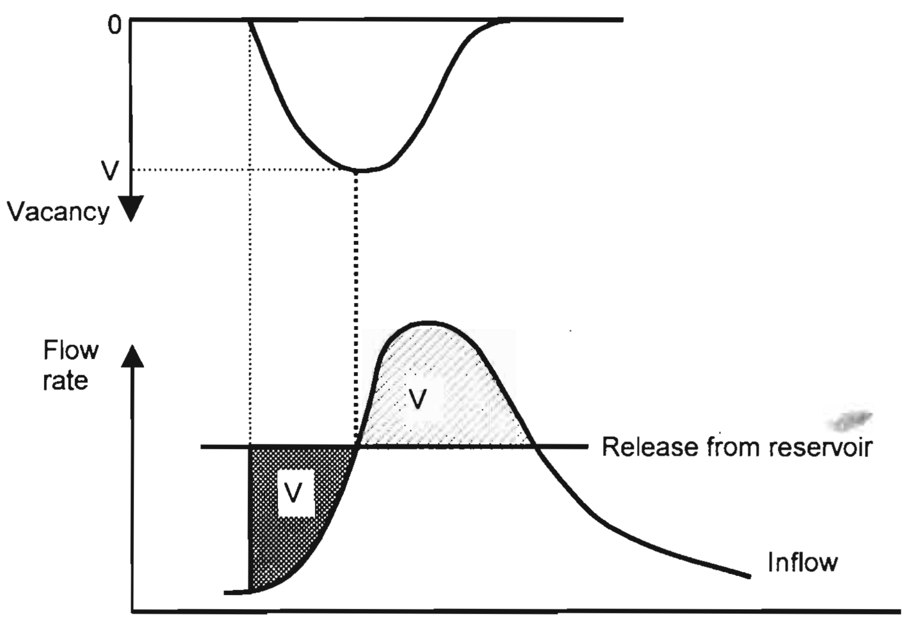
The fact that the water released from the dams includes a large amount of savable water suggests that there may be technical possibilities to improve the use of water in the reservoirs. The problem is how the surplus water should be released from the reservoirs under the condition that the water demand downstream is satisfied as well.

To discuss this possibility, the authors propose two kinds of rule curves or seasonal storage lines in the active storage. One is the "upper storage line" and the other is the "lower storage line". The "upper storage line" is to avoid the spilling of water during flood season: It is designed so that no water spillage occurs as long as the operator follows the line. The "lower storage line" is to keep enough water in the reservoir for downstream water users: It is designed so that no water shortage occurs as long as the stored water under this line is exclusively used for water users. If these two lines can be drawn apart in the reservoirs, the operator can release surplus water freely as long as the water level is between the two lines. If these lines cross each other, however, one of the sectors should be chosen as the sector that benefits prior to the other sector.

4.2 Calculation of Rule Curves

4.2.1 Upper limit/ Vacancy Requirement

A schematic explanation on the vacancy requirement to store a flood in a reservoir is shown in Fig. 6., where the vacancy requirement is *V* at the beginning of the flood time. The vacancy must be prepared through the previous release operation in advance. To gain a seasonal vacancy requirement line to store any type of flood in the past without spilling water, we should overlay the vacancy requirement lines on each day of the year, thus drawing an envelope line. This line will be developed independently for SRN and KHL.



The maximum release from each dam is decided at the maximum release for power generation, which is 255 CMS and 461 CMS for SRN and KHL, respectively, according to the record. In the determination of the flow rate at SRN, the pumping back from the Tha Thung Na reservoir is considered.

The results of the calculation for SRN and KHL are shown in Figures 7, 8 respectively.

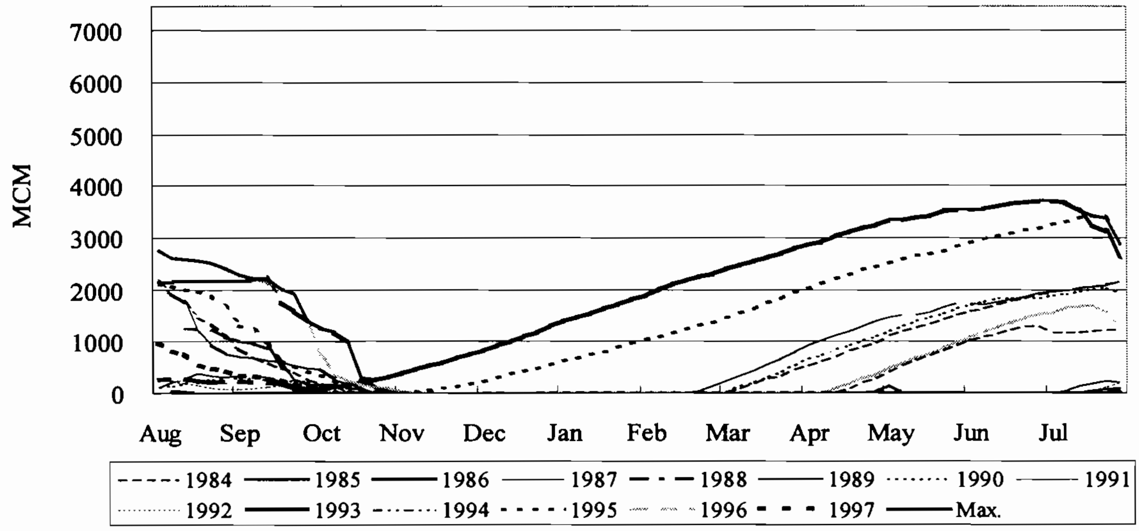


Fig. 7. Seasonal Vacancy Requirement (SRN)

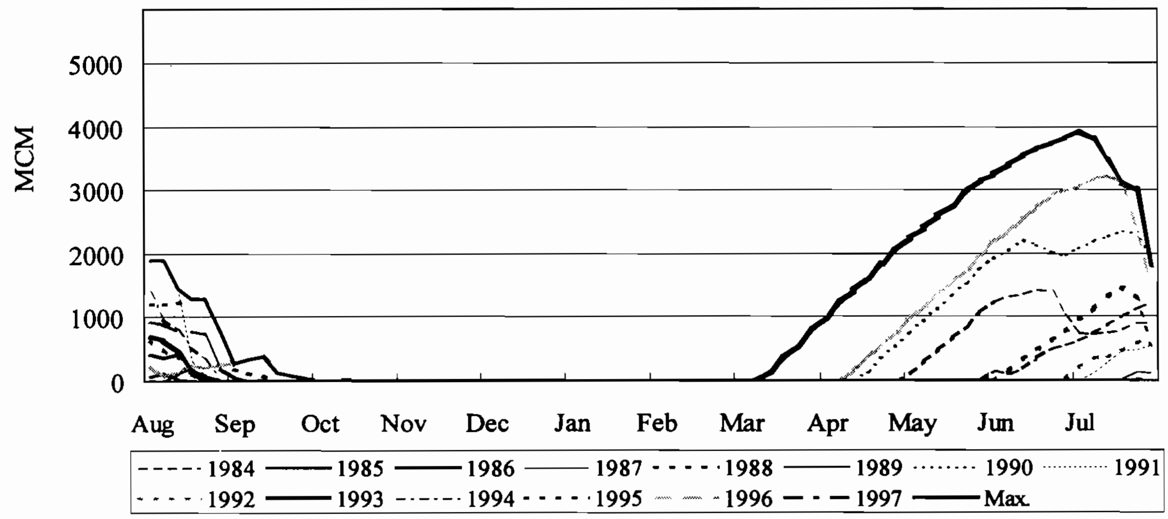


Fig. 8. Seasonal Vacancy Requirement (KHL)

4.2.2 Minimum Storage Requirement

A schematic explanation of the minimum storage requirement for a series of low flows is shown in Fig. 9, where the storage requirement for low flow regulation is W at the beginning of the low flow period. This volume of W is the minimum volume for the regulation when the release operation is subject to the water use sector. However, the water W should be stored through the storing operation in advance. The storage requirement lines determined in this way should be overlaid to draw an envelope line for the seasonal minimum vacancy line. This line assures a full water supply of any type and any magnitude of low flow that has occurred in the past.

The result of calculation for SRN and KHL is shown in Fig. 10, in which the upper limit line presenting the sum of vacancy requirements for SRN and KHL is also included.

4.2.3 Discussion on the Calculation Results

From these figures, we can say that;

1) The upper line is located above the lower line all through the year. This means that there is room for the operators to manage the storage so that both the hydropower sector and wateruse sector can be satisfied simultaneously.
2) The upper line is a guideline used to avoid spilling water in the case of a flood. Therefore, it depends on the operator as to whether he adopts the line strictly or not. However, the higher the water level he keeps, the more likely he will suffer from spilled water.
3) The lower line is a guide line to prevent water shortage for the past cases of low flow. Then, it depends on the operator as to whether he adopts the line strictly or not. However, the lower the water level he keeps, the more likely he will suffer a water shortage. It is also desirable for the hydropower sector to keep the water level above the lower line in order to get stable power generation.
4) These two lines should be adjusted or recalculated when new floods and droughts are experienced in the future.
5) An increase in the future water demands of the river system would also raise the minimum storage line.

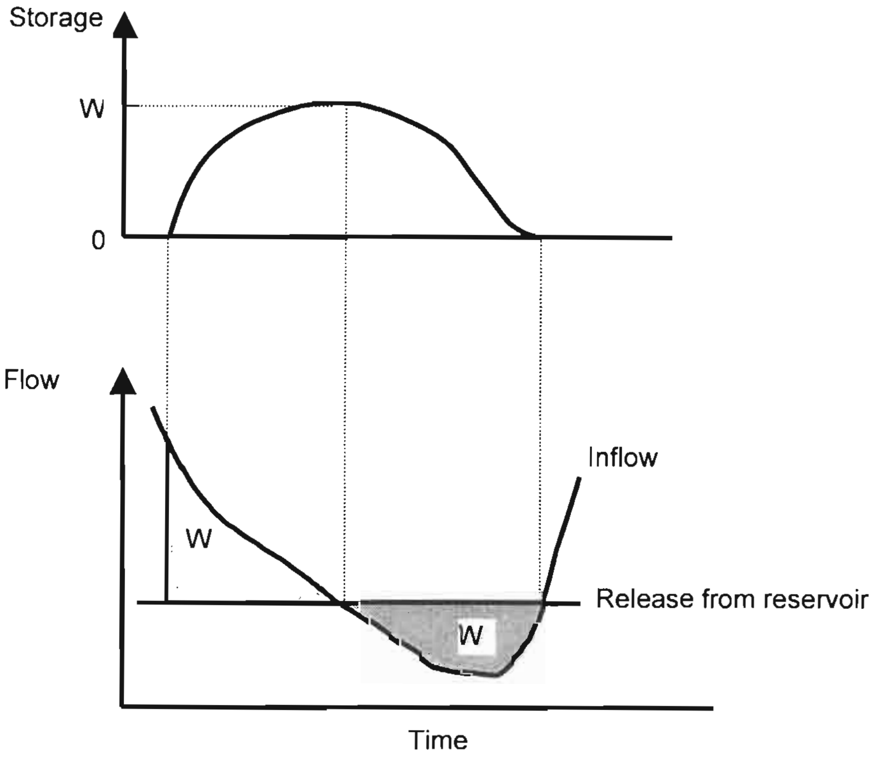


Fig. 9. Storage Requirement for Low Flow Augmentation
Storing water in advance is needed to get enough storage at the beginning of a low flow period.

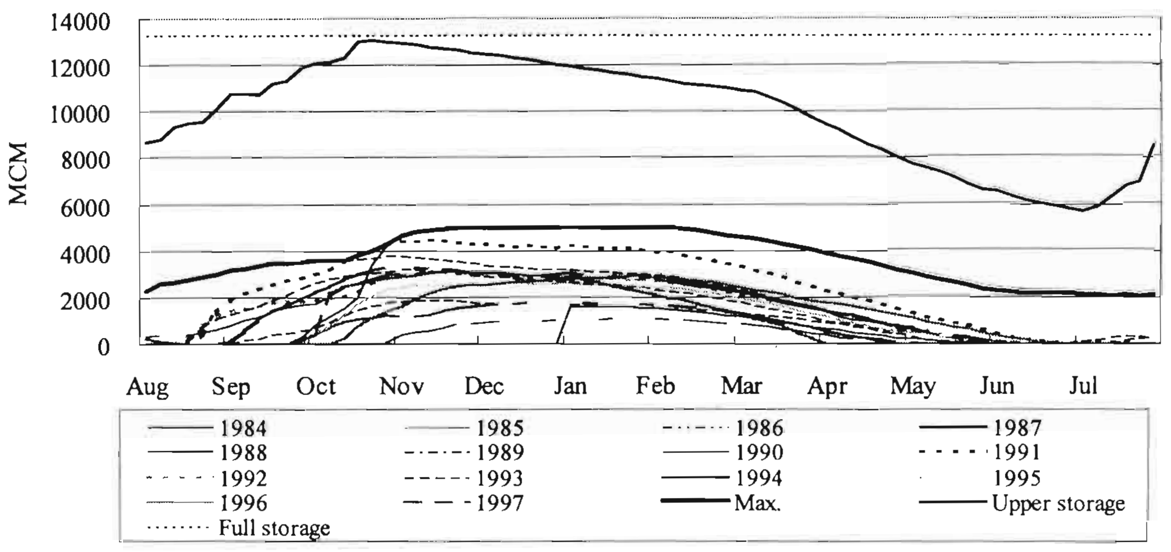


Fig.10. Seasonal Storage Requirement and the Upper line for the two reservoirs

4.3 Proposal of a new operation rule

The upper and the lower lines can be settled separately, which means that it is possible to operate the reservoir without fatal competition between the water use and hydropower sectors. For this purpose, the maximum flow rate of water should be released when the water level in each reservoir is above the upper line, so that there will not be any spilled water. On the contrary, no more than the necessary amount of water should be released when the water level is under the lower line in order to avoid a possible water shortage in the future. The operator may release water, as he wants, when the water level is between the two lines.

With regard to this operation, when the water level is between the upper and lower lines, the operator is requested to have a principle for operation. There are two alternatives. One is to keep the reservoir water level relatively low to avoid a compelled release at the maximum flow rate when the water level comes up to the upper line. However, this operation principle is accompanied with the frequent restriction of release when the water level decreases under the lower line. The other is to keep the water level higher to avoid the low flow restriction. This may also serve more for electricity yields because of a high water head. However, the operator might frequently experience water at a higher level than the upper line in this case.

The authors propose an operation rule for the reservoirs as follows;

1) The standard release of water from each reservoir should be decided according to the rate of stored water to the storage capacity at the upper line.
2) The maximum rate of water should be released from each reservoir when the water level is higher than the upper line.
3) The release from the reservoirs should be restricted to the necessary release when the stored water is less than the storage at the lower line.

5 Simulation of reservoir operation

5.1 Decision of the release from reservoirs

To discuss a reasonable rule for the standard release of water from each reservoir, we have examined the following formula for deciding the release; from the reservoir Q,

$Q = Q_{max} \times (S/S_{up})^{a}$,

where Q_{max} is the maximum release from the reservoir, S is the present storage, S_{up} is the storage at the upper line, and a is a constant. By changing a, different release patterns can be expressed.

In this study, we have adopted these cases of a equaling; 1.0, 2.0, and 3.0. Fig. 11 shows the relationship between S and Q. When $a= 1.0$, the relation is linear, and Q is larger than those in other cases at the same storage level. It will realize a relatively low water level in the reservoir. On the contrary, when $a= 3.0$, the release Q is kept lower, thus resulting in a higher water level as a whole. We should note that Sup is the storage at the upper line and it changes seasonally.

In the actual decision of the releases, two cases arise when the Q calculated by formula (1) should be adjusted;

1) When the sum of the calculated Qs is less than the necessary release (NR), the release must be increased up to the NR: each Q is increased by the same ratio of the NR to the sum of Qs.

2) When the sum of the stored water in the two reservoirs is less than the minimum storage, the sum of Qs must be reduced down to the NR: In this study, each Q was decreased by the same ratio of the NR to the sum of Qs.

The simulation was performed for the period of January 1985 to December 1997. The initial storage conditions for the reservoirs were the same as the actual ones. In this simulation, "potential energy " was estimated. The potential energy here refers to the electricity that might be produced if the turbine efficiency is 100 %, and calculated as

(Water level – Low water level) x (Released water volume) x 9.8 / 3600 (kWh)

Although we don't know the actual turbine efficiency at the different water levels, we can roughly compare the power generation abilities in the historical and simulated operations.

5.2 Results of simulation

Fig. 12 shows the results of the simulation for the total storage in the two reservoirs, in which the equations are changed for $a= 1.0, 2.0,$ and 3.0. Figs. 13 and 14 show the simulated release from each reservoir compared to the recorded ones. The major results of the simulation are summarized in Table 2.

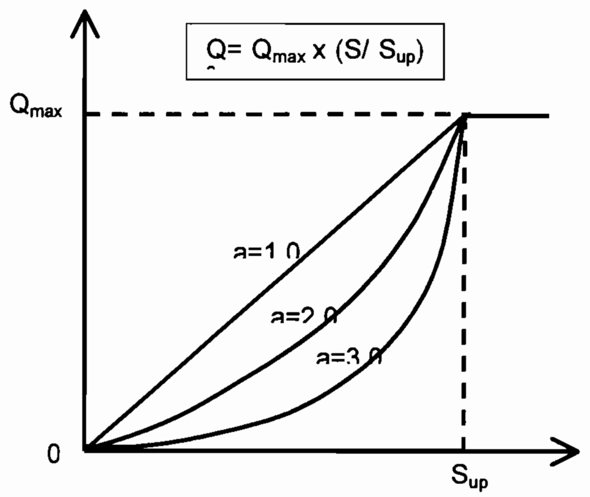


Fig. 11. The Proposed Relation between the Release and the Storage in Each Reservoir

5.3 Discussion

Storage management for water supplies

a= 1.0

Storage was relatively low throughout the period. Even during the last 4 years, when the inflow was successively high, the storage was almost always far less than the S_{up}. It decreased down to almost zero in the dry season of 1990, when the area suffered from 2 successive dry years. It should be stressed that the storage was frequently under the lower line for long periods, thus strongly limiting the use of water for power generation.

a= 2.0

Storage was relatively high throughout the period. However, the storage in the dry seasons of 1990 and 1991 went down below the lower line for 10 months in total.

a= 3.0

Storage was kept at a relatively higher level throughout the period, and only in the dry season of 1990, storage was less than the lower line for several months. The storage was almost always more than the recorded storage after 1991.

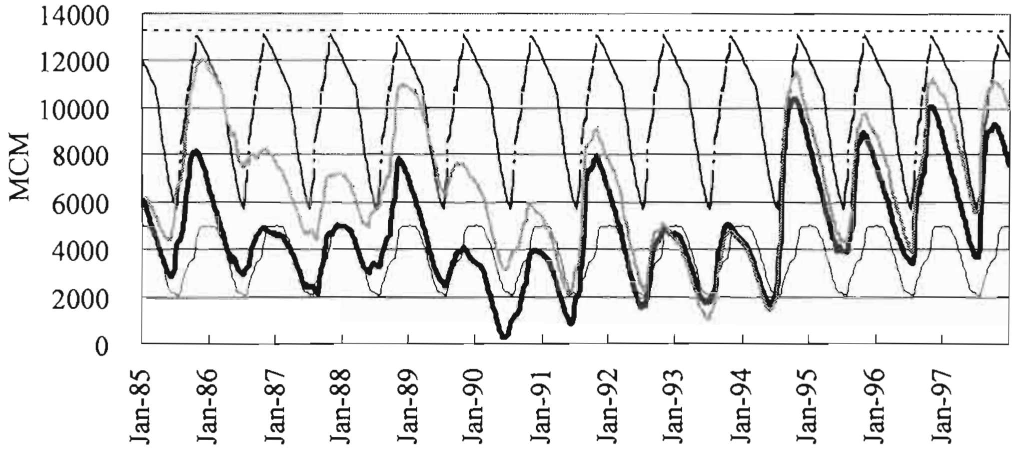
(2) Potential energy for power generation

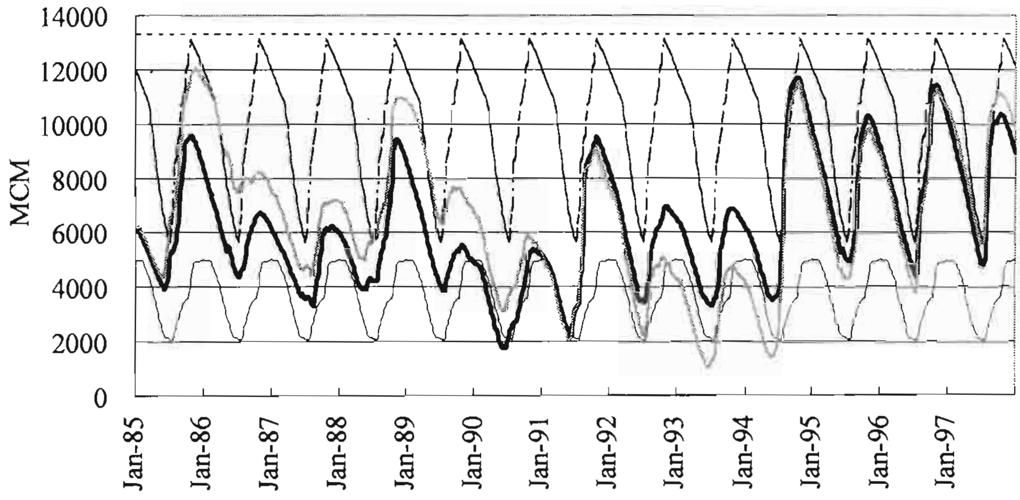
Potential energy for power generation was highest when *a= 3.0* in the equation, in which the gained power was increased by 0.6 % compared to the historical cases. On the contrary, in other cases of *a*, the potential energy was less.

(3) Release from each reservoir

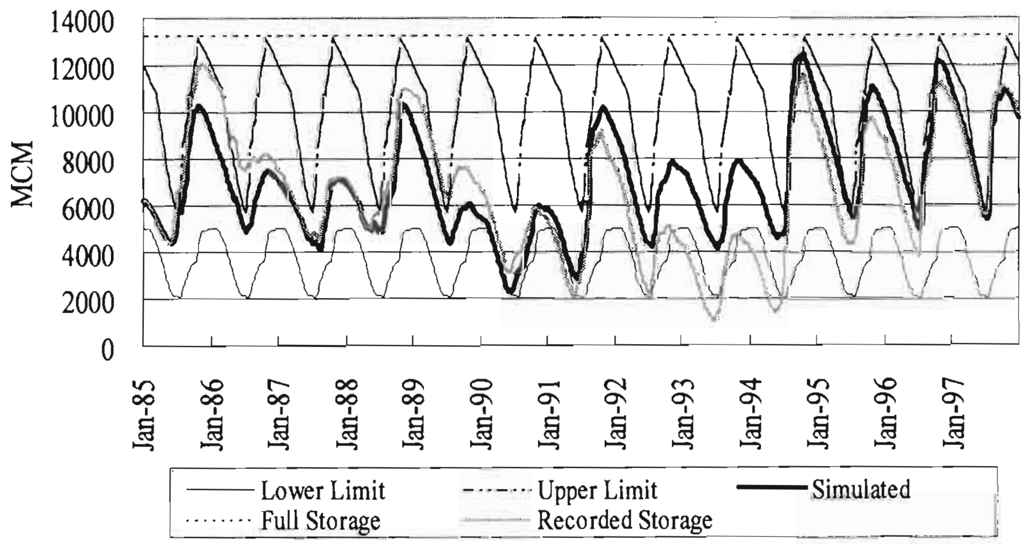
In the case of *a= 1.0*, the release is theoretically stable. However, it actually fluctuated very much by being restricted when storage frequently became less than the lower line.

In the case of *a= 3.0*, the release was limited to a small value when the water level was low, as we can see in Figure 11. It brought high fluctuation to the release, while less fluctuation was seen in the case of *a= 2.0*.



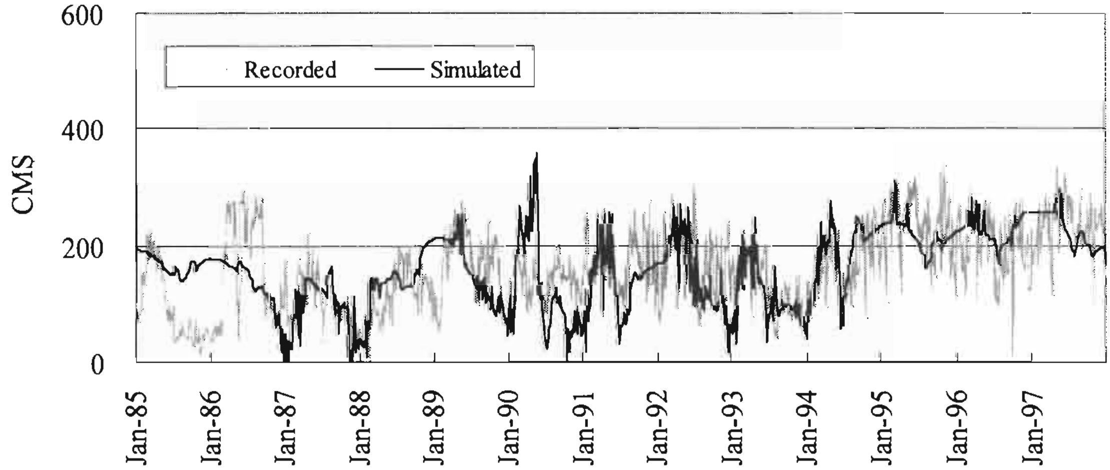


a=2.0

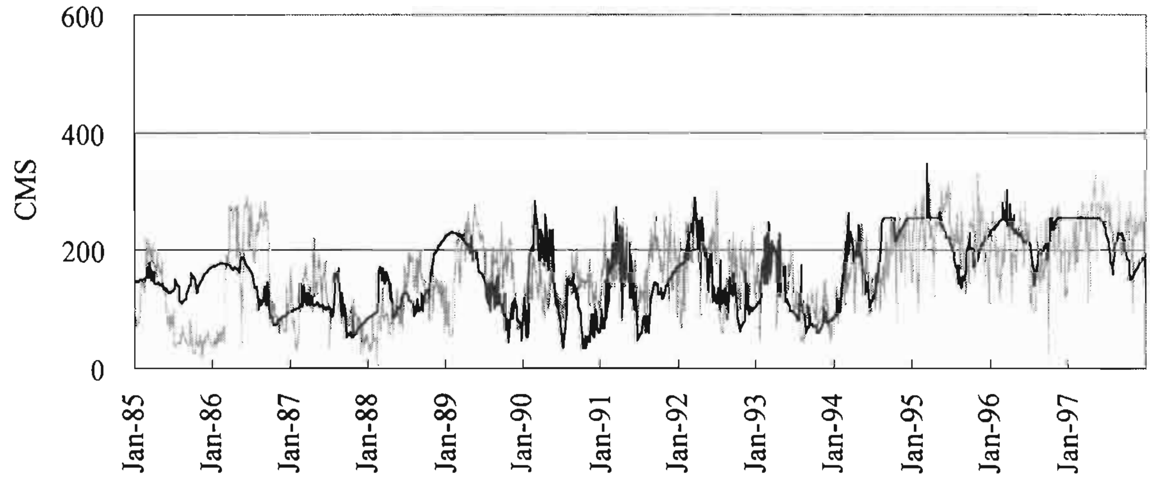


a=3.0

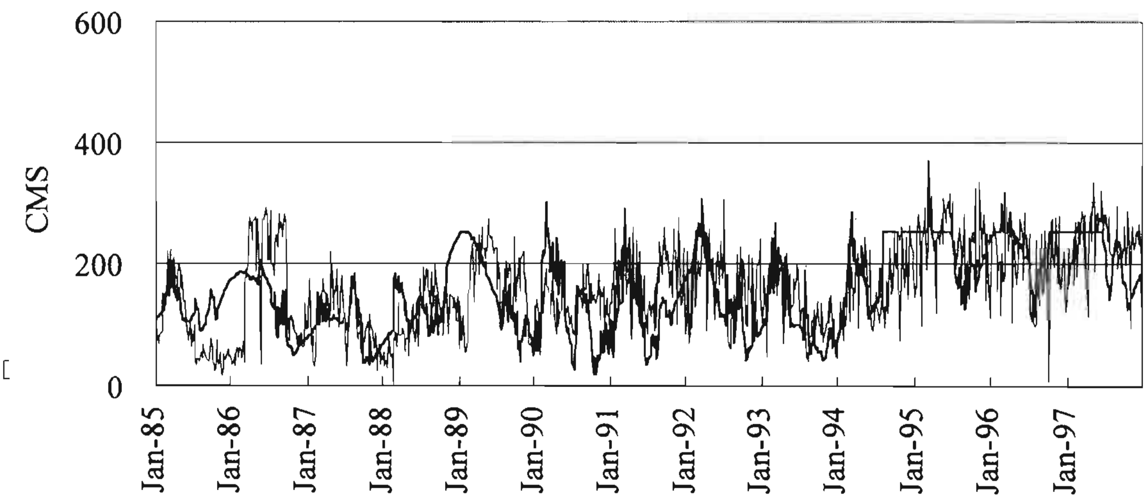
FIG. 12 SIMULATION RESULTS OF TOTAL WATER STORAGE IN THE TWO RESERVOIRS at Different *a* Values in the Proposed Rule


600
400
200
0
CMS
Recorded
Simulated
Jan-85
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97

a=1.0


600
400
200
0
CMS
Jan-85
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97

a=2.0


600
400
200
0
CMS
Jan-85
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97

a=3.0

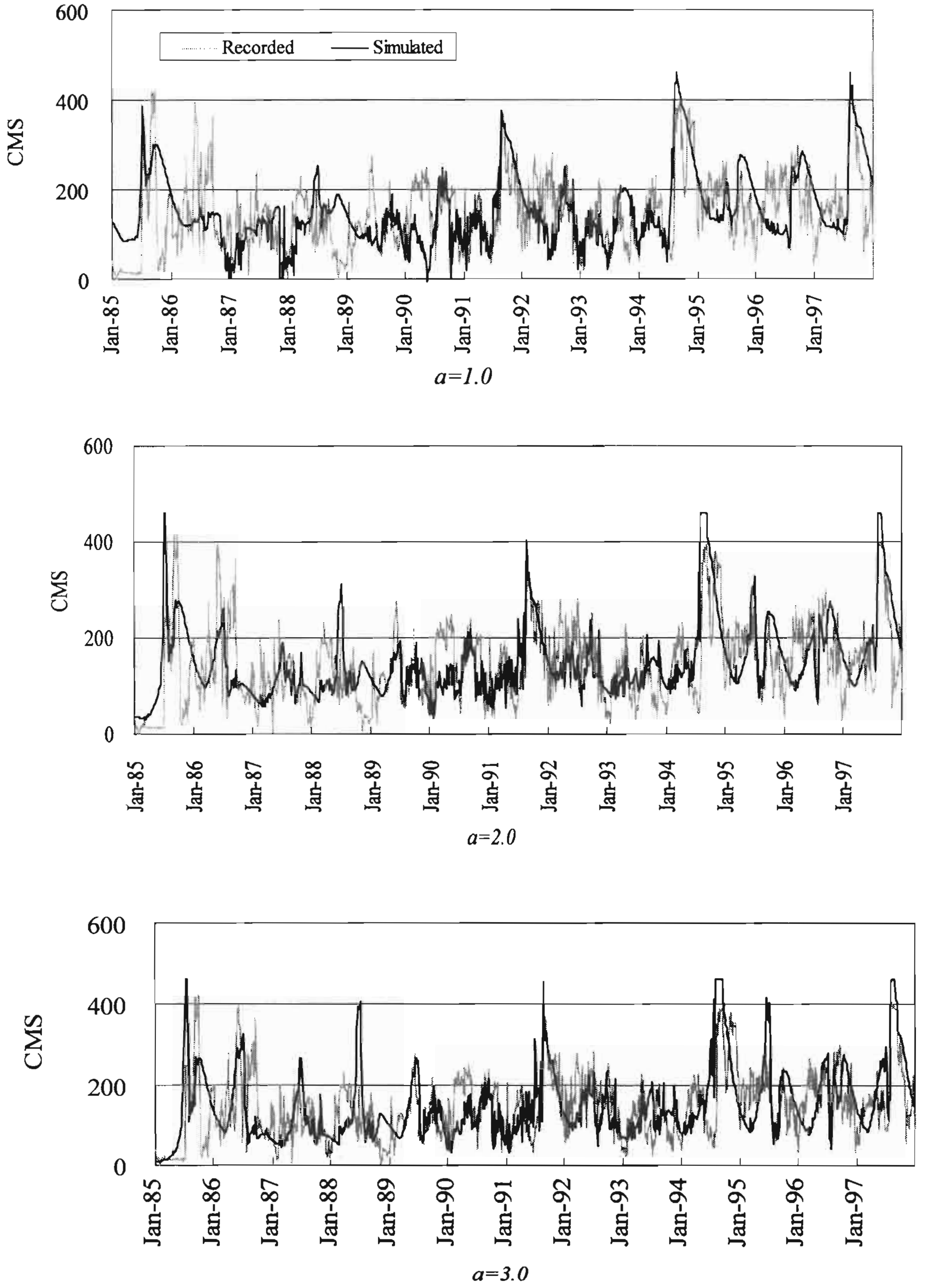


FIG. 14. SIMULATED RELEASE FROM KHL DAM AT DIFFERENT A VALUES.

(4) Overall evaluation

The proposed operation rule could realize the successful regulation of low flow, with no special damage to the power generation sector, especially in the case of *a*= *2.0* and *3.0*.

We can understand that the operator can decide only how the surplus water should be released in addition to the necessary releases. Under this condition, the power generation sector can select any kind of rule. However, the cases of *a*= *2.0* and *3.0* seemed to be most acceptable.

6 Conclusions

(1) Serious water shortages in 1993 and 1994 in the Mae Klong River Basin were brought about not by an absolute water deficiency in the basin but by the improper distribution of excessive water over the years.

(2) The upper and the lower storage lines, which are set in an active storage area to avoid spilling during the flood season and to prevent water shortage during the dry season, respectively, were drawn apart in the two reservoirs in the basin. This shows that the conflict between the water use sectors and the hydropower generation sector does not basically exist.

(3) The proposed rule was proved by simulation to be effective in fulfilling different requests from both the water use sector and the power generation sector.

(4) The upper and the lower lines should be adjusted for new types of floods and droughts in the future, as well as to the changes in water demand. The water demand for the power generation sector should also be considered.

(5) The proposed rule for release is to provide guidelines for the operation of the reservoir. The decisions on the daily release may be made according to the daily water requirements for the power generation. In the daily operation, the traveling time to the point where the water is needed should be properly considered.

Table 3. Summary of Simulation

		Recorded	*a=1.0*	*a=2.0*	*a=3.0*
Spilled water 10^9 m^3	SRN	0	0	0	0
	KHL	0.515	0	0	17.4
Total power generation capacity * 10^{10} kWh	Total	3.301	3.263	3.308	3.321
		(1.0000)	(0.9885)	(1.0021)	(1.0061)

References

Asian Institute of Technology (1994) *Study of Potential Development of Water Resources in the Mae Klong River Basin*, Office of the National Economic and Social Development Board

Vudhivanich Budhivanich, Sittiporn Ngernprasertsri (1998) *Existing Rules for Operation of Stinagarind and Khao Laem Reservoirs and their Effects on Water Management of Mae Klong Irrigation System*, Workshop in Sustainable Development of Agriculture Infrastructure and Organizational Management of Chao Phraya and Mae Klong Basins

Shinzawa, Kagato (1962) kasen Suiri Chouseiron (in Japanese), < Adjustment of Water Users Conflicts in River Systems >□511 pp., Iwanami Shoten, Publishers

Shinzawa, Kagato and Masami Okamoto (1985), Tonegawa No Suiri (in japanese), <Development and Management of Tone River System >, 276 pp., Iwanami Shoten, Publishers

Sugiyama, Hironobu, V. Budhivanich, Sittiporn Ngernprasetsri and Koit Lorsiriat (1998) Proceedings of the Workshop on Sustainable Development of Agricultural Infrastructure and Organizational Management of Chao Phraya and Mae Klong Basins, Kasetsart University and University of Tsukuba

The role of Information for Improved Irrigation in the Phitsanuloke Irrigation Project: Implication for the Chao-Phraya Basin

Gideon Oron[1], Rainer Loof[2], Armin Rieser[3], Sirpong Hungspreug[4], Daniel Greenwald[5], Sabine Höynck[3], Chawee Wongprasittiporn[2], Md. Mainnuddin[2]

Abstract: *Improved operation of water and irrigation systems towards maximizing agricultural productivity can be obtained upon adequate decision making procedures. Reasonable s are made upon having the relevant information allowing to make the best selection among several alternatives.*

Water for irrigation in the Phitsanuloke Irrigation Project (PIP) is based supply via the canal system and local wells owned and operated by the farmers, primarily for rice growth. Having the information related to water supply vs demand and the farmers' needs in regards to water can enhance better operation and increasing agricultural productivity. A survey conducted in the PIP regions during last years indicates possible directions for improvements. The lessons learned form the PIP can be expanded to other regions such as the Chao-Phraya Basin.

1 Introduction

Application of water for cultivating of lands has been a common practice in Thailand for many years. The water, which originates from the northern mountains of the country and is stored in multi-purpose reservoirs and artificial lakes and subsequently is released and conducted in an open canal system for irrigation of the agricultural fields. The water is delivered via a reducing in size capacity branched open canal system until the very end of the last cultivated fields. The water is conducted to the cultivated fields by gravity flow and with supplementary support of small capacity pumps. These pumps, commonly owned by the farmers, are usually lifting the water up to a maximal height of approximately three meters and subsequently the water is released into an additional branched local canal. The

[1] Ben-Gurion University of the Negev, Beer-Sheva 84105 Israel (corresponding author)

[2] Irrigation Engineering and Management Program (IREM), School of Civil Engineering, Asian Institute of Technology, Klong Luang, Pathumthani 12120, Thailand

[3] Water and Agriculture, RFW Universitat Bonn, Nussallee 1,D-5300 Bonn 1, Germany

[4] RID, Project Planning Division, Samsen Road, Bangkok 10300, Thailand

[5] The faculty for Agriculture, The Hebrew University, Rechovot 76100, Israel

pumps are usually operated by a small tractor engine that under conventional conditions also serves as the main vehicle for transportation in the cultivated areas.

Main crop is still paddy that is cultivated twice a year during the dry and wet seasons (Yamazaki, 1992). Other crops (small percentages) include a variety of vegetables, soybeans and, fruit orchards (Anukularmphai, 1996). According to the Royal Irrigation Department (RID) of the Kingdom of Thailand the dry season begins around February and lasts around four months. The wet season begins around August and lasts up to five months.

The Phitsanuloke Irrigation Project (PIP) is located at the north most extremity of the central plain and is typically an agricultural region which is producing primarily rice. Water is supplied form the main canal system and local wells. The canal water is mainly obtained via the Nan River, which originates in the Doi Ohu Wae in the Luang Phra Bang mountain range. The Nan River is around 650 km long and the related basin size is around 33,130 km^2. Several dams (e.g. Naresuan and Sirikit dams) with large water capacities allow to control water delivery for irrigation via the branched canal system. The Nan and Ping rivers merge to form the main water source for the down stream Chao-Phraya river (Figure 1).

The PIP consists of three sub projects. (i) The most northern Plai-Chumphol (PC) sub-project. consisting of 273,000 Rai (one Rai is approximately 0.16 ha) of which around 218,000 Rai are irrigated. The project is divided into 7 zones (with 7 checks on the main canal). Water is supplied form the Naresuan Diversion Dam. The area is protected from floods from the Yom River by a parallel dike. Water is supplied continuously during the wet season and intermittently during the dry season. (ii) The central Dong-Setti (DS) sub-project, which consists of two main regions located in the central region between the Yom River and Nan River. Total irrigated area is approximately 186,000 Rai. The central Dong-Setti sub-project is not included in this work. (iii) The southern Tha-Bua (TB) sub-project that consists of about 168,000 Rai, which are regularly irrigated. Since this region is at the tail of PIP, water supply frequently is less regular and sometimes the farmers have to come-up with alternative solutions. Intense research efforts should be focused on this sub-project, mainly due the relative location in the entire water system.

Water supply for irrigation depends primarily on the growing season. Customarily, during the wet season water is provided for irrigation without restrictions. The situation is different during the dry season: subject to the conditions, when temporary water shortage situations come forth. The temporary water shortage forces the farmers to find alternative solutions or/and to delay the beginning of irrigation and to adjust the application regime to water availability.

Water allocation to the farmers is controlled by the zonemen in the different regions. The zoneman is actually the closet link between the water consumers and the water supply authorities, namely the Royal Irrigation Department (RID) of the Kingdom of Thailand. The canal system, subject to reliability of supply is classified into Good Operated Canals (GOC) and Poor Operated Canals (POC). This comparison is required since it might explain under some circumstances the need to have also the on-farm wells.

On farm water is required for three main purposes: (i) pre-irrigation to prepare the fields for the main growing season; (ii) water application for regular irrigation, and; (iii) to apply water when supply via the main canal system is insufficient. Most of the areas are irrigated by open-surface methods, namely furrow and basin irrigation which is the conventional practice for paddy.

2 The inspiration for the work

During water shortage periods and other unexpected circumstances of water scarcity the farmers dig out shallow wells on their farms. The wells reach a depth of around 20 meters. The on-farm local wells allow the farmers to pump water whenever water is needed on their farms in addition to the supply via the main canal system. The water pumped is mainly consumed during inadequate supply from the main canal system or serves as complementary quota to complete the crops requirements. Frequently the wells are operated with the engine of the small tractors used also for conventional travel, transportation on the farm and for cultivation. Control of the pumpage is usually by the family people (mainly wife) who stay most of the time on the farm.

Operation of the on-farm wells varies seasonally. The wells are primarily operated during the dry season (February to June). However, under specific circumstances the wells are also operated during the wet season (August to November).

The central water authorities of the Kingdom of Thailand have difficulties in controlling the number of wells per farm nor the amounts pumped and the related water quality. Most of the information regarding the wells is scarce. The lack of information holds both for the irrigation season and duration of operation. It was assessed that most of the time the wells are operated during the dry season. However, at the beginning of the study (1995) it was soon realized that the wells are operated during both seasons. The water from the wells is even used as part of the field preparation procedure. That was also true for the last years (1995 and 1996; 2538 and 2539, respectively), when the beginning of operating the main canal system was delayed due to technical damages in the canals due to extreme high floods.

The main purpose of this work is to determine the effectiveness of water supply via the main canal system and the need for on-farm wells use. The use of the water wells refers primarily to the farm characteristics, location along the canal system, pattern of crops, amounts and water quality, growing season and other factors, which might affect the wells operation. The specific objectives of this project are:

1) Quantifying the number of wells per farm considering the farm size and crop pattern.

2) Assessing the amounts of water pumped as related to the season and crop pattern, wells per farm considering the farm size.

3) Finding the main triggers and considerations in digging and operating the on-farm pumps.

4) Only farmers who have paddy fields were included in the analysis.

TABLE 1. NUMBER OF FARMERS AND REPRESENTATIVE AREAS SAMPLED IN THE COMMAND SITES

Sub-project	Perfor-mance level	Canal No.	No. of farmers sampled	Acreage sampled in Wet season 1995, rai	Acreage sampled in dry season 1996, rai	Total area in the project, rai*	Percent sampled out of total area
Phai–Chumphol	Good	5	37	516	507	9059	5.6
	Moderate	17, 18	65	1101	993	5362	18.5
Dong-Setthi	Good	67	30	725	725	17946	4.0
	Poor	45, 58	58	1253	1167	4174	28.0
Tha-Bua	Good	90, 91	29	913	846	4492	18.8
	Poor	106	24	745	722	6421	11.2

* - one Rai is equivalent to 0.16 hectare.

3 Materials and methods

3.1 General

The field study was conducted in Phitsanuloke Irrigation Project. All observed fields are located between the Yom River and the Nan River. Water is primarily supplied via the Sirikat Dam, subsequently the Nan River and canal C-1 (Figure 1). Three complementary modes were adapted for evaluating the use of the alternative water sources:

1) Field interviews with farmers regarding their water use habits and equipment. Analysis of the results using the relevant water supply parameters was continued (Table 1).

2) Assessing crop water requirements before the activation of the main canal system. These calculations are based on crop requirements and historical RID cropping reports.

3) Detailed monitoring of on farm water use and quality (mainly salinity) during the various seasons. This approach had some drawbacks and the information obtained was frequently incoherent.

3.2 On-farm well monitoring in the command sites

In order to have better prospect of the water application practice and performance a detailed survey of the on-farm wells was conducted. It included detailed survey of several on farm wells in each sub-project, partially with the assistance and full cooperation of the farm owners and the irrigation authorities. The survey was conducted in several villages in the command PIP site. Despite the extent use of the alternative waters and its influence on the water consumption efficiency and ability of farmers to cope with water stress conditions, only limited work was accomplished in command site. During 1993 (2536), following a long drought, a tube wells survey was conducted as part of a government program to financially support the drilling of 50,000 tube wells in the Chao-Phraya basin. Unfortunately, the survey was executed several municipal districts and as the PIP is included, it turned out too difficult to determine which of these wells are located in the PIP.

Several parameters were identified and used in order to assess the performance of the water systems, primarily for agricultural irrigation. Quantification of the parameters allows to compare the water delivery systems efficiency, regarding amounts, timing and location.

1) The number of wells per farm represents the option of using ground water however, do not indicate actual use, which varies and is determined by local and individual needs.

2) The lifetime of tube wells is a parameter indicating ground water use as on overall indicator of development of the area.

3) Distribution of wells per acreage. The large variety of farm size requires a parameter that overcomes these differences. In this calculation (number of wells per farm and/or farm size) it is assumed that the water used from the wells can be distributed between all the farm plots on a single farm. The density of the wells is proportional to the ability to use ground water.

4) Total time use of wells. Duration of the tube wells operation consists of the use during field preparation and along the irrigation season. The information compiled during the interviews refers to the days of use and subsequently implication regarding the farm acreage (Rai). It is assumed that the water was used for all the plots equally. The discharge of the well pumps varies from 30 m^3/h to 60 m^3/h, depending on the pump capacity, engine characteristics and hydraulic conditions. The number of pumping hours per day was not observed, however, discussing the matter with farmers many of them pointed-out that the pumps run continuously except for short fueling breaks.

5) Wells dry-up and/or recovery during the season. Retaining on farm well does not necessarily mean that water is available for pumping all throughout the entire season. Well drying is commonly an indication that the water table has decreased to a level that is beyond the withdrawal feasibility of the specific pump (approximately 10 m). The recovery of the well indicates that the decline in the groundwater table level is a short-term phenomena that probably occurred due to over depletion of ground water in adjacent areas.

6) The number of mobile pumps per farm. There are two types of pumps widely used in the PIP. Fixed tube well pumps and mobile multi-purpose field pumps. Typical discharge of the mobile pumps is around 100 m^3/h, depending on the specification (diameter & length), the engine and the elevation, which is commonly up to three meters above the surface level of the water source. This type of pumps is used for many purposes.

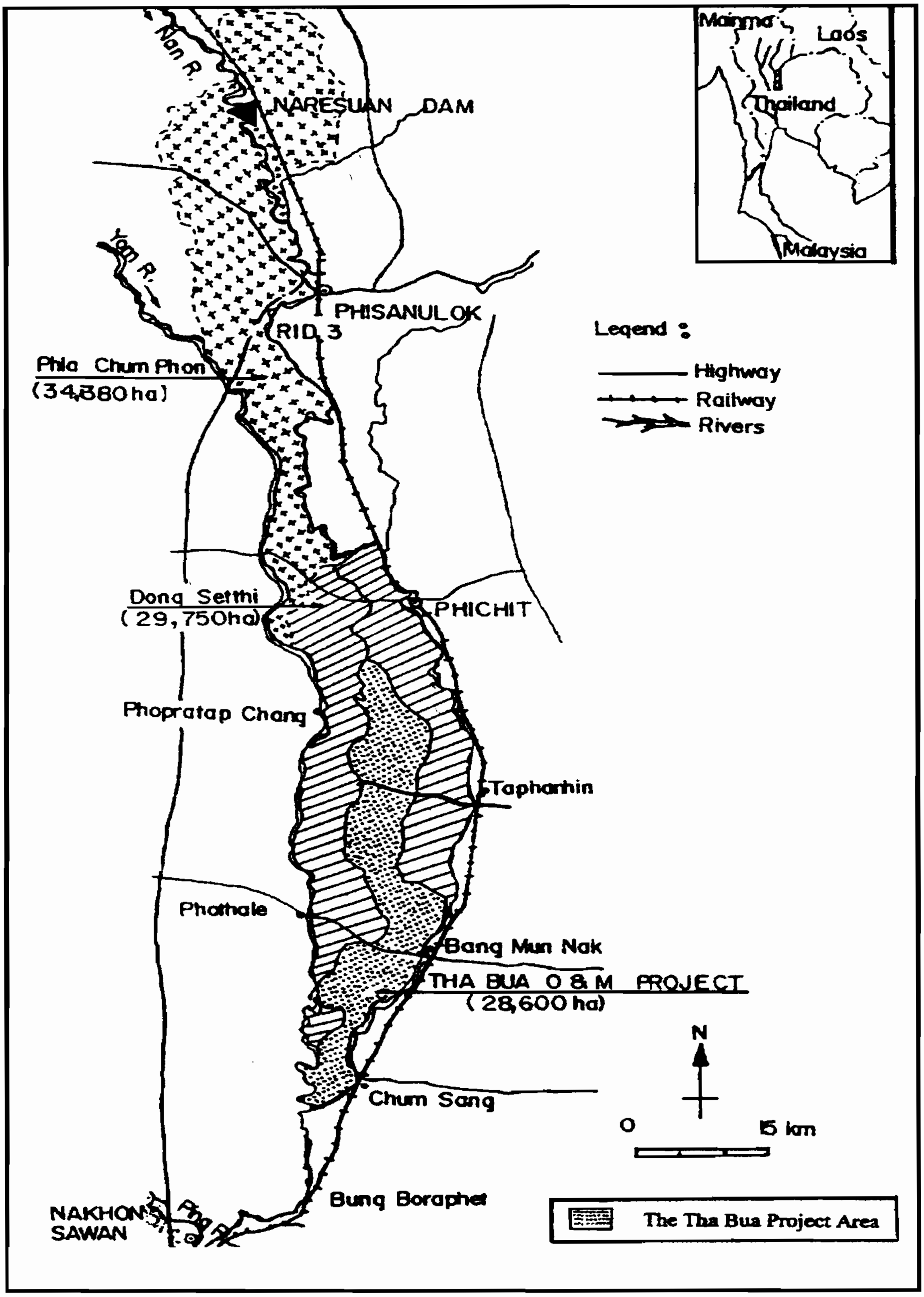


Figure 1. The overall Phitsanulok Irrigation Project, Thailand

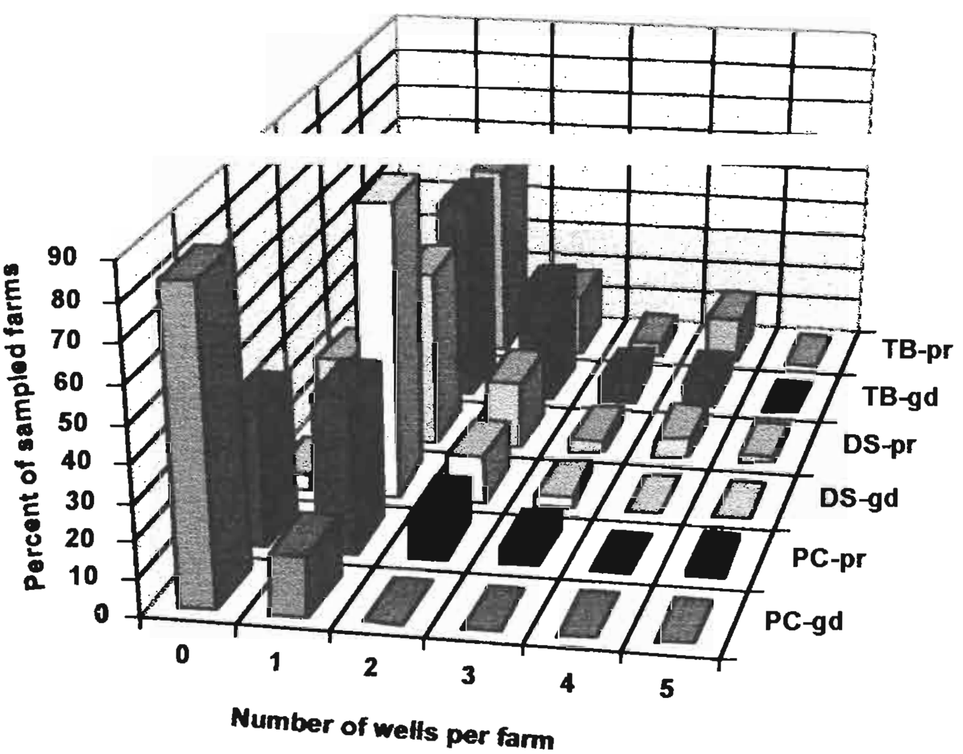


FIGURE 2. NUMBER OF WELLS PER FARM (PC - PHLAI-CHUMPHOL; DS - DONG-SETTHI; TB - THA-BUA; GD - GOOD OPERATING CANALS; PR-POOR OPERATING CANALS)

4 Results

4.1 The wells layout

The presented analysis reflects the analysis of the survey conducted during the last years. Part of the results can be further interpreted into practical solutions to be implemented in other regions as well. The relatively low number of wells observed in Phlai-Chumphol is probably due to inappropriate hydraulic conditions in the region. The information provided includes the number of wells per farm (Figure 2), number of wells per unit area (Figure 3), wells depth (Figure 4) and lifetime of tube wells (Figure 5). Commonly, most of the farms have up to two on-farm wells. A greater number of wells can be identified primarily in the regions which are subject to dry conditions, namely in the poor operated canals and in Tha-Bua. The implication of this finding is the mean number of pumps per Rai which is commonly up to 0.08 pumps per Rai. The prevailing wells depth is in the range of 20 to 30 meters (Figure 4).

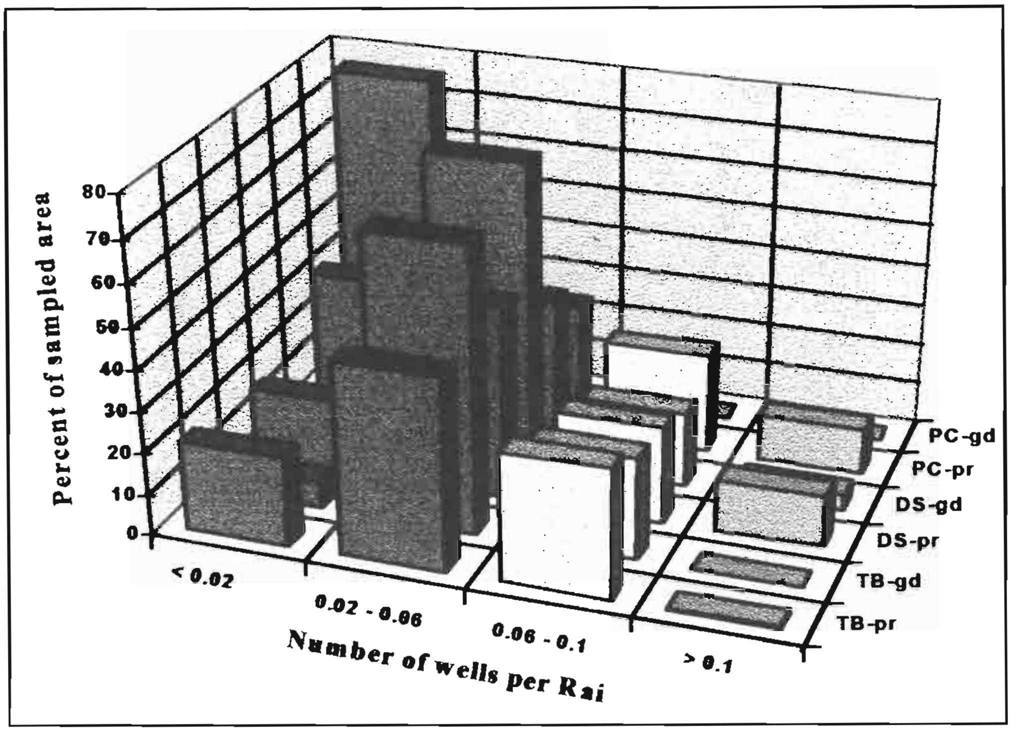


FIGURE 3. WELLS DISTRIBUTION IN THE VARIOUS AREAS(PC - PHLAI-CHUMPHOL; DS - DONG-SETTHI; TB - THA-BUA; GD - GOOD OPERATING CANALS; PR-POOR OPERATING CANALS)

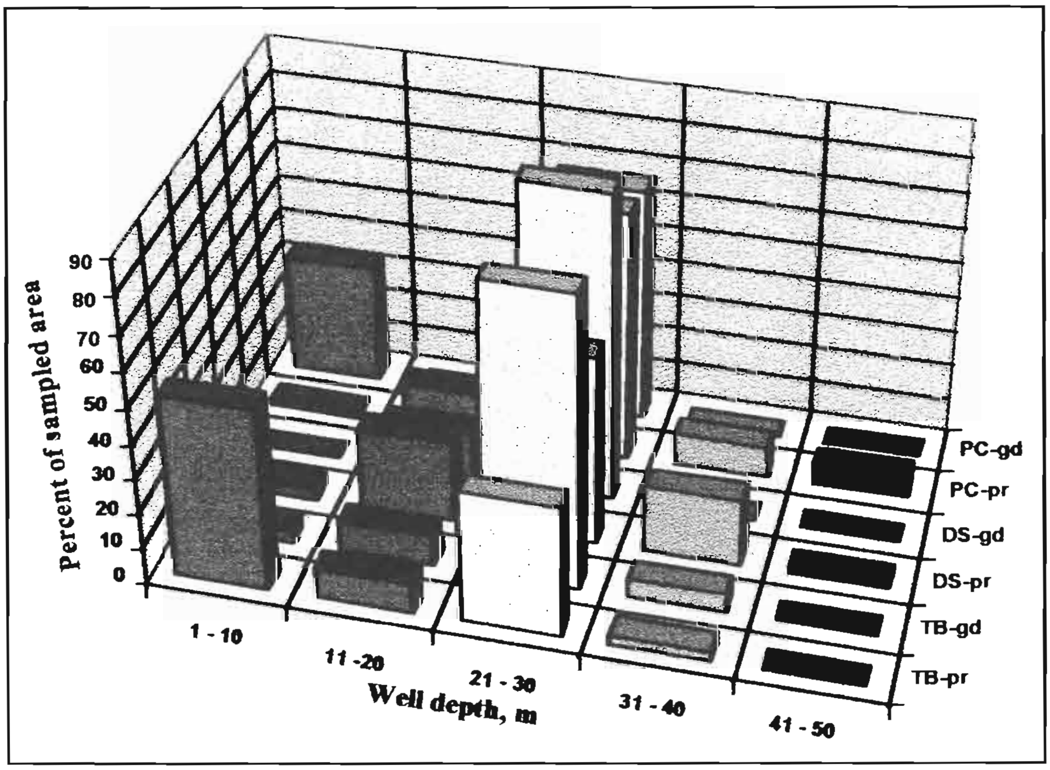


FIGURE 4. VARIATION OF WELLS DEPTH IN THE COMMAND SITES (PC - PHLAI-CHUMPHOL; DS - DONG-SETTHI; TB - THA-BUA; GD - GOOD OPERATING CANALS; PR-POOR OPERATING CANALS)

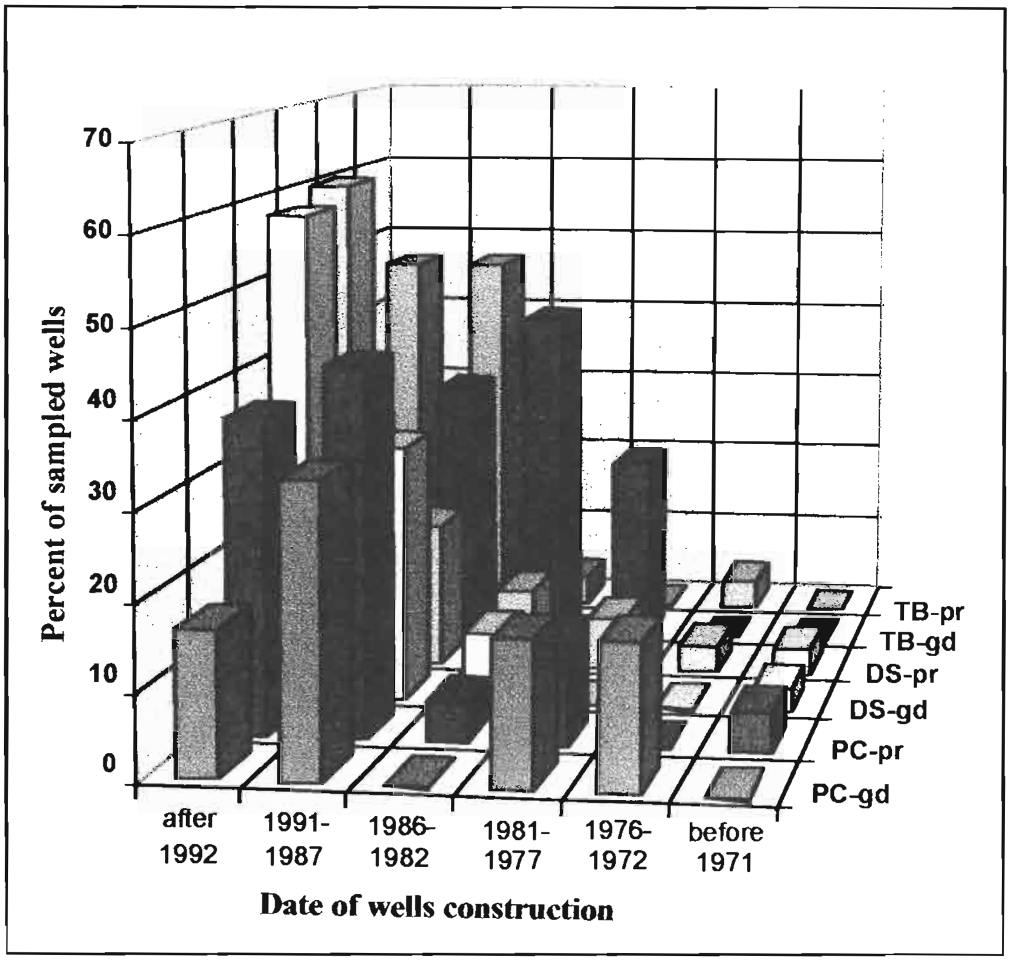


FIGURE 5. LIFETIME OF TUB WELLS (PC - PHLAI-CHUMPHOL; DS - DONG-SETTHI; TB - THA-BUA; GD - GOOD OPERATING CANALS; PR-POOR OPERATING CANALS)

4.2 Wells operation characteristics

Many of the permanent wells are dried-up during the dry season. Consequently, the mobile pumps are used intensively, which emphasizes the burden on the whole system. This finding was also concluded from the survey namely, the farmers are gradually installing new tub wells in order to increase the flexibility to supply water. The largest number of the pumps in all regions was installed after 1987. The number of dried-up wells during the wet 1995 season was small however, large during the dry season for 1996. The incompatible picture can be detected for the number of recovered wells: a large number for the wet 1995 season and a negligible number of pumps were recovered during the 1996 wet season.

Duration of the wells operation in Dong-Setthi region is intermittently between the Phlai-Chumpol and Tha-Bua regions. Duration of wells operation in Tha-Bua region is naturally the longest among all regions (Figure 6). That phenomena is mainly typical for the 1996 dry season and even for the poor operation canal region of Phlai-Chumpol (Figure 7). The inferior conditions in Tha-Bua region are also reflected by hourly operation of the wells (Figure 8).

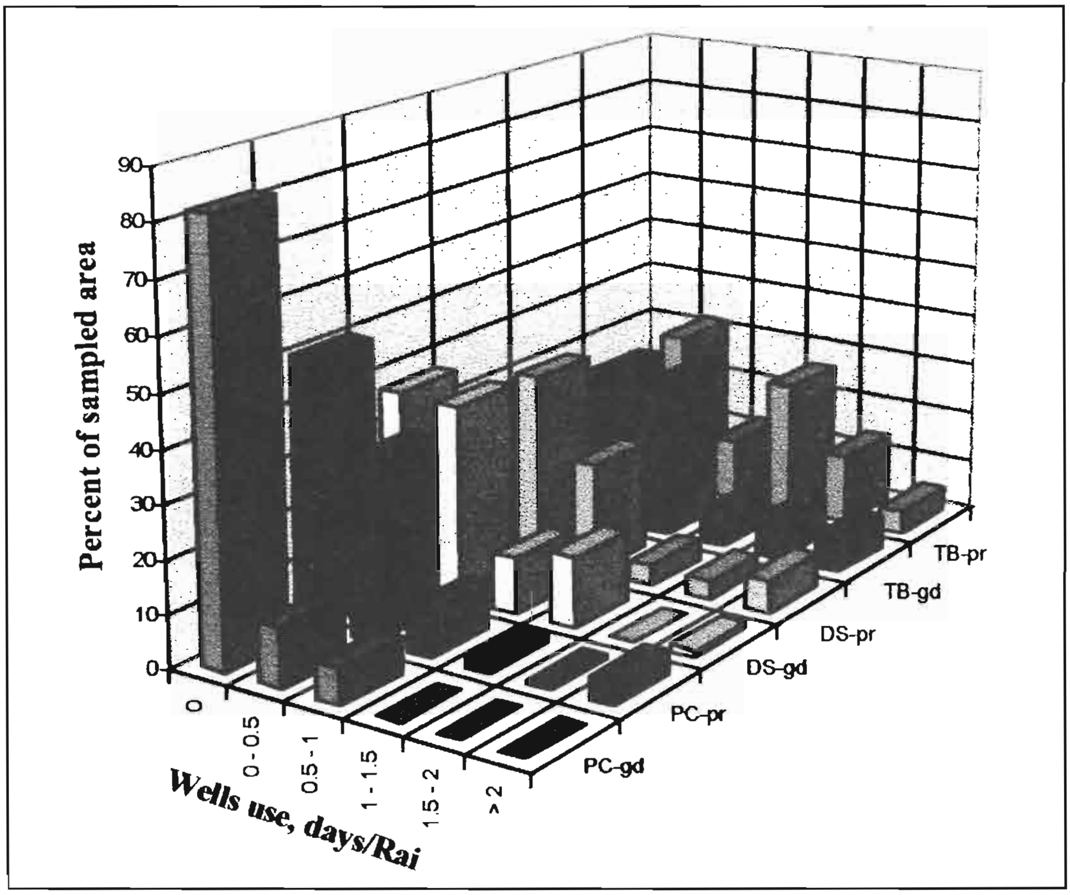


FIGURE 6. USE OF WELLS DURING WET SEASON, 1995

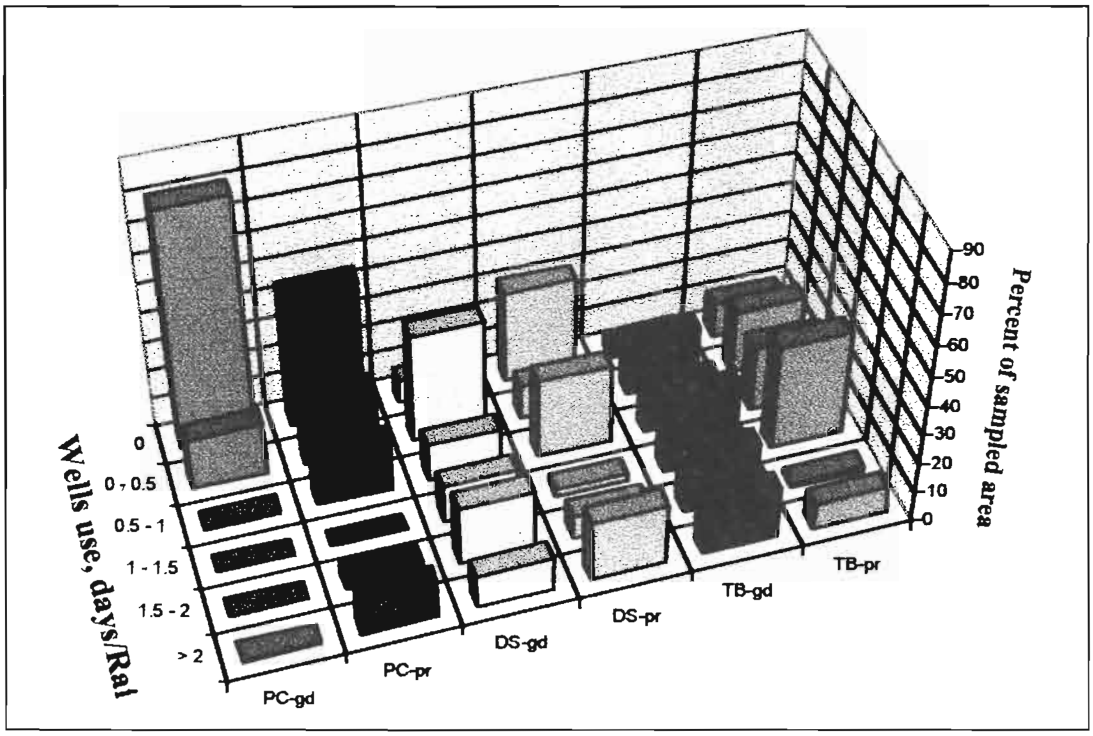


FIGURE 7. USE OF WELLS DURING DRY SEASON 1996 (DAYS PER RAI) (PC - PHLAI-CHUMPHOL; DS - DONG-SETTHI; TB - THA-BUA; GD - GOOD OPERATING CANALS; PR-POOR OPERATING CANALS)

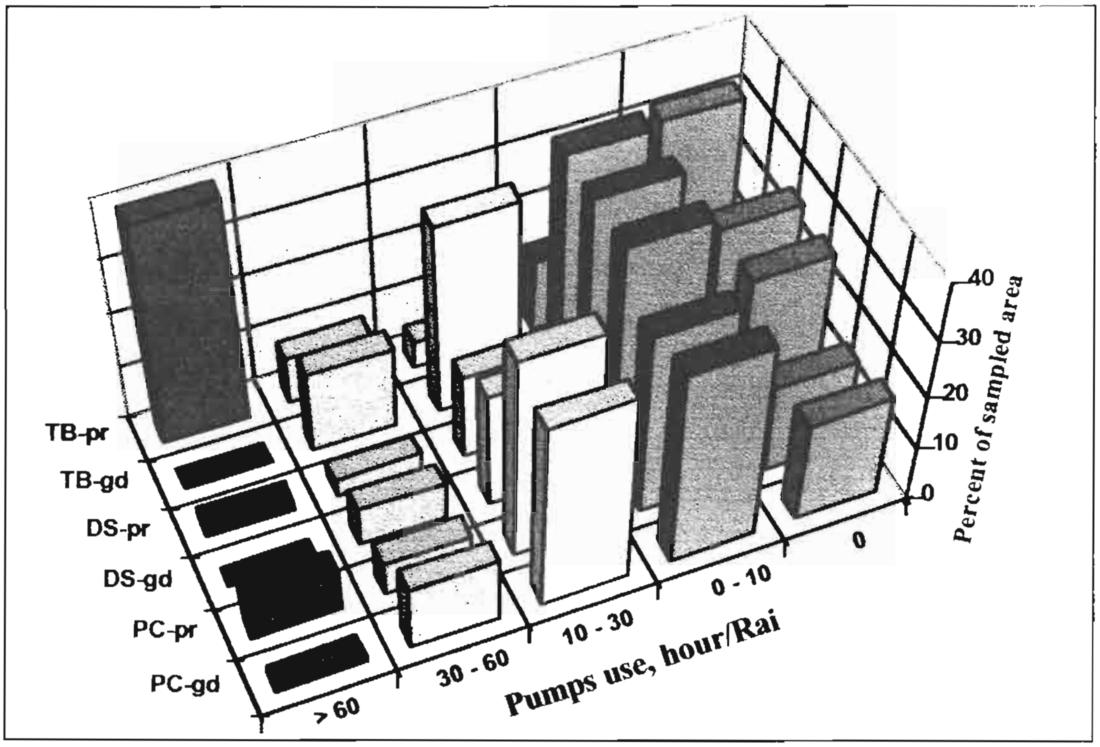


FIGURE 8. DURATION OF WELLS UTILIZATION DURING WET IRRIGATION SEASON 1995 (PC - PHLAI-CHUMPHOL; DS - DONG-SETTHI; TB - THA-BUA; GD - GOOD OPERATING CANALS; PR-POOR OPERATING CANALS)

4.3 Pumps utilization in the command sites

Additional information refers to the inventory and duration of pumps utilization (Figures 9 and 10). Mobile pumps are used according to temporary needs and moved to the fields which need to be irrigated under the highest priority. Both the number of pumps and duration reflect the water state in the command sites. Consequently, it looks as if the highest number of pumps can be found in Tha-Bua region and the lowest in Phlai-Chumphol areas (Figure 9).

It can be observed that a relatively low number pumps are operated in the good performing canal region of Phlai-Chumpol (PC-gd) during both dry and wet season (Figure 10). Duration of pump operation is longer as compared with the good performance region in Phlai-Chumphol area. Duration of pumps operation in Dong-Setthi region is naturally higher during dry season and lower during wet season (Figure 10).

The pumps are operated at various duration in all regions. However, the findings indicate that under most conditions the pumps are operated up to 30 hours per Rai. Similar to previous findings, under extreme conditions the duration of pump operation is extended to 60 hours and above (Figure 10).

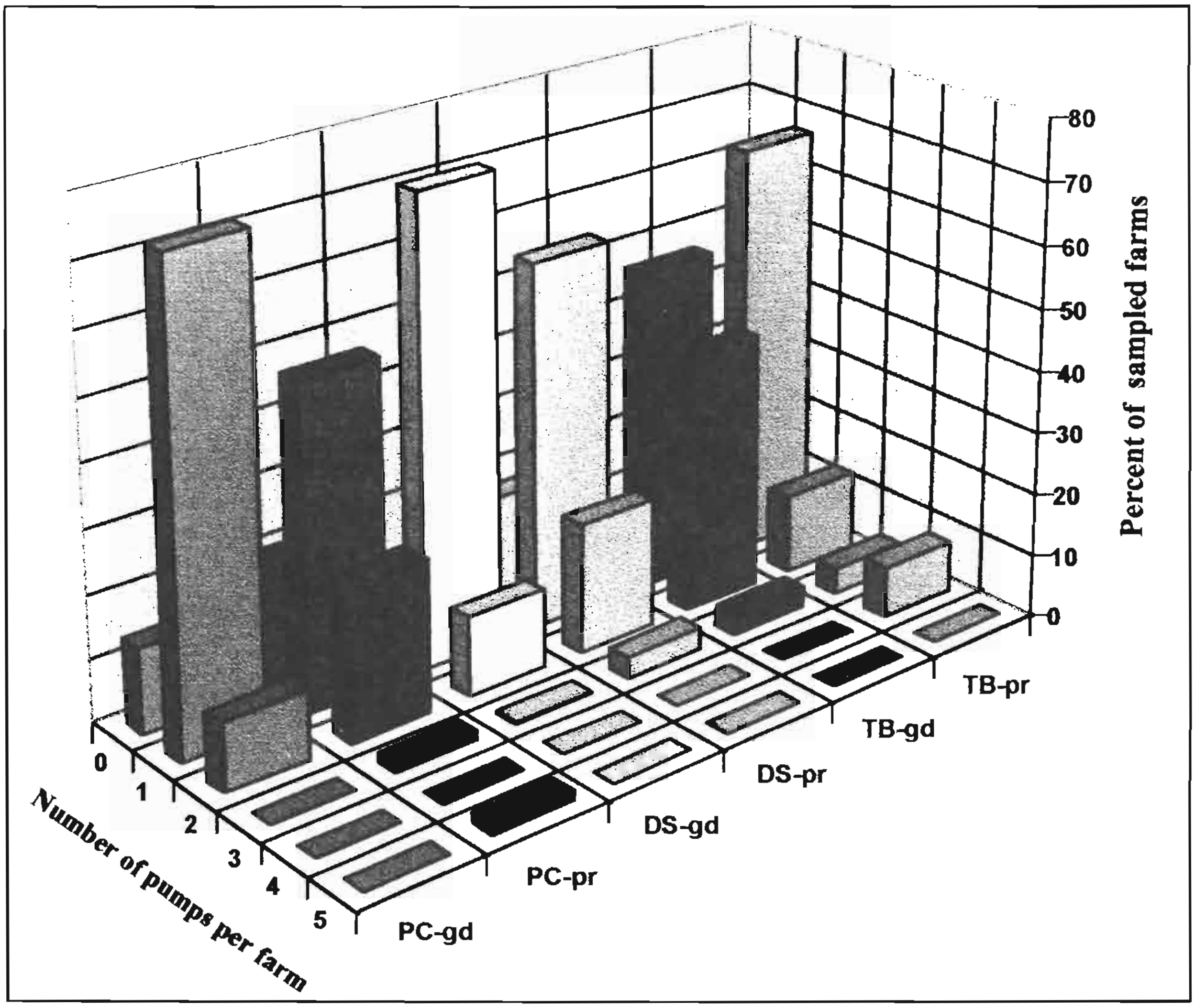


FIGURE 9. THE NUMBER OF PUMPS IN THE VARIOUS IRRIGATED REGIONS (PC - PHLAI-CHUMPHOL DS - DONG-SETTHI; TB - THA-BUA; GD - GOOD OPERATING CANALS; PR-POOR OPERATING CANALS)

4.4 Water supply from alternative sources and the linkage to the central system

Water consumption for irrigation is divided into two periods: (i) The period prior to supply via the main canal system; (ii) the period in which water is utilized simultaneously from the alternative sources and the main system.

Commonly the expenses for water supplied from the alternative sources are higher than the water delivered from the main central system. The reason is primarily the initial capital investment made by the individual farmers in equipment (well and/or pump) and the related operational expenses (fuel and regular maintenance). Since water from the main central system is supplied free of charge (the common approach in Thailand), for given options, this is the preferable alternative selected by the farmer. The use of the local waters simultaneously during the supply from the central system is usually supplementary and is linked to the performance of the canal system. It is subject to the efficiency of performance which varies in time and location.

Based on field observations, farmers' interviews and RID officers, it seems that most of the water from alternative sources is used prior to the water supply from the main central system. In order to assess the quantity consumed during the period prior to operating the main central system, an indirect estimation procedure was adapted. The assessment was based on the fact that paddy production requires water, however, if there is paddy production and no water available in the main central system, by elimination, all the water being used is from the alternative sources

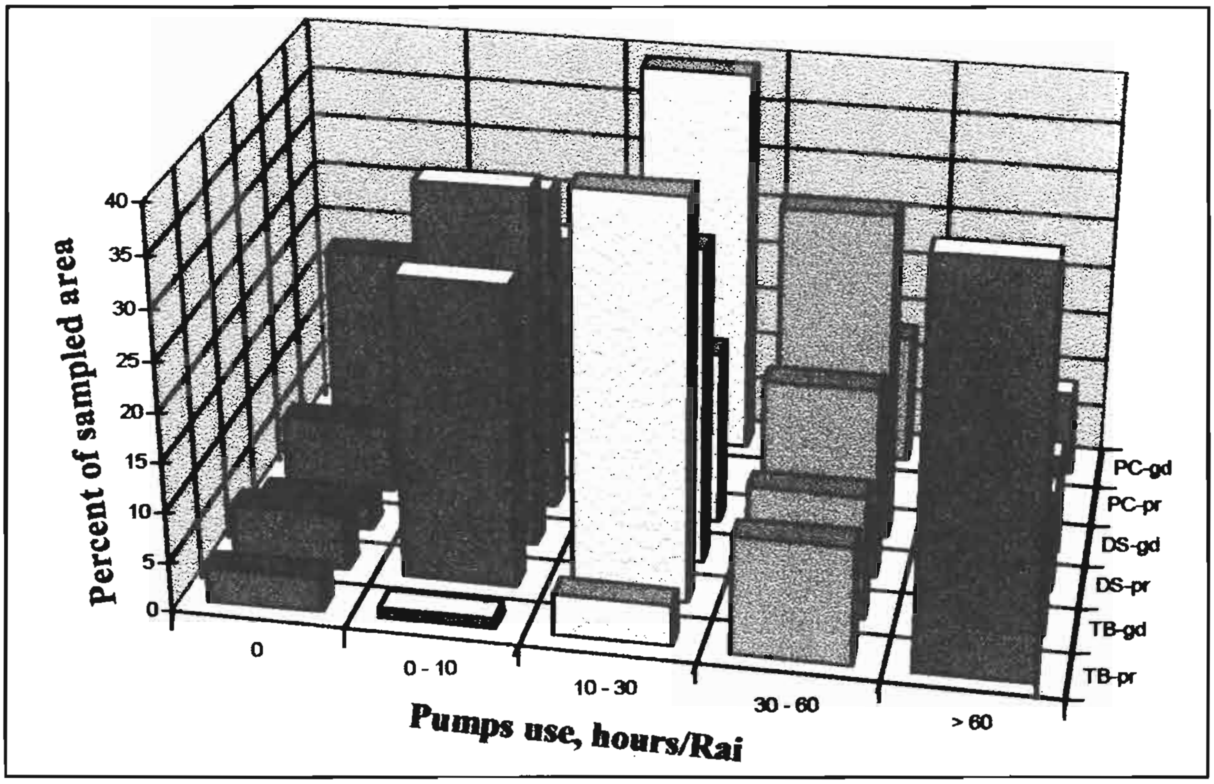


FIGURE 10. DURATION OF PUMPS OPERATION DURING DRY SEASON 1996 (HOURS PER RAI)

Information regarding the cultivated paddy acreage was obtained from RID weekly reports that include information on the crop growing stage. These reports have different versions in the various sub-systems, but all of them have the same basic information: crop varieties, acreage sowed or transplanted, areas damaged (due to floods, drought, or disease) and areas harvested. In some cases water is also supplied to regions that are not included in the PIP responsibility. The basic information of the report is filled out by the RID zonemen and is transferred to higher and more detailed service level [approximately 200 - 1000 Rai each (32 to 160 ha)]. Commonly these reports are modified at higher levels and are also utilized by the operational level of the canals, zones, sections and sub-systems. In some regions there are made additional modifications subject to municipal districts and special needs.

4.5 Crop water requirements (ET_{crop})

Crop water requirements are given by Et_{crop} mm/day (Figure 11). The ET_{crop} is defined as "the depth of water needed to meet the water loss through evapotranspiration of a disease-free crop, growing in large fields under non-restricting soil conditions including soil water and fertility and achieving full production potential under the given growing environment" (Doorenbos et al., 1984). The effect of the crop characteristics and growth stage on water requirements is given by the crop coefficient (K_C) which represents the relationship between a reference crop potential evapotranspiration (Et_o, mm/day) and crop evapotranspiration (ET_{crop}), namely (Figures 11 and 12):

$$ET_{crop} = K_C * Et_O \quad (1)$$

4.6 Seepage and percolation (SP)

Seepage and percolation is the lateral and vertical subsurface movement of water respectively. Texture and structure of the soil profile, elevation of water table, soil permeability, depth of impervious layer, and topography generally determine these natural phenomena. It might as well be influenced by the roots pattern.

Soils suitable for paddy are estimated to have a seepage and percolation rate of 1 to 4 mm/day, depending on the soil characteristics. Kerdsakul (1996) conducted experiments for deep percolation at the Tha-Bua Irrigation Project and found that the average percolation rate was 1.4 mm/day during the wet season 1995 (2538). For this presentation we have used the value of 1 mm/day.

4.7 Water requirements for land preparation (LP)

One of the basic agricultural activity in the paddy fields is the land preparation. The land is first soaked, sloughed and then puddled and leveled in muddy conditions. The three components of the total water requirement for land preparation are:

1) Water used for land soaking.
2) water losses through seepage and percolation.
3) water losses by evaporation.

Common design of irrigation systems in Thailand assumes that an amount of 200 - 300 mm is applied over a one month period is required for land preparation. Songiripon (1990) related study focused in the land preparation requirements for Dong-Setthi, region found that mean requirement was around 270 mm for the dry season. It was found in the PIP survey (Rieser et al., 1997) that land preparation lasts for 2 weeks before sowing. In this study the value of 200 mm two weeks prior to sowing.

4.8 Seasonal field water requirements (ET_{field})

Total water consumption is based on all plants needs and all auxiliary losses. The ET_{field} (mm/season) is defined as the depth of water needed to meet the water loss of the crop during the season for a specific area and definite crop pattern:

$$ET_{field} = \sum^{days} (ET_{crop} + SP) + LP \qquad (2)$$

where, Et_{crop} - Crop water requirements, mm/day.
SP - Seepage/percolation losses, mm/day.
LP - Land preparation requirements, mm/season.
Days - total duration of irrigation season, days.

By multiplying the value of ET_{field} with the cropping field acreage total required water quantity can be assessed.

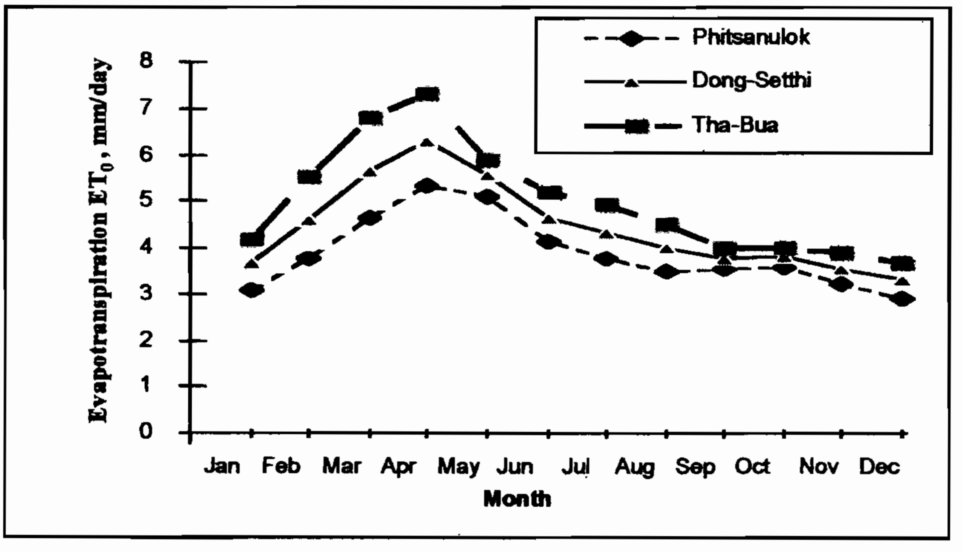


FIGURE 11. MONTHLY MEAN POTENTIAL EVAPOTRANSPIRATION, ET_0

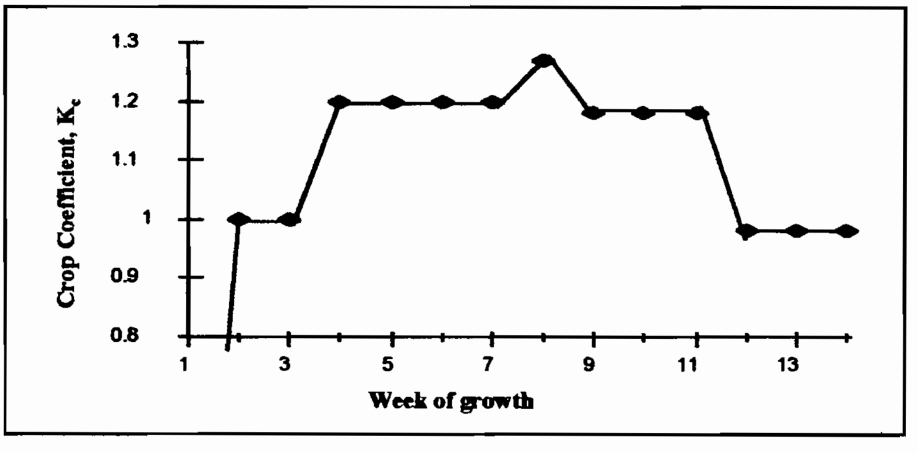


FIGURE 12. CROP COEFFICIENT FOR HIGH YIELD VARIETIES OF PADDY

4.9 Assessment of water supply and use

The crop pattern, the various growth parameters were assessed, subject to the approach that complementary information for water use can be obtained indirectly from the water consumption and acreage. This information was combined with the water requirements.

Monthly mean values for ET_o for PC sub-system were obtained from the Phitsanulok meteorology station. Data for ET_o for Tha-Bua was obtained from the Nakhon Sawan meteorology station and mean values were assumed for Dong-Setthi sub-project. Values for the crop coefficients K_C for different growth stages of high yielding varieties of paddy were obtained from the RID office in Dong-Setthi.

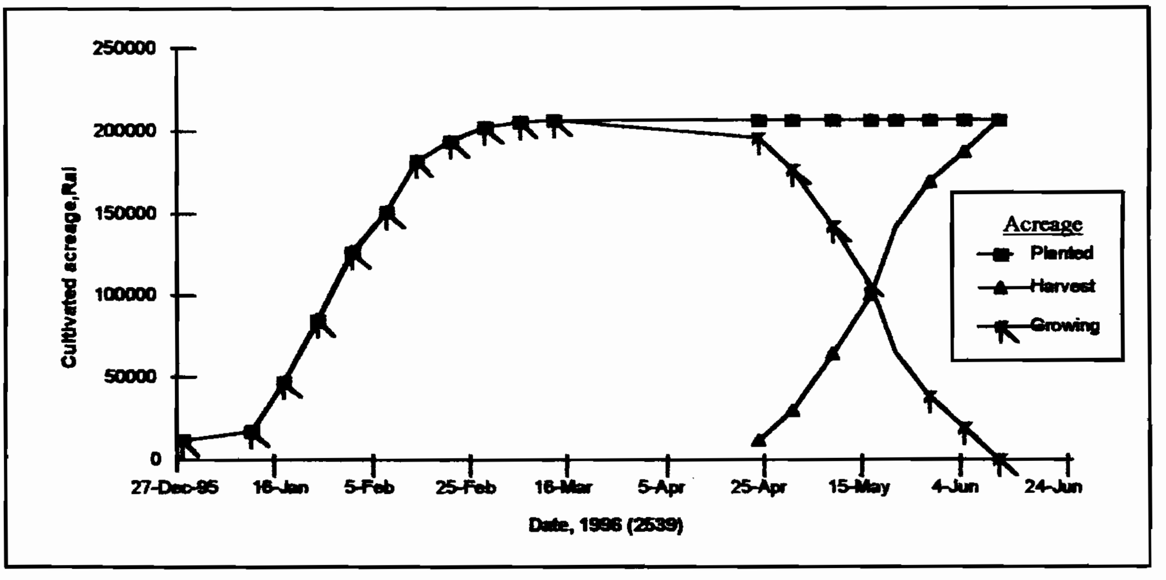


FIGURE 13. SEASONAL CROP ACREAGE VARIATION IN PHLAI-CHUMPHOL DURING 1996 (2539) DRY SEASON

Actual cropping area was obtained from the "Planted Area Progress Report" which is a standard weekly RID report (e.g. RID form code O&M 1-44) and from similar lower level more reports (Figure 13). The data (Figure 13) refers to the Phlai-Chumpol sub-project, for the dry season of 1996 (2539). Since this data is for the dry season there was no flood problem. The data for the acreage of the "land preparation" stage is very similar to the "planted area" acreage stage. It can be explained by recording the end of the field preparation season that is similar to the sowing timing. For this reason instead of using this value it was assumed that the field preparation stage begins two weeks before sowing (Rieser et al., 1997)

The accumulative active cultivated area value is a calculated variable which is given by :

$$A_g = A_p - A_h - A_f \qquad (3)$$

where, A_g - total cultivated acreage, Rai
A_p - planted acreage, Rai
A_h - harvested acreage, Rai
A_f - flooded acreage, Rai

The water delivery from the central canal system during 1997 season was initiated towards the beginning of February. Until then local well water was applied for land preparation and irrigation.

One of the limitation of the presented approximate method is that it does not specify the water source. An additional difficulty is that the quality and accuracy of the data. In some areas monitoring is conducted primarily according to the planned RID cropping schedule. Under these circumstances there is only information regarding the system situation at the beginning of the growing season. In some regions the planted area can be estimated from the harvested acreage. In others the harvested data as well was not complete and then the assessment is based on the existing partial information thus under estimating the use of on farm local waters

An imprecise link in assessing the contribution of the local wells is the water which is utilized in the agricultural plots that by the rotation schedule are not planned to receive water from the main canal system. Hypothetically, it could be claimed that if farmers do not receive water from the canal system - hence, by elimination, use alternative water sources. In practice the picture is different. Field observations show that even during this period, large quantities of water are delivered for irrigation from the main canal system. The farmers from canals close to their plots pump part of the water frequently and intentionally. Complementary amounts of water are supplied via the main canal system in response to strict requests from the farmers. In the future it will be reasonable to develop and adopt a monitoring scheme for assessing the water consumed from the alternative sources primarily in these not planned for irrigation.

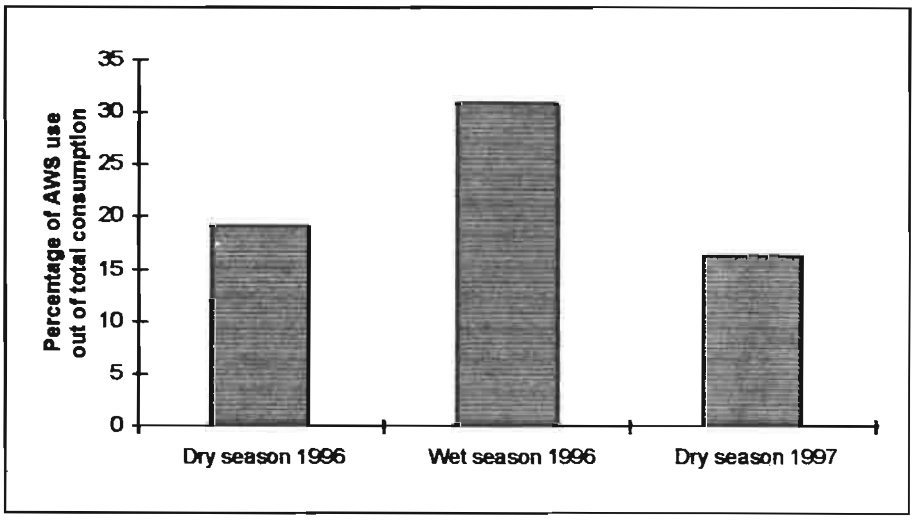


FIGURE 14. PERCENTAGE OF ON FARM LOCAL WATER SOURCES USE OUT OF TOTAL CROP WATER REQUIREMENTS IN THE PIP DURING DRY SEASON 1996, WET SEASON 1996 & DRY SEASON 1997

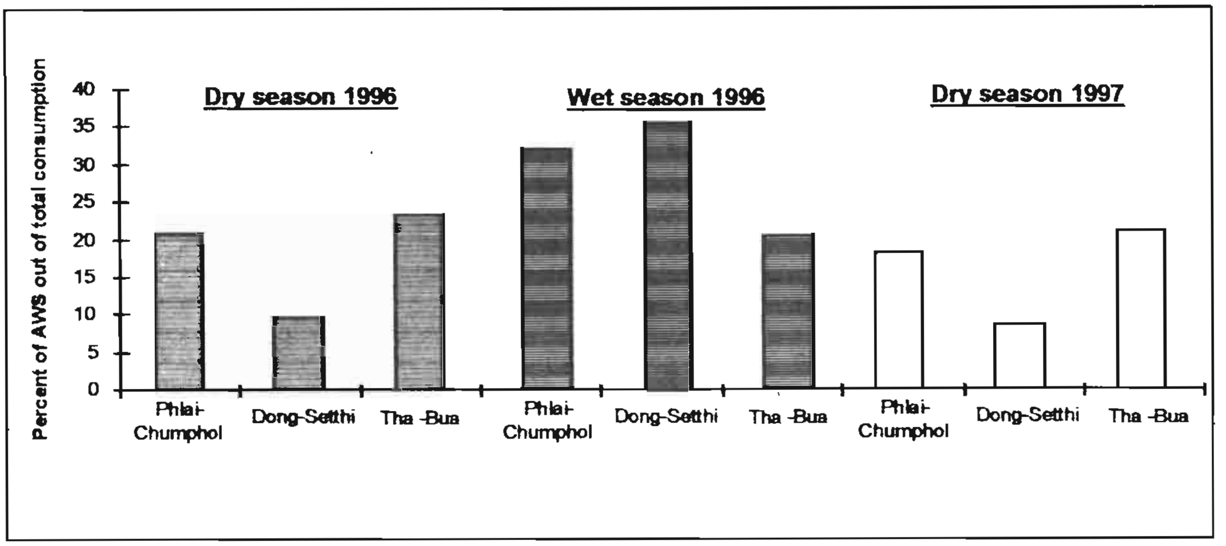


FIGURE 15. PERCENTAGE OF ON FARM LOCAL WATER SOURCES USE OUT OF TOTAL CROP WATER REQUIREMENTS IN THE 3 SUB-SYSTEMS DURING DRY SEASON 1996, WET SEASON 1996 & DRY SEASON 1997

The percentage of water used from alternative sources relative to the total crop water requirement is presented in Figures 14 and 15. As there is no distinction of the on farm local water sources it is reasonable to assume that in the wet season there is a higher dependence on natural precipitation.

Since the assessment method is based on data that is collected commonly by the RID staff, it can be implemented to evaluate water use during preceding irrigation seasons. If necessary, it is relatively simple and inexpensive to implement this approach also on a broader scale in the future.

5 Discussion

Information regarding the number of wells on the farms and their operational routines as a complementary quotas supplied from the main canal system were examined in PIP. It included surveying the number of wells and pumps per farm and per Rai and the operational regime. The survey took into account the irrigation season, the reliability of water supply from the main canal system and practice of irrigation in the region. According to the results large sectors of the farmers in the entire PIP own pumps and wells. These are operated primarily under stress conditions, namely when there is a relatively high probability of insufficient water supply from the main canal system.

The method developed for assessing the alternative water sources use can be implemented in most cases beginning at the service unit level up to the project level. Estimating the use of water from alternative sources after the main system is activated is problematic, but in the irrigated areas seems to be relatively negligible and therefore less significant. The question of water use in areas that are not planned for irrigation during the dry season remains pending.

Mobile pumps are put into use when the water supply system is inadequately operated. It includes water pumping from main canals when the water level restricts gravity flow to the branched canals. The pumps are also used to pump water from local small storage facilities, primarily on the farm. Pumps are also put into use for drainage purposes. Drainage is maintained directly after germination, prior to harvesting and to dispose water during flood events.

ACKNOWLEDGMENTS

The work was supported by the GIARA (a German-Israeli) fund, project number D-204/SAIPA. The research team acknowledges and appreciates the officers and workers of the Royal Irrigation Department for their very genres help and especially Mr. Surapol from Phlai-Chumpol, Mr. Thaworn Tathavee from Dong-Setthi and Mr. Sopinya Kerdsakul from Tha-Bua. The authors are indebted also to thank the GTZ team at AIT (IREM) and to Mr. Nawee Jiracheewee from IREM for their support and significant assistance.

References

Anukularmphai, A. (1996) Irrigation development in Thailand. Proceedings of the 7th International conference on Water and Irrigation, AGRITECH, 13-16 May, 1996, pp. 18-25.

Doorenbos, J., and Kassam, A. H. (1986). Yield response to water. FAO Irrigation and drainage paper 33.

Jiracheewee, N., G. Oron, V. V. N. Murty, and V. Wuwongse. (1996) Computerized database of information use in optimal management of community irrigation systems in Thailand. Agricultural Water Management, Vol. 31, No. 3, October, pp. 237-251.

Kerdsakul, S. (1996). Irrigation water allocation modeling in the Tha-Bua irrigation project. M.Sc. dissertation, AIT, Bangkok.

Rieser, A., Hungspeung, S., Loof, R., and Oron, G. (1977). Systems analysis for irrigation performance assessment. Annual 1996 report, submitted to GIARA Fund, p 236.

Suwanarat, B. (1996). Regional water balance for irrigation planning. M.Sc. dissertation, AIT, Bangkok.

Yamazaki, F. (1992) Paddy field engineering. Irrigation Engineering and Management Program (IREM), Asian Institute of Technology, Bangkok, Thailand, 1992, p-425.

Regional approach of the agricultural dynamics in amphoe Bang Len: regional factors of rice intensification and diversification and interest for the monitoring of changes with a G.I.S.

Eric Mollard[1], Supan Karnchanasutham[2], Yupa Limsawad

Abstract: *The objective of the study is to map the dynamics of diversification and rice intensification in Amphoe Banglen , Nakornpatom Province , Thailand using Remote Sensing and Geographic Information System (GIS). The main changes in Amphoe Banglen showed by mapping the land use in 1988 and 1995 using Satellite imagery TM of different years and seasons with highlighting the regional determinants (ecological, social ,other dynamics). In the future, the monitoring of change in rice cultivation might be improved by designing adequate tools mixing and lead to be instrumental in upgrading a GIS in charge of agriculture by monitoring the changes and by including social characteristics of the farms response to aiding farmers diversification government policies.*

1 Introduction

The Chao Phraya Delta constitutes a core area of the Thai economy , agriculture and history. Although most of the Delta was reclaimed only quite recently, it has undergone deep transformations over the last 150 years. Just as past changes often started in the Chao Phraya Delta then spread to other regions of Thailand.

Major trends in the agriculture of the Chao Phraya Delta are intensification, diversification and mechanization. Rice has been the most important economic crop in terms of both domestic consumption and export. Thailand is ranking first among the world rice exporters with the income of hundreds million baht.

Now a day, it is rapidly change in agricultural dynamics especially in the Chao Praya Delta not only on the areas but also in socio-economic and ecological characteristics. Geographic Information System (GIS) ,the integration between spatial and attribute data, is therefore necessary for the change monitoring of rice intensification and diversification which will eventually lead to aiding farmers diversification policies decision making.

[1] IRD, Agroeconomist

[2] Office of Agricultural Economics - Remote Sensing and GIS

2 Objectives

1).Mapping of the dynamics of diversification and rice intensification in Amphoe Banglen.

2).Highlighting the regional determinants (ecological, social, other dynamics).

3).Upgrading of a GIS by monitoring the change and including layers of social features.

3 Materials and Equipment

Several dates LANDSAT TM images acquired between early January and early July 1988 with early March 1994 and lately December 1995 were used. The band combination was always TM band 2 as blue, TM band 3 as green and TM band 4 as red.

The format and the support of the satellite images were chosen to optimize the cost / benefit of the oata.

In areas of very intense rice cultivation, we used quarter scene images on positive transparency and the Procom enlarger. For less intense areas we used full screen transparencies. The transparency provides finer details than the print.

TABLE 1 : LIST OF LANDSAT TM IMAGES USED

Path – Row	Date
129-50	1988-01-10 1988-02-27 1988-03-14 1988-03-30 1988-08-05 1995-12-31
130-50	1989-02-20 1992-12-13 1993-01-30 1993-03-19 1994-03-06

Some ancillary data were also used.

1.Topographic maps at a scale of 1:50,000

2.Irrigation maps and irrigation plans of 1988

3.List of rice growing villages and crop calendars

4.Procom 2 projector compositor system

4 Methodology

4.1 Ground data collection

The purpose of the ground data collection was to define the satellite image interpretation keys. These keys vary from one area to the other. This activity was also carried out to estimate the yields of the rice crop. The field work was based on the information from the rice calendar. The number of sample sites per area varied between 10 and 40 depending on the surface, the distribution and the homogeneity of the crop.

4.2 Visual interpretation approach

The interpretation was performed using the color positive transparencies at the original scale of 1:1,000,000

The interpretation of the transparencies was done using an optical – mechanical projector called ' PROCOM'. Because of its zooming and roaming capabilities, the PROCOM allows the superposition of the satellite image onto the map and working directly at the map scale without the used of tooking through viewers. Using this equipment, the images were optically enlarged too match with the base maps at the scale of 1:50,000

The interpretation was based on the spectral properties of the crop as well as other characteristics such as tone, shape, size, pattern and temporal changes. The color of the crop rice and upland crop appear in various tones related to the stages of growth.

The blue represents flooded area before the rice is planted. A dark blue color is related to the depth and cleanliness of the water.

The reddish blue represents the area of rice cultivation when the crop is at an early stage. The canopy does not cover the ground completely. Therefore, the color on the image is a combination of the soil (or water) and the rice.

The bright red means that the rice is very healthy and covers the ground completely.

Pale yellow – white represents the areas where the second crop rice has been recently harvested. The sensor records the rice stubble reflectance.

The bright orange represents the areas where the sugarcane is planted and covers the ground completely.

The dark red represents the areas where the tree is planted.

The reddish orange represents the areas where the orchard is planted.

The white pale represents the areas where is no planted call bare soil.

The dark blue represents the fish pond areas.

The white blue represents the built up area.

4.3 The application of GIS and remote sensing

A geographic information system was used for monitoring the landuse of Amphoe Banglen, Nakornpatom province. The input for the landuse data of the different years was based on remote sensing.

From the Thematic Mapper satellite data of 1988 and 1995 a visual interpretation classification on landuse was made.

This resulting map as well as the existing landuse maps with scale 1:50,000 , based on visual interpretation from 1988 and 1995, were digitised for input in the GIS.

Other existing maps on administration, transportation, irrigation were also digitised.

Data conversion from the existing map into digital format by compiling such maps from relevant agencies. The converted relevant maps include:

1).Irrigation map obtained from the Royal Irrigation Department (RID) comprises both irrigation and non – irrigation zones.

2).Road network map, at scales of 1:1,000,000 and 1:250,000 obtained from the Department of Highway and the Royal Thai Survey Department, includes:

2.1) Road comprises:

- Highway with number
- Provincial road with number
- Road under the office of Accelerated Rural Development
- Dirt road and etc

2.2) Railway

2.3)Road along irrigation canal

3).Administrative boundary map, at a scale 1:50,000 obtained from the National Statistical office, includes: Province boundary, District boundary , Sub – district boundary, Locations of province , district and sub – district offices

4). Land use map, at a scale 1:50,000 obtained from 1988 and 1995

Satellite image interpretation by OAE, includes the following categories:

Landuse type	Code
Paddy field	
Rice 0 (4-7/ 9-12) , (growing / harvesting)	Ri 0
Rice 1 (11-2 / 4-7) , (growing /harvesting)	Ri 1
Rice 1,3 (12-3 / 5-8) , (growing /harvesting)	Ri 1,3
Rice 3 (2-5 / 6-9) , (growing /harvesting)	Ri 3
Field crops	
Sugarcane	Su
Horticultural crops	
Orchard , Mixed orchard	Or
Tree crops (Standing trees)	
Trees along the road or riverene trees	Tr
Standing trees in the village	Tr
City , Village	Ur
Fish pond	Fi
Bare soil	Ba
Other	Ot

Data analysis was carried out by using Intergraph GIS and Oracle softwares under Window NT operating system the steps are follows:

1. Project construction and database establishment to integrate spatial information, obtained from digital map, and attribute information so called topology.
2. Data analysis was undertaken by overlaying of multi-layer spatial information.
3. Calculate the land use area in each year and classes.

5 Results

The results comprise 2 types of information: landuse map of 1988 and 1995 in Amphoe Banglen and classification areas which was ranged into 10 classes. They are:

4. RICE0 (4-7/9-12) refers to rice planted from April to July and harvested from September to December.
5. RICE1(11-2/4-7) refers to rice planted from November to February and harvested from April to July.
6. RICE1,3 (12-3/5-8) refers to rice planted from December to March and harvested from May to August.
7. RICE3 (2-5/6-9) refers to rice planted from February to May and harvested from June to September.
8. Sugarcane
9. Tree
10. Orchard
11. Bare soil
12. Fish pond
13. Other

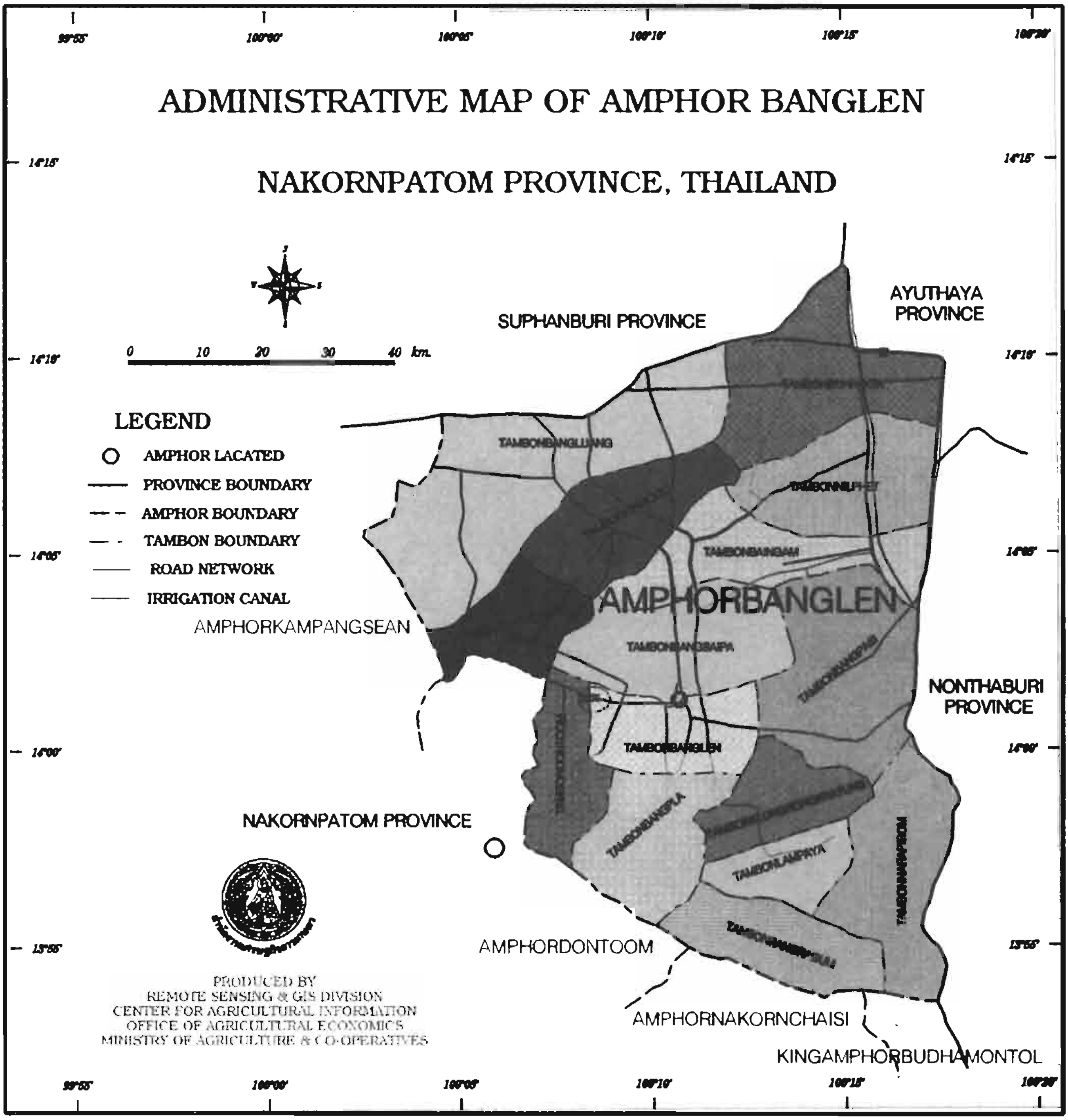
6 Discussion and conclusion

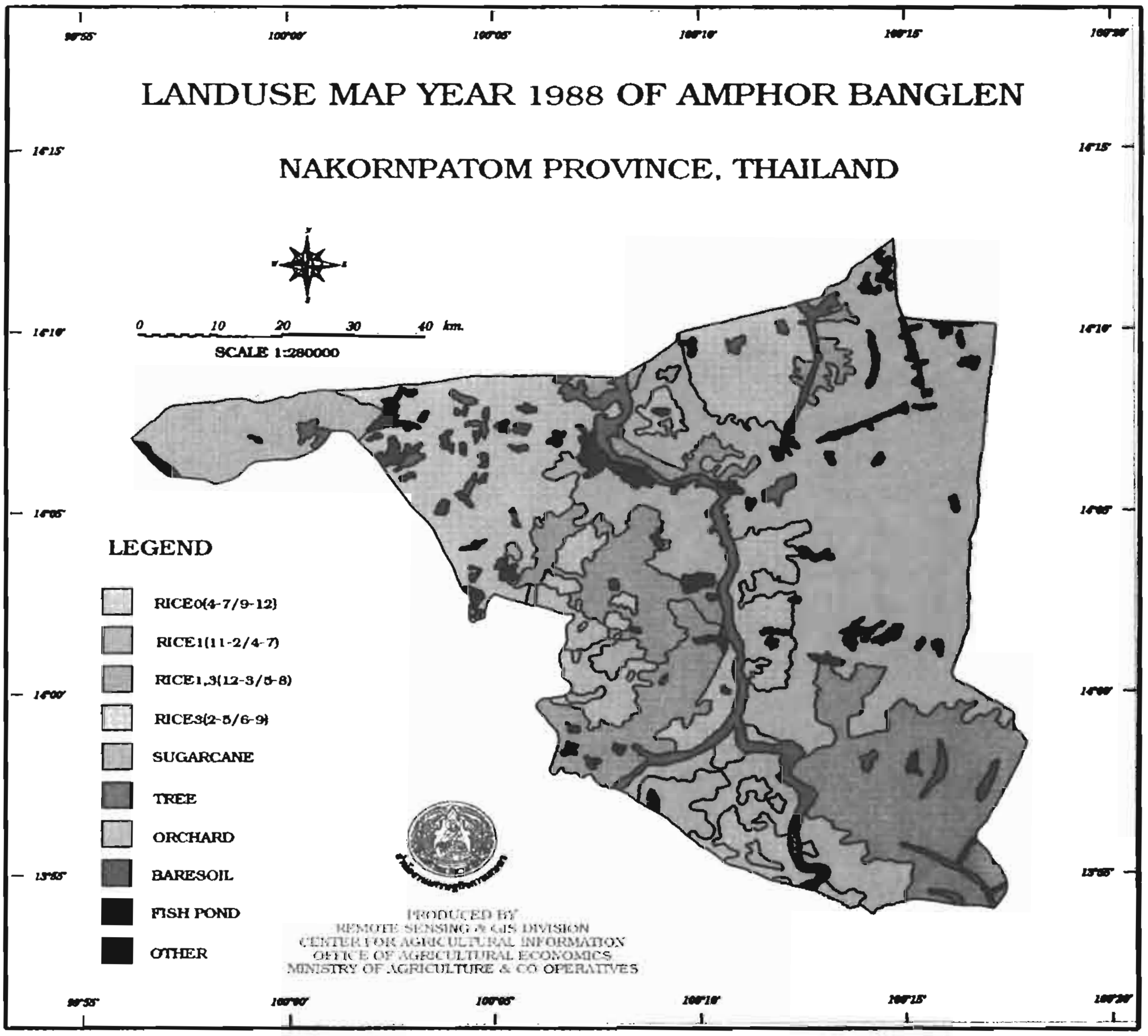
Satellite imagery TM of different years and seasons have been used to map the land use in 1988 and 1995, as well as the main changes in Amphoe Banglen. A questionnaire to farmers in 40 villages in 15 tambons (simple random sampling) will make possible to thoroughly define the changes and to try of explain the particular locations of the change by mapping regional factors such as risk, historical patterns, risk attitude, tenure (given by the Doras-NRC2D Database developed in the phase I) and proximity of rice mills. An historical approach will allow us to understand the personal incentives and the family strategies that are important to promote the change.

Ground information and supplementary data are very important inputs in photointerpretative methodologies. Complete supplementary data and the familiarity of the interpreter with the target area as well as the availability of multidate imagery help to increase the accuracy of the interpretation.

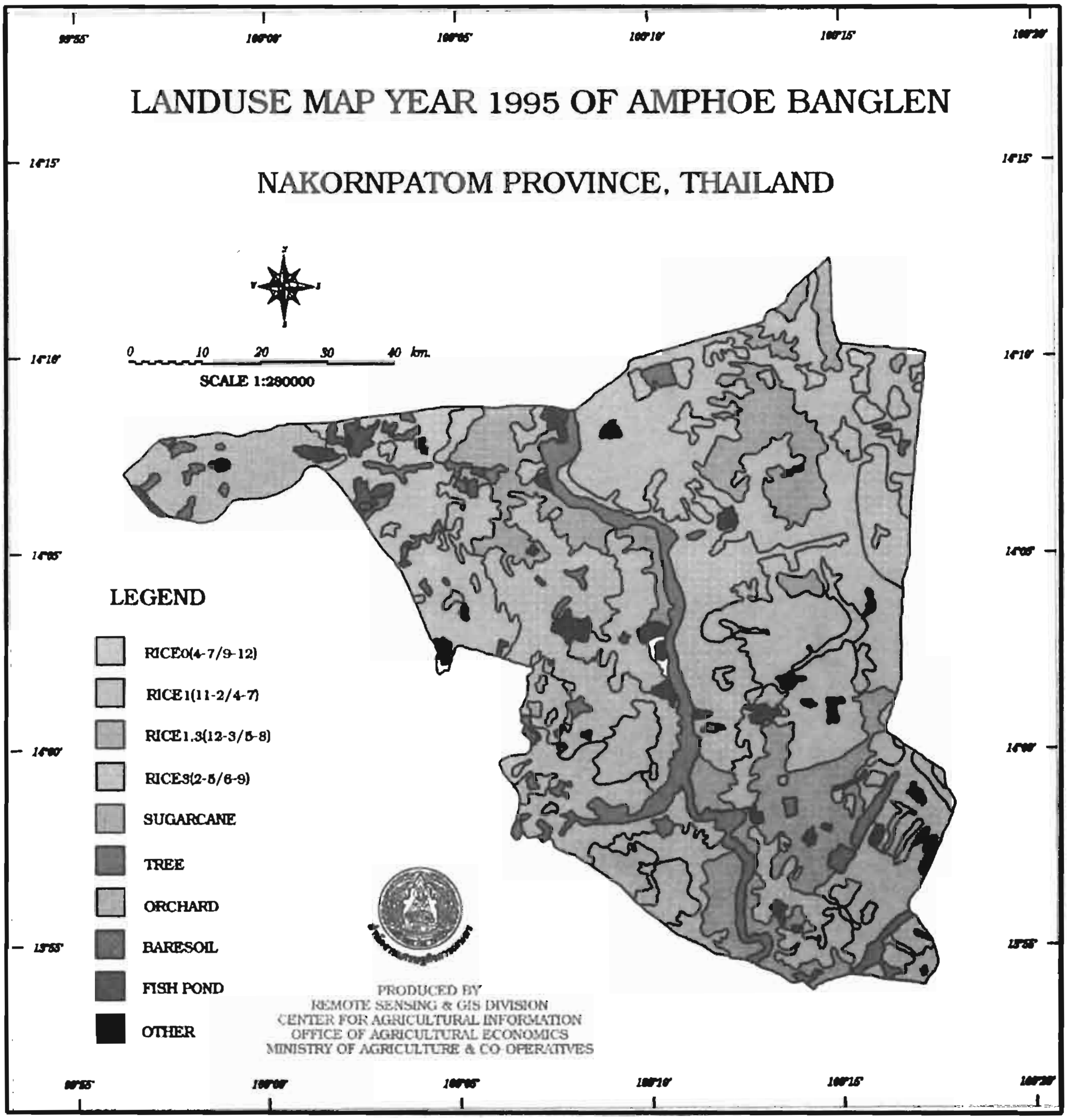
In the future, the monitoring of change in rice cultivation might be improved by designing adequate tools mixing, for example, radar imagery and surveys. Such a research can be instrumental in upgrading a GIS in charge of agriculture by monitoring the changes and by including social characteristics of the farms, in particular from the Doras-NRC2D database. This kind of information would be a useful tool in aiding farmers allowing the necessary help they need (training, credit,.....) to be determined and to swiftly assess the impact of diversification policies.


ADMINISTRATIVE MAP OF THAILAND
DEMOCRATIC PEOPLE'S REPUBLIC OF LAOS
SOCIALIST REPUBLIC OF VIETNAM
GULF OF TONGKIN
THE UNION OF MYANMAR
ANDAMAN SEA
DEMOCRATIC KAMPHUCHEA
GULF OF THAILAND
MALASIA
CHIANG RAI
PHAYAO
CHIANG MAI
NAN
LAMPANG
PHRAE
UTTARADIT
NONG KAI
UDON THANI
SAKON NAKHON
LOEI
PHITSANULOK
TAK
KALASIN
KHONKAEN
PHICHIT
CHAIYAPHUM
MAHA SARAKHAM
ROI ET
NAKHON SAWAN
UBON RATCHATHANI
LOP BURI
NAKHON RATCHASIMA
SURIN
BURIRUM
SISAKET
KANCHANABURI
SARABURI
SA KAEO
BANGKOK
CHACHOENGSAO
RATCHABURI
CHONBURI
PHETCHABURI
RAYONG
TRAT
PRACHUAP KHIRIKHAN
CHAMPHON
SURAT THANI
KRABI
NAKHON SITHAMMARAT
TRANG
SONGKHLA
PATTANI
YALA
NARATHIWAT
STUDY AREA
AMPHOE BANGLEN
NAKORNPATOM PROVINCE
Scale 1 : 7,500,000


99°55'
100°00'
100°05'
100°10'
100°15'
100°20'
ADMINISTRATIVE MAP OF AMPHOR BANGLEN
NAKORNPATOM PROVINCE, THAILAND
14°15'
14°10'
14°05'
14°00'
13°55'
0 10 20 30 40 km.
LEGEND
AMPHOR LACATED
PROVINCE BOUNDARY
AMPHOR BOUNDARY
TAMBON BOUNDARY
ROAD NETWORK
IRRIGATION CANAL
SUPHANBURI PROVINCE
AYUTHAYA PROVINCE
AMPHORBANGLEN
AMPHORKAMPANGSEAN
NONTHABURI PROVINCE
NAKORNPATOM PROVINCE
AMPHORDONTOOM
AMPHORNAKORNCHAISI
KINGAMPHORBUDHAMONTOL
PRODUCED BY
REMOTE SENSING & GIS DIVISION
CENTER FOR AGRICULTURAL INFORMATION
OFFICE OF AGRICULTURAL ECONOMICS
MINISTRY OF AGRICULTURE & CO-OPERATIVES



LANDUSE MAP YEAR 1988 OF AMPHOR BANGLEN
NAKORNPATOM PROVINCE, THAILAND
0 10 20 30 40 km.
SCALE 1:280000
LEGEND
RICE0(4-7/9-12)
RICE1(11-2/4-7)
RICE1,3(12-3/5-8)
RICE3(2-5/6-9)
SUGARCANE
TREE
ORCHARD
BARESOIL
FISH POND
OTHER
PRODUCED BY
REMOTE SENSING & GIS DIVISION
CENTER FOR AGRICULTURAL INFORMATION
OFFICE OF AGRICULTURAL ECONOMICS
MINISTRY OF AGRICULTURE & CO OPERATIVES


LANDUSE MAP YEAR 1995 OF AMPHOE BANGLEN
NAKORNPATOM PROVINCE, THAILAND
0 10 20 30 40 km.
SCALE 1:280000
LEGEND
RICE0(4-7/9-12)
RICE1(11-2/4-7)
RICE1,3(12-3/5-8)
RICE3(2-5/6-9)
SUGARCANE
TREE
ORCHARD
BARESOIL
FISH POND
OTHER
PRODUCED BY
REMOTE SENSING & GIS DIVISION
CENTER FOR AGRICULTURAL INFORMATION
OFFICE OF AGRICULTURAL ECONOMICS
MINISTRY OF AGRICULTURE & CO-OPERATIVES

LANDUSE OF AMPHOE BANGLEN, NAKORNPATOM PROVINCE, THAILAND

ITEM	1988	%	1995	%	DIFFERENCE	%
RICE0(4-7/9-12)	57,500	14.89	43,125	11.17	- 14,375	-25.00
RICE1(11-2/4-7)	143,750	37.22	135,625	35.11	- 8,125	-5.65
RICE1,3(12-3/5-8)	83,750	21.68	63,750	16.5	- 20,000	-23.88
RICE3(2-5/6-9)	43,125	11.17	86,250	22.33	43,125	100.00
SUGARCANE	18,125	4.69	15,625	4.05	- 2,500	-13.79
TREE	23,125	5.99	25,625	6.63	2,500	10.81
ORCHARD	1,250	0.32	1,250	0.32	-	0.00
BARE SOIL	1,250	0.32	1,875	0.49	625	50.00
FISH POND	4,375	1.13	3,750	0.97	- 625	-14.29
OTHER	10,000	2.59	10,000	2.59	-	0.00
TOTAL	386,250	100	386,250	100	-	0.00

REMARK: UNIT = RAIS

Environmental impact of the raised-bed (*rong chin*) system along the Tha Chin River in Supanburi – Nakhon Pathom Provinces

Patcharaporn Phupaibul[1], Udom Kaewsuwan[2], Chatuporn Chitbuntanorm[2], Nanthana Chinoim[1] and Toru Matoh[3]

1 Introduction

Vegetable cultivation under the raised-bed system (*rong chin* in Thai) distributes in the western half of the Chaopraya delta, mainly along the Mae Klong river, Tha Chin (Supanburi) river and many canals in Rachaburi, Nakornpathom, Nonthaburi and Supanburi Provinces. The system might be introduced by paddy farmers who wish to grow other upland crops than rice. He dug ditch while piles up the soil onto the next to the ditch and he got an upland field just in a strip shape surrounded by water. The *rong chin* fields in Dumnoensaduak and Nakhonchaisri area, which are located in the downstream of the Mae Klong and the Tha Chin river respectively, are characterized by fruit orchard such as grape, pomelo and sugar apple, orchid production, and vegetables such as kale (*kana*), chinese chive(*kuichai*), yard-long bean (*tua fac yao*) and chili (*prik*). On the other hand, the *rong chin* fields which have been developed in the Songpinong district, Supanburi province to the Banglen district, Nakhonpathom produces not only leafy vegetables but also bitter guard (*mara*), taro (*puak*) and sweet potato (*man teed*). The latter three vegetables may characterize the system in the Supanburi-Nakonpathom area. According to old farmers in the Bangthaten village, the *rong chin* system in the village started by their grandfathers in 1940s by planting sugarcane. The crop changed to sweet potato and taro, then bitter guard and leafy vegetables. Especially, bitter guard in the Maemai village is famous in their fine quality. The longer shell life of these fruit and root vegetables may compensate for the distance from the market when transportation was not convenient. Recently, however, kale, chili, yard-long bean and shallot (*hom bang*) are produced also.

When some of us (PP and NC) were consulted by farmers that some of kale suffered from damage in their *rong chin* system, we realized that too much dressing of chemical fertilizers onto the crops under the current system, even though any symptom of damages due to excessive fertilizers was not found. Therefore, we started to survey the *rong chin* system to

[1] Sciencific Equipment Center, KURDI, Kasetsart University

[2] CLGC, KURDI, Kasetsart University

[3] Graduate School of Agriculture, Kyoto University

know the input-output balance of plant nutrients, together with a possible pollution of river and canal waters.

2 Materials and method

Water samples of the Tha Chin River was collected at the Bangluang bridge at least once a month. From the middle of the bridge, running river water was collected by an bucket of 10 L and a 100 mL aliquot was kept in a refrigerator until analysis. Soil samples were taken from surface of *rong chin* and paddy and composite samples were taken. Water extract was prepared by mixing 6 g of air-dried soil in 30 mL of water. The mixture was shaken for 30 min and the supernatant was taken by centrifugation (10,000 rpm x 20 min).

pH and EC of the sample were determined by electrodes immediately after sampling and sample preparation. Nitrate was determined with ion chromatography according to the manufacturer's instruction. Nitrite was determined with a diazo coupling using the method of Keeney and Nelson (1982). Phosphorus was determined either by the molybdenum blue method (Attananta and Janchareonsuk, 1984) and the Malachite Green method (Motomizu et al., 1983). Nitrogen was determined by the Kjeldahl and the indophenol blue method.

Record of the water level at the Ban Bangthaten water gate was kindly informed by the local office of the Royal Irrigation Department at the Ban Bangthaten.

3 Results and Discussion

3.1 Cropping pattern

Figure 1 illustrates the surveyed area. Dots numbered 1 to 18 indicate the *rong chin* fields where the cropping sequence has been monitored since March 1999, twice a month. The cropping sequences are shown in Fig. 2. At a first glance, a long flooding period is recognized. In this area, the Tha Chin river floods from late September to December and the fields are under water. When the water level starts to decrease in December, farmers rush to pump out the water to prepare for the next cultivation. Some farmers try to pump out water always to keep the field dry; this can be done where his land is located relatively high. In 1999 there was unusual flooding during May to June due to heavy rainfall (308 mm in May) and poor drainage, and many farmers lost the harvest. April 2000 also had heavy rain in Supanburi province but the *rong-chin* system in the surveyed area was not affected seriously. Some farmers introduce aquatic crops such as water mimosa (*pakkached*) and ipomea (*pakbung*) under flooding or intentionally introduced river water into fields (No. 18).

Favorite crops in this area are taro, sweet potato, kale, yard-long bean and bitter guard. Except kale, the other crops have a long-harvesting period (yard-long bean and bitter guard) and a long-cultivation period (taro and sweet potato). The latter crops are also characterized by less fertilizer input and labor intensity. Kale has become popular in the last five years, because it can be harvested in a short period (40-50 days after sowing). Some farmers specialize in kale production and he grows only kale, often mixed cropping with chili, all through a year (Fig. 3, *rong chin* No. 2, 10, 14 and 17 in Fig. 2). Mixed cropping is also carried out for bitter guard and yard-long bean, and bitter guard and chili. One farmer introduced peanut with yard-long bean and chili (No. 12). What the farmer expected was not the yield but the improvement of the soil fertility, even though he got an enough yield to sell it out.

Most of the farmers like to separate their fields (*rong*) into several crops, at least two. This may reduce the labor intensity for harvesting and the risk due to diseases and insects. According to farmers, introduction of a new crop is dependent on the market, that is, a middleman. Even if the farmer trys a new crop and get a good yield, marketing is not easy. Therefore, a new crop, such as sweet corn in No. 9, is started by a contract with a middleman.

3.2 Soil analysis

The area are roughly divided into 3 zones, namely, Ban Bangluang (Zone A), Ban Bangsam and Ban Bangthaten (Zone B), and Ban Bangthaten and Ban Bangtakhian (Zone C) as shown in Fig. 1. Soil samples were taken from the *rong chin* and from paddy fields adjacent to the *rong chin* field. Therefore, the parent material is common between the soils. The farming practice and crop species differ from field to field, however, differences were found in the chemical characteristics between the soils of *rong chin* and paddy. Data from the zone A is presented in Table 1. The soil pH of the *rong chin* soils seemed slightly higher than those of paddy. For the soil EC, a distinct tendency was not detected, even though the *rong chin* have received a lot of chemical fertilizers. Total nitrogen and NH_4-nitrogen also did not show any consistent tendency, but the values for the *rong chin* soils seem slightly lower. On the other hand, NO_3-N was only detected in the *rong chin* soils, indicating an oxidative condition of the soils and that nitrification occurs vigorously. Of course heavy dressing of chemical fertilizers may stimulate nitrate accumulation. Higher levels for NO_2-N also support the notion. In some *rong*, NO_2-N was extremely high (350 μg NO_2-N kg^{-1} soil, data is not presented), but no NO_3-N. As the soil pH and the water level was high, denitrification may take place. Phosphorus contents both in the Bray-II-extractable form and in a water-soluble form were significantly higher in the rong chin soils than the paddy soils. Usually phosphorus is not extracted with water, but a significant amount was found in a water extract, indicating heavy dressing of phosphorus fertilizers.

In table 2, soil chemical properties before and after the flooding in selected fields are presented. In four out of six fields, the soil EC decreased after flooding, indicating that soluble salts are washed out by the flooding. Decrease in the nitrate concentration also supports the idea. Phosphorus in the Bray II form also decreased. Water soluble P may be washed out. The results clearly indicate that flooding leaches the accumulated salt out. On the other hand, this also suggests that the *rong chin* system wastes nutrients and that the leaching may result in eutrophication of the environment. According to the kale farmers, they apply chemical fertilizers at 25.8 to 104 kg as nitrogen per *rai* (*rong*) in one crop and they harvested kale about 5760 to 9323 kg in a fresh weight per *rai* (*rong*). As their products contain 14.9 to 25.1 kg nitrogen per *rai* (*rong*) in one crop, the recoveries of the fertilizer nitrogen is about 21.6 to 57.8%. Some of the nitrogen in the plant roots remained field, however, the rest of nitrogen may be leached out into canals and the Tha Chin river. Furthermore, a high nitrate content of kale is dangerous to consumers' health. It is now necessary to reduce the application of nitrogen fertilizers without affecting the yield.

3.3 Water quality of the Tha Chin river

Changes in the water level at the water gate in the Ban Bangthaten and the EC values at the Ban Bangluang bridge are presented in Fig. 4a. From March to the next February, the EC values have three peaks, namely in April, July and February. The latter two peaks coincided with the lowest peaks of the water level, while in April both water and EC levels are high. Except for April, the EC values fluctuated as in a mirror image of the water level. We assume that in April some of the fertilizers leak into the river, therefore the EC increases. When the water level peaks in May, farmers start to pump out the field water into the river, then the EC of the river water increases while water level decreases. From September to December the fields are under water by flooding and when the farmers start to drain the field water again in December to January, the EC of the river increases again. The field waters around *rong* have the EC values in a range of 0.4 to 1.2 mS cm^{-1}, sometimes up to 1.54 (data not presented). Therefore, it is likely that the EC increase in June-July and December-January is due to the drainage of the field water of *rong chin* into the river. When farmers stop pumping (drainage) in August and February, the EC value decreases sharply.

Contribution of nitrate to the changes in the EC is confirmed from Fig. 4b. Higher the EC, the nitrate levels are also high. As presented in Table 1 and 2, nitrate is derived from the *rong chin* fields, therefore, the peaks in the nitrate level suggests that the water comes from the *rong chin* fields. The nitrate levels are around 0.1 mM, which is equivalent to 1.4 ppm nitrate-nitrogen. Phosphate concentrations also fluctuated in a similar pattern as nitrate, but in a lower range. However, the phosphate level bursted in May 2000. This may be because of unusual heavy rain fall. Because of the rain the harvest of the second rice was seriously damaged. Vigorous fermentation of the rice grains consume oxygen completely and the anoxia may produce hydrogen sulfide in the paddy fields and canals. The H_2S may react with iron, then produce black-colored water. The anoxia might release phosphate which was fixed in the bottom mud of canals, as a result, the phosphate concentration might increase abruptly. This suggests that a significant amount of phosphate is fixed in the bottom layer of the river and canals.

4 Conclusion

From the field survey, we tentatively conclude as follows.

1. There could not be found definitive cropping sequences in the *rong chin* system in the Tha Chin river, Supanburi-Nakhonpathom area.

2. The *rong chin* system consumes too much chemical fertilizers when the recoveries of the plant nutrients in the crops are taken into account. It is necessary to increase the nutrient use efficiency of the system to reduce fertilizer application.

3. Even though the heavy dressing of chemical fertilizers, accumulation of nitrate is not serious, may be due to active denitrification and leaching by the river. However, phosphorus may have started to accumulate in the soil.

4. It is necessary not only to reduce the application of chemical fertilizers but also to enhance the utilization of the recovered nutrients in the biomass, such as water hyacinthe, duck weed and mud in the bottom layer through utilization of fermented manure.

References

Attananta T, Janjareonsuk J 1984 Soil and Plant Analysis, Faculty of Agriculture, Kasetsart University pp35-39

Keeney DR, Nelson DW 1982 Nitrogen -Inorganic forms. *In* Methods of Soil Analysis Part 2 Chemical and microbiological properties. Eds. Page AL, Miller RH and Keeney DR. Soil Science Society of America, Madison, Wisconsin pp643-698

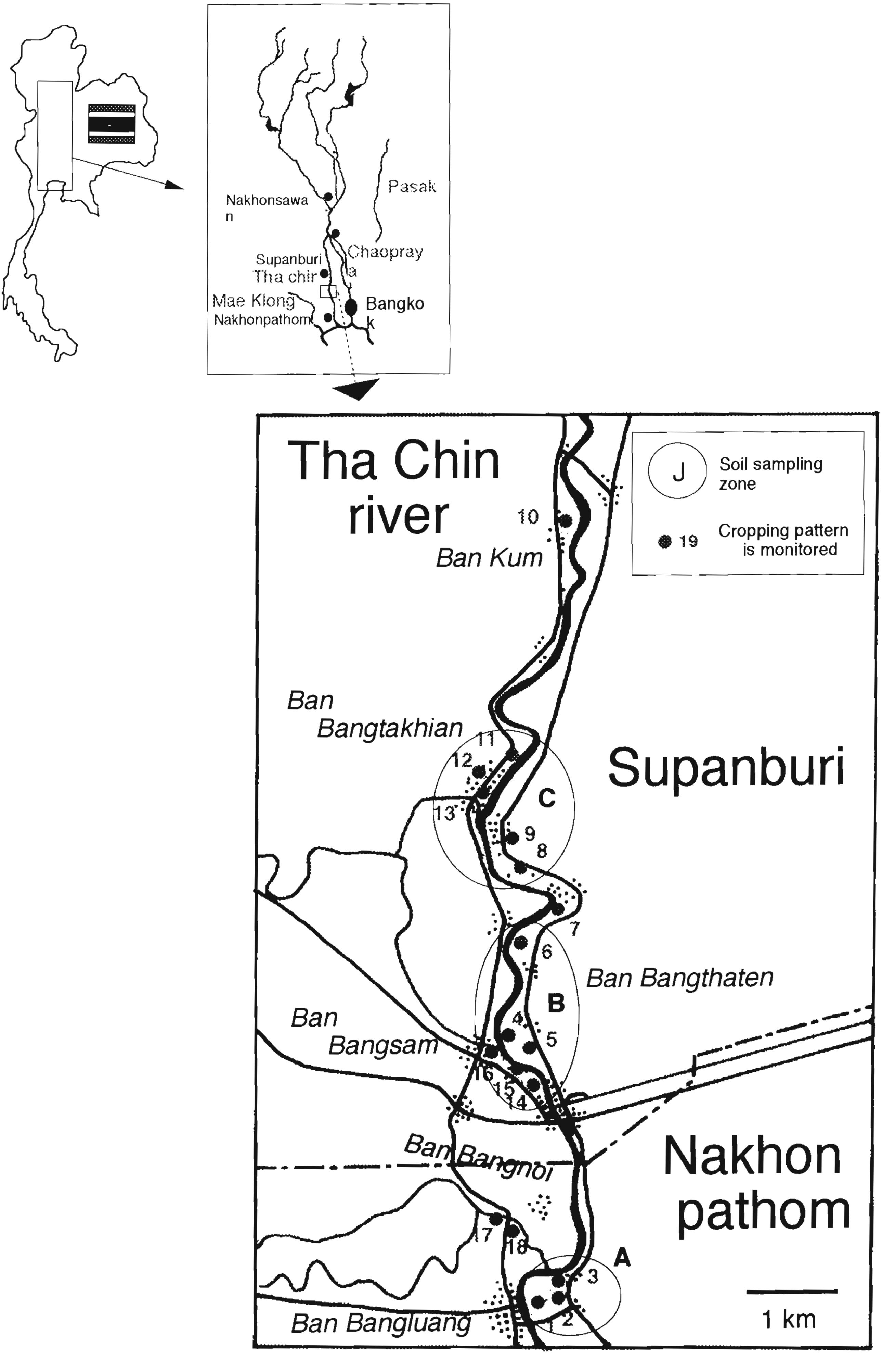
Motomizu S, Wakimoto T, Toei K 1983 Spectrophotometric determination of phosphate in river waters with molybdate and Malachite Green. Analyst 108, 361-367

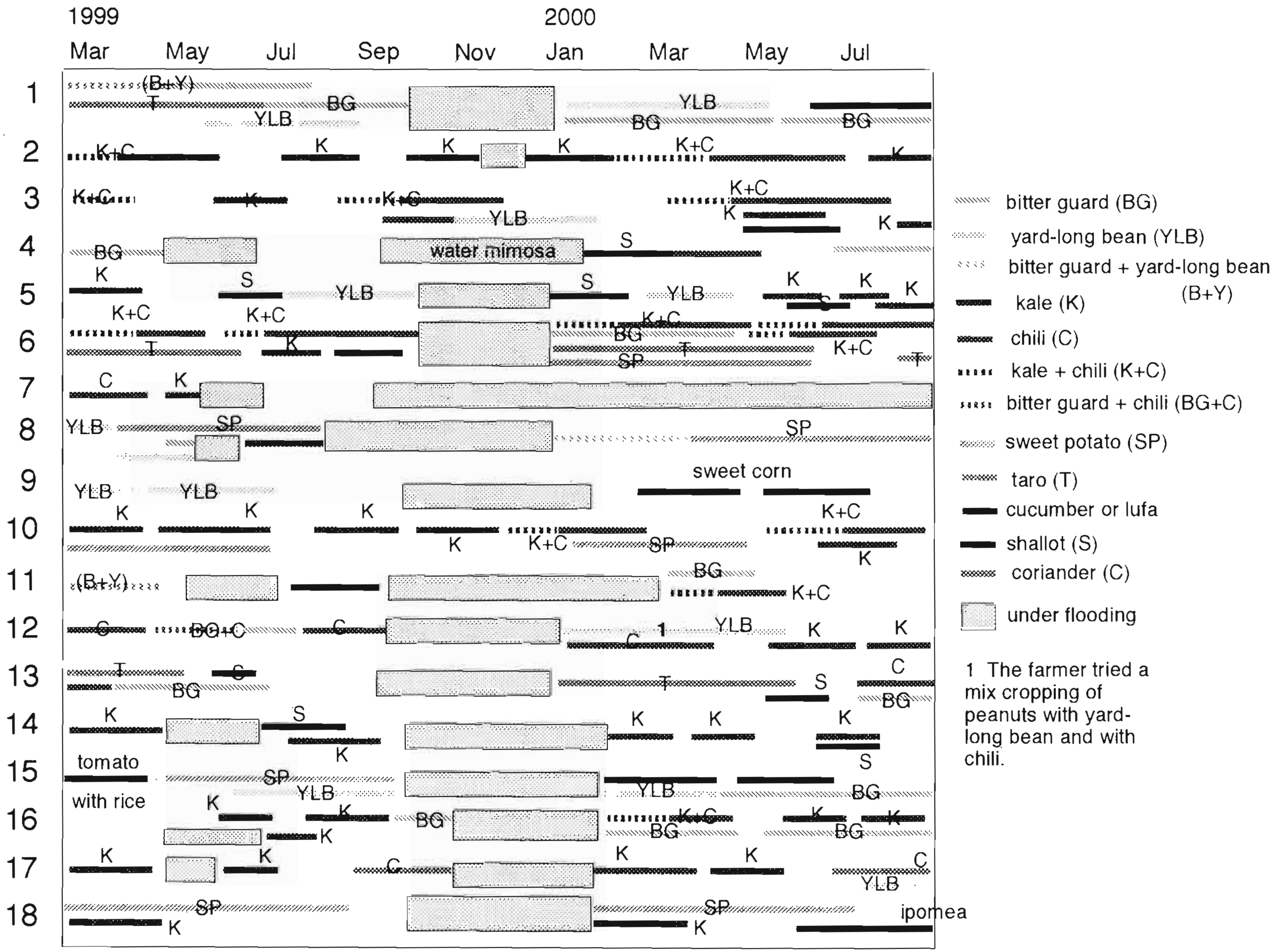
Table 1 Some chemical properties of the soils of *rong chin* fields and paddy fields adjacent to the *rong chin* fields in the Ban Bangluang village, Nakhonpathom Province.

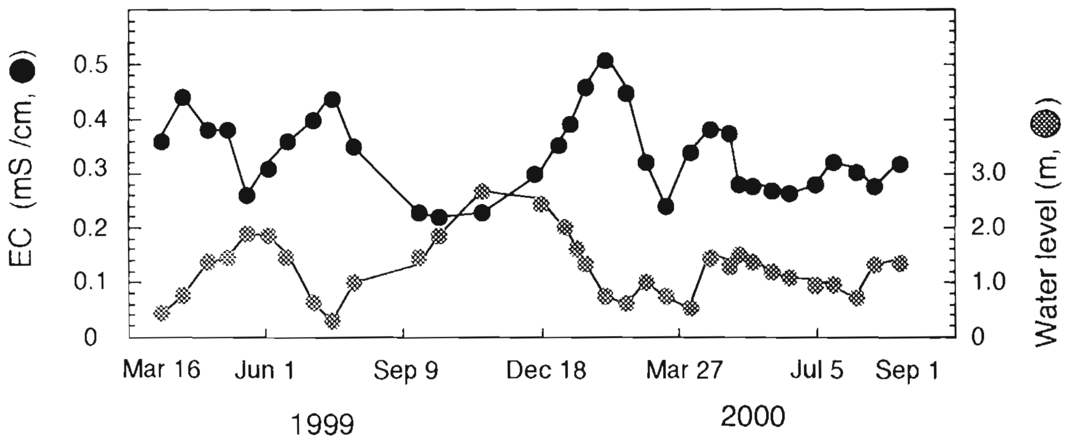
Zone	Land use	pH	EC	Nitrogen				Phosphorus	
				Total N	NH_4-N	NO_3-N	NO_2-N	Soluble P	Bray II-P
			(mS cm^{-1})		(mg kg^{-1})		(µg kg^{-1})	(mg kg^{-1})	
A	Paddy	5.26	0.187	2270	9.9	0	17.3	0.046	22.7
	Paddy	5.14	0.525	1720	11.2	0	14.9	0	19.8
	Paddy	4.07	0.967	3170	23.8	0	2.22	0.046	23.1
	Rong chin	6.17	0.492	1300	4.08	4.30	43.3	1.39	189
	Rong chin	6.27	0.413	1220	15.1	87.8	54.4	17.8	585
	Rong chin	5.89	0.71	1730	70.0	349	54.4	19.9	1380
	Rong chin	5.77	1.20	1620	16.9	134	65.4	9.77	501

Table 2 Some of the chemical properties of the *rong chin* soils before and after flooding in selected *rong chin* fields.

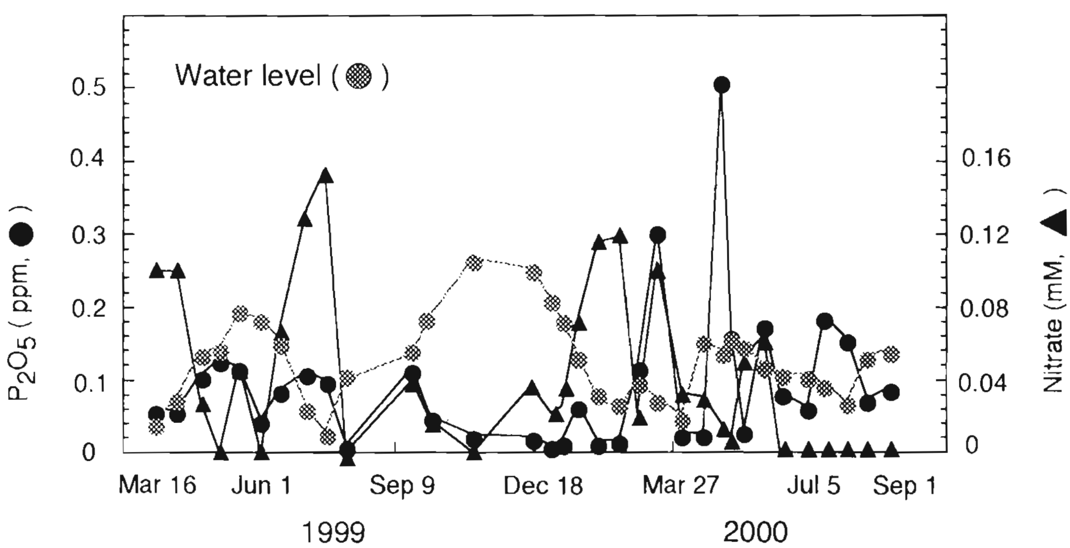
Field No	pH		EC (mS/cm)		Bray II P (P_2O_5 ppm)		NO_3-N (ppm)	
	before	after	before	after	before	after	before	after
1	5.4	6.1	0.37	0.19	233	223	22.3	0
2	5.4	6.1	0.34	0.14	400	288	16.9	11.3
3	6.6	5.2	0.43	0.54	148	275	4.58	6.79
4	7.6	7.5	0.14	0.14	194	108	8.28	3.34
5	6.7	6.4	0.38	0.13	888	575	65.5	13.2
6	6.3	7.7	0.96	0.16	425	255	208	4.94


Pasak
Nakhonsawa
n
Chaopray
a
Supanburi
Tha chin
Mae Klong
Bangko
k
Nakhonpathom
Tha Chin
river
Soil sampling
zone
Cropping pattern
is monitored
Ban Kum
Ban
Bangtakhian
Supanburi
C
Ban Bangthaten
B
Ban
Bangsam
Ban Bangnoi
Nakhon
pathom
A
1 km
Ban Bangluang


1999
2000
Mar
May
Jul
Sep
Nov
Jan
Mar
May
Jul
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
water mimosa
sweet corn
tomato
with rice
ipomea
bitter guard (BG)
yard-long bean (YLB)
bitter guard + yard-long bean (B+Y)
kale (K)
chili (C)
kale + chili (K+C)
bitter guard + chili (BG+C)
sweet potato (SP)
taro (T)
cucumber or lufa
shallot (S)
coriander (C)
under flooding
1 The farmer tried a mix cropping of peanuts with yard-long bean and with chili.



EC (mS /cm, ●)
Water level (m, ●)
0.5
0.4
0.3
0.2
0.1
0
3.0
2.0
1.0
0
Mar 16
Jun 1
Sep 9
Dec 18
Mar 27
Jul 5
Sep 1
1999
2000



Water level (●)
P_2O_5 (ppm, ●)
Nitrate (mM, ▲)
0.5
0.4
0.3
0.2
0.1
0
0.16
0.12
0.08
0.04
0
Mar 16
Jun 1
Sep 9
Dec 18
Mar 27
Jul 5
Sep 1
1999
2000

Kasetsart University
มหาวิทยาลัยเกษตรศาสตร์

IRD
Institut de recherche
pour le développement

Chulalongkorn
University

KYOTO UNIVERSITY
FOUNDED 1897

Proceedings of the International Conference:

The Chao Phraya Delta :

Historical Development, Dynamics and Challenges of Thailand's Rice Bowl

Volume 2

12-13-14-15 December 2000, Kasetsart University, Bangkok

Proceedings of the International Conference:

The Chao Phraya Delta :

Historical Development, Dynamics and Challenges of Thailand's Rice Bowl

12-13-14-15 December 2000, Kasetsart University, Bangkok

Kasetsart University

IRD (Institut de Recherche pour le Développement)

Chulalongkorn University, CUSRI

Kyoto University, CSEAS

Front cover: all snapshots from the Chao Phraya Delta by François Molle

Rice fields in Tha Maka project, Mae Klong	Weir in the Mae Klong Irrigation Project	Mobile pump set used for plot irrigation	Rice fields near a garbage dump	Dredging canals: an unending task
Raising geese	Transmitting culture and wisdom: old woman and her grandson	Lowlift axial pumps used to pump water from the main canal	Fields of taro being irrigated	Motorised spraying of rice fields
Canal in Damnoen Saduak area	Mechanisation of the harvesting of sugar cane	Raised beds for vegetable production	Post harvest work at home	Raised beds in Damnoen Saduak area

Kasetsart University
IRD (Institut de Recherche pour le Développement)
Chulalongkorn University, CUSRI
Koto University, CSEAS

Proceedings of the International Conference:

The Chao Phraya Delta :

Historical Development, Dynamics and Challenges of Thailand's Rice Bowl

Volume 1

Keynote address

P2: Land use: constraints, competition and opportunities

P3: Water resources management and environmental issues

Volume 2

P1: The delta way of life and transformation: tradition and change

P4: The village community: transformations of the farm structure and economy

P5: Rural-urban interactions: the Delta and Bangkok Metropolitan area

P6: The Delta in the National and Regional Context

Scientific Committee of the Conference

Srisak Wallipodom	**Panel 1**
Atsushi Kitahara (Nagoya Univ.)	**Panel 1**
Aphiphan Pookpakdi (Kasetsart University)	**Panel 2**
Booriboon Samrid(IRRI/DOA)	**Panel 2**
Mingsarn Kaosa-ard (Chiang Mai University)	**Panel 3**
Apichart Anukularmphai (A & R)	**Panel 3**
Chatthip Nartsupha (Chulalongkorn University)	**Panel 4**
Akin Rabibhadana	**Panel 4**
Amara Pongsapich (Chulalongkorn University)	**Panel 5**
Ammar Siamwalla (TDRI)	**Panel 5**
Charnvit Kasetsiri (Thammasat University)	**Panel 6**
Yoshihiro Kaida (Kyoto University)	**Panel 6**

Rapporteurs

Naruemon Hinshiranan (Chula)	**Panel 1**
Banthinee Soothsukon (Kasetsart University)	**Panel 2**
François Molle (Institut de Recherche pour le Développement)	**Panel 3**
Somporn Isvilanonda (Kasetsart University)	**Panel 4**
Porphant Ouyyanont (Sukhothai Thammatirat Univ.)	**Panel 5**
Thanawat Jarupongsakul (Chulalongkorn University)	**Panel 6**

Organising Committee of the Conference

Supot Faungfupong
Vice-President for Research and Academic Service, KU

Napavarn Noparatnaraporn
Dir. of Kasetsart University Research and Development Institute

Phacharavadee Paerattakul
International Affairs Division, Kasetsart University

Mailings, registration, information
Amphawan Guadkhan (DORAS, Kasetsart University)

Rooms, catering, reception, transports, social events, field trips
KURDI staff and International affairs Division staff

Conference Secretariat

- François Molle, Institut de Recherche pour le Développement
- Thippawal Srijantr, Faculty of Agriculture, Kasetsart University
- Amara Pongsapich, CUSRI, Chulalongkorn University
- Yoshihiro Kaida, CSEA, Kyoto University
- Bordin Rassameethes , KURDI, Kasetsart University

Contents

Panel 1

The delta way of life and transformation: tradition and change

Panel 4

The village community: transformations of the farm structure and economy

Panel 5

Rural-urban interactions: the Delta and Bangkok Metropolitan area

Panel 6

The Delta in the national and regional contexts

Panel 1

The delta way of life and transformation: tradition and change

The turning point of land policy at the end of the 19th century

Atsushi Kitahara[1]

Abstract: *The presentation will be made by my documentary research in the reign of Rama V at the National Archives. Why was the land policy retarded for ten years from 1892 to 1901, just when thè modern land tenure system began to be introduced into Thailand ?*

There may be given many reasons for the delay. The technical reason is the first plausible one. The ever expanding cultivated area on the vast frontier of the Chao-Phraya Delta might not be caught up by the survey techniques of the less trained technicians of mapping the land. The political reason might be another explanation. There peaked a crisis of French annexation of Laos and Cambodia border in 1983, and the King fell into too much nervous situation to do judge important policies until 1994.

We can find, however, the foregoing efforts on the legal and administrative preparation efforts by the concerned ministers, as Chaophraya Sisuriyawong, just during these ten years, as shown in 1994 and 1996 law manuscripts . They already had given many ideas to promote the modern tenure system by issuing the modern style title deeds. Anyway, the royal cabinet was greatly shuffled and eight of twelve ministers was replaced by "the Young Siam" members in 1896., and the ministry of agriculture was amalgamated into the ministry of finance under the influence of Prince Mahit.

This drastic political process suggests at least the last priority to the agriculture and land policies at this end of 19th century modernization process. It may be one of the reasons why the tenure proof administration and the tax collection administration was technically divided and not related with each other. The ministry of agriculture was merely allocated the former one and gradually limited her role to planting techniques since then, and it has become the long tradition. of the National Archives.

Full paper not provided

[1] Nagoya University, CSEAS

The interactions of the Chola empire in the Chao Phraya delta

G.Deivanayagam[1]

Abstract: *The Chola Empire of South India (9th to 12th C.AD) was in a position to establish strong contracts with the delta of Chao Phraya River of Thailand in the medieval period. They have very well established this contract by Diplomatic trade and religious means. The impact of this South Indian Empire caused a considerable effect in the Customs, Manners, Religious practices, Place names art forms and Architecture etc of the Thais for Example the former name of Bangkok, Krungthep is nothing but Kuranguthope of Tamil means the "Monkey's forest". In the close proximity, at Bujung valley of Malaysia, there was establishment of Cholas in this period, which is very well connected with this delta and gives "Siva, Vishnu, Thirupavai, Mulaipali, etc., and enhances the intrinsic culture and art forms of Thailand. This paper will deal with all these facets and gives substantial conclusions on the history of Thai arts and Religion.*

1 Introduction

The Chola country of South India and the Siam (Thailand) of Indochina are located in the same latitude. The Chola country, the east cost part in the Peninsular India is facing the Chao-Phraya Delta of Siam through Bay of Bengal. Almost similar landscape, climate, flora and fauna are seen on either sides in the Chao-Phraya Delta and of the Kavery Delta. Although differed in physiological forms as Dravidian and Mongoloid, the behavioural pattern of both the Tamils and Thais are identical . Their food stuffs, preparations, manners and customs, ceremonies and rituals, culture and psychology are analogous.

A cultural unity is visible amidst the linguistic and physiological diversity between these two different distant parts of Asia and ethnic groups.

How this similarities or cultural unity happened between South India and Siam?

A thorough probing reveals enormous facts and explores hundreds of evidences in the Chao Phraya Delta.

[1] Tamil University, Thanjavur, South-India

2 Early contacts

Accordingly one may assume the trade contact of these two countries even in the Pre-Christian era along with the ptolemy and periplus references, sea trade was florishing in that early period in the ancient port cities of the Chola's Kaveripumpattinam, Nagappattinam & Puducherry, with both east & west.

The commercial trade contacts between South India and Siam were very well established from Pallava period of 6th A.D.

Before 12th C.A.D. the present day Thailand was longitudinally divided in two halves and ruled by Combodian khmers and Mons of Burma. The Combodia, Burma, Malay Peninsula like south east Asian countries were all well influenced by the South Indian culture and trade in these periods. The close proximity of South Indian port cities like Mahabalipuram, Puducheri, Kaverippumpattinam, Nagappattinam etc. with Malaya, Kedah, Combodia promoted not only the trade but also the culture of these Mon-Khmers, who are with no doubt the forefathers of the Thais. Hence the Thais of Swarnabhumi were not reluctant in accepting the culture of their forefathers, Mon-Khmers, who were very much Indian Brahmanical.

Since these Mons and Khmers were able to cover the lower and middle parts of the Siam, this cultural diffusion reached only in these two parts which received many changes in the course of time, rather than the northern part which received this influence after a long time.

3 Cultural similarities

Inscriptions

The earliest inscriptions numbering more than 200, of all south east Asian countries are all of Sanskrit language written in Grantha script, a common script between Sanskrit and Tamil , which originated in the Pallava period in the Chola country by the Brahmins. No other scripts has been discovered so far. This professes the impact of the Chola country on South east Asian countries in the early period (Chabra 1965; 72-76)

Three Grantha inscriptions of 5th C.A.D. and two of 6th C.A.D. at Kuanlukput , one 7th C.A.D. inscriptions and one of 8th C.A.D. at Nakhon si Thammarad were discovered so far which are all in the southern part of Siam only that is in the Chao-Phraya Delta.

A 5th C.A.D. Sanskrit inscription discovered from «Sithep» of Siam is displayed at Bangkok Museum. Such inscriptions seen at wat Maheyang and Sonkai valley, explains the impact of South Indian Sanscrit in Siam. Since the early scripts used in these countries are all «Grantha». Almost all the scripts of these countries of Indo-China are formulated in an analogous form with Grantha and «Thai» is the typical example for that. The flowing and cursive nature of these scripts proves it.

TAKUA-PA TAMIL INSCRIPTIONS

Above all an important Tamil inscription was found at the Wat Naramiang temple of Takua-pa which confirms the permanent settlements of the Tamils in Chao-Phraya Delta. This inscription reads as follows:

«...(5) Varman Ku (na) ... Manthan

Naankuurula Yaa(n) Thotta Kulam per Siri Avani Naranam Manikkramatharkkum Sena Muhatarkum Patharkum Adaikalam».

Tamil merchant named...Manthan dug one tank (for the Domestic purpose of) by the name of Shri.Avani Naranam (which was) handed over for custody (for it's protection) to the people of the concerned settlement Manik Kramam, Senamuham and Devotees. (Kongknew Veeraprajeck :1986 : 7-20).

TAMIL SETTLEMENTS IN SIAM

The inference from this inscription gives a clear and vivid account of the influence of the Chola country in Chao-Phraya Delta. They were not only well settled with all domestic comforts but also with religious provisions in this distant place.

This researcher consider that digging that tank happened in a later period in that Tamil merchant settlement called Avani Narana Manikkramam which was a vaishnavite above where there was a temple for Vishnu was already existing. Since the inhabitants of this settlement are all very rich traders living with invaluable riches, the entire settlement was well protected by the armed forces called Senamugam. These residents were all staunch Vaishnavites and devotees. Therefore the new comer ... Manthan from Naankur in the Chola country, which was also a Chola's port town near to «Puhar», who earned well after having connection with this «Avani Naranam», decided to dig this temple tank in gratitude.

PEY WORSHIP

The worship of Karaikal Ammaiyar or Peyar is a typical identical and unique religious practice of the trader community of Chola country. This Peyar was a pious lady of this trader community connected with Siva worship celebrated for her chastity depicted in the form of a skeleton along with the image of dancing Siva. Such a Siva panel along with Karaikal Ammaiyar is found at Pimay, and in the triangular pediment of the eastern façade of the Phnam Rung Siva temple of North east Siam. The image of teaching Siva-Dakshinamurthy is also found in this temple.

SAIVISM

The great number of Sivalinga discovered so far in Siam tells the influence of Siavism in Siam in 5th C. and after. The findings of «Muha lingas» prooves that there was a great impact of Saivism in Siam in Pallava period. An image of Siva with five heads and Ten hands is displayed at the Museum of Ayutthaya. Dancing Siva with ornaments is seen at Kut Suen

Teng temple. Three Brahmin temples were discovered at Negara Se Thamma Raja. They are of Brick structures dating to 11th C. AD(Stanley O'connor : 19 : 1-22). In the eastern façade of the Pimay Buddhist temple an image of Rishaba Vahana Siva in seen. Images of Siva, Uma and Yama were discovered at Woa Daeng cave and Prasat Hin – Nong Hong of North East Siam. Tjhey belong to 11th C.A.D. and of Chola in style. It is being confirmed by the Siva of Viengsra.

The practice of Thiruppavai and Thiruvempavai in Siam is an another evidence of the interaction of the Cholas. The Thais are in general familiar with Pranava and Panchatchara that is Om and Namasivaya.

IMPACT OF AGAMAS

Cholas were following the Agama tradition in their temple rituals and chanting the Thevaram, Thiruvasagam, Thiruvempavai and Thiruppavai and Nalayera Thivya Prabantham in temples. Similar practices are found in Siam, should have been by the interactions of the Cholas.

VAISHNAVISM

In 1902 W.Walter Bourke has found out the sculptures of Brahma, Vishmu and Siva on the banks of river Takua Pah at Koupra Narai and declared about the influence of south india over Siam. Vishnu images were found out from Nakhon Sithammarat, Pimay, Bangkok, Cayya, Takua Pah, OCEO, Phetburi etc. According to Pier Dewpond the Takua Pah Vishnu is belongs to Chola style. Almost all the Icnographic details of the available Vishnu images at Siam implies the influence of the Pallavà style. This researcher has studied some of the Buddhist images of Sukkhothai and Ayutthaya collection and came to the conclusion that:

a) Some of them were moulded by the Chola sculptors at Siam in Tanjorian style.

b) Some of them were costed at Thanjavur, Nagappattinam and brought to Siam either to their own settlements or to the Thai public or royalty. Prince Chand Chirayu Rajani, in his book entitled «Thai imageries of Swarnabhumi Art» mentioned about my view points. The area of 'Sitep' should have been a strong hold of Vaishnavism and of Indian settlement in Pallava and Chola period. Stanely O'Connor considers that the ancient architectural and archaeological findings of Thailand dating from 5th to 9th C.A.D. are all Brahmanical and of South India. They are of either late Pallava or early Chola in style. The reclining image of Vishnu, Govarthana lila are also identified at a dilabitated temple in the eastern part of Thailand. One Bairava sculpture of Viang Sira confirms the Indian or Brahmin towns formed in Siam in those period.

TAMIL BUDDHISM – THAI BUDDHISM

This iconographical, religious and cultural influence of the Cholas over Thailand was reflected in Thai Buddhism also. Experts used to classify the Thai Buddhist Bronzes mainly into two categories. They are

1) Pallavanised and

2) Cholified ones.

In *cholification* the «Nagappattinam bronze casting» technique (Tanjorian) was highly appreciated and adopted by the Thais.

RELIGION & PHILOSOPHY

The South Indian philosophy of Hinduism and Buddhism which were prevailing in the Chola period were also being adopted by the Siamese which are clearly referred by Pre Rup Stele Inscription and Prasat Kok Po inscriptions. The South Indian Buddhist Monks like Vinita Ruci and Vajrabodhi spreaded Buddhism of Chola country in Siam, Vietnam and Laos.

RAMAYANA

Another strong proof of Cholas interaction in Siam is Ramayana. The Ramakian practised by the Thais are analogous to Cholas Kamba Ramayanam only and the Mayil Ravanan story is also of South India (Mayirab Story).

There are 21 similarities found between Kamba Ramayanan and Ramakian. For example the love at first sight between Phra Ram and Nangsidha.

The Ramayana sculptures of Lobpuri temple wall and of Pimay Buddha temple depicting the epic with flying Hanuman with Sanjeevi hill, the fainted Lakhsmana, Building the Sethu bridge by the Monkeys, nose cut of Surpanaka, defeat of Vali etc.

The word «Ramakien» is only a corrupt form of «Rama Kirthi».

THIRUPPAVAI - THIRUVEMPAVAI

Chanting of Thiruppavai and Thiruvempavai by the Thai Brahmins were also introduced into Thailand by the Cholas only. Some of the Thevaram like «Mattitta Punnayang Kanal» etc. and Thivya Prapandham like. 'Thiru Valuthi Natennum', «Uyarvara Uyarnalam Udaiyavan» etc are also being mixed in their chanting. They are quite familiar with Thiruchitrambalam, Narayaname and Namasivaya. This author was able to see same Tamil leaf also in the Grantha Palm leaf manuscripts kept by the Thai Brahmans, which reveals that Tamil was familiar with the Thai Brahmans in Chola period. They were well versed in Grantha also. But nowadays without knowing the script and the meaning, the phonemes were written in Thai script in a corrupt form and they are chanted.

Hindu customs and rituals were followed by Thai royalty even in their coronation ceremony.

GARUDA

The image of Garudantika the flying Kite man carrying Vishnu on his shoulder is familiar with Thailand. (Bangkok Emerald Buddha temple, Pimay Buddha temple, etc.)

VISHNU AND RAJA

The reclaiming Vishnu is identical with Chola country is found in Siam. Vishnu with two consorts is a Chola's production which is being seen in Siam. They are Lakshmi and Pudevi. Pudevi is considered or treated as Maheswari by the Siamese.

The Hari-hara (Half Vishnu – Half Siva) is flourished among South Indian smartha Brahmins. The very same practice was in existence at Siam even in 7th C.A.D. when Esana Varman was ruling Siam. There is a great saying among the Cholas as follows. «Seeing the king is seeing the Vishnu» The same concept is seen at Siam. King Ramathipaty who established the Ayutthaya kingdom calling himself as Narayana – Nara, and ordered for a full fledged annual ceremony in the Nagara Sri Thammarat.

THE BRAHMAN TEMPLES

In the Thai Brahman temple complex of Bangkok a Ganesh temple, Siva temple and a Vishnu temple are Seen. This Vishnu is being named as Sugothaya Perumal, typical Tamil name, Sugothayam is the former name of the Thailand. This name consists of two syllables Suga + Uthayam that is the «Pleasant dawn». Like Korea the land of morning calm, Thailand was treated by the Cholas as a land of «Pleasant dawn».

SWINGS

The 'Great Swings' seen in Thai Brahmin temples and the Swing festivals (Login wor) are all of South Indian tradition only.

PAVAAI

The «Paavai Nonbu» (December and January) was familiar with the Thais until 1940. Nowadays it has been reduced to a temple ritual.

RAIN FESTIVAL

The rain festival and the Mantra Chanting that time are all of Tamil in tradition. It affirms the loyalty of the people to the king as «We serve you not only today; but for forth coming 7 births also.

DEEPAWALI & KARTHIKAI

Deepavali and Karthikai festivals were also introduced by the Cholas in Siam. The Karthikai festival is being celebrated as «Malai» (Thiruvannamalai fire festival) by the Thais. The float festivals of Thais are also similar with the Tamil Cholas.

THE THAI CHOLAS

«The kings of Ayutthaya were proud to call themselves as Cholas» (Paul Pelliot – 'Encore A Propos Des Voyages De Tcheng Howo' Toungpao 1936). The story of the Manu neethi Chola was familiar among Sugothays and king Ramakongheng had installed a bell for the public call for justice. (David K.Wyatt 1984 : 54)

TAMILS AND TAMIL IN THAILAND

The Tamil people migrated to Siam in the Chola period, slowly lost their language and culture and mingled with the Thais. But one can see the Physiological features of this Chola Thais from the Mongoloid Thai natives.

The mixing of these Tamils with the Thais long ago also resulted in influence to the Thai Vocabulary. For Example:

Tamil	Thai	English
Thangam	Thongam	Gold
Kappal	Kamban	Ship
Malai	Male	Garland
Krambu	Klambu	Kurry
Kenty	Kently	Small vessel
Appa	Pa	Father
Thatha	Tha	Grandfather
Amma	Me	Mother
Guru	Gru	Teacher
Asan	Asan	Teacher
Puttan	Puttan	Great Grandfather
Puthran	Puthru	Son

And so many others.

In addition the days and months names are similar with the Tamil ones.

CONCLUSION

Hence the interactions of the Cholas in the Chao-Phraya Delta which was named by the Cholas as Meenam treated equally with River Kaveri Delta, preferred to settled and considerably influenced the Thais in all ways of life which excelled even the original Chola culture by its sobere nature.

References

Chabra, Expansion of Indo-Aryan culture during Pallava rule, Munsiram Manoharlal, Delhi.

Daweewarn, Dawee, Brahminism in South East Asia , Sterling publications PVT LTD., New Delhi.

O'Comor stanley, Hindu Gods of Peninsular Siam, Attibus Asia publishes, Switzerland 1971.

Kongkaew Veerpajak, inscriptions from southern Thailand, SPA FA Digest, Vol. VII No.1, 1986.

Settlement in the Central Region of Thailand

Pussadee Tiptus[1]

การตั้งหลักแหล่งในภาคกลาง

Abstract: *Bangkok and Thonburi is situated on a flood plain with the Chao Phraya River. During the beginning of Rathanakosin era, the people built their houses, floating houses and settled their boats along both sides of The Chao Phraya River as well as along the canals. The areas where there were dense settlements were along Ku Muang Derm canal, Bangkok Noi canal, Bangkok Yai canal, the beginning of Rob Krung canal on the side of Ong Ang canal, Banglumphu canal and the part of Rob Krung canal that met with Mahanak canal.*

The areas around the Royal Palace, both the Grand Palace, the Second King's palace and the palace of the eldest son of the Second King, were often the settlements of households belonging to ministers, noblemen, and royal servants. The King usually had a residence built for a minister who would be given both the land and the residence. The palaces of the King's sons were used as residence and office to carry out the various work assigned by the King, and thus became small settlements because the people who worked for which palace often had their houses built near that palace. In addition, the location of households of minister and noblemen as well as the people was often related to the location of the temples that they built or were under their patronage.

The settlement of foreigners was often outside the city wall, on the southern side which was the outlet to the sea or the entrance before entering the city. The King usually allocated the area near the eastern and western side of the Chao Phraya River for foreign consulates, ambassadors' residence, missionaries' houses, merchants' and both western and eastern resident's houses.

The housing settlements of people during Rathanakosin period were therefore horizontal settlement along major transportation routes. With in the city, the settlement extended to the north, the east and the south. On the southern side of the city, from along Rob Krung canal to the southern section of Phadung Krung Kasem canal was a dense Chinese settlement. There were single houses and row shop houses of the Chinese style built along the roads and along both banks of the Chao Phraya River. They were used for storing goods transported by boats, Chinese Theatres, joss-

[1] Prof. Pussadee Tiptus, professor in Architecture, Faculty of Architecture, Chulalongkorn University, Bangkok, Thailand.

houses, residence of wealthy Chinese merchants, and tax officers as well as houses of workers and coolies.

The northern part of the city, which was developed into a new residential settlement of the King, the royal families, noblemen and wealthy royal servants, had thus become sub-urban residential area that was beautifully laid out and was not so densely populated as other parts. Towards the end of King Rama V 's reign, roads had become more preferable to rivers and canals, which increased the price of land along the roads. Entrepreneurs started to buy land in Bangkok and had roads constructed that cut through the land, dividing the land into small pieces for sale so as to build houses on. During the reign of King Rama VI, the city was divided into two provinces: on the east was the Province of Pranakhon or Bangkok, whereas on the west of Chao Phraya River became Thonburi Province. Most of the growth was in the Bangkok side. There was a greater increase of roads and trading areas including residential areas.

After the major political change in AD 2475 , residential areas began to expand to sub-urban areas, because the price of land in the center of the city started to rise. Many landowners therefore preferred to have shophouses built in the central city area so that they can be used both for business and residential purposes, or to buy land further away from the city area so that houses can be built on larger pieces of land. This latter practice made the residential areas expand horizontally from the city center. Houses were built along the roads and in the lanes on both sides of the main streets as well as in sub-urban housing complexes. Those who were wealthy started to live in city condominiums to be near their workplace and to shorten travelling time. This phenomenon has been increasing during the last 10 years.

การตั้งหลักแหล่งในภาคกลาง

บริเวณกรุงเทพฯ และธนบุรี มีแม่น้ำเจ้าพระยาไหลผ่าน เป็นที่ราบลุ่ม ในช่วงต้นรัตนโกสินทร์ราษฎรทั่วไปตั้งบ้านเรือน เรือนแพและจอดเรือตามริมแม่น้ำเจ้าพระยาทั้งสองฝั่งรวมทั้งตามริมคลองด้วย บริเวณที่มีการตั้งบ้านเรือนที่อยู่อาศัยหนาแน่น ได้แก่ บริเวณแนวคลองคูเมืองเดิม คลองบางกอกน้อย คลองบางกอกใหญ่ ปากคลองรอบกรุงด้านคลองโอ่งอ่าง คลองบางลำพู และช่วงคลองรอบกรุงที่บรรจบกับคลองมหานาค

บริเวณโดยรอบพระบรมมหาราชวัง ทั้งพระราชวังหลวง วังหน้า และวังหลังมักเป็นที่ตั้งบ้านเรือนของเสนาบดี ขุนนาง และข้าราชบริพาร ซึ่งพระมหากษัตริย์มักจะสร้างบ้านสำหรับให้เสนาบดีอยู่ และมักได้รับพระราชทานที่ดินและบ้านเป็นกรรมสิทธิ์ด้วย ส่วนวังพระราชโอรส ใช้เป็นที่ประทับและที่ทำงานว่าการในด้านต่างๆ ที่ได้รับมอบหมาย จึงเป็นแหล่งให้เกิดชุมชนขึ้นโดยรอบ สำหรับราษฎรที่รับราชการกับวังใดก็มักจะตั้งบ้านเรือนพำนักอยู่ใกล้วังนั้นๆ นอกจากนั้นตำแหน่งที่ตั้งบ้านเรือนของขุนนางเสนาบดี และราษฎรทั่วไปมักจะสัมพันธ์กับตำแหน่งที่ตั้งของวัดที่ตนสร้างหรืออุปถัมภ์ด้วย

ที่ตั้งชุมชนชาวต่างประเทศมักอยู่นอกเขตกำแพงเมืองทางด้านใต้ของพระนครที่เป็นทางออกสู่ทะเล หรือเป็นต้นทางก่อนเข้าถึงตัวพระนคร ที่ตั้งของกงสุลต่างประเทศ บ้านพักทูต บ้านหมอสอนศาสนา พ่อค้า และราษฎรชาวต่างประเทศทั้งชาวตะวันตกและตะวันออกนั้น พระมหากษัตริย์มักโปรดเกล้าฯให้จัดหาที่อยู่ให้ในบริเวณริมแม่น้ำเจ้าพระยาทั้งฝั่งตะวันออกและฝั่งตะวันตก

ลักษณะการตั้งชุมชนที่อยู่อาศัยของประชาชนในยุครัตนโกสินทร์ จึงเป็นการแผ่กระจายทางแนวราบไปตามเส้นทางคมนาคมหลัก มีการขยายเขตชุมชนในพระนครออกไปทั้งทางด้านเหนือ ด้านตะวันออก และด้านใต้ บริเวณแถบใต้ของพระนคร ตั้งแต่แนวคลองรอบกรุงจนถึงแนวคลองผดุงกรุงเกษมด้านใต้ เป็นชุมชนจีนที่หนาแน่น มีบ้านเดี่ยวและตึกแถวแบบจีนสร้างขึ้นบริเวณริมถนนและริมแม่น้ำเจ้าพระยาทั้งสองฝั่ง เป็นที่ขนถ่ายสินค้าทางเรือ โกดังเก็บสินค้า โรงงิ้ว ศาลเจ้า และที่อยู่ของบรรดาคหบดี นายอากร ตลอดจนกรรมกรและกุลีชาวจีน

ทางด้านเหนือของตัวเมือง ที่พัฒนาเป็นชุมชนที่พักอาศัยแห่งใหม่ของพระมหากษัตริย์ พระราชวงศ์ และขุนนางข้าราชการที่มีฐานะ จึงกลายเป็นชุมชนพักอาศัยชานเมือง ที่เป็นระเบียบสวยงาม และไม่หนาแน่นแออัดเหมือนในเขตอื่นๆ ในปลายรัชกาลพระบาทสมเด็จพระจุลจอมเกล้าเจ้าอยู่หัว เริ่มมีความนิยมถนนแทนที่แม่น้ำลำคลอง ทำให้ที่ดินริมถนนมีราคาแพงขึ้น นายทุนกว้านซื้อที่ดินในกรุงเทพฯแล้วตัดถนนผ่านที่ดิน แบ่งที่ดินเป็นแปลงย่อยๆ สำหรับขายให้ปลูกสร้างบ้านเรือน ในรัชกาลพระบาทสมเด็จพระปกเกล้าเจ้าอยู่หัว มีการแบ่งเขตกรุงเทพฯ เป็น 2 จังหวัด คือ ฝั่งตะวันออกเป็น จังหวัดพระนคร หรือกรุงเทพฯ ส่วนฝั่งตะวันตกของแม่น้ำเจ้าพระยาเป็นจังหวัดธนบุรี ความเจริญส่วนใหญ่จะอยู่ในฝั่งพระนคร มีการตัดถนนและมีการค้าขายมากขึ้นที่ฝั่งนี้ รวมทั้งย่านพักอาศัยด้วย

ในช่วงหลังเปลี่ยนแปลงการปกครอง ใน พ.ศ.2475 เป็นต้นไป การตั้งหลักแหล่งที่อยู่อาศัยของประชาชน เริ่มขยายตัวออกสู่ชานเมือง เพราะที่ดินในเขตใจกลางเมืองเริ่มมีราคาสูงขึ้น เจ้าของที่ดินหลายรายจึงนิยมสร้างตึกแถวในเขตตัวเมืองใช้ประกอบการค้าร่วมไปกับการอยู่อาศัยได้ หรือไปซื้อที่ดินในเขตห่างไกลตัวเมืองออกไปเพื่อปลูกบ้านในที่ดินที่กว้างขวางขึ้น ซึ่งทำให้หลักแหล่งที่อยู่อาศัยของประชาชนขยายตัวออกไปทางแนวราบไกลออกไปจากศูนย์กลางเมือง มีการสร้างบ้านเรือนในที่ดินริมถนนและในซอยที่แยกเข้าไปจากถนนใหญ่ ตลอดจนในหมู่บ้านจัดสรรชานเมือง ในขณะที่ผู้ที่มีฐานะดีเริ่มมีการอยู่อาศัยในอาคารสูงกลางเมืองเพื่อใกล้แหล่งงานและย่นระยะการเดินทาง ซึ่งจะพบมากขึ้นในช่วง 10 ปีที่ผ่านมาด้วย

การตั้งหลักแหล่งในที่ราบลุ่มแม่น้ำเจ้าพระยาภาคกลาง
วิถีชีวิตในชุมชน : การเปลี่ยนแปลงจากอดีตสู่ปัจจุบัน

<u>ลักษณะภูมิประเทศ</u>

บริเวณภาคกลางของประเทศไทยครอบคลุมเนื้อที่ 22 จังหวัด ตั้งแต่จังหวัด นครสวรรค์ ต่อเนื่องลงมาจนถึงอ่าวไทย ที่ราบภาคกลางนี้เกิดจากการทับถมของตะกอน ซึ่งแม่น้ำต่าง ๆ พัดพามาสะสมกันเป็นแอ่งใหญ่ ลักษณะภูมิประเทศของภาคกลางอาจแบ่งได้เป็น 3 เขต ได้แก่ ที่ราบภาคกลางตอนบน ที่ราบภาคกลางตอนล่าง และบริเวณขอบที่ราบภาคกลาง

1. <u>ที่ราบภาคกลางตอนบน</u> ได้แก่ บริเวณซึ่งอยู่เหนือจังหวัดนครสวรรค์ขึ้นไปจนถึงจังหวัดสุโขทัย และจังหวัดอุตรดิตถ์ ประกอบด้วย จังหวัดสุโขทัย พิษณุโลก กำแพงเพชร พิจิตร และเพชรบูรณ์ โดยทั่วไปมีลักษณะเป็นที่ราบลอนลาด และมีเนินเขาสลับ มีบริเวณที่ราบน้ำท่วมถึงอยู่เป็นบริเวณแคบ ดินที่ปกคลุมเป็นดินตะกอนน้ำจืด แม่น้ำที่ไหลผ่านที่ราบภาคกลางตอนบน คือ แม่น้ำปิง แม่น้ำวัง แม่น้ำยม และแม่น้ำน่าน แม่น้ำทั้ง 4 สาย มีต้นน้ำอยู่ในภาคเหนือ และไหลต่อลงมาในภาคกลาง มาบรรจบกันที่ปากน้ำโพ จังหวัดนครสวรรค์ ซึ่งเป็นจุดเริ่มต้นของแม่น้ำเจ้าพระยา ที่ไหลลงสู่ที่ราบภาคกลางตอนล่างออกสู่อ่าวไทย[1]

2. <u>ที่ราบภาคกลางตอนล่าง</u> หรือเรียกอีกชื่อหนึ่งว่าที่ราบเจ้าพระยา ได้แก่ พื้นที่ตั้งแต่จังหวัดนครสวรรค์ลงมาถึงปากอ่าวไทยมีพื้นที่เป็นรูปสามเหลี่ยม มีลักษณะเป็นที่ราบลุ่มต่ำขนาดใหญ่ เรียกว่าที่ราบดินดอนสามเหลี่ยมปากแม่น้ำเจ้าพระยา เพราะเกิดจากการทับถมของตะกอน บริเวณปากน้ำของแม่น้ำหลายสาย ได้แก่ แม่น้ำเจ้าพระยา แม่น้ำท่าจีน แม่น้ำแม่กลอง และแม่น้ำบางปะกง พื้นที่ส่วนใหญ่เป็นที่ราบน้ำท่วมถึง นับว่าเป็นที่ราบที่มีขนาดใหญ่ที่สุดของประเทศ และอาจแบ่งที่ราบภาคกลางตอนล่างเป็น 2 เขตย่อย คือ[1]

2.1 <u>ที่ราบเจ้าพระยาตอนบน</u> มีพื้นที่ตั้งแต่จังหวัดนครสวรรค์จนถึงจังหวัดพระนครศรีอยุธยา เป็นพื้นที่ดินดอนสามเหลี่ยมเก่า มีแม่น้ำเจ้าพระยาที่มีสาขาแยกเป็นแม่น้ำสุพรรณบุรี-ท่าจีน ที่ไหลออกสู่ทะเลที่จังหวัดสมุทรสาคร แม่น้ำน้อย แม่น้ำลพบุรี ไหลมาลงแม่น้ำจ้าพระยาอีกครั้งที่จังหวัดพระนครศรีอยุธยา ที่ราบเจ้าพระยาตอนบน ได้แก่ บริเวณจังหวัด นครสวรรค์ ชัยนาท สิงห์บุรี ลพบุรี บางส่วนของจังหวัดสระบุรี อ่างทอง

2.2 <u>ที่ราบเจ้าพระยาตอนล่าง</u> มีบริเวณตั้งแต่จังหวัดพระนครศรีอยุธยาจนถึงอ่าวไทยอาจเรียกอีกชื่อหนึ่งว่า ที่ราบกรุงเทพฯ พื้นที่มีระดับค่อนข้างราบเรียบโดยตลอด ประกอบด้วยจังหวัด

พระนครศรีอยุธยา ปทุมธานี นนทบุรี กรุงเทพมหานคร สมุทรสงคราม สมุทรสาคร และสมุทรปราการ บริเวณสองฝั่งแม่น้ำเป็นที่ราบน้ำท่วมถึง ลักษณะดินเป็นดินตะกอนที่ถูกแม่น้ำพัดพามาทับถม ในฤดูฝนจะมีน้ำท่วมถึง ที่ลุ่มหลังลำน้ำมีบริเวณกว้างขวางมาก ที่ราบภาคกลางจึงเป็นแหล่งปลูกข้าวที่สำคัญ ส่วนบริเวณที่ติดกับอ่าวไทย เป็นพื้นที่ราบลุ่มต่ำ และลำคลองต่าง ๆ จำนวนมาก จึงมักประสบปัญหาน้ำท่วมอยู่เสมอ

3. <u>บริเวณขอบที่ราบภาคกลาง</u> เป็นบริเวณที่ราบกว้างใหญ่ของภาคกลางตอนล่างบริเวณขอบทางตะวันตก ได้แก่ บางส่วนของจังหวัดอุทัยธานี ราชบุรี นครปฐม มีแม่น้ำแม่กลองและแม่น้ำสะแกกรังไหลผ่าน ส่วนขอบที่ราบภาคกลางของตะวันออก ได้แก่ จังหวัด ลพบุรี สระบุรี และนครนายก มีแม่น้ำป่าสักและแม่น้ำนครนายกไหลผ่าน ภูมิประเทศของขอบที่ราบภาคกลาง เป็นที่ราบลุ่มแม่น้ำสลับที่ราบลูกฟูก มีเนินตะกอนรูปพัดขนาดใหญ่ ที่เกิดจากการทับถมของตะกอนจากแม่น้ำที่ไหลลงสู่ที่ราบภาคกลาง

2. การตั้งหลักแหล่งของชุมชนในอดีตจนถึงปัจจุบัน

2.1 <u>ชุมชนในที่ราบภาคกลางตอนบน</u>

ที่ราบภาคกลางตอนบนที่เริ่มตั้งแต่จังหวัดสุโขทัยลงมานั้น ประกอบด้วยกลุ่มชุมชนที่มีความสำคัญในประวัติศาสตร์มาตั้งแต่ในอดีต เช่น **สุโขทัย** นับว่าเป็นชุมชนขนาดใหญ่ที่เริ่มก่อตัวตั้งแต่ประมาณศตวรรษที่ 18 หลักฐานทางประวัติศาสตร์ จากศิลาจารึกหลักที่ 1 จารึกพ่อขุนรามคำแหงและหลักที่ 2 จารึกวัดศรีชุม ที่มีการบันทึกเรื่องราวของเมืองสุโขทัยยุคต้นอย่างชัดเจน แสดงถึงการปกครองอย่างมีแบบแผน ในสมัยพ่อขุนรามคำแหงอาณาจักรสุโขทัยมีความมั่งคงกว้างขวางทั้งทางด้านอาณาเขต ซึ่งมีการปกครอง เศรษฐกิจ และสังคมที่เป็นปึกแผ่นเป็นราชธานีที่รุ่งเรือง รวมทั้งด้านวัฒนธรรม ประเพณี และศาสนา แม้เมืองสุโขทัยจะถูกทิ้งร้างไปตั้งแต่ พ.ศ. 2376 แต่ก็ได้รับการฟื้นฟูให้เป็นเมืองประวัติศาสตร์ มีการบูรณะขุดแต่งโบราณสถานสำคัญในจังหวัดสุโขทัย สะท้อนความเจริญรุ่งเรืองและวิถีชีวิตของผู้คนชาวสุโขทัยในอดีต

ปัจจุบัน ประชากรจังหวัดสุโขทัยส่วนใหญ่ประมาณร้อยละ 80 อาศัยอยู่ในชนบท ส่วนใหญ่สืบเชื้อสายมาจากคนไทยดั้งเดิมในสุวรรณภูมิ มีชนกลุ่มน้อยที่เป็นชาวไทยภูเขาปะปนบ้าง เช่น กะเหรี่ยง แม้ว เย้า ลีซอ ชนกลุ่มน้อยเหล่านี้บางส่วนย้ายมาจากทางภาคเหนือ และภาคอีสาน นอกจากนั้นยังมีชาวบ้านกลุ่มหนึ่งที่บ้านหาดเสี้ยว อำเภอศรีสัชนาลัย มีเชื้อสายลาวพวน อพยพมาจากเวียงจันทน์ ตอนสมัยต้นกรุงรัตนโกสินทร์ กลุ่มชนเหล่านี้มีการปลูกสร้างบ้านเรือนที่อยู่อาศัย และวิถีชีวิตที่ยังสืบทอดเอกลักษณ์ดั้งเดิมของตนมาจนทุกวันนี้

ส่วนที่จังหวัดพิษณุโลก ซึ่งมีบริเวณตอนกลางและตอนใต้ของตัวจังหวัด มีลักษณะพื้นที่เป็นที่ราบลุ่มแม่น้ำ บริเวณแม่น้ำน่านและสาขาที่ไหลผ่านอำเภอเมืองพิษณุโลก จะมีการตั้งหลักแหล่งเป็น

หมู่บ้านอยู่บริเวณทั้งสองฝั่งของแม่น้ำน่าน เป็นชุมชนขนาดใหญ่ และเป็นเอกลักษณ์ของพิษณุโลก คือ ชุมชนเรือนแพในแม่น้ำน่าน บริเวณตัวเมืองพิษณุโลก ที่ยังมีให้เห็นอยู่แม้จะลดจำนวนเรือนแพลงไปมากจากที่เคยมีมาในอดีต นอกจากนี้บริเวณเมืองพิษณุโลกยังเคยเป็นที่ตั้งของชุมชนโบราณและวัดโบราณจำนวนมาก

สำหรับจังหวัด **กำแพงเพชร** ซึ่งเดิมมีชื่อเรียกกันว่าเมืองชากังราว เป็นเมืองหน้าด่านที่มีความสำคัญยิ่งนั้น การที่ภูมิประเทศเป็นที่ราบลุ่มแม่น้ำ และเป็นที่ราบสลับกับเนินเขาเตี้ย ๆ และภูเขาสลับซับซ้อนเป็นแหล่งแร่ธาตุ ป่าไม้ และพื้นที่การเกษตร จึงมีการอพยพเคลื่อนย้ายของประชากรจากจังหวัดอื่นเกือบทั่วทุกภาคเข้ามาตั้งหลักแหล่งในจังหวัดกำแพงเพชรเป็นจำนวนมาก บางหมู่บ้านหรือบางตำบล มีการอพยพมาด้วยกันเป็นกลุ่มเข้ามาหาที่ทำกินในที่ดินที่ยังรกร้างว่างเปล่าอยู่ นอกจากนั้นยังมีชนกลุ่มน้อย เช่น ชาวไทยภูเขาเผ่าเย้า แม้ว มูเซอ ลีซอ และกะเหรี่ยง เข้ามาตั้งหลักแหล่งปะปนด้วยจำนวนไม่มากนัก ในจังหวัดกำแพงเพชรมีโครงการบ้านเล็กในป่าใหญ่ ตามพระราชเสาวนีย์ของสมเด็จพระนางเจ้าฯ พระบรมราชินีนาถ ในพื้นที่บ้านอุดมทรัพย์ มีวัตถุประสงค์เพื่อฟื้นฟูสภาพป่าให้มีความสมบูรณ์ดังเดิม ทั้งยังเป็นการช่วยราษฎรชาวไทยภูเขาให้มีที่ดินทำกินเป็นหลักแหล่ง ไม่ต้องบุกรุกถางป่าทำไร่เลื่อนลอยอันจะเป็นการทำลายทรัพยากรของจังหวัดด้วย

จังหวัดพิจิตร นั้น ตัวจังหวัดตั้งอยู่บนบริเวณที่ราบกว้างใหญ่สองฝั่งแม่น้ำยมกับแม่น้ำน่าน การตั้งหลักแหล่ง ณ ที่นี้ มีตำนานเล่ากันว่า ตั้งแต่ประมาณ พ.ศ. 1600 เจ้าผู้ครองนครไชยบวร ทอดพระเนตรเห็นพื้นที่จังหวัดพิจิตรในปัจจุบัน ซึ่งในอดีตนั้นเป็นบึงกว้างใหญ่ อุดมด้วยปลาและสัตว์น้ำ เป็นชัยภูมิที่เหมาะสม ถ้าตั้งเมืองในบริเวณใกล้บึงนี้เป็นพื้นที่กว้างขวางเหมาะแก่การขยายตัว พื้นที่เป็นที่ลุ่มเหมาะแก่การเพาะปลูก ทิศตะวันตกมีแม่น้ำน่าน(เก่า) เป็นพรมแดนป้องกันข้าศึกได้ สองฝั่งแม่น้ำเป็นที่ดอน น้ำท่วมไม่ถึง เหมาะแก่การปลูกสร้างบ้านเรือนเรียงรายไปตามสองฝั่งแม่น้ำได้ รวมทั้งการเก็บภาษีทางน้ำ และภาษีสินค้าจะเป็นการเพิ่มรายได้แก่เมืองได้ด้วย ปัจจุบันจังหวัดพิจิตรมีประชากรส่วนใหญ่มีเชื้อชาติไทย จีน ลาว อินเดีย และญวนที่อพยพมาตั้งหลักแหล่งในจังหวัดพิจิตรในระยะหลังด้วย

2.2 ชุมชนในที่ราบภาคกลางตอนล่าง (ที่ราบเจ้าพระยาตอนบน)

ในเขตที่ราบภาคกลางตอนล่าง หรือที่เรียกกันว่า **ที่ราบเจ้าพระยา** ในช่วงบนของบริเวณนี้ตั้งแต่จังหวัดนครสวรรค์ลงไป มีหลายเมืองที่เป็นชุมชนโบราณมาก่อน เช่น จังหวัดนครสวรรค์ เป็นชุมชนสมัยก่อนประวัติศาสตร์ เมื่อประมาณ 3,000 ปีมาแล้ว ชุมชนนี้รู้จักการเพาะปลูก การทอผ้า การทำเครื่องปั้นดินเผา ตลอดจนรู้จักวิธีทำเครื่องมือเครื่องใช้โดยใช้โลหะ คือ สำริด และเหล็ก ประชาชนส่วนใหญ่อาศัยอยู่ในบริเวณที่ดอนใกล้แหล่งที่มีน้ำซึมน้ำซับ เช่น พุขมิ้น ในอำเภอตาคลี เป็นต้น ต่อมาในสมัยทวาราวดี ประมาณพุทธศตวรรษที่ 13-16 ดินแดนแถบนี้ได้รับอารยธรรมภายนอกจากอินเดีย ทำให้มีการ

พัฒนาขึ้นเป็นสังคมเมืองที่มีขนาดใหญ่ขึ้นและตั้งอยู่ในเขตใกล้แม่น้ำ จากภาพถ่ายทางอากาศจะพบชุมชนสมัยทวารวดีมากกว่า 20 เมือง กระจายอยู่ตามอำเภอต่าง ๆ ที่สำคัญ เช่นเมืองจันเสน ในอำเภอตาคลี เมืองบน-โบราณสถานโคกไม้เดนในอำเภอพยุหะคีรี เมืองทัพชุมพล ในอำเภอเมืองนครสวรรค์ เมืองดอนคา ในอำเภอท่าตะโก เป็นต้น เมืองต่าง ๆ เหล่านี้ยังปรากฏร่องรอยของคูน้ำคันดิน และสระน้ำให้เห็นได้ชัดเจน[2]

ความสำคัญของนครสวรรค์ตั้งแต่เริ่มแรก คือการเป็นรัฐกึ่งกลางทั้งในสมัยทวารวดี สุโขทัย และอยุธยาเรื่อยมา สภาพภูมิศาสตร์ที่มีที่ราบอันอุดมสมบูรณ์ในตอนกลางของจังหวัด และเป็นที่รวมของแม่น้ำสายต่าง ๆ ของแม่น้ำที่ปากน้ำโพ ทำให้นครสวรรค์เป็นศูนย์กลางการซื้อขายแลกเปลี่ยนสินค้าระหว่างภาคเหนือกับภาคกลาง สินค้าต่าง ๆ จากภาคเหนือที่ลำเลียงมาทางแม่น้ำปิง แม่น้ำยม แม่น้ำน่าน รวมทั้งจากแม่น้ำป่าสักจะมารวมกันที่นครสวรรค์ซึ่งเป็นชุมทางสินค้า[2]

จากการที่จังหวัดนครสวรรค์ ซึ่งเป็นต้นแม่น้ำเจ้าพระยาที่เกิดจากแม่น้ำปิงและแม่น้ำน่านไหลมาบรรจบกันที่ตำบลปากน้ำโพ อำเภอเมืองนครสวรรค์ ดังนั้นชุมชนในอดีตสองฝั่งแม่น้ำน่านจึงประกอบด้วยเรือนแพของชาวบ้าน ที่ใช้เป็นแหล่งทำมาหากิน เช่น ใช้เป็นกระชังเลี้ยงปลา เป็นตลาดแลกเปลี่ยนสินค้าการเกษตร และเป็นที่อยู่อาศัย ตลอดจนใช้เป็นเส้นทางคมนาคมหลัก มีเรือแพสัญจรไปมาคับคั่ง ปัจจุบันสภาพเช่นนี้ลบเลือนไปมาก ยังคงเหลืออยู่เพียงเล็กน้อยเท่านั้น

นอกจากจังหวัดนครสวรรค์ที่เป็นชุมชนโบราณที่มีความสำคัญในอดีตมาก่อนในบริเวณที่ราบเจ้าพระยาตอนบนนี้แล้ว **สุพรรณบุรี** ก็เป็นอีกจังหวัดหนึ่งซึ่งเป็นดินแดนที่มีอารยธรรมรุ่งเรืองมาในอดีต จากหลักฐานทางโบราณคดีพบว่าบริเวณด้านตะวันตกของสุพรรณบุรี มีมนุษย์อาศัยติดต่อกันมาตั้งแต่สมัยก่อนประวัติศาสตร์ ถึงสมัยทวารวดี ซึ่งเป็นสมัยประวัติศาสตร์ตอนต้น มีการขุดพบโบราณวัตถุ เช่น ขวานหินขัด เครื่องปั้นดินเผา แวเหล็กใน ลูกปัดดินเผา ลูกปัดหอย และลูกปัดหิน เป็นต้น[3]

ชุมชนยุคหินใหม่ในจังหวัดสุพรรณบุรีที่สำคัญ คือ เมืองร้าง อำเภออู่ทอง ชุมชนนี้มีการถ่ายทอดวัฒนธรรมติดต่อกับชุมชนอื่นในลักษณะการแลกเปลี่ยนทางวัฒนธรรม เช่น วัฒนธรรมในการปลูกข้าว นอกจากนี้จากการที่พบเครื่องประดับกับชิ้นส่วนสำริดซอนดอง แสดงถึงการไปมาติดต่อกับชุมชนในอ่าวเปอร์เซียและแถบทะเลเมดิเตอร์เรเนียน ซึ่งการติดต่อกับอินเดียเป็นการเพิ่มพูนปึกแผ่นทางวัฒนธรรม[3] ให้กับชุมชนนี้

ปัจจุบันจังหวัดสุพรรณบุรี ก็ยังอาศัยแม่น้ำท่าจีนซึ่งแยกจากแม่น้ำเจ้าพระยาที่จังหวัดชัยนาท ไหลผ่านกลางจังหวัดไปออกอ่าวไทยที่จังหวัดสมุทรสาคร แม่น้ำสายนี้ยังมีบทบาทในการดำรงชีวิตของประชาชนทั้งในการเกษตรกรรม และการคมนาคมขนส่งตั้งแต่อดีตจนถึงปัจจุบัน

สำหรับ **จังหวัดอ่างทอง** หรือที่เดิมเรียกว่าเมืองวิเศษชัยชาญ ในอดีตเป็นเมืองโบราณตั้งแต่สมัยทวารวดี ซึ่งมีผู้คนเข้ามาตั้งหลักแหล่งอยู่อาศัยเป็นชุมชนเมืองแล้ว แต่ไม่ใหญ่นัก หลักฐานที่ยังเหลืออยู่ในปัจจุบัน คือ คูเมือง ที่บ้านคูเมือง ตำบลห้วยไผ่ อำเภอแสวงหา ซึ่งนายบวชเซลีเย นักโบราณคดีชาว

ฝรั่งเศสและเจ้าหน้าที่กรมศิลปากร ได้สำรวจพบและสันนิษฐานว่าเป็นเมืองโบราณสมัยทวาราวดี ในสมัยสุโขทัยเข้าใจว่ามีผู้คนเข้ามาตั้งถิ่นฐานอยู่อาศัยเช่นกัน สันนิษฐานได้จากวัดร้างซึ่งมีอยู่หลายวัดที่สร้างในสมัยสุโขทัย ต่อมาในสมัยกรุงศรีอยุธยาตอนต้น อ่างทองคงเป็นชานเมืองของกรุงศรีอยุธยา ได้รับการยกฐานะเป็นเมืองมีชื่อว่า แขวงเมืองวิเศษชัยชาญ[4] ปัจจุบันจังหวัดอ่างทองเป็นเมืองเกษตรกรรม มีชุมชนที่เป็นแหล่งผลิตผลงานด้านหัตถกรรม ที่มีเอกลักษณ์ของตนเองอยู่ในหลายอำเภอ

ในพื้นที่ราบภาคกลางตอนบนและตอนล่างนี้ เป็นพื้นที่ที่มีชนกลุ่มน้อยเข้ามาตั้งหลักแหล่งอยู่ในพื้นที่นี้กระจายอยู่ในหลายจังหวัด เช่น ชาวพวน จากเมืองหลวงพระบาง เมืองเวียงจันทน์ ในสาธารณรัฐประชาธิปไตยประชาชนลาว ซึ่งถูกกวาดต้อนเข้ามาเมื่อครั้งมีการสู้รบระหว่างไทยกับลาว รวมกับชาวพวนอีกจำนวนหนึ่งที่สมัครใจอพยพเข้ามาพึ่งพระบรมโพธิสมภารของพระมหากษัตริย์ไทย ได้กระจายไปตั้งบ้านเรือนอยู่ตามจังหวัดต่าง ๆ ในภาคกลาง คือ ลพบุรี สระบุรี สิงห์บุรี สุพรรณบุรี นครนายก ปราจีนบุรี ฉะเชิงเทรา เพชรบุรี เพชรบูรณ์ พิจิตร และสุโขทัย เป็นต้น[5] รวมทั้งจังหวัดอื่น ๆ ในภาคเหนือ และภาคตะวันออกเฉียงเหนือ

สำหรับชาวพวนที่เข้ามาตั้งหลักแหล่งในอำเภอพรหมบุรี จังหวัดสิงห์บุรี นั้น เป็นกลุ่มที่อพยพหนีการรุกรานมาตามลำน้ำเจ้าพระยา เมื่อถึงตำบลบางน้ำเชี่ยว บริเวณที่ลำน้ำมีความโค้งและน้ำไหลเชี่ยว ทำให้แพชนตลิ่งและเกยตื้น ชาวพวนกลุ่มนี้จึงขึ้นฝั่งในบริเวณนั้น ซึ่งเป็นที่ราบลุ่มกว้างใหญ่ มีความอุดมสมบูรณ์เหมาะแก่การเพาะปลูก ชาวไทยพวนกลุ่มนี้จะตั้งบ้านเรือนอยู่รวมกันเป็นกลุ่ม กลุ่มละ 4-6 หลังคาเรือน แต่ละกลุ่มจะประกอบด้วยเครือญาติที่ใกล้ชิด ดำรงชีวิตตามสภาพสังคมชนบท บ้านเรือนของชาวไทยพวนในอดีตจะเป็นบ้านทรงไทย แต่ในสมัยปัจจุบัน สภาพสังคมเปลี่ยนแปลงไป วัฒนธรรมเมืองแพร่กระจายเข้ามาผสมผสาน ทำให้สภาพที่อยู่อาศัย ในชุมชนของชาวไทยพวนซึ่งเป็นส่วนประกอบหนึ่งของวิถีชีวิต และวัฒนธรรมเปลี่ยนแปลงไปตามสภาพสังคมปัจจุบัน[5]

2.3 <u>ชุมชนในที่ราบภาคกลางตอนล่าง(ที่ราบเจ้าพระยาตอนล่าง)</u>

ในบริเวณพื้นที่ราบเจ้าพระยาตอนล่าง หรือเรียกอีกชื่อหนึ่งว่า **ที่ราบกรุงเทพ** ซึ่งเป็นบริเวณตั้งแต่จังหวัดพระนครศรีอยุธยา ลงมาถึงกรุงเทพมหานครและปริมณฑล ได้แก่ นนทบุรี ปทุมธานี ลงมาจนถึง จังหวัดสมุทรสงคราม สมุทรสาคร และสมุทรปราการ ซึ่งเป็นจังหวัดที่ติดอ่าวไทย พื้นที่บริเวณนี้มีจังหวัดที่เคยเป็นเมืองหลวงของประเทศถึงสองเมือง จึงมีความเป็นมาที่น่าสนใจของการตั้งหลักแหล่งชุมชนในอดีตจนถึงปัจจุบันของเมืองในพื้นที่ราบเจ้าพระยาตอนล่างนี้

เริ่มตั้งแต่ **จังหวัดพระนครศรีอยุธยา** จากสภาพทางภูมิศาสตร์และธรณีวิทยา สันนิษฐานว่าพื้นที่ที่ตั้งของจังหวัดพระนครศรีอยุธยาในอดีตเคยเป็นทะเลมาก่อน ต่อมาเกิดการทับถมของตะกอนแม่น้ำทำให้พื้นที่ตื้นเขินและกลายเป็นแผ่นดินงอกไป เมื่อพวกขอมได้เป็นใหญ่ในลุ่มแม่น้ำเจ้าพระยา จึงตั้งเป็นเมืองด่านขึ้นที่ริมทะเล เรียกว่าเมืองอโยธยา ต่อมาในสมัยสุโขทัย ราชธานีตั้งอยู่ที่สุโขทัย ซึ่งห่างจากทะเล

ส่วนเมืองอโยธยาซึ่งเป็นเขตของเมืองอู่ทองนั้นมีสภาพพื้นแผ่นดินที่ดอนขึ้น ราษฎรทำเรือกสวนไร่นาได้มากและเป็นทำเลที่เรือค้าขายผ่านไปมา[6] เพราะอยู่บริเวณแม่น้ำไหลผ่าน 3 สาย คือ แม่น้ำเจ้าพระยา แม่น้ำป่าสัก และแม่น้ำลพบุรี ชุมชนเมือง
อโยธยาซึ่งเป็นเขตของเมืองอู่ทอง จึงเป็นเมืองใหญ่ขึ้น

หลังจากเกิดโรคระบาดในเมืองอู่ทอง พระเจ้าอู่ทองจึงย้ายมาอยู่ที่เมืองอโยธยามาตั้งอยู่ในบริเวณพื้นที่ทางตะวันตกตรงวัดพุทไธสวรรค์ในปัจจุบัน พระเจ้าอู่ทองหรือสมเด็จพระรามาธิบดี ทรงสร้างพระนครขึ้นใหม่ที่ตำบลหนองโสน ขนานนามว่า "กรุงเทพทวาราวดีศรีอยุธยา" เป็นอาณาจักรที่มั่นคง มีความเจริญรุ่งเรือง ติดต่อกันมานานจนถึง พ.ศ. 2310 รวมเวลา 417 ปี ก่อนจะเสียกรุงแก่พม่า

อำเภอพระนครศรีอยุธยามีประชาชนหลายเชื้อชาติหลายศาสนาเข้ามาร่วมตั้งหลักแหล่งเป็นชุมชนย่อย ๆ หลายชุมชน เช่นคนไทยมุสลิมซึ่งเป็นลูกหลานของชาวมุสลิมที่อพยพโยกย้ายมาจากหัวเมืองปัตตานี ชาวมุสลิมกลุ่มนี้อาศัยอยู่หนาแน่นบริเวณคลองตะเคียนอีกกลุ่มหนึ่ง คือ กลุ่มชาวมุสลิมที่สืบเชื้อสายมาจากต่างชาติ เช่น เปอร์เซีย อาหรับ และอินเดีย ตั้งหลักแหล่งอาศัยอยู่บริเวณทุ่งลุมพลี ภูเขาทอง และหัวแหลม กลุ่มคนญวนเป็นอีกกลุ่มหนึ่งที่อพยพเข้ามาในตอนปลายกรุงศรีอยุธยา รวมทั้งเมื่อคราวเกิดกบฏไต้เซินที่ประเทศเวียดนามเมื่อสมัยต้นกรุงรัตนโกสินทร์ รวมกลุ่มกันตั้งบ้านเรือนในพื้นที่ตำบลสำเภาล่ม ที่คนอยุธยามักเรียกกันว่า "บ้านญวน" เป็นชุมชนใหญ่กว่าร้อยหลังคาเรือน ส่วนมากนับถือศาสนาคริสต์นิกายโรมันคาทอลิก มีวัดนักบุญยอแซฟเป็นศูนย์กลาง ลูกหลานของชาวญวนปัจจุบัน กระจายไปตั้งบ้านเรือนอยู่ตามท้องที่ต่าง ๆ
ของจังหวัดพระนครศรีอยุธยา ส่วนกลุ่มชาวจีน ซึ่งเดิมตั้งบ้านเรือนหนาแน่น บริเวณวัดพนัญเชิงและฝั่งแม่น้ำตรงกันข้าม[7] รวมทั้งที่ป้อมเพ็ชร ซึ่งเป็นบริเวณที่แม่น้ำเจ้าพระยาและแม่น้ำป่าสักมาบรรจบกัน ปัจจุบันกลุ่มคนจีนเหล่านี้กระจายตัวอยู่ทั่วไปในตัวจังหวัด โดยเฉพาะในย่านธุรกิจการค้า เช่นที่บริเวณหัวรอ ตลาดเจ้าพรหม ส่วนคนไทยที่ตั้งหลักแหล่งอยู่เดิม มักจะตั้งบ้านเรือนเป็นชุมชนอยู่บริเวณริมแม่น้ำ ริมลำคลองในตัวจังหวัด เช่น คลองหันตรา คลองสระบัว คลองขนมจีน และคลองแม่น้ำอ้อม เป็นต้น

ส่วนจังหวัด นนทบุรี นั้นเดิมเป็นชุมชนเก่าแก่ตั้งแต่สมัยกรุงศรีอยุธยา ตั้งอยู่ที่ตำบลบ้านตลาดขวัญ ซึ่งมีความอุดมสมบูรณ์ เต็มไปด้วยสวนผลไม้ที่ขึ้นชื่อ ต่อมาในสมัยสมเด็จพระมหาจักรพรรดิ โปรดเกล้าฯ ให้ยกฐานะบ้านตลาดขวัญ ขึ้นเป็นเมืองนนทบุรี ประชาชนในจังหวัดนนทบุรีสืบเชื้อสายมาจากหลายเชื้อชาติ เช่น ไทย จีน มอญ แขก เป็นต้น ส่วนใหญ่เป็นคนไทยมาแต่ดั้งเดิม รองลงมาคือคนไทยเชื้อสายจีน นอกจากนั้นยังมีชาวไทยเชื้อสายมอญ และชาวไทยเชื้อสายมลายู ที่อพยพเข้ามาตั้งหลักแหล่งในจังหวัดนนทบุรีตั้งแต่สมัยกรุงศรีอยุธยา ในบริเวณตั้งแต่ปากคลองบางตลาดฝั่งเหนือแม่น้ำเจ้าพระยาด้านตะวันออกและด้านตะวันตก ที่ตำบลอ้อมเกร็ด และที่บ้านท่าอิฐ อำเภอปากเกร็ด เหนือคลองบางภูมิขึ้นไป รวมทั้งที่เกาะเกร็ด จะมีชาวไทยเชื้อสายมอญอาศัยอยู่มาก ชาวมอญเหล่านี้มีความชำนาญในการทำเครื่องปั้นดินเผา จึงยึดอาชีพนี้มาจนกระทั่งทุกวันนี้ นอกจากนั้นยังมีชาวไทยอิสลามเชื้อสายปัตตานี

เข้ามาตั้งบ้านเรือนอาศัยอยู่ที่ตำบลบางกระสอ และที่ตลาดบ้านแก้ว ตำบลบางตะนาวศรี อำเภอเมืองนนทบุรี ตั้งแต่สมัยกรุงศรีอยุธยา รวมทั้งยังมีชาวไทยอิสลามเชื้อสายไทรบุรี เข้ามาตั้งหลักแหล่งในสมัยรัชกาลที่ 3 ที่ตำบลท่าอิฐ อำเภอปากเกร็ดอีกด้วย[8]

ปัจจุบันจากการที่จังหวัดนนทบุรี มีพื้นที่ที่เอื้อต่อการเพาะปลูก ทำเกษตรกรรมมีสวนผลไม้ที่ได้ผลผลิตที่มีคุณภาพ แต่ชุมชนเกษตรกรรมในปัจจุบันลดน้อยลง จากการขยายตัวของกรุงเทพมหานครเข้ามาในเขตปริมณฑล มีความต้องการพื้นที่ดินเพื่อการอยู่อาศัยในรูปของโครงการหมู่บ้านจัดสรรชานเมือง ตลอดจนการขยายตัวของพื้นที่ทำกินที่แปรรูปไปเป็นการเกษตรอุตสาหกรรม อุตสาหกรรมก่อสร้าง สิ่งทอ และเครื่องนุ่งห่ม จึงทำให้สภาพชุมชนในปัจจุบัน กลายสภาพเป็นชุมชนเมืองที่รองรับการขยายตัวของกรุงเทพมหานครไปในที่สุด

กรุงเทพมหานคร ซึ่งเป็นเมืองหลวงของประเทศ และเป็นเมืองขนาดใหญ่ในบริเวณที่ราบเจ้าพระยาตอนล่าง หรือที่ราบกรุงเทพนี้ มีความเป็นมาของการตั้งถิ่นฐานของชุมชนสมัยเริ่มแรกเป็นเวลานานมาแล้ว มีหลักฐานทางประวัติศาสตร์ที่บ่งบอกให้ทราบว่า สมัยที่พระเจ้าอู่ทองทรงสถาปนากรุงศรีอยุธยา เมื่อ พ.ศ. 1893 นั้น เมืองพระประแดงเป็นเมืองหน้าด่านสำคัญที่รักษาพื้นที่บริเวณปากอ่าวไทย ถัดขึ้นมาเป็นชุมชน **"เมืองบางกอก"** ตั้งอยู่ริมฝั่งแม่น้ำเจ้าพระยา[9] ลำน้ำเจ้าพระยาเดิมนั้นไหลวกวนจากทางเหนือ เข้าคลองบางกอกน้อย อ้อมเข้าคลองตลิ่งชัน และคลองบางระมาด แล้วไหลออกทางคลองบางกอกใหญ่ ดังนั้นพื้นที่กรุงรัตนโกสินทร์ในอดีต ก็คือตำบลบางกอก ซึ่งมีพื้นที่ทั้งฝั่งพระนครและฝั่งธนบุรีรวมเป็นแผ่นดินผืนเดียวกันมาก่อน ชุมชนนี้มีความเจริญเติบโตและมีความหนาแน่นเพิ่มขึ้นเป็นลำดับพร้อม ๆ กับความรุ่งเรืองของอาณาจักรกรุงศรีอยุธยา[10]

สภาพพื้นที่ที่เคยเป็นแผ่นดินผืนเดียวกัน ถูกแยกเป็น 2 ผืน มีแม่น้ำเจ้าพระยาผ่ากลาง เมืองบางกอกเริ่มมีความสำคัญทางยุทธศาสตร์มากขึ้น และต่อมาตั้งเป็นเมืองด่านเรียกว่า **"เมืองธนบุรีศรีมหาสมุทร"** ในรัชกาลสมเด็จพระมหาจักรพรรดิ์ (พ.ศ. 2091-2111) กำหนดเป็นจุดบังคับให้เรือและสำเภาทุกลำหยุดจอดทอดสมอ เพื่อแจ้งรายละเอียดเกี่ยวกับการเดินทาง สินค้าที่บรรทุกและผู้โดยสารรวมทั้งเก็บภาษีอากร ทั้งขาขึ้นและขาล่อง ชุมชนเมืองบางกอก จึงเริ่มเปลี่ยนบทบาทจากหมู่บ้านสวนผลไม้และไร่นามาเป็นเมืองด่านสำคัญเป็นเวลานานกว่า 300 ปี ตลอดสมัยกรุงศรีอยุธยา[11]

เมื่อพระบาทสมเด็จพระพุทธยอดฟ้าจุฬาโลกมหาราชทรงสถาปนากรุงเทพมหานครขึ้นเมื่อ พ.ศ. 2325 กรุงธนบุรีขณะนั้นมีแม่น้ำเจ้าพระยาผ่ากลางเป็นชัยภูมิที่ไม่เหมาะต่อการป้องกันเมืองจากข้าศึก ทั้งตัวเมืองยังตั้งอยู่บริเวณท้องคุ้งของแม่น้ำ ทำให้มีกระแสน้ำเซาะริมฝั่งอยู่เสมอ ส่วนพื้นที่ฝั่งตะวันออก คือ พื้นที่ตั้งของกรุงเทพมหานครในปัจจุบัน เป็นที่ราบลุ่มกว้างใหญ่ สามารถขยายตัวเมืองในอนาคตได้มากกว่า จึงโปรดเกล้าฯ ให้สร้างพระนครและพระราชนิเวศน์มณเฑียรสถานขึ้นใหม่บนฝั่งตะวันออกของแม่น้ำเจ้าพระยา แม้กรุงเทพจะเป็นเมืองท่าและเมืองหน้าด่านที่สำคัญของกรุงศรีอยุธยา มีเรือสินค้าไปมาอยู่สม่ำเสมอ แต่สภาพโดยทั่วไปของเมืองบางกอกยังคงเป็นป่าที่อุดมด้วยสัตว์นานาชนิดประชาชนส่วนใหญ่

ตั้งบ้านเรือนเป็นชุมชนอาศัยตามบริเวณริมแม่น้ำลำคลองโดยเฉพาะทางฝั่งตะวันตก ซึ่งเป็นที่ดอนมากกว่าฝั่งตะวันออก

ในสมัยต้นรัตนโกสินทร์ ประชาชนส่วนหนึ่งเป็นคนต่างชาติ ต่างศาสนา ที่อพยพเข้ามาตั้งหลักแหล่งกระจายไปในบริเวณต่าง ๆ ของตัวเมืองร่วมกับคนไทยในพื้นที่ดั้งเดิม ชนต่างชาติซึ่งมีทั้งชาวจีน ญวน ลาว แขก เขมร ทวาย และฝรั่งชาติตะวันตก ชนชาติต่าง ๆ เหล่านี้ต่างตั้งหลักแหล่งถิ่นฐานเป็นกลุ่มเป็นก้อน ในชั้นแรกได้รับพระบรมราชานุญาตให้ตั้งบ้านเรือน บริเวณริมแม่น้ำเจ้าพระยาทั้งฝั่งตะวันออกและฝั่งตะวันตก และในเขตตัวเมืองเป็นย่าน ๆ ไป เช่นชาวจีน อยู่แถวสำเพ็ง เยาวราช ฝั่งธนบุรี แถบวัดกัลยานิมิตร หรือที่เรียกว่ากุฎีจีน และบริเวณท่าดินแดง ฝรั่งชาติตะวันตกอาศัยอยู่ริมแม่น้ำเจ้าพระยาใต้ศาลเจ้ากุฎีจีนลงไป และบริเวณตั้งแต่ปากคลองผดุงกรุงเกษม ริมถนนเจริญกรุง บำรุงเมือง เฟื่องนคร ไปจนถึงถนนสีลม พวกแขกตั้งบ้านเรือนอยู่บริเวณข้างวัดราชาธิวาส ที่เรียกว่าบ้านเขมรหรือหมู่บ้านคอนเซ็ปชั่น ถัดขึ้นไปทางเหนือเป็นหมู่บ้านชาวญวน หรือที่เรียกว่าบ้านมิตตคาม ชาวลาวตั้งบ้านเรือนบริเวณริมคลองบางกอกน้อย ใกล้วังหลังและที่ถนนบ้านหม้อ พาหุรัด ชาวมอญ ตั้งบ้านเรือนริมคลองมอญ ระหว่างคลองวัดระฆังกับคลองวัดอรุณฯ และที่ริมคลองคูเมืองชั้นใน อีกส่วนหนึ่งอยู่บริเวณใต้คลองบางกอกใหญ่ลงไปเล็กน้อย แขกอิสลามนิกายสุหนี่ ตั้งบ้านเรือนอยู่ที่ริมคลองบางกอกใหญ่ มีมัสยิดต้นสนเป็นมัสยิดประจำชุมชน[12]

ส่วนแขกเจ้าเซ็นหรือแขกนิกายชีอะห์ เช่นแขกเปอร์เซีย อินเดีย อาหรับ และอิหร่าน ซึ่งอพยพจากกรุงศรีอยุธยา ตั้งบ้านเรือนอยู่บริเวณด้านเหนือของพระราชวังเดิมขึ้นไปจนถึงคลองมอญ มีกุฎีเจ้าเซ็นของแขกนิกายชีอะห์ที่ริมแม่น้ำตรงข้ามกับชุมชนจีนในพระนคร นอกจากนั้นยังมีแขกอินเดียซึ่งเข้ามาตั้งหลักแหล่งในเมืองไทยกันมาก ตั้งแต่รัชกาลพระบาทสมเด็จพระจอมเกล้าเจ้าอยู่หัว พวกนี้อาศัยอยู่บริเวณตึกขาวตึกแดง ริมแม่น้ำเจ้าพระยาฝั่งตะวันตก บริเวณถนน
ท่าดินแดง บริเวณสะพานช้างโรงสี วัดสัมพันธวงศ์ บางรัก ราชวงศ์ สามเสน เยาวราช วรจักร และสีลม เป็นต้น

เนื่องจากบริเวณกรุงเทพฯ และธนบุรี มีแม่น้ำเจ้าพระยาไหลผ่าน และมีคลองต่าง ๆ ที่แยกจากแม่น้ำเข้าไปยังพื้นที่ทั้งฝั่งตะวันตกและฝั่งตะวันออกของแม่น้ำ ในช่วงต้นรัตนโกสินทร์ ราษฎรทั่วไป จึงตั้งบ้านเรือน เรือนแพ และจอดเรือประทุนอยู่อาศัยตามริมแม่น้ำเจ้าพระยาทั้งสองฝั่ง รวมทั้งตามริมคลอง บริเวณที่มีการตั้งบ้านเรือนที่อยู่อาศัยหนาแน่น ได้แก่ บริเวณแนวคลองคูเมืองเดิมทั้งฝั่งพระนครตามแนวคลองบางกอกน้อย คลองบางกอกใหญ่ ปากคลองรอบกรุงด้านคลองโอ่งอ่าง คลองบางลำพู และช่วงคลองรอบกรุงที่บรรจบกับคลองมหานาค เป็นต้น[13]

บริเวณโดยรอบพระบรมมหาราชวัง ทั้งพระราชวังหลวง วังหน้า และวังหลังมักเป็นที่ตั้งบ้านเรือนของเสนาบดี ขุนนาง และข้าราชบริพาร พระมหากษัตริย์ มักจะสร้างบ้านให้เสนาบดีอยู่ และมักจะได้รับพระราชทานที่ดินและบ้านเป็นกรรมสิทธิ์ด้วย ส่วนวังพระราชโอรส ซึ่งใช้เป็นที่ประทับและที่ทำงานว่าการ

ในด้านต่าง ๆ ที่ได้รับมอบหมาย จึงเกิดชุมชนขึ้นโดยรอบวังแต่ละแห่ง ราษฎรที่รับราชการกับวังใด ก็มักจะตั้งบ้านเรือนพำนักอยู่ใกล้วังนั้น ๆ นอกจากนั้นตำแหน่งที่ตั้งบ้านเรือนของขุนนางเสนาบดีและราษฎรทั่วไปมักจะสัมพันธ์กับตำแหน่งที่ตั้งของวัดที่ตนสร้างหรืออุปถัมภ์ด้วย ส่วนที่ตั้งของชุมชนชาวต่างประเทศ กงศุลต่างประเทศ บ้านพักฑูต บ้านหมอสอนศาสนา พ่อค้าและราษฎรชาวต่างประเทศ พระมหากษัตริย์มักโปรดเกล้าฯ ให้จัดหาที่อยู่ให้ในบริเวณริมแม่น้ำเจ้าพระยาทั้งฝั่งตะวันออกและฝั่งตะวันตก[13]

ลักษณะการตั้งชุมชนที่อยู่อาศัยของประชาชนในยุครัตนโกสินทร์ จึงเป็นการแผ่กระจายทางแนวราบไปตามเส้นทางคมนาคมหลัก มีการขยายเขตชุมชนในพระนครออกไปทั้งทางด้านเหนือ ด้านตะวันออก และด้านใต้ของตัวเมือง ในปลายรัชกาลพระบาทสมเด็จพระจุลจอมเกล้าเจ้าอยู่หัว เริ่มมีความนิยมใช้ถนนเป็นเส้นทางคมนาคมแทนที่แม่น้ำลำคลอง ทำให้ที่ดินริมถนนมีราคาแพงขึ้น มีการตัดถนนผ่านที่ดินและแบ่งที่ดินเป็นแปลงย่อย ๆ สำหรับขายให้ปลูกสร้างบ้านเรือน

ในต้นรัชกาลพระบาทสมเด็จพระปกเกล้าเจ้าอยู่หัว มีการแบ่งเขตกรุงเทพฯ เป็น 2 จังหวัด คือ ฝั่งตะวันออกของแม่น้ำเจ้าพระยา เป็นจังหวัดพระนคร ส่วนฝั่งตะวันตกเป็นจังหวัดธนบุรี ความเจริญส่วนใหญ่จะอยู่ที่ฝั่งพระนครหรือกรุงเทพฯ มีการตัดถนนและมีย่านค้าขายมากขึ้น รวมทั้งย่านพักอาศัยด้วย ในช่วงหลังการเปลี่ยนแปลงการปกครอง ใน พ.ศ. 2475 เป็นต้นไปจนถึงปัจจุบัน การตั้งหลักแหล่งที่อยู่อาศัยของประชาชน เริ่มขยายตัวออกสู่ชานเมือง เพราะที่ดินในเขตกลางเมืองเริ่มมีราคาสูงขึ้น เจ้าของที่ดินหลายรายจึงนิยมสร้างตึกแถวในเขตตัวเมืองใช้ประกอบการค้าร่วมไปกับการอยู่อาศัยด้วย หรือไปซื้อที่ดินในเขตห่างไกลตัวเมืองออกไป เพื่อปลูกบ้านในที่ดินที่กว้างขวางขึ้น ทำให้หลักแหล่งที่อยู่อาศัยของประชาชนขยายตัวออกไปทางแนวราบไกลออกไปจากศูนย์กลางเมือง มีการสร้างบ้านเรือนในที่ดินริมถนน และในซอยที่แยกเข้าไปจากถนนใหญ่ ตลอดจนอยู่อาศัยในหมู่บ้านจัดสรร ซึ่งเกิดขึ้นมากมายในช่วง 20 ปีเศษที่ผ่านมา ในขณะที่เริ่มมีรูปแบบของการอยู่อาศัยในอาคารสูงในเขตตัวเมือง เพื่อใกล้แหล่งงาน และย่นระยะการเดินทาง ซึ่งจะพบมากขึ้นในปัจจุบัน

สำหรับจังหวัดสมุทรสาคร สมุทรปราการ และสมุทรสงคราม ซึ่งเป็นจังหวัดชายทะเล ติดอ่าวไทยนั้น ล้วนเป็นบริเวณที่เคยเป็นชุมชนที่มีลักษณะเฉพาะมาในอดีต เช่น จังหวัดสมุทรสาคร นั้นเป็นชุมชนที่มีมาตั้งแต่สมัยสมเด็จพระมหาจักรพรรดิ์ แห่งกรุงศรีอยุธยา ในสมัยอุธยามีชื่อว่า “บ้านท่าจีน” ซึ่งเป็นชุมชนใหญ่อยู่บริเวณอ่าวไทย มีทำเลที่เหมาะในการพาณิชย์ มีเรือสำเภาค้าขายจากประเทศจีนมาจอดเทียบท่า ซื้อขายแลกเปลี่ยนขนถ่ายสินค้า จนเป็นที่รู้จักและเรียกกันติดปากว่า “ท่าจีน” แต่ยังไม่ได้ยกฐานะเป็นเมืองคงเป็นหมู่บ้านชุมชนหนึ่งเท่านั้น ต่อมาในช่วงหลังสงครามกับพม่าที่สูญเสียสมเด็จพระศรีสุริโยทัยไปนั้น บ้านท่าจีนได้รับการยกฐานะเป็นเมือง “สาครบุรี” ในสมัยพระเจ้าเสือ เสด็จประพาสทรงเบ็ด ที่ปากน้ำเมืองสาครบุรี ต้องเดินทางผ่านคลองโคกขาม จึงเกิดตำนานพันท้ายนรสิงห์ ที่มีการจารึกไว้ในประวัติศาสตร์ขึ้นที่นี่ ต่อมาในสมัยรัชกาลที่ 4 โปรดเกล้าฯ ให้เปลี่ยนชื่อเมือง สาครบุรี เป็นเมือง สมุทรสาคร ในสมัยต้น

รัตนโกสินทร์ มีคนเชื้อสายมอญอพยพเข้ามาตั้งถิ่นฐานที่อำเภอเมืองสมุทรสาคร และอำเภอบ้านแพ้วด้วย[14]

จากการที่จังหวัดสมุทรสาคร เป็นเขตปริมณฑลของกรุงเทพมหานคร แต่มีลักษณะภูมิประเทศและการตั้งหลักแหล่งของประชาชนที่อยู่ในชนบทมากกว่าในเขตตัวเมือง จึงมีสภาพสังคมกึ่งชนบทกึ่งเมือง มีการตั้งบ้านเรือนกระจายอยู่ตามริมแม่น้ำลำคลอง ปัจจุบันเมื่อมีประชากรมากขึ้น มีการขยายตัวที่รองรับการพัฒนาจากกรุงเทพมหานคร ทำให้ชุมชนเมืองส่วนหนึ่งมีการพัฒนาไปทางด้านอุตสาหกรรมและการบริการมากขึ้น มีการปรับปรุงสาธารณูปโภคพื้นฐาน และการคมนาคมมากขึ้น ชุมชนที่มีลักษณะสังคมชนบทจึงเริ่มลดน้อยลง และปรับเปลี่ยนเป็นชุมชนเมืองมากขึ้นตามการเติบโตของประเทศ

ส่วนจังหวัด **สมุทรสงคราม** นั้นสันนิษฐานว่าประชากรดั้งเดิมของจังหวัดส่วนใหญ่เป็นผู้อพยพมาจากที่อื่น โดยเฉพาะในสมัยกรุงศรีอยุธยาตอนต้น มีผู้คนจากหมู่บ้านแม่กลอง จังหวัดอุทัยธานี อพยพเข้ามาตั้งถิ่นฐานบ้านเรือนอยู่ริมปากอ่าวและเรียกหมู่บ้านที่ตั้งใหม่ว่า “หมู่บ้านแม่กลอง” ตามชื่อบ้านเดิมของตน ต่อมามีชาวแม่กลองจากเมืองสุโขทัยหนีศึกระหว่างสุโขทัยกับอยุธยา อพยพเข้ามาสมทบด้วย เมื่อชุมชนหมู่บ้านแม่กลองมีผู้คนอาศัยอยู่มากขึ้น จึงได้รับการยกฐานะขึ้นเป็น “เมืองแม่กลอง” ในสมัยพระเจ้าปราสาททอง ต่อมาเมืองแม่กลอง เปลี่ยนชื่อเป็น เมืองสมุทรสงคราม[15] ปัจจุบันจังหวัดสมุทรสงครามมีลักษณะโครงสร้างทางเศรษฐกิจที่เปลี่ยนจากแบบเกษตรกรรมตามลักษณะภูมิประเทศมาเป็นสาขาการค้าส่งและค้าปลีกที่นำหน้าสาขาเกษตรกรรม การบริการ การท่องเที่ยว และอุตสาหกรรม ตามลักษณะอาชีพในสังคมเมือง

จังหวัด **สมุทรปราการ** ซึ่งเป็นจังหวัดปริมณฑลของกรุงเทพมหานคร อีกจังหวัดหนึ่ง นั้นมีความเป็นมาของชุมชนตั้งแต่สมัยพระเจ้าทรงธรรมแห่งกรุงศรีอยุธยา ที่โปรดเกล้าฯ ให้ยุบเมืองพระประแดง ที่เคยเป็นปากอ่าวแม่น้ำเจ้าพระยา แต่ต่อมาสภาพทางภูมิศาสตร์ ที่ถูกแผ่นดินงอกออกไปปิด ไม่สามารถเป็นปากน้ำได้อีก จึงโปรดเกล้าฯ ให้สร้างเมืองสมุทรปราการเป็นเมืองปากน้ำของกรุงศรีอยุธยาแทน ตัวเมืองในสมัยนั้น ตั้งอยู่ใต้คลองบางปลากดทางฝั่งขวาของแม่น้ำเจ้าพระยา มีชาวตะวันตกเข้ามาตั้งหลักแหล่งเป็นชุมชนเหนือคลองบางปลากด มีชาวฮอลันดาเข้ามาค้าขายกับไทยในสมัยนั้น พระเจ้าทรงธรรมได้พระราชทานที่ดินส่วนหนึ่งให้ชาวฮอลันดา สร้างคลังสินค้าและที่พักอาศัย เรียกว่านิวอัมสเตอร์ดัม ทำให้ชุมชนนี้เจริญขึ้น ต่อมาเมื่อการค้าระหว่างไทยกับฮอลันดา ซบเซาลงบริเวณนี้จึงถูกทิ้งร้างและถูกกระแสน้ำไหลเซาะพังลงในที่สุด

ในสมัยพระบาทสมเด็จพระพุทธเลิศหล้านภาลัยโปรดเกล้าฯ ให้สร้างเมืองสมุทรปราการขึ้นใหม่แทนเมืองเดิมที่ถูกทำลายเมื่อครั้งกรุงศรีอยุธยาเสียกรุงแก่พม่าครั้งที่ 2 และทรงสร้างเมืองพระประแดงหรือนครเขื่อนขันธ์ที่บริเวณปากลัด เป็นเมืองหน้าด่าน ทั้งยังโปรดเกล้าฯ ให้ย้ายครอบครัวมอญจากเมือง

ปทุมธานีที่อพยพหนีภัยสงครามเข้ามาในสมัยรัชกาลที่ 2 นี้เอง มาตั้งภูมิลำเนาที่นครเขื่อนขันธ์ พระประแดงจึงเป็นชุมชนมอญขนาดใหญ่ในสมุทรปราการ ส่วนใหญ่มีอาชีพทำนา

ลักษณะการตั้งถิ่นฐานของประชาชนในสมุทรปราการในยุคต้นรัตนโกสินทร์คงจะหนาแน่นในบริเวณตัวเมืองสมุทรปราการ และนครเขื่อนขันท์ ริมแม่น้ำเจ้าพระยาแต่ยังเป็นชุมชนขนาดเล็ก ที่เหลือก็กระจายกันอยู่ตามริมฝั่งแม่น้ำเจ้าพระยา และลำคลองทั่วไป โดยเฉพาะริมคลองสายใหญ่ เช่น คลองสำโรง ที่พักอาศัยเป็นไม้หรือเพิงที่ใช้วัสดุตามธรรมชาติ เช่น ไม้และจากเป็นวัสดุก่อสร้าง การสัญจรไปมาส่วนใหญ่ใช้เรือ อาชีพหลักของประชากรสมุทรปราการในปัจจุบันเป็นการทำเกษตรกรรม เช่นการทำนา ทำสวนผลไม้ ประมง และนาเกลือ[16] ตัวเมืองมีการขยายตัวตามเส้นทางคมนาคม เช่น มีชุมชนใหม่ ๆ เกิดขึ้นใกล้สถานีรถไฟ และตามเส้นทางรถไฟ เมื่อมีการเดินรถไฟสายปากน้ำ-หัวลำโพง และการสร้างถนนสุขุมวิทผ่านจังหวัดสมุทรปราการ ไปทางภาคตะวันออก ทำให้มีการเกิดชุมชนเกิดใหม่ขึ้นตามเส้นทาง รวมทั้งเมื่อมีการเปิดเส้นทางหลวงสมัยใหม่ คือถนนสายบางนา-ตราด ถนนศรีนครินทร์และเทพารักษ์ ประกอบกับรัฐบาลมีนโยบายส่งเสริมการลงทุนทางอุตสาหกรรม ทำให้มีโรงงานอุตสาหกรรมขนาดใหญ่ เพิ่มขึ้นมาก ตลอดจนมีโครงการพัฒนาที่ดินในบริเวณดังกล่าวเกิดขึ้นอย่างมากมายตามมาด้วย

3. <u>บริเวณขอบที่ราบภาคกลาง</u>

บริเวณที่ราบกว้างใหญ่ ซึ่งอยู่ตามแนวขอบที่ราบภาคกลางตอนล่างนั้น ทางด้านซีกตะวันออกที่ประกอบด้วยจังหวัดลพบุรี สระบุรี และนครนายก ส่วนทางด้านซีกตะวันตก มีบางส่วนของจังหวัดอุทัยธานี สุพรรณบุรี และนครปฐม ในบรรดาจังหวัดต่าง ๆ ในพื้นที่บริเวณนี้มีความเป็นมาของการตั้งหลักแหล่งชุมชนตั้งแต่อดีตถึงปัจจุบันดังนี้

จังหวัดลพบุรี เป็นเมืองโบราณในยุคก่อนประวัติศาสตร์ ซึ่งสันนิษฐานได้จากหลักฐานโบราณวัตถุที่ค้นพบได้ในบางเนื้อที่ของลพบุรี เช่นพบเครื่องมือเครื่องใช้ของมนุษย์ในยุคหินกลาง ที่อำเภอบ้านหมี่ พบโครงกระดูก เครื่องมือเครื่องใช้และเครื่องประดับที่ทำจากหิน ได้จากเนินดิน และบริเวณใกล้ภูเขา รวมทั้งพบเศษเครื่องปั้นดินเผา เครื่องประดับ เช่น กำไล แหวน และลูกปัดที่ทำด้วยสำริด ซึ่งถือเป็นโบราณวัตถุในยุคหินใหม่และยุคโลหะของลพบุรี ส่วนในยุคประวัติศาสตร์ ลพบุรีได้รับเอาศิลปะและวัฒนธรรมจากอินเดีย เช่นเดียวกับเมืองโบราณต่าง ๆ เช่น เมืองศรีเทพ เมืองนครปฐม และปราจีนบุรี เป็นต้น ต่อมาในราวพุทธศตวรรษที่ 16-18 เมืองลพบุรีได้ตกอยู่ภายใต้อิทธิพลของอาณาจักรขอมเป็นครั้งคราว และได้รับเอาวัฒนธรรมต่าง ๆ และรูปแบบสถาปัตยกรรมของขอมเข้ามาด้วย[17]

ในสมัยกรุงศรีอยุธยาเป็นราชธานี ลพบุรียังคงเป็นเมืองที่มีความสำคัญและเป็นหัวเมืองที่อยู่ในเขตราชธานี ในสมัยสมเด็จพระนารายณ์มหาราช โปรดเกล้าฯ ให้มีการบูรณะปฏิสังขรณ์ พระราชวังเก่าให้เป็นที่ประทับของพระองค์ เมืองลพบุรีในสมัยสมเด็จพระนารายณ์มหาราช เป็นเมืองที่มีความสำคัญ

และเป็นราชธานีที่มีผู้คนเข้ามาอาศัยอยู่มากพอสมควร เมื่อสิ้นรัชกาลของพระองค์ ลพบุรีก็มีบทบาทและความสำคัญน้อยลง แต่ก็ยังเป็นเมืองในเขตราชธานี จนสิ้นสมัยกรุงศรีอยุธยา

ต่อมาในสมัยกรุงธนบุรี พระเจ้าตากสินมหาราช มีการกวาดต้อนผู้คนจากเวียงจันทน์ ศรีสัตนาคนหุต และหลวงพระบางมาเป็นจำนวนมาก พร้อมทั้งให้ผู้คนที่ถูกกวาดต้อนเข้าไปตั้งถิ่นฐานอาศัยอยู่ในบริเวณพื้นที่ต่าง ๆ ทางภาคอีสาน และตามเขตหัวเมืองชั้นในที่ยังมีคนอาศัยอยู่น้อย เช่น ที่ลพบุรีปัจจุบันจึงมีชนกลุ่มน้อย ที่อพยพมาจากนครเวียงจันทน์ เข้ามาตั้งรกรากอยู่ที่บ้านหัวช้าง ตำบลท่าศาลา อำเภอเมืองลพบุรี กลุ่มไทยพวนที่อพยพมาจากเมืองหลวงพระบางเข้ามาตั้งหลักแหล่งที่อำเภอบ้านหมี่ ส่วนกลุ่มคนที่พูดภาษาไทยเงี้ยวที่อพยพมาจากกรุงศรีสัตนาคนหุต เข้ามาตั้งบ้านเรือนอยู่ในหลายท้องที่ของจังหวัดลพบุรี นอกจากนั้นยังมีกลุ่มชาวมอญ ที่อพยพเข้ามาอยู่ในตำบลบางขันหมาก อำเภอเมืองลพบุรี ซึ่งเป็นชาวมอญที่มาจากกรุงหงสาวดีนั่นเอง[17]

ส่วนจังหวัด สระบุรี นั้นเคยเป็นเมืองสำคัญมาตั้งแต่ในอดีต สันนิษฐานว่าคงตั้งขึ้นในสมัยสมเด็จพระมหาจักรพรรดิ สมัยอยุธยาตอนต้น และจากการที่ภูมิประเทศตอนเหนือ ตะวันออก และตอนกลางของเมืองสระบุรีเป็นป่าเขา มีเนินเขาสลับที่ราบสูง และทิวเขาดงพญาเย็น จึงทำให้เมืองสระบุรี มีเชิงเขาชะง่อนผาและถ้ำอยู่มาก มีการค้นพบโบราณวัตถุสถานหลายแห่งในบริเวณถ้ำและชะง่อนผาที่สันนิษฐานกันว่าจะเป็นศิลปะสมัยทวาราวดี เช่น ภาพสลักบนผนังถ้ำพระโพธิสัตว์ ตำบลทับกวาง อำเภอแก่งคอย เป็นภาพสลักนูนต่ำ ศิลปะสมัยทวาราวดี เชื่อว่ามีอายุอยู่ในราวพุทธศตวรรษที่ 13-15 คาดว่าเป็นภาพพุทธประวัติ นอกจากนั้นยังมีถ้ำพระธาตุเจริญธรรม อำเภอแก่งคอย ที่บริเวณถ้ำ มีพระพุทธรูปปางมารวิชัย เป็นศิลปะสมัยรัตนโกสินทร์ และที่เชิงเขาปถวี ตำบลหนองปลาไหล มีรอยพระพุทธรูปอยู่บนชะง่อนผา และรอยพระพุทธบาทบนไหล่เขาสุวรรณบรรพต ศิลปที่พบในโบราณสถานเหล่านี้ น่าจะสันนิษฐานว่าอาจจะมีชุมชนโบราณอยู่ในบริเวณเหล่านี้ก็เป็นได้

ปัจจุบันเมืองสระบุรี แม้จะมีความเป็นชุมชนภาคเกษตรกรรมตามลักษณะภูมิประเทศ แต่อัตราการเพิ่มประชากร ค่อนข้างต่ำ เมื่อเทียบกับอัตราเฉลี่ยทั้งประเทศ แต่อย่างไรก็ตามการที่มีวัตถุดิบที่ทำให้เป็นแหล่งผลิตในภาคอุตสาหกรรม ทำให้จังหวัดสระบุรีมีความเป็นชุมชนเมืองค่อนข้างสูงเมื่อเปรียบเทียบกับจังหวัดอื่น ๆ

สำหรับ **จังหวัดนครนายก** นั้น เป็นเมืองโบราณสมัยขอม ยังมีเทวสถานขอมปรากฏอยู่ ตัวเมืองตั้งอยู่ที่ตำบลดงละคร ชาวบ้านเรียกกันว่า "เมืองลับแล" นอกจากนั้นยังมีแนวกำแพงเป็นเนินดินและคูน้ำอยู่ ภายหลังย้ายมาตั้งใหม่ที่ฝั่งขวาของแม่น้ำนครนายก สันนิษฐานว่าคงย้ายมาในสมัยกรุงศรีอยุธยาตอนต้น เพื่อตั้งเป็นเมืองหน้าด่านทางทิศตะวันออก เพราะเมื่อสมเด็จพระรามาธิบดีที่ 1 หรือพระเจ้าอู่ทอง ทรงสถาปนากรุงศรีอยุธยาใน พ.ศ. 1893 นั้น ได้ทรงวางแบบแผนทำนองเดียวกับครั้งกรุงศรีอยุธยาเป็นราชธานี คือ เอาพระนครศรีอยุธยาเป็นราชธานีอยู่กลาง มีเมืองหน้าด่าน 4 ด้าน เมืองลพบุรี อยู่ทางด้านเหนือ เมือง

นครนายกอยู่ด้านตะวันออก เมืองพระประแดงอยู่ด้านใต้ เมืองสุพรรณบุรี อยู่ทางด้านตะวันตก ระยะทางไปมาถึงราชธานีได้ภายใน 2 วัน เช่นกัน[18]

เนื่องจากในอดีตนครนายกเคยเป็นเมืองหน้าด่าน และอาจจะเคยเป็นทางผ่านของขอมโบราณ รวมทั้งการอพยพเข้ามาตั้งบ้านเรือน ของชาวมอญ ลาว พวน ญวน ลาวเวียง จีน เขมร เป็นต้น เมื่อมาอยู่ร่วมกันกับชาวพื้นเมืองไทยดั้งเดิม จึงเกิดการผสมกลมกลืนกันทั้งทางด้านการประกอบอาชีพ วัฒนธรรม ประเพณี และการดำเนินชีวิต ในแต่ละชุมชนด้วย ปัจจุบัน ประชากรส่วนใหญ่อาศัยอยู่ในชนบท และทำการเกษตรกรรมเป็นหลักตามลักษณะของเนื้อที่ที่เป็นที่ราบลุ่ม มีเพียงส่วนน้อยไม่ถึง 10 เปอร์เซนต ของประชากรเท่านั้น ที่อยู่ในเขตชุมชนเมือง

จังหวัดทางด้านขอบที่ราบภาคกลางด้านตะวันตกนั้น **จังหวัดอุทัยธานี** ก็เป็นจังหวัดที่มีหลักฐานทางประวัติศาสตร์ยืนยันว่าเป็นที่อาศัยของมนุษย์ก่อนประวัติศาสตร์ เมื่อประมาณ 3,000 ปีมาแล้ว จากการที่พบโครงกระดูก เครื่องมือหินกะเทาะจากหินกรวดและภาพเขียนสมัยก่อนประวัติศาสตร์บนหน้าผาของเขาปลาร้า เป็นต้น ในสมัยกรุงสุโขทัยเป็นราชธานี บริเวณพื้นที่นี้มีชนชาติไทยมาสร้างบ้านเมืองเรียกว่า บ้านคู่ไทย ซึ่งต่อมาเพี้ยนเสียงเป็นอู่ไทย มีความเจริญขึ้น แต่ต่อมาเมืองนี้เกิดความแห้งแล้งกันดารน้ำ ชาวบ้านจึงอพยพทิ้งบ้านเรือนออกไป ทำให้เมืองอู่ไทยร้างไประยะหนึ่ง[19]

ในสมัยกรุงศรีอยุธยา มีชาวกะเหรี่ยงเข้ามาตั้งบ้านเรือนอีกครั้งหนึ่ง โดยมีการแก้ไขปัญหาการขาดแคลนน้ำ ทำให้ชาวบ้านกลับมาอยู่อาศัยมากขึ้น เมืองอู่ไทยในขณะนั้นมีฐานะเป็นเมืองหน้าด่าน ในสมัยต้นกรุงรัตนโกสินทร์ พระบาทสมเด็จพระพุทธยอดฟ้าจุฬาโลกมหาราชทรงแต่งตั้งเจ้าเมืองไปปกครองด่านของเมืองอุทัยธานี ต่อมาเจ้าเมืองอุทัยธานีเห็นว่าถ้าจะตั้งบ้านเรือน ณ บ้านสะแกกรัง ซึ่งเป็นเขตชุมชนที่อุดมสมบูรณ์ การคมนาคมสะดวกเพราะมีแม่น้ำสะแกกรังไหลผ่านก็จะทำให้การปกครองและการประกอบอาชีพได้ผลดี จึงขออนุญาตจากทางการตั้งบ้านเรือนชุมชนขึ้นที่บ้านสะแกกรัง ต่อมามีการแบ่งเขตเมืองใหม่โดยโอนเขตท้ายบ้านสะแกกรัง ไปจดเขตเมืองอู่ไทยเก่าให้เป็นเขตปกครองของเมืองอุทัยธานี

ปัจจุบันโครงสร้างทางเศรษฐกิจของจังหวัดอุทัยธานี ประกอบด้วยภาคเกษตรกรรม ภาคอุตสาหกรรม และภาคพาณิชยกรรมและการบริการ นอกจากนั้นยังได้นำแนวคิดในการพัฒนาเศรษฐกิจชุมชนพึ่งตนเองหรือเกษตรทฤษฎีใหม่ตามพระราชดำรัสของพระบาทสมเด็จพระเจ้าอยู่หัวมาใช้ มีการพัฒนาแหล่งน้ำขนาดเล็ก มีการดำเนินกิจกรรมกลุ่มสหกรณ์ออมทรัพย์ การพัฒนากลุ่มอาชีพ การพัฒนาเครือข่ายร้านค้าชุมชน เป็นต้น[19]

นครปฐม เป็นจังหวัดทางด้านขอบที่ราบภาคกลางด้านตะวันตกช่วงล่างที่เคยเป็นเมืองเก่า และเป็นเมืองที่มีความเจริญรุ่งเรืองของประเทศไทยมาในอดีต จากหลักฐานการขุดค้นพบโบราณสถาน และโบราณวัตถุ หลายอย่างซึ่งจะพบที่เมืองนครปฐมแห่งเดียวเท่านั้น แผ่นดินที่เป็นที่ตั้งของเมืองนครปฐมในอดีตนั้นเดิมเคยอยู่ริมทะเลและเป็นเมืองท่าที่มีความเจริญรุ่งเรืองมากเมืองหนึ่ง มีแม่น้ำสายใหญ่ไหลจากประเทศอินเดีย ผ่านอู่ทองไปไปออกปากอ่าวที่เมืองนครปฐม แม่น้ำสายนี้ได้พัดพาเอาดินตะกนและแร่ธาตุจาก

บริเวณต้นน้ำ และกัดเซาะตะกอนต่าง ๆ มาทับถมเป็นเวลานาน ทำให้เกิดการตื้นเขินจนกลายเป็นที่ราบลุ่มบริเวณกว้าง เหมาะแก่การตั้งถิ่นฐานบ้านเรือนรวมทั้งการประกอบอาชีพทางเกษตรกรรม[20]

นครปฐมเป็นเมืองมาตั้งแต่สมัยแรกสร้างองค์พระปฐมเจดีย์และเป็นเมืองหลวงของอาณาจักรทวาราวดีประมาณพุทธศตวรรษที่ 11-16 โดยมีปูชนียสถาน สร้างไว้เป็นจำนวนมากที่ยังคงเหลือหลักฐานอยู่ ต่อมาแม่น้ำท่าจีนและแม่น้ำแม่กลอง ซึ่งแต่เดิมเคยไหลผ่านเมืองนครปฐมได้เปลี่ยนทางเดินใหม่ ทำให้นครปฐมขาดน้ำ พื้นที่เป็นที่ดอนที่ไม่เหมาะแก่การทำนาทำไร่ ผู้คนในสมัยนั้นจึงย้ายไปตั้งบ้านเรือนอยู่ริมแม่น้ำ ทำให้นครปฐมเสื่อมลง ต่อมาในสมัยสมเด็จพระมหาจักรพรรดิ พระองค์ทรงตั้งชื่อชุมชนริมแม่น้ำท่าจีนว่าเมืองนครชัยศรี[20]

ในสมัยรัตนโกสินทร์ พระบาทสมเด็จพระจุลจอมเกล้าเจ้าอยู่หัว โปรดเกล้าฯ ให้จัดทำและวางผังเมืองรวมทั้งอาคารสถานที่ แล้วย้ายเมืองนครชัยศรีมาตั้งอยู่ใกล้บริเวณองค์พระปฐมเจดีย์ มีการตัดถนนเพิ่มขึ้นอีกหลายสาย ต่อมาพระบาทสมเด็จพระมงกุฎเกล้าเจ้าอยู่หัว
โปรดเกล้าฯ ให้เปลี่ยนชื่อเมืองนครชัยศรีเป็นเมืองนครปฐม

ปัจจุบันประชาครในจังหวัดนครปฐมส่วนใหญ่เป็นคนไทย แต่มีคนเชื้อสายอื่น ๆ ปะปนด้วย เช่น คนไทยเชื้อสายจีน มอญ และลาว ได้แก่ ลาวโซ่ง จากจังหวัดเพชรบุรี ซึ่งเข้ามาตั้งหลักแหล่ง ในจังหวัดนครปฐมเป็นจำนวนมากนานมาแล้ว ลาวโซ่งในนครปฐมนี้มีรูปแบบของการตั้งถิ่นฐานของหมู่บ้านเป็นแบบรวมกลุ่มในบริเวณใกล้แหล่งน้ำธรรมชาติที่จะเอื้อประโยชน์ในด้านเกษตรกรรม อันเป็นอาชีพหลักที่สำคัญ

จังหวัดนครปฐม ซึ่งเป็นปริมณฑลของกรุงเทพมหานคร มีลักษณะภูมิประเทศ ทรัพยากรและตำแหน่งที่ตั้งที่เหมาะสมต่อการเกษตรกรรม อุตสาหกรรม การค้า การบริการ และการท่องเที่ยว ที่สามารถรองรับการขยายตัวจากกรุงเทพมหานครได้เป็นอย่างดี

<u>สรุป</u> โดยภาพรวมของการตั้งหลักแหล่งเป็นชุมชนในบริเวณพื้นที่ราบภาคกลาง ตั้งแต่ที่ราบภาคกลางตอนบน ที่ราบภาคกลางตอนล่าง ซึ่งแบ่งเป็นที่ราบเจ้าพระยาตอนบน และที่ราบเจ้าพระยาตอนล่าง หรือที่ราบกรุงเทพฯ ตลอดจนบริเวณขอบที่ราบภาคกลาง ซึ่งทั้งหมดครอบคลุมเนื้อที่ 22 จังหวัดนั้น จะเห็นได้ว่าแต่ละจังหวัดล้วนเคยเป็นเมืองโบราณ หรือเป็นเมืองที่เคยมีบทบาทสำคัญในด้านต่าง ๆ มาก่อนในอดีต มีการตั้งบ้านเรือนเป็นกลุ่มเป็นชุมชนที่รวมตัวกันในบริเวณที่เป็นที่ราบลุ่มและลำน้ำ ซึ่งเอื้อต่อความเป็นอยู่และการทำมาหากิน ในลักษณะชุมชนชนบท เมื่อเวลาแปรเปลี่ยนไป แต่ละเมืองล้วนมีการเปลี่ยนแปลงและพัฒนาเข้าสู่ยุคปัจจุบันที่มีจำนวนประชากรมากขึ้น มีความเปลี่ยนแปลงของสังคม เศรษฐกิจ และการประกอบอาชีพอันจะทำให้เกิดการพัฒนาไปตามศักยภาพของแต่ละชุมชนให้เข้าสู่ความเป็นชุมชนเมือง ซึ่งจะต้องนำมาวิเคราะห์ว่าการเปลี่ยนแปลงดังกล่าวจะมีผลกระทบต่อวิถีชีวิตของผู้คนในสังคมเมืองหรือไม่อย่างไร

รายการอ้างอิง

1 ภูมิลักษณ์ประเทศไทย (กรุงเทพมหานคร : จุฬาลงกรณ์มหาวิทยาลัย, 2534), หน้า 44-46

2 สุภรณ์ โอเจริญ, นครสวรรค์, จังหวัด, สารานุกรม วัฒนธรรมไทยภาคกลาง 6 (2542) : 2908- 2910

3 บุญครอง คันธฐากูร, สุพรรณบุรี, จังหวัด, สารานุกรมวัฒนธรรมไทยภาคกลาง 14 (2542) : 6830

4 ธวัช ศรีสว่าง, อ่างทอง, จังหวัด, สารานุกรมวัฒนธรรมไทยภาคกลาง 15 (2542) : 7396

5 วีรนุช ปิณฑวณิช, สิงห์บุรี, จังหวัด, สารานุกรมวัฒนธรรมไทยภาคกลาง 14 (2542) : 6752

6 สุรศักดิ์ ศิริไพบูลย์สินธ์, พระนครศรีอยุธยา, จังหวัด, สารานุกรมวัฒนธรรมไทยภาคกลาง 9 (2542) : 3993

7 วีรนุช ปิณฑวณิช, พระนครศรีอยุธยา, อำเภอ, สารานุกรมวัฒนธรรมไทยภาคกลาง 9 (2542) : 3996

8 ปิยะดา เวชประสิทธิ์, นนทบุรี, จังหวัด, สารานุกรมวัฒนธรรมไทยภาคกลาง 7 (2542) : 2922, 2931

9 กำธร กุลชล และ ทรงสรรค์ นิลกำแหง, "วิวัฒนการทางกายภาพของกรุงรัตนโกสินทร์ฝั่งตะวันออก : ตั้งแต่ก่อสร้างกรุงจนถึงสมัยเปลี่ยนแปลงระบบการปกครอง, "วารสารมหาวิทยาลัยศิลปากร, ปีที่ 45 ฉบับพิเศษ (ธันวาคม 2523- ธันวาคม 2525) หน้า 222

10 แน่งน้อย ศักดิ์ศรี ม.ร.ว., ผุสดี ทิพทัส, ชาญวุฒิ วรวรรณ ม.ร.ว., วีระ สัจกุล, เลอสม สถาปิตานนท์ และ บัณฑิต จุลาสัย, องค์ประกอบทางกายภาพกรุงรัตนโกสินทร์, กรุงเทพฯ : โรงพิมพ์ จุฬาลงกรณ์มหาวิทยาลัย, 2525 หน้า 11

11 กรมศิลปากร, บันทึกเรื่องราวสัมพันธไมตรีระหว่างประเทศไทยกับนานาประเทศ ในศตวรรษที่ 17 เล่มที่ 1 (กรุงเทพฯ : คุรุสภา, 2521) หน้า 105-107

12 วราภรณ์ จิวชัยศักดิ์ และ สุรศักดิ์ ศิริไพบูลย์สินธ์, กรุงเทพมหานคร, จังหวัด, สารานุกรมวัฒนธรรมไทยภาคกลาง 1 (2542) : 137

13 ผุสดี ทิพทัส, การตั้งหลักแหล่งในภาคกลาง, สารานุกรมวัฒนธรรมไทยภาคกลาง 1 (2542) : 310-311

14 รัตนา บำรุงญาติ, สมุทรสาคร,จังหวัด, สารานุกรมวัฒนธรรมไทยภาคกลาง 14 (2542) : 6497

15 สุรศักดิ์ ศิริไพบูลย์สินธ์, สมุทรสงคราม, จังหวัด, สารานุกรมวัฒนธรรมไทยภาคกลาง 14

(2542) : 6487

[16] สุรศักดิ์ ศิริไพบูลย์สินธ์, สมุทรปราการ, จังหวัด, สารานุกรมวัฒนธรรมไทยภาคกลาง 13 (2542) : 6465

[17] สมัย สุทธิธรรม, สารคดีชุดถิ่นทองของไทย : ลพบุรี, กรุงเทพฯ : โอ.เอส.พริ้นติ้งเฮ้าส์, 2539 หน้า 5-13

[18] สุรศักดิ์ ศิริไพบูลย์สินธ์, นครนายก, จังหวัด, สารานุกรมวัฒนธรรมไทยภาคกลาง 6 (2542) : 2875

[19] วีรนุช ปิณฑวณิช, อุทัยธานี, จังหวัด, สารานุกรมวัฒนธรรมไทยภาคกลาง, 15 (2542) : 7445-46, 7456

[20] นำพวัลย์ กิจรักษ์กุล, นครปฐม, จังหวัด, สารานุกรมวัฒนธรรมไทยภาคกลาง, 6 (2542) : 2887 - 2889

Towards sustainable eco-cultural tourism for water-based settlements on the banks of the Chao-Phraya River, a case of Koh kret, Nonthaburi Province

Suwattana Thadaniti [1]

***Abstract**: The Settlements and towns along the Chao-Phraya River banks, river islands and canals constitute a unique aspect of cultural heritage and national identity. With such characteristics, many water-based settlements on the Bank of the Chao-Phraya River are attracting and welcoming the tourism industry. Therefore how to derive the most practical way for the water-based conumunities to achieve a sustainable eco-cultural tourism and benefit from it is the objective of this paper. The study has been done by using "Koh Kret" as a case study. "Koh Kret" is a small island of 4.12 square kilometres in the Chao-Phraya River within the administrative boundary of Nonthaburi Province. The community of Koh Kret is a traditional settlement with historical value and identity. The residents are mainly from the Mon ethnic group, and have preserved their culture as beautifully expressed through the way of living, architectural buildings and cultural activities, eg, temples, ancient houses, settlement styles and the pottery artwork. At present, tourism on this island can be regarded as community development as well as cultural and art conservation. The finding from the study recommends that to prevent the negative impact from tourism leading to the unsustainability of the industry, the participation of Koh Kret community in their own tourism development needs to be promoted by the government. If the Koh Kret community can expose its way of life and manage the impact of tourism then Koh Kret can be protected as a living historic gem of the Chao-Phraya River.*

Full paper not provided

[1] CUSRI, Chulalongkorn University

Chao Phraya river and canal network nostalgia of aquatic heritage

Naruemon Hinsharanan [1]

Abstract: *"Venice of the East" is the term which represents Ayutthaya and Bangkok as cities of waterway network nurturing riparian settlement and transportation. Although Ayutthaya and Bangkok have certain aquatic features comparable to the city of Venice, the term "Venice of the East" does not contribute to the full understanding and appreciation of way of life, conception, beliefs, rituals, artistic and symbolic creations stemming from close association with water. This paper describes Chao Phraya River and its canal network as the origin of unique aquatic traditions. It also explores the decline of aquatic mode of life after rapid urban growth and orientation towards road transportation. In order to create new economic opportunities as well as to satisfy the sense of nostalgia, attempts have been made to revive or even reinvent certain traditions. Yet genuine aquatic traditions are fading through time, as the river and its canal network have been neglected and lost their meaningful existence.*

Full paper not provided

[1] Chulalongkorn University, CUSRI

"The power of local history and community development": a case study in Amphur Phuttamonton's community, Nakhon Pathom Province

Iam Thongdee[1], Varapon Sisupan[2],Wattana Teimpatom[3], Selaphum Voranimanon[4], Samreong Yupracham[5], Viliwan Orot[6]

"พลังประวัติศาสตร์ท้องถิ่นต่อการพัฒนาชุมชน"

กรณีศึกษาชุมชนอำเภอพุทธมณฑล จังหวัดนครปฐม

Abstract: *The Research study of "Community Change and Development in Amphur Phuttamonton, Nakhonpatom Province" was designed as a qualitative research; data collected from documents and field work by personal and collective interviews and group discussions. Two main points are addressed in the study: what are the local events which have shaped local history and how did they become the engine of development and change or not.*

It is found that there were many events that could be linked either directly or indirectly to local transformations. The local events that had the most significant impact on the development, the economic, social, cultural, and environmental changes were the advent of the kingdom of Dhavaravati and Suwanaphum, Buddhism, the king and Chakri dynasty, Government Organisations, Bangkok development and other general events; This reports shows how these events were subsequent causes and consequences of local history but that people were not aware of this causal chain.

The research suggests that an important point is to increase the community's awareness and the value of local history in local development. It can make people feel more conscious about the preservation of their original way of life, responsible and proud of their local culture as a basis for community development.

บทคัดย่อ

การศึกษาวิจัยเรื่อง"**พลังประวัติศาสตร์ท้องถิ่นต่อการพัฒนาชุมชน"กรณีศึกษาชุมชนอำเภอพุทธมณฑล จังหวัดนครปฐม**" เป็นการศึกษาวิจัยเชิงคุณภาพ เก็บข้อมูลจากเอกสารและภาคสนาม โดยการสัมภาษณ์บุคคล กลุ่ม และการจัดเวทีสนทนา โดยมุ่งศึกษาสองประเด็นหลัก คือ มีเหตุการณ์ใด

[1] Institute of Language and Culture for Rural Development, Mahidol University
[2] Faculty of Humanity and Social Science, Mahidol University
[3] Phuttamontol Hotpital, Nakhonpatom Province
[4] Institute of Royal Technology, Salaya. Nakhonpatom Province
[5] Mahidol Vitayanuson School. Nakhonpatom Province
[6] Primary School Office, Amphur Phuttamontol, Nakhonpatom Province

บ้างที่จัดเป็นประวัติศาสตร์ท้องถิ่น และเหตุการณ์เหล่านั้นเป็นพลังต่อพัฒนาการและการเปลี่ยนแปลงที่เกิดขึ้นในชุมชนในลักษณะอย่างไรบ้างหรือไม่ ซึ่งผลการศึกษาพบว่ามีเหตุการณ์หลายอย่างที่เกิดขึ้นและจัดได้ว่าเป็นประวัติศาสตร์ที่เกี่ยวข้องกับท้องถิ่นทั้งโดยตรงและโดยอ้อม และพบว่าประวัติศาสตร์ท้องถิ่น เกี่ยวกับอาณาจักรสุวรรณภูมิ,อาณาจักรทวาราวดี,พระพุทธศาสนา,พระมหากษัตริย์ในราชวงศ์จักรี,หน่วยงานภาครัฐ,การเมืองการปกครอง,กรุงเทพมหานคร,และเหตุการณ์ทั่วไป เป็นปัจจัยสำคัญยิ่งต่อพัฒนาการและการเปลี่ยนแปลงทางเศรษฐกิจ สังคม วัฒนธรรม สิ่งแวดล้อมและทรัพยากรในท้องถิ่น โดยเกิดขึ้นในลักษณะที่เป็นเหตุเป็นผลของกันและกัน ทั้งในส่วนดีและไม่ดี แต่ชุมชนไม่ได้ตระหนักในความสำคัญของพลังดังกล่าว

ข้อเสนอแนะจากการวิจัยครั้งนี้ที่สำคัญคือน่าจะเพิ่มคุณค่าความสำคัญของประวัติศาสตร์ท้องถิ่นต่อการพัฒนาชุมชนให้มากขึ้น โดยการนำเอามิติทางประวัติศาสตร์ท้องถิ่นมาใช้เพื่อการพัฒนาชุมชน คนในชุมชนจะได้รู้รากเหง้าความเป็นมาของตนเอง และเกิดความภาคภูมิใจหวงแหน สำนึกรับผิดชอบต่อท้องถิ่นมากขึ้น พร้อมๆ กับการพัฒนาชุมชนในด้านต่างๆ

1. บทนำ

*เรื่อง **“ประวัติศาสตร์ท้องถิ่น”** น่าจะเป็นองค์ความรู้กลุ่มหนึ่งที่เป็นประโยชน์ต่อการพัฒนาท้องถิ่นหรือชุมชนอย่างยิ่ง เพราะเรื่องราวต่างๆ คือเนื้อหาสาระของท้องถิ่นที่จำเป็นต้องพัฒนาและใช้เป็นเครื่องมือในการพัฒนาโดยตรง เช่น การได้ศึกษาเรียนรู้เรื่องต่างๆ เหล่านี้เป็นการได้เรียนรู้เรื่องราวของตนเองที่สามารถนำมาใช้ประโยชน์ในปัจจุบันและส่งผลต่อไปในอนาคตได้ ด้วยเหตุเหล่านี้ ประเด็นดังกล่าวนี้จึงถูกยกขึ้นเป็นประเด็นวิจัย โดยมีหลักการความเป็นมา และความสำคัญ ดังต่อไปนี้*

1.1 หลักการ ความเป็นมาและความสำคัญของการวิจัย

1.1.1 หลักการ

เป็นที่ยอมรับกันโดยทั่วไปว่า *“สังคมของมนุษยชาติมีความเจริญก้าวหน้ามาสู่ปัจจุบันได้เพราะได้อาศัยพลังทางประวัติศาสตร์เป็นกลไกหรือปัจจัยสำคัญในกระบวนการพัฒนาและการเปลี่ยนแปลงพฤติกรรมต่างๆ ของมนุษยชาติให้กอรปไปด้วยคุณความดีมีคุณธรรม จริยธรรม เป็นบรรทัดฐานในการประพฤติปฏิบัติของชุมชนและสังคมมาแต่โบราณ”* ทั้งนี้เพราะประวัติศาสตร์จึงมีคุณูปการต่อสังคมและชุมชนในท้องถิ่นต่างๆ หลายประการ เช่น

(1) **ประวัติศาสตร์เป็นทั้งโครงสร้างและเนื้อหาสาระที่เป็นรากฐานให้แต่ละสังคมได้เจริญเติบโต** และกลายเป็นองค์ความรู้หรือบทเรียนให้ชุมชนหรือสังคมในท้องถิ่นได้เรียนรู้และนำไปใช้

ประโยชน์เพื่อสร้างสรรค์ลักษณะต่างๆ ของชุมชนหรือสังคมให้มีความเข้มแข็ง มีพลังเป็นต้นทุนเพียงพอที่จะใช้ในการพัฒนา

(2) **เนื้อหาสาระของประวัติศาสตร์กลายเป็นกลไกสำคัญในการปลูกฝังพฤติกรรมแก่บุคคลและสังคม** ให้เกิดสำนึกรับผิดชอบ ยอมรับกฎเกณฑ์กติกา ความชั่ว ความดี ความงาม ความพอดี และกรอบแห่งความสุขของสังคม อันเป็นอุดมการณ์หรือเป้าหมายที่สังคมต้องมุ่งมั่นเพื่อเข้าถึง จึงจะได้ชื่อว่าเป็นผู้สมบูรณ์ อดีตที่ไม่ดีระวังไม่ให้ซ้ำรอย ที่ดีต้องทำตาม

1.1.2 ความเป็นมา

จากงานการศึกษาวิจัยเรื่อง "พัฒนาการและการเปลี่ยนแปลงของชุมชนอำเภอพุทธมณฑล จังหวัดนครปฐม"(เอี่ยม ทองดี และคณะ 2539) แสดงให้เห็นว่าพัฒนาการและการเปลี่ยนแปลงของชุมชนในพื้นที่ดังกล่าวมีส่วนเกี่ยวข้องกับเหตุการณ์ต่างๆ ทางประวัติศาสตร์อย่างใกล้ชิด และดูเหมือนว่าเหตุการณ์ต่างๆ ทางประวัติศาสตร์ของชุมชนเหล่านี้มีคุณูปการอย่างใหญ่หลวงต่อพัฒนาการและการเปลี่ยนแปลงที่เกิดขึ้นในปัจจุบัน แต่ปัญหาสำคัญที่พบคือคนในชุมชนกลับไม่รู้เรื่องประวัติศาสตร์เหล่านั้นมากนัก จะมีก็แต่ผู้สูงอายุ ด้วยเหตุดังกล่าวนี้ทำให้ผู้วิจัยสนใจศึกษาวิจัยในเรื่องนี้ขึ้น

1.1.3 ความสำคัญ

ในกระบวนการปลูกสร้างสำนึกในความเป็นชุมชน เช่น ความภาคภูมิใจในการเป็นคนท้องถิ่น ความภาคภูมิใจที่ได้เข้ามาอาศัยในท้องถิ่น อันจะนำไปสู่ความสำนึกรับผิดชอบต่อท้องถิ่นในด้านต่างๆ นั้น มีเงื่อนไขและปัจจัยหลายอย่าง และเรื่องราวประวัติศาสตร์ท้องถิ่นก็เป็นเป็นปัจจัยหนึ่งที่มีความสำคัญยิ่งในกระบวนการดังกล่าว ซึ่งองค์ความรู้ใน *"มิติประวัติศาสตร์ท้องถิ่น"* สามารถนำไปใช้ได้ในหลายๆ ลักษณะ เช่น

(1) **ประยุกต์ใช้ในการพัฒนาชุมชนในท้องถิ่นให้สอดคล้องกับพื้นฐานด้านต่างๆ ของตนเอง** ซึ่งมิติทางประวัติศาสตร์จะช่วยให้ชุมชนเติบโตขึ้นอย่างมีจิตวิญญาณ

(2) **ใช้ส่งเสริมความรู้ ความเข้าใจ ความภาคภูมิใจ ความรักความหวงแหนในท้องถิ่น** อันจะนำไปสู่ความเข้มแข็งของชุมชน ความสามารถในการพึ่งตนเอง ความเกื้อกูลกันและกัน และความสำนึกรับผิดชอบต่อท้องถิ่น

(3) **ใช้สืบสานคุณค่าความสำคัญของมิติทางประวัติศาสตร์กับการพัฒนาท้องถิ่น** ทั้งนี้เพราะการพัฒนาท้องถิ่นที่ผ่านมา ละเลยการนำมิติทางประวัติศาสตร์ ไปใช้ในการพัฒนา เนื่องจากองค์ความรู้เหล่านี้ยังขาดการศึกษาวิจัยที่เป็นรูปธรรมอย่างเพียงพอที่จะให้ผู้ที่มีส่วนในการพัฒนาได้นำไปใช้ได้

1.2 วัตถุประสงค์

(1) เพื่อศึกษาเหตุการณ์ต่างๆ ที่เกิดขึ้นเกี่ยวข้องกับท้องถิ่นอำเภอพุทธมณฑล

จังหวัดนครปฐม นับทั้งแต่ปรากฏชุมชนขึ้นในท้องถิ่น จนกระทั่งปัจจุบัน

(2) เพื่อศึกษาพลังทางประวัติศาสตร์ท้องถิ่นต่อพัฒนาการด้านต่างๆ ของชุมชนในอำเภอพุทธมณฑล จังหวัดนครปฐม

1.3 ผลที่คาดว่าจะได้รับ

(1) ได้องค์ความรู้ว่ามีเหตุการณ์ใดบ้างที่เกี่ยวข้องจัดว่าเป็นประวัติท้องถิ่นของอำเภอพุทธมณฑล จังหวัดนครปฐม

(2) ได้องค์ความรู้เรื่องลักษณะหรือรูปแบบของพลังประวัติศาสตร์ท้องถิ่นที่มีต่อพัฒนาการและการเปลี่ยนแปลงชุมชนในท้องถิ่น อำเภอพุทธมณฑล จังหวัดนครปฐม

(3) ได้แนวร่วมและแนวทางในการดำเนินงานดังกล่าว รวมทั้งความร่วมมือของเครือข่ายชุมชนในท้องถิ่นอำเภอพุทธมณฑล จังหวัดนครปฐม

2. วิธีดำเนินการวิจัย

2.1 โจทย์ในการวิจัย

ในการวิจัยครั้งนี้ได้กำหนดโจทย์ไว้ว่า **นับตั้งแต่ชุมชนในท้องถิ่นอำเภอพุทธมณฑลปรากฏชัดเจนขึ้น**

(1) มีเหตุการณ์สำคัญๆ ใดบ้าง ที่เกิดขึ้นเกี่ยวข้องกับท้องถิ่นอำเภอพุทธมณฑลทั้งโดยตรงและโดยอ้อมจนถือได้ว่าเป็นประวัติศาสตร์ท้องถิ่นของอำเภอพุทธมณฑล จังหวัดนครปฐม

(2) ประวัติศาสตร์ท้องถิ่นเหล่านั้นเป็นพลังผลักดันหรือดึงดูหรือมีผลต่อพัฒนาการและการเปลี่ยนแปลงชุมชนด้านเศรษฐกิจ สังคม วัฒนธรรม สิ่งแวดล้อมและทรัพยากร อย่างไรบ้าง

2.2 นิยามศัพท์ในการวิจัย

ในการศึกษาวิจัยครั้งนี้

พลัง หมายถึงอำนาจหรืออิทธิพลหรือผลกระทบของสิ่งหนึ่งสิ่งใด ที่มีผลต่อ หรือเป็นเหตุให้ หรือทำให้หรือเป็นปัจจัยหรือเป็นเงื่อนไขหรือเป็นแรงกระตุ้นให้อีกสิ่งหนึ่งเกิดขึ้น เป็นไปในลักษณะต่างๆ

ประวัติศาสตร์ หมายถึงเหตุการณ์ต่างๆ ที่เกิดขึ้นในอดีต จนกระทั่งปัจจุบัน โดยที่ชุมชนหรือสังคมได้บันทึกหรือจดจำไว้ ทั้งส่วนที่เป็นลายลักษณ์อักษรและส่วนที่เป็นการบอกเล่าสืบต่อกันมา

ท้องถิ่น หมายถึงชุมชนบริเวณพื้นที่ตามขอบเขตการปกครองของอำเภอพุทธมณฑล จังหวัดนครปฐม

พลังประวัติศาสตร์ท้องถิ่น หมายถึงอำนาจหรืออิทธิพลหรือผลกระทบของเหตุการณ์ต่างๆ ที่เกิดขึ้นนับตั้งแต่ชุมชนปรากฏขึ้นในพื้นที่ในอำเภอพุทธมณฑล เป็นต้นมา หรือที่เกิด

ขึ้นในพื้นที่อื่นๆ แต่มีผลเกี่ยวข้องหรือเป็นเหตุให้ หรือทำให้ หรือเป็นปัจจัย หรือเป็นเงื่อนไข ต่อการพัฒนาชุมชน อำเภอพุทธมณฑล จังหวัดนครปฐม

การพัฒนาชุมชน หมายถึง การพัฒนาและการเปลี่ยนแปลงลักษณะต่างๆ ของชุมชนให้เป็นไปสู่เป้าหมายอย่างมีแบบแผนหรืออย่างมีทิศทาง

2.3 ขอบเขตการวิจัย

กำหนดพื้นที่ศึกษาในบริเวณอำเภอพุทธมณฑล จังหวัดนครปฐม โดยมุ่งศึกษา เนื้อหา 2 ประเด็น คือ

(1) เหตุการณ์ต่างๆ ที่เกี่ยวข้องโดยตรงหรือโดยอ้อมที่เป็นประวัติศาสตร์ท้องถิ่นของชุมชนอำเภอพุทธมณฑล จังหวัดนครปฐม

(2) พลังทางวัติศาสตร์ท้องถิ่นต่อพัฒนาการด้านเศรษฐกิจ สังคม วัฒนธรรม สิ่งแวดล้อมและทรัพยากรของชุมชน

2.4 การเก็บรวบรวมข้อมูล

2.4.1 ข้อมูลจากเอกสาร เก็บรวบรวมจากเอกสารต่างๆ ที่เกี่ยวกับพัฒนาการของท้องถิ่น เช่น จดหมายเหตุ ใบบอก พระราชบัญญัติต่างๆ ที่เกี่ยวข้อง หนังสือ เอกสารการตรวจราชการหัวเมืองต่างๆ เป็นต้น

2.4.2 ข้อมูลภาคสนาม เก็บรวบรวมจากชุมชนด้วยวิธีการสัมภาษณ์ สังเกต เข้าร่วมกิจกรรม การสัมภาษณ์จะใช้วิธีการบันทึกเสียงลงในแถบบันทึกเสียง และ/หรือจดบันทึกด้วยวิธีการอื่นๆ ตามความเหมาะสม บุคคลที่สัมภาษณ์ได้แก่ชาวบ้านและผู้ที่เกี่ยวข้อง เช่น พระสงฆ์ระดับต่างๆ ผู้นำชุมชนระดับต่างๆ เป็นต้น ส่วนการสังเกตจะใช้วิธีจดบันทึกและถ่ายภาพประกอบ

2.4.3 การสนทนากลุ่ม เชิญผู้ที่เกี่ยวข้อง หรือผู้ที่มีบทบาทสำคัญในเรื่องที่เกี่ยวข้องมาพบปะแลกเปลี่ยนความคิดเห็น หรือรวมกลุ่มแสดงความเห็นในประเด็นต่างๆ ที่กำหนดไว้

2.5 การประมวลผล

2.5.1 นำข้อมูลที่เก็บรวบรวมได้จากเอกสารต่างๆ มาวิเคราะห์และสังเคราะห์ตามขอบเขตด้านเนื้อหา

2.5.2 นำข้อมูลที่เก็บรวบรวมได้จากการสัมภาษณ์และการสังเกต มาจัดหมวดหมู่ ตามขอบเขตของเนื้อหา

2.5.3 ตรวจสอบความถูกต้องสมบูรณ์และเก็บข้อมูลเพิ่มในส่วนที่ไม่สมบูรณ์

2.5.4 วิเคราะห์ข้อมูลตามแนวคิด ทฤษฎีและหลักการต่างๆ

2.5 การนำเสนอผลการวิจัย

นำเสนอผลการวิจัยในรูปแบบของรายงานการวิจัยต่อที่ประชุม 2 ครั้ง เพื่อปรับปรุงแก้ไขและจัดทำรายงานการวิจัยฉบับสมบูรณ์

2.6 ระยะเวลาการวิจัย

กันยายน 2542 – เมษายน 2543.

2.7 แนวคิดและทฤษฎีที่นำมาวิเคราะห์

เนื่องจากพื้นที่วิจัยอยู่ในพื้นที่ที่กำลังเปลี่ยนแปลงจากความเป็นชนบทสู่ความเป็นชานเมือง และกำลังกลายเป็นเมือง ตามอิทธิพลทางการเมืองการปกครอง ภูมิปัญญาและเทคโนโลยีจากชุมชนเมือง จากคนต่างถิ่นมาโดยตลอด ดังนั้น การทำความเข้าใจประเด็นต่างๆ จึงจำเป็นต้องอาศัยแนวคิดและทฤษฎีหลายประการมาใช้เป็นเครื่องมือในการวิเคราะห์ตีความ ซึ่งแนวคิดและทฤษฎีที่ใช้เป็นหลัก ได้แก่

ทฤษฎีการพึ่งตนเองของชุมชนในชนบท หลักการของทฤษฎีการพึ่งตนเองของชุมชนในชนบท คือ ชุมชนในชนบทจะพึ่งตนเองได้ ต้องพึ่งตนเองได้ 5 ด้านด้วยกัน คือ พึ่งตนเองได้ทางเทคโนโลยี ทางเศรษฐกิจ ทางทรัพยากรธรรมชาติ ทางจิตใจ และทางสังคม

ทฤษฎีการแพร่กระจายนวัตกรรม หลักการสำคัญ คือ การแพร่กระจายนวัตกรรมเป็นไป 2 ลักษณะ คือ **แพร่กระจายจากศูนย์กลางอารยธรรมแห่งเดียว** สู่บริเวณอื่นๆ ตามแนวคิดที่ว่ามนุษย์มีธรรมชาติที่ชอบเลียนแบบและเอาอย่างคนอื่นมากกว่าการสร้างสรรค์ และ**แพร่กระจายจากแพร่กระจายจากศูนย์กลางอารยธรรมหลายแห่ง**สู่บริเวณอื่นๆ โดยรอบศูนย์กลางนั้นๆ ตามแนวคิดที่ว่าถ้ามนุษย์อยู่ในสภาพแวดล้อมและบริบทอย่างเดียวกันสามารถจะคิดสร้างสรรค์ในสิ่งต่างๆ ได้เหมือนกันหรือใกล้เคียงกันได้ แม้จะอยู่ไกลกัน หลักการสำคัญของทฤษฎีการแพร่กระจายคือการรับนวัตกรรมขึ้นอยู่กับปัจเจกบุคคล ระบบสังคม การสื่อสาร ตัวนวัตกรรม และระยะเวลา

ทฤษฎีการเปลี่ยนแปลงทางสังคมและวัฒนธรรม แนวคิดและหลักการสำคัญ คือ การเปลี่ยนแปลงต้องมีเหตุปัจจัยเกี่ยวข้องอย่างน้อย 3 ประการ คือ ประชากร ทรัพยากร และเทคโนโลยี หลักการคือเมื่อประชากรเพิ่ม ความต้องการใช้ประโยชน์จากทรัพยากรย่อมเพิ่มตาม ชุมชนจึงจำเป็นต้องพัฒนาภูมิปัญญาและเทคโนโลยีให้สามารถสนองตอบต่อความต้องการให้ได้ จึงทำให้เกิดพัฒนาการและการเปลี่ยนแปลงลักษณะต่างๆ ของชุมชนขึ้น จึงจะอยู่รอด

เมื่อพิจารณาตามแนวคิดและหลักการของทฤษฎีต่างๆ แล้ว คาดหวังว่าสามารถวิเคราะห์สร้างบทสรุปเรื่องพลังทางประวัติศาสตร์ท้องถิ่นต่อการพัฒนาชุมชนดังกล่าวออกมาเป็นองค์ความรู้ที่พอจะนำออกเผยแพร่เพื่อประโยชน์ต่างๆ ที่กำหนดไว้ได้อย่างมีประสิทธิภาพ

3. ผลการศึกษา

จากการศึกษาพบว่า ในชุมชนอำเภอพุทธมณฑล จังหวัดนครปฐม มีประวัติศาสตร์ท้องถิ่นหลายประการ และประวัติศาสตร์เหล่านั้นกลายเป็นพลังสำคัญต่อ

การพัฒนาชุมชนดังกล่าวในลักษณะต่างๆ ซึ่งจากการวิเคราะห์ตามแนวคิดและทฤษฎีต่างๆ ที่กล่าวไว้ข้างต้น สามารถสร้างบทสรุปโดยสังเขปได้ ดังต่อไปนี้

3.1 มีเหตุการณ์ที่จัดว่าเป็นประวัติศาสตร์ท้องถิ่นที่เกี่ยวข้องกับชุมชนอำเภอพุทธมณฑลมาตั้งแต่อดีตจนกระทั่งปัจจุบัน หลายประการ เช่น เรื่องราวความเป็นมาของอาณาจักรสุวรรณภูมิ(ประมาณ พ.ศ.300-1100) เรื่องราวความเป็นมาของอาณาจักรทวาราวดี(ประมาณ พ.ศ.1100-1600) เรื่องราวความเป็นมาของการสร้างเมืองนครชัยศรี(ประมาณ พ.ศ.2092) เรื่องราวการอพยพของคนจีนเข้าประเทศไทย(ประมาณ พ.ศ.2300-2385) เรื่องราวของคลองโยง(ปรากฏหลักฐานประมาณ พ.ศ. 2385) เรื่องราวการออกผนวชของเจ้าฟ้าชายมกุฏ(พ.ศ.2367-2394) เรื่องราวการเสด็จเสวยราชย์ของรัชกาลที่ 4 (พ.ศ.2394) เรื่องราวการเสด็จไปนมัสการองค์พระปฐมเจดีย์ของรัชกาลที่ 4 เรื่องราวสุนทรภู่ไปนมัสการองค์พระปฐมเจดีย์ (พ.ศ.2385) และพระแท่นดงรัง(พ.ศ.2386) เรื่องราวการขุดคลองมหาสวัสดิ์(พ.ศ.2400) เรื่องราวการจับจองที่ดินสองฝั่งคลองมหาสวัสดิ์(หลัง พ.ศ. 2400)และการขุดลอกคลอง เรื่องราวการเกิดชุมชนขึ้นในพื้นที่พุทธมณฑล(พ.ศ.2385, พ.ศ.2411) เรื่องราวการสร้างวัดขึ้นในชุมชน(พ.ศ.2411,2424) เรื่องราวการขุดคลองทวีวัฒนา(พ.ศ.2421) เรื่องราวการสร้างทางรถไฟสายใต้(เปิดใช้ พ.ศ. 2446) เรื่องราวการเปลี่ยนแปลงทางการเมืองการปกครอง พ.ศ.2475 เรื่องราวการตั้งโรงเรียนประถมศึกษา(พ.ศ.2476) เรื่องราวการเกิดน้ำท่วมใหญ่ในพื้นที่ปี พ.ศ. 2485 เรื่องราวการขุดคลองเพื่อสัญจรและควบคุมน้ำ(หลัง พ.ศ.2485) เรื่องราวการก่อสร้างพุทธมณฑล(พ.ศ.2497) เรื่องราวการตัดถนนพุทธมณฑลสาย 4 (พ.ศ.2497) เรื่องราวการสร้างสถานีเครื่องส่งวิทยุ 100 กิโลวัตร(เอเอ็ม) ศาลายา พ.ศ.2508 เรื่องราวการสร้างหน่วยสื่อสารกรมตำรวจ(พ.ศ.2510)เรื่องราวการก่อสร้างมหาวิทยาลัยมหิดล ณ ศาลายา(พ.ศ.2514) เรื่องราวการตัดถนนสายศาลายา-บางภาษี, ศาลายา-นครชัยศรี (พ.ศ.2514) เรื่องราวการสร้างสหกรณ์เพื่อการเกษตร(สปก.)(พ.ศ.2521) เรื่องราวการตัดถนนสายปิ่นเกล้า-นครชัยศรี(พ.ศ.2521) เรื่องราวการประกาศจัดตั้งกิ่งอำเภอพุทธมณฑล (พ.ศ.2533) และยกเป็นอำเภอปี พ.ศ. 2539 เรื่องราวการประกาศจัดตั้งสุขาภิบาลศาลายา(พ.ศ.2534)และยกฐานะสุขาภิบาลเป็นเทศบาลตำบลศาลายา พ.ศ.2542 เรื่องราวองค์การบริหารส่วนตำบล(พ.ศ.2537) เรื่องราวการตั้งโรงพยาบาลพุทธมณฑล(พ.ศ.2537)

นอกจากนี้ยังมีเรื่องราวความเป็นมาของเหตุการณ์ต่างๆ ที่เกิดขึ้นอีกจำนวนมาก เช่น เรื่องราวการสร้างโรงงานอุตสาหกรรม การปรับเปลี่ยนที่นามาเป็นสวนผลไม้ การสร้างหมู่บ้านจัดสรร การย้ายหน่วยราชการจากกรุงเทพฯ มาอยู่ในพื้นที่ และล่าสุดการสร้างทางด่วนคู่ขนานจากสะพานสมเด็จพระปิ่นเกล้า มาถึงสาย 2 และการสร้างถนนอักษะ หน้าพุทธมณฑล

เหล่านี้คือเหตุการณ์ที่เกี่ยวข้องกับชุมชนอำเภอพุทธมณฑลมาตั้งแต่โบราณจากเดิมที่เป็นสภาพรกร้างว่างเปล่า ไม่มีชุมชน ไม่มีทุ่งนา จนกลายมาเป็นชานเมืองที่พัฒนาการและ

เปลี่ยนแปลงไปอย่างรวดเร็ว จนดูเหมือนว่าพื้นที่ดังกล่าวเป็นส่วนหนึ่งของกรุงเทพมหานครมากกว่าจังหวัดนครปฐมไปแล้ว

3.2 ประเภทของประวัติศาสตร์ท้องถิ่นที่เกิดขึ้นเป็นพลังสำคัญต่อการพัฒนาชุมชนในท้องถิ่นอำเภอพุทธมณฑลดังกล่าวในข้อ 3.1 นั้น สามารถแบ่งลักษณะความเกี่ยวข้องได้เป็น 2 ลักษณะ

(1) **เหตุการณ์ประวัติศาสตร์ที่เกิดขึ้นเกี่ยวข้องกับท้องถิ่นโดยตรง** เป็นต้นว่า การเกิดคลองโยง การขุดคลองมหาสวัสดิ์ การจับจองที่ดินสองฝั่งคลองมหาสวัสดิ์ การเกิดชุมชนริมคลอง การสร้างวัดต่างๆ ขึ้นในชุมชน การสร้างพุทธมณฑล การสร้างมหาวิทยาลัยมหิดล การสร้างสนามกอล์ฟ การตัดถนนสายปิ่นเกล้า- นครชัยศรี เป็นต้น ซึ่งเกิดขึ้นดำเนินไปในท้องถิ่นโดยตรง

(2) **เหตุการณ์ประวัติศาสตร์ที่เกิดขึ้นเกี่ยวข้องกับท้องถิ่นโดยอ้อม** เป็นต้นว่า การเกิดอาณาจักรสุวรรณภูมิ(ประมาณพ.ศ.300-1100)การเกิดอาณาจักรทวาราวดี(ประมาณ พ.ศ.1100-1600) การสร้างเมืองนครชัยศรี(ประมาณ พ.ศ.2092) คนจีนอพยพเข้ามาอาศัยในพื้นที่ (ประมาณ พ.ศ.2300-2385) การออกผนวชของเจ้าฟ้าชายมกุฎ (พ.ศ. 2367-2394) การเสด็จเสวยราชย์ของรัชกาลที่ 4 (พ.ศ.2394) การเสด็จนมัสการองค์พระปฐมเจดีย์ของรัชกาลที่ 4 การบูรณะปฏิสังขรณ์องค์พระปฐมเจดีย์ของรัชกาลที่ 4 ที่ 5 และที่ 6 เป็นต้น ซึ่งเกิดขึ้นดำเนินไปในท้องถิ่นอื่น แต่มีผลต่อท้องถิ่นนี้ด้วย

3.3 เหตุการณ์ทางประวัติศาสตร์ท้องถิ่นอำเภอพุทธมณฑล ดังกล่าวข้างต้นหากพิจารณาตามเนื้อหาสาระแล้วสามารถแบ่งออกได้เป็น 6 ลักษณะ คือ

(1) เหตุการณ์ที่เกี่ยวข้องกับอาณาจักรสุวรรณภูมิและทวาราวดีและการพัฒนาชุมชนในท้องถิ่น เช่น การเกิดอาณาจักรสุวรรณภูมิ และอาณาจักรทวาราวดี การสร้างเมืองเมืองเก่าและหลักฐานต่างๆ ทางโบราณคดีที่เกี่ยวข้อง การตั้งถิ่นฐาน ชุมชนโบราณ เมืองเก่าสมัยทวาราวดี เป็นต้น ซึ่งสิ่งเหล่านี้มีผลต่อพื้นที่อำเภอพุทธมณฑลทั้งโดยตรงและโดยอ้อม

(2) เหตุการณ์ที่เกี่ยวข้องกับพระพุทธศาสนา และการพัฒนาชุมชนในท้องถิ่น กล่าวคือพื้นที่อำเภอพุทธมณฑลเป็นพื้นที่ได้รับคุณูปการจากพระพุทธศาสนาเช่นเดียวกับพื้นที่อื่นๆ ในจังหวัดนครปฐม เพราะมีองค์พระปฐมเจดีย์ พระประโทณเจดีย์ ทำให้มีเหตุการณ์ต่างๆ อันเกี่ยวเนื่องกับพระพุทธศาสนามากมาย เป็นต้นว่า ตำนานและการสร้าง การบูรณะปฏิสังขรณ์ องค์พระปฐมเจดีย์ องค์พระประโทณเจดีย์ เกิดงานนมัสการองค์พระปฐมเจดีย์ เกิดการขุดคลอง ตัดถนนหนทาง ฯลฯ จนกระทั่งเกิดการสร้างพุทธมณฑลขึ้นในพื้นที่อำเภอนครชัยศรีและอำเภอสามพรานสมัยนั้น เหตุการณ์ต่างๆ เหล่านี้เป็นเหตุการณ์ทางประวัติศาสตร์ที่เป็นพลังสำคัญให้ชุมชนในพื้นที่อำเภอพุทธมณฑลได้พัฒนาการและเปลี่ยนแปลงมาสู่ปัจจุบัน

(3) เหตุการณ์ที่เกี่ยวข้องกับพระมหากษัตริย์และราชวงศ์จักรี และการพัฒนาชุมชนในท้องถิ่น หากไม่กล่าวถึงเหตุการณ์ที่สมเด็จพระเจ้าจักรพรรดิ์ทรงสร้างเมืองนครชัยศรีขึ้นในสมัย พ.ศ.2095 แล้ว เหตุการณ์สำคัญๆ ที่เกิดขึ้นในพื้นที่จังหวัดนครปฐม ล้วนแต่เกี่ยวข้องกับพระมหากษัตริย์และราชวงศ์จักรีหลายประการที่ซึ่งชาวนครปฐมสำนึกในพระมหากรุณาธิคุณเป็นล้นพ้นตลอดมา เป็นต้นว่า รัชกาลที่ 4 ทรงค้นพบองค์พระปฐมเจดีย์ ทรงบูรณะ ทรงรับสั่งให้ขุดคลองเจดีย์บูชา คลองมหาสวัสดิ์ ทรงจับจองที่ดินในพื้นที่สองฝั่งคลองมหาสวัสดิ์ รัชกาลที่ 5 และรัชกาลที่ 6 ทรงสืบสานเจตนารมย์โดยการสร้างสรรค์และพัฒนาต่อไป เช่น ทางรถไฟ ถนนเพชรเกษม พระราชวังสนามจันทร์ จนกระทั่งสมัยรัชกาลที่ 9 ได้ทรงสร้างพุทธมณฑล ถนนพระบรมราชชนนี ทางด่วนลอยฟ้าคู่ขนาน ทรงบริจาคที่ดินให้ส่วนราชการและสถานศึกษา เป็นต้น นอกจากนั้นยังได้เสด็จฯ ในพื้นที่บ่อยๆ จนกระทั่งปัจจุบัน

(4) เหตุการณ์ที่เกี่ยวข้องกับหน่วยงานภาครัฐและการเมืองการปกครองและการพัฒนาชุมชนในท้องถิ่น หน่วยงานภาครัฐหลายแห่งมีความคิดที่จะย้ายสำนักงานจากกรุงเทพฯ มาตั้งขึ้นในพื้นที่ เช่น มหาวิทยาลัยมหิดล กรมยุทธการทหารเรือ สถาบันวิชาการทหารเรือชั้นสูง เป็นต้น ส่วนในทางการเมืองการปกครองมีการเคลื่อนไหวจัดตั้งกิ่งอำเภอศาลายาขึ้น และการแบ่งเขตการปกครองขึ้นใหม่ เป็นต้น

(5) เหตุการณ์เกี่ยวข้องกับกรุงเทพมหานครและการพัฒนาชุมชนในท้องถิ่น เนื่องจากพื้นที่อำเภอพุทธมณฑลมีอาณาเขตติดต่อกรุงเทพมหานคร เหตุการณ์ต่างๆ ที่เกิดขึ้นในกรุงเทพมหานคร มีผลหรือกลายเป็นพลังสำคัญที่ก่อให้เกิดพัฒนาการและการเปลี่ยนแปลงขึ้นในพื้นที่ด้วย เหตุการณ์สำคัญๆ เช่น การตัดถนนสายวงแหวนรอบนอก การกำหนดลักษณะการใช้พื้นที่สีเขียว การประกาศเขตพื้นที่ปริมณฑลของกรุงเทพฯ การส่งเสริมให้มีการย้ายหน่วยงานราชการออกนอกบริเวณแออัดในกรุงเทพฯ การแก้ปัญหาจราจร เป็นต้น

(6) เหตุการณ์ทั่วไปและการพัฒนาชุมชนในท้องถิ่นทั่วไป เป็นเหตุการณ์ที่เกิดขึ้นต่อเนื่องมาจากการขยายตัวทางเศรษฐกิจของประเทศที่เกิดขึ้นในช่วงเวลาต่างๆ เช่น การเปิดตลาดค้าข้าวกับต่างประเทศในสมัยรัชกาลที่ 4-5-6 การส่งเสริมการทำอุตสาหกรรมน้ำตาลทรายสมัยรัชกาลที่ 4 -5 – 6 การที่คนจีนอพยพเข้ามาเป็นแรงงานในชุมชนรับจ้างทั่ว ในสมัยรัชกาลที่ 3-4-5 การส่งเสริมการลงทุนในสมัยรัฐบาลพลเอกเปรม ติณสูลานนท์ การขยายตัวของชุมชนและเมืองในสมัยเศรษฐกิจรุ่งเรืองในยุครัฐบาลพลเอกชายชาย ชุณหะวัณ เป็นต้น สิ่งเหล่านี้มีผลต่อพัฒนาการและการเปลี่ยนแปลงของพื้นที่พุทธมณฑลอย่างสำคัญยิ่ง

เหตุการณ์ประวัติศาสตร์เหล่านี้คือเนื้อหาสาระที่ปรากฏอยู่ในท้องถิ่น เป็นสิ่งที่เกิดขึ้น เปลี่ยนแปลง และมีลกระทบหรือเป็นเหตุให้เกิดพัฒนาการด้านอื่นๆ มาแต่โบราณ เท่าที่พอจะ สืบค้นหลักฐานได้

3.4 ประวัติศาสตร์ท้องถิ่นแสดงพลังพัฒนาชุมชนออกมาในลักษณะที่เป็นเหตุเป็นผล เป็นอิทัปปัจจยตาหรือเป็นวัฏจักรหรือเป็นพลวัตร(dynamic) ต่อเนื่องถึงกันโดยตลอด ถือเป็นต้นทุนสำคัญในการพัฒนาท้องถิ่น ดังแสดงในตารางต่อไปนี้

ตารางแสดง

ความเป็นพลัง/เหตุผล/พลวัตร(dynamic)ของประวัติศาสตร์ท้องถิ่นต่อการพัฒนาชุมชน

เหตุ	ผล
ประวัติอารยธรรมสุวรรณภูมิและทวาราวดีและการพัฒนาชุมชนในท้องถิ่น	*เกิดเหตุการณ์เกี่ยวข้องกับพัฒนาการของพระพุทธศาสนาและการพัฒนาชุมชนขึ้นในท้องถิ่น*
ประวัติศาสตร์ท้องถิ่นเกี่ยวกับพระพุทธศาสนาและการพัฒนาชุมชนในท้องถิ่น	*เกิดเหตุการณ์เกี่ยวข้องกับพัฒนาการของพระมหากษัตริย์และราชวงศ์จักรีและการพัฒนาชุมชนขึ้นในท้องถิ่น*
ประวัติศาสตร์ท้องถิ่นเกี่ยวกับพระมหากษัตริย์และราชวงศ์จักรี และการพัฒนาชุมชนในท้องถิ่น	*เกิดเหตุการณ์ที่เกี่ยวข้องกับพัฒนาการของหน่วยงานภาครัฐ การเมืองการปกครองและการพัฒนาชุมชนขึ้นในท้องถิ่น*
ประวัติศาสตร์ท้องถิ่นเกี่ยวกับหน่วยงานภาครัฐและการเมืองการปกครองและการพัฒนาชุมชนในท้องถิ่น	*เกิดเหตุการณ์เกี่ยวข้องกับกรุงเทพมหานครและการพัฒนาชุมชนขึ้นในท้องถิ่น*
ประวัติศาสตร์ท้องถิ่นเกี่ยวกับกรุงเทพมหานคร และการพัฒนาชุมชนในท้องถิ่น	*เกิดเหตุการณ์ทั่วไปและและการพัฒนาชุมชนทั่วไปขึ้นในท้องถิ่น*
ประวัติศาสตร์ทั่วไปของท้องถิ่น และการพัฒนาชุมชนทั่วไปในท้องถิ่น	*เกิดเหตุการณ์เกี่ยวข้องกับสิ่งอื่นๆ และการพัฒนาชุมชนลักษณะเฉพาะทางในท้องถิ่นขึ้น*
ฯลฯ	*ฯลฯ*

โดยพบว่า เหตุการณ์ต่างๆ เหล่านี้ สามารถเป็นเหตุเป็นผลให้แก่กันและกันได้อย่างอิสระด้วย เช่นเหตุการณ์เกี่ยวข้องกับพระพุทธศาสนา สามารถเป็นเหตุเป็นผลให้เกิดเหตุการณ์ทางการเมืองการปกครองขึ้นได้ด้วย ขณะเดียวกันเหตุการณ์ทางการเมืองการปกครองก็สามารถก่อให้เกิดเหตุการณ์เกี่ยวกับพระมหากษัตริย์และราชวงศ์ได้ด้วย

3.5 พลังทางประวัติศาสตร์ท้องถิ่นต่อการพัฒนาชุมชนด้านต่างๆ *จากการศึกษาพบว่าประวัติศาสตร์ท้องถิ่นในการวิจัยครั้งนี้ เป็นพลังต่อการพัฒนาชุมชนด้านเศรษฐกิจ สังคม วัฒนธรรม สิ่งแวดล้อมและทรัพยากรในท้องถิ่นอำเภอพุทธมณฑล ดังต่อไปนี้*

3.5.1 **ด้านเศรษฐกิจของชุมชน**

เหตุการณ์หลายอย่างที่เกิดขึ้นทั้งโดยตรงและโดยอ้อมกลายเป็นพลังขับเคลื่อนเศรษฐกิจชุมชน เป็นต้นว่า *การเกิดอาณาจักรสุวรรณภูมิ อาณาจักรทวาราวดี การสร้างพระปฐมเจดีย์ พระประโทณเจดีย์ การสร้างเมืองนครชัยศรีสมัยกรุงศรีอยุธยา ฯลฯ* มีส่วน

สำคัญที่ทำให้พื้นที่พุทธมณฑลได้รับการพัฒนาให้เป็นพื้นที่ทำมาหากิน เกิดเป็นชุมชนขึ้น *การที่คนจีนอพยพเข้าประเทศไทย ช่วงปี พ.ศ.2300 – 2385* กลายเป็นแรงงานพื้นฐานสำคัญในการผลิตเพื่อการค้าและอุตสาหกรรม และเป็นกรรมกรในไร่นา ในโรงงาน และรับจ้างทั่วไป เช่น รับจ้างขุดและขุดลอกคลองมหาสวัสดิ์ คลองซอยต่างๆ ในพื้นที่อำเภอพุทธมณฑล ส่งผลให้ภาวะการทำมาหากิน การค้าขายในพื้นที่ดีขึ้น *การเกิดคลองโยง* และ *การขุดคลองมหาสวัสดิ์* เป็นเงื่อนไขที่ทำให้ภาวะทางเศรษฐกิจของพื้นที่มีความเจริญขึ้นอย่างรวดเร็ว เกิดชุมชน เกิดการจ้างงานขึ้น ต่อมาพระบาทสมเด็จพระจอมเกล้าโปรดเกล้าฯ รับสั่งให้ขุดคลองมหาสวัสดิ์ ช่วยให้การสัญจรสะดวกรวดเร็วย่นระยะทางการขนส่งผลิตผลทางการเกษตรจากลุ่มแม่น้ำท่าจีนเข้าสู่แม่น้ำเจ้าพระยาได้มาก เป็นการเพิ่มคุณค่าและมูลค่าของพื้นที่อำเภอพุทธมณฑลในทางเศรษฐกิจขึ้นอย่างชัดเจน

การจับจองที่ดินสองฝั่งคลองมหาสวัสดิ์ ซึ่งเป็นผลจากการขุดคลองมหาสวัสดิ์โดยตรง เป็นพลังขับเคลื่อนเศรษฐกิจชุมชนให้เจริญก้าวหน้าอย่างยิ่ง แม้ว่าระยะแรกไม่เป็นผลดีต่อชุมชนมากนัก เพราะไม่ได้ใช้ประโยชน์พื้นที่เท่าที่ควร แต่ระยะหลังเมื่อมีการเปลี่ยนแปลงกรรมสิทธิ์พื้นที่ ก่อให้เกิดคุณูปการทางเศรษฐกิจอย่างยิ่ง ธุรกิจใหญ่ๆ เข้ามาตั้งในพื้นที่ รวมทั้งหน่วยงานต่างๆ ทั้งภาครัฐและเอกชน ก่อให้เกิดการจ้างงานและการขยายตัวทางเศรษฐกิจเพิ่มมากขึ้นเพราะพื้นที่ดังกล่าวกลายเป็นที่ตั้งขององค์กรใหญ่ๆ ที่ก่อให้เกิดการสร้างงานสร้างรายได้ขึ้นในพื้นที่ ***ส่วนการเกิดชุมชนและวัดต่างๆ*** กลายเป็นแหล่งเพิ่มพลัง เพิ่มขวัญกำลังใจ และเป็นแหล่งที่ตอบคำถามการผลิตทั้งในส่วนที่ประสบความสำเร็จและล้มเหลว ปัจจุบันชุมชนและวัดก็ยังคงเป็นพลังทางเศรษฐกิจเหมือนเดิมต่างแต่เพิ่มความสลับซับซ้อนมากขึ้น ดัชนีการทำบุญกับวัดสามารถบ่งชี้ถึงความเป็นไปทางเศรษฐกิจของชุมชนได้ด้วย เช่น ในยุคเศรษฐกิจรุ่งเรือง การซื้อขายที่ดินก่อให้เกิดการกินมัดจำ การได้ค่านายหน้า การขายที่ดินได้ราคาสูง ผู้ได้เงินมักบริจาคเงินให้แก่วัดจำนวนมาก บางคนสร้างเสนาสนะถวายวัด อนึ่งพื้นที่ใกล้วัดกับพื้นที่ไกลวัดก็มีนัยทางเศรษฐกิจที่แตกต่างกันด้วย ชุมชมและวัดจึงมีคุณูปการที่สำคัญยิ่งต่อพัฒนาการและการเปลี่ยนแปลงทางเศรษฐกิจดังกล่าว

บันทึกการเสด็จพระราชดำเนินไปนมัสการองค์พระปฐมเจดีย์ของรัชกาลที่ 4 และเดินทางไปนมัสการองค์พระปฐมเจดีย์ของสุนทรภู่และมหาฤกษ์นั้น เป็นการเพิ่มคุณค่าทางเศรษฐกิจให้พื้นที่ เพราะเส้นทางเหล่านี้กลายเป็นเส้นทางโบราณ เป็นโอกาสให้ชุมชนที่จะนำไปพัฒนาได้ **ส่วนการขุดคลองทวีวัฒนา(พ.ศ.2421)** เป็นเส้นทางสายหลักเข้าถึงพื้นที่การผลิต นำปัจจัยการผลิตเข้าและนำผลผลิตออกสู่ตลาดได้สะดวก โดยคลองดังกล่าวเชื่อมพื้นที่ต่างๆให้ถึงกันและเชื่อมชุมชนกับตลาดด้วย นอกจากนี้ยังช่วยเรื่องการควบคุมน้ำเพื่อการผลิต และเป็นแหล่งโปรตีนที่สำคัญของชุมชน **การสร้างทางรถไฟสายใต้(พ.ศ.2440)** ผ่านพื้นที่ เป็นพลังสำคัญที่ก่อให้เกิดพัฒนาการและการเปลี่ยนแปลงทางเศรษฐกิจในพื้นที่ครั้งสำคัญ แม้ว่าผลผลิตหลักคือข้าวยังคงขนส่งทางเรือ แต่ผลผลิตอื่นๆ ได้เปลี่ยนแปลงมาใช้ทางรถไฟมากขึ้น ที่สำคัญคือเพิ่มทางเลือกใน

การนำสินค้าเข้าออกชุมชนได้ เพิ่มโอกาสแก่คนในชุมชนที่จะทำมาค้าขายหรือแสวงหาข้าวของบริโภคอุปโภค ศักยภาพทางเศรษฐกิจของชุมชนจึงเพิ่มมากขึ้น

การเปลี่ยนแปลงการเมืองการปกครอง พ.ศ.2475 กลายเป็นพลังสร้างสรรค์เศรษฐกิจแก่ชุมชนในโอกาสต่อมา เจ้าของที่ดินหลายรายที่ไม่เคยสนใจในที่ดินของตนเองมาก่อน เมื่อเปลี่ยนแปลงการปกครอง อำนาจหลายอย่างหมดไป ทำให้รายได้หมดไปด้วย บางรายจึงขายที่ดินในพื้นที่พุทธมณฑล ชาวบ้านที่เคยเช่าที่อยู่รวมเงินซื้อพื้นที่เหล่านั้นมาเป็นของตนเอง เจ้าของพื้นที่บางรายก็ส่งคนมาดูแลผลประโยชน์อย่างใกล้ชิดทำให้เกิดผลทางเศรษฐกิจเพิ่มมากขึ้น **การตั้งโรงเรียนวัดมะเกลือ(2476) โรงเรียนวัดสุวรรณาราม(ดีราษฎร์รังสฤษดิ์)(2477) โรงเรียนวัดสาละวัน (2477) โรงเรียนบ้านคลองมหาสวัสดิ์ (2481) ตั้งโรงเรียนคลองสว่างอารมณ์ ปี พ.ศ.2492** เป็นพลังเสริมสร้างสถาบันเศรษฐกิจของชุมชนให้เข้มแข็งมีความเป็นระบบและปึกแผ่นทั่วถึงมากขึ้น ครั้น**เกิดเหตุการณ์น้ำท่วมใหญ่(2485)** เกิดความเสียหายมหาศาล แต่ในระยะยาวกลายเป็นพลังบันดาลให้ชุมชนหาทางเลือกเพื่อป้องกันน้ำท่วมได้ ซึ่งในที่สุดก็เกิดทางเลือกใหม่ในการประกอบอาชีพคือการทำไร่นาสวนผสมบ้าง การปรับเปลี่ยนที่นามาเป็นที่สวนบ้าง โดยดูแบบอย่างจากชุมชนริมแม่น้ำท่าจีน ปัจจุบันการทำไร่นาสวนผสมหรือการทำสวนเป็นอาชีพหลักกลับเพิ่มผลผลิตต่อไร่แก่ผู้ทำการเกษตรในชุมชนได้ดี ผลต่อเนื่องมาจากน้ำท่วมอีกประการ**คือการขุดคลองซอยเพื่อสัญจรและควบคุมน้ำในพื้นที่เกิดขึ้น**หลายสาย คลองเหล่านั้นสามารถควบคุมน้ำได้อย่างมีประสิทธิภาพ พื้นที่ที่เคยให้ผลผลิตข้าวน้อยกลับได้ผลผลิตดี และสามารถนำผลผลิตจากท้องนาสู่ตลาดได้โดยตรง ซึ่งคลองซอยต่างๆ เหล่านี้กลายมาเป็นรากฐานสำคัญของชุมชนมาถึงปัจจุบัน ทั้งในแง่ของการใช้น้ำ การสัญจร การระบายน้ำทิ้งและการรักษาสิ่งแวดล้อม ในยุคนี้จึงเป็นยุคทองสมัยแรกๆ ของพื้นที่อย่างแท้จริง อย่างไรก็ตาม **เหตุการณ์การปล้นสถานีรถไฟศาลายา**(2490) กลับเป็นพลังที่ทำลายภาพพจน์ทางเศรษฐกิจชุมชนมาเป็นเวลานาน คำกล่าวที่ว่า **"พื้นที่บริเวณนี้คือดงเสือหรือชุมทางโจร"** ยังคงติดปากมาจนปัจจุบัน ทำให้มีผลต่อการลงทุน เกิดซบเซาทางเศรษฐกิจ พื้นที่เหมือนกับถูกปิดหรือพื้นที่ตาบอดอยู่ช่วงเวลาหนึ่ง ต่อเมื่อเกิดการก่อสร้างพุทธมณฑล (2497) จึงเป็นเสมือนกับการลงรากฐานความเชื่อมั่นในทางเศรษฐกิจในพื้นที่ขึ้นใหม่ การตัดถนนพุทธมณฑลสาย 4 (2498) ตามหลังการอนุมัติสร้างพุทธมณฑลจึงสร้างทางเลือกในการลงทุนได้มากขึ้น เหตุการณ์ดังกล่าวนี้เป็นพลังเปลี่ยนแปลงความคิดในทางเศรษฐกิจชุมชนอย่างหน้ามือเป็นหลังมือ เศรษฐกิจชุมชนกลับถูกกำหนดหรือถูกกระทำโดยคนนอกชุมชนมากขึ้น แม้ว่าในทางการผลิตพุทธมณฑลไม่ได้เพิ่มผลผลิตขึ้นแต่อย่างใด ตรงกันข้ามกลับสูญเสียพื้นที่ไป แต่กลับเพิ่มคุณค่าและมูลค่าทางเศรษฐกิจแก่ผลผลิตมากขึ้น ราคาที่ดินสูงขึ้นหลายเท่าตัว ถนนพุทธมณฑลสายสี่ทำให้สามารถนำผลผลิตส่งตลาดได้รวดเร็ว

ที่สำคัญคือ **การตั้งโรงเรียนบ้านคลองโยง (2500) การสร้างสถานีเครื่องส่งวิทยุ100กิโลวัตต์(เอเอ็ม)ศาลายา (2508) การสร้างหน่วยสื่อสารกรมตำรวจ (2510) การสร้างวัดเทพนิมิตร(2511)และวัดมงคลประชาราม (2514) เป็นกลุ่มองค์กร**ที่เกิดจากพลังทางประวัติศาสตร์ท้องถิ่นที่เกิดขึ้นในพื้นที่ก่อนนี้แล้ว เช่น การจับจองพื้นที่ของพระบาทสมเด็จพระจอมเกล้าเจ้าอยู่หัวที่เกื้อกูลให้หน่วยงานเหล่านี้มีพื้นที่รองรับความคิดในการจัดตั้งหน่วยงานหรือขยับขยายหน่วยงานขึ้น ในทางเศรษฐกิจก่อให้เกิดการสร้างงาน และการกระจายรายได้เกิดขึ้นด้วย **เมื่อมีการก่อสร้างมหาวิทยาลัยมหิดล ณ ศาลายา** (2514) เป็นการเพิ่มฐานความเชื่อมั่นทางเศรษฐกิจแก่ชุมชนมากขึ้น การเปลี่ยนแปลงต่างๆ ทางเศรษฐกิจจึงก้าวกระโดดอย่างรวดเร็ว แต่เป็นที่น่าสังเกตว่าภาวะเศรษฐกิจของชุมชนที่เปลี่ยนแปลงส่วนใหญ่ตกอยู่ในมือของผู้คนที่เพิ่งอพยพเข้ามาอยู่ในชุมชน ส่วนผู้ที่อยู่มาแต่เดิมก็อยู่ในฐานะผู้ส่งเสริมสนับสนุน เช่น ขายที่หรือดูแลผลประโยชน์ให้ ผลประโยชน์ทางเศรษฐกิจจึงไหลออกนอกชุมชนมากกว่าจะอยู่กับชุมชนจะมีบ้างก็เป็นการสงเคราะห์ เช่น **กรณีการตั้งโรงเรียนบุญยศรีสวัสดิ์** (2515) นายทุนท่านหนึ่งบริจาคเงินสร้างขึ้น อย่างไรก็ตาม เหตุการณ์**การสร้างทางสายศาลายา-บางภาษี และศาลายา-นครชัยศรี** (2514) นับเป็นความพยายามของคนในท้องถิ่นที่จะพัฒนาโครงสร้างพื้นฐานทางเศรษฐกิจของชุมชนอย่างแท้จริง ซึ่งเหตุการณ์ดังกล่าวนี้เกิดคุณูปการต่อชุมชนในปัจจุบันและอนาคตอย่างประเมินค่าไม่ได้ การเสียสละที่ดินเพื่อสร้างถนน การใช้คุณความดีขอพื้นที่สร้างถนน เป็นสิ่งที่ทำได้ยากในปัจจุบัน และถ้าไม่มีถนนดังกล่าวมูลค่าและคุณค่าทางเศรษฐกิจของผลผลิตในชุมชนยังต่ำอยู่ ต่อมาเมื่อสร้างสหกรณ์เพื่อการเกษตร(สปก.)(2521) เป็นการสร้างความมั่นคงแก่เกษตรกรผู้ไม่มีที่ดินทำกินเป็นของตนเองซึ่งเป็นผู้เช่าพื้นที่ทำกินสืบมาแต่เดิมให้อยู่ในฐานะมั่นคงขึ้น มีรายได้มากขึ้น และเมื่อมี**การตัดถนนสายปิ่นกล้า-นครชัยศรี** (2521) ทำให้ภาวะทางเศรษฐกิจของชุมชนก้าวกระโดดและเปลี่ยนมืออย่างรวดเร็ว นักธุรกิจในกรุงเทพมหานครต่างก็เข้ามาลงทุนในกิจการต่างๆ ในพื้นที่มากขึ้น เกิดหมู่บ้านจัดสรร เกิดโรงงานอุตสาหกรรม เกิดสถานบริการต่างๆ ที่สำคัญคือการจัดตั้งหน่วยงานภาครัฐและภาคเอกชนขึ้นในชุมชน เช่น โรงเรียนรัตนโกสินทร์สมโภชน์บวรนิเวศศาลายาในพระสังฆราชูปถัมภ์(2525) หน่วยงานของกรมศิลปากร กระทรวงศึกษาธิการ(2526) มูลนิธิอุบลรังสีจุฬามณี (2530) สำนักสงฆ์หทัยนเรศวร์(2530) โรงงานอุตสาหกรรม เป็นต้น ในทางเศรษฐกิจหน่วยงานเหล่านี้เป็นทั้งหน่วยผลิตและหน่วยบริโภคที่สำคัญ ก่อให้เกิดการผลิต นำไปสู่การสร้างงาน การสร้างแลกเปลี่ยนสินค้าขึ้นในพื้นที่ เป็นผลให้เศรษฐกิจของชุมชนท้องถิ่นขยายตัวขึ้นอย่างรวดเร็ว การดำเนินงานมีความสลับซับซ้อนเพิ่มขึ้น มีรายได้จากภาษีอากรมากขึ้น ชุมชนใหม่มีความต้องการบริการจากรัฐที่รวดเร็วประหยัดมากขึ้น ในที่สุดจึงนำมาสู่การประกาศจัดตั้งกิ่งอำเภอพุทธมณฑล (2533) และเหตุการณ์ต่างๆ ดังต่อไปนี้ เช่น สร้างโรงเรียนมหิดลวิทยานุสรณ์(2533) การประกาศจัดตั้งสุขาภิบาลศาลายา(2534) สถาบันวิชาการทหารเรือชั้นสูง(2537) ตั้งสถาบันเทคโนโลยีราชมงคล ศาลายา (2538) ตั้งองค์การบริหารส่วนตำบล (2537) ตั้งโรงพยาบาลพุทธ

มณฑล(2537) ตั้งโรงพยาบาลศาลายา(2537) ตั้งโรงพยาบาลตุลาการเฉลิมพระเกียรติ (2537) ตั้งสถานฝึกอบรมเด็กและเยาวชนสิรินทร(2537) ตั้งโรงเรียนกาญจนาภิเษกวิทยาลัยนครปฐม(พระตำหนักสวนกุหลาบมัธยม) (2538) ยกฐานะกิ่งอำเภอพุทธมณฑลขึ้นเป็นอำเภอ(2539) โรงพิมพ์มูลนิธิมหามกุฏราชวิทยาลัย (2540) ตั้งโรงเรียนพระตำหนักสวนกุหลาบมหา(2540) ตั้งวิทยาลัยการอาชีพพุทธ (2540) ประกาศยกฐานะสุขาภิบาลขึ้นเป็นเทศบาลตำบล (2542) สิ่งเหล่านี้คือพลังสำคัญทางเศรษฐกิจ ทั้งในแง่ของการผลิต การบริโภค การแจกจ่าย การแลกเปลี่ยน และเงื่อนไขอื่นๆ แก่ท้องถิ่นเป็นต้นว่า โรงเรียนมหิดลวิทยานุสรณ์ มีนักเรียนเป็นจำนวนมาก เป็นตัวเร่งให้เกิดการลงทุนมากขึ้น เช่น ทำให้เกิดหอพัก เกิดร้านค้า เกิดสถานบริการซักรีด เป็นต้น

เหตุการณ์ที่เกิดขึ้นในท้องถิ่นดูผิวเผินจึงไม่เห็นว่ามีความสำคัญนักแต่ถ้าพิจารณาอย่างรอบคอบจะเห็นว่ามีพลังอย่างมหาศาล หากชุมชนท้องถิ่นพุทธมณฑลไม่มีเหตุการณ์ต่างๆ ดังกล่าวข้างต้น สถานภาพทางเศรษฐกิจของชุมชนก็จะไม่เป็นเช่นในปัจจุบัน หากไม่มีพื้นที่เป็นที่ทรัพย์สินส่วนพระมหากษัตริย์ไว้เป็นฐานคิดในการสร้างพุทธมณฑลก็ดี สร้างมหาวิทยาลัยมหิดลก็ดี หรือหากพระบาทสมเด็จพระจอมเกล้าเจ้าอยู่หัวไม่เสด็จพระราชดำเนินไปนมัสการองค์ปฐมเจดีย์ก็ดีหรือหากไม่มีองค์ปฐมเจดีย์ก็ดีจะเป็นการตัดเหตุผลที่เป็นอิทัปปัจจยตาในทางเศรษฐกิจให้ขาดลง กล่าวคืออาจจะไม่มีคลองมหาสวัสดิ์ ไม่มีทางรถไฟ ไม่มีถนนสายปิ่นเกล้า-นครชัยศรี ไม่มีมหาวิทยาลัยมหิดล ไม่มีพุทธมณฑลเกิดขึ้นในพื้นที่พุทธมณฑลปัจจุบันก็ได้ พลังทางเศรษฐกิจที่เป็นอยู่ในปัจจุบันจึงเนื่องมาจากพลังทางประวัติศาสตร์ของท้องถิ่นทั้งที่เกี่ยวข้องโดยตรงและโดยอ้อม

3.5.2 ด้านสังคมของชุมชน

จากการศึกษาเหตุการณ์ต่างๆ ข้างต้นพบว่าแต่ละเหตุการณ์เป็นพลังต่อพัฒนาการทางสังคมที่แตกต่างกัน ทั้งนี้เพราะเหตุการณ์ทางประวัติศาสตร์ดังกล่าวบางส่วนก็เป็นสิ่งที่เกิดขึ้นเกี่ยวข้องกับชุมชนในพื้นที่โดยตรง และหลายเหตุการณ์เกิดขึ้นเกี่ยวข้องทางสังคมของชุมชนโดยอ้อม ซึ่งในกรณีดังกล่าวนี้จะเป็นพลังที่แตกต่างกัน อย่างไรก็ตามเมื่อพิจารณาเหตุการณ์แต่ละประการณ์หรือแต่ละกลุ่มแล้วพบลักษณะต่างๆ ดังต่อไปนี้

การเกิดอาณาจักรสุวรรณภูมิ(พ.ศ.300–1100) ก็ดี การเกิดอาณาจักรทวาราวดี(พ.ศ.1100–1600)ก็ดี ทั้งสองเหตุการณ์นี้จัดเป็นพลังเกียรติยศและศักดิ์ศรี ของผู้คนในสังคมที่สืบทอดต่อมาในปัจจุบัน เป็นเหตุการณ์ที่หล่อหลอมพื้นฐานความเป็นอันหนึ่งอันเดียวกันของคนในสังคม ยิ่งมีเหตุการณ์การสร้างเมืองนครชัยศรีในสมัยกรุงศรีอยุธยา(พ.ศ.2092)สืบเนื่องให้เห็นพัฒนาการด้วยแล้ว เท่ากับยิ่งเพิ่มพลังความรักความหวงแหนในท้องถิ่นมากขึ้น คนที่อาศัยอยู่ในพื้นที่อำเภอพุทธมณฑลที่จดจำเหตุการณ์ดังกล่าวได้จึงมีความภาคภูมิใจเป็นอย่างยิ่ง ยิ่งมีเหตุการณ์การอพยพของคนจีนเข้าประเทศไทย(พ.ศ.2300 – 2385) ด้วยแล้ว เป็นการยืนยันให้เห็นถึงความโดดเด่นของอารยธรรมที่มีอยู่ก่อนมากขึ้น บางคนกล่าวว่าการได้เป็นทายาทสืบสานมรดกอารยธรรมเก่า

แก่เหล่านี้ ทั้งโดยการเข้ามาอาศัยหรือเกิดมาในดินแดนแห่งนี้ ถือเป็นเกียรติประวัติที่สำคัญยิ่งของชีวิตและวงศ์ตระกูล

ส่วนการเกิดคลองโยง คือ การเกิดเส้นทางเชื่อมสังคมพื้นที่ลุ่มน้ำท่าจีนกับลุ่มน้ำเจ้าพระยาให้ถึงกัน เป็นเส้นทางการถ่ายโอนอำนาจทางสังคม เช่น อำนาจทางการเมืองการปกครอง อำนาจทางการทหาร โดยเฉพาะอย่างยิ่ง*การออกผนวชของเจ้าฟ้าชายมงกุฎ(พ.ศ.2367-2394) การเสด็จเสวยราชย์ของรัชกาลที่ 4(พ.ศ. 2394 –2511) การเสด็จนมัสการองค์พระปฐมเจดีย์ของรัชกาลที่ 4* เหตุการณ์เหล่านี้เชื่อมต่อกับอำนาจทางการเมืองการปกครองอย่างชัดเจน ดังจะเห็นได้ว่านับตั้งแต่รัชกาลที่ 4 เป็นต้นมาจนกระทั่งถึงรัชกาลที่ 6 เมืองนครปฐมเจริญก้าวหน้าอย่างรวดเร็ว เรื่องราวขององค์พระปฐมเจดีย์ก็ดี องค์พระประโทณเจดีย์ก็ดี ล้วนเป็นพลังพื้นฐานทางการเมืองการปกครองทั้งสิ้น *โดยเฉพาะอย่างยิ่งพลังของชาวพุทธที่ทุ่มเทและเชื่อมั่นในผู้นำที่ผ่านการศึกษาธรรมะมาอย่างแตกฉาน* พื้นที่และเส้นทางอำเภอพุทธมณฑลจึงเป็นเสมือนเส้นทางเชื่อมอำนาจทางศาสนจักรกับอาณาจักรเข้าด้วยกัน การที่สุนทรภู่เดินทางไปนมัสการองค์พระปฐมเจดีย์(พ.ศ.2385) และองค์พระแท่นดงรัง แสดงให้เห็นถึงทิศทางของอำนาจหรือกระแสของอำนาจทางการเมืองการปกครองที่ดึงดูดเอาผู้คนในเมืองหลวงให้ดำเนินไปตาม การขุดคลองมหาสวัสดิ์(พ.ศ. 2400-2403) เป็นอีกเหตุการณ์หนึ่งที่แสดงความสัมพันธ์ทางสังคมระหว่างพุทธจักรกับอาณาจักรและกลายเป็นพลังที่เกื้อกูลสิ่งอื่นๆ สืบต่อมา เช่น การเกิดวัด ชุมชน โรงเรียน เป็นสถาบันทางสังคมขึ้นในชุมชน ยิ่งเหตุการณ์การจับจองที่ดินสองฝั่งคลองมหาสวัสดิ์ด้วยแล้วยิ่งเป็นพลังทางสังคมที่ซับซ้อนมากขึ้น ทำให้เกิดชุมชนใหม่ มีทั้งเช่าที่อยู่อาศัยและอยู่อาศัยบนพื้นที่ตนเอง เกิดตำแหน่งผู้ดูแลผลประโยชน์ในพื้นที่ที่มีอำนาจมากเนื่องจากมีความสนิทสนมกับเจ้าของที่ดินที่ซึ่งเป็นเจ้านาย นายกองบางคนมีอำนาจสามารถสร้างคอกไว้ใต้ถุนบ้านสำหรับขังคนที่ตนเห็นว่าผิดได้ อนึ่ง การเกิดชุมชนวัดสุวรรณารามก็ดี ชุมชนวัดมะเกลือก็ดี ชุมชนคลองโยงก็ดี และชุมชนศาลายาก็ดี เท่ากับเป็นการเพิ่มผู้นำทางสังคมขึ้น มีผู้อาวุโส มีขุน มีกำนัน ผู้ใหญ่บ้าน มีลูกบ้าน มีผู้ช่วยผู้ใหญ่บ้านตามโครงสร้างทางสังคมของชุมชนทั่วไป และผู้นำเหล่านั้นก็มีหน้าที่ในการปฏิบัติต่อสังคมที่ชัดเจน ยิ่งมีการสร้างวัดสุวรรณารามก็ดี วัดมะเกลือก็ดี วัดสาละวันก็ดี เป็นการเพิ่มผู้นำให้แก่ชุมชนให้ได้ช่วยกันทำหน้าที่สร้างสรรค์ความเข้มแข็งแก่ชุมชนมากขึ้น ซึ่งสิ่งเหล่านี้กลายเป็นพลังที่สร้างสรรค์สังคมสืบต่อมาถึงปัจจุบัน การที่มหาฤกษ์เดินทางไปนมัสการองค์พระปฐมเจดีย์แล้วได้บันทึกสภาพต่างๆ ของชุมชนไว้ถือเป็นโอกาสทางสังคมที่สำคัญยิ่งที่คนรุ่นปัจจุบันได้รับทราบความเป็นไปในอดีต เป็นปัจจัยสำคัญที่เสริมสร้างความภาคภูมิใจที่เป็นชุมชนมีประวัติความเป็นมายาวนาน มีประวัติศาสตร์ให้สังคมได้รับทราบ

การขุดคลองทวีวัฒนา(พ.ศ.2421)และ**การสร้างทางรถไฟสายใต้**(พ.ศ.2440) เป็นอีกเหตุการณ์ที่แสดงให้เห็นเครือข่ายทางสังคมของชุมชนและอำนาจรัฐที่เข้ามาในท้องถิ่น การตั้งถิ่นฐานก็ดี ประชากรก็ดี เริ่มมีความสลับซับซ้อนมากขึ้น รัฐเข้ามาจัดการมากขึ้น

เส้นทางทั้งสองสายจึงเป็นพลังให้ชุมชนเปิดตัวเองติดต่อกับชุมชนภายนอกมากขึ้น จะเห็นได้ว่าในการตั้งโรงเรียนก็ดี การตัดคูคลองถนนหนทางก็ดี เริ่มจะต้องประสานกับหน่วยราชการเพื่อความถูกต้องตามกฎหมาย คลองซอยที่เชื่อมคลองมหาสวัสดิ์กับคลองโยงบางสายต้องขออนุญาตจากกรมชลประทานจึงจะขุดได้ อำนาจรัฐเข้ามามีส่วนกับชุมชนมากขึ้น มาถึงสมัยการเปลี่ยนแปลงการเมืองการปกครอง(พ.ศ.2475) อำนาจทางสังคมของคนบางกลุ่มที่เคยสนิทกับเจ้าของที่ดินกลับลดถอยลงตามอำนาจของเจ้าของที่ดิน สามัญชนทั่วไปเริ่มมีอำนาจมากขึ้น โดยเฉพาะอย่างยิ่งผู้ที่มีเงินให้กู้ สามารถรับซื้อที่ดินมาเป็นของตนเองได้ ซึ่งกลายมาเป็นคุณูปการอันใหญ่หลวงแก่ลูกหลานในปัจจุบัน ลูกหลานบางคนขายที่ได้เงินจำนวนมากก็นำเงินส่วนหนึ่งไปถวายวัด ทำบุญอุทิศให้แก่บรรพบุรุษผู้ซื้อกรรมสิทธิ์ในที่ดินเหล่านั้นไว้ วัดหลายวัดได้รับอานิสงส์ ในทำนองดังกล่าว การตั้งโรงเรียนวัดมะเกลือ(พ.ศ.2476) โรงเรียนวัดสุวรรณาราม(ดีราษฎร์รังสฤษดิ์)(พ.ศ.2477) โรงเรียนวัดสาละวัน(พ.ศ.2477)และโรงเรียนบ้านคลองมหาสวัสดิ์(พ.ศ.2481)คือพัฒนาการของสถาบันการศึกษาของชุมชนที่เป็นพลังสร้างสรรค์สติปัญญาแก่ผู้คนในชุมชนสืบมาถึงปัจจุบัน

กรณีเกิดน้ำท่วมใหญ่ปี พ.ศ.2485 เป็นเหตุการณ์ที่สอนให้ชุมชนต้องคิดพึ่งตนเองและไม่ประมาท ซึ่งผลจากน้ำท่วมแม้ว่าทางเศรษฐกิจจะเสียหายเป็นจำนวนมาก แต่ทางสังคมกลับเกิดพลังที่สร้างสรรค์ขึ้นหลายประการ เช่นเกิดทางเลือกในการประกอบอาชีพ เช่น มีการทำสวนขึ้นในพื้นที่ เกิดเครือข่ายความร่วมมือทางสังคมระหว่างชุมชนและราชการขึ้น ชาวบ้านหลายคนออกเงินส่วนตัวขุดคลองสัญจร หลายคนออกแรงงาน และหลายคนมอบพื้นที่ขุดคลองเป็นความร่วมมือทางสังคมของชุมชนที่สำคัญ อย่างไรก็ตามปัญหาสังคมหลายอย่างก็มีอยู่ เช่น การปล้นสถานีรถไฟศาลายา(พ.ศ.2490) แต่เหตุการณ์นี้ก็ได้แสดงให้เห็นบทบาทอำนาจรัฐว่าดูแลไม่ทั่วถึง นิยมใช้ความรุนแรงแก้ปัญหา โดยอาศัยระบบอุปถัมภ์เป็นเครื่องมือและเกราะคุ้มกัน และแม้ว่ารัฐและประชาชนได้ร่วมมือกัน ตั้งโรงเรียนคลองสว่างอารมณ์ (พ.ศ.2492) ขึ้นในชุมชนเพิ่มขึ้น แต่ภาพความเป็น"ชุมชนโจร"อันเนื่องมาจากการละเลยของรัฐก็ยังมีอยู่ จนกระทั่งมีการก่อสร้างพุทธมณฑล(พ.ศ.2497) และตัดถนนพุทธมณฑลสาย 4 ขึ้น ภาพชุมชนโจรเริ่มจางไป พุทธมณฑลได้สร้างภาพพจน์ใหม่ให้พื้นที่อย่างดียิ่ง แต่อย่างไรก็ดีอบายมุขยังคงมีอยู่ในบางพื้นที่

อนึ่ง **การสร้างโรงเรียนบ้านคลองโยงก็ดี** (พ.ศ.2500) การสร้างสถานีเครื่องส่งวิทยุ100กิโลวัตต์(เอเอ็ม)ศาลายา(พ.ศ.2508)ก็ดีการสร้างหน่วยสื่อสารกรมตำรวจ (พ.ศ.2510) ก็ดี การสร้างวัดเทพนิมิตร(พ.ศ.2511) และวัดมงคลประชาราม (พ.ศ. 2514) ก็ดี เหตุการณ์เหล่านี้แสดงให้เห็นพลังทางสังคมของผู้นำชุมชน และพลังของพุทธศาสนาที่เกิดขึ้นในชุมชนอย่างการบริจาคที่ดินสร้างวัดนับสิบไร่ ต้องมีศรัทธาอย่างแรงกล้าในพระพุทธศาสนา และมีความพอใจกับผู้ประสานงานให้เกิดการบริจาคเป็นอย่างยิ่ง เหตุการณ์จึงเกิดขึ้นได้ เหตุการณ์เหล่านี้ส่งผลให้ชุมชนปัจจุบันมีวัด มีโรงเรียน มีผู้นำวัด ผู้นำโรงเรียน หรือกล่าวง่ายๆ ทำให้เกิดผู้นำทางสังคมขึ้นอีกหลายคน ทั้งสถานที่ บุคคล สถาบันทางสังคมเหล่านั้นคือพลังสำคัญของชุมชนในปัจจุบัน

การก่อสร้างมหาวิทยาลัยมหิดล ณ ศาลายา(พ.ศ.2514) เป็นการยกฐานะทางสังคมของพื้นที่อำเภอพุทธมณฑลให้สูงยิ่งขึ้นจากเดิม รวมถึงการเข้ามาของสถาบันการศึกษาอื่นๆ ในระยะหลังๆ จึงทำให้ดูเหมือนว่าชุมชนพื้นที่อำเภอพุทธมณฑลถูกสถาปนาทางสังคมให้สูงขึ้นโดยอัตโนมัติ พลังของสถาบันการศึกษาดังกล่าวผลักดันให้ชุมชนเปลี่ยนแปลงไปอย่างรวดเร็วจากสังคมเกษตรกรรมมาเป็นสังคมผสมผสานหรือผสมปนเปจนยากที่จะควบคุมทิศทางการเจริญเติบโต มาตรการทางสังคมหลายอย่างตามไม่ทัน เกิดช่องว่างทางกฎหมายโดยเฉพาะอย่างยิ่งปัญหาความเป็นเมืองในพื้นที่ชนบท เช่น ความสัมพันธ์ทางสังคมแบบเมือง ขณะที่ลักษณะทางกายภาพของพื้นที่เป็นแบบชนบท สิ่งเหล่านี้เป็นพลังสำคัญที่นำไปสู่การสร้างกฎเกณฑ์ทางสังคมใหม่ๆ ขึ้นและทำให้ชุมชนต้องปรับตัวในหลายด้าน

การสร้างทางสายศาลายา-บางภาษี และศาลายา-นครชัยศรี(พ.ศ.2514) ช่วยแก้ปัญหาทางสังคมได้บ้างแต่ก็นำปัญหาใหม่เข้ามาด้วย เช่นค่าใช้จ่ายเพิ่มขึ้น การสร้างสหกรณ์เพื่อการเกษตร(สปก.)(พ.ศ.2521) ช่วยขจัดปัญหาความยากจนได้บ้าง ส่วนการตัดถนนสายปิ่นกล้า-นครชัยศรี (พ.ศ.2521) ทำให้เกิดช่องว่างระหว่างสังคมมากขึ้น ถนนนำพลังสร้างสรรค์ความเจริญมาสู่ชุมชนพอๆ กับพลังทำลายชุมชน ชาวบ้านส่วนหนึ่งที่ไม่มีที่ทำกิน เคยเช่าพื้นที่ทำกิน เมื่อถนนเข้ามาราคาที่ดินสูงขึ้นเจ้าของที่ดินขายที่ เจ้าของใหม่มาซื้อ เปลี่ยนสภาพการใช้ประโยชน์พื้นที่เป็นอย่างอื่น คนที่เคยอาศัยอยู่ที่นั้นก็ต้องไร้ที่อยู่ พื้นที่ที่เคยเลี้ยงควายหมดไป บางแห่งก็ปล่อยให้รกร้างแต่ห้ามคนเอาควายไปเลี้ยง ชุมชนที่เคยให้ความสำคัญกับคลองก็แปรเปลี่ยนมาเป็นถนนหนทาง

ปัจจุบันถนนยังนำพาคนแปลกหน้าเข้าสู่ชุมชนอยู่ทุกเมื่อเชื่อวัน โรงเรียนรัตนโกสินทร์สมโภชน์บวรนิเวศศาลายา ในพระสังฆราชูปถัมภ์ (พ.ศ.2525) เป็นสถานที่เดียวที่ลูกหลานของคนในชุมชนได้เข้าไปใช้บริการได้มาก แต่หน่วยงานอื่นๆ ทั้งของภาครัฐและเอกชนต่างก็มุ่งทำงานเพื่อชาติทั้งสิ้น บุคลากรส่วนใหญ่มาเช้าเย็นกลับ น้อยคนนักจักรู้ถึงสุขทุกข์ของคนในชุมชน หน่วยงานเหล่านี้ไม่ภาระหน้าที่ช่วยเหลือชุมชน การเปลี่ยนแปลงที่เกิดขึ้นจึงเป็นไปอย่างไร้ระเบียบ ทำให้เกิดความยุ่งยากแก่ชุมชนมากมาย ***ปัจจุบันชุมชนเดิมกำลังจะกลายเป็นชนกลุ่มน้อยในเรื่องต่างๆ ของท้องถิ่นแล้ว เช่น การเก็บภาษีรายได้ จำนวนประชากร การถือครองพื้นที่ เป็นต้น ภาพของชุมชนเดิมกำลังให้ความรู้สึกเป็นแหล่งเสื่อมโทรมตามกาลเวลาที่ผ่านไปและตามภาวะลักษณะรูปทรงสัณฐานของสิ่งปลูกสร้างที่เกิดขึ้นใหม่ด้วย***

องค์กรชุมชน เช่น องค์การบริหารส่วนตำบล(พ.ศ.2537)โรงพยาบาลพุทธมณฑล(พ.ศ. 2537) อำเภอพุทธมณฑล(พ.ศ. 2539) เทศบาลตำบลศาลายา(พ.ศ. 2542) ไม่ได้อาศัยพลังทางประวัติศาสตร์ท้องถิ่นมาเสริมสร้างความเข้มแข็งมั่นคงมากนัก ทั้งๆ ที่องค์กรเหล่านี้คือผลการแสดงออกของประวัติศาสตร์เหล่านั้น

3.5.3 ด้านวัฒนธรรมของชุมชน

ในอดีตพลังประวัติศาสตร์ท้องถิ่นเข้ามาเป็นรากฐานด้านวัฒนธรรมของชุมชนในเรื่องต่างๆ เช่น ภูมิปัญญา เงื่อนไขหรือแรงจูงใจ แบบแผนพฤติกรรม และองค์วัตถุต่างๆ อย่างเด่นชัด เช่น ความคิด ความเชื่อ เกี่ยวกับเรื่องต่างๆ ในชีวิตมักเกี่ยวข้องอยู่กับพุทธศาสนาเป็นหลัก แม้จะมีความเชื่อเรื่องอื่นๆ แต่ไม่สำคัญเท่ากับเรื่องของพระพุทธศาสนา ในครอบครัวหนึ่งๆ แม้จะมีศาลเจ้าที่ ศาลพระภูมิแล้วก็ตาม แต่บนบ้านเรือนจะต้องมีพระพุทธรูปบูชา การประกอบพิธีกรรมต่างๆ จะต้องมีพระพุทธพระธรรม พระสงฆ์เป็นสิ่งศักดิ์สิทธิ์สูงสุด

ปัจจุบัน เป็นที่น่าเสียดายว่า จากการที่ธรรมชาติทางวัฒนธรรมต้องมีการเปลี่ยนแปลงไปเป็นธรรมดา ทำให้ภูมิปัญญาเหล่านี้ เปลี่ยนแปลงสูญหายไปจากชุมชนปัจจุบันมากแล้ว เป็นต้นว่า ความคิด ความรู้ หรือองค์ความรู้ ความเชื่อ ความนิยม หรือค่านิยม ความเห็น หรือ ความคิดเห็น ไม่ได้ตั้งอยู่บนรากฐานของประวัติศาสตร์ท้องถิ่นมากนัก ยิ่งเป็นเหตุการณ์ที่เกิดขึ้นไกลตัวก็ยิ่งจางไป เหตุการณ์ที่เกิดขึ้นใกล้ตัวก็ยังพอมีพลังบ้าง เช่นการสร้างพุทธมณฑล การสร้างมหาวิทยาลัยมหิดล เป็นต้น

ด้าน **เงื่อนไขหรือแรงจูงใจ** ในอดีตเหตุการณ์ที่เป็นประวัติศาสตร์ท้องถิ่นดังกล่าวข้างต้นไเข้าไปเป็นเงื่อนไขหรือแรงจูงใจที่จะกระตุ้นให้เกิดพฤติกรรมต่างๆ ที่พึงประสงค์ของบุคคล ครอบครัวและสังคม แต่ปัจจุบันสิ่งเหล่านี้อ่อนพลังไปมากแล้ว ในชุมชนปัจจุบัน **ไม่มีแบบแผนธรรมเนียมประเพณีใดๆ** ที่เกี่ยวกับอาณาจักรสุวรรณภูมิ อาณาจักรทวาราวดี เมืองนครชัยศรี คลองมหาสวัสดิ์ คลองทวีวัฒนา คลองโยง พระบาทสมเด็จพระจอมเกล้าเจ้าอยู่หัว องค์พระปฐมเจดีย์ พุทธมณฑล ฯลฯ แม้แต่การสร้างวัตถุบูชาหรือเหรียญที่ระลึกถึงก็ไม่ปรากฏ จะมีก็เป็นธรรมเนียมประเพณีที่เนื่องด้วยศาสนาหรือความเชื่อในท้องถิ่น เช่น งานประจำปีวัดสุวรรณาราม ช่วงเดือนเมษายน งานประจำปีวัดมะเกลือ ปิดทองหลวงพ่อสิทธัตถะ เดือนเมษายน งานประจำปีวัดมงคลประชาราม เดือนเมษายน งานประจำปีวัดสาละวัน เดือนเมษายน เท่านั้น

โดยสรุปประวัติศาสตร์ท้องถิ่นแม้ว่าจะเกิดคุณูปการต่อชุมชนต่างๆ ในพื้นที่มากมายก็ตาม หรือต่อชุมชนและองค์กรต่างๆ ที่เข้ามาอยู่ใหม่ก็ตาม แต่เขาเหล่านั้นก็ไม่ได้แสดงอะไรว่าได้กตัญญูกตเวทีต่อสิ่งเหล่านั้น เช่น ถ้ารัชกาลที่ 4 ไม่ทรงจับจองพื้นที่บริเวณนี้ไว้แต่แรก วันนี้ก็ไม่น่าจะมีองค์กรต่างๆ หลายองค์กรในบริเวณนี้ รวมทั้งพุทธมณฑลด้วย พลังทางประวัติศาสตร์เหล่านั้นแม้ยังคงส่งผลต่อชุมชนในท้องถิ่นแต่ก็ไม่ได้สร้างสรรค์วัฒนธรรมชุมชนมากนัก และดูเหมือนชุมชนปัจจุบันกำลังแสดงออกในทางตรงกันข้ามด้วย

3.5.4 ด้านสิ่งแวดล้อมและทรัพยากรของชุมชน

พฤติกรรมด้านสิ่งแวดล้อมและทรัพยากรทั้งในด้านการใช้ประโยชน์ การบำรุงรักษา และการอนุรักษ์และพัฒนา ซึ่งเป็นผลพวงมาจากระบบวัฒนธรรมในอดีต ได้รับอิทธิพลหรือพลังของประวัติศาสตร์ท้องถิ่นเข้ามาเกี่ยวข้อง เป็นต้นว่า การดูแลรักษา การใช้ประโยชน์ สิ่งแวดล้อมและทรัพยากรเป็นไปอย่างเคารพ ปัจจุบันเมื่อเกิดการเปลี่ยนแปลงใน

กรรมสิทธิที่ดิน สิ่งเหล่านี้ถูกกระทำในลักษณะต่างๆ ที่แสดงให้เห็นว่าเป็นการละเลยความสำคัญ เช่น ถมคลองบางคลอง ใช้คลองบางคลองเป็นที่ระบายน้ำเสียหรือทิ้งของเสีย ปล่อยให้คลองบางคลองตื้นเขินไม่ได้รับการขุดลอก ที่สำคัญยิ่งคือถมคลองสาธารณะมาเป็นที่ส่วนตัว

องค์กรและหน่วยงานต่างๆ ที่เข้ามาอยู่ในท้องถิ่นก็ไม่ได้แสดงอะไรให้เห็นว่าเข้าใจและตระหนักในความสำคัญอย่างจริงใจต่อสิ่งเหล่านั้น พฤติกรรมทางสิ่งแวดล้อมของแต่ละองค์กรในพื้นที่มุ่งหวังที่จะทำพื้นที่ในขอบเขตของตนเองให้ดี โดยไม่คำนึงถึงพื้นที่รอบข้าง พลังทางประวัติศาสตร์ท้องถิ่นจึงไม่สามารถขับเคลื่อนพฤติกรรมของชุมชนในท้องถิ่นในด้านนี้ให้เป็นที่พึงปรารถนาได้

4. อภิปรายผล

จากโจทย์การวิจัยที่กำหนดไว้ว่า นับตั้งแต่ชุมชนในท้องถิ่นอำเภอพุทธมณฑลปรากฏชัดเจนขึ้น

(1) มีเหตุการณ์สำคัญๆ ใดบ้าง ที่เกิดขึ้นเกี่ยวข้องกับท้องถิ่นอำเภอพุทธมณฑลทั้งโดยตรงและโดยอ้อมจนถือได้ว่าเป็นประวัติศาสตร์ท้องถิ่นของอำเภอพุทธมณฑล จังหวัดนครปฐม *พบว่า มีเหตุการณ์สำคัญต่างๆ มากมายที่เกิดขึ้นเป็นประวัติศาสตร์ท้องถิ่นอำเภอพุทธมณฑล ดังแสดงไว้ข้างต้น*

(2) ประวัติศาสตร์ท้องถิ่นเหล่านั้นเป็นพลังผลักดันหรือดึงดูหรือมีผลต่อพัฒนาการและการเปลี่ยนแปลงชุมชนด้านเศรษฐกิจ สังคม วัฒนธรรม สิ่งแวดล้อมและทรัพยากร อย่างไรบ้าง *ประเด็นนี้เมื่อพิจารณาตามแนวคิดและหลักการต่างๆ ของทฤษฎีต่างๆ ที่นำมากล่าวไว้ข้างต้น พบว่า พัฒนาการและการเปลี่ยนแปลงของชุมชนในพื้นที่นี้ได้รับคุณุปการจากพระพุทธศาสนา และสถาบันพระมหากษัตริย์ เป็นสำคัญ เริ่มต้นที่ท้องถิ่นหรือชุมชนถูกกระทำจากอิทธิพลของนวัตกรรม เทคโนโลยีและภูมิปัญญาตามกระแสการพัฒนาจากสังคมภายนอกชุมชน แล้วนำมาปรับเปลี่ยนเพื่อให้เกิดประโยชน์ขึ้น โดยพยายามสร้างเอกลักษณ์ของตนเองขึ้นท่ามกลางการเปลี่ยนแปลงบนกระแสของนวัตกรรมใหม่ จนกลายมาเป็นตัวตนของตนเอง*

ที่สำคัญคือการที่ชุมชนอำเภอพุทธมณฑลอยู่ระหว่างกรุงเทพมหานครกับเมืองนครปฐม ที่ซึ่งด้านหนึ่งมีอารยธรรมและประวัติศาสตร์ทางพุทธศาสนาและพระมหากษัตริย์และราชวงศ์ เป็นพลังพื้นฐาน ขณะที่อีกด้านหนึ่งมีอายรธรรมเมืองทั้งทางเศรษฐกิจ สังคมและวัฒนธรรมที่บูรณาการจากทั่วโลกเข้ามาครอบงำเป็นต้นแบบ บูรณาการที่เกิดขึ้นคือการพึ่งตนเองที่ต้องพึ่งคนอื่นมากขึ้น การเป็นตัวตนของตนเองที่เหมือนกับคนอื่นมากขึ้น เช่น การสร้างงานและรายได้ที่เกิดขึ้นต้องอาศัยผู้บริโภคและผลิตจากสังคมอื่นมากขึ้น แม้แต่ผู้ที่ประกอบการ ก็มาจากท้องถิ่นอื่น บุคลากรของหน่วยงานราชการมากกว่าร้อยละ 80 เป็นคนในพื้นที่อื่นๆ มาเช้าเย็นกลับ โรงงาน

อุตสาหกรรมทั้งหมดไม่ได้ใช้วัตถุดิบในพื้นที่ ชุมชนต้องรับนวัตกรรมต่างๆ ที่แพร่กระจายเข้ามาอยู่ตลอดเวลา ภูมิปัญญาเดิมในท้องถิ่นหดหายไป

อย่างไรก็ตามพัฒนาการและการเปลี่ยนแปลงของชุมชนอำเภอพุทธมณฑลที่เกิดขึ้นแม้ว่าเป็นผลมาจากพลังประวัติศาสตร์ท้องถิ่นทั้งโดยตรงและโดยอ้อมอย่างชัดเจน แต่ยังไม่มีกิจกรรมใดในชุมชนที่แสดงให้เห็นว่าชุมชนหรือท้องถิ่นสำนึกในคุณค่าความสำคัญในประวัติศาสตร์เหล่านั้น เรื่องราวต่างๆ ไม่ได้เล่าเรียนสืบสานในโรงเรียน ในชุมชน ในสำนักงานต่างๆ คนส่วนใหญ่ไม่มีความรู้ในประวัติศาสตร์เหล่านั้น

ประวัติศาสตร์ท้องถิ่นจึงยังไม่ถูกนำมาใช้เป็นเครื่องมือในการพัฒนาชุมชนในท้องถิ่นชุมชนอำเภอพุทธมณฑลแต่อย่างใด ความรัก ความภาคภูมิใจ ความหวงแหน ความผูกพันของผู้คนที่อาศัยอยู่ต่อชุมชนหรือท้องถิ่นจึงไม่ปรากฏ ความรับผิดชอบในเรื่องต่างๆ จึงถูกผลักดันให้เป็นของราชการ หรือองค์การที่เกี่ยวข้องในชุมชน ไม่ปรากฏสำนึกสาธารณะแต่อย่างใด

5. บทสรุปและข้อเสนอแนะ

บทสรุป

(1) มีเหตุการณ์ที่เกิดขึ้นจัดเป็นประวัติศาสตร์ท้องถิ่นอำเภอพุทธมณฑล จังหวัดนครปฐม หลายประการ แต่ประวัติศาสตร์เหล่านั้นยังไม่ถูกนำมาใช้เป็นเครื่องมือในการพัมนาชุมชนมากนัก คนในชุมชนไม่ได้สืบสานศึกษาเล่าเรียนแต่อย่างใด

(2) ประวัติศาสตร์ท้องถิ่นอำเภอพุทธมณฑล จังหวัดนครปฐม เป็นพลังสำคัญต่อพัฒนาการและการเปลี่ยนแปลงชุมชน ทั้งทางเศรษฐกิจ สังคม วัฒนธรรม ทรัพยากรและสิ่งแวดล้อม มาตั้งแต่อดีตจนกระทั่งปัจจุบัน จนสามารถกล่าวได้อย่างชัดเจนว่าหากปราศจากประวัติศาสตร์เหล่านั้น พื้นที่อำเภอพุทธมณฑลจะไม่เจริญก้าวหน้าอย่างปัจจุบัน

(3) ชุมชนและผู้ที่เกี่ยวข้องในพื้นที่ยังไม่เห็นคุณค่าความสำคัญของประวัติศาสตร์ของท้องถิ่นมากนัก ไม่ได้ให้ความสำคัญในสิ่งเหล่านั้น ไม่ได้พัฒนาสิ่งเหล่านั้น ไม่ได้กตัญญูกตเวทีต่อสิ่งเหล่านั้นอย่างชัดเจน ไม่มีแม้ลายลักษณ์บันทึกเรื่องราวเหล่านั้น ไม่มีรูปเคารพหรืออนุสาวรีย์ แห่งคุณความดีของประวัติศาสตร์เหล่านั้น

ข้อเสนอแนะ

(1) ข้อเสนอแนะเพื่อการพัฒนา ควรให้ท้องถิ่นได้เรียนรู้ประวัติศาสตร์ท้องถิ่นให้มากขึ้น เพราะเท่าที่ผ่านมาคนส่วนใหญ่ในท้องถิ่นไม่รู้ไม่ทราบเรื่องราวใดๆ ของท้องถิ่นเลย ก็มี เข้ามาอยู่ สักแต่ว่าอยู่อาศัย ไม่มีส่วนร่วมใดๆ กับชุมชน

(2) ข้อเสนอแนะเพื่อการวิจัย ควรส่งเสริมให้มีการวิจัยเรื่องต่างๆ เกี่ยวกับชุมชนให้รอบด้าน เพื่อจะได้องค์ความรู้เกี่ยวกับชุมชนไว้เป็นเครื่องมือในการพัฒนางานด้านต่างๆ มากขึ้น

บรรณานุกรม

นุกูล ชมพูนิช.

2537. **วัฒนธรรมลุ่มแม่น้ำนครชัยศรี**. นครปฐม ; สถาบันราชภัฏนครปฐม.

ประสงค์ น่วมบุญลือ.

2540. **รายงานการศึกษารวบรวมหลักฐานเกี่ยวกับเมืองเก่ากำแพงแสนของอำเภอกำแพงแสน**. กรุงเทพมหานคร ; อมรินทร์พริ้นติ้งแอนด์พับลิชชิ่ง จำกัด.

มนู วัลยะเพ็ชร์.

2522. **รายผลการวิจัยเรื่อง การศึกษาทางภูมิศาสตร์เกี่ยวกับชื่อภูมิประเทศของจังหวัดนครปฐม**.นครปฐม; คณะอักษรศาสตร์ มหาวิทยาลัยศิลปากร พระราชวังสนาม

มหาฤกษ์.

ม.ป.พ. **นิราศพระปฐม**. กรุงเทพมหานคร ; โรงพิมพ์ราษฎร์เจริญ.

ราชบัณฑิตยสถาน.

2521. อักขรานุกรมภูมิศาสตร์ไทย. กรุงเทพมหานคร : กรมศิลปากร. ครั้งที่ 2.

สภาวัฒนธรรมจังหวัดนครปฐม.

2540. **ปฐมสภา**. กรุงเทพมหานคร ; พี.เอ.ลีฟวิ่ง.

สุนทรภู่.

ม.ป.พ. **นิราศพระประธม-พระโทณ**. กรุงเทพมหานคร ; โรงพิมพ์ราษฎร์เจริญ.

สำนักงานจังหวัดนครปฐม.

2541. **บรรยายสรุปจังหวัดนครปฐม**. นครปฐม ; สำนักงานจังหวัดนครปฐม.

เอี่ยม ทองดี และคณะ.

2539. พัฒนาการและการเปลี่ยนแปลงของชุมชนอำเภอพุทธมณฑล. มหาวิทยาลัยมหิดล : เอกสารโรเนียวในการสัมมนางานครบรอบวันสถาปนามหาวิทยาลัยมหิดล 2542.

ข้อมูลภาคสนาม :

สัมภาษณ์ผู้บอกข้อมูลหลักในชุมชนต่างๆ เช่น

นายถาวร เทียมปฐม ไวยาวัจกรวัดสุวรรณาราม	นายเขียว ไทยนิยม อดีตกำนันตำบลมหาสวัสดิ์
นายจุ่น เซ็งมณี อดีตกำนันตำบลศาลายา	เจ้าอาวาสวัดมะเกลือ ตำบลคลองโยง
เจ้าอาวาสวัดสาละวัน	รองเจ้าอาวาสวัดมะเกลือ ตำบลคลองโยง
พระครูนิมิตรกัลยานวัตร เจ้าอาวาสวัดเทพนิมิตร	เจ้าอาวาสวัดมงคลประชาราม
พระอธิการจรูญ อนาลโย เจ้าอาวาสวัดสุวรรณาราม	นายปุญญเสริฐ ยงใจยุธ
นายสุพจน์ แจ้งเสม ตำบลคลองโยง	นายวิเชียร ยิ้มสุข ตำบลศาลายา
ประชาชนทั่วไปในทุกชุมชน	- ฯลฯ -

Panel 4

The village community: transformations of the farm structure and economy

Government policy and farmers' decision making: the agricultural diversification programme for the Chao Phraya river basin (1993 – 1995) revisited

Siriluck Sirisup[1], H. Detlef Kammeier[2]

Abstract: *The paper is based on a long-term research study (1994-2000) of the rice diversification policy of the Ministry of Agriculture and Cooperatives, which had begun in 1993. The policy still continues, from now on to be implemented in modified form, under a work plan for restructuring agricultural production. The underlying research study which has just been completed (and is to be published shortly), covers an in-depth empirical analysis of the implementation of the policy in six provinces of the Central Plain (Ayutthaya, Angthong, Suphanburi and Lopburi) and the Central North (Phitsanulok and Kamphaengphet). So the Chao Phraya Basin in its entirety (not only the Delta), as the agricultural heartland of the Thai economy, is at the focus of this paper. As a large part of the same area has also become the industrial core of Thailand, the paper also contributes to the discussion of rural-urban interaction and transition processes.*

Extending time frame and scope of the study permitted the researcher to cover a large number of social and economic factors, as well as the effects of the economic downturn of 1997. The paper deals with agricultural development policy in response to changing external development factors, and the response of farmers who are making their decisions in different agro-economic settings, and with different degrees of non-agricultural work opportunities in the vicinity.

The diversification policy was launched in response to a dual problem – the low world market price of rice, and the competition of the urban-industrial sector for the national water resources. So the policy was designed to encourage farmers to adopt permanent crops or other alternatives to rice, so as to obtain higher incomes and, at the same time, consume much less water than by growing rice only.

Due to the relatively long observation period covered, the case studies discussed in this study illustrate the unexpected changes that occurred after the diversification project was first piloted in 1993 and then extended nationwide, with a very large five-year budget (65,000 million Baht) in 1995. Only a few years after the launching of the

[1] Senior Research Scientist, Agricultural Development and Regional Planning, AIT

[2] Professor of Urban and Regional Planning, Asian Institute of Technology (AIT), Bangkok, School of Environment, Resources and Development, P. O. Box 4, Klongluang, Pathumthani 12 120, Thailand, e-mail kammeier@ait.ac.th

programme, rice prices reached an unprecedented level (in 1997/1998), and there was also more than enough water for second rice. Thus both factors made rice the most profitable option again for a few years.

The long-term sustainability of the diversification policy also depends on other influences such as availability and constraints of farm resources, opportunity of off-farm work in the context of industrial development in the region, and the dynamic changes of the national economic structure, from agriculture to industry/services based. Due to the relatively long observation period (with several rounds of fact finding in the six provinces), it is now possible to discuss the effectiveness of the diversification policy in an overall development context. Based on empirical evidence from the project implementation in six provinces, the "lessons learnt" have been elaborated and turned into a discussion on the sustainable continuation and modification of the policy.

The emphasis of the paper is on the conceptual questions arising from agricultural planning and policy making: To what extent is a government policy able to influence farmers' decision-making? How far is commercial agriculture determined by world market prices and international competitiveness? Farmers, as this study clearly shows, make rational decisions that are based on a careful evaluation of the risks and gains involved in their agricultural enterprise. Having evaluated their own socio-economic conditions (family labour in particular), farmers are responding to market signals (farm gate prices for their products), but increasingly they also make use of non-agricultural opportunities, and, last but not least, signals that come through the agricultural extension services of the government. These include, as the focus of this paper, the opportunities offered by the diversification policy - i.e. credit facilities and prospects for alternative crops (such as fruit trees).

The paper will be organized into four sections dealing with the conceptual framework of farmers' decision-making in an increasingly complex world, the diversification policy of the Thai Government in the context of Thailand's long-term economic and social development trends, a summary of the findings from the empirical study, and the lessons learnt for further policy formulation and implementation.

The main recommendation arising from the empirical research is to refine the diversification policy to a flexible and participatory agricultural extension approach, which should be adaptive to changes in the local conditions, especially to the reactions and emerging needs of the target groups. This requires a structure that allows decentralized and democratic decision making. This style of the approach, however, also requires technical support and training for the officials, to develop their social competence for a participatory style of leadership and two-way communication in their daily work. Summing up, the long-term analysis of the diversification policy results is a principally positive assessment of the government's approach, with an emphasis on those critical areas where the approach needs to be further modified and fine-tuned.

1 Introduction

The theme of the conference includes aspects of historical development but also the dynamics and challenges of the Chao Phraya Delta, as experienced at the present time and, by implication, as they might be projected into the future. As the economic heartland of the country, the whole river basin has usually experienced those socio-economic changes first that, later on, spread around the rest of the country. Eighty percent of the central plains, in the southern part of the Chao Phraya river basin, consist of fertile agricultural land. This constitutes the proverbial 'rice bowl' of Thailand, where more than half of the irrigated areas of the whole country are concentrated, where much of the rice surplus is harvested. Rice still is one of the major export commodities but far behind electronics and garments. The 'rice bowl' also includes the largest metropolitan agglomeration, which is Thailand's centre of gravity in terms of population concentration, political and economic power. So the same 'rice bowl' accounts for the bulk of the modern industrial and service outputs in the entire country. Managing the competition for resources - land, water, infrastructure investment - is one of the major challenges for the Chao Phraya Delta now and in the near future. This paper is meant to contribute a view of a specific form of resource management to the discussion - one in which the farmers are the local decision-makers in an enabling framework set by national government policy.

1.1 Objectives and organization of the paper

The main objective is to present the agricultural restructuring policy under the Seventh and Eighth Plans in a longer-term perspective, although there is a certain emphasis on its first phase, the diversification pilot project of 1993/1994. The conceptualization and implementation of this policy coincided with the most drastic changes of the economy of the last 50 years, the 'boom and bust' years before and after July 1997. Therefore, it would be interesting to examine how the farmers as risk-takers and decision-makers, and as recipients of this policy, responded to it, especially as they were simultaneously exposed to changes that were not influenced by the government policy. As the policy was designed to be participatory and its implementation was supposed to be decentralized, the analysis is on farmers as decision-makers, and the emphasis is on the significant local variations in farming systems.

The paper is organized into three major parts that are further divided into six sections:

1. The introduction begins with a view of 'Thailand in transition' to set the scene for a brief discussion about agricultural development policies and in particular, in section 2, the shifting styles of agricultural extension policies and practices in Thailand. In section 3, this first part includes a summary of the agricultural diversification and restructuring programme of the Thai Government, which began in 1993.
2. Against this background, section 4 of the paper presents a profile of the approach and the main findings of an empirical study, which is the main source of information for this paper. Initially, the focus of the study was on the beginning of launching the policy in 1994 and

1995, but it turned into a larger, long-term study which has only recently reached the stage of final completion (Siriluck, 2000).

3. The last two sections present a discussion of the empirical findings on farmers' decision-making in response to government policy and other determinants, especially market signals, along with a view at the changes in implementing the full-scale national agricultural restructuring programme that had begun in 1994, and finally, conclusions and policy perspectives.

1.2 The Thai economy in transition

The title of this section intentionally alludes to that of the remarkable book published not very long before the economic crisis of 1997. The title, *The Thai Economy in Transition,* is the theme of two dozen contributions by an all-Thai team of scholars. Edited by the Australian economist Peter G. Warr [3] (1993), who also wrote the comprehensive introduction, the volume provides an excellent overview of the long-term changes of the socio-economic and political setting in this country. It would be beyond the scope of the paper to go into greater detail as to the general long-term trends, but it may be useful to briefly recall the more recent events, before and after 1997, as they have affected those farmers who had been studied as the target group of the diversification policy.

The downturn in the economy since July 1997 has profoundly influenced Thai society at large, and the re-orientation period is not over yet. The "boom and bust" scenario has been analyzed by many, but perhaps the most popular reference is the bestseller by Pasuk and Baker (1998). The main features of economic growth and change in the 1980s and the accelerated growth during the early 1990s were foreign investments in industries (notably from East Asia), growing domestic investment capability, a transformation of the economic structure, but with it also increasing inequality. The political economy and the social dimension of the unprecedented growth in Southeast Asia has been analyzed by Muscat (1994) and Rigg (1997), among many other scholars.

Thailand as a target for foreign investments was particularly suitable because of the combination of relative political stability and a relatively cheap and docile labour force. The total inflow of the last three years before the downturn was greater than the total foreign investment in Thailand over the thirty years before, but the upsurge in local investment was even larger. The key characteristics of the Thai economy changed in a very short period. In 1980, three-fifths of exports originated from agriculture, but by 1995, over four-fifths came form manufacturing. Over just one decade, the urban population doubled and the average per capita income doubled. In these fifteen years, the economy's main export emphasis moved from crops, to services, to labour-intensive manufacturing, and to medium-tech manufacturing.

[3] A new edition of the book that updates the analysis to the year 2000 is expected to be published in 2001 (personal communication with Peter G. Warr).

Unlike the benefits of the boom which were rather unequally distributed, the impact of the burst of the bubble economy was indiscriminate. Urban income and employment have shrunk, and millions of people were estimated to have lost their jobs, although this was less acute among farmers. The rural 'shock-absorber' still works to some extent perhaps, because the agricultural sector is so large and because the bonds of family and community remain. On the other hand, the rural economy is so much intertwined with the urban one, that there has been a heavy rural impact from the urban economic crisis too. The lost urban jobs must have resulted in decreasing remittances to the families in the village back home, and the unemployed urban migrants seeking work in the village, where there is not much of an economic basis for more people anyway.

1.3 Decentralization as an important political dimension

Three major legislative events have pushed the political debate about decentralization into a situation of rapid and drastic changes - the new Constitution (1997), preceded by the local government legislation (*Tambon Act,* 1994, followed by several "organic laws"), as well as the participatory style of preparing the Eighth National Plan (1997-2001). For at least three years now, decentralization has become one of the hottest political issues in Thailand, with far-reaching implications and strong impacts on areas as different as development of basic democracy, local government capacity, fiscal reform, and - closer to the subject of this paper - content, style and operations of agricultural extension programmes.

Essentially, government line agencies from the central ministerial level down to the de-concentrated provincial and district levels, are going through considerable changes as the political, administrative and fiscal reforms are empowering the 'grass-root' level, in the form of some 7,000 newly created local authorities (*Tambon Administrative Organization* and many new small municipalities). Content and style of decision-making are shifting towards real participation, while local capacity for filling in the constitutional rights and replacing the top-down traditional patterns remains severely limited. It will take many years until the current situation of "incomplete", or perhaps "incongruent", decentralization eventually turns into a truly functional system of distributed authority and responsibility, which would then reflect the spirit of the Constitution (Kammeier, 2000).

2 Agricultural policy, with a focus on agricultural extension practices in Thailand

This section begins with a broad review of agricultural development in the rice-growing areas, including a sketch of the major irrigation improvements in the Chao Phraya basin which facilitated the modern highly intensive export production of rice. The second part of this section features the shifts and changes in agricultural extension approaches and the increasing attention to decentralized participatory decision-making. The critical constraints that emerged at the beginning of the 1990s are then shown as the background of the agricultural restructuring policy which was supposed to include a strong element of decentralized local decision-making.

2.1 Critical dimensions of agricultural development

"There is rice in the field and fish in the water", the famous statement ascribed to King Ramkamhaeng (13th century) was a valid description of the agricultural abundance so characteristic of long periods of Thai society. This was based on the right combination of rainfall, soils, temperatures and topography in large parts of the country. Such favourable conditions made Thailand an agrarian land the economic structure of which was dominated by the agriculture sector until only thirty or forty years ago.

The history of Thailand shows a number of significant changes in agricultural development which were certainly not just induced by market signals, but by deliberate policies, and the formation of agricultural and rural development policy is well documented (for example, Judd, 1989).

For a long time, up to the 1960s, agriculture provided both the highest share of GDP and national export earnings. In the course of national development, the contribution of the agriculture sector to the GDP began to decrease, still reached about 50% in 1951, but it has come down to a mere 12% (in 1997). The industrial sector has been developed rapidly to surpass agriculture in 1975, while the service sector increased more gradually to its current dominating position. The labour force employed in these two sectors has been increasing gradually too, but not reaching the size of the agricultural labour force. The discrepancy of GDP share and share of labour force in agriculture indicates an unbalanced condition with enormous gaps between the industrial-urban and the agricultural-rural sectors, as well as the strong external influences on any agricultural development policy. As a consequence of the ongoing structural change in the national economy, the competition for resource utilization, i.e. land, water and human resources, is manifest and increasing. Especially for the agriculture sector, this results in increasing scarcity and higher costs of these resources.

The continuing existence of the 'rice bowl' is linked to the farmers' ability to make a living, which largely depends on the rice price. Thailand as an open economy is exposed to considerable fluctuations of agricultural products according to the world market price. Over the past 25 years, rice prices have fluctuated between 2 and 7 Baht per kg (Figures 1 and 2), and such fluctuations significantly affect farmers' income and the regional economy. In the early 1990s, when the rice price was only 2.5-2.6 Baht per kg, the farmers could hardly exist, as the farm-gate price barely covered the input costs. This was one of the strongest reasons for launching the diversification programme in 1993, along with a critical water shortage, which had emerged as a new constraint in agriculture. However, only a few years later, rice prices reached an unprecedented high level (in 1997/1998, largely because of the new exchange rate of the Baht against the Dollar), and there was also more than enough water for second rice. Thus both factors made rice the most profitable option again for the last few years.

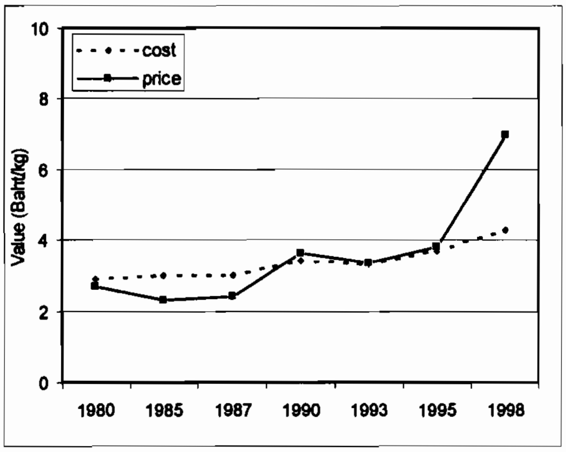


Figure 1: Comparison of cost of production and price of major rice, 1980 - 1998

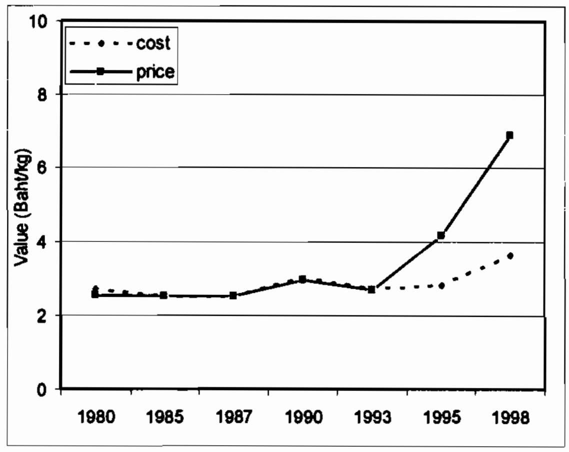


Figure 2: Comparison of cost of production and price of second rice, 1980 - 1998

Source (both figures): OAE, various statistical yearbooks

2.2 Irrigation development and changes in rice cultivation practices in the Chao Phraya River Basin since the 1960s

It appears to be necessary to provide a sketch of the great economic importance of the Chao Phraya river basin and the considerable changes in the rice cultivation system over the past half century, as a background to the circumstances under which the diversification pilot project was designed and launched in 1993, as a test for the agricultural restructuring policy.

The Chao Phraya river system, including all its tributaries, covers a very large area, which includes about 160,000 sq km (or nearly one third of Thailand's land area). However, the 22 provinces that are fully or partially included in the Chao Phraya basin, comprise more than 50 percent of all irrigated areas in Thailand, the bulk of which is in the Central Region. Figure 3 shows an orientation map.

As a subsistence crop, rice has been grown in the 'rice bowl' area for a long time. The most common rice growing system in the plains in former times was broadcasting for a single crop, relying on rainfall or natural inundation from the annual flooding of the major rivers, and using a variety of locally suitable rice strains. The present rice-growing practices in the central plains differ very significantly from those only thirty years ago, even though, at first sight, the appearance of the traditional rice-bowl landscape may not have changed so much.

It was only since the mid-1960s and particularly in the latter half of the 1970s, that rice culture in the central plains changed remarkably by the widespread introduction of double cropping, high-yield varieties, improvements in the traditional broadcasting methods and transplanting, all of which has expanded greatly since that time. Such changes in rice culture also reflected an increase in intensity which was made possible by increasing mechanization and the extension of irrigation facilities over the last fifty years. The first very large-scale irrigation works after the Rangsit drainage and irrigation scheme north of Bangkok (around 1910), was the Greater Chao Phraya Irrigation Project which commenced in 1952, followed by a number of related improvement projects and, later on, the Phitsanulok system which was completed in 1986.

Although extensive areas have been consolidated through redesign and re-allotment of plots, not enough attention has been paid to on-farm development as many areas still suffer from improper control (irrigation and drainage) at plot level, with impact on the level of yield (OSTROM, 1996). The Royal Irrigation Department (RID) keeps statistics about the developments in the major irrigation areas throughout the country, especially those twelve projects initiated and operated by the Department. The RID statistics provide interesting background information on to the relatively new irrigation project 3 (the Phitsanulok system in the lower north) and projects 7 and 8 (in the central plains) where the six study areas are located.

The change in cultivated areas under second rice, field crops, and sugar cane in project 3 was very dynamic. From 1985/86 to 1989/90, the cultivated area of second rice increased by about 200%, while it was rather stable in the older project areas 7&8 (only 10% increase). The expansion of the second-rice area was large (and fluctuating in response to market prices), it was particularly large in sugar cane with cultivated area in crop year 1995/96 being 35 times (!) larger than that in 1985/86. Field crops increased in cultivated area, and fruit trees increased in a very significant way, especially in the central plain.

As a preliminary interpretation of the RID statistics, one might conclude that the expansion effect of irrigation improvements was felt very strongly in the area of project 3, because the ten years observed coincided with the period of time right after the opening of all-year irrigation. In contrast, the changes in the older areas (projects 7 and 8) where irrigation had been available before 1985, reflected the changes in market opportunities for the various cash crops that could be grown (or not) during the dry season.

2.3 Stages of agricultural extension services: Relating international experiences to Thailand

The major policy in the early years of agricultural extension organizations in most developing countries was to increase crop yields and animal production. After some time, more attention began to be paid to improving production efficiency, and after that, to environmental issues, and finally, to the institutional framework for delivering extension services. Such long-term changes reflect the steadily increasing experience with extension services, the availability of resources, the adoption of technical innovations, and marketing mechanisms. Box 1 shows how the system changes over time have been conceptualized for developing countries.

FIGURE 3: THE CHAO PHRAYA RIVER BASIN WITH THE SURVEY SITES (*AMPHOE*) IN SIX PROVINCES

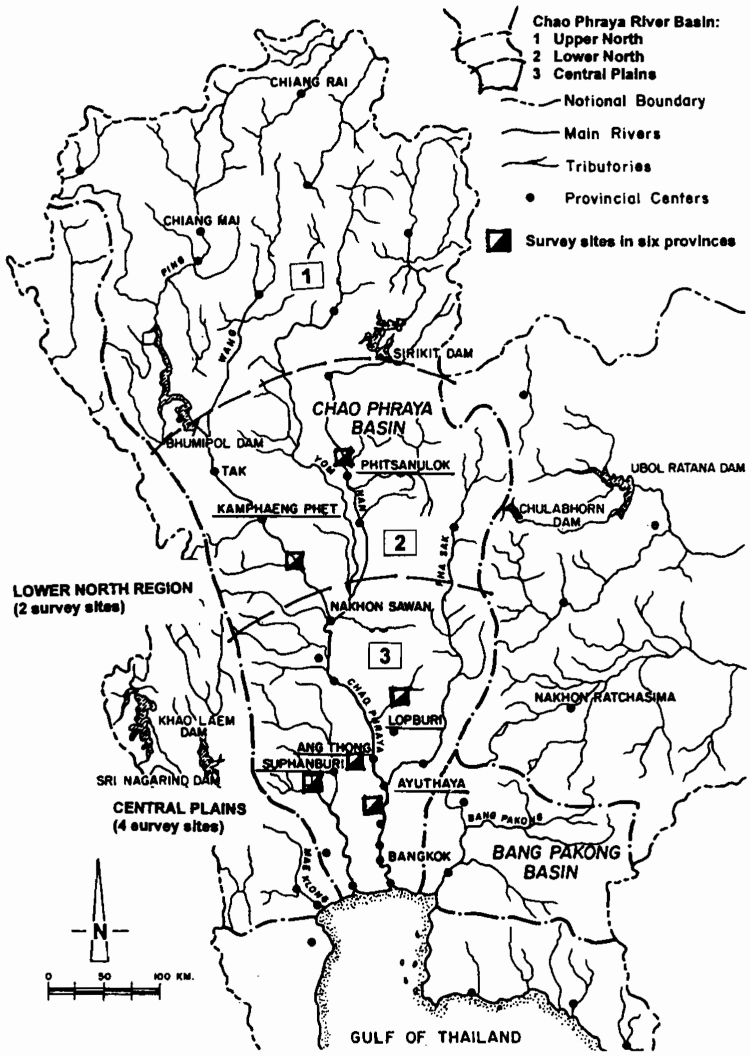


Figure 3: The Chao Phraya River Basin with the survey sites (amphoe) in six provinces

It is interesting perhaps to relate the generalized international pattern to that of Thailand, which seems to have followed the international pattern with a delay of some ten years, while it is now catching up rapidly (Box 2), especially in conjunction with the policies for decentralization and public participation under the new Constitution. In this interpretation of the recent introduction of Farmers Centres at *tambon* level, Thailand would have reached the stage of emphasizing the institutional stage. The changes in agricultural development policy and extension style are so fast that there are considerable contradictions between the principles of 'sustainable agriculture' and export-focused production.

Box 1: Four periods of shifting emphases in international agricultural development

Agricultural research and development has become increasingly diverse, with a growing number of disciplines engaged. Based on international comparative research, four stages can be defined for developing countries (summarized by Pretty, 1995, from several sources):

1. **Production stage** (roughly 1950-75), in which the pioneer disciplines were breeding and genetics, and farmers were seen as recipients of technology.
2. **Economic stage** (roughly 1975-85), in which Farming Systems Research was pioneered by economists and agronomists, and farmers were seen as sources of information for technology design.
3. **Ecological stage** (roughly 1985 – 95), in which anthropology, agro-ecology and geography are pioneers, and farmers contribute their indigenous knowledge, and are seen as victims and causes of unsustainable development.
4. **Institutional stage** (roughly 1995 onwards), in which the pioneering disciplines are management specialists / scientists, training specialists and educators, in which farmers are full collaborators in research and extension; and where alliances are developed between different institutions.

Box 2: Shifts in the orientation of agricultural extension and development in Thailand

Reflecting the principal changes in orientation in other countries (as outlined in Box 1), but with a delay of some 10 years, the shifts in the orientation of the Thai agricultural research, extension and development may be interpreted as follows:

1. **Production stage** (roughly 1960 – 1980s): Thai farmers as recipients of technology provided through extension services by the Rice and Horticulture Departments. Large-scale dissemination of technology with adoption of the Train and Visit (T&V) model; spread of the green revolution and intensified farming from about 1975 through the 1980s.
2. **Economic stage** (roughly late 1980s – 1990): This stage started by the introduction of the alternative systems which were adopted under the influence of Farming System Research since the mid-1980s. Alternatives offered to the farmers however are designed by the extension officers, but based on the farmers' conditions.
3. **Ecological stage** (beginning in the 1990s): Following the call for sustainable development, agricultural development policy began to use "sustainable agriculture" terminology since the Sixth Plan (late 1980s). Promotion of sustainable agriculture is in the form of encouraging farmers to practice natural farming, organic farming, integrated farming and agro-forestry. Target - 20% of total agricultural land (25 million rai) to be under sustainable agriculture by the end of the Eighth Plan (2000). Conflicting goals - sustainable agriculture vs export production; and little real effort for implementation; difficult to implement for extension officers.
4. **Institutional stage** (just beginning, from 1999 onwards): Farmer's institute is established to serve the people-centred approach, farmers are supposed to fully collaborate in extension while support is provided by the DOAE. However, this approach is still in an early stage and not yet fully developed. (Also refer to Table 1: Changes in farmers' participation)

Reconciling the principles of sustainable development and production promotion is difficult indeed, and it seems to lead to problems of understanding and some confusion among the extension officers as an amusing play on words related by one of the extension officers illustrates.[4]

2.4 Degrees of farmers' participation in decision-making

Similar to the changes in extension approaches, the increasing involvement of farmers as decision-makers, rather than recipients of expert advice from extension officers, shows how Thailand's experience follows that of patterns in other countries. The "Farmer-Centre Approach", which is complementary to the "Alternatives System", lets farmers and *tambol* extension officers play much greater roles in local-level planning and implementation, while the upper-tier officers' role shifts from advisor to facilitator. This reflects the objectives of the Eighth Plan, while it is also consistent with the core of planning management processes, which is being promoted worldwide by the concept of Local Agenda 21. Apart from its focus on the environmental cause, this would encompass full involvement of local people in developing and implementing strategies, including contributing in design, information exchange and sharing in decision making.

Pretty (1995) has described seven degrees of participation, i.e.

1. Passive participation
2. Participation in information giving
3. Participation by consultation
4. Participation for material incentives
5. Functional participation
6. Interactive participation
7. Self-mobilization

The summary in Table 1 (next page) relates such changes to the emerging new styles of extension services in Thailand. The design of the agricultural restructuring policy (perhaps more than its actual implementation) aims to include elements of Pretty's advanced stages of participation, and the new concept of *tambon*-level Farmer Centres (since 1999) would definitely require truly functional or interactive participation. So far, there are only a few pilot centres of this kind, and it is therefore too early to assess their viability and effectiveness.

[4] Reconciling the conflicting goals of the government, for example, increased food production and environmental protection, almost amounts to squaring a circle. So it is difficult for for the extension officers, especially those who work at the *tambon* level to encourage sustainable agriculture (such as the King's model of a sulf-sufficient rural economy), while at the same time promoting export-oriented production of cash crops. One of the *tambon* extension officers in Supanburi said that the sustainable agriculture concept, which is translated as "*Kaset Yang Yuen*" , turned the officers into "*Kaset Yuen Ngong*" ("confused agricultural officer"). He used the word "Kaset" to mean "agriculture" in the first phrase, while in the latter it means "agricultural extension officer". Similarly he used the word "yuen" also in two meanings. The former is mixed with "yang" which means sustainable or standstill, while the latter is mixed with "ngong", which means standing and confused.

Table 1: Participation levels associated with the changing extension system in Thailand

Type of extension	Time period	Participation characteristics (using Pretty's typology of seven stages of participation)
Transfer of Technology	Until 1977	Modern technology based on research results is introduced to farmers without farm trials. So technology belongs to external professionals and is announced without listening to people's response. This is characteristic of *passive participation*.
Transfer of Technology with the T&V model	1977 – 1990	With the newly introduced resource of Tambol extension officers, it became possible to conduct structured surveys nationwide. However, farmers only answered the questions without having any influence; and most of the findings were never to be shared or checked for accuracy. This is typical of *participation in information giving*.
Alternatives approach	1990s	With the approach of offering alternatives, extension officers began listen to farmers. Both problems and solutions are defined in accordance to farmers' needs and local conditions. This is in line with *participation by consultation*.
Extension style used in the agricultural restructuring programme	Since 1993	For the first time, the diversification pilot project (and later on, the restructuring programme) coupled low-interest credit with diversification. The extension approach used here includes elements of *participation for material incentives*, apart from the alternatives approach that had been introduced before.
Farmer-centre approach	Since 1999	The establishment of farmers' institutions incorporated with the Tambol Administration Organization (TAO) aims at encouraging farmers to carry out joint analysis leading to action plans, while these groups have control over decisions and maintaining the agricultural practices in the form of "Farmers' Field School". This seems to resemble the model of *functional* and *interactive participation*.

Source: Interpretative table designed by Siriluck (2000), linking the extension stages in Thailand with the seven participation stages described by Pretty (1995).

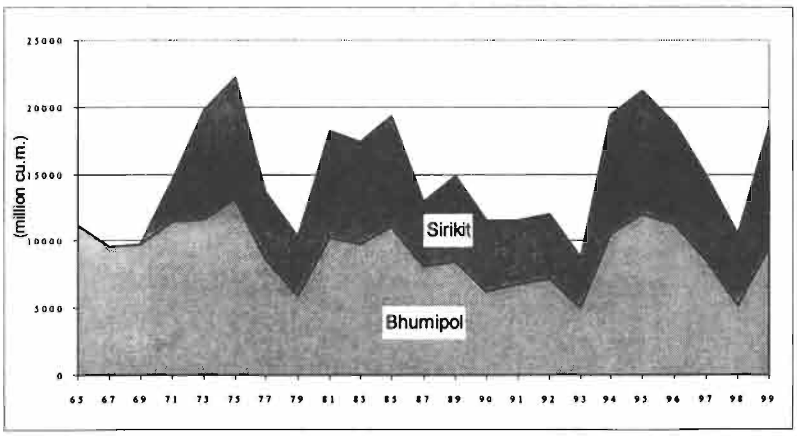
3 The national agricultural restructuring programme

Thailand had reached the 'land frontier' some 25 years ago, when it was no longer possible to accommodate increasing population pressure and agricultural production needs by opening up new farm land (as is well known, very much at the price of reducing the forest cover of the upland areas). What was new at the end of the 1980s, however, was that the country was reaching a 'water resources frontier', realizing that the seemingly abundant water resources are in fact limited and need to be allocated among the competing objectives of rural and urban development. Team Consulting Engineers (1993) concluded that Thailand had to act on the critical competition between agriculture, industries and urban domestic consumption. Thailand is only one of several developing countries in the wet tropics where the water frontier is being reached, because of the increasing demand from urban-industrial uses in conjunction with agricultural use of finite water resources. So an elaborate water management plan was recommended (Binnie and Partners, 1997) in which the agriculture sector would have to play a significant role.

For the first time in crop year 1993/1994, reservoir water for agriculture had to be limited in an unprecedented way. The two large dams (Bhumipol and Sirikit) that had been supplying irrigation water to the central plain since the 1960s and 1970s, reached exceptionally low levels (Figure 4). The graph in Figure 4 also shows the fluctuation cycle of water resources in those reservoirs, and by implication, the ups and downs of the rainfall regime.

The two causes of the water shortage in 1993 were the periodically experienced low rainfall intensity for three years (1990-1993), and, at the same time, the demand for electricity generation and water supply for the metropolitan region, which had been growing tremendously due to the expansion of industrial development and settlement. This forced the Royal Irrigation Department (RID) to reverse its 40-year policy of water use for agriculture.

FIGURE 4: AVAILABILITY OF WATER IN THE BHUMIPOL AND SIRIKIT RESERVOIRS, 1965-1999



Source : RID

3.1 The background of the national agricultural restructuring programme

Under such conditions, any agriculture development policy would have to deal simultaneously with several critical problems, i.e. periodic shortages of water for agriculture (which was due to reduced rainfall and poor distribution of water), declining land resources and high competition in the world market for rice (and other commodities). Thus a policy for "Agriculture Restructuring for the Chao Phraya River Basin" was set up in 1993, in the framework of a "Work Plan for Restructuring Agricultural Production" which was formulated as the most important policy thrust in line with the Seventh National Plan (1992 – 1996). Following the principal guideline of utilizing the national resources and meeting the market demand, the operational plan for this area emphasizes the promotion of crop diversification in order to mitigate against the risk of the low rice price and to consume less water for cultivation.

The main strategy implied in the crop diversification in the Chao Phraya Basin was twofold, i.e.

(i) as a minor strategy component, to substitute the second rice crop with other crops (such as vegetables or flowers), and

(ii) as the major strategy thrust, to permanently replace rice cultivation with other forms of land use, notably fruit trees, but also animal husbandry or aquaculture.

The minor strategy component of substituting for the second rice crop in the dry season does not change the land use pattern. Rice is still cultivated in the wet season while other crops are grown in the dry season. In comparison, the major strategy thrust is to permanently replace rice cultivation with other forms of land use. The emphasis of this study is on this second component of the diversification policy, because it is more complex and requires much more far-reaching decisions by the farmers than the first component.

It was the first time that the Thai Government allocated a large budget in the form of credit support to farmers who wanted to diversify. Despite the incentive of low interest rate and long-term credit, taking the loan still involved the farmers' own decision-making and risk-taking. This is especially true for small-scale farmers who have limited farm resources of land, labour and capital. These farmers will not accept the alternatives offered by the extension officers if unless the market opportunities for the fruits, flowers or fish are better than for rice. So a number of factors and their possible combinations determine whether a small farm is able to effectively participate in the diversification programme. The main reference document would be the proposal of the Department of Agricultural Extension (DOAE, 1994).

3.2 The diversification pilot project in rice-farming areas of the Chao Phraya river basin, 1993

Under the Seventh National Plan, crop diversification was strongly promoted in order to respond to the risks caused by natural disasters and price fluctuation, in the framework of restructuring agricultural production. The target crops were rice and cassava, but also coffee and pepper, all of which tended to give low returns, and the main instruments for making diversification attractive and effective were credit support as well as local extension services. The water shortage of the early 1990s gave rise to the somewhat urgent additional objective of saving water as part of the diversification strategy, but no target figures were given for how much water was to be saved.

Originally, the diversification programme was supposed to cover all 22 provinces of the river basin (see Figure 3 above) from the beginning in 1993, but due to budget limitations for the first year, it was decided to begin with a pilot project in four provinces, i.e. Lopburi, Angthong, Suphan Buri and Ayutthaya. The selection was based on good accessibility (from the national agricultural planning headquarters) rather than these provinces' representativeness of the different agro-ecological zones in the river basin. The pilot project was under the authority of the Department of Agricultural Extension (DOAE), which had a budget of 29 million Baht [5] for the initial one-year operations.

The pilot project operations covered one district each in the three provinces of Ayuthaya, Supanburi and Lopburi, and two districts in one province (Angthong). Each of the districts had a target area of 500 rai, but the first-year operations covered 2,355 rai belonging to 517 farms. The project performance thus exceeded the target figure of 2,000 rai, while underspending on the budget available - just under 25 million Baht were spent on credit that was actually supplied to farmers (DOAE, 1994).

When a much larger budget (of over 65,000 million Baht) became available a year later (1994), the crop diversification out of rice in the Chao Phraya River Basin was integrated into the main work plan for a national project called *Restructuring Agricultural Production.* This programme aimed to support farmers in diversifying out of the major cash crops which had been facing serious problems of price fluctuation. First of all, rice, but also, to a lesser extent, cassava, were the main target as they are the major crops with the largest number of farmers affected. The programme design also included pepper and coffee as less important, but regionally important, cash crops, although they were later dropped from the project implementation. Within this larger national framework, crop diversification out of rice was then not limited to the irrigated areas anymore (as in the pilot project), but also covered rice cultivation in rainfed areas.

The 'jump' from a pilot project worth 29 million Baht which was limited to four provinces and rice as the single target crop, to a very important national policy worth 65,000 million Baht (for a five-year period) was enormous. A simple arithmetic comparison of the size of the pilot project with that of the full-scale programme would show this: The pilot project had provided approximately 7.25 million Baht per province (for one year and one *amphoe* only), but the full-scale programme would allocate an average of 171 million for each year per province - an increase by a factor of 23. Surprisingly, however, this 'jump' was made without an in-depth evaluation of the pilot project, which had been designed to test the national strategy for a one-year period. Apart from that, this very large and complex national programme was launched without a detailed framework for monitoring and evaluation, although it would have been obvious that the different crops (rice and cassava) needed to be evaluated separately, and ideally, at least each province would have to be monitored and evaluated. [6]

The main features of the design of the diversification pilot project are outlined in Box 3. They are similar to those of the much larger national agricultural restructuring programme which began in 1994. The procedures that are summarized in Box 3 have been applied since 1993,

---

[5] Reportedly, this budget came from the proceeds of the former rice export premium.

[6] This has made it virtually impossible for the author of the study presented in this paper to obtain any detailed data on the performance of the restructuring programme after 1995. This is unfortunate because it is now not possible to compare the detailed analysis of the baseline survey data (as outlined in this paper) with the actual implementation of the programme in the same provinces, or other areas, over the past five years.

although they may have been adapted along with increasing experience (in this respect, refer to the handbook published by the Ministry of Agriculture and Cooperatives, 1998).

Box 3: Main features of implementing the diversification pilot project: Design from the top, and recognition of local farm resource constraints

The project package was designed at the top level of the vertically organized bureaucracy. For the central plain, orchard cultivation was targeted as the most appropriate crop for substituting rice, because of soil suitability, market demand, and lower water consumption. The project design aimed at the conversion of small plots (3 - 5 rai) from rice to orchard, in combination with a special long-term, low-interest credit line (15 years, and only 5% p.a.). To bridge the first 3-4 years with no returns from the young fruit trees, intercropping with vegetables or flowers was recommended, apart from the possibility of raising fish in the irrigation ditches of the newly created orchard plots (for supplementary income).

In implementing the programme, the Department of Agricultural Extension (DOAE) as the lead agency cooperated closely with the Royal Irrigation Department (RID) and the Bank of Agriculture and Agricultural Cooperatives (BAAC) as well as several other agencies.

Provincial targets and information transmission: Budgets and target areas in each province were identified at the level of central-government Departments, and provincial-level offices were instructed accordingly to implement the programme. They had to find farmers who would be interested to join the project so as to prepare definite area and credit targets for each *tambon*. The *tambon* extension officers were given the task of encouraging farmers to diversify. They together with the BAAC branch officers held meetings with farmers, explaining the project objectives, outlining the benefits that farmers might receive, and setting out the conditions for receiving the credit, repayment rates and so on.

Local farm plans: Farmers who were ready to join the project had to work on a relatively detailed farm plan together with the *tambon* extension officers (land use, land holding status, labour available, proposed diversification pattern, budget estimate for the diversification activities). These farm plans were compiled at the *tambon* level, submitted to the agricultural district officers, and forwarded to the BAAC district branch. After screening the applications, the farmers were visited for in-depth investigation, before loans were approved.

Budget approval at the highest level: Approved farm plans were compiled at the district level and processed at provincial level, within the target figures given for land areas and credit for each province. DOAE and BAAC operated through their own channels for credit supply and input support (fruit tree saplings, e.g.) to be prepared at the central level.

Local distribution of support: After approval, credits and material inputs were allocated to the provincial level. Flows of information and distribution at farm level was organized through the district and *tambon* officers. This process also included a stepwise disbursement of loan funds to farmers, in line with implementing the individual farm plan.

4 Research approach and findings

The original rationale for undertaking this study was to describe the diversification project and its first-year implementation as an example of the decentralization policy of the Thai Government (Siriluck, 2000). Decentralization had already been very prominent during the Seventh National Plan (1992-1996), but it is even more pronounced in the present Eighth

Plan (1997-2001). The agricultural diversification policy thus has to be seen in the changing framework of policy planning and implementation at the various levels, especially at the provincial and local levels. The focus was on agricultural planning procedures and experiences, as one of the centrally important forms of government intervention at the local and regional levels.

4.1 Research methodology

The Department of Agricultural Extension (DOAE) was very supportive of the researcher's plans for conducting empirical field research into the innovative diversification project, because the results of the field survey were expected to contribute to DOAE's own efforts for project monitoring and evaluation. So the field surveys were designed as baseline surveys, using the classical approach of comparing carefully selected project target groups with similarly structured control groups from the same study areas.

The methodology included a number of preparatory steps, before the sampling was decided upon in a statistically reliable manner. Methods such as RRA (rapid rural appraisal) were used before going into elaborate interviews with more than 300 farmers. Later on, all areas were revisited, using methods like focus group meetings and PRA (participatory rural appraisal) for updating the information obtained from the initial survey. The first pilot project areas in the four provinces in the Central Region that had been selected by the DOAE were surveyed twice, in the first crop year (1993/1994) and a year after that. They were Ayutthaya, Angthong, Suphan Buri and Lopburi, with those one to two *amphoe* each, where the test programme was carried out by the DOAE. When the full-scale national programme had begun in crop year 1994/1995, two more provinces in the lower north were added, Kamphaeng Phet and Phitsanulok, using essentially the same approach as in the four central provinces. The basic framework was a quota sample of 30 farmers in a 'project group' in each province, in comparison with an equally carefully selected sample of about 20 farmers in a 'non-project group'. In this way, the study in six selected provinces was reasonably representative of the various agro-ecological and socio-economic conditions in the Chao Phraya basin, although obviously, DOAE might have been able to conduct more such surveys in other provinces, using the same model.

The Annex of this paper provides some supplementary information on the field research that was conducted in the form of structured interview surveys in 1994, 1995, and later on, in the form of focus group meetings and interviews with DOAE officers at all levels, from 1996 to 1999 (refer to Table A-1 for an overview of the quota sample). The analysis of the survey data consisted of descriptive statistics, specific statistical tests of some of the crucial factors for understanding the farmers' attitudes and behaviour with regard to the diversification project, and qualitative discussion of the results, in comparison with the published policy documents and statistics.

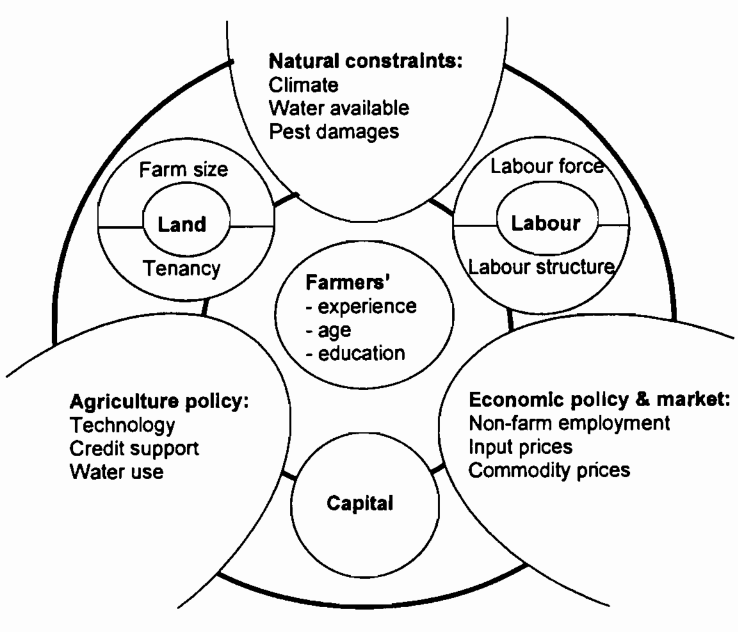
Understanding the effects of public sector policies on farmers is not possible without adopting a holistic approach where the individual farmer is at the centre of a farming system, which is part of the entire agricultural system (Chudleigh, 1984; Siriluck, 1993). The farming systems approach was used as a conceptual basis for setting up the survey and analysis methodology because it was only in this way that the farmers' situation vis-à-vis the alternatives offered by the diversification project could be understood. The methodology included exploratory reconnaissance trips, talks with key informants at all levels, 'rapid-appraisal' meetings with farmers, and in-depth interviews based on structured and open questions, apart from reviewing all relevant statistics and other published materials.

Figure 5 shows a conceptual diagram of the basic framework for the determinants of farmers' decision-making. All farming decisions are based on constraints and opportunities that lie within the farmer's personality and family (at the centre of the graph), the farm resources of capital, labour and land (shown in the intermediate circle), and the farmer's response to market signals and other determinants that are shown in the outer circle of exogenous factors.

Although the field surveys in 1994 and 1995 were only conducted in rice-growing irrigated areas, the principal framework of the approach was such that it could be adapted to any other areas under the agricultural restructuring policy. The aim was to conduct a systematic empirical study into the various factors that are involved in the implementation of the agricultural restructuring policy, and to fully understand the farmers' actual decisions. In the long run, it would even be possible to expand the method into a multi-criteria model, which would eventually lend itself to predicting farmers' behaviour under various farming system conditions, simulating the expected effects of alternative restructuring scenarios. In this way, the initial research effort could have been utilized in monitoring and adjusting the national policy, through systematic feedback from the actual local implementation experience.

The farmer (at the centre), surrounded by endogenous factors (concerning the farm, inner circle) and exogenous factors (natural environment, national and international policies and market) determining the farmer's decisions (based on Siriluck, 2000)

FIGURE 5: A CONCEPTUAL DIAGRAM OF THE FARMING SYSTEM



4.2 Assessment of project planning and implementation

In view of the objectives of participatory project implementation, as intended under the national plans, the first question to be asked when assessing the style of project planning and implementation would be: Did the field officers administer an agency blueprint plan, or did they facilitate farmers' decision-making? Despite the national promotion of more decentralization, planning and implementation of the project were in the typical bureaucratic manner, with decision-making and budget control still from the top and down the line of the individual agency. As the package had been designed and set out in the form of a 'blueprint' from the top, it was not easy to change and adapt at the bottom of the pyramid. So the *tambon* extension officers who were working at the grass roots level acted more or less as postmen, transferring the message they had received from above to the farmers. This is in contrast with the promotion of active plan formulation at the provincial and district level, responding more directly to farmers' needs as stated in the Seventh Plan. So the local diversification pilot plans did not come from a bottom-up approach, and the farmers basically adopted the package offered by the DOAE. However, the recruitment of farmers for the diversification project brought in a new element in the extension approach, where farmers had to make their own decisions in response to the alternatives offered, rather than just receiving technology transferred to them. [7]

4.3 Baseline research findings

The questionnaires yielded a rich amount of detailed information which would have been impossible to gather through a more broad-brush RRA-type approach. [8] The survey sites in four, and then six, provinces included from four to ten *tambon* each, and almost each of them represented a different microcosm of farming conditions. The farmers' and their household members' demographic data, their educational and experience backgrounds, and their individual resource base - land ownership and size, labour structure, capital, and access to non-farm work - provided a range of basic conditions for the decisions they were expected to make. The decisions were, first of all, whether or not to join the attractive credit-supported package of converting some plots of their land into orchards, and to add fish raising to their rice-farming operations. The second stage of decision-making concerned the mix of new farm enterprises to be added, for example which fruit trees, or which flowers and vegetables. All such details turned out to be very relevant to the success or failure of each farmer over the years after the baseline survey.

[7] Dr. Pote Chumsri, then the director of the Agro-Business Promotion Division of the DOAE, who played a leading role in initiating this project, was proud to say that this was the first project in Thailand, which was established in response to the real problems that farmers faced (personal communication at the beginning of the pilot project).

[8] This confirms the views of the FAO experts (Norman et al., 1995) and other researchers who underlined the importance of structured interviews (in addition to other methods) as a means of obtaining the quantitative and detailed information that is needed for agricultural policy research.

The first part of the analysis focused on the structure of the household income as derived from many different farm and non-farm sources. Figure A-1 (Annex) visualizes the systematic of the analysis, and Table 2 presents a summary of results. The point here is to show the ranges of incomes from different sources, rather than the actual amounts. Expectedly, the household incomes varied considerably, depending on land resources, crops grown and other variables. As all respondents have irrigated land with the possibility of growing a second crop after rice, the average extent of non-farm income was somewhat smaller than the figures from national statistics (at an average of about 50%). However, wherever farmers were in easy reach of industrial plants such as in Ayutthaya, the income from the factory work and other off-farm employment of at least one household member, was reflected in a relatively large proportion (of up to 50%) of total household income.

The decisions these farmers had made, in many ways reflected the constraints they had, but this was not obvious when the interviews were conducted, because so many different factors must be considered. It was only after careful analysis that the initially intended differentiation of farmers, in or outside the project, turned out to be misleading, because there were those farmers in both groups, who had to be seen as a distinctly different third group - i.e. those who had already invested in alternatives to growing rice only. So the sample of 310 farmers was re-shuffled into three groups as shown in Table 3. The emphasis here is on 'innovators', i.e. those who had either previously diversified their farm operations on their own, or they had joined the project, being attracted by the low-interest loan (see Table A-2 for further details). It is almost equally important to understand the 'non-innovators' or 'non-diversifiers', because their conditions would provide the reasons for not being able, or not wanting, to change from the farming operations they already have.

The analysis on the basis of those three groups included a statistical test of those factors that could be used as variables in a possible future model for predicting farmers' attitudes towards farm restructuring options. Tables A-3 and A-4 (Annex) provide more details on this interesting point. In summary, the interpretation of the three groups showed that the resource constraints of the 'non-diversifiers' were such that they did not really have the options that the other two groups had. The decisive factors are land tenure (not enough owned, and too much rented land, which is difficult to use as collateral); and labour constraints (which would not allow to go for the more labour-intensive fruit-tree option). Instead, those households had already decided on the most suitable way of increasing their meager farm incomes - outside work; so the analysis showed that they had a greater extent of off-farm employment than those in the two groups of 'innovators'. The reasons given for not adopting any diversification clearly reflected those resource constraints (Table A-5).

Table 2: Ranges of income from main components of total farm household income

Principal component of total farm household income (total = 100)		Sub-systems (Farm income = 100) (Non-farm inc. = 100)		Main categories of each sub-system (Farm income = 100) (Non-farm income = 100)	
A. Farm Income (gross margin)	40-75	A.1 Crops	82-95	A.1.1 Rice	38-95
				A.1.2 Other crops (sugar, vegetable, fruits, flowers)	0-55
		A.2 Fish	0-7	(commercial scale, home consumption)	
		A.3 Livestock	0-16	(poultry, pigs, cattle)	
B. Non-farm income (gross income)	25-60	B.1 On-farm	3-45	B.1.1Home industries	0-40
				B.1.2 Petty trading & services	0-5
		B.2 Off-farm	55-97	B.2.1 Gov't employment (full-time)	3-45
				B.2.2 Agric employment (part-time)	5-8
				B.2.3 Non-agric employment (full or part-time)	20-55
				B.2.4 Remittances	5-45

Source: Data from 310 households in six provinces, field surveys 1994, 1995; Percentages in relation to total household income, farm and non-farm income

TABLE 3: FORMATION OF THREE NEW GROUPS FOR FURTHER STATISTICAL AND QUALITATIVE ANALYSIS

Separating both project/non-project groups into 'old innovators' (diversified before the project), policy adopters (with project support), and non-diversifiers (in the non-project group)	**A. Project group: 182**		**B. Non-project group: 128**	
	157 farmers joined the project	25 had diversified earlier but also joined the project	45 had started to diversify	83 would / could not do it, for various reasons	Total 310
	1. Project-support group: 157	**2. Self-support group: 70**		**3. Non-diversifiers: 83**	**Total 310**

Note: Only after evaluating the survey results, it turned out that farmers who had already diversified on their own are an important group. So further analysis was on the basis of a re-shuffled grouping

TABLE 4: AN INTERPRETATIVE SUMMARY OF THE FARM RESOURCES OF THE THREE GROUPS

Farm resources	**Group 1: Self-support**	**Group 2: Project-support**	**Group 3: Non-diversifiers**
Labour	Sufficient	Sufficient	Partly employed outside the farm
Land	Sufficient	Sufficient	Limited: partly rented
Capital	Sufficient	Not sufficient. Therefore, credit support required	The land /labour constraints are so strong that even the low interest rate of credit does not act as incentive

Source: Interpretation of survey findings, 1994 - 1996

4.4 Follow-up survey results

The two main reasons for launching the diversification project in 1993 had been the exceedingly low rice prices, that were hardly above the production costs (see Figures 1 and 2); and the acute water shortage. A year after the first survey, the water shortage had become a non-issue, as it rained so much more that there was enough water for agriculture and industries. However, the rice price was

only slowly going up. So the survey results for the two northern provinces were essentially similar to those for the central provinces, except for those differences that could be traced to location relative to non-farm jobs, land consolidation and land tenure patterns, and soil suitability. Also, for those farmers that were interviewed for the second time, the baseline conditions had not changed much in just one year; so the survey results of 1995 in the first four provinces largely confirmed those of 1994. However, a only one year later, in 1996, and especially after the economic downturn of 1997, things had changed considerably, and the focus group surveys that were held then in all survey sites (in 1998 and 1999), added new insights.

Those farmers who had planted fruit trees in 1993 and 1994 had several years of experience now, including the first few years of harvesting and marketing the alternative crops. That was a happy and successful experience for some, and some had turned more plots into orchards, but - many farmers had given up on diversification. They had stopped maintaining their orchards and some had even converted the land back to rice. This was unexpected, but understandable: First of all, the seasonal water shortage had not occurred since 1993, so it was not an issue anymore, even though the level was critically low again in 1998 (see Figure 4 above). However, there was no pressure from the industrial sector as the demand had gone down with the economic crisis. Second, and more important, rice prices had reached an unprecedented high level in 1997. So it was as attractive as never before to grow rice (refer to Figures 1 and 2 above), even though the production costs had gone up too.

It is most unfortunate that it was not possible to quantify exactly how many farmers had continued or stopped the alternatives for which they had taken out a loan (and still had to pay back), and how many of them had actually reverted back to rice (Table 5 and Table A-6, Annex). One of the reasons for this is that the extension officers did not dare to face the farmers who were disappointed and in debt for what they saw as a costly and painful adventure that had been so highly recommended to them. So it was not possible to contact all those farmers who had been interviewed several years before, without any support by the extension officers. Unfortunately, the apparent lack of systematic and detailed monitoring did not only apply to the six survey sites of this study, but to all provinces that had now gone into the full-scale restructuring programme.

TABLE 5: THE CONDITIONS AFTER FIVE TO SIX YEARS OF PROGRAMME IMPLEMENTATION, 1998 / 1999

Focus group discussions in six provinces, including several specific case studies

1. Self-support group 70 farmers initially	**2. Project support group** 157 adopters initially	**3. Non-diversifiers** 83 farmers initially
After 1997: Some farmers stopped growing fruit trees and converted some of their land back to rice	After 1997: Many farmers in this group stopped growing fruit trees, and several of them converted the land back to rice	After 1997: Some farmers may have gone for some farm restructuring, and some may have left farming altogether

Note: No detailed figures are available to confirm such conjectures after the focus group interviews of 1998 and 1999, as there has not been any systematic monitoring of the three groups by DOAE

As it was not possible to re-survey all those farmers that had been interviewed at the beginning, a meaningful alternative was to identify several farmers in each site whose experience would be interesting enough to study in more detail. The in-depth interviews that were conducted in 1998 provided the material for some exemplary case studies that provided further evidence of the farmers' rational decision-making.

Expectedly, the farmers' motives for diversifying are the same as the objectives of the project - manage within limited land and water resources, and achieve better and more stable income from the farm. All case-study farmers stated that unstable and low price of rice, coupled with higher income expectation is the main reason for their interest in the project, while better income distribution and no need of searching for off-farm work were stated in addition by some of them. Therefore, whole-farm analysis was done to compare the traditional and alternative systems. This was not on economic analysis criteria only, but also on farm resources utilization in a time series. Results show that returns from diversification in the first few years was lower than rice anyway. The break-even was found from year 4 onwards. With a long-term perspective, the selected farmers studied in this way were able to rely on cultivation on their own land and stopped renting a part of their land after 2 – 3 years of diversification. The detailed analysis of such cases showed that the managerial capacity among project-support and self-support farmers does not differ, but the 'non-diversifiers' had valid reasons for not wanting to join the project.

5 Farmers as decision-makers, policy shifts, and lessons learnt

The many variations among the local conditions of farmers (and based on those, their behaviour and their attitudes towards the diversification project) are caused by exogenous natural factors like climate and topography, or man made ones, such as agricultural land reform, irrigation system, opportunities from industrial development and others. As the mix of these factors varies considerably even within the same province or the same *amphoe,* the implementation of a national policy such as agricultural restructuring, must be adapted to local conditions.

So the conceptual questions arising for further agricultural planning and policy making are: To what extent is a government policy able to influence farmers' decision-making ? How far is commercial agriculture determined by world market prices and international competitiveness ? Do local extension officers have the ability, and the authority, to modify a national policy in such a way that they actually enable farmers to make the best decisions ? Farmers, as this study clearly shows, make rational decisions that are based on their own careful evaluation of the risks and gains involved in their agricultural enterprise. Having evaluated their own socio-economic conditions (family labour constraints in particular), farmers are responding to market signals (farm gate prices for their products), but increasingly they also make use of non-agricultural opportunities, and, last but not least, signals that come through the agricultural extension services of the government. These include the opportunities offered by the diversification policy - i.e. credit facilities and marketing prospects for alternative crops (such as fruit trees).

5.1 Farmers' attitudes in relation to the diversification pilot project

The survey results clearly show that marketing problems are perceived by most farmers as the main obstacles to successful and profitable farm operations. Natural hazards such as the flooding of 1995, and pest damages, were perceived as problems of secondary importance. Low prices for farm products, the main point mentioned again and again as the main point among marketing problems, seriously affects the entire farm economy. As rice continues to be the main crop in all areas surveyed, low farm gate prices and related aspects of marketing are primarily perceived in relation to rice. However, as experienced in those areas where farmers have already begun to diversify, marketing and price problems were also felt with regard to other crops such as fruits and flowers, where better storage facilities and grading procedures would be needed to achieve better farm gate prices.

Changing external factors such as the formation of the rice price and its share for the producers, is well beyond the capacity of the farmers themselves. Therefore, many farmers have resorted to other means of their being totally dependent on low rice prices which is the dominant problem, in conjunction with the problem of seasonal water shortages. The survey results reflect the great variety of agricultural land uses and farming practices, especially in the non-rice sectors, where farmers in some areas have been surprisingly innovative and sharp in responding to opportunities and incentives offered by government (such as in Suphan Buri). The survey results also show the great range of sources of household income (as summarized in Table 2 above), where the income from non-farm sources in some places, and at least at certain times of the year, exceeds the income from crops and other farm sub-systems. The findings from the survey do not seem to confirm the figures from the national statistics on the very large extent of the non-farming proportion of farm household income, presumably because farmers in irrigated areas are better off than those in rainfed areas. Nevertheless, the figures for 1994/95 (i.e., a year after when the main diversification investments had been done in the central region areas) show that some 25 to 40 (and more) percent of the household income was from non-farm sources. This would indicate the transition, in these households, from full-time farming as the main source of income to mixed patterns, with a large extent of part-time farming.

It would appear that useful diversification experiences are found among two types of farm households, i.e. not only among the 'innovators' among the farmers, but also those who had increasingly utilized non-farm income options. In a way, both of these groups exhibit responses to the challenges of change, away from being totally dependent on rice farming. So their experiences include changing farm practices, such as introducing new crops and new varieties of seeds, or managing seasonal labour constraints, as well as resorting to non-farm opportunities. Table 6 provides a broad summary of the survey findings from 1993 to 2000.

Government support would be needed particularly with regard to those key factors that are beyond the farmers' control, such as farm gate prices and water availability. Therefore, the diversification pilot project, and later on, the agricultural restructuring programme, were formulated and implemented in order to help farmers to adjust to the two core problems, by offering additional options and real alternatives. The pilot project for diversification out of rice initially only offered fruit trees and some other alternatives to growing rice. It thus provided an initial and partial solution to the government's core problem, i.e. untenable competition for limited water resources, and a perspective for the farmers' core problem, i.e. better and more diverse sources of farm income. However, the project did not provide much of a solution to the related core problems of the farmers, i.e. those related to marketing, including more information, better quality, and higher farm gate prices.

5.2 Longer-term policy implementation and monitoring

The remarks on the performance of the restructuring policy over the past five years must be tentative, because the data and documents available do not permit any in-depth assessment at this stage.

As stated before, the launch of the large national programme does not seem to have used a detailed evaluation of the pilot project. Also the water conservation aspect of the pilot project was not pursued in any way as part of the national programme. Both these points are indicative of a style of swift policy changes in the government, which appear to be dominated by international development fashions, specific conditions (such as the water shortage in 1993), and ideas that are championed by influential personalities in the agencies. Once they have been transferred to other positions, and as soon as the emergency is over (although the long-term threat may still be there, such as in the case of the 'water frontier'), the policy is changed, dropped or not properly monitored.

Further examples to be referred to in this context, is the attention given to strategic-planning methods and techniques (such as the popular SWOT analysis) which seems to be coming and going with the promoters of such ideas instead of staying in place for consolidation and systematic testing.

TABLE 6: A BROAD SUMMARY OF THE SURVEY FINDINGS ON THE DIVERSIFICATION PILOT PROJECT / AGRICULTURE RESTRUCTURING POLICY -- FARMERS' RESPONSE TO POLICY AND MARKET SIGNALS

Time period	**Crop year 1993/1994 (Survey in 4 provinces)**	**Crop year 1994/1995 (Survey in 6 provinces)**	**1997- 2000 (Policy review)**
Agriculture Policy	Four pilot provinces (of 22 provinces in the Chao Phraya Basin) selected for **experiments with diversification out of rice** (in irrigated areas) Main objectives: (1) Water conservation, (2) Promotion of alternatives to low rice price	The diversification project becomes part of the more general **national agriculture restructuring programme** for major crops: - Rice (irrigated / non-irrigated areas) - Cassava (upland areas) - Pepper and Coffee (hardly implemented because of price recovery after introduction of policy)	Agriculture restructuring policy continuing but apparently not very successful. This is difficult to verify because of unavailable data, and unclear monitoring system. Adoption rates low because of - market price recovery - water availability
Farmers' responses (sample groups in 6 provinces)	**Project Group:** Farmers in pilot provinces responded well to diversification policy, despite the expenditure and risks involved in land conversion; some farmers had begun to diversify prior to the project, but also joined the project, attracted by its opportunities **Non-Project Group:** (a) Diversification into fruit and flower production in response to market demand and farmers' own initiatives prior to the project (b) To some extent, non-adoption for good reasons	**Self-support** and **project- support groups** of farmers continued to diversify, depending on a mix of factors such as own ability to take initiate and risk, and credit support offered by government	Many farmers (numbers hard to verify) have abandoned fruit trees and other options under the diversification project, and reverted back to rice, in response to rice price recovery and water availability, but other farmers continued on a more diversified basis.
Lessons to be learnt	Very different local conditions of individual farmers even within the same province. These have not been sufficiently addressed by the 'blueprint policy' although credit support offered for diversification was initially successful and advice given in the target districts was supposed to be area-specific.	Increasingly evident local differences based on a mix of factors, such as own ability and experience, non-farm income opportunities in the vicinity, and quality of local implementation of the restructuring policy by the extension officers.	It is difficult to generalize on the chances of success for such policies at national or provincial levels, because decision-making factors are highly localised. Further decentralized policy implementation and monitoring to be carefully adapted to local conditions.

One of the most important sources of information is the evaluation report for the Budget Bureau, which was written by researchers based at Chulalongkorn University (Chula Unisearch, 1996). In addition, there are evaluations of the implementing agencies, i.e. OAE and BAAC, for their own areas of responsibility. All of these evaluation reports present highly aggregated statistics (that given for the macro-regions only), but no detailed information as to programme performance by province, or by agro-ecological zone, and not even separated for rice and cassava. This is a serious shortcoming, which does not only make it impossible to relate the detailed survey results presented here to the general nation-wide policy experience, but it also makes any real feedback into policy adjustment impossible.

The Chula Unisearch Report is critical of the low achievement rates of the programme (p. 10) which is evident from the following figures for 1994: Of the 6,500 million Baht available for credit, only 3,000 million were approved and disbursed, based on farm plans submitted for just over 1 million rai. Similarly, the figures for 1995 show that the size of the programme had grown into considerable proportions -- 95,203 farmers received credit support for farm plans on a total area of 662,350 rai, but 122,243 had applied.

The report also states for 1995 (p. 75) that while the area targets were met at a rate of 66%, the credit disbursement targets were met at a very low rate of 16% only. The main problem that prevented higher disbursement rates was given as the farmers' inability to provide land for collateral. This was traced to the prevailing land tenure pattern with high rates of rented land or land without appropriate title documents.

The documentation in hand appears to be focused on specific aspects such as loan repayment patterns, but not on the core questions to be covered by objective-oriented monitoring reports, such as the degree of restructuring achievements, and the effectiveness of the farmers' projects.

These are just a few preliminary examples from the analysis that is still being completed on the basis of the officially available documentation. It should be obvious that this kind of highly aggregated statistics are not suitable for monitoring and evaluating a policy of the calibre of the agricultural restructuring programme. For any such policy to be successful, there needs to be a consistent implementation and monitoring system that stays in place over a long period of time, apart from being detailed enough to capture the important local variations (van den Ban and Hawkins, 1996).

6 Conclusions

Some concluding remarks can be made at this stage. Conclusions on the basis of the field surveys in conjunction with a more general assessment of decentralized agricultural planning and implementation are on rather firm grounds of data and comparative interpretation, but those related to the national agricultural restructuring programme are not. So there is a 'missing link' between evidence from detailed empirical research and general programme monitoring, which should not be left unattended on the part of the Ministry of Agriculture and its agencies.

The diversification pilot project shows that Thailand is advancing as far as farmers' participation in extension work is concerned, although progress is more limited than desirable and targeted under the last two National Plans.

The empirical study has shown that farmers act in a rational way, making decisions that are consistent with their own constraints and opportunities in a farming system framework. The 'discovery' of the third group of farmers, the self-support innovators, is particularly relevant in this context. At the same time, this part of the analysis proves the importance of detailed and well-structured field research methods in order to gain real insight and to support policy formulation.

So the main recommendation arising from the empirical study is not to turn the diversification policy into a rigid programme, which would be difficult to change and adapt over time. The agricultural extension approach should be flexible in its reactions to changes in the local situation, and especially to the reactions and emerging needs of the target groups. This requires a structure that allows decentralized and democratic decision making. This style of the approach however requires technical support for the officials so they can have the social competence and be able to practice a participatory style of leadership and two-way communication in their daily work. Furthermore support has to be on agricultural technology as part of the recommended packages for diversification, which are new for both extension officers and farmers.

With regard to the transition from pilot project to full-scale programme, the conclusion is that there was no sufficient evaluation of the lessons that could have been learnt from the pilot sites. Apart from this, the local officers seem to have lost interest in the pilot project as soon as the much larger national programme was in sight.

The longer-term observation shows that the two most pressing needs of 1993, low rice price and acute water shortage, were temporary, but it would have been very difficult indeed to predict the changes that happened afterwards. Moreover, it would have been impossible to foresee the crisis of 1997 and its specific impact on agriculture, which was the fortuitous increase of rice prices due to exchange rate adjustment.

Many farmers did gain from the diversification project because they had the right combination of experience and farm resources so they could do it on their own or with project support. On the other hand, however, many farmers who had experimented with fruit trees without being confident as to their skills and labour resources to handle the new crop, paid a high price of being in debt from the loan that still has to be paid back. At the same time, they gained from the windfall profit of high rice prices in 1997/1998.

In retrospect, the extension officers may not have been as efficient as they should to handle such a project. In combination with the unpredictable change in rice prices, this resulted in a difficult 'loss of face' vis-à-vis the farmers who do not trust such officers anymore.

The monitoring system of the national programme seems to be insufficient, and it is impossible to trace the long-term changes among the farmers' groups that had been surveyed at the beginning. Moreover, the monitoring system, as well as the documentation of programme implementation, appear to be inadequate as a basis for assessing the long-term performance of this large programme.

ANNEX:

SUPPLEMENTARY INFORMATION

Objectives of the Study (Siriluck, 2000)

The overriding objective of the study is to determine the opportunities and constraints of government-induced agricultural restructuring in a decentralized regional planning context. The related specific objectives are:

1. To describe and assess the framework of policy planning and implementation at the various levels, especially at the provincial and local levels, following the decentralization framework of the 7[th] and 8[th] National Plans. The emphasis is on agricultural planning procedures and experiences, as one of the centrally important forms of government intervention at the local and regional levels.

2. The focus of the study is on the agricultural diversification programme and the related planning and implementation practice in the Central Plain. This includes attention to the differences of programme implementation in selected provinces and localities within the same province.

3. In turning empirical evidence into "lessons learnt", the study then aims at generalizing them into recommendations for further development of the agricultural restructuring programme, to support realistic national policy making.

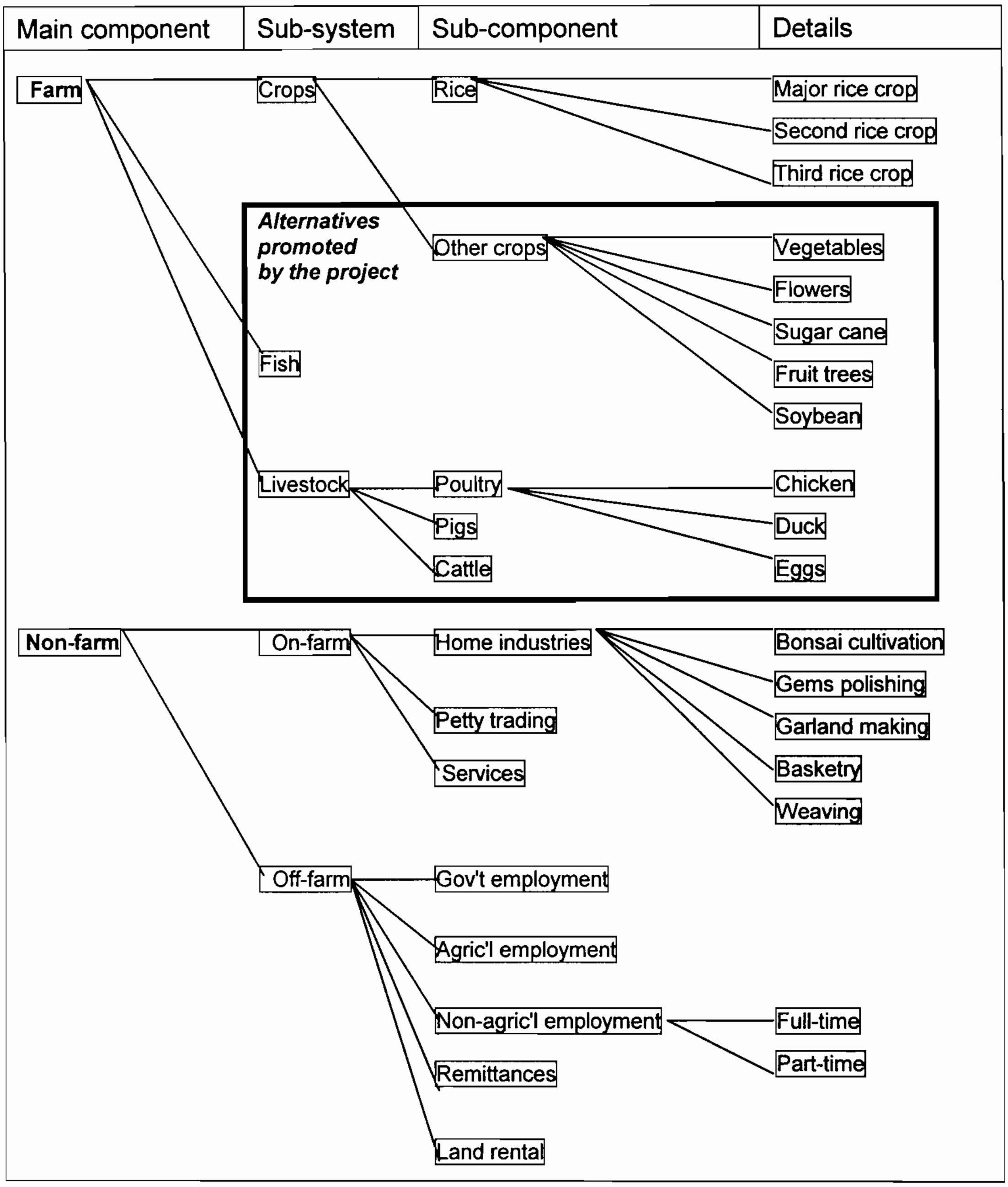
The six provinces selected represent distinctly different agro-ecological conditions, but more so, different conditions as far as exogenous factors are concerned, such as off-farm employment opportunities. The six provinces studied are reasonably representative of the conditions in the 'rice bowl' of Thailand, i.e. the Central Plain (Ayuthaya, Angthong, Supanburi, Lopburi) and the Central North (Kampaengphet, Phitsanulok).

TABLE A-1: QUOTA SAMPLES SELECTED FOR THE BASELINE SURVEYS IN SIX PROVINCES, 1994 AND 1995

Two baseline surveys	Provinces	**Project Group**	**Non-project group**	Total
1994, covering the first year of the pilot project in four provinces, crop year 1993/94 (Repeat survey of the same respondents in 1995)	Lopburi	32	21	53
	Angthong	30	20	50
	Ayuthaya	30	20	50
	Supanburi	30	26	56
	Subtotal	122	87	209
1995, covering the first year of the national restructuring project, selecting two provinces in the lower north	Phitsanulok	30	21	51
	Kampaengphet	30	20	50
	Total	182	128	310

Note: The original sample design aimed at a comparison between the project-group farmers with those in a control group, the 'non-project group'

FIGURE A-1: COMPONENTS OF FARM HOUSEHOLD INCOME AND THE MAIN ALTERNATIVES TO 'RICE ONLY' PROMOTED BY THE DIVERSIFICATION PROJECT (SMALL INSET BOX)



Note: The systematic shown in this figure is based on the guidelines for farm income analysis issued and published annually by the Office of Agricultural Economics (for example, OAE, 1998)

TABLE A-2 : THREE GROUPS OF FARMERS: 'INNOVATORS' VS. 'NON-INNOVATORS' BY PROVINCE

Groups		Definition	Number of households							
			Provinces						Total	
			L	A	Ay	S	P	K	No.	%
'Innova-tors'	1. Self-support group	Farmers who initiated diversification independently	9	12	8	23	7	11	70	22.6
	2. Project-support group	Farmers who diversified with the help from the project (credits and advisory services)	26	26	27	24	29	25	157	50.6
'Non-innova-tors'	3. Non-diversifying group	Farmers who did not take any initiative towards diversification (although the Projects were available in the district)	18	12	15	9	15	14	83	26.8
Total	All respondents by province		53	50	50	56	51	50	310	100

Central Region: Pilot provinces in 1993/94
L – Lopburi, A – Angthong
Ay – Ayuthaya S – Supanburi

Northern Region: Provinces joining in 1994/95
P – Phitsanulok
K - Kampaengphet

TABLE A-3: LAND TENURE STATUS BY GROUP

Land tenure status	Group 1 70 self-support farmers	Group 2 157 project-support farmers	Group 3 83 non-diversifying farmers
Proportion of land owned (as percentage of total farmland)	80	64	47
Proportion of land rented (as percentage of total farmland)	15	25	44
Others (rented out and wasteland)	5	11	9

TABLE A-4: LABOUR STRUCTURE AND LABOUR FORCE BY GROUP

Labour structure	Group 1 Self-support farmers	Group 2 Project-support farmers	Group 3 Non-diversifying farmers
(a) Full-time farming	51%	47%	35%
(c) Farming with part-time employment	13%	12%	28%
(d) Others (outside work and not working)	36%	41%	37%
Labour force (persons per household)	2.6	2.5	2.5

TABLE A-5: REASONS FOR NOT ADOPTING DIVERSIFICATION AS OFFERED BY THE PROJECT (GROUP 3)

Reasons	Percentage (multiple choice)
Land constraints	54
Labour constraint s	34
Preference for existing system	23
Capital constraints	14

TABLE A-6: SUMMARY RESULTS OF FOCUS GROUP INTERVIEWS CONDUCTED IN 1996-1999

Reasons for giving up on fruit trees and converting the land back to rice (1995 - 1996):
- Flood damage in August 1995, affecting all study areas, and destroying the new orchards of some farmers who then gave up
- Labour constraints proved too heavy, so it was not possible to maintain the new orchards
- Back to sugar cane in 1997, because the price was attractive again
- The Kiew Savoy variety of mango is too difficult to cultivate for farmers without specific experience
- Fruit tree seedlings provided by the extension service were not good

Focus group interviews (1997-1999):
- Fruit prices dropped from 1997 (economic crisis - market demand shrinking)
- Good rice price, but low orchard price
- Stocks for fruit trees unavailable in some localities due to increasing demand
- Kiew Savoy continues to be disappointing in yields and too demanding in maintenance
- Labour constraints increasing, as orchards had grown and needed more attention
- Blaming the extension officers for luring the farmers into a costly 'adventure', ending up in debt

References

Binnie and Partners (Overseas) Ltd., 1997. *Chao Phraya Basin Water Management Strategy* (Main Report), Bangkok

Chudleigh, Peter D., 1984. *Report of Agricultural Systems Advisor*, Integrated Rainfed Farming Research and Development Project, Farming Systems Research Institute, Department of Agriculture, Ministry of Agriculture and Cooperatives, Bangkok

Chula Unisearch, 1996. Final Evaluation Report on Agricultural Restructuring and Adjustment Project submitted to the Budget Bureau Office, Chulalongkorn University, Bangkok (in Thai)

Department of Agricultural Extension (DOAE), 1994. *Alternatives for Agricultural Production: The Project for Restructuring Agricultural Production*, Bangkok (in Thai)

Judd, L.C., 1989. *In Perspective: Trends in Rural Development Policy and Programs in Thailand 1947-1987*, Research Report Series No. 41, Payap University Center for Research and Development, Chiang Mai, Thailand.

Kammeier, Hans Detlef, 2000. "Thailand's Incomplete Decentralization Process: Policy Options for Further Local Government Reforms", in: Hans Detlef Kammeier and Harvey Demaine (eds.), *Decentralization, Local Governance and Rural Development*, Bangkok: AIT, pp. 173 – 207.

Ministry of Agriculture and Cooperatives, 1998. *Handbook for the Programme on Restructuring and Adjusting Agricultural Production*, Bangkok (in Thai)

Muscat, Robert J., 1994. *The Fifth Tiger: A Study of Thai Development Policy*, Tokyo: United Nations Univ. Press

Norman, D. W., F. D. Worman, J. D. Siebert, and E. Modiakgotla, 1995. *The Farming Systems Approach to Development and Appropriate Technology Generation*, FAO Systems Management Series, Rome: FAO

Office of Agricultural Economics (OAE), 1998. *Agricultural Statistics of Thailand, Crop Year 1996/97*, Ministry of Agriculture and Co-operatives, Bangkok (in Thai)

ORSTOM, Kasetsart University, 1996. *Agricultural and Irrigation Patterns in the Central Plain of Thailand: Preliminary Analysis and Prospects for Agricultural Research and Development (DORAS Project)*, Bangkok.

Pasuk Pongpaichit and Chris Baker, 1998, *Thailand's Boom and Bust*, Chiang Mai: Silkworm Books

Pretty, Jules N., 1995. *Regenerating Agriculture: Policies and Practice for Sustainability and Self-Reliance*, London: Earthscan.

Rigg, Jonathan, 1997. *Southeast Asia: The Human Landscape of Modernization and Development*, London: Routledge

Siriluck Sirisup, 1993. "Farming Systems Research and Development, and Rural-Regional Planning", SPRING Working Paper No. 8. Dortmund (Germany): Faculty of Spatial Planning, University of Dortmund.

Siriluck Sirisup, 2000. "Government Policy and Farmers' Decision-Making in Thailand: Agricultural Diversification Programme in Rice-Farming Areas of the Chao Phraya River Basin, 1993 - 2000" (draft unpublished research report, publication expected in 2001)

Team Consulting Engineers Co., Ltd., 1993. *Managing Water Resources to Meet Megacity Needs, Case Study of Bangkok Metropolis*, Bangkok

Van den Ban, A.W. and H.S. Hawkins, 1996. *Agricultural Extension*, Oxford: Blackwell Science (second edition)

Warr, Peter G. (ed.), 1993. *The Thai Economy in Transition*, Melbourne: Cambridge University Press

การเกษตรแบบมีสัญญาผูกพันในภาคกลาง: กรณีศึกษากลุ่มเกษตรกรผู้ปลูกหน่อไม้ฝรั่ง จังหวัดนครปฐม

Contract farming in Central Plain: a case study of asparagus grower groups in Nakhon Pathom Province[1]

รองศาสตราจารย์ ดร. ชัชรี นฤทุม2

Assoc. Prof. Dr. Chatcharee Naritoom

Abstract: *Nakhon Pathom Province sited in the central plain of Thailand. The main products were rice, sugar cane, vegetable and animal production such as milk, chicken and swine by using irrigation system from Tha-Chin and Mae-klong rivers. Most of products were commercial and individual or group contract farming system. Asparagus was only one of group contract farming that farmers could get more advantage than individual contract. In Nakhon Pathom, farmers who grow asparagus could receive net income USD 7,438 per ha, meanwhile other vegetable only USD 2,784 and rice USD 227. The sustainable of asparagus growers group contract farming depended on: (1) collaboration of farmers on produce high quality of asparagus production by using local inputs (2) agri-business and government agency should seek new market and new product for future (3) training new technology for high quality and market knowledge were need. Developing of this group contract farming to be active co-operative can use as case study for other agriculture production.*

จังหวัดนครปฐมตั้งอยู่ในพื้นที่ภาคกลาง มีการผลิตทางการเกษตรหลักที่สำคัญคือ ข้าว อ้อย พืชผักชนิดต่าง ๆ รวมทั้งการเลี้ยงสัตว์ เช่น โคนม สุกรและไก่ โดยอาศัยระบบน้ำชลประทานจากแม่น้ำสายสำคัญคือ ท่าจีนและแม่กลอง

การผลิตดังกล่าวข้างต้นเป็นการผลิตเพื่อการค้าและส่วนใหญ่เป็นการผลิตภายใต้สัญญาผูกพัน เช่นการปลูกอ้อย หน่อไม้ฝรั่ง เลี้ยงไก่ โดยมีรูปแบบของสัญญาผูกพันที่แตกต่างกันทั้งในรูปการทำสัญญาเดี่ยวและเป็นกลุ่ม

หน่อไม้ฝรั่งเป็นพืชชนิดเดียวที่เป็นการเกษตรแบบมีสัญญาผูกพันระหว่างกลุ่มเกษตรกรกับผู้รับซื้อ (ยกเว้นโคนมซึ่งทำเป็นรูปของสหกรณ์) ซึ่งมีข้อดีสำหรับกลุ่มเกษตรกรคือ สามารถตกลงราคาใหม่ทุกปี (ลดความเสี่ยงด้านราคาไม่แน่นอน) สามารถขายผลผลิตได้ทั้งหมด (ลดความเสี่ยงด้านผลิตแล้วไม่มีตลาด) ได้รับความรู้และเทคโนโลยีใหม่ ๆ จากผู้รับซื้อและหน่วยงานของรัฐ (รักษาคุณภาพของผลผลิต) เป็นต้น ส่วนผู้รับซื้อสามารถตกลงซื้อขายกับตลาดล่วงหน้าโดยไม่เสี่ยงทั้งด้านราคา คุณภาพและปริมาณ

หน่อไม้ฝรั่งให้ผลตอบแทนต่อไร่ประมาณ 42,000 บาท ในขณะที่การปลูกผักอื่น ๆ ได้รับเพียง 29,000 บาท และข้าวเพียง 2,600 บาท การผลิตหน่อไม้ฝรั่งโดยมีสัญญาผูกพันแบบกลุ่มจะมีความยั่งยืนหรือไม่

---

[1] The International Conference on The Chao Phraya Delta: Historical Development, Dynamic and Challenges of Thailand's Rice Bowl, 12-14 December 2000, Kasetsart University, Bangkok.

[2] The National Agricultural Extension and Training Center, Kasetsart University, Kamphaengsaen Campus, Nakhon Pathom Province 73140, E-mail: eatchn@ku.ac.th

ขึ้นอยู่กับสมาชิกกลุ่มเกษตรกรที่ต้องร่วมมือกันผลิตหน่อไม้ฝรั่งที่มีคุณภาพ ปราศจากสารพิษตกค้าง
โดยมุ่งใช้วัตถุดิบและเทคโนโลยีที่มีอยู่ภายในท้องถิ่นเป็นหลัก
ส่วนผู้รับซื้อและหน่วยงานของรัฐควรให้ความร่วมมือด้านการจัดหาตลาดเพิ่มขึ้นทั้งในด้านปริมาณและชนิดของสินค้าเกษตร
นอกจากนั้นควรให้ความรู้ด้านการผลิตและการตลาดแกเกษตรกร การผลักดันให้กลุ่มเกษตรกรผู้ปลูกหน่อไม้ฝรั่ง
(หลังจากเรียนรู้กระบวนการกลุ่มมาแล้ว)
ก้าวไปสู่การเป็นกลุ่มสหกรณ์ที่เข้มแข็งจะเป็นแนวทางสำคัญในการพัฒนาระบบการเกษตรแบบมีสัญญาผูกพันที่การผลิตทางการเกษตรชนิดอื่น ๆ
สามารถนำไปใช้เป็นกรณีตัวอย่างได้

1 Introduction

The agribusiness development in Thailand has demonstrated remarkable progress during the last 15 years. A key factor in support of the successful transformation from traditional to commercial agriculture has been the dynamic adjustment of Thai farmers and agribusiness entrepreneurs to the varying needs of world market (Chaiwat, 1996). In the 6th Economic and Social Development Plan(1987-1991), the Thai government adopted the policy to develop agricultural production systems to serve agro-industry development and world markets. This policy emphasizes the reduction of risk of agricultural product prices, a steady market and guaranteed price, and the improvement of the quality and quantity of production with high market demand. The strategy to achieve these policies is to support the collaboration of agribusiness and farmers through "contract farming" under the supervision of government agencies. Now, contract farming has spread through each region of the country that is suitable for a given commodity with or without support from the government. In Thailand, contract farming has several patterns depending on the commodity, farmers, agribusiness companies, and the agreement between them.

This study intends to understand the process, development, and problems of each system of contract farming, and to define their potentialities and constraints for further development. A methodology should be derived to help in forming contract farming for the purpose of stabilizing agricultural production.

All data and information used in this study come from secondary data and from in-depth interviews with farmers and related persons who were engaged in each system of contract farming. All these details will contribute to make clearer the system of contract farming in Thailand.

2 Importance of contract farming in agricultural development

As the world market became more competitive, processing firms placed top priority on product quality. Furthermore, expansion of business depended heavily on the reliability of supply of good quality raw materials at reasonable cost. Contract marketing and contract farming had been employed to serve these purposes for some firms (Aree,1997). So contract farming plays an important role for agricultural development in the following issues.

1. The potential of agriculture production: - Farmers can produce the new commodities by using new technologies and materials provided by agribusiness firms. On

the other hand, farmers can produce continuously for agribusiness firms according to their high quality control

2. The potential of marketing: - Agribusiness firms buy all the production from the contract farmers all year long, so that farmers have no risk for marketing. On the other hand, usually contract commodities are export goods for the world market and the price will generally be higher than for common, non export goods.

3. The support from the government: - the government sets policies to support this kind of collaboration, and provides infrastructure and input to catalyses this program. On the other hand, the government ensures the contracts are fair for the two sides. In cases of conflict, the government will also intervene

4. The profits of contract farmers and agribusiness firms: - From points 1 and 2, contract farmers and agribusiness firms receive profits from this business such as technical know-how, input, high and stable price. Agribusiness firms can contract and sell the products in advance on the world market and can generate high profits from this.

3 Development of contract farming in Thailand

Contract farming in Thailand, similarly to other countries in the world, has both verbal and written forms, but whereas verbal contracts or agreements have a long history, the written form is a much more recent development (T. K. Warley, 1967).

The verbal contracts farming has a long history and starts with surpluses from consumption of agricultural products such as rice, and develops to other commodities such as fruit, vegetables, field crops and animal production. This kind of contract farming uses the advantage of long relationships established between middlemen and farmers, and the honesty of farmers.

Written contract farming started with the coming of new agribusiness firms (Thai and alliance companies) who needed to export some commodities such as vegetables and fruit to serve industrial countries, especially during winter. Those agribusiness companies collaborated with the Thai government (the Ministry of Agricultural and Cooperative) who has a policy to develop and help farmers to achieve better living standards. This written contract farming uses government assistance to have farmers join the project. Usually this kind of contract will be signed between the agribusiness company and farmer's group and be witnessed by government officials.

4 Contract farming in Nakhon Pathom

4.1 Types of commodities

The agribusiness firms using contract farming have 4-5 types of agreement that can be divided by middlemen and commodities as stated below:

(a) Sugar cane

In the western region of Thailand, the province of Kanchanaburi has 2 or 3 sugar mills along the riverside of the Mae-klong river. To make sure that their factory have the raw materials that they need, all the sugar mills have their own land to produce sugarcane, but it is not sufficient so they need to ask “quota men” or “toa-kae” to collect certain amounts of sugarcane from farmers for their factory. The sugar mill will provide fertilizer and money for farmers through the quota men and quota men will also manage land preparation, labor for planting and harvesting, trucks for carrying sugar cane to the factory, and some chemicals such as pesticide and extra fertilizer for their farmers who are called “luk-rai”. The sugar mill and quota men will sign a loose agreement on the amount of sugar cane to be produced. Quota men and farmers usually do not sign a written agreement because quota men are village middlemen who often have large farms in the same village of the farmers and some are even relatives of the farmer (Mr. Vichai). (Fig.1)

(b) Baby corn

Nakhon-Pathom province is the main area for baby corn production. Farmers in this area mostly grow baby corn by contract with the village middlemen. Village middlemen also contract with “toa-kae” or “kiew”, or local middlemen, who give farmers the seeds, fertilizer, loan of tractors to prepare land and some money for daily earnings if they need it. On the other hand, the products had collected by village middlemen for peeling or some send the produce directly to local middlemen for peeling before being sent to Bangkok or abroad. The contract between farmers and village middlemen involves guaranteeing a minimum price for baby corn. However, if the market price is higher than the guaranteed price, farmers are able to obtain this higher price. (Mr. Sutaum and Mrs. Thong-dee) (Fig.2)

(c) Broiler

Contract broiler farms started more than 15 years ago with the largest agricultural enterprise, named C.P Company. Now more than 10 companies are dealing with this kind of contract farming. In Nakhon-Pathom, farmers invest to prepare the chicken coop and some materials for raising broiler chickens by themselves. The company gives them the baby chickens, feed and medicine, through the local middlemen. After 45 days , the local middlemen receives those broilers from the farmer and sends them back to the company factory(Fig.3). He gives the farmer 1.5 baht per head. In this kind of contract farming, it seems that farmers are workers of the company, raising chickens with their own investment and land. But in the opinion of the farmer, they say that risk is low for them because they invest only for the chicken coop and do not pay anything for materials. (Mrs. Boon-ma)

(d) Asparagus

The largest area of asparagus growing in Thailand is Nakhon Pathom province, particularly in the Kampaengsaen district. The asparagus grower groups in Kamphaengsaen started in 1989 and contracted with 3 agribusiness companies. The main condition of the contract is to guarantee a fixed price all year by quality grading of the asparagus. Technical support and advice are given to farmers by technicians of the agribusiness companies and government agencies in that area. The contract is signed between the group and the company, while the government agency plays the role of witness. In cases where some farmers do not like this process, he will not join the group and will sell his product directly to individual middlemen (Fig 4).

(e) Safety Vegetables (Non Toxic)

Nakhon Pathom province is only 30 kilometers from Bangkok, and has a wholesale vegetable market in the evening the whole year round. Eight percents of agricultural production in this province are vegetables. The Agricultural Extension Provincial Office of Nakhon Pathom therefore establishes farmer groups to produce vegetables under enclosed nets so as to prevent insect damage and reduce the need for chemicals. These so-called "safety vegetables" are sent to supermarkets in Bangkok and surrounding provinces with a fixed price by managing of extension officers. The farmers who register to be members of the group will receive free material when they start, such as net, building material, organic matter to produce organic fertilizer and some seeds, etc. The technical support and advice will be given to farmers by the government agencies. No contract is signed between farmers and agribusiness companies but extension officers will have a verbal contract with farmers to establish a guaranteed price, such as 10 bath per kilogram all year round. Most farmers will collect their products, package them in a large container and sell directly to the extension officer. The extension officer will re-pack these in smaller package, label them "safety vegetables" and send to supermarkets (Mrs.Pa). Now this kind of activity is diffusing to other provinces such as Ratchaburi, Kanchanaburi, Supanburi with the support of the government and agribusiness companies such as the CP. Group. (Mr. Sumeth)

(f) Dairy Cattle

Most of farmers who raise dairy cattle in Nakhon Pathom keep 2-5 dairy cattle and grow baby corn in an area of generally 2-3 rai. Thus an integrated farming system is used because baby corn stem will be the roughage feed for cattle and also cattle dung is used as manure for baby-corn fields. The dairy cattle farmer registers to be a member of the dairy cattle cooperative near their farm. The price of his product depends on the quality of milk but there is also a guaranteed minimum price. Usually farmers borrow money from the cooperative or the Bank of Agriculture and Agricultural Cooperatives (BAAC) for their first investment. (Mr. Laun)

4.2 Type of contract farming

From the six commodities described above, by emphasis on the farmer who engage in contract farming system and characteristics of contract farming system, we can divide the contract farming pattern in Nakhon Pathom into 3 types as described below:

(a) Individual Directed Contract Farming (IDCF)

This type of contract farming is more popular in Thailand as a traditional system of marketing agricultural product such as vegetables, rice or swine. Each farmer will sell his products to middlemen with whom they had a contract before. This type has verbal agreement between both of them. The farmer will buy materials himself or obtain credit from middlemen. This debt will be cleared after the farmer sells his products to the middlemen. Farmers of this kind of contract farming may feel free or independent but there is a risk with price fluctuation in the market.

(b) Individual Sub-Contract Farming (Through Quota Middlemen) (ISCF)

This type of contract farming is concerned with the agro-industry or agribusiness companies (such as sugar cane, baby corn, broiler-chicken) that need raw material for their factories. The company needs some middlemen to supply a given quota and lets them identify farmers to be the members. The company supplies farmers with some material to maintain the quality of production and collects their products. In this kind of contract farming, farmers will have security with the market because of the minimum price of product and some support from their middlemen or company.

(c) Farmers Group Contract Farming (FGCF)

This type of contract farming is quite new, it started around 10-15 years ago with the government policy to increase commodity exports to the world market such as vegetables (asparagus, okra, vegetable soybean). The agribusiness companies which export this products to the world market need to control both quality and quantity of the production, so they must deal directly with contract farmers to set up the farmer groups with support from the government. In this type of contract farming, farmers will have more power and security with the market and price of products but they must manage their farm under the directions of the group.

4.3 Characteristics of 3 types of contract farming

Table 1 summarizes the main characteristic of each contract farming type

(a) Characteristics of Agreement

For individual contract farming, there is no written agreement but only a verbal agreement between farmers and middlemen base on trust. So there is no standard quality of product and no fixed price. It is different from group contract farming in which farmers set up groups and sign written agreements with agribusiness companies under the eye of the government type agency. This kind of agreement includes guaranteed product prices and quality standard. Another contract farming is through quota middlemen which quota middlemen and companies sign up loosely written agreements.

(b) Characteristics of Commodity Produced

Each type of contract farming produces different commodities i.e. individual contract farming has no written agreement, no quality standards for the product, so the quality of the production from this type is unfit for export and is reserved for local consumption only. On the contrary, group contract farming has strong agreements regarding quality standards, so most products from this type are for export. On the other hand, quota middlemen of contract farming aim to collect raw materials for factories such as sugar cane, broiler or baby-corn.

(c) Characteristics of Investment

Usually, Thai farmers invest in basic fixed costs such as land, housing, and family labor for cultivation. Only some varied input such as seeds, fertilizer, pesticide or labor hire may need support from outside agencies and this depends on the type of contract farming involves. In individual contract farming, farmers have cash to buy such varied inputs at the agricultural shop near their farms. If farmers have no cash, they will get these inputs from middlemen with interest, and middlemen will clear this debt when farmers sell their products to them. For group contract farming, the agribusiness companies need a high quality of product to compete in the world market. Farmers must use certain varieties, safe chemicals required by the market, so agribusiness companies and government agencies try to convince farmers' groups by supporting some inputs and technology at the beginning. Also, for the quota middlemen contract farming system, the factory supports the farmer with some inputs through quota middlemen, and also quota middlemen support the farmers with their tractors for plowing and cars for transportation when the farmer need heavy machines.

(d) Characteristics of Marketing

Most agricultural products are collected by middlemen, farmer groups or cooperatives, and sent to factories, local market or are exported. The different characteristics of marketing of each type of contract farming are the price and the demand for products. In individual contract farming, the product price will fluctuate with the market situation and depends on marketing demand and supply from the farmer's side. But for group contract farming, the price is fixed all year long with a standard quality and demand for product. For quota middlemen contract farming, the price is fixed at the minimum and all the production goes through the quota system from the factory that ensures no risk with the marketing situation.

4.4 The group contract farming system and its merits

(a) The Merits of Contract Farming

From the type and characteristics of contract farming that discussed above, we can sum up the merits of contract farming in this way

(1) Farmer advantages

- Input support: provided with certain inputs such as seed, fertilizer, and chemicals at basic prices and high quality by agribusiness companies.
- Technology transfer: receive technology transfers from agribusiness companies on the basis that the market requires high quality products
- Price fluctuation risk reduced: product price guaranteed, either at a minimum level or a fixed year round.

TABLE 1 CHARACTERS OF 3 TYPES OF CONTRACT FARMING IN WESTERN REGION OF THAILAND

Type	4.4.1 Characteristics of				Potential or constraint
	Agreement	Commodity	Investment	Marketing	
I. IDCF	Non or verbal or gentlemen agreement	local consumption goods such as vegetables, baby corn	Most of invest by farmer and some part from middlemen with interest	Local middle men come to collect the product with the market price	Farmer feel free but risk with the product price and no support from other
II. ISCF	Loosely written agreement between factory and quota middlemen	Raw material for agro-industry, or export good such as sugar cane, baby corn or broiler.	Most of invest by farmer and some part from factory through local middlemen	All product collected by quota middlemen and send directly to factory or exporting company	Farmer secure with product price and market, and some materials support from factory pass through the quota middlemen
III. FGCF	Written agreement between group and agribusiness company	Export good that need high quality of product such as asparagus, non poison vegetable	Agribusiness company support some input and technology to get high quality of product	All product collect by group with fixed price all year and standard quality	Farmer or group have power and feel secure with product price and market, and more support from the other

Remark: - IDCF = Individual Directed Contract Farming
ISCF = Individual Sub-Contract Farming
FGCF = Farmers Group Contract Farming

(2) Agribusiness advantages

- Constant adequate supply of raw materials
- Ease of factory management
- Cost management: agribusinesses can predict management costs and calculate business profits

(3) Government advantages

- Reduce product oversupply and price fluctuation
- Establishes corporation among farmers, agribusiness companies and government officers

(b) Merits of the Group Contract Farming System

Contract farming merits are as follows

(1) For farmers

- Similar to individual contract farming
- bargaining power increased through collective organization
- Fostering from government and agribusiness

(2) For agribusiness

- Similar to individual contract farming
- Easy to collect product from group points.
- Easy to communicate with farmers through the group
- Easy to control the quality and quantity of product through agreed group standards

(3) For government

- Similar to individual contract farming
- Easy to communicate with farmers through the group
- Easy to support or foster farmers as a group

5 Asparagus grower group in Nakhon Pathom

5.1 General features of asparagus cultivation

Asparagus was introduced for cultivation as a commercial crop in 1972 under the King's initiative to demonstrate and practice cooperative systems. The crop was first cultivated in Nakhon Pathom in 1989 within the group contract farming system and this spread to nearby provinces. The study area now has five contract farming asparagus growers' groups comprising 385 members and 685 ha of cultivation area.

5.2 Asparagus production and its export value

Since its introduction in 1956, asparagus in Thailand has been produced for home consumption and export. In recent years, Thailand has begun selling asparagus to Japan and to some European countries (Table 2) and it has therefore become an important export crop(Table 3). Fresh/chilled vegetables such as this one are in high demand by the agribusiness companies as they do not need to be processed with expensive equipment. But there are very few studies about the process of diffusion and development of this new crop.

TABLE 2 GREEN ASPARAGUS EXPORT FROM THAILAND TO OTHER COUNTRIES 1991-1994

Volume (tons), Value (USD1,000)

Country	1991		1992		1993		1994	
	Volume	Value	Volume	Value	Volume	Value	Volume	Value
Japan	2,345	7,676	2,093	6,108	2,184	6,804	2,044	7408
Hong Kong	19	61	14	58	15	57	17	61
Europe	6	12	14	94	42	159	125	428
Australia	12	39	41	127	47	174	48	202
Others	13	60	22	10	41	98	41	121
Total	2,395	7,848	2,184	6,397	2,329	7,292	2,275	8,221

Source: Department of Business Economics, 1995; 2

TABLE 3 EXPORT VALUE OF FRESH/CHILLED VEGETABLES AND ASPARAGUS IN THAILAND

Year	Fresh/chilled vegetable	Fresh/chilled asparagus
1991	19,613.8	7,812.7 (39.8%)
1992	40,104.4	6,394.2 (15.9%)
1993	34,837.7	7,292.1 (20.9%)
1994	40,401.6	8,221.7 (20.4%)
1995	37,757.4	6,706.6 (17.8%)

Source: Agricultural Statistics of Thailand Crop Year 1995/1996 (USD 1,000)

Note: Fresh /chilled vegetable: Bamboo-shoots, Asparagus, onion, shallot, garlic, leeks and other fresh or chilled vegetables.

5.3 History of asparagus cultivation in Thailand and the study area

5.3.1 History of asparagus cultivation in Thailand

In 1956, a Kasetsart University professor introduced an American asparagus variety called 'Mary Washington', and conducted experiments at the Bang Khaen campus of the university in Bangkok. Later, asparagus production expanded to some commercialized and modernized farms in Chiang Mai, Phetchabun and Chon Buri. At that time, these farms could grow asparagus quite well but asparagus varieties and growing technology was not widely available to the farmers. Asparagus produce was only grown for the local market (with green asparagus sent to high standard hotels or big restaurants) or factory processed (white asparagus for canning and direct consumption, replacing imported asparagus. (Laowapoalaya, T -).

The first drive to grow asparagus as a commercial crop was undertaken in 1972 as part of the Hup-ka-pong King's Project in Phetchaburi province in southern Bangkok (The Hup-ka-pong King's Project was a collaborative project with the Israeli government to promote and set up a demonstration cooperative for project member farmers) . The asparagus produced as part of the King's project was largely sent direct to their cooperative and sold to Thai Airways Cuisine at an all year round fixed price of THB50-60/kg (USD2-2.4/kg). Any surplus was sent to markets in Bangkok for local consumption and export.

The farmers living near the project obtained this asparagus variety and the corresponding cultivation techniques from project members. They began to grow this new crop and sold their products to middlemen. The export of asparagus started around 1973, but quantity remained low at 290 kg a year (Kosum, 1985). At the peak of the export period (the Northern Hemisphere winter, when Japan and European countries sought vegetable imports from tropical countries to replenish their stocks), many middlemen visited Hup-ka-pong village and surrounding villages to buy asparagus from outside project farmers. They paid a higher price than the peak local summer tariff and, in doing so, destroyed the group system of Hup-ka-pong village.

Hup-ka-pong is located 120 km south-east of its main market, Bangkok. Conditions for agricultural there were poor. Its irrigation system was inadequate, the soil was infertile, there were many diseases and pests, input costs were high and the marketing was unstabilized.

In 1987, the Ministry of Agriculture and Cooperatives announced that farmers who wanted to grow asparagus must register with the extension office in 'the agro-economic zone for asparagus'. A total of 15 districts in nine provinces (Phetchabun, Prachuap Khiri khan, Ratchaburi, Kanchanaburi, Phetchaburi, Nakhon Pathom, Nonthaburi, Rayong and Nakhon Ratchasima) were appointed for asparagus cultivation to enable the ministry to predict and manage the level of asparagus production. The district of Bang Len is the sole agro-economic zone for asparagus production in Nakhon Pathom province (Agriculture Statistics Center, 1988).

But Bang Len district is not suitable for asparagus cultivation. The soil is loamy, which causes it to remain damp during the rainy season and thus leaves the crop vulnerable to attack by pests. All product grown in this is sent to Taniyama Siam Co. (a Japanese firm). (Sataapornvorasakdi, 1997)

5.3.2 History of asparagus cultivation in the study area

The Asian Vegetable Research and Development Center (AVRDC), situated at Kasetsart University's Khampaeng Saen campus, in 1987 introduced many asparagus varieties from various countries for trial. The AVRDC selected two varieties - 'Block's improved' and 'UC. 309'-, which suited the climate of Thailand. The AVRDC also researched asparagus cultivation techniques including fertilizer formulations, watering systems, mother stem numbers and so on. (AVRDC. 1988)

The AVRDC, the National Agricultural Extension and Training Center (NAETC) and The Development Oriented Research on Agrarian System Project (DORAS) of Kasetsart University in 1989 jointly released these recommend varieties and cultivation techniques to farmers living in Thung Kwang village in Kamphaeng Saen. (Naritoom,1990 and 1991) They selected this village for these reasons

1. The farmers in this village had experience of growing vegetables and therefore were accustomed to intensive farming.
2. Seven farmers in this village expected to participate in this pilot project and three of them had been doing so on a farm trial. They were motivated to begin producing this new export vegetable because its price was more attractive than other vegetable crops.
3. The village soil was loamy and of the type suitable for asparagus growing. There was also an adequate irrigation system.
4. The village is situated 70 km. or 2 hours from the main market, Bangkok, and 30 km. or 40 minutes from the minor local market of Nakhon Pathom.

5.3.3 Development of asparagus grower group contract farming

Before the harvest of 1989, the AVRDC, NAETC, DORAS and the community's leader initiated and formulated the rules of the seven-member 'Thung Kwang asparagus growers group'. Membership of the group increased gradually until it entered into a contract with the Japanese agribusiness company Thai - Topy Co. The group then numbered 47 members, and planted a 32 ha area. (Table 4).

TABLE 4 EVOLUTION OF THE MEMBERSHIP OF THE THUNG KWANG ASPARAGUS GROWER GROUP 1989 - 1993

Year	Thai Topy Co.	Eastern Fruit Co	Ampol Food Co	Swift Co.	Total Members
1989	47	-	-	-	47
1990	47	77	-	-	124
1991	212	77	280	-	562
1992	-	77	537	-	614
1993 – now	-	-	-	74	74

Source: Memorandum of Thung Kwang asparagus grower's group meeting 1991-1997[3.38]

Other farmers in the village introduced the crop in 1990 and started production. However, Thai - Topy could only accommodate products from a 32 ha area. So another agribusiness company, Eastern Fruits Co., signed a contract with the new 77-strong group to buy produce from their 24 ha planting area

In 1991, farmers unattached to any group showed interest in joining in order to produce asparagus. However, as the existing two agricompanies were already fully supplied, the committee of the Thung Kwang Asparagus Grower Group signed a contract with the Ampol Food Processing Co. This new company accommodated crops produced from 80 ha of land by 280 new members.

The group by the end of 1991 thus had established contracts with three agribusiness companies. This period however also was marked by a series of problems, as listed below: (Memorandum of meeting from 1989 - 1993)

1. Production prices differed between the three agribusinesses companies.
2. The grading standard differed between the three agribusiness companies.
3. Group membership was too high, making it difficult to exchange opinions and information.
4. The contract farmer group committee could not control the members. Some members took their product to other companies that were offering better prices or accepting a lower standard of grading.

TABLE 5 ASPARAGUS PRICES AT FARM IN CROP YEARS 1989, 1991 AND 1999, UNIT: THB/KG

Asparagus grade	Muang group*			Thung kwang group**		
	1989	1991	1999	1989	1991	1999
AI	-	45	50	40	42	45
A	-	35	40	30	32	35
BI	-	26	31	26	28	31
B	-	-	-	21	23	26
C	-	-	-	5	6	20

Note: * Contract company is Taniyama Siam Co.

** Contract companies are Thai Topy Co., Eastern Fruit Co. and Ampol Food Processing (1989 and 1991), and Swift Co. in 1999

In 1998 Nakhon Pathom province has 5 asparagus grower group that contact with 3 agribusiness companies. Muang, Khampaeng Saen and Bang Len are the asparagus cultivation areas and all data is collected from this area (Table 6).

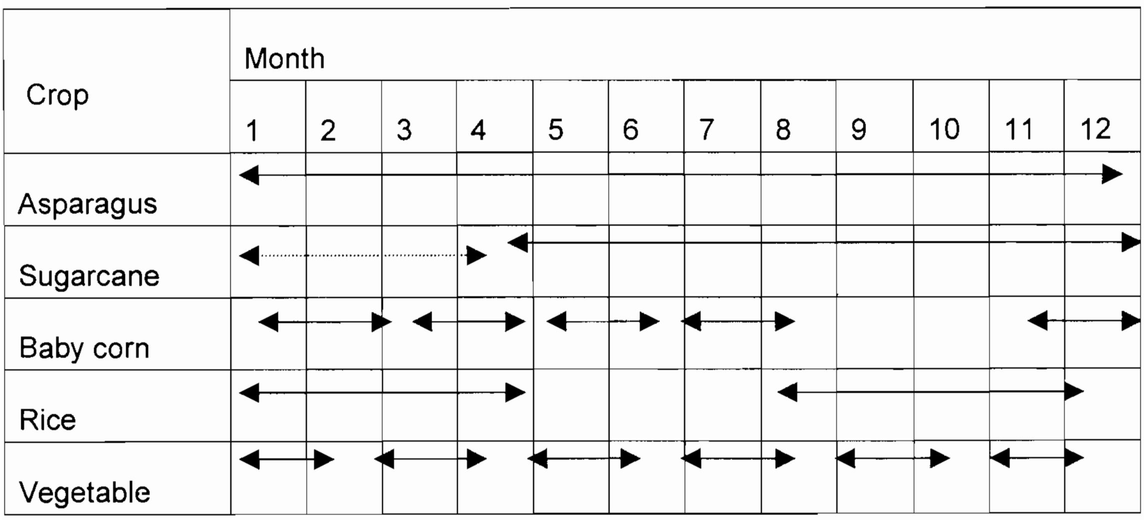
TABLE 6 NAME OF ASPARAGUS GROWER GROUP AND NUMBER OF MEMBER

Name of group	Location (District)	Number of	
		Member	Contract company
Thung Kwang	Khampaeng Saen	79	SWIFT.Co
Nong Tak Lan	Khampaeng Saen	89	Village middlemen
Muang (Nong Ngu Lauem)	Muang	234	Taniyama-Siam. Co.
Kaset Patana	Muang	77	Taniyama-Siam. Co.
Bang Pla	Bang Len	35*	Taniyama-Siam. Co.
Total		514	

Note: * All members quit from asparagus farming after flooding and pest damage in 1994

5.3.4 Diversification farming in asparagus grower group

Figure 5 shows the pattern of land use in the study area. Asparagus and sugar cane occupied land throughout the year. Baby corn was cultivated 4-5 times a year due to its short life of 45-60 days from planting to harvesting. The rainy season prevents it from being planted at all during August to November. Paddy refers to the while has the potential to be cultivated 2-3 times per year if it is the main crop. However, as the main crop in the study area was asparagus, paddy was cultivated only twice a year.



REMARK: ◄·········► HARVESTING AND NEW SUGARCANE SHOOTS

FIGURE 5 PATTERN OF LAND USE BY CROP

(1) Cropping Patterns

Table 6 and Figure 6 shows that farmers in Group 2 (Nong Tak Lan) on average cultivated the greatest range of commodities (3.2/farm) while farmers in Group 4 (Kaset Patana) ranked last with an average count of 1.5. Group 1 (Thung Kwang) and Group 3 (Nong Ngu Laeum) farmed nine different crops while Group 4 had only four kinds of commodity. Group 3 and Group 4 did not cultivate baby corn and rice.

Figure 6 shows a tree chart of cropping patterns. Cropping patterns for each Group are described below.

Example: Group 1 chart, Figure 6: The middle line, As14 indicates that 14 farmers grew asparagus. The figure Sc8[1] indicates that of these 14 farmers, eight grew asparagus and sugar cane. The figure Bc4[2] indicates that of the 8 farmers who grew asparagus and sugar cane, four grew asparagus, sugar cane and baby corn. The figure Ri2[3] indicates that of the four farmers who grow asparagus, sugarcane, and baby corn, two grew asparagus, sugar cane, baby corn and rice. The figure Ok1[4] indicates that of the two farmers who grew asparagus, sugar cane, baby corn and rice, one grew asparagus, sugar cane, baby corn, rice and okra.

The left-hand line, Ri2[5] indicates that of the 14 farmers who grew asparagus, two grew asparagus and rice. Ve1[9] indicates that of the two farmers who grew asparagus and rice, one grew asparagus, rice and vegetables. Ri2[6] indicates that of the eight who grew asparagus and sugar cane, two grew asparagus, sugar cane and rice. Ve2[10] indicates that the two who grew asparagus, sugar cane, and rice also grew vegetables. Fr1[11] indicates that of the 2 farmers who grew asparagus, sugar cane, rice and vegetables, one farmer grew fruit trees. Cat1[7] indicates that of the four farmers who grew asparagus, sugar cane, and baby corn, one farmer raised cattle. Cat1[8] indicates that of the two who grew asparagus, sugar cane, baby corn and rice, one raised cattle.

The right-hand line, Co1[12] indicates that of the 14 farmers who grew asparagus, one raised cows. Cat1[13] indicates that the one farmer who grew asparagus and raised cattle also raised cows.

TABLE 6 CROPPING PATTERN BY NUMBER OF FARMERS FARMING EACH COMMODITY

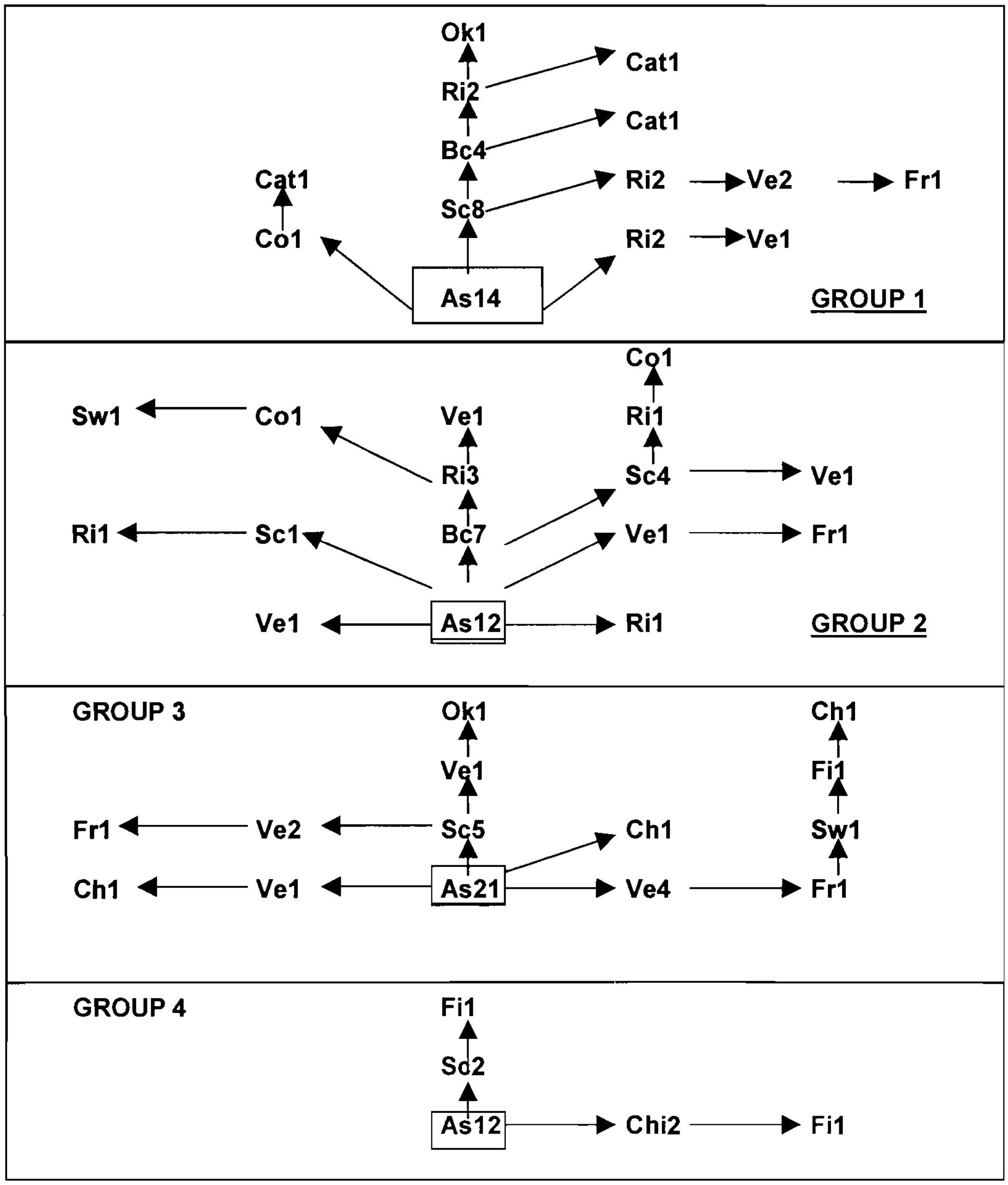
Unit = number of farmers (man)

Item	G1	%	G2	%	G3	%	G4	%
Number of farm households	14		12		21		12	
Asparagus	14	34.1	12	31.6	21	44.7	12	66.7
Baby corn or sweet corn	4	9.8	7	18.4	1	2.1	0	0.0
Sugar cane	8	19.5	5	13.2	5	10.6	2	11.1
Rice	6	14.6	6	15.8	0	0.0	0	0.0
Vegetables	3	7.3	4	10.5	10	21.3	0	0.0
Okra	1	2.4	0	0.0	1	2.1	0	0.0
Fruit trees	1	2.4	0	0.0	4	8.5	0	0.0
Cha-om (Acacia pennata, Willd.)	0	0.0	0	0.0	3	6.4	0	0.0
Cows	1	2.4	2	5.3	0	0.0	0	0.0
Cattle	3	7.3	0	0.0	0	0.0	0	0.0
Chicken	0	0.0	0	0.0	0	0.0	2	11.1
Swine	0	0.0	1	2.6	1	2.0	0	0.0
Fish	0	0.0	1	2.6	1	2.1	2	11.1
Total commodities	41	100.0	38	100.0	47	100.0	18	100.0
Average commodities per farm household	2.9		3.2		2.2		1.5	

Source: From author's survey

Note: Vegetables are peppermint, coriander, egg plant, Chinese key, spring onion, cabbage, cucumber, water spinach (Ipomoea aquatica.Forsk), young ginger, pepper,

G1 refers to the Thung Kwang Asparagus Growers Group
G2 refers to the Nong Tak Lan Asparagus Growers Group
G3 refers to the Nong Ngu Lauem Asparagus Growers Group
G4 refers to the Kaset Patana Asparagus Growers Group



Note: As = asparagus, Bc = baby corn, Sc = Sugar cane, Ri = rice, Ve = vegetable, Ok = okra, Fr = fruit, Co = cow, Cat = cattle, Chi = chicken, Sw = swine, Fi = fish, Ch = cha-om (Acacia pennata,Willd. Sub.sp insuavia nielsen)

FIGURE 6 CROPPING PATTERN OF EACH GROUP

(2) Farming Economics

Table 7 shows the average asparagus income per ha. of Group 4 (Kaset Patana) at USD 14,351.2 ranked the first while Group 2 (Nong Tak Lan) ranked last at USD 8,103.2. Total expenditure costs were greatest in Group 4 at USD 6,088.0 and lowest in Group 2 at USD 3,902.1. Average net income per ha of asparagus was greatest in Group 1 (Thung Kwang) at USD 9,322.4 and lowest in Group 2 (USD 4,201.1).

TABLE 7 AVERAGE INCOME OF ASPARAGUS FARMING
UNIT = USD

Item	Group 1	Group 2	Group 3	Group 4	Average
Cultivation area (ha)	0.4	0.3	0.4	0.4	0.4
Gross income/ ha	14,021.7	8,103.2	12,392.9	14,351.2	12,217.2
Variable cost/ha	4,476.8	3,708.5	4,130.2	5,578.9	4,473.6
Depreciation cost/ha	222.5	193.5	296.2	513.8	3.06.5
Total cost/ha	4,699.3	3,902.1	4,426.6	6,088.0	4,779.0
Net income/ha	9,322.4	4,201.1	7,966.3	8,263.2	7,438.3
Total net income/ farm household	3,729.0	1,260.3	2,947.5	3,057.4	2,677.8

Source: From author's survey

Note Group 1 refers to the Thung Kwang Asparagus Growers Group
Group 2 refers to the Nong Tak Lan Asparagus Growers Group
Group 3 refers to the Nong Ngu Lauem Asparagus Growers Group
Group 4 refers to the Kaset Patana Asparagus Growers Group

Table 8 found that asparagus generated the greatest net income per ha at USD 7,438.3, followed by vegetables (USD 2,783.5), baby corn (USD 867), sugar cane (USD 393.1) and rice (USD 227.1). However, when multiple cultivation cycles per year are taken into account, four times per year-harvested baby corn can generate a net income per ha per year of USD 3,467.8, and rice, harvested twice a year, USD 454.1. The crop which generated the lowest net income per ha per year was sugar cane at USD 393.1.

TABLE 8 COMPARISON OF AVERAGE INCOME AMONG MAIN CROPS IN THE STUDY AREA
UNIT = USD

Item	Asparagus	Sugar cane	Baby corn	Rice	Vegetables
Cultivation area (ha)	0.4	2.7	0.7	0.8	0.2
Yield /ha (kg or ton)	0.0	1.9	71.6	111.2	664.0
Price / ton (USD)	0.0	15.8	426.3	112.3	314.9
Main gross product income / ha	12,217.2	1,179.2	1,191.8	487.6	8,167.5
Byproduct income/ha	0.0	0.0	89.0	0.0	6.7
Gross income/ha	0.0	1,180.4	1,280.8	487.6	8,174.2
Total cost/ha	4,779.0	787.3	413.9	260.5	5,390.7
Net income/ha	7,438.3	393.1	867.0	227.0	2,783.5
Time/year (time)	1.0	1.0	4.0	2.0	1.8
Total net income/ha/year	7,438.3	393.1	3,467.8	454.1	5,093.8
Total income/farm household	2,677.8	1,077.1	2,392.8	372.4	1,171.6

Source: From author's survey

(3) Farm Household Economy

Table 9 shows the non-farm income of Group 1 of USD 2,961.2 was the highest due to the presence of sugar cane middlemen who rented equipment such as tractors and trucks for sugar cane cultivation. Group 1 farm income was also the highest at USD 7,507.5, followed by Group 4 (USD 5,448.9), Group 3 (USD 5,112.3), and Group 2 (USD 2,924.8).

TABLE 9 COMPARISON OF FARM HOUSEHOLD ECONOMY

Unit = USD

Item	Group1	Group2	Group3	Group4	Total	Average
Non-farm income	2,961.2	511.9	179.6	1,175.5	4,828.2	1,207.1
Farm income	7,507.5	2,924.8	5,112.3	5,448.9	20,993.5	5,248.4
Total income	10,468.7	3,436.7	5,291.9	6,624.4	25,821.7	6,455.4
Family expenditure	3,138.9	1,317.1	2,695.2	3,695.2	10,846.4	2,711.6
Net income	7,329.8	2,119.6	2,596.8	2,929.2	14,975.3	3,743.8

Source: From author's survey

Note Group 1 refers to the Thung Kwang Asparagus Growers Group
Group 2 refers to the Nong Tak Lan Asparagus Growers Group
Group 3 refers to the Nong Ngu Lauem Asparagus Growers Group
Group 4 refers to the Kaset Patana Asparagus Growers Group

6 Conclusions

6.1 Contract types

We can state that the potentialities and constraints of these 3 types of contract farming are as follows:

(a) Potential

The group contract farming gives the highest potential to farmers. Because farmers can get more support (material, technology and technical assistance) from government agencies and agribusiness companies, the farmers feel more secure with the product price which be can negotiate year by year between the group and the company. For the company or factory, the group contract farming and quota middlemen give the highest potential to collect enough production for export or to serve his factory. On the other hand the company can estimate the cost of their business all year. Government agencies foster the spread of knowledge for farmers through farmer groups, and receive some financial support from the agribusiness companies.

(b) Constraints

The constraint of contract farming is the lack of freedom for the farmer who must cultivate according to markets, especially the group contract farming which is strongly directed and managed by the agribusiness companies. Some independent farmers cannot join this type of contract farming and attempt individual contract farming, but with the risk that the product price could fluctuate with the market situation.

It can be understood that each type of contract farming is adapted to each commodity, the flow of investment and marketing. Each type has its own historical back ground or developing process which makes it different in potential and constraints for both farmers, government agencies and agribusiness companies.

6.2 Problem and its solution

From the above discussion, We can state that each type of contract farming is important and useful for agricultural development in Thailand. But the most useful and that which provides more benefit to small farmers, is probably the group contract farming. But group contract farming is still limited and cannot spread to other commodities, even though this type of contract farming is very useful. On the other hand, some farmers who have been engaged in the group contract farming quit their groups. The sustainable of asparagus growers group contract farming depended on

(1) Collaboration of farmers on produce high quality of asparagus production by using local inputs

(2) Agri-business and government agency should seek new market and new product for future

(3) Training new technology for high quality and market knowledge were need.

Developing of this group contract farming to be active co-operative can use as case study for other agriculture production.

Acknowledgement

The author would like to thank Prof. Dr. Hiroshi Kumagai and Prof. Dr. Shun Suzuki from Tokyo University of Agriculture, Japan for their best advice of this article.

REFERENCES

Agricultural Statistics Center. 1988. Report on registration of asparagus growers 1987. Bangkok. (in Thai)

Aree Wiboonpoongse, 1997. The role of contract farming in agricultural transition in Thailand._Monograph.

Asian Vegetable Research and Development Center (AVRDC). 1988. Report on asparagus research 1987. Kasetsart University Bangkok. (in Thai)

Chaiwat Konjing. 1996. Agriculture and agribusiness development in Thailand during 1980's - 1990's . International Seminar on Development of Agribusiness and Its Impact on Agricultural Production. November 11-16,1996. Tokyo University of Agriculture. Tokyo, JAPAN.

Kosum, P. 1985. A study of cost and rate of return on investment in asparagus plantation at Hup-Ka-pong. Master's degree thesis (Accountancy) at Chulalongorn Unversity

Lao-vapao-laya, T. – Asparagus culture in Thailand. Thai manuscript

Memorandum of meeting of the Thung Kwang Asparagus Grower Group

Nakhon-pathom province agricultural extension office diary 1997. Agricultural statistic of Nakhon-pathom province 1997

Naritoom, C. and S. Suzuki. 1999. Classification and characteristics of contract farming in the west of Thailand. English manuscript

Naritoom, Chatcharee, et al. 1990. A typology of farming systems based on their functioning and history in Tambon Thung Kwang of Khampaeng Saen District. Kasetsart Journal (Social Science) 11:141-150(1990).

Naritoom, Chatcharee, et al. 1991. On-farm diagnosis on the intensification of vegetable cropping system for exports to improve the sustainability of small scale farming systems in the Khampaeng Saen area. The Kasetsart Journal (Social Science) 12: 118-127.

Sataporнvorasakdi, T.1997. Attitude of farmers in the western region toward green asparagus growing systems. Master's degree thesis (Agriculture Science) (Kasetsart University).

Warley. T.K. 1967. Agricultural producers and their markets. New York . p 505.

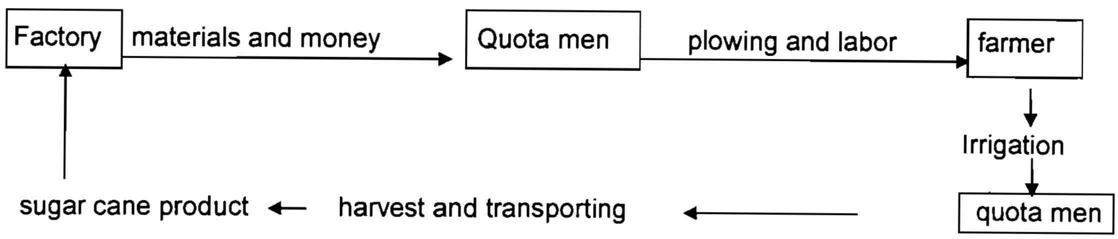


FIGURE 1 THE CONTRACT FARMING SYSTEM OF SUGAR CANE

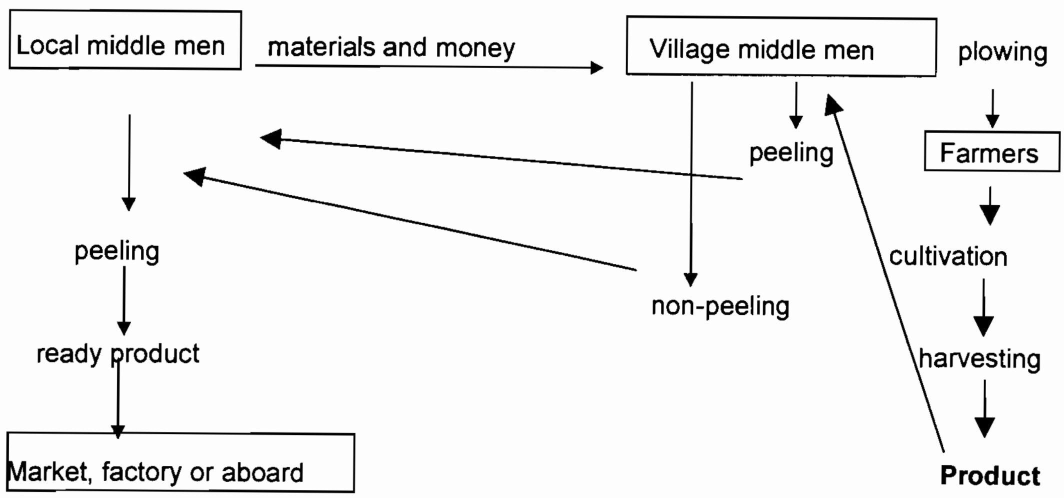


FIGURE 2 THE CONTRACT FARMING SYSTEM OF BABY CORN

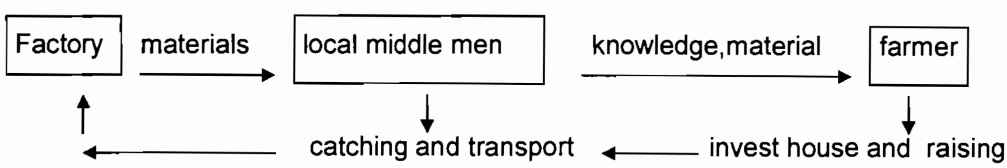


FIGURE 3 THE CONTRACT FARMING SYSTEM OF BROILER

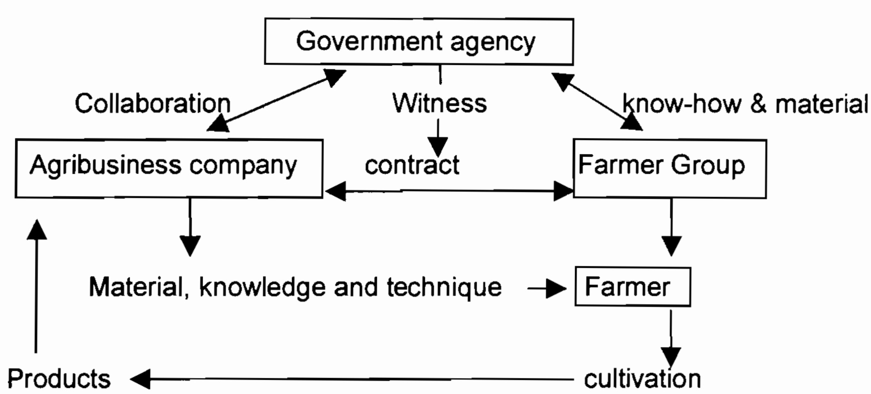


Figure 4 The contract farming system of asparagus

Fruits and vegetables in Thailand's rice bowl: the agricultural development of poldered raised bed systems in Damnoen Saduak area

Blandine Cheyroux*

Abstract: *On the fringe of the rice based systems which have dominated the Chao Phraya delta agriculture, Chinese migrants and theirs sino-thai descendants have developed an particular agrarian system in the lowland of Damnoen Saduak area (low Mae Klong basin). They have resorted to raised bed technique to polderise this old tidal marsh and have built a huge canal network ensuring drainage and irrigation year round. In this gardens between land and water, the farmers arable to grow a vast range of vegetables and fruits.*

The proximity of the Bangkok market, the development of transport infrastructures between Damnoen Saduak and Bangkok and the efficient market connection via a middlemen's networks constitute important socio-economic conditions for the development of this merchant agriculture.

Contrasting with the extensive rice based systems which provide nowadays a fairly low income, the poldered raised beds systems which use a greater labour force and high capital, are much diversified (more than 20 main crops) and oriented towards crops with high added value such as fruits and vegetables. This partly explains the expansion of the raised bed area at the expense of the rice fields.

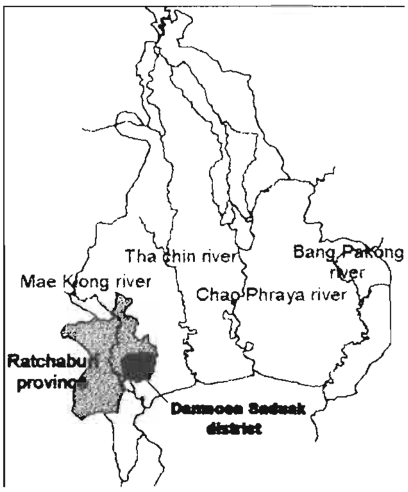
1 Agricultural diversification and study area presentation

The Chao Phraya delta is dominated by widespread rice cultivation. But aquaculture, animal husbandry, fruit tree cultivation and vegetable cropping constitute the most predominant aspects of an agricultural diversification process which stands out as the main feature of the current evolutions in the region (Kasetsart University and ORSTOM, 1996).

Beside the improvement of rice farming, the agricultural diversification represents for the farmers one of the many way to increase their incomes : in the Chao Phraya delta, orchard and vegetable farming systems provide high profitability but require some particular conditions that will be discussed in the present paper through the case study of Damnoen Saduak agriculture.

* INA-PG / Department of Social and Economic Science / U.E.R. Comparative Agriculture and Agricultural Development

Map 1 : Damnoen Saduak location
In the Chao Phraya delta



Picture 1 : Poldered raised bed plot in
Damnoen Saduak district

In the western part of the Chao Phraya delta, the low Mae Klong basin stands out as the main fruit and vegetable cropping area. On the fringe of the rice-based systems that have dominated the agriculture of the Chao Phraya delta, Chinese immigrants and their sino-thai descendants have developed a particular agrarian system in the lowlands of Damnoen Saduak area (map 1).

They have resorted to raised bed technique to polderise this old tidal marsh. They have built a huge canal network providing drainage and irrigation all along the year. In these gardens between land and water (picture 1), the farmers are able to grow a large range of vegetables and fruits.

The proximity of the Bangkok market, the development of transportation infrastructures and the efficient market connection through a network of middlemen constitute important socio-economic conditions for the development of this market-oriented agriculture.

In contrast with the extensive rice-based systems which provide nowadays a fairly low income, the agriculture in the poldered raised beds system uses much labor force and a high level of capital. It is much diversified (more than 20 main crops) and oriented towards crops with high added value such as fruits and vegetables.

Ecological conditions and natural water regime

Around 20 kilometers to the north of the coastline, Damnoen Saduak area corresponds to an old tidal marsh : marine and brackish clays have been covered by deposits brought by the Mae Klong River in spate.

Damnoen Saduak forms part of the perennially wet zone (Takaya, 1987) and represents the transitional zone between the inland zone governed by floods and a coastal zone governed by tides.

The natural hydrological regime was marked by a sharp contrast between the rainy season (July to November) and the dry season (December to June). During the rainy season, the marsh area was flooded by the fresh water from the Mae Khlong river in spate. During the dry season, the river discharge was much reduced and the tidal effect brought saline water influence further inland.

Until the middle of the 19th century, the Damnoen Saduak area, like most of the lower Chao Phraya delta, remained a wasteland. This lowland, altemately flooded by fresh and saline water, represented a hostile environment for human: access was difficult and agriculture would not be implemented without important land development (Phongpaichit & Baker, 1995).

2 1850-1870 : historical background and Damnoen Saduak canal excavation

The main feature of the agricultural development in the Chao Phraya delta during the 19th century was the shortage of labor force relatively to the abundance of available land[1]. Due to a high land/man ratio, a large part of the delta was still uncultivated: most of the population was settling in the upper delta where peasants developed rice based systems and the lower delta would not be fully exploited until the 1920s. Farming systems were oriented towards subsistence (Douglas, 1984).

In 1856, the Bowring Treaty with England and similar treaties with other European nations resulted in free trade and in the insertion of Siam into intemational trade, thus triggering the development of rice export trade. To supply the increasing demand in rice from French and Britain colonies in Asia, the wastelands of the lower delta were rapidly opened up for rice cultivation on a large scale (Douglas, 1984).

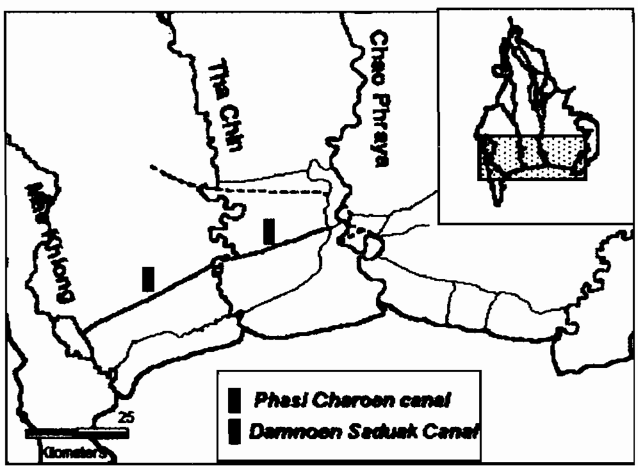
Major reforms like the abolition of slavery and corvée freed labor force and contributed to the rapid expansion in paddy production and of the area under cultivation (Ishi, 1975). Deprived of the corvée, Government resorted to the numerous Chinese coolies in Siam[2] in order to dig several canals in the delta. The new canals were aimed at giving access to the new lands and allowed the collection and the transportation of marketable surpluses from the zone of production to the export Port of Bangkok (Witayakom,1983).

[1] The abundance of land and the shortage of labor force was closely reflected in the overall organization of the Thai State. The major source of government revenue was the four-month corvée imposed on all the active freemen. Thus, if one considers the organization of freemen corvée in conjunction with the high incidence of slavery, it is overwhelming that the primary source of wealth and power in Thai society was not land but the control of labor force (Kemp, 1981; Akin, 1969).

[2] The Chinese have a long presence in Siam, but the Chinese immigration speeded up during the 19th century : Chinese arrivals were estimated at around 7000 immigrants per year in 1833 and around 15,000 per year in 1851 (Skinner, 1957). This immigration of numerous Chinese coolies provided the country with labor force at a low cost.

The digging of the Phasi Charoen canal (1867) and the Damnoen Saduak canal (1867-1868) formed a transversal line connecting the Chao Phraya River and the Mae Klong River. The objective was to allow convenient transportation of the rice, salt and sugarcane from the Mae Klong basin to Bangkok (Takaya, 1987; Manarangsan, 1989): the main purpose of the Damnoen Saduak Canal excavation was the development of a communication way for trade, and the agricultural development of this area was considered of secondary importance (Brown, 1988; Zimmerman, 1931).

MAP 2 : CANALS DUG IN THE LOWER CHAO PHRAYA DELTA (1851-1868)



The wealthy Chinese traders dominated rapidly the trade activities in this area and took over the lands along the new canals (Ishii, 1975). They rented these lands to the numerous Chinese coolies who settled in Damnoen Saduak after the excavation works. In 1877, a large community of Chinese was living along the Damnoen Saduak canal (Skinner, 1957).

3 1870-1950 : The first step of the Damnoen Saduak agricultural development

3.1 Hydraulic system and land development

To develop the swampy lowlands around the main canal of Damnoen Saduak, these numerous new farmers first had to drain this perennially flooded area and they resorted to the poldered raised bed technique[3]. They progressively developed a hydraulic system with 3 main levels :

[3] In the beginning of the 19th century, fruit and vegetables were already grown on such poldered raised bed plots around Bangkok. (Pallegoix, 1854)

- To drain the swamp and to evacuate water excess, farmers dug several canals serving each plot;
- To protect the plot from the flood and the intrusions of saline water, farmers built a dike around it;
- Because of the seepage and the rise of the water table , the plot was still flooded most of the year. That is why the third level of land development consisted in building raised beds separated by ditch inside the plot.

This land development allows very good conditions of drainage but not all of the year: the plots were still flooded during the rainy season (from July to November). consequently, farmers could cultivate only annual crops (Boonma, Issariyanukula, Tugsinavisuitti, 1974).

3.2 Market-oriented farming systems

A large part of the market production from the Mae Khlong basin (mainly rice and sugar) transited through the Damnoen Saduak canal to reach Bangkok : the digging of the canal boosted trade development in this region and had a dramatic effect on the Damnoen Saduak agrarian economy: farmers from Damnoen Saduak had outlets for marketable production.

They developed farming systems combining crops for family consumption, such as rice in the ditches and vegetables on the beds, and cash crops. These cash crops such as onions, shallot, garlic and chili were dried up to make them less perishable in order to withstand bad conditions of transportation (by boat) and delays (Skinner, 1957).

Most of the vegetable production was exchanged in the floating markets that appeared in some main canals in the early morning. Thanks to the canal network, the farmers-sellers could transport by boat their marketable production from their plot to the floating markets. There, the traders were buying the productions, loaded their goods in their boats and took 24 hours to reach Bangkok where they resold goods to retailers or directly to consumers. The floating market has allowed to concentrate an atomized supply from scattered farms.

3.3 An original agriculture development in the Chao Phraya delta

At this time, most of the Chao Phraya farming systems consisted in a self-sufficient rice-based system, even if rice farmers sold a rice surplus. Some marketable vegetable productions concentrated in areas around big towns. Nevertheless, the intensive productions of vegetables found in some distance areas with some favorable conditions represented an exception, since such advantages offsets the disadvantage of the long distance to the market (Von Thünen, 1826, Moustier & Pages, 1997).

The vegetable production in Damnoen Saduak was one of this exception. The main advantage of farmers in Damnoen Saduak was the availability of labor force for land development and intensive farming system but also a privileged access to markets: Damnoen Saduak farmers could benefit from transportation infrastructures. They were integrated in the same language community than the Chinese traders (Teochu) who had dominated the trade sector in Chao Phraya delta[4] and had developed monetary and market economy. Therefore, Damnoen Saduak agriculture was integrated to the market since its origin: farmers have adopted merchant strategies and have developed cash crops.

4 1950-1975 : transportation improvement and agricultural transformations

Before 1950, more than 24 hours were needed to go from Damnoen Saduak to Bangkok. In the 50's and the 60's, motorboats appeared and their number increased in Damnoen Saduak canal. Traders needed only 8 hours and could transport bigger quantities at lower costs. Due to this transportation facilities and in order to satisfy an increasing urban demand, the merchant exchanges increased and extended to more perishable productions like green vegetables.

Some farmers from Damnoen Saduak responded to these new outlet opportunities and developed green vegetable productions. They associated chili, onion, garlic and shallot and new crops such as cucumber, yard-long bean or cabbage. But the new crops required better irrigation conditions and pest control: a part of the farmers could invest in pumps and inputs to be able to cultivate these more profitable productions (Boonma et al., 1974).

Traders played an increasingly important role and, indeed, became middlemen: they collected products in the farms, transported them by motorboat to Bangkok where they resold them to retailers, and then carried commodities and basic agricultural inputs (pesticides, gasoline for pumps...) back to Damnoen Saduak.

As the production and trade development and transportation costs decreased, Damnoen Saduak farmers could buy rice at a lower price. Therefore, they gave preference to a system concentrating their activities on more profitable productions (dry and green vegetables) and progressively gave up growing rice in the ditches of the raised beds plot.

The agricultural diversification is a process accompanying trade development, characterized by a gradual shift out of self-sufficient production to productions exclusively aimed at sale. The Damnoen Saduak agriculture was more and more integrated in the developing market economy, especially with the building of roads in the 70's and the 80's.

5 1975-2000 : new environmental and economic conditions and theirs consequences on the agrarian system

From 1960, Thai government began to implement policies and programs based on the idea that economic growth would be better stimulated by infrastructures of a modern economy.

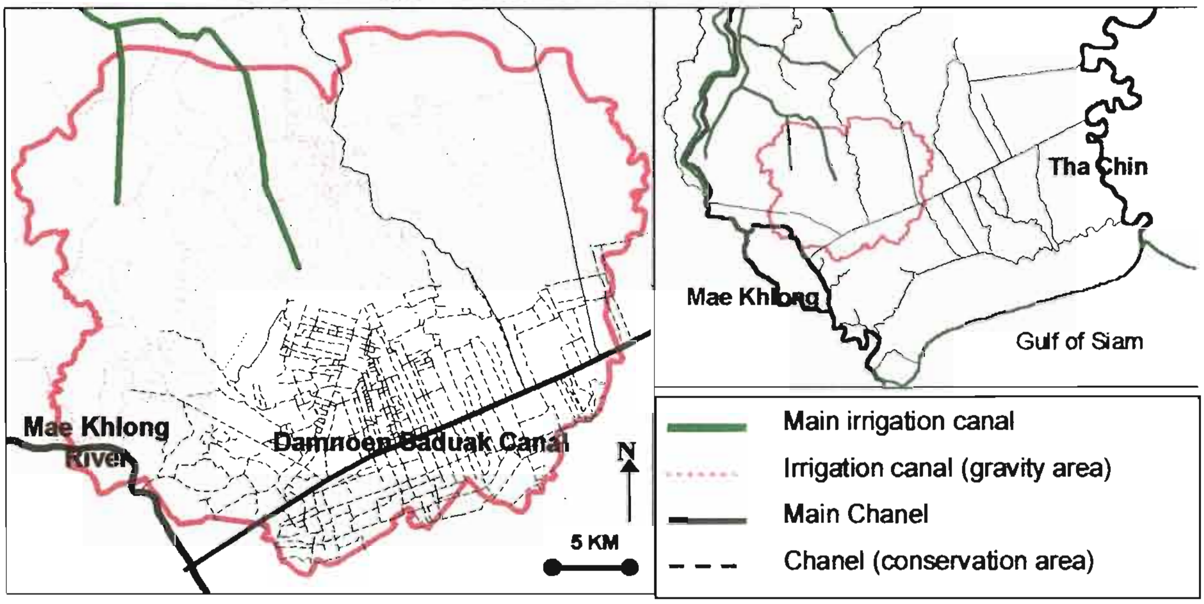
[4] By 1850, it appears that the Chinese, in particular the Teochu Chinese, controlled almost totally the trade in Siam. (Fistié, 1967)

Increasing public expenditures were thus concentrated on the development of hydraulic systems and the construction of road networks.

5.1 Transformation of the water regime and consequences

The Great Mae Khlong Project (public project) was initiated in 1964 with the objective to improve water control in the basin. In the 70's, the annual flood ceased to occur and an irrigation network was developed in the basin.

Map 3 : Drainage and irrigation networks in Damnoen Saduak



The transformation of the water regime had three main consequences on the Damnoen Saduak raised bed agriculture:

- With the end of the annual flood and the possibility to have a year round irrigation, the farmers could thus cultivate on raised beds all along the year, in particular perennial crops.
- Thanks to the development of the gravity irrigation system, the uplands in the northern part of Damnoen Saduak benefited from a regular water supply all year long; farmers were thus able to extend their raised bed cultivated area in this zone[5].
- Before the development of the Mae Khlong Project, the silt deposits by the annual flood constituted the main means of fertility reposition and the flood was also a way to control pests. As the annual flood ended, it became necessary to resort to fertilizers and pesticides.

The new physical environment offers new constraints and new possibilities: farmers in Damnoen Saduak have responded to them according to the transformation of socio-economic environment.

[5] Before, farmers grew there only one rice season in the rainy season.

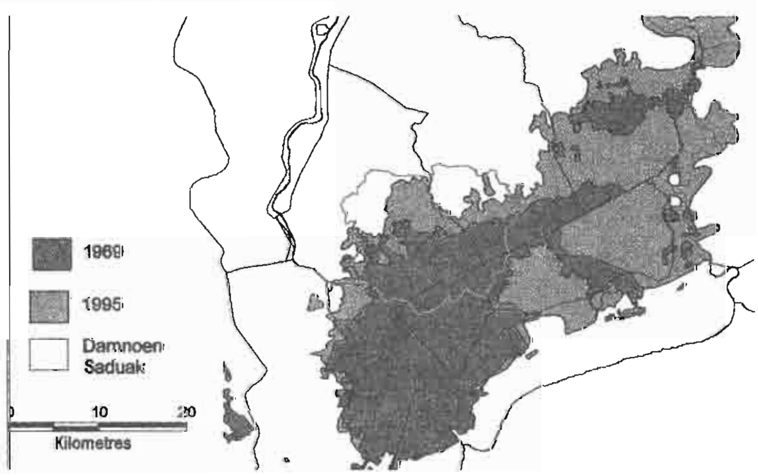
5.2 New crops development and extension of the raised bed area

In spite of these new technical possibilities to increase the quantity and the diversity of productions, farmers could take advantage of them only if they could find outlets for these additional productions. The urbanization and the increase in income resulted in increased demand for vegetable and fruit, especially in Bangkok. The food industry took off and export trade developed, creating news outlets for Damnoen Saduak productions (Mubaric,1998). These new market conditions provided incentives for farmers to increase and diversify their productions.

The gardeners in Damnoen Saduak lowlands now had good irrigation and drainage conditions all year long. They extended their cropping season of vegetables up to 3 or 4 crops per year (only 1 or 2 was possible before). From the end of the 1970s, some farmers begun to develop orchards and vineyards; the area cultivated in perennial crops gradually increased and represents today more than 70% of the agricultural area of Damnoen Saduak.

The rice farmers in the northern part of Damnoen Saduak were faced with declining rice prices[6]. Because of the lower profitability of rice production, farmers have progressively transformed rice fields in raised bed plots to grow orchards and vegetable gardens (Molle et al., 1998). The expansion of the raised beds zone (map 4) involved the extension of the garden area and an increase in vegetable and fruit production in Damnoen Saduak district.

Map 4 : Expansion of gardens on raised beds in Damnoen Saduak area (1969-1995)



The agricultural production from Damnoen Saduak has increased in volume and has been more and more diversified. Even if this agricultural development has brought about an increasing added value per farm, it has also induced increasing agricultural investments (input, plantation investments..) and new needs in capital.

[6] This period marked the beginning of the rice intensification in the Chao Phraya delta. In the rice sector, productivity growth has been accompanied by declining real prices of rice and then lower incentives for farmers to cultivate rice. In the north of Damnoen Saduak, the income of rice farmers has declined and they have developed alternative sources of income with off-farm activities or agricultural conversions.

5.3 Marketing, Input supplies and credit

As the end of the annual flood in the 70's resulted in more problems to control pest and to recover fertility, agriculture required more chemical fertilizers and pesticides. Middlemen developed their input supplying activities thanks to the new road network. But the use of fertilizers and pesticides created additional costs. Most of farmers could not afford these costs and needed to resort to credit. In the 70's, institutions of agricultural credit were not developed in Damnoen Saduak and the sources of capital came from the trade sector (Dufumier & Srijantr, 1997). The middlemen became money lenders: a farmer could borrow money from the middleman only if he committed himself to sell him his production at a pre-determined price. This price, given the fluctuations of the market, was usually underestimated regarding the value of the crop at harvest (Phonpaichit & Baker 1995). Because of the lack of credit institutions, the middlemen began quickly to give short-term credits with high interest rates. In this way, the middlemen supplied farmers with financial means to develop new cropping practices and new crops like orchards and vineyards: in the 70's and the beginning of the 80's, the trade sector invested capital in the agricultural development of Damnoen Saduak.

Public and private banks were opened in Damnoen Saduak in the 80's and the 90's. Alternative sources of institutional credit became more accessible to a growing number of farmers (Siamwalla, 1993). Institutional interest rates fluctuated between 10 and 20% per year, while middlemen interest rates were around 10% per month. Nevertheless, some farmers who had been forced to borrow money from middlemen have already been rejected by the institutional credit organizations. In this way, middlemen can be seen to be filling a role as risk-takers that the banks are presently unwilling or unable to fill. But, as the usurer activities of middlemen declined in general, the profits generated by the input supply activities decreased too. Decreasing transportation costs permitted some traders to specialize in the sales of input. There was a differentiation between upstream and downstream activities: on the one hand, some middlemen marketing production; on the other hand, other ones selling input to the farmers and finally banks giving credits. The farmers' bargaining power shifted in favour of the farmers.

With the end of the flood, it was possible to develop a permanent road network (the road were before partly damaged every year by the flood) financed by the government. The progressive improvement of the transportation allowed to connect production areas with consumption places in little time, a prerequisite for perishable goods production. Moreover the transport by road turned out to be less expensive than by boat (Hafner, 1970): In the 80's, trucks spent only 4 hours to go from Damnoen Saduak to Bangkok, against 10 hours by motorboat. The farmers were less isolated and as a result had access to more middlemen and alternative marketing channels. Farmers could travel more widely in order to sell at a best price their production; middlemen were able to broaden their marketing areas with an increasing ease of transportation. These developments resulted in an increasing competition between middlemen. The possibilities to exploit farmers who benefited from a better marketing information were limited and, as a result, the profit margins of the middlemen were reduced.

Today, in contrast with the traditional extensive rice based systems, which provide nowadays a fairly low income, the intensive and diversified agriculture on raised beds oriented toward crops with high added value uses a great amount of labour (picture 2) and capital.

PICTURE 2 : WORK IN THE RAISED BED PLOT (DAMNOEN SADUAK)

(Papaya harvest)

(Vineyard Pruning)

(Aspergus plot plowing)

Map 5 : Landuse of Damnoen Saduak district (1998)

Picture 3 : Watering of vegetables

6 Agricultural diversification, cropping systems and socio-economic differentiation of the Damnoen Saduak farms

6.1 Agricultural diversification

Agricultural diversification can be analyzed at various levels:

- At the regional level (lower Mae Klong basin), the diversification process is represented by the expansion of raised beds area at the expense of the rice field zone with single-crops farming.
- At the raised bed area level, there is a great diversity of cropping system, especially in Damnoen Saduak district where more than 20 different crops are grown (chili, coriander, kale, papaya, asparagus, rose apple, guava, coconut, sapodilla, grape, jujube, lemon...). In every Damnoen Saduak village, a vast number of different crops tangles up[7].
- At the farm level, the gardeners develop diversified cropping systems to face some economic constraints. They grow simultaneously different crops mainly to spread the needs of labor force, to get regular incomes and to weather the risks of price and production fluctuations.
- At the plot level, there are crops associations and rotations. Annual crops are, in general, grown in association (for example chili with yard-long bean and cucumber). Perennial crops (as orchards and vineyard) are mono-specific, even if some vegetables can be associated at the beginning of plantation (when trees are still small). At last, farmers make crops rotations in a given plot. They never grow successively the same crop in the same plot : they change every time to cope with soil fertility and phyto-sanitary problems.

In the raised beds zone, the highly artificialised environment allow the growth of a large range of crops. The Damnoen Saduak farmers have a privileged access to the marketing system and can easily find buyers for different kinds of fruits and vegetables. In this agro-ecological and marketing context, farmers can chose between different cropping systems, according to their available means of production.

6.2 Cropping systems

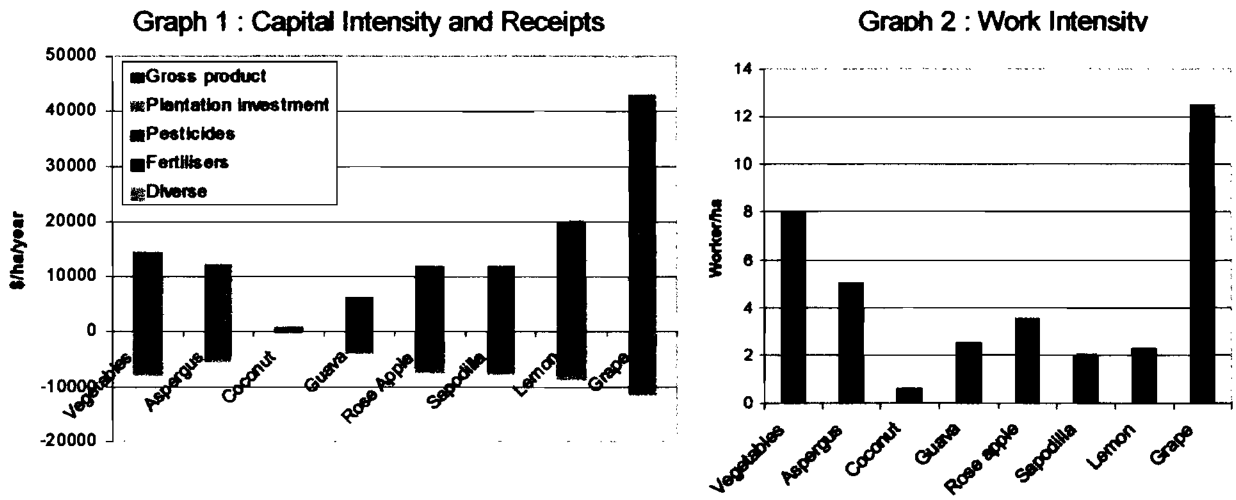
The different crops growing requires a variable level of capital (graph1) and labor force (graph2) and provides variable receipts (graph 1). Cropping systems cover a large range of more or less intensive system (from highly intensive and profitable vineyard to lower intensive and profitable coconuts plantations).

The flexibility of this agriculture can be partially explained by the limited capital invested in the different plantations. Because of the low costs of crops change, farmers are very responsive to the evolution of relative prices. For example, a farmer don't hesitate to destroy a guava orchards to grow rose apple orchards if the price of guava become too low.

The fertilizer and pesticide costs represent the main part of the capital needs (especially in vineyard). To buy this input, farmers often have to resort to credit : 80% of Damnoen Saduak farmers are more or less in debt.

[7] We find an exception in the south-western part of Damnoen Saduak where coconut plantations dominate the landscape because of particular ecological constraints (seepage influence).

In the case of very risky crops, like vineyard, a farmer, who has successively 2 or 3 bad harvests, can't pay back his credit and should sell his land. In fact, the most profitable cropping systems is also the most risky. Only the farmers, who have accumulate enough capital, can invest in this risky but profitable cropping system and deal with bad harvests. Rather than to resort to short-term credit, some farmer grow low risky crops harvested year round : these crops such as vegetables, guava, rose apple, coconut allow to get predicatble and regular incomes.



* We retained only the 8 main cropping system between the 20 different crops found in Damnoen Saduak: vegetables associations (cucumber, chili, yard long bean, coriander, papaya), asparagus, coconut, guava, rose apple, sapodilla, lemon and grape. The calculations are made after 130 farmers surveys from 1997 to 1999.

In this labour intensive agriculture, most farmers resort to temporary hired labour to face with work peaks (harvest, pruning...). But due to the increasing salaries in the last 20 years, the farmers are trying to reduce this cost. The cropping system choice take into account the family labor force availability. The spread and staggering of activities is also taken into consideration when choosing the crop combination.

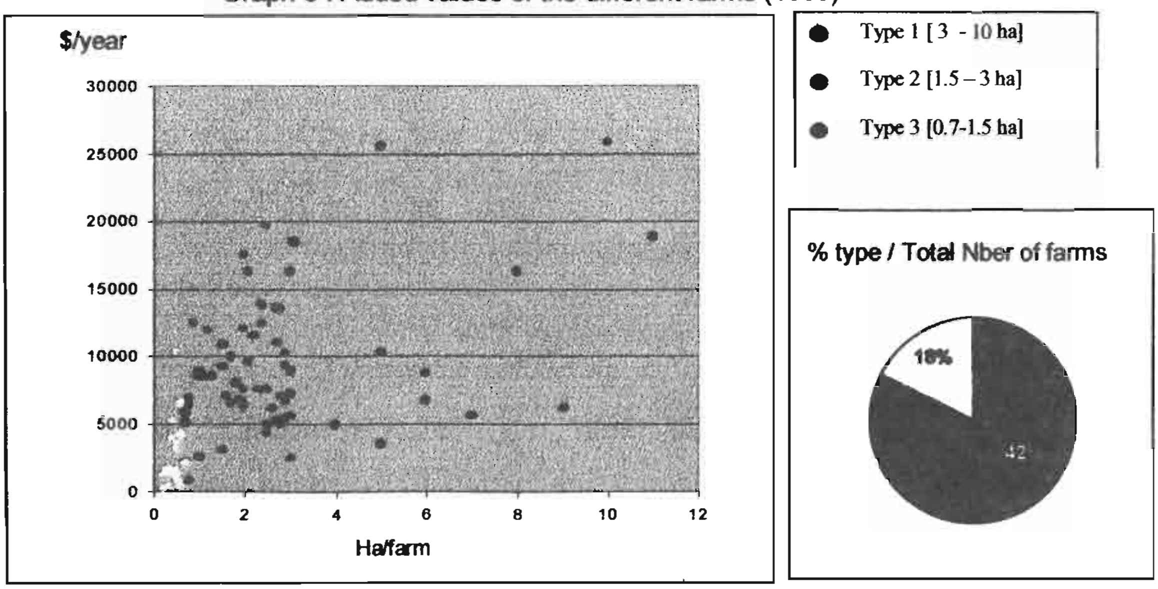
Depending on their individual situation (farm size, family labor force, capital accumulation and access to credit), farmers develop different cropping systems more or less intensive in work and capital, more or less risky and profitable. The socio-economic differentiation of farms partly explains the cropping diversity in Damnoen Saduak.

6.3 Socio-economic farm differentiation

In Damnoen Saduak the average farm area is 2 ha, which is quite low regarding to the average size of farms (4 ha) in the Chao Phraya delta (Kasetsart University and ORSTOM, 1996; Molle and Srijantr, 2000). In fact, the Damnoen Saduak agriculture is mainly manual. It's nearly impossible to develop the mechanization of the work pick operations like harvest or pruning. In this labour intensive agriculture, the farm area is limited by the labor force availability.

Nevertheless, behind this average area, there is some differentiation of the farms size. The fragmentation of farms have produced the concentration of small farms (less than 1,5 ha), especially in the oldest raised bed villages, along the Damnoen Saduak canal. Some farmers have succeeded to extend their area by buying rice fields in the northern part of Damnoen Saduak and by transforming them into raised plots.

Graph 3 : Added values of the different farms (1999)



Farmers with similar areas can nevertheless produce very variable levels of added value (graph 3). In fact, the productivity and the profitability of a farming system depends more on the kind of cropping system developed by farmers than on the cultivated surface[8]. Even if the capacity of capital accumulation is positively correlated with surface, small farmers, who have a high availability of capital and labor force, can develop more intensive and profitable cropping system than some bigger farmers who have a shortage of capital and family labor force.

But, different types of farms develop different strategies, according to their access to means of production. They try to maximize the productivity of the scarce factor (labor force for the big farms, capital and labor force for the medium farms, land and capital for the small and very small farms).

- The labor force of the big farms (Type 1) is fully employed. They have a good access to credit because they have large land to be mortgaged. The farms durability depends of the availability of agricultural employees in the area and of the evolution of their salaries. But they have enough area to get sufficient agricultural income, even if they grow low intensive and low profitable crops.

[8] A farmer who grow vegetable on one ha create more added value than the farmer who grow coconuts on ten ha.

- In medium farms (Type 2), farmers use family labor force and employees to cope with labour peaks. They have a limitation for borrowing capital and tend to diversify their farming system to spread their capital and labor force needs.
- Small farmers (type 3) cultivate work intensive crops that allow them to get a high added value with small capital investment (vegetables). So, they succeed to have enough capital to reproduce their farming system. When there is insufficient work in their small farms, a part of the family labor force can take temporary jobs in bigger farms and increase family incomes.
- With an added value inferior to 4000 $ per year[9], most of the very small farmers (type 4) should have off-farm activities to get a supplement of income. The temporary jobs opportunities are numerous in Damnoen Saduak because a lot of medium and big farms regularly resort to employees.

It is common to see situations of agricultural development where the smaller farmers get lower income, are progressively eliminated and go to the cities increasing the number of workers in the expanding secondary or tertiary economic sectors. The medium and big farms can extend their surfaces at the expense of the evicted small farms, and accumulate capital to invest in the improvement of work productivity (mechanization, inputs...).

But in Damnoen Saduak, the rural de-population has been slow. The small farmers develop intensive systems oriented toward high added value or/and have off-farms activities as agricultural employees; in this way they can reproduce their farming system and get sufficient income to stay in Damnoen Saduak. The medium and big farm need these small farmers, who are temporary employees, to supply them the necessary labour force; in this way, they can develop intensive and profitable crops. The different kinds of farmers are complementary in the development of this diversified and intensive agrarian system. This is much similar to the situation described by Molle and Srijantr (2000) for rice areas, where land and labour markets have been found to operate rather flexibly, where smaller farms tend to diversify production and where the proportion of wage labourers in the agricultural population is neatly correlated with the demand for off-farm and on-farm hired labour.

7 The particular conditions of agricultural development in Damnoen Saduak

The raised beds farming systems provide high profitability and we can really wonder why this kind of system has not expanded on a larger scale in the Chao Phraya delta. Through the development of Damnoen Saduak agrarian system, we have seen that it required particular agro-ecological and socio-economic conditions.

[9] The agricultural income is equal to added value less salaries, land rent, tax and credit interest. With an added value about 4000$/year, the farmers have in average an income close to 1,500$. That is lower than in the industrial sector.

- This agricultural development has been possible in Damnoen Saduak thanks to favorable ecological conditions (high availability of water, fertile clayey soils) and a highly artificialised environment[10] (very dense network of waterways and important land development).
- To develop this environment and this agriculture, a huge labor force have been mobilized. At the first stage of Damnoen Saduak history, Chinese coolies provided this necessary labor force. Later, in spite of new opportunities and remunerative jobs in the developing industry, this agriculture was able to generate relatively high levels of agricultural incomes and to limit out-migration to the cities, retaining labour force in Damnoen Saduak.
- Huge capital was also necessary to intensify cultivation practices, particularly fertilizer and pesticide use. The start-up money was provided by the trade sector. Today, farmers' capital accumulation and institutional credit substituted middlemen credit.
- The Damnoen Saduak agricultural development is a process accompanying the economic and trade growth and is triggered by improved rural infrastructure and marketing system development. The area has a privileged access to markets thanks to the proximity of Bangkok, the development of the road network and an efficient marketing system. Therefore, it could benefit from the emergence of new markets (vegetables and fruits) induced by the national economic growth. They have also developed well-diversified market oriented production systems and have been able to gain sufficient flexibility to adjust to the market changed conditions smoothly.

But the Thailand economic crisis (1997-1998) has revealed the limits of the agricultural development in Damnoen Saduak. This agriculture is very dependent on the market for the supply of a high level of inputs and for the sale of it market-oriented productions. Farmers have developed a diversified cropping systems to cope with the high fluctuations of fruit and vegetable prices; they largely resort to institutional credit to finance their inputs. But the agriculture in Damnoen Saduak proved to be vulnerable to the general decrease of vegetables and fruits prices, the increasing prices of input and the escalation of credit interest rate: some farmers have changed their farming system to less intensive system, some farmers have gone bankrupt[11].

New threats for the agriculture in Damnoen Saduak are looming. Agricultural practices (high level of fertilizer and pesticide use) impact on the environment (Joannon, Poss, Dr. Korparditskul, 1999): the degradation of the water quality and the accumulation of toxic elements in the soils might become an important problem which questions the ecological sustainability of this agricultural development. New producers have developed fruits and vegetables productions for the Asian markets, like gardeners in the Mekong delta (Vietnam)

---

[10] The Damnoen Saduak landscape has been built and sculptured by human : nearly almost lump of earth has been dug to make canal, ditch, dike and raised bed.

[11] Today, it's too soon to evaluate the number of farmers who have gone bankrupt; a few years are needed to allow sufficient hindsight.

and will be able to compete with the farmers of Damnoen Saduak on the national and international markets. This questions the economical sustainability of this type of agriculture.

All along the past, the farmers of Damnoen Saduak area have shown their capacity to quickly change agricultural practices and cropping systems, and smoothly adapt their agrarian system to the rapid and in-depth transformations of the agro-ecological and socio-economic conditions. This suggests that farmers of Damnoen Saduak will be able to successfully address future challenges and that fruits and vegetables will not disappear so soon from the Thailand's rice bowl...

References

Abhakorn R. 1984 Ratburi, an inner province : local and central politic in Siam 1868-1892, Ph.D Political Science, Chulalongkorn University

Akin R. 1969. The Organization of the Thai Society in the Early Bangkok Period, 1872-1873 , Cornell University, Departement of Asian Studies, Data paper n°74, Ithaca, p 42.

Ammar. S, Receuil d'articles, 1999

Boonma C., Issariyanukula A., Tugsinavisuitti S. 1974 Vegetable production in amphoe Damnoen Saduak, Changwat Ratchaburi, 1972-1973, Department of Agricultural Economics, Faculty of Economics and business Administration, Kasetsart University, p13, p41.

Brown I. 1988, The Elite and the Economy in Siam, 1890-1920, Oxford, University Press, p16.

Chapphit N. & Suthy P. 1981, The political Economy of Siam, 1851-1910, Social Science Association of Thailand, Bangkok.

Cheyroux B. 1997 Analyse des systèmes agraires passés et actuels d'un village de la plaine centrale Thaïlandaise, DEA Géographie et Pratique du Développment, INA-PG.

Dufumier M. & Srijantr T. 1996, Agriculture Paysanne, Inyterventions de l'Etat et Limites de la « Révolution Verte» en Thaïlande, Revue Tiers Monde, pp 121-136.

Donner W. 1978. The five Faces of Thailand – An economic geography , Institute of Asian Affairs, Hamburg, p211.

Kasetsart University and Orstom. 1996. Agricultural and Irrigation Patterns in the Central Plain of Thailand, DORAS Project, Bangkok, 220 p.

Douglas M. 1984. Regional Integration on the capitalist Periphery : The central plains of Thailand, Institue of Social Studies, The Hagues, p35, p 47.

E.A.A.U. (East Asia Analytical Unit) 1995. Overseas Chinese Business Networks in Asia, Australian Department of Foreign Affairs and Trade, p 74.

Fistié P. 1967, L'évolution de la Thaïlande contemporaine , Armand Colon, Paris, p 48.

Hafner, J.A. 1970. The impact or road development in the central Plain of Thailand, The University of Michigan, PH.D.

Ishii Y. 1975, Thailand : A Rice-Growing Society, The university Press of Hawaii, Honolulu, 1975, p 30.

Joannon G. Poss R. Korpardltskul, R. 1999 Impact of grape cultivation on the environment – the case of Damnoen Saduak area, Kasetsart University, IRD

Kemp J. H. 1981, Legal and Informal Land Tenures in Thailand, Modern Asian Studies, V15, page 1-23, Cambridge University Press.

Moustier P., Pages J. 1997 Le péri-urbain : une agriculture en Marge. Economie Rurale Vol 241 sept-oct 1997 pages 48-56

Molle F., Sutthi c., Keawkulaya J., Korpraditskul R. 1998 Water management in poldered raised bed systems : a case study in the Chao Phraya delta, Doras Center

Molle, François; Srijantr, Thippawan. 1999. Agrarian change and the land system in the Chao Phraya Delta, DORAS Project, Kasetsart University, Bangkok, Research Report n°6, 191 p.

Mubaric A. 1998 A. La nouvelle problématique de la production de fruits et légumes en Asie , Revue Tiers-monde, t XXXIX n°153, janv-mars 1998

P. Phonppaichit & C. Baker 1995, Thailand - Economy and Politics Oxford University Press, New York, p11, p24, p41

Pallegoix 1854, Description du Royaume Thaï ou Siam, DK Book House, Bangkok 1976, p46.

Siamwalla Ammar 1993 The thai rural credit system and elements of a theory : public subsidies, private information and segmented markets, Oxford University Press

Silcock T.H. 1970, The Economic Development of Thai Agriculture, Australian National University Press, Canberra p 64.

Sompop M. 1989, Economic Development of Thailand, 1850-1950 : Response to the Challenge of the World Economy, Institute of Asian Studies, Bangkok, p55.

Takaya Y. 1987, Agricultural Development of a Tropical Delta - Study of the Chao Phraya, University of Hawaii Press, Honolulu, p19, p180.

Tomosugi T. 1966, Historical Development of Irrigation and Drainage in the Chao Phraya Delta, Southeast Asian Studies, page 165-175.

Skinner W. 1957, Chinese Society in Thailand, Cornell University Press, New York, p80, p113.

Witayakorn C. 1983 The effects of capitalist penetration on the transformation of the agrarian structure in the central region of Thailand (1960-1980), Social Research Institute, Chulalongkorn University, Bangkok, p33.

Yacoob O., Subhudrabandhu S., 1995 The Production of Economic Fruits in South-East Asia Oxford university press

Zimmerman C.C . 1931, Siam – Rural Economic Survey 1930-1931 , Harvard University Press, p167.

Dynamics of rice farming in Chao Phraya Delta: a case study of three villages in Suphan Buri province

Somporn Isvilanonda[1] and Mahabub Hossain[2]

Abstract: *In the past few decades, rice production in Chao Phraya Delta has been transformed continuously due largely to impacts of modern rice technology adoptions and farm labor out-migration. A wide adoptions of modern rice varieties (MVs) in irrigated area increased cropping intensity and farm productivity which consequently induced an increase in farm labor demand during peak seasons. On the other hand, a rapid development of non-farm sector stimulated a rise in non-farm employment and wage rate. A disparity of wage rate between farm and non-farm sectors created farm labor out-migration from lower wage rate areas. Consequently, a scarcity of farm labor supply and a rise in rural wage rate stimulated changes in farming practices toward an increasing adoption of labor saving technology for reducing the production costs. The paper employed farm survey data of rice villages in Suphan Buri during 1987, 1995, and 1998 to explain adjustments of rice production villages in the Delta.*

1 Introduction

A green revolution in Thailand's rice sector has taken place since late 1960s. It has later created a wide adoption of modern rice varieties (MVs) in area where water supply is less constraint, particularly in irrigated area of Chao Phraya Delta. The adoption pattern essentially generated a marked increase in rice cropping intensity and farm productivity. On the other hand. a rapid rural development in the recent past has essentially improved the off-farm and non-farm activities in rural areas. Increasing employment and wage rate in non-farm activities attract farm household members to work outside farms which consequently generate the other source of household income. In addition, a disparity of wage rate between rural areas and cities has created farm labor out-migration. A scarcity of farm labor supply and a rise in rural wage rate stimulated the adjustment in farming practices toward increasing adoption of labor saving technology for reducing production costs. This paper employed farm survey data of rice villages in Suphan Buri during 1987 and 1998 to explain dynamics of rice farm households in the Delta. After introduction, section two describes the sampled village and differential effects of rice production environments on technology adoption. Changes in factor price and factor income are discussed in section three. Section

[1] Associate professor, Department of Agricultural and Resource Economics, Faculty of Economics, Kasetsart University

[2] Head, Social Sciences Division, International Rice Research Institute, Los Banos, Philippines

four examines income sources of the rice farming households. The last section is conclusion and suggestions.

2 Village characteristic and changes in rice farming condition

2.1 Village and households characteristics

The selected villages were classified according to production environments. Three villages in Suphan Buri were purposively selected based on production environments. Wang Yang (SP1), Sa Ka Chome (SP2), and Jora Khae Yai (SP3) were represented for irrigated, rainfed, and flood prone environments, respectively. The 1995 and 1998-surveys villages were followed the 1987-survey village but the sampled households, however, may not be totally the same. The amounts of samples in 1998 were totally 104 farm households, comparing to 142 farm households in 1987.

Table1 shows distribution of samples, average household size and other characteristics of sampled households in the three villages. For the three surveys, the average family sizes were slightly different among the sampled villages. The family sizes in 1998-surveys tend to decline from those in 1987-survey as a result of out-migration of family members for working in non-farm activities. It is interesting to note that the average age of rice farming household head seems to increase during the past decade, reflecting the old age farmers engaging in rice farming occupation. These people also had less schooling background.

Percents of landless households in the second and third surveys seem to decline from the 1987- survey. Attractiveness of employment opportunities in city as construction workers stimulated the poor to out-migrate from rural to urban areas. Large percentages of households in flood prone and rain-fed villages received a remittance from family members.

2.2 Agricultural Land holding and tenurial characteristics

Table 2 shows average farm size where the smallest was in irrigated environment. A relatively poor productivity per unit area in rain-fed and flood prone conditions resulted farmers to employ a relatively larger land area to maintain their size of farm income. Man-land ratio in nearly all villages in 1998-survey was lower than that in 1987-survey, except for flood prone village(SP3), but farm size was larger in almost all villages with exception in rain-fed area (SP2), reflecting a decline in rice labor force, in all production environments. A higher wage rate in city attracted the younger laborers temporally and permanently out-migration from villages.

Tenurial patterns in all villages has been changed during the two survey periods. There were relatively more owner-operators in all villages in 1987. A larger lease holding proportion was found in flood prone village (SP3) in 1998 Moreover, the owner –operator share in irrigated village tended to decline from 1987 to 1998. A share tenancy system which found in rain-fed village in 1987-survey was unobserved in 1998-survey, reflecting a development in land leasing market in all rice production environments.

2.3 Cropping patterns

Cropping patterns in study villages were different. The cropping structure between the two period surveys had substantially changed toward an increasing diversification, the cropping structure in 1998-survey seems to expand non-rice crop in irrigated environment. In flood prone environment, double rice cropping dramatically increases as a result of changing rice crop calendar and adoption of MVs. Table 3 shows that double rice cropping in SP1 in recent survey (1998-survey) contributed 52.2 percent of the total area. A major non-rice crop in this area mainly consists of water chestnut. Water chestnut can grow all year round in this area and some farmers choose to grow water chestnut instead of rice. Horticulture and fruit trees practices were increasing trend in a recent year, particularly in irrigated environment. In rain-fed village (SP2), rice-fallow contributed a relatively larger share. In SP3 village, fallow-rice was replaced by rice–rice as a result of un-planting deep water rice during wet season and adoption of MVs in the dry season.

2.4 MV adoption, fertilizer use, and yield performances

About three decades of MVs[3] dissemination to farmer fields, it seems that MV adoption was location-specific and more confined in the irrigated environment where water level can be controlled.

Table 4 shows the adoption rate of MVs by production environments. In irrigated village (SP1) , a dissemination of MVs was fully completed in both wet and dry seasons. Furthermore, the adoption of MVs in flood prone induced a change in rice crop seasons. In stead of broadcasting their local varieties (deep water rice varieties) in May or June before the area are submerged, they leave the area idle for few months during the wet season and wait until the rain water is drained away in December or January before broadcasting the MVs. By this adjustment, the area adoption of MVs has dramatically increased in 1998-surveys comparing to the 1987-survey. In rain-fed village (SP2), uncertainty of rain water and no irrigation system prevented farmers to adopt the MVs. Instead, improved local varieties which mostly are exotic and lower amirose grain quality rice, particularly KDM105 and Khaow Tahang, were commonly grown.

Because, MVs responds to chemical fertilizer application. In the areas where MV adoption rate was high, the fertilizer application rate significantly increased. In 1998-survey, the application rate of fertilizer was shown in the form of mixed chemical fertilizer. It can not be comparable with that of 1987-survey which is in the form of nitrogen equivalent.

[3] Modern rice varieties in this context means non-photo period sensitive varieties

Land productivity is reflected by the yield performance. In irrigated and flood prone environments, the yield performances were better than that of rain-fed area due significantly to MV adoption (Table 5). In recent survey (1998-survey), it seems that the yield performances in irrigated and flood prone villages increased from 1987-survey as a result of modern varieties adoption. However, a frequent drought in rain-fed village(SP2) created a dramatically yield reduction.

2.5 Adoption of labor saving technology

2.5.1 Direct seeding adoption

A transplanting rice (TPR) method was previously practiced for rice crop establishment among Thai farmers. The TPR method is a labor using technique. On the other hand, direct seeding rice (DSR) and wet-seeded rice (WSR) methods are labor saving techniques. The DSR method was previously employed only in flood prone area where water level can not be controlled. The WSR method was later introduced to farmers in 1980 for saving labor in transplanting activity, particularly in Suphan Buri (Isvilanonda, 1990). A higher wage rate in irrigated areas and a scarcity of hired labors during transplanting activity induced farmers to widely adopt this method. In 1987, the adoption rate for WSR technique in irrigated village (SP1) was almost fully completed. But, that in flood prone was used only in dry season (Isvilanonda and Wattanutchariya, 1992). Table (6) indicates that the adoption of

WSR method in irrigated and flood prone villages were fully completed in 1998-survey in both wet and dry seasons.

2.5.2 Adoption of mechanization

Labor saving technology, particularly four wheel tractors, was introduced to Thai agriculture long before the introduction of the MVs (Siamwalla, 1987). However, most of them were used for upland crop land preparation, especially for opening up new land. A development of tractor contractor service by that time was spread rapidly to the deep-water rice areas in Chao Phraya Delta (Wattanutchariya, 1983). A power tiller was originally imported from Japan during early 1960's. They were soon simplified by local manufacturers. The locally produced power tiller was rapidly utilized in the irrigated areas of Chao Phraya Delta. Increase in rice cropping intensity in irrigated environment and low interest rate of agricultural credit were major factors in stimulation of farmers in irrigated areas to quickly adopt the power tillers. (Onchan, 1983). In Chao Phraya Delta, the adoption of power tiller in all production environment was fully completed in 1998-survey.

Mechanical threshers were introduced in the Delta during the 1970s and were rapidly adopted. By 1987, they have been fully adopted in both irrigated and non-irrigated areas. This is because threshers save time for continuing a second crop, particularly in irrigated area. In less favorable areas, the availability of off-farm and non-farm employment were the major factor in adoption. However, the situation has been changed, the mechanical thresher was disappeared from the Central Plain as a result of combined harvester adoption (Isvilanonda and Wattanutchariya, 1990). The machine contractors provide service for both harvesting and threshing activities, simultaneously. The competitive market of rental service and the high wage rate are important factors contributing to quick adoption of the machine in these villages.

3 Changes in factor price, factor use, and factor income

Differential effects of MV adoption on productivity and factor use were previously documented by Srisawasdirek and et al (1975). Increase in productivity in favorable environment as a result of MV adoption raises labor demand for crop care, harvesting, and threshing. Also, a rise in cropping intensity raises labor demand due mainly to its affects labor use throughout the year (Sudaryanto and Kasryno, 1994; Hossain et al, 1994). In Thailand, the effect of MV adoption on labor demand was quickly offsetted by a rapid adoption of labor saving technology, particularly power tiller, wet-seeded rice method, and mechanical thresher (Isvilanonda and Wattanutchariya, 1994). A higher relative factor prices, resulting from a change in factor share, and a slower increase in rice price consequently induced farmers to adopt labor saving technology for maintaining their profit. Comparison of the output and factor prices in 1987 and 1998 surveys evaluated at 1998 price are shown in Table 7. Rice price seems to decline during the two surveys. The real fertilizer price between the two surveys can not be compared. The fertilizer price in 1987 was in terms of nutrient price of nitrogen but the later was in terms of mixed fertilizer price.

Real wage rates in 1987-survey were marked different between irrigated and rain-fed villages. However, that in 1998-survey was nearly equalized for all production environments and higher than the wage rate in 1987. This indicated the dynamic adjustment of rural labor markets to equalize the wage rates in the region. Furthermore, high competitiveness of rental markets of machine services throughout the country, particularly tractors, mechanical threshers, and combine harvesters, created a decline in rental rate of those machines overtime.

The total labor use for rice production for the two survey declined significantly in all villages. In 1987-survey, the amount of labor use was larger in irrigated village (SP1). However, in 1998-surveys, a wider adoption of mechanization for harvesting and threshing reduces labor use in SP1 and SP3 villages. Rice income of farm households depends on payment to factors of production owned and hired by the households. Such payments depend essentially on technology and factor prices. To quantify differences in factor earnings among production environments, the conventional accounting technique was applied (Rannade and Herdt, 1978). The weighted average gross returns of rice per hectare in both wet and dry seasons were distributed among groups of factors of production. Return to current inputs was the sum of expenses on fertilizer, seeds, pesticides ,and gasoline. Imputed payment to owned machinery and actual payment to hired machinery were formed the return to capital. Return to labor was calculated by the sum of expenses to hired labor for all operation and imputed expenses to family labor man-days for all operations multiplying by average wage rate. Return to land was obtained from reduction of gross output by the sum of other expenses.

Table 9 compares factor payments (evaluation at 1998 price) and factor shares in rice production. In irrigated and flood prone villages, returns to land and current input were the larger share as a result of MVs adoption.. Changes in factor shares observed from the first and second surveys were stemmed from changes in absolute return on capital and labor because the high wage rates induced a substitution of mechanization for labor. The absolute return on hired labor in 1998-survey declined substantially from 1987-survey whereas that return on hired machinery rose significantly. The increasing use of rental service for farm mechanization in many activities generated the higher value of hired capital in 1998-survey. A wide adoption of fertilizer and herbicide created a larger share of expenses for current input in 1998-survey. A negative surplus in rainfed village(SP2) in 1998-survey was a result of heavy drought in this village.

4 Household Income by sources

Household income is determined not only by the distribution of rice income, but also by the possession of productive resource such as land, human capital, and capital assets, as well as by market and institutional factors such as opportunities for non-rice production, access to non-farm employment opportunity, and land tenure. In this section, factors affecting differential level of household income are examined.

Tables 10 shows sources of the households incomes (evaluation at 1998 price). Income from their own rice production was by far the highest in irrigated village (SP1) in 1987 surveys. However, except flood prone village, rice production income relatively declined its important role in 1998-survey since it shared less than half of total household income. Instead, the major source of household income was obtained from non-rice production income in almost villages. In SP3-village, rice income contributed a major share in 1998-survey as a result of change in crop calendar and adoption of MVs. Furthermore, a sizable of income from remittance was found in the rain-fed and flood prone households.

5 Conclusion

This study examined the recent development trend of rice growing households in different production environments in Chao Phraya Delta. It is found that the difference in production environments, as determined by the availability of irrigation, had the influential factor in determining the modern rice variety adoption and rice cropping intensity. The adoption also created differential land productivity between irrigated and non-irrigated villages. The major change in rice farming practice during the two survey periods was stemmed from the increasing adoption of labor saving technology, particularly mechanization for land preparation, harvesting, and threshing activities. However, the adoption of power tiller and tractor was almost completed in all rice production villages but the adoption of combined harvesters was concentrated in irrigated and flood prone villages. As a consequence of increasing adoption of labor saving technology, the total amount of labor uses per hectare in rice farming activities declined significantly in all production environments.

Real wage rates in both irrigated and non-irrigated villages dramatically increased, particularly in rain-fed village as a result of rural labor market adjustment to equalize the wage rates within the Delta.

The marked rise in real factor price and a decline in real paddy price would reduce the surplus or land income between 1987 and 1998 survey. However, the substitution of capital to labor inputs which took place simultaneously help to maintain the land income in all villages. That is, the share of labor income significantly declined, particularly hired labor income, but that of capital income rose substantially. Share of real rice income was found to decline its important source in the rural household income surveys, exception in flood prone village. Instead, the main source of rural household income was from non-rice production income and non-farm income.

This study suggests that modern rice technology is biased toward favorable production environment. It created income disparity of farm households between irrigated and rainfed village. Improvement in labor productivity of rainfed households through human resource development program is primarily concerned for enhancing their ability to access non-farm activities. In the Deltas' irrigated and flood prone areas, improvement in common canals and on- farm irrigation systems is necessary to increase land productivity and farm income. Moreover, government should pay more attention on crop restructure program in these production environments for improving the non-rice activities.

References

Fei, J. C. H.; Ranis, G.; Kuo, S.W.Y. (1978). 'Growth and family distribution of income by factor component", Quaterly Journal of Economics, 92:17-53.

Hossain, M. ; Quasem, M. A.; Jabbar, M. A.; and Akash, M. M. (1994) "Production environments, modern variety adoption, and income distribution in Bangladesh", in Modern Rice Technology and Income Distribution in Asia edited by Cristina David and Keijiro Otsuka (London: Lynne Rienner Publishers).

Isvilanonda, S. and Wattanutchariya, S. (1990) "Differential impact of modern rice technology across production environments: a case study of Thai rice villages', Research Report no. 90-1, Dept of Agricultural and Resource Economics, Faculty of Economics and Business Administration, Kasetsart University, Bangkok, Thailand.

Isvilanonda, S. and Wattanutchariya, S. (1994) "Modern Variety Adoption, Factor-Price Differential, and Income Distribution in Thailand" in Modern Rice Technology and Income Distribution in Asia edited by Cristina C. David and Kejiro Otsuka (Manila: International Rice Research Institute)

Isvilanonda, S. (1990). "Effects of pre-germinated directseeding technique on factor use and the economic performance of rice farming: a case in irrigated area of Suphan Buri, in Thai Rice Farming in Transition edited by Akimi Fujimoto, Kamphol Adulavidhaya, and Toshiro Maytsuda (Tokyo: World Planning Co.Ltd).

Onchan, T. ((1983). "Farm mechanization policy in Thailand", Staff paper no. 51, Department of Agricultural Economics, Kasetsart University.

Ranade, C. G. and Herdt, R. W. (1978). " Shares of farm earnings from rice production" in Economic Consequences of New Rice Technology (Los Banos: IRRI).

Rice Research Institute (1985). "RD rice varieties of Thailand", Department of Agriculture, Ministry of Agriculture and Cooperative, Bangkok, Thailand.

Siamwalla, A. (1987). "Thailand's agricultural future: what are the question?", Thailand Development Research Institute, Bangkok, Thailand.

Srisawasdilek, J.; Adulavidhaya, K.; and Isvilanonda, S. (1975). "Thailand: Don Chedi Suphan Buri" in Changes in Rice Farming in Selected Areas of Asia, International Rice Research Institute, Los Banos, Philippines.

Sudaryanto, T. and Kasryno, F. (1994). "Modern rice variety adoption and factor-market adjustment in Indonesia", in Modern Rice Technology and Income Distribution in Asia edited by Cristina David and Keijiro Otsuka (London: Lynne Rienner Publishers).

Wattanutchariya, S. (1983). "Economic analysis of the farm machinery industry and tractor business in Thailand", in Consequences of Small-farm Mechanization, International Rice research Institute and Agricultural development Council (Philippines: IRRI)

TABLE 1 SELECTED SOCIO-ECONOMIC CHARACTERISTICS OF SAMPLE HOUSEHOLDS BY ECOSYSTEMS IN 1987 AND 1998 SURVEYS

	Suphan Buri		
	SP1	SP2	SP3
No. of sample households (HH)			
1987	45	56	41
1998	34	43	27
HH size			
1987	5.4	6.0	6.5
1998	4.2	5.1	6.6
No. of adults/HH			
1987	4.0	4.8	5.1
1998	3.4	4.1	4.4
Average age of HH head			
1987	50.6	53.4	60.3
1998	55.0	59.9	60.5
Average years of schooling HH head			
1987	3.8	2.8	3.7
1998	4.1	2.5	4.2
% of landless HH			
1987	6.0	5.6	14.6
1998	na	Na	na
% of HH receiving remittance			
1987	6.7	7.1	21.9
1998	7.9	39.5	42.9

Source: Kaetsart University-IRRI survey data base .

TABLE 2 SIZE OF LANDHOLDING AND TENURIAL CHARACTERISTICS OF SAMPLE HOUSEHOLDS BY ECOSYSTEMS IN 1987 AND 1998 SURVEYS

	Suphan Buri		
	SP1	SP2	SP3
Average size of agr. holding (ha)/HH			
1987	2.8	6.5	8.4
1998	3.6	6.0	8.8
Population/ ha of land			
1987	1.9	0.9	0.8
1998	1.2	0.8	0.8
% of land area under different tenurial arrangements			
1987			
1. owner cultivation (%)	72	82	52
2. fixed-rent (%)	28	4	48
3. share cropping	0	14	0
1998			
1. owner cultivation (%)	41	75	44
2. fixed-rent (%)	60	25	52
3. share cropping	0	0	0

Source: Kaetsart University-IRRI survey data base .

TABLE 3 RICE CROPPING INTENSITY (% OF TOTAL CULTIVATED AREA) OF FARM SAMPLES BY ECOSYSTEMS IN 1987 AND 1998 SURVEYS

	Suphan Buri		
	SP1	SP2	SP3
1987			
Rice-rice	77	0	0
Rice-nonrice			
rice-fallow	0	90	67
rice-field crops[a/]	23	1	-
Falllow – rice	0	0	32
Others	5	9	11
1998			
Rice-rice	52.2	-	82.2
Rice-nonrice			
rice-fallow	5.2	81.2	7.1
rice-others[a/]	-	-	-
Fallow-rice	-	-	7.1
Others	42.6	18.8	3.6

Source: Kasetsart University-IRRI survey data base .

Note: a/ Field crops include vegetable.

b/Others include cassava, banana, tobacco, sugar cane, mangoes, yams, water -chest nut.

TABLE 4 MODERN TECHNOLOGIES ADOPTIONS (%OF TOTAL CULTIVATED AREA)OF FARM SAMPLES BY ECOSYSTEMS IN 1987 AND 1998 SURVEYS.

	Suphan Buri		
	SP1	SP2	SP3
Adoption rate of MVs			
1987			
Wet season	61.1	0.2	0
Dry season	100.0	-	100.0
1998			
Wet season	100.0	0	92.9 1/
Dry season	100.0	0.0	100.0
Fertilizer use (kg/ha)			
1987			
Wet season 2/	242.0	11.25	0
Dry season 2/	306.1	-	275.9
1998			
Wet season 2/	354.1	66	356.6
Dry season 3/	347.4		368.1

Source: Kasetsart University-IRRI survey data base .

Note: 1/ In SP3 village, wet season represents the first rice crop which starts to grow in December or January.

2/ In the term of nitrogen content.

3/ In the term of mixed chemical fertilizer.

TABLE 5 YIELD PERFORMANCE (KG/HA) OF FARM SAMPLES BY ECOSYSTEMS IN 1987 AND 1998 SURVEYS

	Suphan Buri		
	SP1	SP2	SP3
1987			
MV Wet season	4.1	-	0
MV Dry season	4.7	-	4.1
LV wet season	3.3	1.3	1.1
1998			
MV Wet season	5.4	0.4	4.8
MV Dry season	5.3		4.9
LV wet season		0.2	

Source: Kasetsart University-IRRI survey data base .

TABLE 6 ADOPTION OF LABOR SAVING TECHNOLOGY (%OF TOTAL CULTIVATED AREA) OF FARM SAMPLES BY ECOSYSTEMS IN 1987 AND 1998 SURVEYS

	Suphan Buri		
	SP1	SP2	SP3
Adoption of direct seeding method			
1987			
Wet season	93.6 1/	100.0 2/	100.0 2/
Dry season	85.2 1/	-	100.0
1998			
Wet season	100.0 1/	100.0 2/	100.0
Dry season	100.0 1/		100.0
Adoption of power tiller			
1987	100.0	98.0 2/	100.0 3/4/
1998	100.0	100.0	100.0
Adoption of mechanical thresher			
1987	100.0	100.0	100.0
1998	0.0	0.0	0.0
Adoption of combined harvestor			
1987	0	0	0
1998	100.0	55.8	100.0

Source: Kasetsart University-IRRI survey data base .

Note: 1/ Indicates adoption of wet seeded rice technique 2/ Indicates adoption of direct seeding rice technique 3/ Using four wheel tractor 4/ Power tiller is used in dry season.

TABLE 7 COMPARISON OF OUTPUT AND FACTOR PRICE OF FARM SAMPLES (EVALUATED AT 1998 PRICE) BY ECOSYSTEMS IN 1987 AND 1998 SURVEYS

	Suphan Buri		
	SP1	SP2	SP3
Paddy price (B/kg)			
1987	7.6	6.6	7.0
1998	5.9	6.2	6.1
Fertilizer price (B/kg)			
1987 1/	23.5	26.8	-
1998	6.1	6.4	6.9
Wage rate in			
Crop establishment (B/day)			
1987	109 3/	64.5	103 3/
1998	120	100	120
Harvesting (B/day)			
1987	71 3/	62 3/	70 3/
1998	120	100	120
Custom rate			
Tractor (B/ha)			
1987 two passes	2,063	2,292	2,292
1998 two passes	1,875	1,375	1,563
Tresher (B/ton)			
1987	180	190	180
1998	-	175	-
Combine harvester (B/ha)			
1987	-	-	-
1998	2,581	-	2,354

Source: Kasetsart University-IRRI survey data base .

Note: 1/refer to nutrient price of nitrogen 2/ Referring to mixed fertilizer. In Suphan Buri, the popular fertilizer used by farmers are Urea, Ammonium Sulphate, and 16-20-0. 3/Imputed daily earning under piece rate contract.

TABLE 8 LABOR USE (MAN-DAY/HA) AND SHARE OF MECHANIZATION BY ECOSYSTEMS IN 1987 AND 1998 SURVEYS

	Suphan Buri		
	SP1	SP2	SP3
Land preparation			
1987	7.4	6.4	5.2
1998	2.6	3.1	1.3
Crop establishment			
1987	7.0	2.6	1.7
1998	1.1	0.5	0.3
Care of crop			
1987	14.4	3.2	8.2
1998	4.3	2.3	2.3
Harvest and thresh			
1987	28.7	27.5	21.9
1998	0.1	7.0	2.2
Total labor			
1987	57.5	39.8	37.0
(% of hired labor)	(49.1)	(27.5)	(49.6)
1998	8.0	12.9	6.2
(% of hired labor)	(63.3)	(45.6)	(22.5)

Source: Kasetsart University-IRRI survey data base .

TABLE 9 FACTOR PAYMENTS (EVALUATED AT 1998 PRICE,1,000BAHT/HA) AND FACTOR SHARES BY ECOSYSTEMS IN 1987 AND 1998 SURVEYS [a/]

	Suphan Buri		
	SP1	SP2	SP3
	1987		
Gross value of output	28.0(100)	8.4(100)	13.5(100)
Current input	4.2(15)	0.9(11)	2.7(20)
Fixed capital	2.5(9)	1.1(13)	1.2(10)
Owned	2.0	0.6	0.9
Hired	0.5	0.5	0.4
Labor	6.4(23)	3.0(35)	3.7(27)
Family	3.2	2.2	2.0
Hired	3.1	0.7	1.7
Land	14.9(53)	3.5(41)	5.8(43)
Leasehold rent	1.6	2.0	3.5
Surplus	13.2	1.5	2.4
	1998		
Gross value of output	24.9(100)	4.5(100)	29.2(100)
Current input	6.9(28)	0.8(28)	6.2(21)
Fixed capital	1.9(7)	1.6(35)	1.9(6)
Owned	0.9	0.8	0.9
Hired	1.0	0.8	1.0
Labor	0.9(4)	1.8(40)	1.7(6)
Family	0.5	0.8	0.7
Hired	0.4	1.0	1.0
Land	15.3(61)	0.3(7)	19.4(67)
Leasehold rent	1.8	0.6	1.2
Surplus	13.5	-0.3	18.2

Source: Kasetsart University-IRRI survey data base .
Note: a/ Using cultivated area as a weighted unit for wet and dry seasons. In parenthesis is a percentage.

TABLE 10 AVERAGE ANNUAL INCOME (EVALUATED AT 1998 PRICE,1,000 BAHT) OF FARM HOUSEHOLDS BY SOURCE AND ECOSYSTEMS IN 1987 AND 1995-SURVEYS

	Suphan Buri		
	SP1	SP2	SP3
	1987		
Rice production	**94.2(55.8)**	**36.3(53.1)**	**59.5(52.6)**
Labor	16.6	14.5	16.6
Capital	9.9	3.5	6.9
Land	67.7	18.3	36.0
Non-rice production	**74.7(44.2)**	**32.2(46.9)**	**53.7(47.4)**
Farm	61.1	18.3	8.8
Non-farm	12.1	12.3	41.7
Remittance	1.5	1.6	3.2
Total income	**168.9(100.0)**	**68.4(100.0)**	**113.2(100.0)**
Household size	5.4	6.0	6.5
No. of working member	4.1	4.4	5.0
Per capita income	31.3	11.4	17.4
Per working member	41.2	15.5	22.6
	1998		
Rice production	**103.2(28.6)**	**2.6(3.7)**	**101.7(83.4)**
Labor	4.1	2.3	10.6
Capital	36.1	1.8	27.6
Land	63.0	-1.5	63.5
Non-rice production	**258.2(71.4)**	**67.4(96.3)**	**20.2(16.6)**
Farm	218.8	24.7	1.4
Non-farm	37.5	34.9	10.3
Remittance	1.9	7.9	8.5
Total income	**361.4(100.0)**	**70.0(100.0)**	**121.9(100.0)**
Household size	4.2	5.1	6.6
No. of working member	3.4	4.1	4.4
Per capita income	86.0	13.7	18.5
Per working member	106.2	17.1	27.7

Source: Kasetsart University-IRRI survey data base .

Note: In parenthesis is a percentage

Development pattern and strategies to strengthen the existing community groups in Saklee, Ayutthaya

Suwida Thammaneewong , Kiriboon Jongwutiwes, Maream Nillapun, Somkid Phumkokrux, Hansa Nilapun

รูปแบบและแนวทางการพัฒนาความเข้มแข็งของการรวมกลุ่มในชุมชนสาคลีจังหวัดพระนครศรีอยุธยา[1]

สุวิดา ธรรมมณีวงศ์ [2], ดร.คีรีบูน จงวุฒิเวศย์[3], ดร.มาเรียม นิลพันธุ์[4], พันจ่าอากาศเอก สมคิด , ภูมิโคกรักษ์[5], หรรษา นิลาพันธ์[6]

Abstract: *The study on "Development Patterns and Strategies to Strengthen the Existing Community Groups in Saklee, Ayutthaya" was a development oriented research, based on an analysis of the community groups in various contexts: group formation, group cohesion, group development and group obstruction, to search, with the objective to experiment and develop patterns and strategies aiming at strengthening the groups.*

The study covered the altemative agriculture group, the saving group, and the indigenous knowledge of the groups and community in Saklee Community, Se-na District, Ayutthya Province, encompassing 3 tambol (sub-districts): Bang-nom-ko, Sam-tum, and Ban-luang. The study included document analysis, formal and informal interviews, participatory observation, focus group and Geographic Information System (GIS). The duration of the study and activities in the community was 3 years from 2541-2543 B.E.

The study found that the evolution of the community could be periodised as follows:

- *Subsistence agriculture stage (before 2512 B.E.)*
- *Modem agriculture stage (2512-2531 B.E.)*
- *Off-farm stage (2531- 2539 B.E.)*
- *Self-reliance stage (2539 - present)*

The altemative agriculture group originated from the integrated farming system at the level of the school. The project was initiated by a school teacher of the community in

---

[1] บทความนี้เป็นส่วนหนึ่งของรายงานการวิจัยเรื่องรูปแบบและแนวทางการพัฒนาความเข้มแข็งของการรวมกลุ่มในชุมชนสาคลีจังหวัดพระนครศรีอยุธยา

[2] ภาควิชาสังคมศาสตร์ คณะอักษรศาสตร์ มหาวิทยาลัยศิลปากร นครปฐม

[3] ภาควิชาการศึกษานอกโรงเรียน คณะศึกษาศาสตร์ มหาวิทยาลัยศิลปากร นครปฐม

[4] ภาควิชาหลักสูตรและวิธีสอน คณะศึกษาศาสตร์ มหาวิทยาลัยศิลปากร นครปฐม

[5] ภาควิชาภูมิศาสตร์ คณะอักษรศาสตร์ มหาวิทยาลัยศิลปากร นครปฐม

[6] สถาบันวิจัยและพัฒนา มหาวิทยาลัยศิลปากร นครปฐม

2524 B.E., then the idea was spread off the school to the community. Thus the alternative agriculture group was formed, and the contact was established between the factories and the community, in order to sell their produce. The visits from govemment and non govemment organizations thereafter had influence on the groups in starting networking with other agriculture groups and other occupation groups in the forms of community market and community kitchen. For example Toxic- free agriculture group and sustainable agriculture group have emerged in other 3 Tambol (sub-districts), following the alternative agriculture group. The main problem of the altemative agriculture group was the lack of basic agriculture information to assist the members in the management of production and in the analysis of the situation.

The saving group. This group was formed in Saklee Community to be the fund for helping the members in occupation. In this research, three saving groups: Saklee Honest Saving Group, Saving Group for Production, and Sustainable Agriculture Saving Group were studied. The findings were that all groups required the members to save by depositing every month, and allowed the members to have loan by helping each other. All groups shared the same problems in that they lacked proper accounting system and financial control, that the members paid more attention to loan and to share benefits than on developing saving habits.

Indigenous knowledge. Saklee Community can be considered to be a learning community. It adjusted itself smartly in the current of change thanks to local wisdom, for example, in agriculture management, health care, production transformation. It has a long successful culture and tradition from past to present and could adjust its way of life for self survival in the present situation of the society. Yet, the community needs to leam from outside to better adjust itself.

The findings of the study indicated the problems and situation of various groups in the community. The research team organised various activities to strengthen the community as follows:
Meetings with key persons and people of various groups both formally and informally were organized regularly in order to exchange information, ideas, suggestion, and advice if needed.
Knowledge support activities were organized by inviting experts from outside to transfer knowledge to the community by training, seminar, practice, field study to various places of interest.
Network coordination was provided to link various groups with the outside, such as government and non govemment organization to strengthen their community.
Problem solving of some cases were experimenting with groups such as survey and collection of agriculture data for the community and data on saving group members, for the saving group to analyze their potentiality, and solve some problems such as designing new accountancy system for the group.
Local dialogues were organized to present and exchange information with community leaders by using GIS data for the community to examine and analyse relevant data. This helped the community see their situation in various dimensions.

From the study and experiment in Saklee Community, the research team concluded that the approach implemented had a role in strengthening the community. Especially, the research team must have real attention in working with the community, without taking benefit from it but facilitating it; the community itself must have a highly intentioned people, self-reliance consciousness, love of community and coordination among key leaders of various groups, in order to significantly push the community to achievements and to be ready to adjust to any coming changes.

1. ความนำ

สังคมชนบทถูกผนวกรวมเข้าไว้เป็นส่วนหนึ่งของระบบเศรษฐกิจโลก ดังนั้นการเปลี่ยนแปลงของระบบเศรษฐกิจโลกจึงส่งผลกระทบเชื่อมโยงต่อลักษณะและทิศทางการพัฒนาสังคมเกษตรกรรมในชนบท และแม้ระบบทุนนิยมจะขยายตัวแทรกซึมเข้าไปในภาคเกษตรมากขึ้นแต่ระบบการผลิตของชาวนาบางส่วนยังคงดำรงอยู่ มิได้แปรสภาพเป็นแรงงานรับจ้างไปหมด เพราะระบบทุนนิยมโลกมิได้ทำลายล้างระบบการผลิตที่มีอยู่เดิมเพียงแต่เป็นการผสมผสานกันทำให้สถานะของชาวนาเป็นส่วนหนึ่งของระบบทุน เช่นเราพบการปรับตัวและการเปลี่ยนแปลงของชาวนาบางกลุ่มที่ไม่เพียงถูกครอบงำด้วยอิทธิพลการเปลี่ยนแปลงจากภายนอกเท่านั้น แต่สามารถแสดงบทบาทและผลักดันเลือกและใช้ประโยชน์จากการเปลี่ยนแปลงนั้น ๆ

อิทธิพลและอำนาจรัฐที่ขยายและแทรกตัวเข้าไปในชนบท ในรูปแบบต่าง ๆ ค่อนข้างจะมีประสิทธิภาพในการครอบงำควบคุมชาวบ้าน แต่อำนาจรัฐมีความคลุมเครือด้านอุดมการณ์และการพัฒนาจึงผลักดันให้ชาวบ้านเลือกแสวงหาอุดมการณ์ใหม่ๆ ที่สอดคล้องกับสภาพปัญหาและความต้องการของกลุ่มต่างๆ เช่นเพิ่มมิติทางสังคมและวัฒนธรรมชุมชนเข้าไปในกิจกรรมทางเศรษฐกิจ จึงเกิดการจัดตั้งองค์กรในรูปแบบต่างๆ ที่เป็นอิสระจากการครอบงำจากรัฐ หรือการรวมตัวเป็นเครือข่ายเพื่อสร้างพันธมิตรของชาวบ้านในหลายแห่ง เพื่อการแสวงหากลยุทธในการอยู่รอดและการแสดงพลังในการต่อรองกับอำนาจรัฐและอิทธิพลทุนนิยมโดยนัยนี้ อานันท์ กาญจนพันธุ์ (2538:183-184) เรียกว่าเป็นกระบวนการผลิตใหม่ของความเป็นชุมชน ในการปรับตัวต่อการเปลี่ยนแปลงเข้าสู่ระบบตลาดแบบทุนนิยม

แนวคิดดังกล่าวสอดคล้องกับนักวิชาการ และผู้ที่สนใจงานประชาสังคม (อนุชาติ พวงสำลี และกฤตยา อาชวนิจกุล บรรณาธิการ, 2542) เช่น การประชุมสัมมนาทางวิชาการประชาสังคม ครั้งที่ 1 เรื่อง "ประชาสังคม:พลเมืองไทย ณ จุดเปลี่ยนแห่งศตวรรษ" ซึ่งจัดเมื่อวันที่ 2 – 4 เมษายน ได้กล่าวถึงความสำคัญของการสร้างความเข้มแข็งของชุมชนให้กับชุมชนฐานรากว่าเป็นพื้นฐานในการพัฒนาที่ยั่งยืน

ชุมชนสาคลี7 อำเภอเสนา จังหวัดพระนครศรีอยุธยาปัจจุบันคือชุมชนวัฒนธรรมคลองขนมจีน เป็นชุมชนที่มีอาณาเขตครอบคลุมบางส่วนของพื้นที่ 3 ตำบล 7 หมู่บ้าน ได้แก่ หมู่ 9 หมู่ 10 บางนมโค หมู่ 1 หมู่ 2 ตำบลสามตุ่ม และหมู่ 3 หมู่ 4 หมู่ 5 ตำบลบ้านหลวง ตั้งอยู่ทางด้านตะวันตกของตัวจังหวัดมีระยะห่างประมาณ 20 กิโลเมตร และอยู่ห่างไปทางตอนใต้ของอำเภอเสนาระมาณ 6 กิโลเมตร มีถนนสายเสนา-คลองประสิทธิ์ผ่านชุมชนควบคู่ไปกับลำคลองขนมจีน (ดูแผนภาพที่ 1)

[7] **ชุมชนสาคลีในปัจจุบันเอกสารบางเล่มเรียก ชุมชนวัฒนธรรมมารวิชัย เนื่องจากมีวัดมารวิชัยเป็นศูนย์กลางของชุมชน หรือ ชุมชนวัฒนธรรมคลองขนมจีน เนื่องจากมีลำคลองขนมจีนไหลผ่านชุมชน**

ปัจจุบัน สาคลีได้เปลี่ยนแปลงโครงสร้างการผลิตของชุมชนไปจากเดิมอย่างรวดเร็วภายหลังจากโรงงานอุตสาหกรรมเข้ามาตั้งอยู่ในละแวก ด้วยผลจากนโยบายการกระจายอุตสาหกรรมไปสู่ภูมิภาค ได้กำหนดจังหวัดพระนครศรีอยุธยาเป็นเขตส่งเสริมการลงทุนเขต 2 มีโรงงานขนาดใหญ่เข้าไปดำเนินงานในพื้นที่จำนวน มาก ก่อนวิกฤตการณ์ทางเศรษฐกิจกลางปีพ.ศ. 2540 มีคนงานจากในชุมชนและนอกชุมชนจากภาคอีสานและจังหวัดใกล้เป็นแรงงานจำนวนนับหมื่น มีผลให้ชาวบ้านในชุมชนสาคลีประกอบอาชีพเกษตรกรรมลดลง นอกนั้นเป็นอาชีพนอกภาคเกษตรกรรม ที่มีความหลากหลาย อาทิเช่น ค้าขาย ธุรกิจขนาดเล็ก ธุรกิจบ้านเช่า รับจ้างทั่วไป รับราชการ และประชากรวัยหนุ่มสาว ส่วนใหญ่เป็นแรงงานในโรงงานอุตสาหกรรม หลังจากมีโรงงานเข้ามาตั้งทำให้ราษฎรบางส่วนมีการขายที่ดินเพื่อนำเงินมาใช้หนี้แล้วหันมาประกอบอาชีพรับจ้าง บางพื้นที่เลิกทำการเกษตรกรรมแล้วหันมาลงทุนทำการค้า การเปลี่ยนแปลงอาจมิใช่จากปัจจัยภายนอกเพียงประการเดียว ปัจจัยภายในชุมชนก็เป็นอีกสาเหตุที่ทำให้เกิดเหตุการณ์ดังกล่าว กล่าวคือ ชาวบ้านประสบปัญหาหนี้สินจากการทำเกษตรกรรม

ชุมชนดังกล่าวข้างต้น เป็นชุมชนตัวอย่างที่สะท้อนให้เห็นความพยายามในการปรับตัวของชาวบ้านภายใต้กระแสของระบบทุนนิยม การปรับตัวของชุมชนเป็นกระบวนการต่อสู้เพื่อการปรับเปลี่ยน ให้มีชุมชนมีอิสระในการเลือกปฏิสัมพันธ์กับสังคมภายนอกอย่างเท่าเทียม กล่าวคือ คนในชุมชนมีการรวมกลุ่มต่าง ๆ ขึ้นเพื่อแก้ปัญหาเศรษฐกิจ และปรับเปลี่ยนวัฒนธรรมให้เกื้อกูลต่อการดำรงอยู่อย่างเข้มแข็งในชุมชน ตัวอย่างเช่น

การรวมกลุ่มออมทรัพย์สาคลี เพื่อระดมทุนให้แก่ผู้ด้อยโอกาสทางเศรษฐกิจ ทำการค้าหรือธุรกิจขนาดเล็กรองรับการขยายตัวของอาชีพที่หลากหลายของชุมชน ในช่วงหลังได้ขยายวัตถุประสงค์ การออมเงินออกไปเพื่อพัฒนาอาชีพและคุณภาพชีวิต และมีกิจกรรมเสริมการฟื้นฟูความสัมพันธ์ของชุมชนในรูปแบบต่าง ๆ เพื่อให้เกิดความสามัคคีและการเอื้ออาทรต่อกัน กิจกรรมเหล่านี้นำมาซึ่งความเชื่อถือศรัทธาของคนในชุมชน

การรวมกลุ่มเกษตรทางเลือกและผักปลอดสารพิษ เพื่อพัฒนาเกษตรกรรมให้สอดคล้องกับบริบททางสังคมที่เปลี่ยนไป จากการทำนาอย่างเดียวมาเป็นการทำเกษตรผสมผสาน มีทั้งการทำนา ทำสวนพืชผัก เลี้ยงสัตว์ เลี้ยงไก่บนบ่อปลา ฯลฯ หลากหลายรูปแบบไปตามความถนัดและความพร้อมของแต่ละครอบครัว ปัจจุบันมีสมาชิกทำเกษตรผสมผสาน 15 ครอบครัว และแตกตัวออกไปเน้นการปลูกผักปลอดสารพิษ 20 ครอบครัว ผลผลิตที่เหลือจากการบริโภคในครัวเรือนก็นำออกจำหน่ายในชุมชน ในโรงงานอุตสาหกรรมและในตลาดอำเภอเสนา โดยมีเกษตรกรเป็นผู้นำผลผลิตออกจำหน่ายเอง

ความพยายามในการปรับตัวของชุมชน ท่ามกลางบริบททางสังคมที่เป็นอยู่นี้ ทำให้การรวมกลุ่มขององค์กรฐานรากมีความเข้มแข็งขึ้นหรือไม่อย่างไร รวมทั้งกลไกรัฐและเครือข่ายพันธมิตรขององค์กรชุมชน

ซึ่งหนุนช่วยชุมชนอยู่ในขณะนี้ ควรจะมีแนวทางอย่างไรในการสนับสนุนความเข้มแข็งของชุมชนไทยเหล่านี้เป็นสิ่งที่น่าสนใจศึกษา

แม้ชุมชนสาคลีจะเป็นชุมชนที่หลายฝ่ายทั้งนักวิชาการ ข้าราชการ นักธุรกิจเอกชนและนักศึกษาให้ความสนใจว่าเป็นตัวอย่างของชุมชนที่เข้มแข็ง แต่จากการพูดคุยกับแกนนำของชุมชนทั้งครูและชาวบ้านประกอบกับการสำรวจข้อมูลโดยการสังเกตการณ์และสัมภาษณ์ และจากการศึกษารายงานการวิจัยของคณะครูในโรงเรียนสาคลี (สุรินทร์ กิจนิตชีว์และคณะ,2540) ซึ่งสะท้อนถึงความพยายามในการปรับตัวของชุมชนท่ามกลางการเปลี่ยนแปลงพบว่าการปรับตัวของกลุ่มต่างๆ ยังต้องการการสนับสนุนจากหน่วยงานภายนอก เช่น ความรู้ทางวิชาการ การปรับบทบาทของหน่วยงานต่าง ๆ เพื่อส่งเสริมการทำงานขององค์กรชุมชน เป็นต้น ดังนั้น คณะนักวิจัยจึงสนใจว่า แม้ชุมชนสาคลีที่เข้มแข็งในระดับหนึ่ง ยังต้องการการสนับสนุนจากภายนอกอย่างไร สาระของการสนับสนุนอย่างไรที่จะนำไปเสริมความเข้มแข็งของกลุ่ม และชุมชน จึงเป็นที่มาของการศึกษาวิจัยครั้งนี้

2. กรอบการศึกษา

"ความเข้มแข็งของการรวมกลุ่ม" จะพิจารณาความเข้มแข็งของการรวมกลุ่มในเชิงโครงสร้างและกระบวนการ กล่าวคือวิเคราะห์ว่ากลุ่มที่เข้มแข็งมีโครงสร้างความสัมพันธ์ในองค์กรอย่างไร และในลักษณะกระบวนการคือการพิจารณาว่ากลุ่มสามารถดำรงรักษาความเป็นกลุ่ม และสามารถระดมพลังในการแก้ปัญหาที่เกิดขึ้นได้หรือไม่และอย่างไร การพิจารณาในลักษณะดังกล่าวเป็นการพิจารณาความสามารถในเรียนรู้และปรับตัวเพื่อสนองตอบต่อกระแสการเปลี่ยนแปลงใหม่ ดังที่สีลาภรณ์ นาครทรรพ (2539:116) กล่าวว่าความสำเร็จของชุมชนอยู่ที่กระบวนการในการเรียนรู้และปรับตัวเพื่อสนองตอบต่อกระแสการเปลี่ยนแปลงใหม่ ๆ การวัดความเข้มแข็งของชุมชนจึงควรพิจารณา กระบวนการในการที่ชุมชนดำรงรักษาความเป็นกลุ่ม และพลังในการแก้ปัญหาเอาไว้ด้วย ทั้งสองส่วนนี้จึงเป็นการศึกษารูปแบบความเข้มแข็งของการรวมกลุ่ม อย่างไรก็ตามในกระบวนการดำรงรักษาความเป็นกลุ่มนั้น ชุมชนได้อาศัยภูมิปัญญาที่มีอยู่ปรับตัวไปตามสภาพ เงื่อนไข ปัจจัย และมีข้อจำกัดในการปรับตัว ดังที่สุรินทร์ กิจนิตย์ชีว์ (2540) กล่าวว่าการปรับตัวของกลุ่มต่างๆ ยังต้องการการสนับสนุนจากหน่วยงานภายนอก เช่น ความรู้ทางวิชาการ การปรับบทบาทของหน่วยงาน ดังนั้น หน่วยงานภายนอกจะมีแนวทางอย่างไรในการเข้าไปเสริมกระบวนการปรับตัวของกลุ่มต่าง ๆ ในส่วนนี้จึงเป็นโจทย์วิจัยส่วนที่สองนั่นคือ คือหาแนวทางในการพัฒนาความเข้มแข็งของการรวมกลุ่ม

2.1 วิธีดำเนินการวิจัย

คณะผู้วิจัยดำเนินการในลักษณะของการวิจัยและพัฒนา (Research and Development) ดำเนินการเป็นขั้นตอนดังนี้

ขั้นตอนที่ 1 การวิจัย (Research : R) เป็นการศึกษาและวิเคราะห์สภาพการรวมกลุ่มต่าง ๆ ของชาวบ้านในชุมชนสาคลี

ขั้นตอนที่ 2 การพัฒนา (Development : D) เป็นการศึกษารูปแบบและแนวทางในการพัฒนาความเข้มแข็งของการรวมกลุ่ม

ขั้นตอนที่ 3 การวิจัย (Research : R) เป็นการทดลองรูปแบบและแนวทางในการพัฒนาความเข้มแข็งของการรวมกลุ่ม ต่าง ๆ โดยการจัดกิจกรรมต่าง ๆ เสริมกระบวนการกลุ่ม

ขั้นตอนที่ 4 การพัฒนา (Development : D) เป็นการพัฒนารูปแบบและแนวทางในการพัฒนาความเข้มแข็งของการรวมกลุ่ม

2.2 ขอบเขตของการวิจัย

การวิจัยนี้ คณะผู้วิจัยมุ่งศึกษาการรวมกลุ่มในบริบททางสังคมต่างๆ ของชุมชนโดยศึกษาจากกลุ่มเกษตรทางเลือก กลุ่มออมทรัพย์ และศึกษาภูมิปัญญาของกลุ่มทั้งสองในการจัดกลุ่มให้ดำรงอยู่ได้ และเนื่องจากในครั้งนี้เป็นการวิเคราะห์ระดับกลุ่ม การเก็บข้อมูลใช้พื้นที่ขยายไปตามเครือข่ายของสมาชิกกลุ่มต่าง ๆ มิใช่ศึกษาการรวมกลุ่มเฉพาะในพื้นที่ชุมชนสาคลี

2.3 การเก็บรวบรวมข้อมูล

เนื่องจากคณะผู้วิจัยมีความสัมพันธ์กับชาวบ้านมานานก่อนการทำวิจัย การเก็บรวบรวมข้อมูลจึงใช้วิธีการต่าง ๆ ทั้งการศึกษาเอกสาร (Document Analysis) การสัมภาษณ์แบบเป็นทางการ (Formal Interview) และไม่เป็นทางการ (Informal Interview) โดยเฉพาะการสัมภาษณ์ผู้ให้ข้อมูลสำคัญ (Key Informant) ในประเด็นต่างๆ ที่เกี่ยวข้อง ใช้การสังเกตการณ์แบบมีส่วนร่วม (Participant Observation) และการสนทนากลุ่ม (Focus Group)

เมื่อได้ข้อมูล คณะผู้วิจัยจะนำข้อสรุปมาทดลองจัดกิจกรรมต่าง ๆ เพื่อเสริมกระบวนการกลุ่ม โดยมีการจัดกิจกรรมหลายลักษณะ ทั้งการศึกษาดูงาน การประชุมอย่างเป็นทางการ การช่วยจัดระบบข้อมูล การสำรวจข้อมูลพื้นฐานของกลุ่มต่าง ๆ ร่วมกับชาวบ้าน และนำข้อมูลพื้นฐานมาวิเคราะห์และนำเสนอต่อชาวบ้านเพื่อรับฟังความคิดเห็นและข้อแก้ไข

2.4 เครื่องมือที่ใช้ในการวิจัย

ในการวิจัยครั้งนี้มีเครื่องมือที่ใช้ในการเก็บรวบรวมข้อมูลคือแบบสอบถาม (Questionaire) เกี่ยวกับข้อมูลพื้นฐานของกลุ่มต่าง ๆ ภาพถ่ายทางอากาศ ระบบสารสนเทศภูมิศาสตร์ โปรแกรม Arcinfo และ Arcview กล้องถ่ายภาพเพื่อประกอบการบันทึกข้อมูล

2.5 การวิเคราะห์ข้อมูล

ใช้การวิเคราะห์ข้อมูลโดยการวิเคราะห์ค่าร้อยละ วิเคราะห์เนื้อหาแปลภาพถ่ายทางอากาศ กำหนดพิกัดทางภูมิศาสตร์ จัดทำฐานข้อมูลสภาพชุมชน สภาพกลุ่มเชื่อมโยงกับแผนที่ทางภูมิศาสตร์

2.6 ระยะเวลาในการศึกษา

การวิจัยครั้งนี้ใช้เวลาในการศึกษาประมาณ 2 ปีเศษ ตั้งแต่ปลายปีพ.ศ. 2540 – กลางปีพ.ศ. 2543

3. ผลการศึกษา

3.1 พัฒนาการชุมชนสาคลี ได้มีพัฒนาการจากอดีตถึงปัจจุบัน แบ่งได้เป็น 4 ระยะ คือ

3.1.1 ช่วงการทำการเกษตรยังชีพ (ก่อน พ.ศ. 2512)

ระบบการผลิตเป็นการผลิตเพื่อยังชีพ ช่วงเวลาดังกล่าวคนในชุมชนมีความเป็นอยู่อย่างเรียบง่าย สอดคล้องกับธรรมชาติ มีการพึ่งตนเองสูง มีความสัมพันธ์ระหว่างชุมชน และมีวัดเป็นศูนย์กลางในการทำกิจกรรม กล่าวได้ว่า ในชุมชนมีวัฒนธรรมชุมชนเป็นสายใยร้อยรัดเกาะเกี่ยวของคนในชุมชน

3.1.2 ช่วงการเปลี่ยนแปลงสู่การเกษตรแผนใหม่ (พ.ศ. 2512 – 2531)

การเปลี่ยนแปลงของชุมชนเข้าสู่การทำเกษตรแผนใหม่ได้เริ่มจากการตัดถนนเข้าสู่หมู่บ้าน และการส่งเสริมของหน่วยราชการ ทำให้ชาวบ้านได้ปรับระบบการผลิตจากการผลิตเพื่อการพึ่งตนเองไปสู่การผลิตเพื่อขาย เนื่องจากการทำนาในระบบการผลิตสมัยใหม่นั้นไม่คุ้มกับการลงทุนต้องอาศัยสารเคมี เครื่องจักรกลต่างๆ ทำให้ต้นทุนกับรายรับไม่สมดุลกัน ชาวบ้านจำนวนมากปรับเปลี่ยนวิถีชีวิตจากการทำนาที่ต้องพึ่งตนเอง ไปพึ่งระบบตลาด

การผลิตในช่วงปี พ.ศ. 2520 - 2524 ถึงภาวะวิกฤติ ชาวบ้านประสบภาวะขาดทุนติดต่อกันถึง 5 ปีน้ำท่วม ราคาตกต่ำ ศัตรูพืชระบาด ฯลฯ ทำให้เกิดภาวะหนี้สิน กันถ้วนหน้าและยังประสบปัญหาสุขภาพชาวนาต้องเสียชีวิตเพราะสูดดมสารเคมี สัตว์น้ำในแหล่งธรรมชาติเริ่มสูญหายไปตามลำดับ

แม้ว่าชาวบ้านจะได้รับผลกระทบจากการเปลี่ยนแปลงอย่างไร แต่ส่วนหนึ่งก็ได้พยายามดิ้นรนต่อสู้ตามความสามารถ สติปัญญาของแต่ละคนและแต่ละกลุ่มมีการนำภูมิปัญญาของชาวบ้าน ภูมิปัญญาของหมู่บ้านมาปรับปรนกับวิถีชีวิตปัจจุบันในรูปแบบและลักษณะต่างๆ แต่โดยรวมเป็นการปรับตัวในลักษณะของการสูญเสียที่ดินมากขึ้น เนื่องจากปีพ.ศ. 2526 ทางการสร้างถนนหลวงสายสามโคก - เสนา พาดผ่านด้านตะวันออกของหมู่บ้าน ชาวบ้านซึ่งมีหนี้สินได้พากันขายที่กับบุคคลภายนอก

แม้ภาพรวมของชุมชนสาคลีในช่วงเวลาดังกล่าวจะเกิดการเปลี่ยนแปลงไปในทิศทางที่ชุมชนไม่สามารถกำหนดได้ แต่ท่ามกลางการเปลี่ยนแปลงดังกล่าว มีการเปลี่ยนแปลงในกลุ่มเล็ก ๆ ที่พยายามทวนกระแสหลักของการพัฒนาในช่วงนั้น ไปสู่การพึ่งพาตนเอง โดยคณะครูในโรงเรียนสาคลีเป็นผู้ขยายแนวคิดการทำเกษตรผสมผสานสู่ชุมชนในปีพ.ศ. 2529 อย่างไรก็ตามสมาชิกในชุมชนส่วนมากกำลังสูญเสียที่ดิน รวมทั้งหมดหวังกับการทำการเกษตร อยู่ในสภาวะสับสนกับทางออกของตนเอง เกษตรกรกลุ่มนี้จึงเป็นกลุ่มผู้ริเริ่มการเปลี่ยนแปลง

3.1.3 ช่วงการเริ่มขยายสู่อาชีพนอกภาคเกษตร (พ.ศ. 2531 – 2539)

ในปีพ.ศ. 2531 ในเขตอำเภอเสนาได้เกิดอุตสาหกรรมขนาดใหญ่ ทำให้เกิดอาชีพใหม่ ๆ รองรับการขยายตัวของโรงงาน อาชีพใหม่ ๆ ที่เกิดขึ้น เป็นช่องทางในการหารายได้เป็นตัวเงินรวดเร็ว และมากกว่ารายได้จากภาคเกษตร เช่น ทำธุรกิจรับเหมาก่อสร้าง ค้าขายรอบ ๆ โรงงาน ธุรกิจบ้านเช่า ฯลฯ อาชีพเหล่านี้ปรับตัวไปตามกลุ่มผู้บริโภคซึ่งเป็นผู้ใช้แรงงานในโรงงานอุตสาหกรรม และเป็นกลุ่มที่เพิ่มขึ้นอย่างรวดเร็ว

ราคาที่ดินในบริเวณนี้สูงขึ้นไปเรื่อย ๆ และมีความถี่ในการเปลี่ยนกรรมสิทธิ์การถือครองสูง กล่าวได้ว่าการสูญเสียที่ดินของคนในชุมชนเป็นไปอย่างรวดเร็ว ซึ่งนอกจากสาเหตุจากภายในชุมชนเองซึ่งประสบปัญหาการผลิต และการบริโภคเกินกำลังแล้ว กระแสการพัฒนาของรัฐเป็นแรงผลักดันสำคัญอีกแรงหนึ่งที่ทำให้ชุมชนปรับเปลี่ยนไปตามทิศทางที่ไม่สามารถควบคุมได้

ต่อกรณีดังกล่าวคณะนักวิจัยได้ข้อสังเกตว่าความคิดในการกลับลำสู่การเกษตรเพื่อการพึ่งตนเองไม่สามารถเกิดขึ้นได้หากไม่ได้รับการสนับสนุนจากภายนอก โดยเฉพาะจากหน่วยราชการ

กล่าวได้ว่า โครงสร้างอาชีพของสมาชิกในชุมชนได้ปรับตัวเพื่อรองรับกับการเข้ามาของโรงงานหรือกระแสภายนอกมากขึ้น ขาดความมั่นคงในอาชีพ ความมั่นคงในรายได้ และเกิดปัญหาสิ่งแวดล้อมและปัญหาสังคมในชุมชน เช่นปัญหาขยะ ปัญหายาเสพย์ติด ปัญหาค่านิยมทางเพศและอาชญากรรม

นอกจากการปรับตัวของสมาชิกในแต่ละบุคคลแล้ว ยังพบว่ามีการปรับตัวของชาวบ้านโดยการรวมกลุ่มในลักษณะต่าง ๆ เพื่อแก้ปัญหาทางเศรษฐกิจ สังคม สิ่งแวดล้อมในชุมชน เช่น กลุ่มเกษตรกรรมทางเลือก กลุ่มออมทรัพย์สาคลี (ดูแผนภาพที่ 2)

การรวมกลุ่มออมทรัพย์กลุ่มแรกเกิดในตำบลบางนมโค เกิดขึ้นเพื่อระดมทุนให้กับผู้ด้อยโอกาสทางเศรษฐกิจ หรือผู้ที่ทำการค้า หรือธุรกิจขนาดเล็กรองรับการขยายตัวของอาชีพที่หลากหลายของชุมชน และขยายขยายวัตถุประสงค์การออมทรัพย์ไปเพื่อพัฒนาอาชีพและพัฒนาคุณภาพชีวิต การฟื้นฟูความสัมพันธ์ในรูปแบบต่าง ๆ ก่อนวิกฤตการณ์เมื่อกลางปีพ.ศ. 2540 กลุ่มออมทรัพย์มีเงินหมุนเวียนประมาณ 1 ล้านสี่แสนบาทเศษ และมีสมาชิกกว่า 200 คน

กลุ่มเกษตรกรรมทางเลือกตำบลบ้านหลวง (เรียกกันว่ากลุ่มผักปลอดสารพิษ)ก่อตัวในช่วงปีพ.ศ. 2534 และมีสมาชิกเพิ่มขึ้นเป็น 15 รายในปี พ.ศ. 2537 ระยะหลังมีหน่วยงานต่าง ๆ ทั้งภาครัฐและเอกชนเข้ามาศึกษา วิจัย และให้ความช่วยเหลือแก่กลุ่ม รวมทั้งการให้เงินสนับสนุน ทำให้มีสมาชิกเพิ่มขึ้น และเพิ่มกิจกรรมการเกษตรไปสู่การออมทรัพย์เพื่อการผลิต สมาชิกส่วนใหญ่ยังขาดความรู้ความเข้าใจเกี่ยวกับการทำผักปลอดสารพิษ แต่การก่อตัวเกิดจากแรงจูงใจทางการตลาด กล่าวคือกลุ่มสามารถนำผลผลิตไปจำหน่ายในโรงงาน

อย่างไรก็ตามการปรับตัวทำกิจกรรมในหลายลักษณะที่กล่าวมา เป็นการรวมตัวโดยอาศัยภูมิ-ปัญญาของชุมชนที่มีอยู่เดิมในการปรับตัวเพื่อความอยู่รอดท่ามกลางการเปลี่ยนแปลง และพบว่ากลุ่มที่

รวมตัวกันทำกิจกรรมอย่างต่อเนื่องคือ กลุ่มออมทรัพย์ตำบลบางนมโค เนื่องจากกลุ่มดังกล่าวมีกิจกรรมการฝาก การให้กู้ ซึ่งตอบสนองกับความต้องการของสมาชิกในช่วงเวลาดังกล่าว อีกกลุ่มหนึ่งคือ กลุ่มเกษตรกรรมทางเลือกตำบลบ้านหลวง (หรือกลุ่มผักปลอดสารพิษ)ซึ่งรวมกลุ่มนำผักปลอดสารพิษไปจำหน่ายในโรงงาน

3.1.4 ช่วงการปรับเปลี่ยนสู่การพึ่งตนเอง (พ.ศ. 2539 – ปัจจุบัน)

วิกฤติการณ์ค่าเงินบาทและปัญหาระบบสถาบันการเงินที่เกิดขึ้นตั้งแต่กลางปีพ.ศ. 2540 ได้ส่งผลให้ผลิตภัณฑ์มวลรวมในประเทศหดตัวถึงร้อยละ 8 ในปีพ.ศ. 2541 เกิดผลกระทบต่อประชาชนทั่วไปอย่างกว้างขวาง และผลกระทบเหล่านี้ได้ส่งผลต่อกลุ่มต่าง ๆ ในชุมชน ซึ่งรวมถึงกลุ่มออมทรัพย์ และกลุ่มผักปลอดสารพิษด้วย เนื่องจากกลุ่มทั้งสองพึ่งพารายได้จากโรงงานอุตสาหกรรม โดยเฉพาะสมาชิกกลุ่มออมทรัพย์มีรายได้จากการเป็นแรงงานรับจ้าง รายได้จากการค้าขายขนาดย่อยรอบ ๆ โรงงาน

เมื่อกลุ่มออมทรัพย์ ตำบลบางนมโคประสบปัญหาดังกล่าว กรรมการกลุ่มได้พยายามแก้ปัญหาที่เกิดขึ้นในหลาย ๆ ลักษณะเพื่อแก้ปัญหาสภาพคล่องทางการเงินภายในกลุ่ม เช่น กู้ยืมจากแหล่งเงินอื่นเพื่อบรรเทาปัญหาสภาพคล่อง การขอความร่วมมือกับสมาชิกที่ต้องการกู้ยืมเงินชลอการกู้ยืม หรือให้กู้ยืมเฉพาะรายที่จำเป็นจริง ๆ ขอความร่วมมือกับสมาชิกที่ต้องการถอนเงินฝาก ชลอการถอนเงิน สถานการณ์ดังกล่าวจึงทำให้กลุ่มออมทรัพย์เกิดภาวะชะงักงัน และหยุดปล่อยสินเชื่อ นอกจากรอการเรียกเงินคืนจากสมาชิกเพื่อให้กลุ่มมีสภาพคล่องทางการเงินมากขึ้น กลุ่มออมทรัพย์จึงไม่มีกิจกรรมใดๆ ในช่วงเวลาที่คณะนักวิจัยไปศึกษาข้อมูล

กลุ่มเกษตรกรรมทางเลือก ตำบลบ้านหลวงได้รับผลกระทบจากการลดจำนวนคนงานในโรงงานและลดรายได้ของแรงงาน ทำให้รายได้จากการจำหน่ายผักปลอดสารพิษลดลง กลุ่มจึงรับซื้อผลผลิตจากสมาชิกได้ในจำนวนจำกัด ผลกระทบดังกล่าวทำให้สมาชิกที่เข้าร่วมกลุ่มในระยะหลัง ๆ ประสบปัญหาผลผลิตล้นเกิน และไม่สามารถนำออกจำหน่ายได้ บางรายจึงถอนตัวออกจากการเป็นสมาชิกเพราะกลุ่มไม่สามารถรับซื้อผลผลิตของสมาชิก สมาชิกกลุ่มบางรายได้ปรับตัวโดยนำผลผลิตไปจำหน่ายด้วยตนเอง

บริบททางสังคมที่สนับสนุนการพึ่งตนเองของชุมชน

หลังวิกฤตการณ์ทางเศรษฐกิจกลางปีพ.ศ. 2540 ได้มีกระแสเรียกร้องให้สังคมให้ความสนใจต่อเศรษฐกิจแบบพึ่งตนเอง ชุมชนเข้มแข็ง ซึ่งกระแสเหล่านี้ได้ส่งผ่านกลไกต่าง ๆ ทั้งภาครัฐ องค์กรพัฒนาเอกชน ภาคธุรกิจให้ดำเนินไปในทิศทางดังกล่าว อาจกล่าวได้ว่าบริบททางสังคมได้เอื้อต่อการก่อตัวทางความคิดของชุมชน ทำให้การกลับลำสู่การรวมกลุ่มเพื่อการพึ่งตนเอง บริบททางสังคมที่ส่งผลต่อชุมชนสาคลีได้แก่ กระแสพระราชดำรัส "ทฤษฎี ใหม่" ที่เอื้อต่อแนวความคิดในการทำการเกษตรแบบพึ่งตนเอง

โครงการลงทุนเพื่อสังคม (Social Investment Project) ซึ่งมุ่งเน้นการบรรเทาปัญหาทางสังคมอันเนื่องมาจากวิกฤตการณ์ทางเศรษฐกิจ โดยเฉพาะการแก้ปัญหาการว่างงานด้วยการสร้างงานและโอกาสใน

กลุ่มผู้มีรายได้น้อยและยากจน มุ่งเน้นให้บริการทางสังคมและการพัฒนาโครงการสาธารณูปโภคพื้นฐานขนาดเล็ก การเพิ่มอำนาจและความเข้มแข็งของท้องถิ่น และการสร้างเศรษฐกิจชุมชนให้มีเครือข่ายที่สมบูรณ์และมีประสิทธิภาพ นอกจากนี้ยังส่งเสริมให้คนในท้องถิ่นมีส่วนร่วมในการพัฒนาสังคม และเน้นให้บริการทางสังคมขั้นพื้นฐานแก่กลุ่มผู้ว่างงาน และกลุ่มผู้มีรายได้น้อยและยากจน โดยเฉพาะโครงการที่จัดสรรผ่านธนาคารออมสิน โดยมีเป้าหมายหลักเพื่อเสริมความเข้มแข็งให้กับชุมชนเมืองและชนบท เพื่อเพิ่มทุนทางสังคม โดยเน้นโครงการที่เสนอโดยองค์กรท้องถิ่น (สำนักงานกองทุนเพื่อสังคม,2541)

และมาตรการกระตุ้นเศรษฐกิจโดยเร่งด่วน 30 มีนาคม 2542 หรือที่เรียกกันว่า "งบมิยาซาวา" เพื่อกระตุ้นเศรษฐกิจปีงบประมาณ 2542 เงินจำนวนนี้ได้กระจายไปดำเนินการในทุกจังหวัดทั่วประเทศผ่านกระทรวง/ทบวงกรม ต่าง ๆ ลงสู่หมู่บ้าน ตำบล โดยเฉพาะโครงการตามแผนยุทธศาสตร์ร่วมเศรษฐกิจชุมชนพึ่งตนเองระดับจังหวัดของกระทรวงมหาดไทย (2542) ซึ่งมีวัตถุประสงค์กระตุ้นเศรษฐกิจ โดยเน้นการลงทุนที่ก่อให้เกิดผลผลิตและการสร้างงาน เน้นพื้นที่/กลุ่มเป้าหมายที่ยากจน หรือได้รับผลกระทบจากวิกฤติทางเศรษฐกิจทั้งในเมืองและชนบทในทุกจังหวัด และส่งเสริมรากฐานในการพัฒนาประเทศและให้ประชาชนสามารถพึ่งตนเอง

การปรับตัวสู่กิจกรรมการพึ่งตนเองของชุมชน

แกนนำชุมชนสาคลีมีการก่อตัวมานานตั้งแต่ในอดีต และได้พยายามปรับตัวสู่การพึ่งตนเองกำหนดทิศทางการพัฒนาไปสู่ความยั่งยืน โดยเฉพาะช่วงหลังจากปีพ.ศ. 2537-2538 แต่กระแสสังคมภายนอกทำให้แกนนำชุมชนขาดเวลาในการพูดคุย พบปะกันอย่างสม่ำเสมอ เนื่องจากทุกคนต้องดิ้นรนเพื่อความอยู่รอดจากเศรษฐกิจ ภาระหนี้ แต่แกนนำชุมชนก็ได้พยายามแก้ไขตามกำลังที่ชุมชนมีอยู่ ช่วงเวลาที่ผ่านมาการพัฒนางาน กิจกรรมต่างๆ อยู่ในช่วงเริ่มต้น หากกระแสสังคมภายนอกไม่เอื้ออำนวยชุมชนซึ่งกำลังเริ่มต้นรวมกลุ่มอาจได้รับแรงกระทบจนไม่สามารถตั้งรับได้

เมื่อเกิดวิกฤตการณ์ทางเศรษฐกิจในปีพ.ศ. 2540 แนวคิดการสนับสนุนการพึ่งตนเองเริ่มชัดเจนขึ้นทำให้แกนนำชุมชนสามารถใช้ประโยชน์จากสถานการณ์ภายนอกมาผลักดันการดำเนินกิจกรรมของกลุ่มต่าง ๆ โดยเฉพาะโครงการของรัฐซึ่งสนับสนุนการพึ่งตนเองของชุมชน สนับสนุนการระดมความเห็นจากชาวบ้านก่อนดำเนินการ กระแสสังคมภายนอกเหล่านี้ทำให้แกนนำขับเคลื่อนงานไปสู่การพึ่งตนเองได้อย่างสะดวก สามารถดึงทรัพยากรจากภายนอกมาสร้างกระบวนการเรียนรู้ต่าง ๆ ในชุมชน โดยเฉพาะงบสนับสนุนจากกองทุนชุมชน (social investment fund)

หลังวิกฤตการณ์ทางเศรษฐกิจ ชุมชนสาคลีได้ปรับตัวเพื่อตอบรับกับกระแสภายนอกในหลายลักษณะกล่าวคือการจัดองค์กรชุมชนโดยแบ่งหน้าที่การทำงานภายในชุมชนเพื่อให้การขับเคลื่อนงานเป็นไปอย่างมีระบบ โดยรับผิดชอบกิจกรรมต่าง ๆ และประสานการทำงานร่วมกันเป็นเครือข่าย แสวงหาภาคี

สนับสนุนความเข้มแข็งของชุมชน เช่น ประสานกับหน่วยราชการระดับอำเภอ เพื่อสนับสนุนงานพัฒนาไปในทิศทางที่ชุมชนต้องการ การสนับสนุนแกนนำชุมชนเป็นสมาชิกองค์การบริหารส่วนตำบล

กล่าวโดยรวม กระแสสังคมภายนอกที่ให้ความสำคัญกับ เกษตรทฤษฎีใหม่ การพึ่งตนเองของชุมชน ชุมชนเข้มแข็ง ทำให้แกนนำชุมชนสามารถฟื้นคืนกิจกรรมการพึ่งตนเองโดยเฉพาะกิจกรรมการเกษตรได้รวดเร็วขึ้น .

3.2 การดำรงอยู่ของกลุ่มเกษตรกรรมทางเลือก กลุ่มออมทรัพย์ และภูมิปัญญาในกระแสการเปลี่ยนแปลง

3.2.1กลุ่มเกษตรกรรมทางเลือก

เมื่อประมาณ ต้นปีพ.ศ. 2542 กระแสหน่วยราชการซึ่งขานรับ แนวคิดทฤษฎีใหม่ เศรษฐกิจชุมชน ชุมชนเข้มแข็ง ได้ลงมาสู่ชุมชน โดยหน่วยราชการต่าง ๆ เข้ามาสนับสนุนให้เกิดกิจกรรมดังกล่าว ทำให้ชุมชนได้รับงบสนับสนุนการผลักดันเศรษฐกิจชุมชน ของกระทรวงมหาดไทย กลุ่มเกษตรกรรมทางเลือกจากเดิม 1 กลุ่มในตำบลบ้านหลวง ได้เกิดขึ้นใหม่เพิ่มอีก 3 กลุ่ม เป็นกลุ่มเล็ก ๆ กระจายใน 3 ตำบล 3 กลุ่มนี้ประสานเป็นเครือข่ายกลุ่มเกษตรกรรมทางเลือก ได้แก่อยู่ในตำบลบ้านหลวงซึ่งเป็นเขตปฏิรูปที่ดินเพื่อเกษตรกรรม 1 กลุ่ม ตำบลบางนมโค 1 กลุ่ม และตำบลสามตุ่ม 1 กลุ่ม ซึ่งเป็นกลุ่มที่เคยก่อตัวในช่วงปี พ.ศ.2529 และชลอกิจกรรมไป สำหรับกลุ่มเกษตรกรรมทางเลือกกลุ่มแรก (กลุ่มผักปลอดสารพิษ) ไม่ได้เข้าร่วมเครือข่าย (ดูแผนภาพที่ 3)

กลุ่มผักปลอดสารพิษเป็นกลุ่มที่เน้นการพึ่งตนเอง และเป็นกลุ่มที่ไม่ได้รับเงินสนับสนุนจากหน่วยราชแต่กลุ่มสามารถดำรงอยู่ได้ เนื่องจากกลุ่มมีตลาดรองรับผลผลิตอย่างสม่ำเสมอ กล่าวคือ นำผลผลิตไปจำหน่ายในโรงงาน และสมาชิกบางส่วนนำผลผลิตไปจำหน่ายด้วยตนเองในตลาดท้องถิ่น และผู้นำกลุ่มมีความเข้าใจเกี่ยวกับการทำการเกษตรแบบธรรมชาติ และได้ทำกิจกรรมการเกษตรในพื้นที่ของตนเป็นแบบอย่าง กลุ่มดังกล่าวได้ขยายกิจกรรมจากการเกษตรไปสู่กิจกรรมออมทรัพย์ โดยมีวัตถุประสงค์จะให้เงินออมทรัพย์เป็นเงินกองทุนในการสนับสนุนกิจกรรมการผลิตทางการเกษตรของสมาชิก เช่น นำเมล็ดพันธุ์ผักมาจำหน่ายสมาชิกในราคาถูก และนำผลกำไรเข้ากองทุน เป็นต้น คณะนักวิจัยพบว่ากลุ่มดังกล่าวยังประสบปัญหาการผลิต เช่น การวิเคราะห์พันธุ์พืช พันธุ์สัตว์ที่เหมาะสมกับท้องถิ่น

กลุ่มเครือข่ายเกษตรกรรมทางเลือก เป็นกลุ่มที่เริ่มก่อตัว และยังขาดความรู้ทางวิชาการในการสนับสนุนการผลิตเพื่อการพึ่งตนเอง แต่เชื่อว่าหากทำการเกษตรในลักษณะดังกล่าวจะได้รับการสนับสนุนจากหน่วยราชการ ยกเว้นกลุ่มเกษตรกรรมทางเลือกตำบลสามตุ่มที่มั่นใจต่อการทำการเกษตรเพื่อการพึ่งตนเอง และมีบทบาทนำในการขยายความคิดสู่กลุ่มในเครือข่าย เนื่องจากมีผู้นำบางรายมีความรู้และประสบการณ์ต่าง ๆ เช่นการเพาะพันธุ์ปลา การแปรรูปสินค้าเกษตร บางรายเคยประสบผลสำเร็จจนสามารถปลดหนี้ แต่เหล่านี้เป็นความสำเร็จในระดับบุคคล

การดำเนินงานของกลุ่มเครือข่ายเกษตรกรรมทางเลือก ได้สนับสนุนการตลาดแก่สมาชิกในกลุ่มเครือข่าย โดยรวบรวมผลผลิตของสมาชิกไปส่งตลาดภายนอก จัดทำตลาดภายในชุมชน แต่ก็ทำได้จำกัด เพราะขาดเงินทุน ประกอบกับผลผลิตจำนวนน้อย และไม่หลากหลาย แกนนำได้สรุปบทเรียนจากกรณีดังกล่าวร่วมกันในหลายครั้ง และพบว่าความผิดพลาดที่ผ่านมาเป็นเพราะกลุ่มเน้นการผลิตผักปลอดสารพิษที่กลุ่มไม่มีทักษะ ในขณะที่ชุมชนพบว่า ปลา ซึ่งเป็นอาหารหลักประจำวัน สามารถขายได้สม่ำเสมอ และราคาไม่ตกต่ำ ประกอบกับชุมชนมีผู้นำที่มีทักษะในการเลี้ยงปลา เพาะพันธุ์ปลาด้วย จึงเห็นว่าทำอย่างไรจะพัฒนาทักษะที่มีเป็นทุนเดิมอยู่แล้วให้เกิดขึ้น และขยายให้ครบวงจรของการทำการเกษตร เช่นการผลิต การแปรรูป การวิจัยและพัฒนาพันธุ์พืช พันธุ์สัตว์ อาหารสัตว์ ฯลฯ ในช่วงเวลาดังกล่าว "กองทุนชุมชน" หรือ SIF ได้เข้ามา แกนนำชุมชนจึงได้ประชุมชาวบ้านทำโครงการเสนอ และได้รับอนุมัติ

การดำเนินกิจกรรมการทำการเกษตรไปสู่การพึ่งตนเองจากงบกองทุนชุมชนนี้ ได้ก่อสร้างศูนย์การเรียนรู้เพื่อพัฒนาอาชีพครบวงจร โดยเริ่มการเพาะพันธุ์ปลา และขยายพันธุ์ปลา และแกนนำคาดว่าจะทำการวิจัยและพัฒนาอาหารสัตว์ ในลำดับต่อมา

คณะนักวิจัยได้เสวนา และสังเกตการณ์แบบมีส่วนร่วมพบว่า การผลักดันงานของกลุ่มเครือข่ายเกษตรกรรมทางเลือกยังขาดข้อมูลพื้นฐานของสมาชิกแต่ละกลุ่ม ที่เข้าร่วมโครงการ จึงไม่สามารถจัดกิจกรรมที่สอดคล้องกับสมาชิกแต่ละกลุ่ม คณะนักวิจัยได้พยายามทำความเข้าใจประเด็นดังกล่าวจนในที่สุดแกนนำบางคนจึงเข้าร่วมกับคณะนักวิจัยทดลองจัดเก็บข้อมูลพื้นฐานของเครือข่ายกลุ่มเกษตรกรรมทางเลือก

3.2.2กลุ่มออมทรัพย์

คณะนักวิจัยไปศึกษากลุ่มออมทรัพย์จำนวน 3 กลุ่มในชุมชน (ดูแผนภาพที่ 4) แต่ละกลุ่มมีการบริหารจัดการโดยอิสระ ไม่มีการรวมตัวเป็นเครือข่าย บางกลุ่มเกิดขึ้นเพื่อเสริมกลุ่มเกษตรกรรมทางเลือกที่มีอยู่ และพบว่าหากกลุ่มเกษตรกรรมทางเลือกสามารถจัดการตลาดให้กับสมาชิก กลุ่มออมทรัพย์ที่เกิดขึ้นจะช่วยสนับสนุนให้กลุ่มมีความเข้มแข็งมากขึ้น ต่อประเด็นดังกล่าวสะท้อนว่าการออมทรัพย์เปรียบเสมือนสินเชื่อทางการเงิน หรือสถาบันการเงินของกลุ่ม หากภาคการผลิตเข้มแข็ง ภาคการเงินย่อมเข้มแข็งตามมาด้วย

กลุ่มออมทรัพย์บางกลุ่ม เป็นกลุ่มอิสระมีสมาชิกทุกเพศ ทุกวัย ทุกอาชีพ และเน้นการออม แต่ระมัดระวังการปล่อยสินเชื่อในวงเงินจำกัด โดยเน้นการปล่อยสินเชื่อเพื่ออาชีพ ทำให้จำนวนเงินฝากเพิ่มมากขึ้น และผู้นำกังวลว่าจะทำให้กลุ่มประสบปัญหาสภาพคล่องล้นเกินในอนาคต กลุ่มดังกล่าวคณะนักวิจัยได้เข้าไปช่วยจัดระบบบัญชีเพื่อให้กลุ่มเห็นสถานะการเงินของกลุ่มทั้งรายได้ รายจ่าย(ต้นทุนเงินฝาก) และช่วยสำรวจข้อมูลพื้นฐานของสมาชิก

กลุ่มออมทรัพย์ทุกกลุ่มจะพบปัญหาการจัดระบบบัญชีไม่รัดกุมพอ ทำให้ไม่ทราบว่าในแต่ละเดือน มีเงินฝาก เงินกู้ เงินคงเหลือ ดอกเบี้ย และเงินหมุนเวียน เป็นอย่างไร จำนวนเท่าไร และจำนวนเงินที่ฝากมีมากแต่กลุ่มไม่รู้วิธีการจัดการเพื่อให้ได้ดอกผลเพิ่มพูน ซึ่งจะทำให้ไม่เพียงพอที่จะจ่ายเงินปันผลหรือดอกเบี้ยเงินฝากให้กับสมาชิกในอนาคต

3.2.3 ภูมิปัญญาในกระแสการเปลี่ยนแปลง

ความพยายามของชุมชนสาคลีในการต่อสู้กับกระแสพัฒนาโดยอยู่บนพื้นฐานของภูมิปัญญานั้น ปรากฏให้เห็นในรูปของกลุ่มออมทรัพย์ กลุ่มเกษตรกรรมทางเลือก กลุ่มเหล่านี้พัฒนาขึ้นโดยอาศัยภูมิปัญญาของตนเอง ภูมิปัญญาแทรกอยู่ในทุกกิจกรรมของชุมชน มีการเรียนรู้และสั่งสมภูมิปัญญาท้องถิ่นเพื่อการพึ่งตนเองได้ในระดับหนึ่ง แต่เมื่อชุมชนได้รับแรงกระทบจากการพัฒนาเศรษฐกิจแผนใหม่ ทำให้ชุมชนนำเทคโนโลยีและภูมิปัญญาจากภายนอกชุมชนเข้ามาแทนที่ภูมิปัญญาเดิม ทำให้การเรียนรู้ของชุมชนหยุดลง ขาดการพัฒนาทำให้หมดคุณค่าและความหมายไป แต่ภูมิปัญญาของชุมชนยังพอมีอยู่และสามารถพัฒนาให้เข็มแข้งและต่อยอดให้สอดคล้องกับการเปลี่ยนแปลงของสังคมได้ เช่น ภูมิปัญญาด้านการเกษตรของผู้นำกลุ่มผักปลอดสารพิษ ตำบลบ้านหลวง ซึ่งเน้นการเกษตรธรรมชาติ พุทธเกษตร ภูมิปัญญาในการแปรรูปผลผลิตทางการเกษตร หรือน้ำดื่มสมุนไพร ภูมิปัญญาในการจัดการกลุ่มออมทรัพย์ ภูมิปัญญาในการประสานทรัพยากรจากภายนอก เช่น การขอเงินสนับสนุนจากหน่วยราชการต่าง ๆ หรือภาคเอกชน

ที่กล่าวมาทั้งหมดแสดงให้เห็นว่า พัฒนาภูมิปัญญาของชุมชนสาคลีจากอดีตสู่ปัจจุบัน เป็นการปรับตัวต่อกระแสเศรษฐกิจแผนใหม่ ซึ่งเป็นกระแสบริโภคนิยม ที่นำเอาปัญหาทั้งทางกายภาพ ทางสังคม ทางจิตใจ และสภาพแวดล้อมเข้ามาอย่างมากมาย ในขณะที่ชุมชนขาดความรู้เท่าทัน ไม่ทราบว่ากระแสเศรษฐกิจแบบอุตสาหกรรมหรือทุนนิยมเข้ามาทำลายระบบการพึ่งตนเองของชุมชนอย่างไร ส่วนใหญ่ปรับตัวไป จึงทำลายทุนเดิมไปเรื่อยๆ ที่เป็นเช่นนี้เพราะคนในชุมชนขาดภูมิปัญญาแบบใหม่ในการตั้งรับปัญหาและขาดวิสัยทัศน์ที่ปรับตัวไปสู่ความยั่งยืน สุรินทร์ กิจนิตย์ชีว์ (2540 : 84) ได้ชี้ให้เห็นถึงความจำเป็นที่จะต้องพัฒนาภูมิปัญญาดั้งเดิมของชุมชนโดยเสริมด้วยภูมิปัญญาแผนใหม่ เพื่อให้ชุมชนเกิดสติปัญญาที่สามารถอยู่ร่วมกันอย่างสันติสุขและรู้จักระบบความสัมพันธ์ระหว่างตนเองกับครอบครัว ตนเองกับชุมชน ตนเองกับธรรมชาติให้สมดุลกัน และพัฒนาไปสู่ความยั่งยืนของชุมชน

3.3 การจัดกิจกรรมเสริมความเข้มแข็งของการรวมกลุ่ม

ผลจากการศึกษาบริบททางสังคมของชุมชนสาคลี ทำให้ทราบสภาพและปัญหาต่างๆ ของกลุ่มคณะผู้วิจัยจึงได้จัดกิจกรรมหลายประเภทเพื่อเป็นการเสริมความเข้มแข้งของชุมชน กิจกรรมต่าง ๆ ที่จัดให้กับชุมชนสรุปได้ดังนี้

1. มีการพบปะร่วมพูดคุยกับแกนนำและบุคคลกลุ่มต่างๆ ในชุมชนอย่างสม่ำเสมอ ทั้งอย่างเป็นทางการและไม่เป็นทางการ โดยประเด็นการสนทนาเพื่อสอบถามข้อมูลแลกเปลี่ยนความคิดเห็น และให้คำแนะนำ ข้อเสนอแนะหากกลุ่มต้องการความช่วยเหลือ

2. จัดกิจกรรมเสริมความรู้ทางวิชาการ โดยการเชิญผู้รู้จากภายนอกมาเสริมความรู้ให้แก่ชุมชน และการนำคนในชุมชนไปศึกษาดูงานตามแหล่งความรู้ต่างๆ ที่ชุมชนคิดว่าจะเป็นประโยชน์

3. ช่วยประสานเครือข่ายของชุมชนทั้งภายใน คือระหว่างสมาชิกกลุ่มต่างๆ กับภายนอก คือหน่วยงานทั้งภาครัฐและเอกชนที่จะช่วยเอื้ออำนวยให้งานต่างๆ ของชุมชนได้ขยายเข้มแข็งขึ้น

4. ช่วยแก้ปัญหาเฉพาะกรณีต่างๆ และทดลองใช้กับกลุ่ม เช่น การรวบรวมและสำรวจข้อมูลด้านการเกษตรของชุมชน และข้อมูลเกี่ยวกับสมาชิกกลุ่มออมทรัพย์เพื่อให้กลุ่มสามารถวิเคราะห์ศักยภาพของตนเองได้ และช่วยแก้ปัญญาเฉพาะเรื่อง เช่น การจัดทำระบบบัญชีให้กับกลุ่มออมทรัพย์

5. จัดเวทีนำเสนอและแลกเปลี่ยนข้อมูลกับแกนนำของชุมชน โดยการวิเคราะห์ข้อมูลโดยใช้ระบบสารสนเทศทางภูมิศาสตร์ นำเสนอให้ชุมชนได้ตรวจสอบและร่วมกันวิเคราะห์ ซึ่งทำให้ชุมชนสามารถเห็นสภาพของชุมชนได้ในหลาย ๆ มิติ

3.4 รูปแบบและแนวทางในการพัฒนาความเข้มแข็งของการรวมกลุ่ม

3.4.1 รูปแบบความเข้มแข็งของการรวมกลุ่ม

จากการศึกษาและทดลองกิจกรรมต่างๆ ในชุมชนสาคลี คณะผู้วิจัยเห็นว่าแนวทางต่างๆ ที่ได้ดำเนินงานในชุมชนสาคลีเป็นเพียงส่วนหนึ่งที่ช่วยเสริมสร้างความเข้มแข็งของกลุ่ม ในส่วนของแต่ละกลุ่มชุมชนควรมีความเข้มแข็งภายในก่อน และมีความพร้อมที่จะต่อสู้เพื่อรับการเปลี่ยนแปลงที่เข้ามาตลอดเวลา เพื่อผลักดันให้กลุ่มประสบความสำเร็จ

ความเข้มแข็งของการรวมกลุ่มในชุมชนสาคลี ได้พิจารณาจากรูปแบบ คือลักษณะโครงสร้างความสัมพันธ์ และพิจารณากระบวนการ คือความสามารถดำรงรักษาความเป็นกลุ่ม และความสามารถในการระดมพลังในการแก้ปัญหาที่เกิดขึ้น

การศึกษาพบว่า การรวมกลุ่มในชุมชนสาคลีมีความเข้มแข็งในประเด็นของ "กระบวนการ" คือสามารถดำรงรักษาความเป็นกลุ่ม และระดมพลังในการแก้ปัญหาที่เกิดขึ้น กล่าวคือมีความสามารถในการต่อรอง หรือจัดการกับภายนอกที่เข้ามาในชุมชน ในประเด็นต่าง ๆ ต่อไปนี้

การต่อรองให้การจัดสรรงบประมาณของหน่วยราชการจัดสรรลงตามหมู่ต่าง ๆ ที่แกนนำชุมชนเป็นผู้นำกลุ่มอยู่ เพื่อสามารถควบคุมการใช้จ่ายงบประมาณตามวัตถุประสงค์ของโครงการ

การเข้าร่วมกับคณะทำงานกองทุนชุมชน จังหวัดพระนครศรีอยุธยาซึ่งเป็นกลไกที่สนับสนุนองค์กรชุมชนท้องถิ่นตามจังหวัดต่าง ๆ เพื่อทำเครือข่ายการแลกเปลี่ยนในโอกาสต่อไปต่อไป กรณีนี้จึงเป็นความสามารถในการใช้ประโยชน์จากกลไกภายนอกชุมชนเข้ามาเชื่อมเครือข่าย

สนับสนุนสมาชิกองค์กรชุมชนเข้าร่วมแข่งขันเป็นสมาชิกองค์การบริหารส่วนตำบลทั้งสามตำบล เพื่อควบคุมทรัพยากรของหน่วยราชการให้เป็นประโยชน์โดยรวมสมาชิกในชุมชน

เน้นการพัฒนาคน พัฒนากระบวนการเรียนรู้ในกิจกรรมต่าง ๆ ดังนั้นกิจกรรมอาจล้มเหลวแต่คนในกลุ่มได้เรียนรู้

สำหรับโครงสร้างความสัมพันธ์ของกลุ่มต่าง ๆ พบว่า แต่ละกลุ่มค่อนข้างมีอิสระมาก หรืออาจเรียกได้ว่าเป็นกลุ่มปัจเจก และยังไม่พบกิจกรรมที่เชื่อมโยงระหว่างเครือข่าย อีกลักษณะหนึ่งคือ เป็นกลุ่มอิสระไม่เข้าร่วมเครือข่าย โดยเริ่มกิจกรรมการเกษตรแล้วแตกกิจกรรมไปสู่การออมทรัพย์ กลุ่มดังกล่าวคือกลุ่มเกษตรปลอดสารพิษตำบลบ้านหลวง

สำหรับโครงสร้างของกลุ่มออมทรัพย์ในชุมชนสาคลีนั้น พบว่าแต่ละกลุ่มแยกการบริหารจัดการโดยอิสระ ไม่พบการรวมตัวเป็นเครือข่าย บางกลุ่มเกิดจากการขยายกิจกรรมการเกษตร กลุ่มออมทรัพย์บางกลุ่มเน้นการออมและกู้ยืมไม่มีการขยายกิจกรรมไปสู่กิจกรรมอื่น

สิ่งที่น่าสนติดตามคือโครงสร้างที่มีอยู่นั้นจะดำรงอยู่ต่อไปได้หรือไม่อย่าง และโครงสร้างแบบใดที่จะเอื้อต่อบริบททางสังคมในภาคกลาง ซึ่งยังไม่สามารถหาข้อสรุปได้ในขณะนี้ เนื่องจากกลุ่มกลุ่มเหล่านี้ได้ก่อตัวในช่วง10 ปีที่ผ่านมา และส่วนใหญ่ก่อตัวในช่วงหลังปีพ.ศ. 2540

มีข้อสังเกตบางประการที่พบคือ แม้ชุมชนจะจัดแบ่งกลุ่มการทำงาน แต่หากสาระของการทำงานร่วมกันยังไม่นำไปสู่การค้นหาทุนทางสังคมที่ชุมชนมีอยู่เดิม ย่อมทำให้การพัฒนาความเข้มแข็งเกิดขึ้นได้ยาก ดังกรณีตัวอย่างกลุ่มเกษตร ตำบลบ้านหลวงซึ่งเป็นเครือข่ายกลุ่มเกษตรกรรมทางเลือก ได้ทำกิจกรรมการผลิตแชมพู แต่กิจกรรมดังกล่าวกลับนำผลตอบแทนกลับสู่ชุมชนน้อยมาก เนื่องจากต้นทุนการผลิตกว่าร้อยละ 60 ต้องใช้วัตถุดิบจากภายนอก และในที่สุดกิจกรรมไม่นำไปสู่ความยั่งยืน

ดังนั้นการเสริมความเข้มแข็งของการรวมกลุ่ม ควรเริ่มที่ภายในชุมชนหรือภายในกลุ่มก่อน ส่วนภายนอกเป็นเพียงการเสริมหรือสนับสนุน และควรเปลี่ยนแนวทางการพิจารณาจากเดิม ที่มักพูดถึงปัญหาในชุมชนว่ามีปัญหาอะไร อะไรคือปัญหาก่อนหลัง ลำดับความสำคัญปัญหา อย่างที่เคยปฏิบัติ (อาจเรียกได้ว่าเป็น negative approach) มาเป็นการค้นหาทุนเดิมที่มีอยู่และนำมาปรับใช้ในบริบทของสังคมใหม่และดูว่าจะสานต่อ ก่อขยายได้อย่างไร (อาจเรียกได้ว่าเป็น positive approach) โดยเริ่มจากการจัดเวทีภายในชุมชนก่อน ส่วนการสนับสนุนจากภายนอกเป็นเรื่องที่สำคัญในลำดับหลัง

3.4.2 แนวทางการพัฒนาความเข้มแข็งของการรวมกลุ่ม

การจัดกิจกรรมเชิงปฏิบัติการร่วมกับชุมชนพบหลายกิจกรรมที่ประสบผลในการแก้ปัญหากลุ่มต่าง ๆ เช่นคณะนักวิจัยพบว่าการจัดระบบบัญชีให้แก่กลุ่มออมทรัพย์ ได้ช่วยให้กลุ่มสามารถทราบสถานะการเงินของกลุ่มโดยรวม และช่วยในการวางแผนและตัดสินใจในการดำเนินงานของกลุ่มได้

การจัดกิจกรรมที่นับว่าช่วยเสริมความเข้มแข็งของการรวมกลุ่มได้ดีคือการนำเสนอข้อมูลพื้นฐานของกลุ่มต่างๆ รวมทั้งข้อมูลทางกายภาพของชุมชน โดยอาศัยระบบสารสนเทศทางภูมิศาสตร์ (Geographic Information System) และให้แต่ละกลุ่มได้ตรวจสอบความถูกต้อง การนำเสนอข้อมูลส่วนนี้ทำให้แต่ละกลุ่มเห็นสถานะของกลุ่มตนเองชัดเจน

ในกรณีกลุ่มออมทรัพย์ได้นำข้อมูลการฝากเงิน การกู้เงิน ข้อมูลพื้นฐานของสมาชิก เช่น เพศ อาชีพ อายุ รายได้ สาเหตุการกู้ สภาวะการเป็นหนี้ ฯลฯ มานำเสนอพร้อมตำแหน่งที่ตั้งของสมาชิก และชี้ให้เห็นความสัมพันธ์ระหว่างตัวแปรต่าง ๆ มากกว่า 1 ตัวแปร การพยากรณ์สภาพคล่องทางการเงินของกลุ่มออมทรัพย์จะประสบปัญหาเงินฝากล้นเกินเมื่อใด การให้สินเชื่อของกลุ่มสัมพันธ์กับสมาชิกหรือไม่อย่างไร และกลุ่มควรขยายกิจกรรมการกู้ยืมอย่างไร

เครือข่ายกลุ่มเกษตรกรรมทางเลือก ได้ทดลองนำเสนอข้อมูลพื้นฐานของสมาชิกที่เข้าร่วมโครงการ และนำเสนอกำลังการผลิตของสมาชิก และของกลุ่ม ทั้งจำนวนประเภทของการผลิต และตำแหน่งที่ตั้งของสมาชิก ความสัมพันธ์ของข้อมูลพื้นฐานต่าง ๆ ฯลฯ

นอกจากนี้ยังนำเสนอตำแหน่งที่ตั้งของกลุ่มออมทรัพย์ กลุ่มเกษตรกรรมทางเลือก และข้อมูลทางกายภาพของชุมชน เช่นสถานที่สำคัญ หรือทรัพยากรส่วนกลางของชุมชน ผู้นำอาชีพต่าง ๆ กลุ่มต่าง ๆ กระจายตัวอยู่ตรงส่วนใด ฯลฯ

เมื่อการนำเสนอเสร็จสิ้นแกนนำชุมชน ผู้นำกลุ่ม และครู ได้กล่าวว่าการนำเสนอเช่นนี้มีประโยชน์ เพราะช่วยให้เห็นภาพรวมของชุมชน ซึ่งเดิมแต่ละกลุ่มจะทำงานแยกเป็นส่วน ๆ จึงมองไม่เห็นภาพรวมทั้งหมด และข้อมูลที่นำเสนอเป็นการสะท้อนภาพที่เป็นจริง ทำให้เห็นตัวตนชัดเจน ที่ผ่านมากลุ่มต่าง ๆ ดำเนินกิจกรรมไปตามความคิด ความรู้สึก ทำให้การตัดสินใจขาดข้อมูลประกอบ การตัดสินใจจึงผิดพลาด

นอกจากนี้ในที่ประชุมได้พูดคุยกันถึงความเป็นไปได้ในการจัดเก็บข้อมูลดังกล่าวให้ครบทุกครัวเรือนและครบทั้ง 3 ตำบลด้วย ผู้นำชุมชนและปลัด อ.บ.ต. ได้จัดสรรงบประมาณเพื่อการจัดทำข้อมูลดังกล่าวในปีงบประมาณ 2544 โดยขอให้คณะนักวิจัยช่วยจัดอบรมการใช้เครื่องมือสำหรับเจ้าหน้าที่ของ อ.บ.ต.

3.5 ข้อเสนอแนะต่อหน่วยงานภายนอกที่ทำงานสนับสนุนความเข้มแข็งของการรวมกลุ่ม

3.5.1 ข้อเสนอแนะต่อนักวิชาการ/นักวิจัย/งานวิจัย

แกนนำชุมชนได้กล่าวกับคณะนักวิจัยว่า ที่ผ่านมามีนักวิชาการมาทำวิจัยหลายเรื่อง บางกรณีทำให้เกิดปัญหากับชุมชนมาก เพราะต้องสละเวลามาตอบคำถามที่ผู้วิจัยต้องการ และเมื่องานวิจัยนั้นจบลงชุมชนไม่ได้ประโยชน์จากการวิจัยดังกล่าว แต่ชาวบ้านก็ไม่สามารถปฏิเสธการขอความช่วยเหลือได้ เพราะสังคมชนบทยังมีความเกรงใจ ต่อกรณีดังกล่าวตรงกับข้อสรุปของงานวิจัยเพื่อท้องถิ่น(2543:1) ซึ่งกล่าวว่า

งานวิจัยส่วนใหญ่ที่ผ่านมาถึงแม้ว่าจะเป็นประโยชน์อยู่พอสมควร แต่ดูเหมือนว่าเป็นการทำงานแบบตั้งโจทย์จากภายนอกชุมชน และหวังว่าชุมชนหรือผู้อื่นจะนำผลงานวิจัยไปใช้ให้เกิดประโยชน์กับชุมชนได้เมื่องานวิจัยเสร็จแล้ว ซึ่งในหลายกรณีพบว่าไม่เป็นไปตามนั้น และถึงแม้ว่างานวิจัยจะนำไปใช้แก้ปัญหาบางอย่างได้ แต่เมื่อโครงการวิจัยสิ้นสุดแล้ว งานก็มักจะหยุดตามไปด้วย เพราะคนในท้องถิ่นไม่รับช่วงงานนั้นต่อไป

จากปัญหาดังกล่าว เราจะทำอย่างไรให้งานวิจัยนำไปสู่การสนับสนับความเข้มแข็งของสังคม ชุมชนโดยรวมในวิกฤตการณ์ขณะนี้ โดยเฉพาะการทำงานวิจัยที่ไปเกี่ยวข้องกับชาวบ้าน หรือคนในชุมชน ควรจะปรับเปลี่ยน "ข้อสงสัย" ที่เริ่มจากผู้วิจัยเป็นผู้ตั้ง "ข้อสงสัย"ไปให้คนในท้องถิ่น หรือคนในชุมชน เป็นผู้ตั้งข้อสงสัย หรือตั้งโจทย์เอง ได้หรือไม่

ปัจจุบันนี้ มีการสนับสนุนงานวิจัยในลักษณะดังกล่าวด้วยเชื่อว่าจะก่อให้เกิดการเปลี่ยนแปลงที่ฐานรากอย่างแท้จริง ตัวอย่างงานวิจัยลักษณะนี้คือ งานวิจัยเพื่อท้องถิ่นของ สำนักงานกองทุนสนับสนุนการวิจัยกำลังสนับสนุนอยู่ และได้ทดลองทำประสบผลสำเร็จในภาคเหนือ โดยหลักของการสนับสนุนงานวิจัยดังกล่าวคือให้ชาวบ้านธรรมดาๆ ได้ "ใช้" งานวิจัยโดยตรง ให้งานวิจัยตอบคำถามของชาวบ้านได้ และมีประโยชน์เป็นรูปธรรมในการช่วย แก้ปัญหาของชุมชน งานวิจัยลักษณะนี้จะเริ่มงานที่ "ชุมชน" ไม่ใช่ที่ตัวนักวิจัย กล่าวคือ เรื่องวิจัยต้องเป็นเรื่องที่เป็นปัญหาของชุมชน หรือเป็นสิ่งที่ชุมชนอยากได้คำตอบ มิใช่ทำวิจัยในเรื่องที่นักวิจัยอยากรู้เชิงวิชาการ หรือสิ่งที่ นักพัฒนาอยาก จะให้ชุมชน "เป็น" เท่านั้น แต่ชุมชนต้องเป็นผู้เลือก และเป็นผู้ตั้งหัวข้อการวิจัยที่จะทำงานต่อไป และในกระบวนการวิจัยจะต้องมีคนในชุมชนและนักพัฒนาร่วม ทำงานด้วย ในฐานะเป็นสมาชิกในโครงการ บทบาทของสมาชิกก็คือร่วมสุขร่วมทุกข์ในโครงการร่วมกันแก้ไขปัญหาอุปสรรค และร่วมรับผลจากความสำเร็จของงาน

จากการทำงานวิจัยและปฏิบัติการร่วมกับชุมชนสาลีพบว่า กลุ่มต่าง ๆ ต้องการองค์ความรู้ในการเสริม หรือต่อยอดความรู้เดิมที่มีอยู่ งานวิจัยที่จะช่วยขยายองค์ความรู้ให้กับกลุ่มต่าง ๆ มีหลาย ๆ กรณี เช่น การสำรวจกำลังการผลิตของชุมชน การวิจัยเพื่อค้นหาสูตรผสมอาหารสัตว์ที่เหมาะสมกับท้องถิ่น การวิจัยรูปแบบเกษตรกรรมทางเลือกที่เหมาะสมกับเกษตรกรในภาคกลาง เป็นต้น

3.5.2 ข้อเสนอแนะต่อหน่วยราชการ

ที่ผ่านมาหน่วยราชการมักจะเน้นการสนับสนุนวัสดุ อุปกรณ์ มากกว่าการสนับสนุนการพัฒนาความรู้ จึงทำให้ความเข้มแข็งของการรวมกลุ่มเกิดขึ้นได้ยาก ดังนั้นหากหน่วยราชการจะสนับสนุนให้เกิดความเข้มแข็งของการรวมกลุ่มแล้วควรให้งบสนับสนุนกระบวนการเรียนรู้ ดังที่สำนักงานกองทุนเพื่อสังคม ธนาคารออมสินได้สนับสนุนอยู่

อย่างไรก็ดี การสนับสนุนวัสดุอุปกรณ์อาจจำเป็น แต่ควรปรับวิธีการให้สอดคล้องกับความต้องการของชุมชน ดังกรณีตัวอย่างงบมิยาซาวา ซึ่งเน้นการมีส่วนร่วมของชาวบ้านเป็นหลัก

Figure 1 : Location of Saklee Community

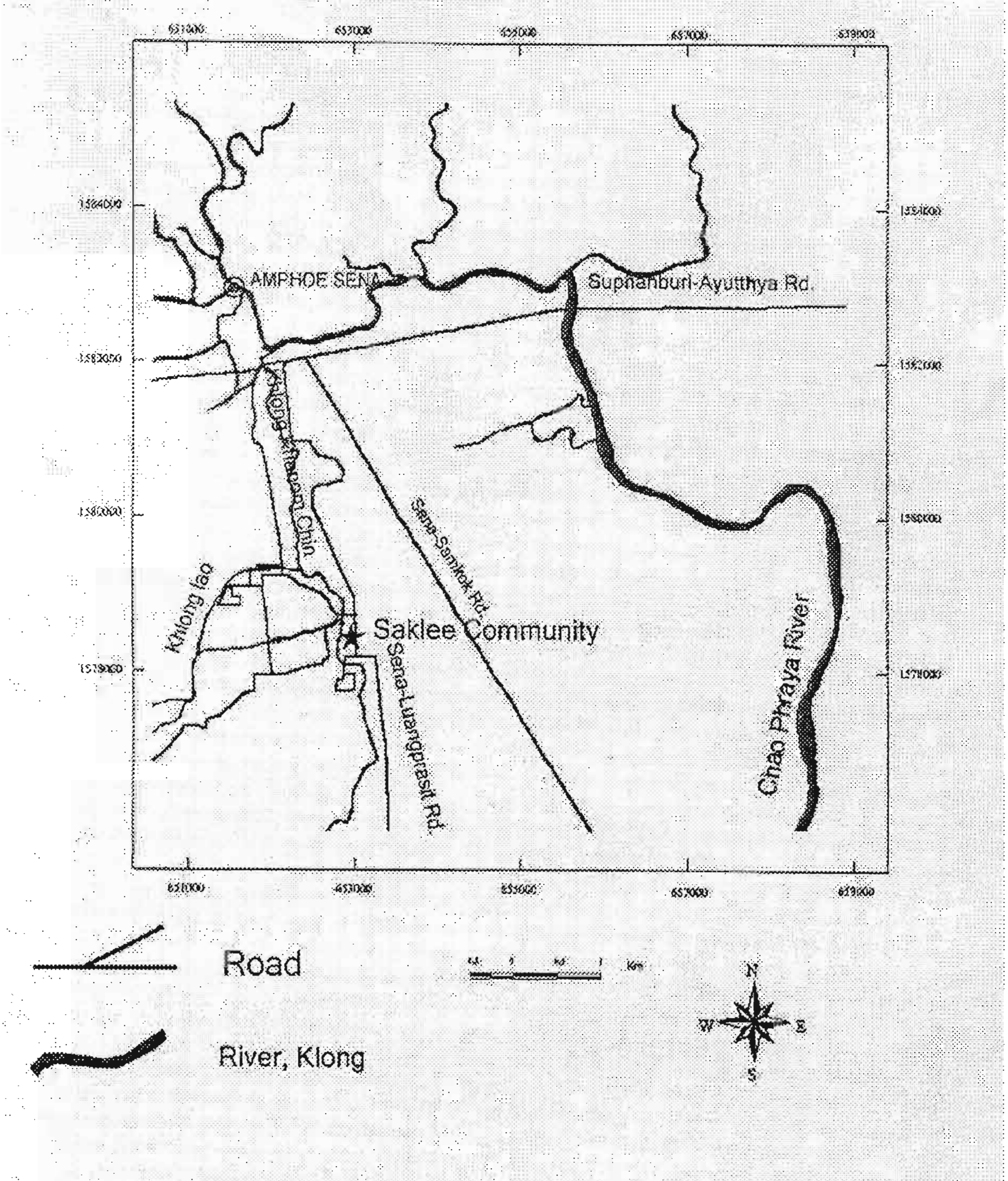


Figure 2 : Location of The Saklee Saving Group and Toxic-free Agriculture Group

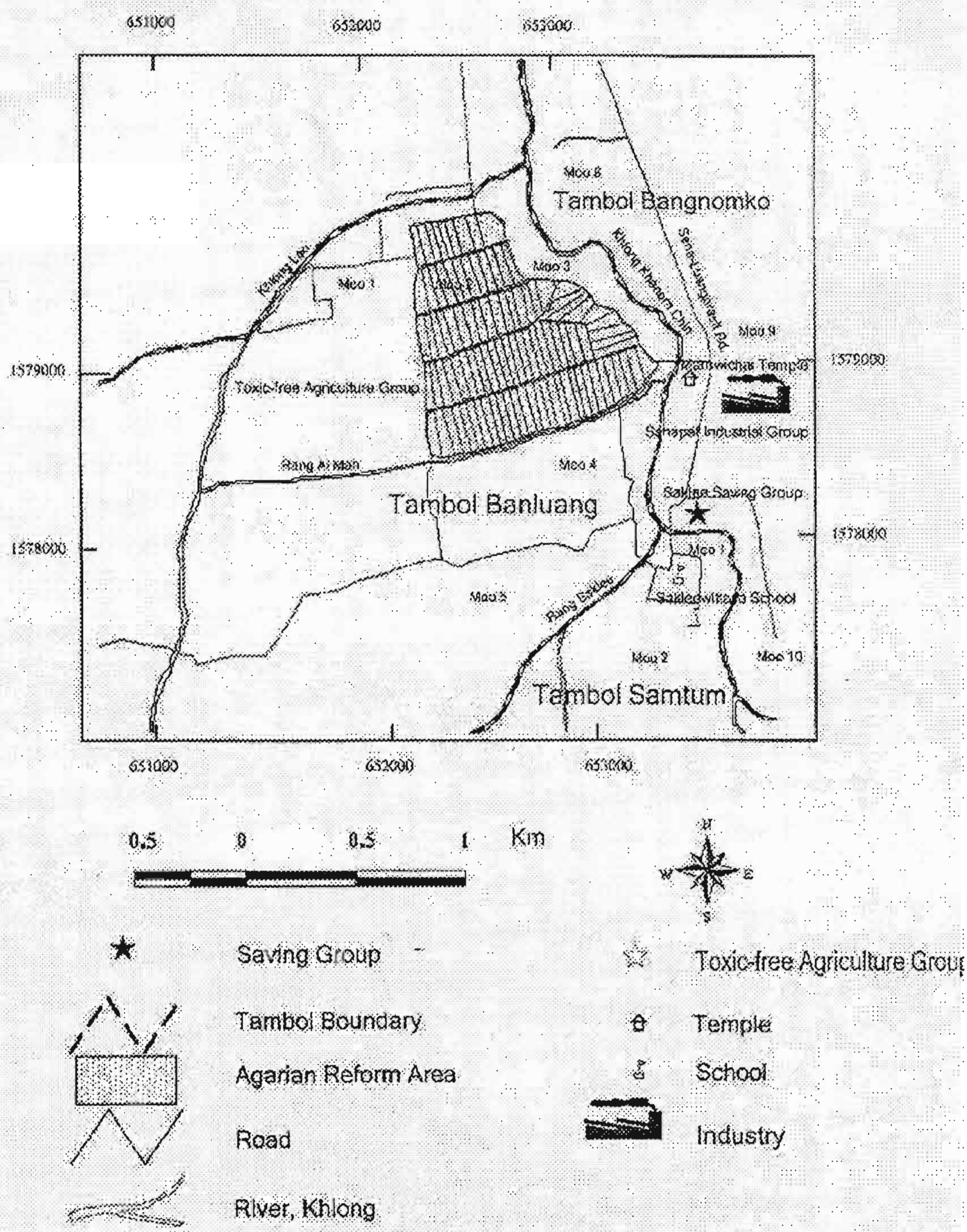


Figure 3 : Location of The Alternative Agriculture Groups in Saklee Community

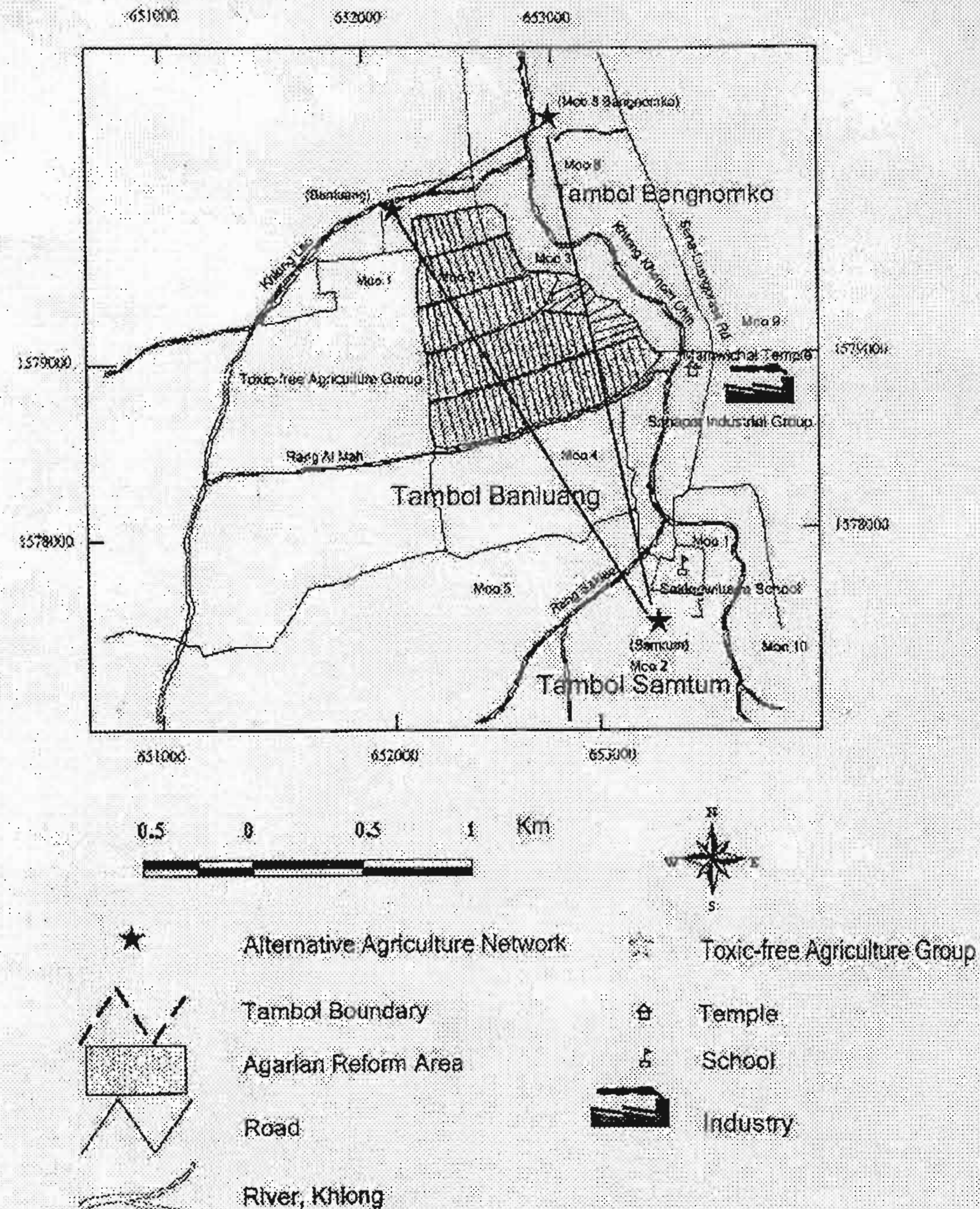
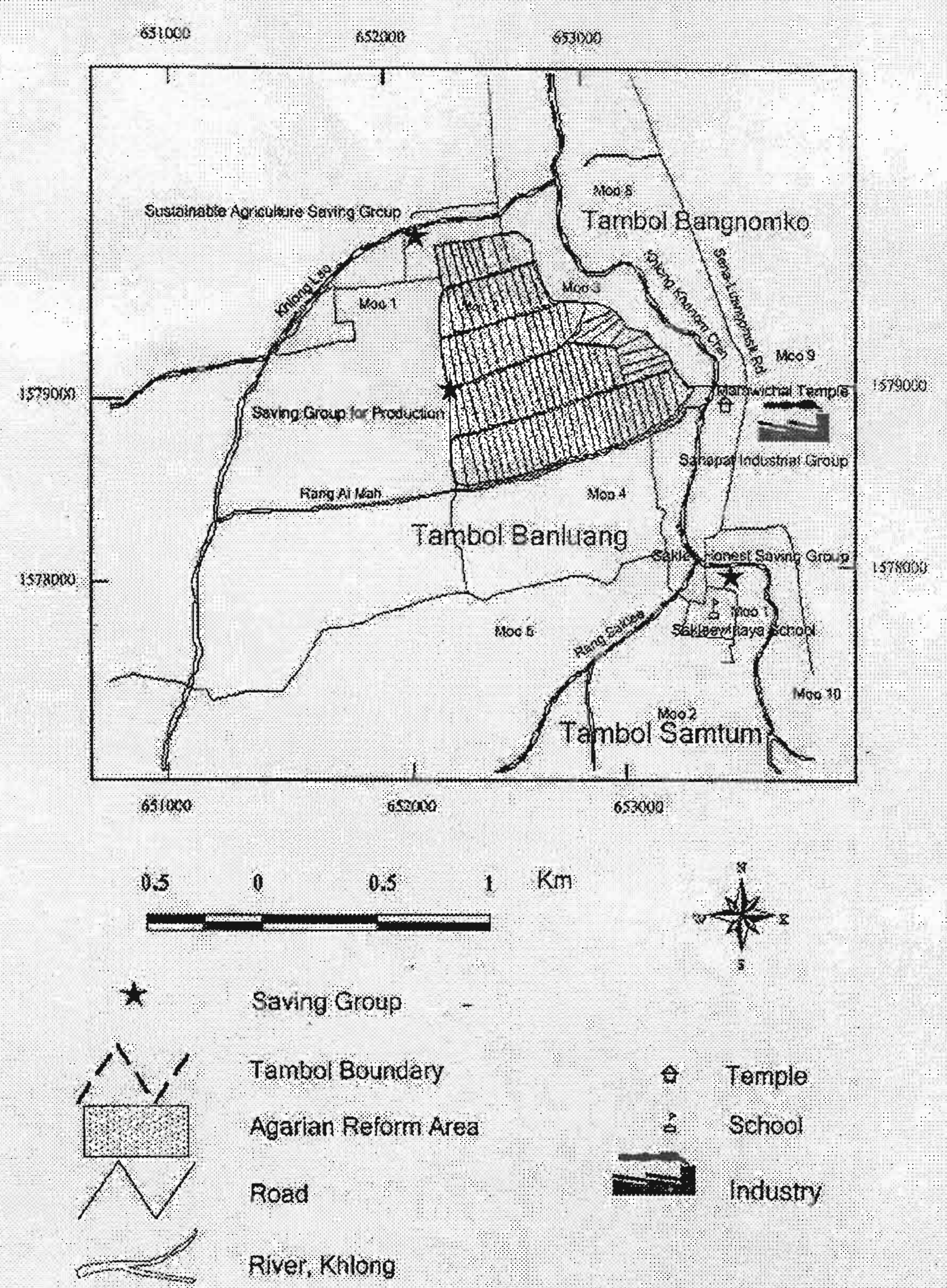


Figure 4 : Location of The Saving Groups in Saklee Community



บรรณานุกรม

มหาดไทย, กระทรวง.

2542 **เอกสารรายละเอียดประกอบแผนปฏิบัติงาน/โครงการเงินกู้กระตุ้นเศรษฐกิจของกระทรวง มหาดไทย**. ที่ มท 0210.1/ว 790 ลงวันที่ 23 มีนาคม 2542

สีลาภรณ์ นาครทรรพ.

2539 "การศึกษาเพื่อการพัฒนาที่ยั่งยืน," ใน **การศึกษากับการวิจัยเพื่ออนาคตของประเทศไทย**. กรุงเทพ : สำนักงานกองทุนสนับสนุนการวิจัย.

สุรินทร์ กิจนิตชีว์และคณะ.

2540 **กระบวนการเรียนรู้เพื่อการปรับตัวของชุมชนสาคลี ท่ามกลางการเปลี่ยนแปลงทางสังคมและวัฒนธรรม**. กรุงเทพฯ : สำนักงานคณะกรรมการวัฒนธรรมแห่งชาติ.

สำนักงานกองทุนเพื่อสังคม ธนาคารออมสิน.

2541 **ชุมชนเข้มแข็ง** : **ทุนทางสังคมของไทย** .พิมพ์ครั้งที่ 2 กรุงเทพฯ : สำนักงานกองทุนเพื่อสังคม.

สำนักงานกองทุนสนับสนุนการวิจัย.

การวิจัยเพื่อท้องถิ่น. พิมพ์ครั้งที่ 4 กรุงเทพฯ : สำนักงานกองทุนสนับสนุนการวิจัย.

อานันท์ กาญจนพันธุ์.

2538 "การเปลี่ยนแปลงสังคมกับศักยภาพของชุมชนไทย," ใน **วิพากษ์สังคมไทย**. เอนก เหล่าธรรมทัศน์และคณะ. กรุงเทพฯ : สมาคมสังคมศาสตร์แห่งประเทศไทย.

อนุชาติ พวงสำลี และกฤตยา อาชวนิจกุล ; บรรณาธิการ.

2542 "ขบวนการประชาสังคมไทย : ความเคลื่อนไหวภาคพลเมือง," ใน จากปัจเจกสู่สาธารณะ. กรุงเทพฯ : โครงการวิจัยและพัฒนาประชาสังคม มหาวิทยาลัยมหิดล.

Rangsit settlement in the Chao Phraya delta

Suphang Chantawanit [1]

Abstract and full paper not provided

[1] Chulalongkorn University

Access to land resources in the Chao Phraya Delta: land tenure issues revisited[1]

François Molle[2] and Thippawal Srijantr[3]

Abstract: *Land systems undergo constant processes of redistribution through inheritance, sale or rentals. Imbalances may appear and create economic non-viability (fragmentation) or ownership concentration. The Chao Phraya delta is often considered as an example of subsistence peasant economy and culture destabilised, or disintegrated, by the opening to markets and capitalism. This papers examines historical trends in farm size, land distribution and tenure, and concludes that there is no evidence of drastic imbalances in the land system. It shows that crises were experienced in some points of space and time, in particular around 1970, but that they do not adequately describe longer historical transformations.*

1 Introduction

Access to land is a critical aspect of agrarian systems. Farm land endowments vary with the course of time as population grows and land is transmitted from one generation to the following one. Possible land fragmentation is a strong concern of Asian agrarian systems characterised by a high rate of small farms and generally high demographic growth. In addition, the distribution of land among a given population can reveal varied degrees of skewedness. An egalitarian distribution will be challenged by several processes that tend to create disparities constantly: heterogeneity in the family structure (number of children, health status, etc), in human resources (skill, will, risk-management, etc) or in the socio-cultural structure (differentiated access to productive resources according to social and political stratification; patterns of land transmission by inheritance); heterogeneity in the land itself (lowland/upland, fertility, varied climatic risk, etc) and, therefore, on the economic return of the products it yields. Subsequently, in a dynamic process, these imbalances will tend to strengthen some farms while others will be weakened. Traditionally, subsistence economies in Southeast Asia and elsewhere have developed social means to control such disparities that may destroy the cohesion of the group. Distribution of land according to family size, needs for mutual help, labour sharing at critical times of the agricultural calendar and food redistribution in case of shortage – regardless of whether they are seen as a normative moral ideal or as a mere subsistence prerequisite - were salient features of such economies.

[1] Most of the quantitative analysis presented in this paper is drawn from Molle and Srijantr (1999) to which the reader interested by further details is referred.

[2] Researcher at IRD (Institut de Recherche pour le Développement): odoras@ku.ac.th

[3] Lecturer at Kasetsart University; agrtws@nontri.ku.ac.th

In general terms, the structure of the *land system* (*the characteristics of the access to and of the use of the land resources within a given agrarian system*) appears to be extremely complex when one considers the different factors that govern its dynamic over time. The number of possible combinations between the set of farms (holdings) of a given region and the set of cultivated plots – in numeric and tenurial terms, and also regarding the social arrangements attached to transactions - are extremely high and their re-combination over time is governed by varied agro-ecological, physical and socio-economic factors that are also subject to change.

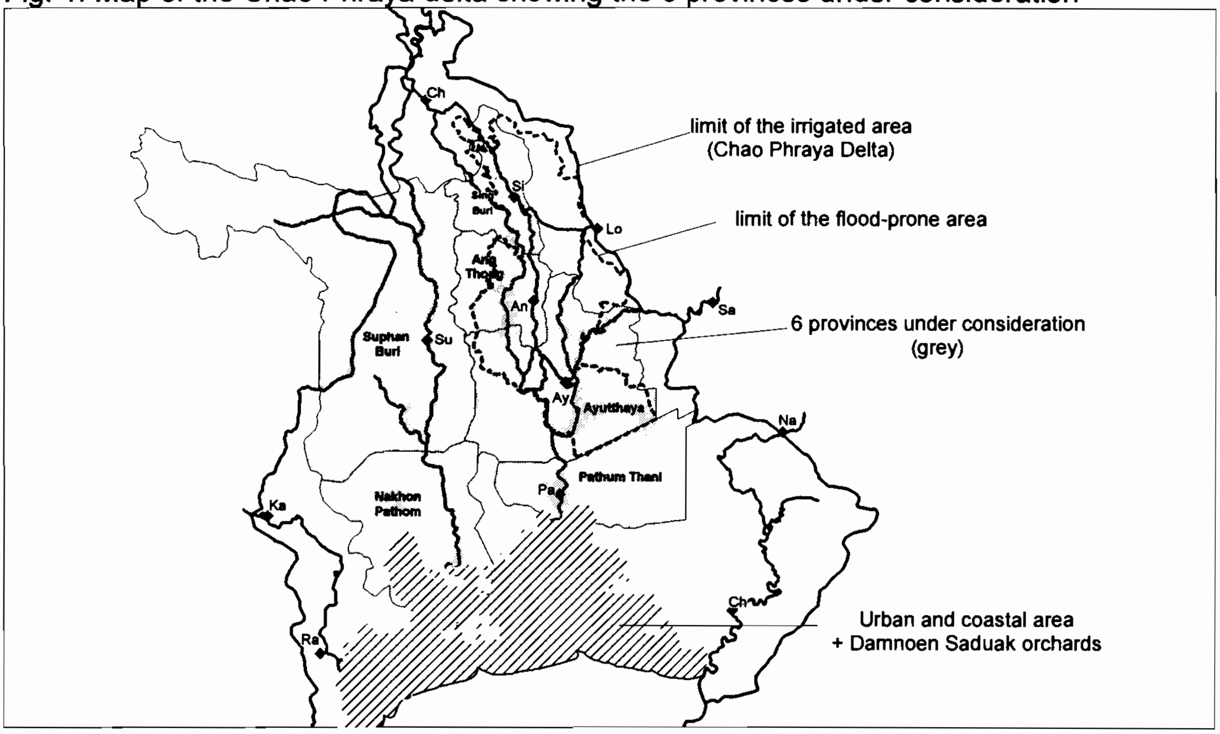
The case of Thailand, most specifically its Central Region and the 1850-1930 period, has aroused considerable scholarly interest and work[4]. Although it escaped the rule of colonial powers, Thailand is often believed to provide an example of subsistence economy disintegrated by the irruption of market and capitalist forces (Douglass, 1984; Chiengkul, 1983a, Nartsupha, 1999). Skewed ownership is often traced back to the early times of land reclamation, where the nobility and the officialdom acquired most of the land located in Bangkok's vicinity, notably on the lower Chao Phraya East Bank, including the Rangsit Project. Indebtedness, landlessness or landlords abuses are noted all along the history of the rural delta, in particular in times of crisis such as 1930 or the late 1960s-early 1970s (hereafter the "*1970 crisis*"). Along with the dismantling of traditional subsistence economies and the sharpening of social differentiation, increasing differences in holdings appear and capital excess or deficit (debts) are believed to translate into the accumulation of more land in fewer hands, following a classical *Marxian scenario* of polarisation.

The *1970 crisis* sparked off an abundant literature on different aspects of an agrarian deadlock: several reports warned that "population pressure and inheritance practices are constituting the primary pressures upon farmers to engage in tenancy; (...) the percentage of owner-tenants and tenants among all farmers will increase tremendously in the future" (Wagstaff, 1970). This concern was echoed by Ramsson (1977) who stated that "as the remaining frontiers in farm land begin to close, it can be expected that farm land tenancy will become more widespread". Piker (1975) opportunely raised concern about land speculation on the part of the urban strata and sees the "ownership of rice lands passing increasingly and irreversibly out of the local rural community". Tomosugi (1969) noted that "nearly 50% of paddy fields are now tenant cultivated" and that the "trend is still continuing at present". Resanond (1979) admitted that "if this trend [3% population growth] continues, and it is very likely to do so, (...) how to keep all of them [farmers] in agriculture is *another big problem*"... Chiengkul (1983a) and Douglass (1984) see this period as the outcome of a deleterious process of capitalist penetration in the Central Plain.

The present paper is devoted to assessing why, how and to what extent the ensuing decades have conformed or not to these expectations. More generally, it will consider the aspects of land distribution, land fragmentation, tenancy, landlessness and landowner/tenant relationships within a wider historical perspective and will try to reassess the common wisdom on such issues.

[4] The circumstances of its historical transformations have been analysed by several classical studies to which the reader may refer (see, in particular, Ingram, 1971; Manarangsan, 1989; Feeny, 1982; Johnston, 1975; Ishi, 1975).

Fig. 1: Map of the Chao Phraya delta showing the 6 provinces under consideration



From north to south: **Ch**: Chai Nat; **Sl**: Sing Buri; **Lo**: Lop Buri; **An**: Ang Thong; **Sa**: Saraburi; **Su**: Suphan Buri; **Ay**: Ayutthaya; **Na**: Nakhon Nayok; **Pa**: Pathum Thani; **No**: Nonthaburi; **Ka**: Kanchanaburi; **Na**: Nakhon Pathom; **Ba**: Bangkok; **Ch**: Chachoengsao; **Ra**: Ratchaburi; **S.P**: Samut Prakan; **S.S**: Samut Sakorn; **S.S**: Samut Songkram.

In an attempt to avoid the pitfall of aggregated data[5], we will consider only six provinces entirely included in the delta; an exception has been made for Suphan Buri Province, which has almost half of its land outside the irrigated delta and will serve as a point of comparison for the other provinces, namely Sing Buri, Ang Thong, Ayutthaya, Pathum Thani and Nakhon Pathom (Fig. 1). Ayutthaya, Ang Thong and Sing Buri (most especially the former) have a large share of their areas cropped with traditional rice varieties and low crop intensity (this "*flood-prone area*", as it will be called hereafter, is indicated on the map by a dotted lines). In these areas, off-farm activities are common and the agricultural population is ageing markedly. Other provinces included in the delta have been discarded, either because they are too close to the capital or because they are located in coastal areas, with limited and/or specific agricultural activities (aquaculture, orchards).

[5] Many studies on rural Thailand are based on aggregated data at the regional level. However, the high heterogeneity of agro-ecological and development conditions does not allow interpretation at that level. Even at the provincial level, it is often dangerous to draw conclusions: in the Central Region, provinces such as Lop Buri, Saraburi or Ratchaburi encompass a wide variety of agricultural conditions, ranging from forests, upland cultivation, to irrigated and lowland flood-prone conditions. The density of population, the rental and land markets, the level of land titling, and integration into the market are other important factors with significant spatial heterogeneity. Provinces with recent expansion into the uplands produce statistics that are an average of very different situations (rice-based long-settled core areas; expanding field crops in uplands, etc) and offer little support to disentangle such an intricate process. In this light, many analyses done on the Central Plain appear to be marred by the inconsistency of the spatial units used and/or by the undue generalisation of site-specific observations.

The study first presents a set of historical quantitative data (namely the agricultural censuses of 1950, 1963, 1978, and 1993 complemented with data from population censuses, various surveys and investigations) and subsequently interprets them within a wider framework of social, economic and demographic change.

2 Change in farm land and patterns of land tenure

2.1 Number of farms and distribution by size classes

Table 1 shows that an increase in farm land of 14% is still recorded between 1950 and 1963 (residual land brought under cultivation, part of which is attributable to the implementation of the Chao Phraya Irrigation Scheme). Agricultural land in the delta probably started to decline in the1970s. This *regression of the land frontier* is now very significant, most especially around Bangkok and, with regard to the provinces included in our sample, Pathum Thani and Nakhon Pathom: these last two provinces lost around 1.4% of their agricultural land every year in the 1963 -1993 period. While Ang Thong and Sing Buri have limited their losses to 15 and 18% of the total land farmed in 1963, Ayutthaya has lost 24%. Suphan Buri stands out as an exception, with an increase of 9% due to the opening of new uplands to the west of the province.

This reduction is due principally to urban and industrial growth and to the transformation of agricultural land into real estate, sand pits, golf courses, sunday-gardens, roads, etc. Speculation is also responsible for some fallow land, especially along the main roads and near urban centres. Not considering Suphan Buri, the remaining provinces undergo an overall loss of 27% of their agricultural land in a 30 year span.

TABLE 1: TOTAL FARM AREA (RAI), BY PROVINCE AND BY CENSUS.

	1950	**1963**	**1978**	**1993**	**1993/1963**	**(±)% year**
Ayutthaya	1,100,311	1,382,460	1,269,611	1,045,584	0.76	-0.93
Ang Thong	444,214	494,659	503,808	420,251	0.85	-0.54
Pathum Thani	796,295	830,040	750,931	554,135	0.67	-1.34
Sing Buri	389,754	440,187	371,604	358,908	0.82	-0.68
Suphan Buri	915,553	1,852,298	1,946,310	2,012,113	1,09	0,28
Nakhon Pathom	926,596	1,035,579	812,181	672,996	0.65	-1.43
Total	4,572,723	6,035,223	5,654,445	5,063,987	0.84	-0.58
Total – Suphan	**3,657,170**	**4,182,925**	**3,708,135**	**3,051,874**	**0.73**	**-1,05**

Note; 6.25 rai = 1 ha

The total number of farms also rose during the 1950-63 interval (with a rate of 100% for Suphan Buri (upland frontier) and an average rate of 20% for the other provinces), then later levelled off and only slightly decreased (the overall growth for the subsequent 30 years is only 7%, but if Suphan Buri, with its expansion towards uplands, is disregarded, we obtain on the contrary a *reduction of 5% of the total number of farms).* Table 2 shows that, in fact, this average trend varies according to the province: Ang Thong and Sing Buri experienced an increase in the number of farms (+5% and +3% respectively), while the three more urbanised provinces (Pathum Thani, Nakhon Pathom and Ayutthaya) underwent a net decrease, especially the latter (- 13%).

TABLE 2: EVOLUTION OF THE TOTAL NUMBER OF FARMS, BY PROVINCE

Province	1950	1963	1978	1993	1993/50	93/63	% year
Ayutthaya	36,875	44,037	42,258	38,462	1.04	0.87	-0.45
Ang Thong	20,329	25,039	25,640	26,208	1.29	1.05	0.15
Pathum Thani	17,388	19,695	19,625	17,711	1.02	0.90	-0.35
Sing Buri	15,671	18,841	20,049	19,500	1.24	1.03	0.11
Suphan Buri	31,452	63,895	73,931	85,495	2.72	1.34	0.98
Nakhon Pathom	35,972	44,078	41,056	42,274	1.18	0.96	-0.14
Total	**157,687**	**215,585**	**222,559**	**229,650**	**1.46**	**1,07**	**0.21**
Total – Suphan Buri	**126,235**	**151,690**	**148,628**	**144,155**	**1.14**	**0.95**	**-0.17**

Source: Agricultural censuses (respective issues)

Data on average farm size prior to the middle of the current century are scant. Prince Dilok reports that at the turn of the century farms in the central valley were commonly in the 80-100 rai bracket. Zimmerman's survey in 1930 is too fragmentary to derive a clear picture of that question but points out to much smaller areas. It is believed that the average farm size may have been attuned to the family labour force until the 1920s, when saturation became sensible in some parts of the delta and the average farm size started to decline. Table 3 reveals the gradual trend which has affected all provinces since 1950, giving an overall decrease from *30.1 to 22.1 rai between 1950 and 1993*[6].

Regarding the 1963-93 period, the slight decrease of the number of farms in the 5 core provinces (-5%) combined with the overall decrease of the total farm land (-26%), translates into varied evolutions of the average farm size by province, but all trends are downwards (Table 3). This shows that even Provinces with a clear decrease in the number of farms also underwent an even more drastic decline of farm land. Pathum Thani, although presenting a decrease of 26%, is still noticeable for its higher average farm size which is due to its specific historical pattern of land reclamation. Ang Thong and Sing Buri are the most alarming provinces, with a decline of approximately 20%. Nakhon Pathom scores even lower but this rate is concomitant to a significant trend towards diversified production farmed on smaller land. Although it has upland reserve, Suphan Buri does not succeed in compensating the strong fragmentation observed in the irrigated part.

[6] It is worth noting, too, that if a similar calculation is carried out for the *rural delta* (i.e the set of amphoe best matching the current irrigated area, BMA set aside), the decrease in farm size appears of lesser magnitude, *from 28 to 24 rai between 1963 and 1993, showing that land division is more advanced in the core delta* (our 6 provinces).

TABLE 3: EVOLUTION OF THE AVERAGE FARM AREA, BY PROVINCE (IN RAI)

Province	1937	1950	1963	1978	1993	93/63	% year
Ayutthaya	30.5	29.8	31.4	30.0	27.2	0.87	-0.48
Ang Thong	21.3	21.8	19.8	19.7	16.0	0.81	-0.71
Pathum Thani	47.7	45.9	42.1	38.3	31.3	0.74	-0.98
Sing Buri	25.7	24.8	23.4	18.5	18.4	0.79	-0.79
Suphan Buri	26.4	29.1	29.0	26.3	23.5	0.81	-0.70
Nakhon Pathom	25.4	25.7	23.5	19.8	15.9	0.68	-1.29
Total	**29.5**	**30.1**	**28.0**	**25.4**	**22.1**	**0.79**	**-0.79**

Source: Population and agricultural censuses (respective issues)

Similar data relative to farms growing only rice show that, Pathum Thani aside, the reduction in average farm size is less severe than for other farms: from 28 to 24 rai/farm between 1978 and 1993. Sing Buri even registers an increase, due to the consolidation of some very large farms in this province (see later section).

These considerations, however, refer to average values and do not tell the whole story. It is necessary to have a closer look at the distribution of farms according to size class. Fig. 2 is quite illuminating in revealing the change in the number of farms for each size class (5 provinces). It specifies these variations for each inter-census period, 1950-1963,1963-78 and 1978-93[7]. The 1950-63 period differs from other periods in that all size classes are numerically on the rise. On the contrary, the two following periods are marked by a surge of smal(ler) holdings, with areas lower than 15 rai, while larger holdings are depleted.

Fig. 3 proposes a complementary reading in terms of total farm area by class. It reveals how the increase in total farm land of the 1950-63 period has predominantly benefited larger farms: this does not mean that these farms have absorbed the new land brought under cultivation but that the overall redistribution process shows both a pattern of land concentration in some larger farms (> 30 rai) and a rise of small farms, possibly losing land because of inheritance division and/or forced land sale. The component of land concentration, however, appears radically reversed in the two later intervals: farms over 30 rai (and, notably, farms between 60 and 100 rai) have provided most of the land corresponding to the surge of the small holdings. To put it another way, these small holdings probably originate from the division of the larger ones (either by inheritance or by land sale). An extremely interesting phenomena also appears in the last upper range: the area farmed by holdings over 140 rai has been on the rise during the 78-93 period. A total of 90,000 rai has been transferred to this category, showing that there is an embryonic development of (very) large farms. Data by *changwat* reveal that 140,000 rai should be added to this category if Suphan Buri Province was added: the trend is much larger in the upland. All the

[7] The size classes in the three census are not exactly the same and some interpolations between some classes have been necessary in order to allow their comparison. This may have generated slight distortions between adjacent classes but does not affect the trends evidenced in the charts. In addition, the lower limit of farm size is 1 rai in the 1950 census, whereas it is taken as 2 rai in the following censuses. Therefore, the growth of the farms under 2 rai between 1950 and 1963 is underrated (although it already appears quite considerable).

provinces, to a lesser or greater extent, show a positive trend on that range, especially Sing Buri and Pathum Thani.

Also of great significance is the fact that the absolute number of these farms over 140 rai is declining (from 872 in 1963, to 588 in 1993, for the 5 inner *changwat*). This means that the average size of these farms has boomed up, from 189 to 352 rai.

FIG. 2: CHANGE IN THE TOTAL NUMBER OF FARMS, BY FARM SIZE CLASS AND 3 INTER-CENSUS PERIODS

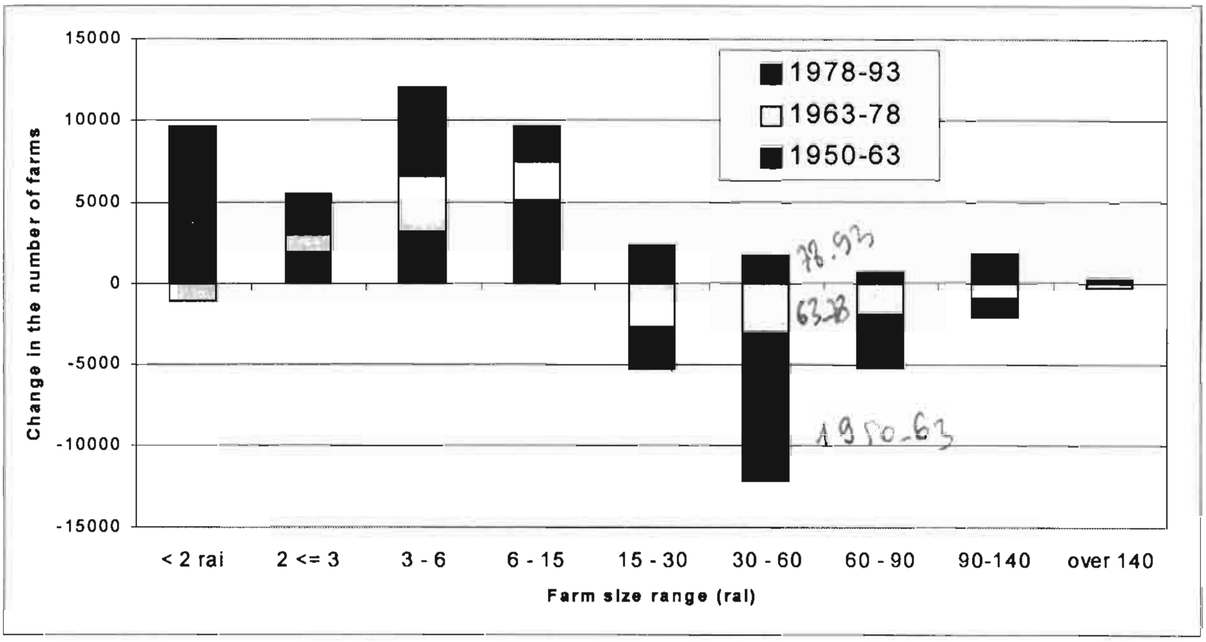
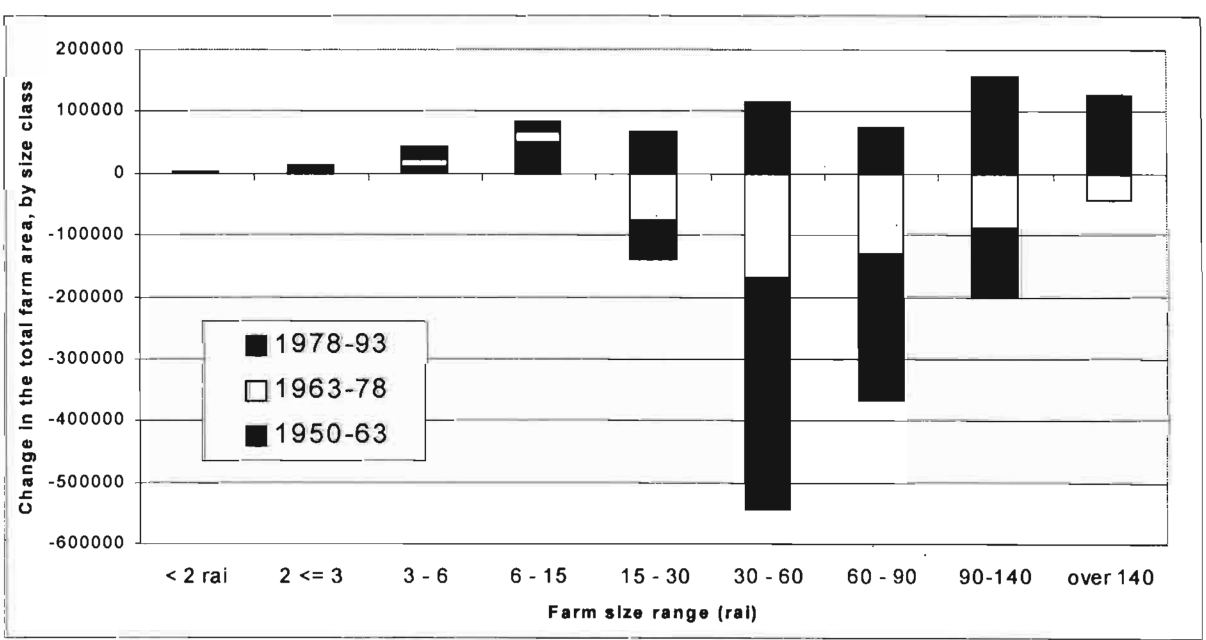


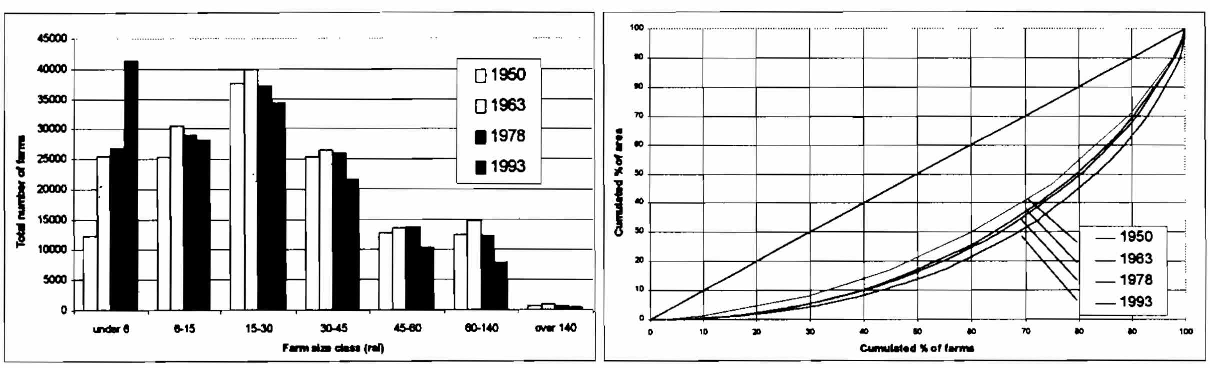
FIG. 3: CHANGE IN THE TOTAL FARM AREA, BY SIZE CLASS AND 3 INTER-CENSUS PERIODS (5 PROVINCES)



The distribution of holdings by farm size class is rather different *for each changwat*. Ayutthaya differs from other provinces in that no (or a very limited) increase of the smaller farms is registered. This obviously reflects the fact that the agro-ecological conditions do not allow more fragmentation of these holdings. Pathum Thani has lost many of its large holdings (> 60 rai). Nakhon Pathom (diversification), Ang Thong and Sing Buri show a farm distribution with a high number of small farms. Although parts of these last two provinces have notably intensified their agriculture, the trend is worrying as their population density is high. Suphan Buri still has a large share of medium farms (upland areas) but its irrigated part is also undergoing fragmentation.

In 1993, farms under 20 rai make up 60% of the total holdings but cover only 21% of the total farm area. The 10% larger farms (over 40 rai), on the other hand, correspond to 36% of the total farm land. Fig. 4 plots the cumulated percentages of both the number of farms and their corresponding areas for the three censuses, and reveals that the change in farm size distribution commented earlier resulted in an overall worsening of the distributional pattern. This can be seen from the fact that the curve gradually strays from the diagonal, especially during the 1950-63 and 1978-93 periods. The Gini indice[8], computed for the four years, yields values of 0.41, 0.46, 0.47 and 0.52 respectively. The change of the 1978-1993 interval is mostly due to the increase of farms in the 0-6 rai range, which shifts the curve to the right. To what extent income disparities are associated with these gradual increase of the Gini indice is not readily available. Land productivity must be taken into account and some small holdings which engaged in cash crop production in the 1978-93 interval are better off than bigger ones with rice monoculture.

FIG. 4: THE DISTRIBUTION OF THE ABSOLUTE NUMBER OF FARMS BY SIZE CLASS (5 *CHANGWAT*)



sources: agricultural census

The data presented above refer to all the farms, irrespective of their land use. Between 1978 and 1993, mono-rice growers have undergone a severe cut in all size classes, some of them shifting to the "mixed" category, which shows net gains for all categories under 30 rai. In addition data show that the increase in small farms in the 1963-93 period chiefly relates to non-rice growing farms. This is an important point as it smoothes the vision of poverty associated with very small holdings. This complements the overall picture and allows one to

[8] which measures the total area between the diagonal and the curve, the unit being the half rectangle representing the worst possible distribution.

state that both mixed farms and farms diversifying out of rice are increasing at the expense of mono-rice farms.

TABLE 4: EVOLUTION OF THE PERCENTAGE OF FARMS GROWING RICE

	All farms growing rice					Farms with only rice		Rice/mixed farms	
Province	% total 1937	% total 1947	% total 1963	% total 1978	% total 1993	% total 1978	% total 1993	% total 1978	% total 1993
Ayutthaya	98	97	95	96	91	88	79	8	12
Ang Thong	98	96	94	93	79	79	55	14	24
Pathum Thani	94	95	93	78	64	64	48	14	18
Sing Buri	97	95	95	95	84	81	65	14	19
Suphan Buri	95	91		72	67	66	47	6	20
Nakhon Pathom	96	81	79	61	46	41	31	20	15
Total	**96**	**92**	**90**	**84**	**70**	**68**	**52**	**16**	**18**

Source: Population and Agricultural Censuses (respective issues)

A last mention can be made regarding the average number of plots per farm. Contrary to expectations, it has been declining since the post-war period. Zimmerman's estimates in 1930 gives an average of 1.64 but this value sharply rises to 2.6 in 1953 (Ministry of Agriculture, 1953). It was found as low as 1.83 in 1978 and further declined, with a value of 1.64 in 1993[9], in line with the augmentation of small farms, most of which have only one parcel.

2.2 Change in land ownership and patterns of land tenure

In the above discussion, a holder may operate owned or rented land, and may also lease some. The analysis must therefore be deepened in order to assess whether and how the change in farm size is related to tenure conditions.

Tenancy in the delta dates back as soon as the late XIXth century, when urban landlords (crown, nobility, high-ranking officials) – further to the gradual emancipation of their serves and dependants -, had to rely increasingly on tenants and/or wage labourers to farm the large domains they had acquired. This became prominent from 1868 onward in the Rangsit area but also applies to other large scale areas opened by the digging of other canals, most often located on the East Bank (Tanabe, 1978). Estimates for Rangsit in the 1910's put the area owned by large absentee landowners at 81% of the total (Manopimoke, 1989), while Zimmerman (1931) found (in villages of Rangsit) a share of rented land as high as 95.5%. Out of this *landlord area* (see Fig. 1), tenancy was not an issue, as land was available and the grip of urban capitalists was negligible.

[9] Ayutthaya, Ang Thong and Singburi have values slightly higher than the average, while Pathum Thani is the least fragmented. All values for 1993 are smaller than 2.

After WWII the situation evolves quite rapidly. A first agricultural census (1950) and a survey on the total rice-farmers of the Central Plain in 1967-68 (DLD, 1969) provide details on the distribution of farms according to land tenure status: full-owner, tenant/owner, full tenant. The latter can be used for comparison with later censuses with little bias[10], thus compensating for the 1963 census data[11], because the distributions of farms according to land tenure for all farms and for rice-growers only differ by less than 2% (Wagstaff, 1970). Data from 1973 (OAE, 1975) appear somewhat dubious in that full tenancy rates are much lower than in other surveys. Data from DLD cited by Ramsay (1982) for the year 1975 (1974-76) and available for three of our provinces (Table 5) confirm the bias attached to these data. Table 5 presents the evolution of land tenure types in 1950, 1967, 1973, 1975, 1978 and 1993 for our 5 provinces (Suphan Buri excluded because of its specific pattern).

It appears that, much contrary to expectation, the percentage of full owners has gradually increased over the 30 years span, from around 40% to 61%. The percentages of full tenants undergo a clear decrease from one third in 1967 to less than one fourth in the last decade. Last, the significant proportion of owner/tenants in the early 70's is reduced down to 16% in 1993.

If we now look at the data at the *changwat* level, we are once again struck by the diversity of situations. It appears that, from a probable rather low value after Word War II[12], the late 60's have witnessed a maximum in the percentage of full tenants, which have been declining hitherto. The rise of full-owners is all the more spectacular in all provinces since 1973[13], except in Nakhon Pathom, where there is a 2.5% decrease between the last two censuses. This goes together with a squeeze of the owner/renter category, now reduced to less than 19% in all provinces except Ayutthaya (23%). Almost 3,000 full-tenants have disappeared from Pathum Thani, causing indirectly a spectacular reversal of the historical prevalence of tenancy in this province. This population most probably corresponds to the newly urbanised areas, which was both historically in the hands of urban families and subject to speculation,

[10] Data from a survey in five provinces of central Thailand in 1964 (Chaiyong et al. n.d.), show a distribution of holdings between "full-owner", "owner/tenant", "tenants" and "others" of 41, 29, 27 and 3% respectively (Tomosugi, 1969), which is quite consistent with the 1967 data. Unfortunately, the report only provides the data aggregated for the 5 provinces.

[11] Land tenure studies in Thailand have been marred by the inconsistency of the variables adopted, since the first surveys of Zimmerman in 1930 (Sternstein, 1967; Wagstaff, 1970). The four main censuses in consideration here unfortunately allow limited insight on tenure issues. One of the main flaws is that the 1963 census does not distinguish between (full)owners and owner-tenants. In addition, full tenants are divided between cash-renters and crop-renters (tenants paying their rent in kind) but those renting land on both systems or on a free basis come under the "other" category.

[12] Ingram has computed the share of full tenants for the years 1937, 1950, 1963 (underrated) and 1967 for the 26 provinces of the 1967 survey and obtained shares of 26.7%, 15.6%, 9.9% and 22.5% respectively, showing that the post-war period is characterised by a low level of full-tenancy. It is believed that post-war disturbances, skyrocketing prices in 1947 and, later, the expansion of the upland frontier, have reduced the proportion of full tenants.

[13] The data for 73/74 also bear (in small letters), for information, the percentage of area rented free. It must not be included when comparing with the later censuses. For the 1978 census, people using land free (usually from relatives) are in the "other" category. It is probably also the case in the 1993 census but no specific mention of this is given. The rate of "free renting" is believed to have significantly declined.

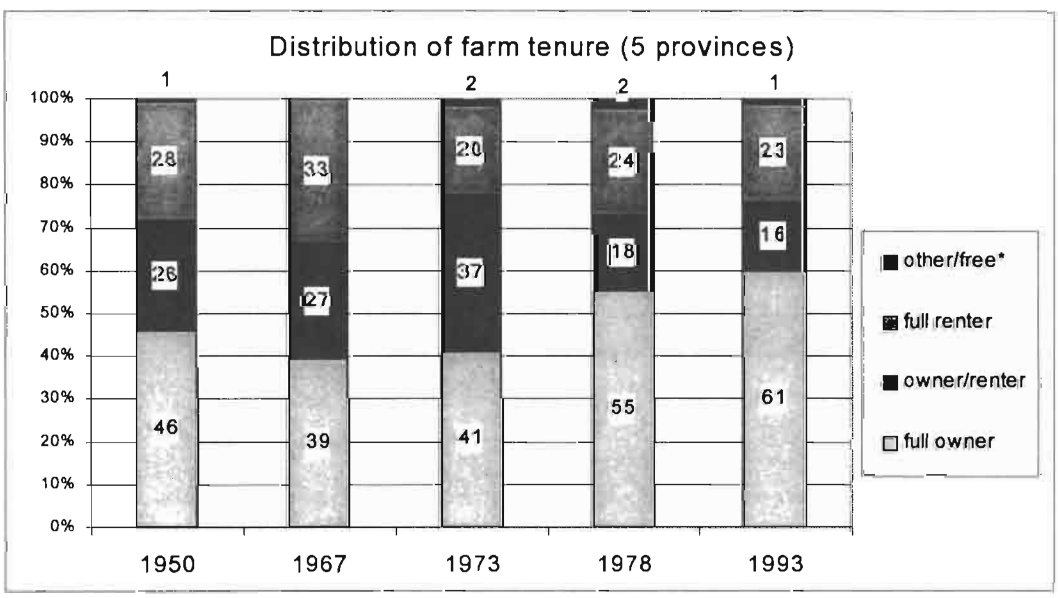
therefore tenanted, while the relative weight of the farms bought by orchard growers who moved into the area is sharpened.

TABLE 5: FULL OWNERS AND FULL TENANTS, IN TOTAL NUMBER OF HOLDINGS AND PERCENTAGES

Year	1950		1963	1967		1973		1975	1978		1993	
	Full owners	Full Tenants	Full* Tenants	Full owners	Full Tenants	Full owners	Full Tenants**	Full Tenants	Full owners	Full tenants	Full Owners	Full Tenants
Ayutthaya	38	28	(12)	27	37	23	20+1	26	39	29	45	32
Ang Thong	58	13	(3)	53	19	48	7+2	14	62	15	66	14
Pathum Thani	23	59	(40)	23	61	14	59+2	60	31	57	51	39
Sing Buri	63	11	(2)	56	19	58	10+5	-	68	14	70	13
Suphan Buri	68	12	(7)	60	18	66	6+1	-	51	14	65	17
Nakhon Pathom	51	27	(19)	47	31	61	16+1	-	73	16	71	18
Total	50	24	(13)	45	29	49	15+1	-	54	21	62	21
Total – Suphan	46	28	(15)	39	33	41	20+2	-	55	24	61	23

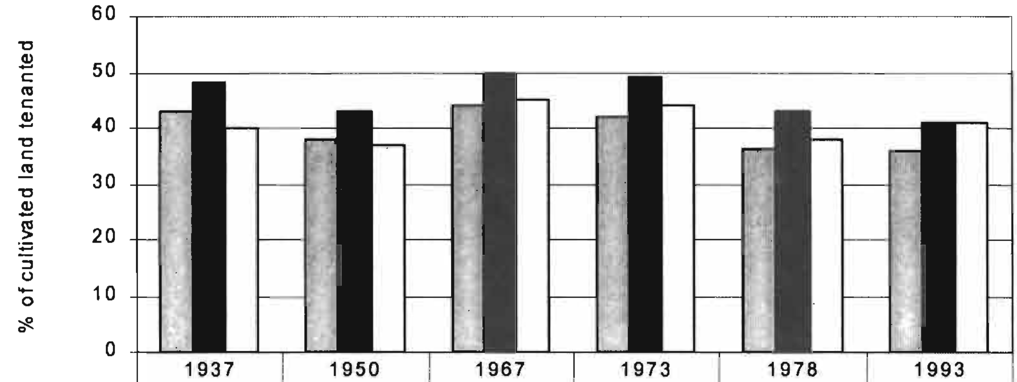
* "Full tenants" in 1963 do not include holdings with rented plots paid in both shared or fixed (cash or kind) rents; the totals are therefore underrated.** the number added on the right stands for the "free rental" category.
Sources: Population and agricultural censuses (respective issues); DLD 1967; data for 1973: OAE (1975); data for 1974-1976 (noted 1975), taken from Ramsay (1982).

FIG. 5: EVOLUTION OF THE DISTRIBUTION OF FARM TENURE TYPES



Another way to measure the incidence of tenancy is to look at the share of the total farm land which is operated by their owners or by tenants. Fig. 6 shows the overall evolution for the 1937 – 1993 period. It appears that for our sets of 6 or 5 provinces the share of tenanted land is slightly declining since the late sixties. The current share of tenanted land (not considering Suphan Buri) is around 40%.

FIG. 6: EVOLUTION OF THE PERCENTAGE OF THE FARMLAND TENANTED (% OF TOTAL FARM LAND)



	1937	1950	1967	1973	1978	1993
6 provinces	43	38	44	42	36	36
5 provinces	48	43	50	49	43	41
4 provinces	40	37	45	44	38	41

Values for 1937 have been estimated[14]; the 1947 Population census, which shows very low levels of tenancy. Data for this census are not shown here because it bears obvious inconsistencies.

We may also consider these evolutions at the *changwat* level (Table 6). For all the provinces without exception the share of tenanted land significantly decreased during the 1973-78 period. This may be associated with the period of intensification (double-cropping, spread of HYV) which made many farmers get their land back to operate it by themselves. With the perspective of attractive profits, land tends to be farmed by owners and tenancy decreases.

Table 6 also reveals that the impact of the drastic decrease of the tenanted land in Pathum Thani over the 1978-1993 period *offsets the rise of approximately 3-4% in the other changwats.* In fact, the apparent levelling off of the tenanted land over the last two censuses *conceals a growth* of approximately 3-4% in all provinces <u>but</u> Pathum Thani. This is why we also plotted the evolution of the set of the 4 provinces obtained after removing Pathum Thani. This slight growth can be ascribed to a growing supply of land for rent (see interpretation in the next section).

The most striking point of the table, however, is that by and large the rates of tenanted land observed in the 1930's[15] did not vary that much during the remaining part of the century !

[14] Data on the area of the mixed (owner/tenant) farms do not specify the respective shares of owned and rented land. Based on later data, which show that these two parts are of the same order of magnitude, half of the total area has been attributed to each of the two categories.

[15] This gives the opportunity to comment the data derived from Zimmerman's survey in 1930, in particular the well known "36%" rate of tenanted land in the Central Region widely cited in the literature. "In this study all classes of people were included because in an undifferentiated society it is possible to tell who is a farmer and who is not. Except in the Central Plains, where the differentiation has proceeded a little more than in other districts, it may be said that everyone farms a little and everyone does a little of something else. Even this applies largely to Central Siam". Consequently the 50 families sampled in each village include landless families which "were merchants, shopkeepers and laborers, some were well-to-do and some were poor".

TABLE 6: PERCENTAGE OF TOTAL FARMED AREA OPERATED BY TENANTS (BY *CHANGWAT*)

Province	1930*	1937**	1947**	1950	1957#	1967	1973	1978	1993
Ayutthaya	(42)	50	*[15 ?]*	47	*(47)*	55	59	51	54
Sing Buri		28	*26*	24		32	29	28	31
Ang Thong		30	*31*	26	*(36)*	33	34	29	34
Pathum Thani	(68)	72	*[14 ?]*	66	*(59)*	68	74	64	44
Nakhon Pathom		40	*37*	35		42	36	27	31
Suphan Buri	(8)	26	*27*	18	*(31)*	28	29	23	28
Total		43		28		44	42	36	36
Total-Suphan		48		43		50	49	43	41

(*): from Zimmerman (1931), on a limited sample; (**) from Population Censuses; 1937 data are estimated assuming that mixed farms have, on average, 50% rented and 50% owned: see footpage note 14. (#) from Uthit Naksawat (1961: in Tomosugi, 1969), the only set of data derived from a limited sample; other data from Agricultural Censuses.

To get a clearer spatial vision of the situation in recent times, Fig. 7 shows the share of tenanted land in 1993. Not surprisingly, the East Bank is almost totally[16] over 45%, together with the banks of the Pasak river and the south of Suphan Buri. Tenanted land is lower than 30% in the Mae Klong area and in the upper delta, between the Noi and Tha Chin river. If we consider the tenanted area for the *rural delta*[17] shown on the map, we obtain an overall value of 37%, 41% for Bangkok's Vicinity and 65% for the remaining agricultural areas of Bangkok (86,000 ha). Corresponding estimates[18] for the three zones are 34%, 59% and 53% for 1978; 41%, 61% and 61% for 1967. In summary, *the rural delta had 41% of his land tenanted in 1967 but this share declined during the seventies to reach 34% in 1978; it later took an upward trend, with a value of 37% in 1993.*

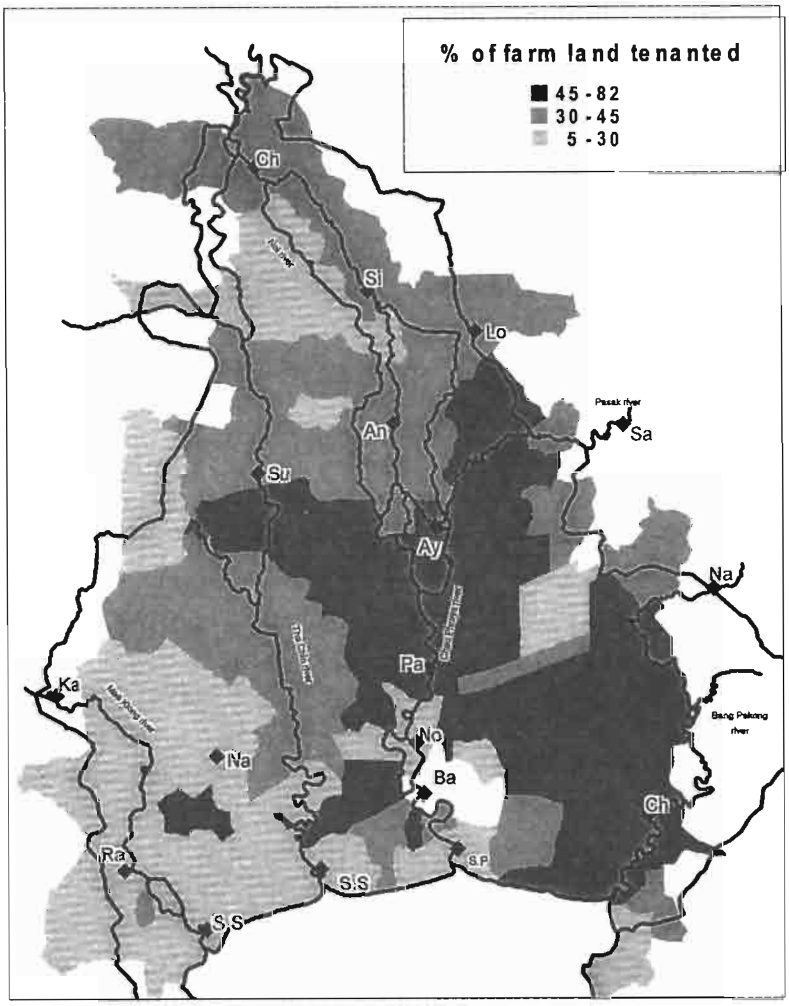
In addition, the total cultivated average area is calculated for the whole village land, and reported to the whole population, including landless (and non-farmers); this tends to show that effective average cultivated areas by family were higher than the values provided in the table. The "number of people renting some land" of the table "Land rented by family" is not clearly defined and regardless of whether it is understood as an absolute number (on a sample of 50 families) or as a percentage it is incompatible with the table giving the average land by tenure an by family.

[16] With the exception of the area growing orange trees which is predominantly owner-operated (see chapter 2).

[17] In what follows, the "rural delta" will designate a set of amphoes excluding Bangkok and its vicinity and best matching the actual irrigated delta.

[18] For 1967 only the percentage by province are given. These values have been weighted by areas of agricultural land as in 1963. For 1978, data by amphoe do not specify the shares of owned and tenanted land of mixed owners. These shares have been derived from data at the provincial level (45% of owned land, 55% of tenanted land for our 5 provinces).

FIG. 7: TENANTED LAND IN THE DELTA (1993)

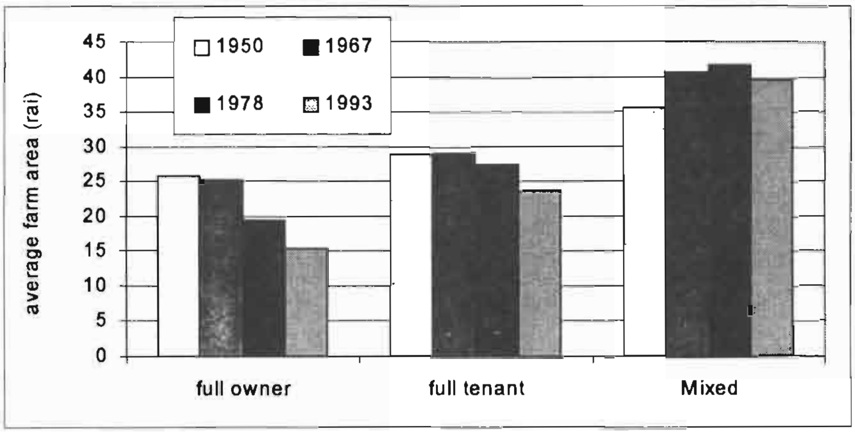


2.3 Land tenure and farm size

Translated in terms of average size of holding, the opposite trends in the number of full-owners and the area they farm entail a significant decrease of the average farm size of this category (from 19.4 to 15.4 rai). Since 1963, full tenants undergo a similar process (but they farm a larger area), while both the owned and rented areas farmed by owner-tenants are rather stable (Fig. 8). If we examine the corresponding data from the 67-68 survey on rice farms, we find values of 25.2, 29.2, 20 and 20.8 rai for the 4 categories. The value for full owners' farms (25.2 rai) is much higher than the value in 1978 (19 rai) but the latter also includes non-rice growing farms which are in general much smaller than rice-growing ones. Therefore the comparison is not fully relevant.

Full owners undergo the highest cut of (average) area but it may well have been offset by the intensification which occurred during the same period. Full renters farm larger areas and it can be hypothesised that the difference with full owners is linked to the necessity to farm larger areas to achieve sustainability (as the payment of rents decreases the per rai income). It is also pushed upward by the larger full-tenant farms of Pathum Thani and Ayutthaya.

FIG. 8: CHANGE IN THE AREAS FARMED UNDER DIFFERENT TENURES (5 PROVINCES)



Details by *changwat* bring about some interesting complements. Table 7 shows that the full-tenants farm area does not decrease, with the exception of Pathum Thani (encroachment of urban growth) and Nakhon Pathom (viability of smaller farms because of diversification). Full owners are more affected, the least in Ayutthaya, where agro-ecological conditions do not permit drastic cuts in an already very low value around 20 rai. Ang Thong, which also has a large share of deep-water rice area, appears as the most worrying *changwat*, with a decrease from 17.8 to 12.3 rai. Many of these full owners are probably ageing farmers with other sources of revenue.

Owner/tenant farmers fare higher, with an overall average of 40 rai, and correspond to farmers which are in a position to make rice-farming profitable. Noteworthy is the exception of Nakhon Pathom: the total average area of these farmers, very high in 1978, has been divided by three. This is, at least in part, a direct consequence of the disappearing of deep-water cultivation in the southern part of the province and of the rise of many small farms engaged in diversification.

TABLE 7: EVOLUTION OF AVERAGE FARM SIZE, BY LAND TENURE TYPE

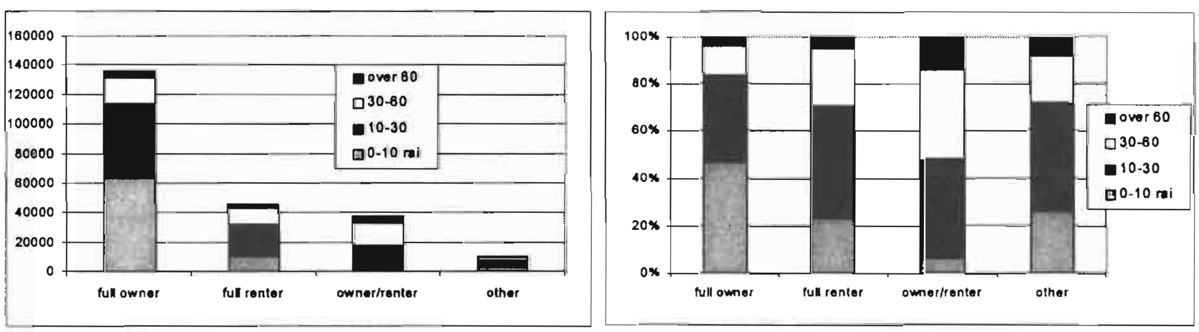
	Full owner				full renter				Owner/renter (mixed)					
									owned part			rented part		
	1950	*1967**	1978	1993	1950	*1967**	1978	1993	*1967**	1978	1993	*1967**	1978	1993
Ayutthaya	25,9	*28*	21.7	18.5	27,3	*27*	27.5	27.6	*21*	18.8	17.8	*23*	24,0	25.8
Ang Thong	21,1	*19*	17.8	12.3	15,2	*15*	16.1	16.5	*14*	12.6	12.7	*14*	14.9	16.2
Pathum Thani	45,2	*45*	34.3	24.9	43,5	*44*	37,0	28.7	*31*	25.4	49,0	*31*	30.8	26.6
Sing Buri	24,2	*23*	16.3	13.9	19,5	*21*	18.7	20,0	*17*	12.9	17.7	*16*	15.4	19.2
Suphan Buri	30,2	*28*	34,0	19.4	19,0	*22*	20.2	20.5	*21*	20.6	19.6	*19*	19.3	20.8
Nak. Pathom	25,2	*23*	17.2	13.3	20,4	*23*	21.5	17.4	*22*	43.3	15.1	*20*	49.2	17.7
Total	**26,9**	**26**	**23.9**	**16.9**	**28,0**	**28**	**25.8**	**22.7**	**20**	**19.4**	**18.9**	**20**	**21.9**	**21.1**
Total- Suphan	**25,7**	**25**	**19**	**15**	**28,9**	**29**	**27**	**24**	**20**	**19**	**19**	**21**	**23**	**21**

Source: Population and agricultural censuses (respective issues)
* Data for 1967 relate to rice-growing farms only and, therefore, cannot be compared directly to those of 1978 and 1998

With such disparities of average farm area among tenure types, it is obvious that – reciprocally - land tenure types are not uniformly distributed within the different farm size classes. In 1978, farms smaller than 10 rai are mostly fully owned, while for the 10-30 rai range full owners are only slightly dominant; for larger farms the proportion is reversed, as expected, given that most farmers willing to cultivate more land have interest to rent it rather than to buy it. Fifteen years later, proportions are quite similar, *except for the 0-10 range*: the increase of small farms in this range is almost totally due to full-owners. This is probably the direct result of land fragmentation by inheritance and suggests that small farms succeeded in intensifying and/or that the land market is not favourable to land renting, smaller farms being less able to afford paying rents than larger ones.

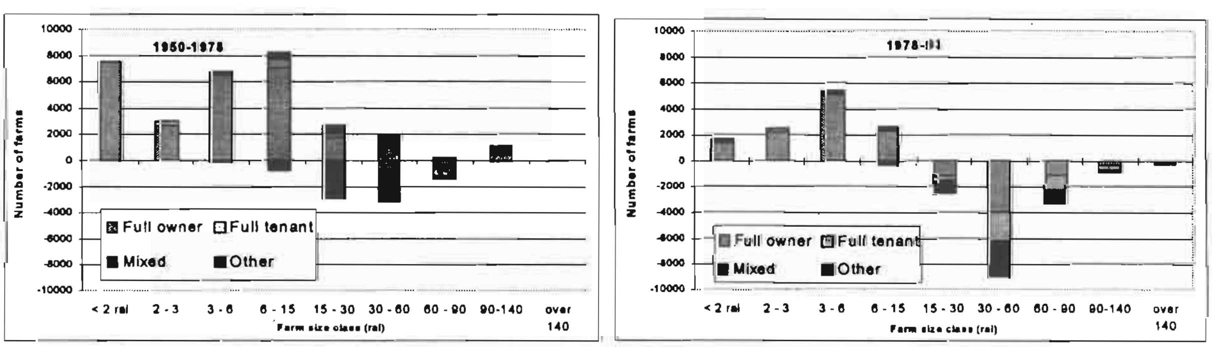
Viewed another way, the dominant class of full owners is found chiefly in the 0-10 rai and the 10-30 rai classes (Fig. 9). Full tenants prevail in the two medium strata, while owner/tenants are rather found in the medium and upper strata. This, of course, directly translates into varied average farm sizes, as evidenced earlier.

FIG. 9: FARM SIZE DISTRIBUTION FOR EACH TENURE TYPE (NB. OF FARMS AND %, 1993, 6 PROVINCES)



All these interlinked variables of farm size and tenure and their evolutions over the 1978-93 period are best summarised in Fig. 10. We clearly see how all tenures types of farms over 25 rai have been depleted to yield an increasing number of smaller owner-operated holdings.

FIG. 10: EVOLUTION OF THE NUMBER OF FARMS BY SIZE CLASS AND TENURE TYPE (1978-1993)



3 Interpretation

We may now attempt a re-appraisal of the evolution of the land system, based on the interpretation of the above data and their linkage with the most relevant changes of the delta agrarian system. We will in particular show that images of drastic land fragmentation or land concentration do not adequately describe the situation and emphasise some of the processes at work which have contributed to avert an agrarian crisis.

3.1 Demographic change: averting the Malthusian crisis

Although there are significant regional and local variations, the Thai tradition of inheritance follows in general a pattern of equal division among heirs (Prince Dilok, 1908; Kaufman, 1960; Toru, 1968, Wagstaff, 1970). Partible inheritance implies a simple arithmetic of land division. This process is at work since the very beginning of the reclamation of the delta, as described by Hanks (1972) in his historical account of Bang Chan village, who observed that new farmers with too little land sold their share to siblings and moved to the periphery. However, the cost of such a move explains that other preferred to stay on family land (Molle and Srijantr, 2000), creating conditions described by Montri (1930) as an alarming "congestion [...] in many of the best rice producing districts". After the war, the phenomena turns more critical (Kaufman, 1960), until some respite is provided by the upland expansion in the 50's and 60's; but land saturation culminates in the *1970 crisis.*

A few years later, however, several timely factors would contribute to avert the worst perspectives of a Malthusian crisis. An extremely rapid demographic transition initiated in the early 70's, together with massive out-migration towards Bangkok and the land frontier, have first controlled the absolute population and were sufficient to level off the growth of the agricultural population and labour force.

The rural part of the Chao Phraya Delta underwent dramatic demographic changes during the second half of the present century. The Thai demographic transition has been one of the fastest observed in developing countries (Knodel et al., 1987; Siriprachai, 1996). After World War II, soaring birth rates and declining death rates sustained a growth rate slightly above 3% until the late 1960s. In 1970, government agencies (more effectively paralleled by NGOs) launched several programmes to disseminate family planning and population control measures (Wongboonsin, 1995). These actions, together with a surge in urbanisation contributing to the adoption of an urban way of life (reduced family size, higher education, later age at marriage, etc), dramatically cut off population growth to a rate of 1.2% in 1995 (NSO, 1997a) and 1.05% at present (NSO, 2000 census). By the same token, the average woman fertility dropped from 5.6 to 2,0 children/woman.

As a result, the average family size of agricultural households in the *rural delta* dwindled from 5.74 in 1960, down to 5.32 in 1980 and 4.38 in 1990, and is probably now under 4.00[19]. This situation is further compounded by the fact that the average age of the members of a given holding is on the rise. The overall ageing of the agricultural population in the delta is clear and is a logical consequence of: 1) the declining fertility; 2) out-migration (the great majority of migrants are under 35 years old), and 3) the increase in life expectancy[20].

[19] extrapolating from the national values in 1990 and 2000: 4.4 and 3.9

[20] Between 1975 and 1995, life expectancy increased from 58 to 70 and 64 to 75 for males and females respectively.

Farmers under 35 now make up only 13% of the total. Regions with the highest percentage of elderly people include the flood-prone area but also Nakhon Nayok Province and the south-east of Chai Nat province.

This demographic transition was paralleled by a process of out-migration. During the upland expansion in the 50's and 60's, the flow of farmers from the delta to the adjacent upland was high enough to provoke an absolute decrease of the agricultural population. All along the second half of the century, out-migration was also directed towards Bangkok, provincial centers and to foreign countries (middle-east). The still significant overall population net growth (1.5 % in the last two decades) appears to have been – in numerical terms – *entirely transferred* to non agricultural sectors: the agricultural population in the *rural delta* (Bangkok and its vicinity excluded) appears on a slight decline (from 2.5 million people in 1960 to 2.2 in 1990) but its share in the total population has collapsed from 70% to 40%. It is noteworthy that this did not however translate into a reduction of the number of agricultural families which are on the rise (from 430,000 in 1960 to 510,000 in 1990) because of the decrease in the average family size. Furthermore, the Labour Force Surveys show that agricultural population data may give an overestimated view of the rural sector, as the percentage of persons employed in the agricultural sector was found to slump from 48% in 1990 to 33% in 1996[21] !

The effect of the demographic transition since roughly 1970 first had an impact on the number of mouths-to-feed (thus on *per capita* income) then, 15 years later, on the labour force and, 30 years later, upon the number of heirs at the time of inheritance (thus on land fragmentation). This now combines with migration out of the agricultural sector and a decreasing rate of children willing to engage in agricultural activities, contributing to the relative stabilisation of the situation. Under such conditions, it may even be expected that fragmentation soon reverse towards concentration. In areas of older settlements and limited potential for agricultural diversification, this may even be something not new. Large farms consolidation has now materialised (during the 1978-93 period) in some parts of Ayutthaya and Sing Buri flood-prone areas, as seen earlier.

The alteration of customary inheritance practices has also smoothened the impact of land fragmentation. It is observed that when the family land is reduced to an amount which does not allow viable farming, it tends to be passed on to only one child (often a girl), while other children are given inheritance in the form of money or other good (Kaufman, 1960; Mehl, 1981). In all cases the share of land received by children not engaging in agriculture is in general rented out (sometimes free) to those of the siblings who remain in the village.

The fertility revolution, together with the development of non-agricultural activities and the attractiveness of the urban way of life have succeeded in dramatically curtailing the impact of population pressure and property division at the *very moment it was endangering* the whole agrarian system.

---

[21] While in the same time the ratio for the whole of Thailand was reaching the symbolic value of 50% (NSO, 1997c).

3.2 Polarisation and landlordism reassessed

The confrontation of subsistence peasant economies with market forces and capitalistic logic generally triggers some degree of social differentiation which may result in a process of polarisation, with the emergence of landlords and the continuous eviction of small farmers. The Malthusian fragmentation under population pressure appears as both one of the driving forces of the stratification process, by broadening the range of land endowment at inheritance, and the origin of the excess of population, eventually evicted, either by force or by will. Several factors have, nevertheless, contributed to both hampering an excessive land concentration and limiting the process of eviction of small farmers in the delta.

The first historical factor is the absence of colonisation: nowadays, only 588 farms have more than 140 rai (only 26 ha) in our 5 inner provinces and no capitalistic "plantation farms" are observed, such as is the case in some ex-colonial countries with comparable human densities. Another factor was the set of constraints imposed by the Siamese kings in order to limit the concentration of territorial wealth of their officials and nobility. They range from a formal overall land ownership to the crown, rules of land return to the crown in case of non use during three years, to the later abolition of corvée, which undermined the nobility's control upon the labour needed to cultivate their land. On the farmers' side, laws limited the amount of land owned by farmers to 25 rai but concentration was chiefly limited by the magnitude of family labour and the absence of mechanisation.

During the rice boom of the late 19th century, urban-based owners bought land to extract rents from rice cultivation and a class of "hacienderos" could have emerged. However, these owners had most of the time little familiarity with rural life, no desire to engage in it, and were constrained by the necessity to control a large labour force at a time in which slaves and retainers were being emancipated. The rather high prices of wage labour (Mehl, 1981) and the labour shortage at that time were indicative of the increasingly difficulties faced by landlords in mobilising labour force, as large virgin areas were offered to farmers for clearing. It follows that no rural aristocracy emerged at that time.

Focusing on the fragmentation of small land, attention is diverted to what appears to be an equally significant process, especially in the last three decades: the fact that large holdings are *also* subject to the law of division by inheritance. While the negative impact of Thai inheritance customs on land division is often stressed, the positive impact on deterring land concentration is seldom mentioned. Large land owners also divide their land between their children ! This, to some extent, also holds for urban landlords: these absentee owners are not local "hacienderos" trying to enlarge their property at whatever cost. They are far away from the land they bought or inherited and there is a trend towards the division and dislocation of their assets over time too. A rare example of study of family trajectories has been carried out by Stifel (1976) in Nakhon Pathom, who notes that "the top 20% landholders have experienced mixed fortunes over these four decades. The largest families have not inexorably swallowed the smaller landowners".

A reservation must be made here: the data on farm size presented earlier refer to farm operators, not to land owners. Phiphatseritam's survey in 1969 in the Provinces of Pathum Thani, Nakhon Nayok, Ayutthaya and Chachoengsao found a total of 127 landlords with land over 1,000 rai and owning together 378,000 rai, 11% of the total area (1978, cited by Suehiro, 1982). The crown had a holding of 10,041 rai in Ayutthaya; M.R. Suwanaphang Sanitwong owned more than 35.000 rai in Pathum Thani Province and more than 60,000 rai in the whole central Plain. This suffices to remind us that most of these very large properties of the East Bank and Bangkok vicinity remain as a *legacy of history*, rather than as a result of a continuous process of accumulation by a small class of rural landlords.

Land acquisition by urban capitalists has nevertheless been a continuing process. Unfortunately, the magnitude of this transfer of ownership cannot be assessed with the data in hand. We can only get some hint from the fact that the percentage of cultivated land rented-out has been rather stable, and even declining since the late sixties. If we consider the current share of 40% and the evidence that at least one half of the rentals corresponds to transactions between relatives (see Molle, *forthcoming*), a remaining 20% of the land is rented out by other local farmers and outsiders. It follows that the extent of transfer of landownership to urban capitalist might be less (10-15%) than what suggested by the situation observed in some districts of Ayutthaya or Suphan Buri provinces, for example.

Although there is no evidence of polarisation, a peculiar process has been found at work in the delta: mentioned in the 70's by Amyot (1977) in relation to some villages near Ayutthaya, the possibility to farm increasingly large pieces of land is now being observed in the flood prone area, north of Ayutthaya, north of Sing Buri and in some other parts. This process is the outcome of the combination of several factors: 1) the lower profitability of rice growing in this sub-region, which pushes some farmers to farm larger areas; 2) correspondingly, lower rents and land prices; 3) the higher availability of land for rent (many old farmers); 4) a higher supply of non-agricultural jobs in the area and higher emigration rates; 5) the limited labour requirements of this type of rice cultivation: the main operation is land preparation, which can be performed on large areas with a four-wheel tractor. This is *now accentuated by the mechanisation of harvest,* which removed the last bottleneck in farm operation. In more intensive areas, the picture is quite different: unimaginable at the time of transplanting, larger farms are also appearing but, as land preparation, water management and crop care require much more attention, the case is rather exceptional and the trend not yet significant.

Rather than the mark of a capitalistic attempt to seize land, this incipient concentration of land (mostly through the rental market) appears as a result of the dramatic decline of the number of children engaging in agriculture and of the possibility to farm larger areas with mechanisation (and therefore less hired labour). This, so far, remains limited to *flood-prone ecosystems* where the average farm area had already levelled off close to the sustainability threshold, where little intensification was possible and *where economies of scale are possible,* due to the peculiarities of the rice system. Furthermore, as the effect of the demographic transition initiated *circa* 1970 is at present starting to impact on the average number of heirs, we may expect this trend to gain momentum in the future. With the demise of agriculture, one can legitimately envisage in the long run a growth of larger mechanised farms, predominantly based on family labour, with limits in size well below European or American standards but significantly higher than Asian averages of 1-2 ha.

On the other side of the spectrum, however, it remains to be seen what the is magnitude of the possible process of eviction of small farmers, a point to which we now turn.

3.3 Tenancy, landlessness and farmers eviction

Several episodes of history have pointed out to high levels of indebtedness in the rural delta. The 1970 crisis was also characterised by the growth of the population of wage labourers and abuse by landlords. Surveys by the Agricultural Land Reform Office in the 1970s found a percentage of landless labourers between 5 and 23% of the total farms, with the exception of Ayutthaya (30%).

The interpretation of the causes and consequences of landlessness is a subject of much controversy[22]. It is a widely held view that landlessness is the result of the eviction of small and poor farmers from an increasingly capital intensive agriculture, through the accumulation of debts (Tomosugi, 1969; Turton et al. 1978; Douglass, 1984, Chiengkul, 1983; Tanabe, 1994). Other authors lay emphasis on population pressure and land fragmentation by inheritance as the main causes of landlessness (Montri, 1930; Wagstaff, 1970; Piker, 1975; Chumphot, 1975; Chirapanda and Tamrongtanyala, 1981). Both processes are obviously at work, but in different proportions according to the sub-area and the point in time, which calls for a cautious treatment.

More generally, the origin of the population of wage labourers lacks of clear evidence. It is often assumed that they correspond to a further downfall of full-tenant farmers. The 1964 survey over *5 central provinces*[23] found that 81% of the full tenants never possessed any land prior to becoming tenants (Chaiyong et al, n.d.). Similarly, the 1965 survey over *11 central provinces*[24] found a percentage of 87% (Chaiyong et al, 1965.). Ten years later, ALRO surveys found that most of the landless were born or long-time residents of their province (only 13% of landless had moved from another province in the last 5 years preceding the surveys), it was still not clear how they had become landless (Chirapanda and Tamrongtanyala, 1981). Only 7% of the landless had land 10 years ago; similarly, only 13% of people with less than 5 rai had more land 10 years ago (11.5% had less and 76% the same amount), of which about a third (*only 4% of the total farms*) said that the loss of land was caused by indebtedness. A good proportion of them attributed it to land fragmentation as a result of inheritance.

The 60's surveys suggest that there is a large part of the population of wage labourers which is rather "stable" and descend from one or several generations of landless farmers. In 1975, Kitahara (1977) also notes that, in the village he surveyed near Ayutthaya, "there are large numbers of descendants of the rural labourers going back many generations. These families can partly be traced back to the descent of slaves".

---

[22] And resist simplification: "Landlessness and near-landlessness, like poverty and inequality, are the result of a complex interaction of topographical, socio-economic and political forces operating over centuries and it is difficult to disentangle these causes from one another or indicate their relative importance" (Sinha, 1984).

[23] Pathum Thani, Ayutthaya, Lop Buri, Nakhon Nayok, Nakhon Sawan.

[24] Incuding Phetburi, Nakhon Pathom, Suphan Buri, Chai Nat, Singburi, Saraburi, Bangkok, Chachoengsao, Samut Prakan, Thonburi, Kanchanaburi.

This situation can be tentatively explained by two lines of arguments: the first one is that many (probably most) landless farmers have left for the land or urban frontier and that they were therefore not captured by surveys carried out in the delta. This probably applies to the surveys carried out in the mid-sixties, at a time of sustained migration. The second is that there are several factors which can be raised to explain the lower geographical mobility of landless people, particularly wage labourers: their lower economic status implies a greater precariousness and a greater risk aversion; their lower educational level does not favour the obtention of skilled jobs; elderly also have no opportunity to migrate and may require more economic support and the proximity of children who tend to stay in the neighbourhood.

Most surveys suggest that the economic situation of landless people is inferior to that of other farmers, although with varying degrees (see Wagstaff, 1970). It stands to reason that the status of wage labourer or tenant being more precarious and less desirable than that of landed farmers, this difference is likely to translate into income differentials. Assessing this difference is uneasy because it is extremely difficult to capture the income of wage labourers or small farmers with multiple incomes through surveys: in the 1979 survey, for example, their non-farm income was found to be 7,200 baht, while farm income was only 5,184 baht, and 40% would receive remittances. In addition to the difficulties in capturing composite and fluctuating incomes, the auto-consumption of farm products (eggs, hens, backyard fruits and vegetables) and self-caught fish is often extremely significant and not little contributes to shoring up the family's subsistence needs[25].

In contravention to the picture of destitution commonly raised when it comes to the landless issue, two points also deserve mention. A first one is the impression or evidence gathered by some observers that "although non-landowners on the average do not do as well as their landed neighbours, the combination of mainly local employment opportunities has made it possible for a number of village families to subsist as non-landowners for two generations at a decent standard of living by village norms" (Piker, 75). This is echoed ten years late by Visser (1980) who reckons that "even landless villagers, who do not rent land, do not feel the pinch so strongly that they are inclined to consider migration or to find out about the labour market in the towns".

These fragmentary observations do not serve to deny the existence of instances of rural poverty, even less to justify policies or historical facts adverse to the delta's peasantry. Nevertheless, they may serve to put the delta into a wider historical comparative perspective (as historical accounts from other Asian countries are generally much drearier) and also contribute to explain the existence of a population of landless families which appears to be both growing in numerical terms, and stable in terms of family reproduction.

These observations date back twenty years or more. No additional comprehensive data on the question have been provided hitherto, raising the concern that the rapid change occurring in the agrarian system (Kasetsart University and ORSTOM, 1996) may have led to a recent increase in landlessness or a worsening of the income differential. In 1987, landless

[25] "The average household has animal protein obtained from self-caught fish, eggs from their own chickens, or meat from their own slaughtered animals as well as home grown vegetables at its disposal for about 200 days per year, and self cultivated rice for the entire year" (Visser, 1980).

agricultural holdings were estimated at 500,000 in Thailand (Chirapanda, 1998). Regarding the central Plain, some hints on the present situation can be derived from an analysis of the national population (1960, 1970, 1980, 1990) and agricultural (1963, 1978, 1993) censuses data. As the former defines *agricultural households* by the fact that agriculture is the main occupation of the head of the household, while the latter consider *agricultural holdings* if they cultivate a land of at least 2 rai (regardless of the tenure status), the difference is strongly correlated with the number of agricultural wage labourers. It can be shown that the two variables have increasingly diverged in the course of the past 30 years, amounting to 100,000 households (20 % of agricultural households) in 1990 for the rural delta. A mapping by amphoe of this difference (see Molle and Srijantr, 2000) shows that the areas with higher rates are around Bangkok (with extension towards the coastal area, Chon Buri and Chachoengsao), and in the flood prone area (with an unexpected extension to the south of Suphan Buri). The first zone is associated with labour intensive peri-urban horticulture, and aquaculture, while the second zone is correlated to the low profitability/risk of rice cultivation in flood-prone areas, a high proportion of old farmers unable to carry out farm operation by themselves and to the proximity of factories and urban centres providing complementary job opportunities[26].

In contrast with the situation in the 60's and 70's, there remains little doubt that this increase in wage labour in recent years is almost totally due to the reproduction of the population of wage labourers itself. On-going field surveys in 3 villages[27] of the Central Plain found with very few exceptions that landlessness had happened in the preceding generation.

Let us now reconsider the meaning of tenancy and landlessness. If ones focuses on the aspects of subsistence and security, then "the conventional hierarchy of status among the rural poor is usually smallholder, tenant, wage-labourer" (Scott, 1976). Following this line of reasoning, Chiengkul (1983b) considers that "the measurement of social class differentiation in the agrarian sector of the Central Region could be based on the distribution of land holdings data". Village studies and statistical data, by and large, don't make a very good case for such rather straightforward points of view; this may be linked with the difficulty to define the Delta agrarian system as a subsistence economy[28]. As soon as the postwar period, Janlekha (1955) observes that "it does not hold, as it seems to imply, that an owner-operator has a superior economic status than a part owner and that a part-owner is still in a better economic position than a tenant". Mehl (1981) also proposes a more qualified analysis: "full tenancy, predominantly on smaller farms, indicates economic hardship, but part tenancy, largely on medium and large farms, indicates a degree of well being". The first part of the statement, however, is known to have notable exceptions, such as most of the cases of peri-urban vegetable farming and some raised beds orchards in Damnoen Saduak area (Cheyroux, 1998), which combine tenancy and high value crops on small plots of land.

---

[26] In addition the regions of Ayutthaya and Ang Thong are also known for their non-agricultural activities (bricks, handicrafts, etc)

[27] Located respectively in Suphan Buri, Lop Buri and Ayutthaya provinces and chosen for their contrasting cropping intensities.

[28] Indeed, the few references to the Chao Phraya delta made by Scott (1976) generally picture it as a particular case rather than an example to which his theory should be applied.

More generally, over our 5 inner Changwat, full tenants with less than 10 rai amount to only 5% of the total farms, or 9% if we consider the 0-15 rai range. Moreover, half of these are found in Nakhon Pathom and Pathum Thani provinces and are much likely to correspond to cash crops and peri-urban vegetable/fruit production farms. Thus the category of small full-tenant farmers (also mostly engaged in other activities: see later section) who are most likely to suffer hardship, say 5%, appears not negligible but nevertheless secondary.

The second statement is worth being emphasised. Not rarely is the case of Rangsit and other areas in the surrounding of Bangkok mentioned in a negative fashion because of their high rates of tenancy, an exception in Thai landscape. A closer look at statistics, limited to Pathum Thani province, reveals that the average size of rice-growing farms is 29 rai in 1993 (and was 39 rai in 1978, at a time when tenancy was raising more concern than now). Land rents have also been shown to be in general low on the East Bank. Rice double-cropping over 29 (rented) rai gives an income which compares favourably with average rural incomes.

As for mixed owner/tenants farms, their share is higher than 20% for size classes over 25 rai. Although in absolute numbers about half of them farm less than 30 rai, their average farm size (40 rai) is drastically higher than that of owners (17 rai) and tenants (23 rai). Smaller farms do not tend to (or cannot) compensate their lack of land by a higher share of rented land, as the distribution of rented and owned land appears to be totally homogenous: in all size classes, the share of rented land varies in a very narrow interval of 40 to 50% (1993 data). Again, it is difficult to separate "well-to-do" farmers in this category based on the sole farm size. However, renting land is indicative of farms which are attempting to expand activities in order to accumulate. "Dynamic and prosperous, these part-owners/part-tenants break the traditional association of tenancy with penury" (Montesano, 1992). The rental market (supplied in particular by absentee owners) appears to perform an extremely important function of land re-allocation (Stifel, 1976). Based on a comparison of ten villages in Southeast Asia, Fujimoto (1996) observes that, "in contravention of the common view of tenancy as detrimental to agriculture development, the prevalence of tenancy appeared to have provided an opportunity not only for landless villagers to earn a living but also for some farmers to expand the size of their farm activities".

Eventually, a striking conclusion of the figures presented in § 2 is that both the hypotheses of the emergence of a growing class of mixed owner/renter farmers (Mehl, 1981; Montesano; 1992) and the spread of tenancy are invalidated. Rather, it is the unexpected spectacular growth of small-size fully owned farms which is put in sharp relief.

3.4 The land jigsaw: an interpretative dilemma

The agrarian dynamics underpinning these evolutions of the land system are subject to interpretation but it is attempted here to show how they come down to a dichotomic dilemma.

The evolution of the 1950-63 period can be seen in two different ways. We may argue that the differences in farm size strongly reflect the logic of the family cycle (farm land dovetails the amount of labour force in the household), rather than absolute differences in land endowment, and that the new land brought under cultivation is (numerically) allotted to all types of farms. In other words, there is an increase in the number of farms (with a limited decline of 6% of the average farm size) which is distributed over the whole spectrum of farms found at different stages of evolution. The growth of farms under 6 rai, however, is very significant and this period can also be said to experience a growing land saturation, the emergence of very small farms and, probably, the growth of landless holdings. However, no real polarisation is observed, as all categories grow in number. The increase of large farms between 90 and 140 rai, from 2,436 to 4,349 units, might well be interpreted as an emergence of a class of large landowners at the time. However, this trend will be discontinued in the next decades.

After 1963, a large erosion of large and middle size farms was observed, which can probably be ascribed to the fragmentation of these units into smaller ones; as the total number of farms is only slightly decreasing, *it is likely* that the increase in the number of farms due to partible inheritance is compensated by the disappearance of other farms, presumably small ones. This mirrors the increasing difficulty to access additional land along the family cycle (either through purchasing or through renting-in), which reduces the amount of land transferable to children but also shortens the odds on their being able to offset a poor initial land endowment by further land acquisition or rental. It is also likely that in recent years both the rates of farm creation and farm eviction have been reduced to smaller values. The number of heirs willing to continue farming may well, in some sub-regions, be nearing or be under the average reproduction floor value of two[29], while effectively failed and evicted farmers may be correspondingly limited in number[30].

The number of farms and farmers who have "disappeared" in the process described above *remains indeed the key – but still concealed – point of the final interpretation.* In fact, there is no way to estimate these rates from the statistics in hand. The only evidence is that there was a massive transfer of the labour force (and of the main occupation of the holdings) from agriculture to the other economic sectors (locally and in Bangkok), together with a growing class of wage labourers. *The fulcrum point is whether this shift has been predominantly governed by will (say a "pull" process) or by force (a "push");* in other words, whether it has been fuelled by young generations *choosing* to stray from the agricultural life of their parents, or by failed landless tenants and miserable wage labourers escaping a life with no future; whether a population of wage labourers remains because of local job opportunities or because they are facing constraints to move. In the first case, no farms disappear and the move, on the contrary, allows the maintaining of a viable farm size for fewer holdings (for other siblings); in the second case, small farms fail and do "disappear", forcing people out of agriculture into undesired alternatives.

The difficulty lies in that both processes are probably at work in parallel. In addition, the decision not to engage in agriculture may be a mixture of personal taste – clearly influenced by a cultural context which does not see farming as prestigious (see below) - and of the fact that the family land endowment does not allow a sustainable division. On the other hand,

[29] Or even less if we consider the total average including those who do not continue farming because the land is transformed to non-agricultural uses. In other areas, 2 (or a bit less because of singles) is the approximate threshold under which the number of farm will be declining, because of the recomposition of farms at marriage.

[30] A low rate of farm creation, as prevailing nowadays, and a high rate of small farmers eviction would translate into a decreasing number of farms and a growing average farm size, which are not observed.

giving up farming after a failure may be forced but also be attenuated by the facts that higher, or at least more stable, wages are offered in the cities, that other non-farm activities are possible, or that the sale of land appears as a viable option (especially to ageing farmers with no heir willing to take over the farm, and/or where land prices are high). The whole dynamic is further governed by the possibility of "horizontal" expansion (when land was available) and "vertical" expansion (intensification), a process which, timewise, is linked to technical change and market opportunities, and, spacewise, is constrained by agro-ecological conditions.

The *jigsaw* eventually lies in an interrelated set of interactions: 1) the agricultural and non-agricultural sectors income differential, which conditions labour flows between the two sectors and, in return, is altered by these flows; 2) the sustainability of farming, dictated by, among many factors, the technological level, the price system within the economic environment, and the average farm size which, in its turn, is a result of: 3) the rate of fragmentation at inheritance, which is governed by demography (mainly fertility), the percentage of children not engaging in agriculture (i.e linked to [1]), and the extent to which the family land is passed on to its farming members (alteration of the equal division custom; preferential rental or sale of land from non-farmer siblings, etc).

On the whole, the general impression is that the transformation process has mainly been a "pull" process, especially during the last 15 years, although the *1970 crisis* probably corresponds to a transient increase of the "push" factors. Several indications supporting this hypothesis are provided by an analysis of the labour market and of agricultural trends (see next section). In addition, since as early as the 60's, the status of full-tenancy and landlessness cannot be strongly linked with a previous status of small holder, weakening the hypothesis of a "push" process. A last point to be mentioned is that emigration out of the rural delta is by no means a feature of lower economic strata. On the contrary, the big farmers invariably invest part of their surplus in the education of their children who, consequently, preferably look for jobs outside the family farm. This preference may be in part motivated by obvious differences of income between urban job opportunities for educated people and farming but we would miss the point should we concentrate only on economic aspects. All the village studies have repeatedly stressed the negative cultural connotation of farming and of rural life, the desire of parents to see their children embracing non-farming activities and the attractiveness of urban ways of life in general and of Bangkok in particular [see for example Thompson (1941), Kaufman (1960)[31], Smuckarn (1972), Amyot (1975) and Douglass (1984)].

3.5 Agricultural intensification, diversification and wider economic changes

There is a strong case for thinking that it is, nowadays, misleading to judge the precariousness of small farms based only on the sole farm size or farm ownership: intensification (triple cropping), diversification (high value-added crops), multiple-activity and

[31] "Villagers themselves emphasise that real success in Thai society, to which they aspire and which an occasional individual may achieve, involves not becoming a successful farmer in a rural area but rather getting oneself placed in a high position in an urban occupation, usually the civil service".

multi-incomes (including remittances[32]) outline a complex household economy which cannot easily be grasped. The distinction between farmers and non-farmers is blurred. This brings some inaccuracy to the census definition of agricultural holdings (the head of holding's main activity is agriculture) because "main" is not clearly defined (is it in terms of labour time or money ?) and because household incomes are much more composite than the sole head's revenue. It might therefore not be relevant to stick to the idea of "all-agricultural" small farms, even if there is some evidence that pluri-activity might be associated with lower average incomes and, therefore, be less desirable. This section provides a few elements in support of this view.

The growth of wage labour can be linked to the increase of pluri-activity and to the structural transformation of the Thai economy. The 1993 census shows that small farmers tend to have other sources of income: this is true for half of the holdings with less than 2 rai and for one third of those in the 2-5 rai category, which draw their income "mainly from other (non agricultural) activities". Even among those reporting activities on their own holding as the source of main income, 40% also have secondary additional incomes. Non-farm cash income in the Central Region represented 40% of the total income in 1976, and up to 65% in 1991[33] (TDRI, 1995).

Another important point is that agriculture in the last 30 years has undergone processes of both intensification and diversification which compensate, and mot probably offset, the declining average farm size.

A first set of significant transformations concern the physical infrastructure of the delta, radically modified by the implementation of the Chao Phraya Irrigation Project from the late 50's onward. The later concomitant and much interrelated advents of High Yield Varieties, rice double cropping[34] and on-farm improvement together with drainage works in the upper delta, have allowed a quantitative leap in productivity. Triple rice cropping is now common and has reached a record value of one million rai in 1998 and 1999. In addition to rice intensification, agricultural diversification gradually came out as a significant transformation process in the delta. In the *rural delta*, the area cropped with non-rice crops increased from 19 to 26% between 1978 and 1993, while the proportion of farmers not growing rice[35] moved from 19 to 28%. During the same time, the share of farmers planting a non-rice crop (irrespective of whether they also grow rice or not) rose from 35 to 44%.

[32] 34% of migrants in Bangkok with origin in the Central region were regularly sending remittances home, 30% of them less than 1,000 baht/month; 39.3% between 1,000 and 2,000 baht, 16% between two and three thousands and 15% over 3,000 baht/month (NSO, 1997a).

[33] Khumvilai (1984) also comes to the conclusion that "non-agricultural incomes narrow income disparities among households in the community. They are correlated with farm size, farming net income and inversely associated with dependence ratio".

[34] Developing in larger scale after the construction of the Sirikit dam in 1974. However, limited available water resources and infrastructure constraints only allow to cultivate an average of 50% of the paddy land in the dry season.

[35] These include the sugar-cane growers of the Mae Klong area.

Although supported by government policies (TDRI, 1995), diversification is an endogenous dynamic constrained by several factors (markets, credit, skill learning, water and soil conditions, reliability of the irrigation system, competition with off-farm opportunities). In any case, crop diversification represents a mainstream and far-reaching process, aiming at reducing risk against price fluctuations and increasing income on a shrinking land through cash crops and high value-added productions such as aquaculture, vegetables, fruits, orchids, etc. The fact that the hike in small holdings is associated with full ownership and areas of agricultural diversification (Nakhon Pathom, Bangkok's vicinity) is indicative of a significant, albeit spatially limited, "vertical growth", which pulls economic thresholds downward.

The quasi absence of unemployment (before the crisis) in urban areas[36], and/or acute poverty in the delta, also gives credence to the idea that migration was a demand-driven process; although the conditions of life in the poorest areas of Bangkok are known to be harsh, the situation is quite different from other cities from India, Africa or South America, where the phenomena is clearly of the "push" type, urban unemployment and criminality are high, and the rate of return to rural areas very low. In other words and in relative terms, and although this may not do justice to the poorest urban strata, it would probably be darkening the picture a bit too far to state that, to use Engels' expression, farmers unwilling to get frizzled in the (rural) frying-pan chose to take a walk into the (urban) fire.

The second element supporting the "pull" side, is that a "push" process would tend to be associated with an excess of labour in the countryside. This is in contradiction with the well established fact that the disappearance of transplanting in the 80's and the mechanisation of harvesting in the 90's have been driven by labour shortage (Molle and Chompadist, 2000). It can be argued, however, that labour shortages were experienced only at the time of transplanting and harvesting and that in other instances labour would probably be in excess. There is some truth in this statement and the reduction of these job opportunities has contributed to turn wage labour less regular and more precarious.

Another argument is provided by Labour force surveys which evidence a differential between rural wage labour and urban work in manufacture or construction. Industrialisation and a slow agricultural development have widened the productivity gap between agriculture and non-agricultural sectors. As a result, rural resources have been shifted to the non-agricultural sector (Poapongsakorn, 1996). Between 1975 and 1988, the ratio of mean per capita income of non-agricultural households to that of agricultural households increased from 2.08 to 2.55 (these figures apply to the national level).

This line of argument is further strengthened by considering deflated wages, which evidence a turning point in 1988. While real rural wages have been stagnating during the 1965-85 period, agricultural real wages have almost doubled during the last ten years and progressed in line with the construction sector in Bangkok[37]. This, together with the sustained differential

[36] Only 0.3% of the labour force was looking for work in August 1996. 0.5% was seasonally inactive and 0.8% available but not looking for work (NSO, 1997c).

[37] But without its irregularities: interestingly enough the crisis is sharply felt in Bangkok construction sector but not in the country side until 1999.

shown above, is characteristic of a "pull" process. Other data from the Labour Force Surveys show that *1988 is a watershed* for the Central region: from this date onwards, the total labour force engaged in agriculture started to decline sharply, *losing one million workers out of 3.5 million in the ensuing decade.* This is consistent with the hike in real wages and shows that since the late 80's at least labour is getting scarcer in agriculture (Central Region).

This turning point is correlated with the record-breaking inflow of foreign investments over the 1986-95 period, when a new Japanese-owned factory was opening every three days (Nation, 16 November 1999), with demographic trends (the rate of the population entering the labouring class age is now declining in both relative and absolute terms[38]), which contributes to the decline of the labour force engaged in agriculture. This is further compounded by the fact that the decline in the agricultural labour force affects exclusively the younger strata of the population, mostly the 15-24 years old category and, secondarily, the 25-34 one (Siamwalla; 1999).

4 Conclusion

The evidence presented in this paper, somewhat unexpectedly[39] dismisses much of the common knowledge on the Chao Phraya delta land system. *"The past 25 years has been one of a trend toward the gradual concentration of land into larger and larger owned units and the development of tenancy.(...) this will lead to a greater concentration of land."* Dating as early as 1930, this statement (Zimmerman, 1931) has been issued in one form or another all along the XX[th] century. The data compiled in this study show that this process, visible in time of crisis, did not eventually materialise as a hallmark of the delta agrarian system. The share of land cultivated by tenants was found rather stable since the 1930s (around 40%) and no significant trend of land concentration was evidenced, albeit in the 1950-63 period, but the larger farms were subsequently fragmented and tenancy levelled off, while the full-owners of reduced farms outnumbered all other categories. The concentration of ownership observed in the East Bank cannot be interpreted as the result of a gradual process of capitalistic land accumulation. Rather than its outcome, this peculiarity was at the *origin* of the history of the agrarian system and remained as a stigmata all along the century.

Many scholars have often extrapolated evidence concerning some part of the region (notably Rangsit[40] or Ayutthaya) or some particular periods of history notably the 1910, 1930 and 1970 crises). Focus on Rangsit-centred evidence (the Rangsit case is more documented because the interests of the nobility were at stake) may lead to a distorted vision of the overall situation in the delta (the "*Rangsit bias*") and tells little about the process in other areas (the "silent frontier": see Molle (forthcoming)).

[38] 15 years ago, natural growth was already reduced down to 1.75% *per annum*

[39] It must be acknowledged that most of these conclusions stand in contrast with the working hypotheses of the authors at the inception of their investigation.

[40] The Rangsit area was the first large scale development scheme: most of it is located within Pathum Thani Province (see Fig. 1)

However significant, the decline of the average farm size (30 to 21 rai) and the growth of small scale holding have been counterbalanced, and probably offset, by the increase in cropping intensity (development of dry-season irrigated crops), of labour-intensive cash productions (diversification) and overall pluri-activity. The Malthusian threat of fragmentation has therefore been weathered by a Boserupian response of agricultural intensification, but also drastically diffused by sweeping demographic changes (fertility, out-migration to the upland frontier and to cities), and by some degree of alteration of customary partible inheritance. There is little doubt left that without these timely relieving factors, the agrarian system in the delta would have undergone a major crisis. That such an evolution was not obvious beforehand can be well captured by recalling Van Roy's paper (1967) on the "Malthusian squeeze" and its pessimistic acknowledgement that the reorientations in socioeconomic organisation required to alter demographic parameters and structures of production "are innately gradual, not cataclysmic".

Through these processes, not deprived of hardships and periodical deadlocks, the delta has succeeded in avoiding the situation too often observed in Asia and described as follows by Hayami and Kikuchi (1982): "The increase in non-agricultural employment [is] grossly inefficient to absorb the increments to the labour force, resulting in rapid increases in rural labour population pressing hard on limited agricultural land (...) the wage rate is bound to decline, the return to land to rise and the income position of labourers and tenants to deteriorate relative to that of landowners". While the late 60s and the 70s constitute a period of stagnation and crisis, they are best seen as a transient period of agrarian saturation between a previous period in which relief was provided by the upland boom and a later period of re-balancing marked by a decrease of rural population pressure on land, better access to credit and rising rice prices (1973-1980), decreased taxation and technical change (introduction of High Yield Varieties, double cropping, improved water control). Real land rents gradually declined and local absentee landowners tended to turn their interest to and invest their capital in other developing sectors of the economy (Molle, forthcoming).

This refers to a "pull" process, in which alternatives to agriculture are relatively attractive, urban unemployment is negligible and rural real wages appreciate. All of the net population increase has been numerically transferred to non-agricultural sectors, rather by will than by destitution. This transfer is not limited to lower economic strata and overwhelmingly concerns younger generations. While a "push" process points out to failed farmers encountering no other option than surviving as precarious wage labourers (Chiengkul, 1983a; Douglass, 1984), a "pull" interpretation tends to stress the fact that this class of labourers exists *because* there is a local demand for agricultural labour (Ramsay, 1985), due to intensification and to ageing farmers hiring labour, complemented by non-agricultural job opportunities.

This paper showed that sticking to simple categories of "landless", "tenant" and even "farmer" as measures of social and economic well-being, or as normative representations, was increasingly inadequate and might be misleading. As emphasised by Rigg (1996), "the distinctions between rural and urban are becoming blurred as households increasingly occupy, or have representation in both the rural and urban worlds and, more to the point, earn a living in both agricultural and non-farming activities. (...) This requires a re-thinking of the rural economy and rural life, a re-appraisal of policy initiatives and planning strategies, and a reformulation of theories of agricultural and rural development". Wage labourers and farmers are engaged in and draw income from a wide portfolio of activities, or receive remittances from relatives: this prompted Koppel and Zurick (1988) to observe that this "rural employment shift" suggests "that an increasing proportion of rural labour relations are *not* connected directly with traditional agrarian processes, but rather with more complex socio-economic relationships in which agrarian processes may be only one part".

An emerging trend of consolidation of larger mechanised farms (mostly through the rental markets) was observed in the flood prone area and, though still limited, is historically extremely meaningful. To what extent the combined effect of demographic change and labour seepage to other economic sectors will be gradually strengthened remains a surmise. While there is no reason to transpose the experience of developed countries in an Asian context, there is also no reason to rule out the possibility that the rural Chao Phraya delta will, at least partly, undergo, a process of consolidation of larger farms. Its characteristics of rather low population density (for Asian standards), high level of mechanisation and numerous and increasing non-agricultural job opportunities with relatively higher wages contribute to lend credence to the hypothesis. The Central Plain of Thailand could foreshadow a deeper historical demise of agriculture, somewhat similar to what is already on the way in Malaysia.

Most of the analysis presented in this report has remained little judgmental of the processes which have been highlighted. The notion of "non-sustainability", which governs some of the trajectories, is in line with the historical context and conditions *observed*: it is, however, also highly *relative,* and conditioned by a series of parameters and policy orientations, all lying beyond the scope of this study. Caution is also needed not to extrapolate the situation of the delta to other regions of Thailand, all with markedly distinct features.

Data on indebtedness, though numerous, have been found inconclusive and do not allow a clear longitudinal analysis. Debts vary in kind, amount and purpose and cannot be systematically correlated to farm assets and farm categories. With the growing supply of institutional credit in the late seventies, the working capital needed to buy agricultural input is mostly provided by Banks, co-operatives or farmers themselves.

In addition to the blurring of the frontier between rural and urban domains alluded to earlier, the study has also pointed out to an emerging wider structural change which might foreshadow far-reaching evolutions of agriculture. In the last 10 years, the agricultural labour force in the Central Region has declined from 3.5 to 2.5 million people, with a drastic depletion of the younger age class. Due to the advance in educational standards and the rising opportunity cost of labour, this process is unlikely to be reversed. With an ageing and shrinking population of farmers, the demise of agriculture could develop and reach proportions only witnessed in Malaysia (in the region).

The final picture is one of a growing process of specialisation (Pingali, 1997) leading to (very) small farms dedicated to intensive cash crops or animal productions, larger farms specialising in the mechanised agriculture of rice and medium holdings characterised by extensive pluri-activity and drawing most of their income from non-farm sources (as seen in East Asia). The respective profitability of rice and sugar cane cultivation, fruit production and aquaculture, as compared with the supply and remuneration of non-farm activities will determine the pace of the transformation. The pressure on land, especially as manifested by the evolution of the rental market and tenure patterns, will reflect this wider transformation.

References

Amyot, Jacques. 1976. Village Ayutthaya: Social and Economic Conditions of a Rural Population in Central Thailand, Chulalongkorn University/Social Research Institute, 404 p.

Chaiyong, Chuchart; Praiwan, Resanon and Amnuay Chumsamut. [n.d.] Relationship between Land Holding and Production Conditions of the Farmer in 5 Central Changwats, B.E. 2507 = 1964. Bangkok: Ministry of National Development/ Department of Land Development / Technical cooperation and Planning Office; Asia Foundation, 76 p.

Chaiyong, Chuchart; Praiwan, Resanon and Amnuay Chumsamut. 1965. Relationship between Land Holding and Production Conditions of the Farmer in the Central Region of Thailand (11 Provinces), B.E. 2508, Bangkok: Ministry of National Development/Department of Land Development, 103 p.

Cheyroux, Blandine. 1998. Analyse des systèmes agraires passés et actuels de la région de Damnoen Saduak (Plaine centrale thaïlandaise): Diversification agricole et extension des zones de maraîchage et d'arboriculture sur planches surélevées, Master degree, National Institute of Agronomy, Paris, 240 p.

Chiengkul, Witayakorn. 1983a. The effects of capitalist penetration on the transformation of the agrarian structure in the central region of Thailand. 1960-1980. Chulalongkorn University. Bangkok, 253 p.

Chiengkul, Witayakorn. 1983b. The transformation of the agrarian structure of Central Thailand, 1960-1980, Journal of Contemporary Asia, 13: 340-360.

Chirapanda Suthiporn. 1998. The Thai Land Reform, 66 p.

Chirapanda, Suthiporn and Worwate Tamrongtanyala. 1981. Landlessness in Central Thailand, ALRO, 135 p.

Chumphot, Suvaphorn. 1975. Model of agricultural development in the less-developed country: a study of rice production in Thailand; PhD dissertation, University of North Carolina, 301 p.

Cleary, E. and P. Eaton. 1996. Tradition and reform: land tenure and rural development in Southeast Asia. University Press, Southeast Asian Social Sciences Monographs, pp. 146.

Department of Land Development, n.d. Agricultural Land tenure, 1974-76, Division of land policy and planning, cited in Ramsay, 1982.

Department of Land Development. Land Division, Ministry of National Development. 1969. Land Tenure Situation in Twenty Six Changwats of Central Plain Region, 1967-1968, Bangkok, 72 p.

Douglass, Mike. 1984. Regional integration on the capitalist periphery: the central plains of Thailand, in: research report series n° 15. Institute of Social Studies. The Hague, 230 p.

Fujimoto, Akimi. 1996. Rice land ownership and tenancy systems in Southeast Asia: facts and issues based on en village studies; The Developing Economies, XXXIV-3, pp. 281-315.

Hanks, L.M. 1972. Rice and man; Agricultural ecology in Southeast Asia, University of Hawaii Press, 172 p.

Hayami, Y. and M. Kikuchi. 1982. Asian village at the crossroads: an economic approach to institutional change, University of Tokyo Press, The Johns Hopkins University Press, 275 p.

Ingram, James, C. 1971. Economic change in Thailand 1850-1970. Oxford University press, Kuala Lumpur - London - Singapore. 350 pages.

Ishii, Yoneo (ed.). 1978. Thailand: A rice-growing society. The university press of Hawaii, Honolulu. 339 pages.

Janlekha Kamol O. 1955. A study of a rice growing village in central Thailand, unpublished PhD thesis, Cornell University, 421 p.

Johnston, D.B. 1975. Rural society and the rice economy in Thailand: 1880-1930. PhD dissertation thesis, Yale University, 443 p.

Kasetsart University, ORSTOM, 1996. Identification of agricultural and irrigation patterns in the Central Plain of Thailand: prospects for agricultural research and development, 220 p., DORAS Project, Bangkok

Kaufman, Howard Keva. 1960. Bangkhuad: a community study in Thailand, Locust Valley, N.Y.: Augustin, 1960, 235 p.: ill

Kitahara, Atsuchi. 1977. The forms of rural labour and their role in the rural economy in Thailand, in S. Hirashima (ed.): Hired labour in rural Asia, pp. 127-153.

Knodel, J.; Chamratrithirong, A. and N. Debavalya. 1987. Thailand's reproductive revolution: rapid fertility decline in a third-world setting, The University of Wisconsin Press, 251 p.

Koppel, B. and D. Zurick. 1988. Rural transformation and the future of agricultural development policy in Asia. Agricultural Administration and Extension 28, 283-301.

Manopimoke, Supachit. 1989. Choice of rice production technique in Thailand, 1980-1940. Unpublished PhD thesis, University of Hawaii, 190 p.

Mehl, Charles B. 1981. Social class and land ownership in the rice agriculture of Central Thailand, 1930-1980. Unpublished master's thesis, Cornell University, 123 p.

Ministry of Agriculture. 1951. Agricultural Census of Thailand: 1950

Ministry of Agriculture. 1953. Thai Economic Farm Survey, 269 p.

Ministry of National Development/Land Development Dept./Land Division, 1969. Land Tenure Situation in Twenty Six Changwat of Central Plain Region, 1967-1968, Bangkok, 72 p.

Molle, François. *forthcoming*. Social and economic patterns of landlord-tenant relationships in the Chao Phraya Delta, Thailand: an historical perspective, submitted to *The Journal of Rural Studies*.

Molle, François; Chompadist, Chatchom. 2000. Factors and constraints of the adoption of wet broadcasting in the Chao Phraya delta, Thailand , paper presented at the International Workshop on "Direct seeding in Asian rice systems : strategic research issues and opportunities", IRRI, Bangkok, 25-28 January, 2000, 14 p.

Montesano,M J. 1992. Local knowledge of another sort: relationships among land transfer, mortage, and rental in three sub-districts of Sukhotai, Phrae and Chai Nat provinces. Unpublished PhD thesis, Cornell university. 318 p.

Montri, Phraya Indra. 1930. Note on paddy and rice, transcribed in Nartsupha et al. 1981.

Nartsupha, Chatthip. 1999. The Thai economy in the past, Silkworm books, Chiang Mai, first Thai edition from 1984, 131 p.

NSO. 1965. Agricultural Census of Thailand: 1963 (several reports).

NSO. 1980. Agricultural Census of Thailand: 1978 (several reports).

NSO. 1995. Agricultural Census of Thailand: 1993 (several reports).

NSO. 1997c. Social Indicators: 1997, p. 183.

OAE (Office of Agricultural Economics). 1975. Patterns of landownership in agriculture: 1973-74, Document on Agricultural Economics No 83, 77 p.

Phipatseritham, Krirkkiat; 1978. An analysis of land reform planning, Setakit, October 1978 (in Thai), cited in Suehiro (1982).

Piker, Steven. 1975. The Post-Peasant Village in Central Plain Thai Society, from Change and Persistence in Thai Society, Essays in Honor of Lauriston Sharp, Ithaca: Cornell University Press, pp. 298-323.

Poapongsakorn, N.; 1996. Implications of modernization on the agricultural resource base in Thailand. In: Pingali, P.L. and Paris, T.R. (eds) proceedings of the Workshop on Social Science Methods in Agricultural Systems: Coping with Increasing Resource Competition in Asia. Chiang Mai, Thailand. 2-4 November. IRRI Discussion paper Series No. 11. International Rice Research Institute, Los Banos, Laguna, Philippines.

Prince Dilok Nabarath. 1908. Siam's rural economy under King Chulalongkorn, White Lotus Press (ré-edition 2000), 314 p.

Ramsay, Ansil. 1985. Population pressure, mechanization and landlessness in Central Thailand, the Journal of Developing Areas 19 (April 1985), pp. 351-368.

Ramsay, J. Ansil. 1982. The limits of land reform in Thailand, The Journal of Developing Areas, 16:2, pp. 173-195.

Ramsson, R. E. 1977. Closing frontier farmland tenancy and their relation: a case study of Thailand 1937-1973. University of Illinois, PhD dissertation thesis. 221 p.

Ratanadilok, Tienchai. 1990. Agricultural credit repayment problems of farmers in Amphoe Kamphaeng Saen, Changwat Nakhon Pathom, Master Thesis, Kasetsart University, 107 p.

Resanond, Praiwan. 1979. Land Development Programmes in Thailand, from Rural Development in Southeast Asia, [S.l.]: Vikas Publishing House PVT Ltd, 8 p.

Rigg, Jonathan. 1996. Agricultural Transformation in Thailand: From Rice Farm to Non-Farm, presented to the 6th Conference on Thai Studies, Chiang Mai, 20 p.

Scott, James C. 1976. The moral economy of the peasant. Yale University Press, 246 p.

Siamwalla, Amar. 1999. The future of agriculture and agro-industry, 24 p. mimeo.

Siriprachai, Somboon. 1996. Population growth, fertility decline, poverty and deforestation in Thailand, 1850-1990, in Hoadley, M. C.; Gunnarsson, C. (ed.), The Village concept in the transformation of rural Southeast Asia. Curzon Press, 229 p.

Smuckarn, Snit. 1972. Peasantry and Modernization: A Study of the Phuan in Central Thailand, Ph.D. Dissertation Thesis, University of Hawaii, 305 p.

Stifel, L. D.; 1976, Patterns of land ownership in Central Thailand during the twentieth century, Journal of the Siam Society, vol. 64. pp. 237-274.

Suehiro, Akira. 1981. Land reform in Thailand; the concept and background of the Agricultural Land Reform Act of 1975, The Developing Economies, p. 314-347.

Tanabe, Shigeharu. 1978. Land reclamation in the Chao Phraya delta, in Ishi, Y. (ed.), "Thailand, a rice growing society, Monographs of the Center for Southeast Asian Studies, Kyoto University, pp. 40-82.

Tanabe, Shigeharu. 1994. Ecology and practical technology: peasant farming systems in Thailand, White Lotus, Bangkok, 300 p.

Thailand Development Research Institute Foundation (TDRI). 1995. Agricultural diversification/ Restructuring of agricultural production systems in Thailand, 236 p.

Thaveesilp, Subvattana. 1978. Rice production and rice trade in Central Thailand from the reign of King Rama V to the reign of King Rama VII, Unpublished PhD thesis, Chulalongkorn University, 355 p. in Thai.

Thompson, Virginia. 1941. Thailand: the new Siam, second edition, Paragon Book Reprint Corporation, 1967, New York.

Tomosugi, Takashi; 1969; The land system in Central Thailand, The Developing Economies 7:3, pp. 284-309.

Toru, Yano. 1968. Land tenure in Thailand, Asian Survey, pp. 853-863.

Turton, Andrew; Fast, J. and Malcom Caldwell. 1978. The roots of conflict, Spokesman, 195 p.

Visser, R. 1980. Aspects of social and economic change in a village in the Central Plain of Thailand, paper presented at the Thai-European seminar on social change in contemporary Thailand, University of Amsterdam.

Wagstaff, P.C. 1970. Problems associated with rural land tenure in Thailand, 58 p.

Wongboonsin, Kua. 1995. Population policy and programmes in Thailand: 1929-present, Institute of Population Studies, Chulalongkorn University, 61 p.

Wongsith, Malinee and Siriwan Siriboon. 1999. Family and the elderly: case study of Bangkok and Phra Nakorn Sri-Ayutthaya, College of Population studies, Chulalongkorn University, 109 p.

World Bank. 1982. Thailand: Program and Policies priorities for an agricultural economy in transition, Vol. I, Overview and recommendations, 20 p.

Zimmerman Carle C. 1931. Siam: Rural Economic Survey: 1930-31. The Bangkok Times Press. 322 p.

Transformations of Thung Look Nok's agrarian system (Central Plain) and perspectives of Thai Agriculture[1]

Thippawal Srijantr[2]

Abstract: *What is the right place for the agriculture in the economy of Thailand ? This critical issue was adressed through the detailed study of the Thung Look Nok area, in the West of the Central Plain. An historical view of agricultural change shows that the past self-sufficient system was turned into a modem system mostly devoted to the export of agricultural products. After a period of sugarcane domination, a wide scale diversification is observed in the study area, with the spread of baby corn and cow breeding.*

This area may be kept for agriculture, or dedicated to urbanisation and industrialisation in the next years. This situation is a good example of the main challenge for the country in the future: to gain an harmonious and efficient development of both agriculture and industry.

Our detailed investigation of the Thung Look Nok area led us to realize that a diversified and versatile agriculture-mainly relying on middle-size familial farm units-would constitute the only reasonable and sustainable approach : such an agricultural system should ensure the food independence of the country and enable a large part of the population to live from agricultural activities.

<u>บทคัดย่อ</u>

ตำแหน่งที่เหมาะสมของภาคเกษตรในระบบเศรษฐกิจโดยรวมของประเทศไทยอยู่ตรงไหน? คำถามเชิงวิพากษ์นี้ได้นำไปสู่การศึกษาอย่างละเอียดด้านระบบชุมชนเกษตรกรรมในเขตพื้นที่ทุ่งลูกนก ซึ่งตั้งอยู่ทางทิศตะวันตกของที่ราบลุ่มภาคกลางของประเทศไทย มุมมองด้านประวัติศาสตร์เกษตรแสดงให้เห็นถึงการเปลี่ยนผ่านของระบบชุมชนเกษตรจากการผลิตเพื่อการบริโภคที่พอเพียงไปสู่การผลิตแบบใหม่ที่มีวัตถุประสงค์เพื่อการค้าโดยเน้นการส่งออกของผลผลิตการเกษตร ในพื้นที่ทุ่งลูกนกภายหลังช่วงระยะเวลาของการปลูกอ้อยเป็นพืชหลักแล้ว ความหลากหลายของระบบการผลิตทางการเกษตรเป็นสิ่งที่สังเกตุเห็นได้อย่างชัดเจน โดยเฉพาะการปลูกข้าวโพดฝักอ่อนและการเลี้ยงโคเนื้อ – โคนม

พื้นที่ทุ่งลูกนกอาจจะเก็บรักษาไว้เป็นพื้นที่ผลิตทางการเกษตร หรืออาจจะเปลี่ยนเป็นพื้นที่ที่ใช้ในการขยายตัวของชุมชนเมืองหรือการพัฒนาด้านอุตสาหกรรมในระยะเวลาข้างหน้า สถานการณ์ของพื้นที่ทุ่งลูกนกเป็น

---

[1] Synthesised from Ph.D. dissertation, Institut National Agronomique Paris-Grignon (INA-PG), Paris, France

[2] Lecturer of Agricultural extension and communication Dept., Faculty of Agriculture, Kasetsart University and Coordinator of Delta project, DORAS center, Kasetsart University

ตัวอย่างของความท้าทายสำคัญสำหรับประเทศในอนาคต : การพัฒนาที่มีประสิทธิภาพและมีดุลยภาพระหว่างภาคเกษตรและภาคอุตสาหกรรม

การศึกษาพื้นที่ทุ่งลูกนก นำเราไปสู่การตระหนักถึงความหลากหลายของระบบผลิตทางการเกษตร และความสามารถในการปรับตัวของภาคเกษตรในพื้นที่ โดยเฉพาะครัวเรือนเกษตรกรขนาดกลาง ซึ่งเป็นกลุ่มเกษตรกรกลุ่มเดียวที่จะมีการพัฒนาที่ยั่งยืนและมีระบบการผลิตทางการเกษตรที่มีเหตุมีผล ซึ่งจะสามารถสร้างความมั่นคงในด้านความปลอดภัยทางอาหารของประเทศและทำให้ภาคเกษตรเป็นแหล่งรองรับแรงงานที่สำคัญของประเทศต่อไปได้

1. บทนำ

นับเป็นระยะเวลาอันยาวนานที่ภาคการเกษตรมีบทบาทสำคัญต่อระบบเศรษฐกิจส่วนรวมของประเทศ การผลิตทางการเกษตรได้ก่อให้เกิดความมั่นคงทางอาหาร (food security) และเป็นแหล่งสร้างรายได้ให้แก่ประชาชนในประเทศทั้งทางตรงและทางอ้อม ผลผลิตการเกษตรส่วนเกินที่เหลือจากการบริโภคภายในประเทศ สามารถส่งออกเป็นรายได้ให้แก่ประเทศ อย่างไรก็ตาม เมื่อประเทศไทยเริ่มมีการพัฒนาประเทศโดยใช้แนวทางที่เน้นความสำคัญกับการเร่งรัดพัฒนาอุตสาหกรรม ระดับการพึ่งพิงการเกษตรได้ลดลงอย่างรวดเร็ว และบทบาทของภาคอุตสาหกรรมและภาคบริการได้เพิ่มความสำคัญขึ้นตามลำดับ

วิกฤติเศรษฐกิจในช่วง 3 ปีที่ผ่านมา (พ.ศ. 2540-2543) ทำให้ประเทศไทยตระหนักถึงความสำคัญของภาคการเกษตรเพื่อการพัฒนาที่มีดุลยภาพและมีเสถียรภาพของประเทศ เนื่องจากในขณะนี้ประชาชนที่อาศัยอยู่ในชนบทมีจำนวนถึง 38 ล้านคน คิดเป็นสัดส่วนเกือบ 2 ใน 3 ของจำนวนคนไทยทั่วประเทศ และร้อยละ 90 ของประชาชนในชนบทประกอบอาชีพทางการเกษตร มีผลผลิตคิดเป็นร้อยละ 11 ของผลิตภัณฑ์มวลรวมประชาชาติในประเทศ (GDP) และผลผลิตทางการเกษตรคิดเป็นร้อยละ 25 ของมูลค่าการส่งออก นอกจากนั้นการเกษตรยังมีความสำคัญทั้งทางด้านวัฒนธรรมและสังคมอีกหลายประการ การฟื้นฟูและสร้างความมั่นคงของระบบการเกษตรจึงนับเป็นพื้นฐานในการพัฒนาประเทศให้ยั่งยืน

ที่ราบลุ่มภาคกลางจัดเป็นแหล่งผลิตทางการเกษตรที่สำคัญของประเทศ ผลผลิตข้าวจากพื้นที่ภาคกลางคิดเป็น 1 ส่วนใน 3 ส่วนของผลผลิตข้าวทั่วประเทศ ในขณะที่พื้นที่ปลูกข้าวในภาคกลางมีเพียง 19% ของพื้นที่ปลูกข้าวทั้งหมดทั่วประเทศ พื้นที่ภาคกลางยังเป็นแหล่งผลิตพืชและสัตว์ต่างๆ ที่สำคัญอีกหลายชนิด เช่น อ้อย (ผลผลิตอ้อยจากภาคกลางคิดเป็น 53% ของผลผลิตรวมทั้งประเทศ) ผักและผลไม้ซึ่งนับวันจะทวีความสำคัญในระบบเศรษฐกิจ เนื่องจากการเพิ่มขึ้นทั้งในด้านปริมาณและมูลค่า สัตว์ปีก สุกร โคนมและโคเนื้อ ซึ่งนับเป็นอาชีพการเกษตรที่ได้รับการพัฒนาอย่างรวดเร็วในพื้นที่ภาคกลาง นอกจากพื้นที่ภาคกลางจะมีความสำคัญในด้านการเกษตรแล้ว ยังเป็นภูมิภาคที่มีการลงทุนด้านโครงสร้างพื้นฐานและสาธารณูปโภคที่ค่อนข้างสมบูรณ์ ก่อให้เกิดการเติบโตของชุมชนเมือง (urbanisation) มีการพัฒนาด้านอุตสาหกรรม

(industrialisation) และด้านพาณิชกรรม (commercialisation) อย่างรวดเร็ว ทำให้เกิดคำถามที่ว่า การพัฒนาที่สมดุลระหว่างภาคเกษตรกรรม อุตสาหกรรมและพาณิชกรรมในเขตพื้นที่ราบลุ่มภาคกลางจะเกิดขึ้นได้หรือไม่ ยุทธศาสตร์การพัฒนาประเทศหลังวิกฤติที่จะสนับสนุนเกื้อกูลภาคเกษตรและเกษตรกรให้พึ่งตนเองได้อย่างแท้จริง จะมีแนวนโยบายและแนวทางการปฏิบัติอย่างไร

การวิจัยครั้งนี้ได้เลือกพื้นที่ทุ่งลูกนก ซึ่งตั้งอยู่ในเขตลุ่มน้ำแม่กลองทางทิศตะวันตกของที่ราบลุ่มภาคกลางเป็นพื้นที่กรณีศึกษา โดยมีวัตถุประสงค์เพื่อศึกษาระบบสังคมเกษตร (agrarian system) องค์ประกอบของระบบเกษตรกรรมทั้งด้านระบบนิเวศเกษตร (agro-ecosystem) ด้านระบบการผลิตทางการเกษตร (agricultural production system) ซึ่งประกอบด้วยระบบการปลูกพืชและระบบการเลี้ยงสัตว์ (cropping/animal system) และด้านเศรษฐกิจ-สังคม (socio-economic) ความสัมพันธ์ระหว่างองค์ประกอบต่างๆ เหล่านั้น ตลอดจนศึกษาลักษณะของเกษตรกรประเภทต่างๆ ที่มีอยู่ในพื้นที่ ทั้งนี้ได้นำแนวคิดด้านระบบอะกราเรี่ยนหรือระบบสังคมเกษตร (agrarian system) ที่เป็นทฤษฎีว่าด้วยการวิวัฒนาการและการแตกแยกสาขาของระบบมาใช้

องค์ความรู้ที่ได้รับจากการศึกษา สามารถนำมาเป็นแนวทางในการกำหนดกรอบนโยบายการพัฒนาการเกษตรในพื้นที่ทุ่งลูกนกและอาจเป็นแนวทางการศึกษาวิจัยในหัวข้ออื่นๆ ในพื้นที่ราบลุ่มภาคกลางหรือพื้นที่อื่นๆ ในประเทศไทยได้

2. วิธีการศึกษา

(1) ศึกษาจากการวิเคราะห์ เอกสาร (documentary)

(2) ศึกษาจากข้อมูลทุติยภูมิจากแหล่งข้อมูลต่างๆ

(3) การเก็บข้อมูลภาคสนาม (field works)

3.1 การสำรวจพื้นที่ เพื่อศึกษาสภาพทั่วไปของพื้นที่ศึกษาทั้งด้านกายภาพ, ชีวภาพ การใช้ประโยชน์ที่ดิน สภาพเศรษฐกิจและสังคม

3.2 การสอบถามจากผู้ให้ข้อมูลที่สำคัญ (key informace) เช่นผู้นำหมู่บ้าน ผู้สูงอายุ พระสงฆ์ แกนนำชุมชน เจ้าหน้าที่ทั้งภาครัฐและเอกชนที่เกี่ยวข้องทั้งในส่วนกลางและส่วนท้องถิ่น

3.3 การสัมภาษณ์เชิงโครงสร้าง (structural interview) โดยใช้แบบสอบถามข้อมูลพื้นฐานโครงสร้างระบบการผลิตทางการเกษตร สอบถามเกษตรกรทั้งหมดในพื้นที่ตำบลทุ่งลูกนก

3.4 การสัมภาษณ์ระดับลึก (indepth interview) โดยทำการคัดเลือกตัวอย่างเกษตรกรแบบเจาะจง (purposive sampling) ซึ่งถือเป็นตัวแทนของระบบการผลิตทางการเกษตรที่มีในพื้นที่ศึกษา

3.5 การสนทนากลุ่มย่อย(focus group) เพื่อนำประเด็นสำคัญที่ได้จากการสัมภาษณ์มาตรวจสอบความถูกต้องของข้อมูลและศึกษารายละเอียดที่สนใจ

3.6 การศึกษารายกรณี (case study) ในประเด็นหัวข้อที่ต้องการข้อมูลเป็นกรณีเฉพาะ เพื่อให้ได้รายละเอียดในประเด็นนั้นๆอย่างชัดเจนที่สุด

(4) การวิเคราะห์ข้อมูล โดยนำข้อมูลที่ได้จากการศึกษาเอกสาร รายงาน ข้อมูลที่ได้จากการสำรวจภาคสนาม และข้อมูลจากการสัมภาษณ์ มาทำการวิเคราะห์ทางสถิติ (statistic analysis) และวิเคราะห์เนื้อหา (content analysis)

3. ผลการศึกษา

3.1 สภาพทางภูมิศาสตร์และที่ตั้งของพื้นที่ทุ่งลูกนก

ตำบลทุ่งลูกนกครอบคลุมพื้นที่ประมาณ 50 ตารางกิโลเมตร หรือประมาณ 31,000 ไร่ มีความยาวของพื้นที่วัดจากทิศเหนือจรดทิศใต้ประมาณ 17 กิโลเมตร และมีความกว้างของพื้นที่วัดจากทิศตะวันออกประมาณ 11 กิโลเมตร ประกอบไปด้วยหมู่บ้านจำนวน 25 หมู่บ้าน ตำบลทุ่งลูกนกอยู่ในเขตพื้นที่อำเภอกำแพงแสน จังหวัดนครปฐม ซึ่งตั้งอยู่ทางตะวันตกของที่ราบลุ่มภาคกลาง มีระยะทางห่างจากกรุงเทพฯ เมืองหลวงของไทยประมาณ 100 กิโลเมตร

พื้นที่ทุ่งลูกนกเป็นส่วนหนึ่งของที่ราบลุ่มตะกอนรูปพัด (alluvial fan) ของลุ่มน้ำแม่กลอง มีความสูงจากระดับน้ำทะเล (altitude) ลาดเทจากทิศตะวันตกไปทิศตะวันออกที่ 2 เมตรและ 1 เมตร สภาพพื้นที่มีลักษณะเป็นลอนลูกคลื่น พื้นที่บางแห่งเป็นที่ราบและบางแห่งเป็นที่ลุ่ม

ดินแบ่งออกเป็น 2 ลักษณะด้วยกัน คือ

- บริเวณที่ลุ่มทางตอนใต้ของทุ่งลูกนก เป็นดินชุดสระบุรีและดินชุดนครปฐม เนื้อดินมีลักษณะเป็นดินเหนียว และดินร่วนปนเหนียว มีปัญหาในการระบายน้ำ
- ส่วนบริเวณที่เหลือของทุ่งลูกนก เป็นดินชุดกำแพงแสน เนื้อดินมีลักษณะหลากหลาย ได้แก่ ดินร่วนปนเหนียว ดินร่วน ดินร่วนปนทรายและดินทรายปนร่วน

สภาพภูมิอากาศเช่นเดียวกับสภาพภูมิอากาศของภาคกลางโดยทั่วไป คือ อยู่ภายใต้อิทธิพลของลมมรสุมทำให้มีสภาพภูมิอากาศกึ่งร้อนชื้น ฤดูฝนอยู่ในช่วงเดือนพฤษภาคมถึงเดือนตุลาคม ปริมาณน้ำฝนเฉลี่ย 1,000 มิลลิเมตรต่อปี ความชื้นสัมพัทธ์โดยเฉลี่ยอยู่ที่ 71 %

ระบบเครือข่ายชลประทานได้รับการพัฒนาในพื้นที่ทุ่งลูกนกมานับแต่มีการก่อสร้างเขื่อนวชิราลงกรณ์ในปี พ.ศ. 2515 โครงการชลประทานกำแพงแสนนับเป็นโครงการชลประทานโครงการแรกของโครงการชลประทานแม่กลองใหญ่ เกษตรกรส่วนใหญ่ได้รับน้ำจากคลองส่งน้ำสายหลัก (main canal) และคลองส่งน้ำสายรอง (secondary canal) ที่พาดผ่านพื้นที่

จากสภาพภูมิอากาศที่เหมาะสม สภาพดินและน้ำที่อุดมสมบูรณ์ การคมนาคมขนส่งสะดวก ประกอบกับระยะทางซึ่งอยู่ไม่ไกลจากกรุงเทพฯ และปริมณฑล อันเป็นฐานที่ตั้งของโรงงานแปรรูปผลผลิตทางการเกษตร และเป็นที่ตั้งของตลาดสินค้าผลผลิตการเกษตรที่สำคัญทั้งภายในและภายนอกประเทศ (ท่าอากาศยานดอนเมือง, ท่าเรือ) เมื่อเปรียบเทียบกับภูมิภาคอื่นๆ พื้นที่ทุ่งลูกนกจึงมีความได้เปรียบเชิงเปรียบเทียบ จัดเป็นพื้นที่ที่มีศักยภาพในการผลิตทางการเกษตรระดับสูง

3.2. วิวัฒนาการของระบบสังคมเกษตรในพื้นที่ทุ่งลูกนก (ช่วงปี พ.ศ. 2433-2539)

พื้นที่ทุ่งลูกนกได้แสดงให้เห็นถึงการเปลี่ยนแปลงของระบบเกษตรกรรมที่ประเทศไทยประสบตลอดช่วงระยะเวลา 80 ปีที่ผ่านมา คือ การเปลี่ยนจากการเกษตรที่ผลิตเพื่อการบริโภคในครัวเรือนและเพื่อการยังชีพมาเป็นเกษตรเพื่อการค้าและการส่งออก ภาพการเปลี่ยนแปลงของระบบสังคมเกษตรทุ่งลูกนกตั้งแต่อดีตจนถึงปัจจุบัน สามารถแบ่งออกเป็น 3 ระยะดังนี้

(1.) ช่วงเริ่มแรกของการจับจองที่ดิน (พ.ศ. 2433-2503)
กำเนิดชุมชนที่มีวิถีการผลิตแบบธรรมชาติและพึ่งตนเอง

(2.) ช่วงเปลี่ยนแปลงสู่การเกษตรเพื่อการค้า (พ.ศ. 2503-2528)
การเกษตรแผนใหม่ที่มีอ้อยเป็นพืชหลัก

(3.) ช่วงเปลี่ยนแปลงสู่กิจกรรมหลากหลาย (พ.ศ. 2523-2538)
การเกษตรแบบผสมผสานและอาชีพนอกภาคเกษตร

3.2.1 ช่วงเริ่มแรกของการจับจองที่ดิน (พ.ศ. 2433-2503)

- **การอพยพของชาวนาไทยเพื่อทำนาปลูกข้าว**

จากหลักฐานภาพถ่ายทางอากาศและแผนที่ภูมิประเทศของกรมแผนที่ทหารในปี พ.ศ. 2453 พบว่าได้เกิดมีชุมชนตั้งหลักแหล่งขึ้นแล้วในพื้นที่ทุ่งลูกนก โดยตั้งบ้านเรือนถิ่นฐานบริเวณที่ลุ่มทางตอนใต้ใกล้แหล่งน้ำและทำนาเพาะปลูกข้าวเป็นอาชีพหลัก ชุมชนทุ่งลูกนกเป็นชุมชนของผู้อพยพมาจากต่างท้องถิ่น จากการสัมภาษณ์เกษตรกรผู้สูงอายุในพื้นที่ทุ่งลูกนกและพื้นที่ใกล้เคียง สันนิษฐานว่าผู้ที่อพยพรุ่นแรกมาจากเขตหนองโพ บางแพและดำเนินสะดวก จังหวัดราชบุรี (ตั้งอยู่ทางทิศตะวันตกเฉียงใต้ ห่างจากพื้นที่ทุ่งลูกนกประมาณ 60 กิโลเมตร) เนื่องจากที่ดินทำกินเดิมไม่เพียงพอ

จากการเพิ่มขึ้นของสมาชิกครัวเรือน ประกอบกับในช่วงเวลาดังกล่าว (พ.ศ. 2433-2443) เป็นช่วงที่สยามประเทศเปิดตัวเข้าสู่การค้าโลกและเน้นการผลิตข้าวเป็นสินค้าหลักในการส่งออก ความต้องการในด้านที่ดินทำกินโดยเฉพาะที่ลุ่มในการทำนาจึงเพิ่มขึ้นสูงมาก

เกษตรกรที่อพยพเข้ามาในพื้นที่ทุ่งลูกนก ได้นำความรู้และเครื่องมือเครื่องใช้ในการผลิตมาใช้ในการปรับปรุงสภาพแวดล้อม ซึ่งเป็นที่รกร้างว่างเปล่าให้กลายเป็นแหล่งที่อยู่อาศัยและที่เพาะปลูก ในช่วงปี พ.ศ. 2473 ยังคงมีการอพยพโยกย้ายของผู้คนเข้าสู่พื้นที่ทุ่งลูกนก ที่ดินในที่ลุ่มใกล้หนองน้ำและลำรางน้ำเริ่มมีจำกัด เกษตรกรเริ่มจับจองที่ดินค่อนข้างดอนซึ่งอยู่ห่างไกลออกไปและมีการปลูกข้าวไร่ในเขตที่ดอนนี้

พันธุ์ข้าวที่ใช้เป็นข้าวพันธุ์พื้นเมือง ใช้แรงงานคนและแรงงานสัตว์ในการผลิต ปลูกข้าว 1 ครั้งต่อปีโดยใช้น้ำจากธรรมชาติ ในเขตที่ลุ่มในฤดูน้ำหลาก ข้าวพันธุ์พื้นเมืองจะสามารถยืดตัวพ้นน้ำได้ ส่วนในเขตที่ดอนเกษตรกรใช้พันธุ์ข้าวไร่ มีการปลูกผัก-ผลไม้ไว้รอบบ้านเพื่อการบริโภคในครัวเรือน ความอุดมสมบูรณ์ของดินได้จากสารอินทรีย์ที่มาพร้อมน้ำหลากและมูลวัว-ควาย เกษตรกรบางรายมีการปลูกถั่วเขียวซึ่งช่วยในการบำรุงดิน

พื้นที่เพาะปลูกของเกษตรกรแต่ละครัวเรือนไม่แตกต่างกันเท่าใดนัก คืออยู่ระหว่าง 20-30 ไร่ ในขนาดที่แรงงานครอบครัวจะสามารถผลิตได้ ผลผลิตข้าว ผัก-ผลไม้ เป็นไปเพื่อตอบสนองต่อการบริโภคในครัวเรือน หากมีผลผลิตส่วนเกินก็นำไปแลกเปลี่ยนเป็นสิ่งของอื่นๆ ที่จำเป็น พื้นที่ทุ่งลูกนกในช่วงนี้จัดเป็นพื้นที่ทุรกันดารห่างไกล ตลาดอันเป็นศูนย์กลางการแลกเปลี่ยนสินค้าต่างๆ อยู่ห่างไปทางตอนใต้ของทุ่งลูกนกประมาณ 20-25 กิโลเมตร และการคมนาคมเป็นไปด้วยความยากลำบาก ความต้องการของชุมชนในยุคแรกนี้จึงจำกัดอยู่เฉพาะในส่วนที่จำเป็นต่อการดำรงชีวิต ซึ่งสอดคล้องต่อวิถีการผลิตแบบธรรมชาติและพึ่งพาตนเอง

- **การตั้งชุมชนชาวจีนและการขยายพื้นที่เพื่อปลูกยาสูบ**

ประมาณปี พ.ศ. 2473 กลุ่มชาวจีนได้อพยพมาจากพื้นที่จังหวัดกาญจนบุรี เข้ามาตั้งถิ่นฐานอยู่ทางตอนเหนือของพื้นที่ทุ่งลูกนก และเช่าพื้นที่ที่ยังรกร้างว่างเปล่าทำการเพาะปลูกยาสูบ การอพยพของชาวจีนสู่สยามประเทศนับแต่รัชกาลที่ 3 เป็นต้นมา ส่งผลให้จำนวนคนจีนในเขตภาคกลางและเขตลุ่มน้ำแม่กลองมีจำนวนเพิ่มมากขึ้น พื้นที่ทางตอนเหนือนี้ไม่เหมาะต่อการทำนาปลูกข้าวเนื่องจากสภาพพื้นที่เป็นที่ดอนและลักษณะดินเป็นดินร่วนปนทราย

ชาวจีนกลุ่มนี้ได้พัฒนาระบบการปลูกยาสูบขึ้นโดยขุดบ่อบาดาลเพื่อดึงน้ำมาใช้ในด้านการอุปโภค-บริโภคและใช้ในการเพาะปลูก ยาสูบเป็นพืชที่ต้องการแรงงานในการดูแลสูง พื้นที่ในการปลูกยาสูบนอกจากจะถูกจำกัดด้วยปัจจัยด้านน้ำแล้ว ยังถูกจำกัดจากจำนวนแรงงานที่มีในพื้นที่ด้วย ยาสูบเป็นพืชที่ผลิตเพื่อการค้าโดยมีพ่อค้าคนกลางจากจังหวัดกาญจนบุรีและนครปฐมเป็นผู้มารับซื้อผลผลิตจากชุมชนชาวจีนทุ่งลูกนก

ในช่วงเวลา 10 ปี (พ.ศ. 2473-2483) พื้นที่ดอนทั้งหมดทางตอนเหนือของทุ่งลูกนกได้ถูกใช้เพื่อการเพาะปลูกยาสูบ โดยชาวจีนได้อพยพเข้ามาตั้งหลักแหล่งทำกินในพื้นที่ทางตอนเหนือนี้เป็นระยะๆ และแม้ว่าพื้นที่ทำ

กินทางตอนเหนือของทุ่งลูกนกได้ถูกจับจองเป็นเจ้าของจนหมดสิ้นแล้วโดยชาวจีนอพยพรุ่นแรกๆ แต่ก็ยังคงมีชาวจีนอพยพเข้ามาในพื้นที่เพื่อเป็นแรงงานรับจ้างในไร่ยาสูบ ระบบการเกษตรที่ผลิตเพื่อการค้าและมีระบบการจ้างแรงงานนี้ ทำให้ชุมชนชาวจีนทางตอนเหนือของทุ่งลูกนกเข้าสู่กระบวนการสะสมทุนได้อย่างรวดเร็ว แตกต่างจากชุมชนชาวไทยที่ทำนาปลูกข้าวเพียงเพื่อการบริโภคที่จำเป็นในครัวเรือน

3.2.2 ช่วงเปลี่ยนแปลงสู่การเกษตรเพื่อการค้า (พ.ศ. 2503-2528)

การพัฒนาระบบการปลูกอ้อยในพื้นที่ทุ่งลูกนก เป็นผลมาจากนโยบายรัฐในการพัฒนาอุตสาหกรรมน้ำตาลของประเทศ โดยรัฐบาลได้นำมาตรการต่างๆ มาใช้เพื่อเร่งผลิตอ้อยและน้ำตาลในประเทศเพื่อทดแทนการนำเข้า เช่น การปล่อยให้ราคาน้ำตาลในประเทศขึ้นลงได้อย่างเสรี การตั้งกำแพงภาษีการนำเข้าน้ำตาล การจัดตั้งหน่วยงานของรัฐเพื่อส่งเสริมและสนับสนุนอุตสาหกรรมน้ำตาล เป็นต้น รัฐได้สนับสนุนให้ความช่วยเหลือในด้านเงินลงทุนแก่เอกชนในการจัดตั้งโรงงานน้ำตาลทราย (ในปี พ.ศ. 2496 มีโรงงานน้ำตาลทั่วประเทศประมาณ 330 โรง เป็นโรงงานน้ำตาลทรายขาว 30 โรง และโรงงานน้ำตาลทรายแดง 300 โรง) ทำให้ไทยสามารถผลิตน้ำตาลทรายได้เพียงพอต่อความต้องการบริโภคภายในประเทศ มีการจัดตั้งโรงงานน้ำตาลขึ้นเป็นจำนวนมาก โดยเฉพาะในเขตลุ่มน้ำแม่กลองซึ่งเป็นพื้นที่ที่เหมาะสมในการปลูกอ้อย (ดิน, น้ำ, การคมนาคมขนส่ง, แรงงาน)

พื้นที่ทางตอนใต้ของทุ่งลูกนกได้เริ่มมีการปลูกอ้อยตั้งแต่ปี พ.ศ. 2493 โดยมีการตั้งโรงงานน้ำตาลขึ้นที่บริเวณตลาดห้วยกระบอกทางตอนใต้ของพื้นที่ทุ่งลูกนก โรงงานนี้มีกำลังผลิตประมาณ 5,000-7,000 ตันต่อปี (คิดเป็นพื้นที่ปลูกอ้อยประมาณ 2,000-3,000 ไร่) เมื่อเปรียบเทียบผลตอบแทนระหว่าง “อ้อย” และ “ข้าว” ในพื้นที่ทุ่งลูกนกในช่วงปี พ.ศ. 2500 พบว่า “อ้อย” เป็นพืชที่เกษตรกรผู้ปลูกได้รับผลตอบแทนดีกว่า โดยระบบการปลูกข้าวในที่ดอน (นาดอน) จะมีรายได้ประมาณ 240-280 บาทต่อพื้นที่ 1 ไร่ ในขณะที่อ้อยให้รายได้ 340 บาท ดังนั้นเกษตรกรที่มีพื้นที่เพาะปลูกทางตอนใต้ของทุ่งลูกนกซึ่งเป็นพื้นที่ดอน จึงเปลี่ยนจากการทำนามาเป็นการปลูกอ้อย

ส่วนทางตอนเหนือมีการจัดตั้งโรงงานหีบน้ำเชื่อมขึ้น 2 แห่ง เป็นโรงงานขนาดเล็ก มีกำลังผลิต 1,000 ตันต่อปี ประกอบกับช่วงเวลานั้นเกษตรกรผู้ปลูกยาสูบในเขตพื้นที่ดอนทางตอนเหนือของทุ่งลูกนก ได้พยายามที่จะปรับเปลี่ยนการผลิตจากยาสูบเป็นพืชชนิดอื่น เนื่องมาจากปัญหาด้านโรคและแมลงศัตรูพืช ตลอดจนความอุดมสมบูรณ์ของดิน โดยการปลูกยาสูบติดต่อกันเป็นระยะเวลานานในพื้นที่เดียวกัน ทำให้คุณภาพของยาสูบไม่ดีเท่าที่ควร การปลูกอ้อยซึ่งเป็นพืชที่ต้องการแรงงานและปัจจัยน้ำน้อยกว่าจึงแพร่กระจายในเขตพื้นที่ทางตอนเหนือของทุ่งลูกนกอย่างรวดเร็ว

สำหรับพื้นที่ลุ่มยังคงใช้ในการทำนาปลูกข้าวเป็นหลัก การปรับเปลี่ยนระบบการผลิตของพื้นที่ทุ่งลูกนกจากระบบข้าว-ยาสูบ มาเป็นระบบข้าว-อ้อยนี้ ทำให้เกิดความยืดหยุ่นในด้านความต้องการแรงงานมากขึ้น อย่างไรก็ตาม พื้นที่ในการปลูกอ้อยยังไม่ขยายตัวมากนักเนื่องจากข้อจำกัดในด้านความสามารถของแรงงานสัตว์ที่ใช้ในการเตรียมดิน

การปฏิวัติการเกษตร (agricultural revolution) ของพื้นที่ทุ่งลูกนกเกิดขึ้นในช่วงปี พ.ศ. 2518 ในด้านการปลูกอ้อยได้มีการนำพันธุ์อ้อยที่ให้ผลผลิตสูงมาใช้ มีการนำเครื่องจักรกลการเกษตรเข้ามาใช้ในพื้นที่ ได้แก่ รถแทรกเตอร์ในการเตรียมดิน (ไถดิน, พรวนดิน, ยกร่องปลูก) และรถบรรทุกขนาดใหญ่เพื่อใช้ในการขนส่งอ้อยจากแปลงปลูกเข้าสู่โรงงาน นอกจากนั้นนโยบายของรัฐในการส่งเสริมการปลูกอ้อยเพื่อผลิตน้ำตาลทรายเป็นสินค้าออกทำรายได้ให้แก่ประเทศ ทำให้เกิดการขยายตัวของอุตสาหกรรมอ้อยและน้ำตาลทรายอย่างรวดเร็ว โรงงานน้ำตาลที่มีกำลังการผลิตขนาดใหญ่ 13 โรงงาน ได้จัดตั้งขึ้นในบริเวณลุ่มน้ำแม่กลอง

กลุ่มเกษตรกรที่ได้มีการสะสมทุนในการผลิตอย่างเพียงพอในช่วงเวลาที่ผ่านมา เป็นเกษตรกรเพียงกลุ่มเดียวที่สามารถลงทุนในด้านปัจจัยการผลิตชนิดใหม่ๆ นี้ (รถแทรกเตอร์และรถบรรทุก)

ชนชั้นใหม่ได้เกิดขึ้นในชุมชนเกษตรทุ่งลูกนก คือ กลุ่มนายทุนผู้บริหารกิจการ (entrepreneur) ซึ่งทำหน้าที่เป็นผู้ให้บริการเครื่องจักรกลการเกษตรและบริการด้านอื่นๆ ให้แก่เกษตรกรผู้ปลูกอ้อย ซึ่งไม่สามารถลงทุนซื้อปัจจัยการผลิตที่มีราคาแพงเหล่านี้ได้ นายทุนกลุ่มนี้จะรับบทบาทเป็นพ่อค้าคนกลาง (middleman) ระหว่างเกษตรกรผู้ปลูกอ้อยและโรงงานน้ำตาล โดยทำหน้าที่เป็นหัวหน้าโควต้าอ้อยในพื้นที่ ทำสัญญาส่งอ้อยให้แก่โรงงานน้ำตาลที่ตั้งอยู่ไม่ไกลจากพื้นที่ทุ่งลูกนก และคิดค่าบริการในการเก็บรวบรวมผลผลิตอ้อยสู่โรงงานจากผู้ผลิตรายอื่นซึ่งไม่มีพาหนะในการขนส่งอ้อย เกษตรกรกลุ่มนี้ผสมผสานกิจกรรมภาคเกษตรและกิจกรรมในด้านบริหารกิจการเข้าด้วยกัน นอกจากนั้นยังอาจมีกิจกรรมด้านการให้สินเชื่อ(ปล่อยเงินกู้) และการให้ปัจจัยการผลิตล่วงหน้า(โดยคิดดอกเบี้ย) แก่เกษตรกรรายเล็กที่ขาดเงินทุน

การนำเข้าเครื่องจักรกลการเกษตร คือ รถแทรกเตอร์และรถบรรทุกซึ่งเป็นเครื่องทุ่นแรงที่มีประสิทธิภาพสูงนี้ ทำให้พื้นที่การปลูกอ้อยขยายตัวอย่างรวดเร็ว ประกอบกับแรงจูงใจในด้านราคาอ้อยที่เพิ่มสูงขึ้นในช่วงนั้น ทำให้พื้นที่ดอนและค่อนข้างดอนที่มีอยู่ในทุ่งลูกนก เปลี่ยนมาเป็นพื้นที่ปลูกอ้อยทั้งหมด

การปฏิวัติด้านการปลูกข้าวในพื้นที่ทุ่งลูกนกเกิดขึ้นเช่นกัน ในช่วงตั้งแต่ปี พ.ศ. 2515 เป็นต้นมา การก่อสร้างเขื่อนวชิราลงกรณ์และการพัฒนาเครือข่ายระบบชลประทานของโครงการชลประทานแม่กลองใหญ่ (พ.ศ. 2515-2525) นอกจากจะช่วยทำให้น้ำหยุดท่วมพื้นที่แล้ว ยังช่วยทำให้พื้นที่ทุ่งลูกนกได้มีน้ำใช้ตลอดทั้งปี การนำเครื่องจักรกลการเกษตรคือรถไถนา เข้ามาใช้แทนแรงงานสัตว์ช่วยให้การเตรียมดินทำได้รวดเร็วขึ้น ระบบการปลูกข้าวในพื้นที่ทุ่งลูกนกจึงเปลี่ยนจากการปลูกข้าวพันธุ์พื้นเมืองพึ่งพาน้ำธรรมชาติ มาเป็นการ

ปลูกข้าวพันธุ์แนะนำและใช้น้ำชลประทาน โดยเกษตรกรสามารถปลูกข้าวได้ 2 ครั้งในรอบปี ข้าวพันธุ์แนะนำนี้ให้ผลผลิตสูงกว่าพันธุ์พื้นเมือง (พันธุ์พื้นเมือง 200-300 กิโลกรัม/ไร่, พันธุ์แนะนำ 500-800 กิโลกรัม/ไร่)

3.3.3 ช่วงเปลี่ยนแปลงสู่กิจกรรมหลากหลาย (พ.ศ. 2523-2538)

ในช่วงปี พ.ศ. 2523 เป็นต้นมา ราคาผลผลิตสินค้าเกษตรในตลาดโลกลดต่ำลงอย่างต่อเนื่อง โดยเฉพาะสินค้าเกษตรส่งออกหลักของประเทศไทย (ข้าว, อ้อย) ส่งผลให้เกษตรกรที่ปลูกพืชเหล่านี้ในลักษณะของพืชเชิงเดี่ยว (monoculture) ต้องประสบปัญหาและภาวะหนี้สินจำนวนมาก รัฐได้มีนโยบายในการปรับเปลี่ยนโครงสร้างการผลิตทางการเกษตรของประเทศให้มีความหลากหลายมากขึ้น เพื่อลดความเสี่ยงจากความผันผวนของราคาผลผลิตเกษตรในตลาดต่างประเทศ ขณะเดียวกันการขยายตัวของชุมชนเมืองและการมีคุณภาพชีวิตที่ดีขึ้นของคนไทย ได้ก่อให้เกิดความเปลี่ยนแปลงด้านความต้องการทางโภชนาการ ได้แก่ การบริโภคเนื้อ นม ผักและผลไม้ในปริมาณที่สูงขึ้นและมีการคัดเลือกคุณภาพมากขึ้น

การพัฒนาให้เกิดความหลากหลายของการผลิตทางการเกษตรในประเทศไทย จะช่วยให้อัตราการนำเข้าสินค้าเกษตรและผลิตภัณฑ์เกษตรบางชนิดลดลง เป็นการเพิ่มความปลอดภัยด้านอาหาร (food security) ให้แก่ประชาชนในประเทศ และลดการพึ่งพาตลาดภายนอก เมื่อพิจารณาถึงแนวโน้มการลดลงของขนาดที่ดินถือครองการเกษตรต่อครัวเรือนในประเทศไทย การปลูกพืชหรือเลี้ยงสัตว์ที่หลากหลายจะเป็นการสร้างมูลค่าเพิ่มทั้งต่อหน่วยพื้นที่และต่อหน่วยแรงงาน ซึ่งจะเป็นการเพิ่มรายได้ให้แก่เกษตรกรผู้ผลิตในที่สุด

รัฐได้ร่วมมือกับภาคเอกชนในการสนับสนุนและส่งเสริมให้เกิดการพัฒนาทั้งด้านเกษตรอุตสาหกรรม (agro-industrialisation) และด้านวิถีการตลาด (commercial channels) ส่งผลให้เกิดการจัดตั้งโรงงานแปรรูปผลผลิตทางการเกษตรจำนวนมากในเขตพื้นที่ภาคกลาง โดยเฉพาะในเขตกรุงเทพฯ- ปริมณฑลและเขตลุ่มน้ำแม่กลอง พื้นที่ทุ่งลูกนกซึ่งอยู่ไม่ไกลจากกรุงเทพฯ อันเป็นที่ตั้งของตลาดสินค้าที่สำคัญ และอยู่ไม่ไกลจากโรงงานแปรรูปอันเป็นแหล่งรับซื้อผลผลิต ประกอบกับการคมนาคมขนส่งที่สะดวกและการมีระบบชลประทานที่ค่อนข้างสมบูรณ์เหมาะแก่การผลิตทางการเกษตร การพัฒนาการปลูกพืชและเลี้ยงสัตว์ชนิดใหม่ที่หลากหลายจึงเกิดขึ้นอย่างรวดเร็วในพื้นที่ทุ่งลูกนก ซึ่งได้แก่ การปลูกข้าวโพดฝักอ่อน การปลูกผักและไม้ผล การเลี้ยงสุกร การเลี้ยงวัวเนื้อและวัวนม

ในกรณีของข้าวโพดฝักอ่อน ได้มีการนำเข้ามาปลูกในพื้นที่ทุ่งลูกนกตั้งแต่ปี พ.ศ. 2527 การพัฒนาเครือข่ายการตลาดและการจัดตั้งโรงงานแปรรูปข้าวโพดฝักอ่อนในจังหวัดนครปฐมจังหวัดกาญจนบุรีและราชบุรี ทำให้การพัฒนาการปลูกข้าวโพดฝักอ่อนในพื้นที่ทุ่งลูกนกเป็นไปอย่างรวดเร็ว พื้นที่ปลูกและจำนวนเกษตรกรที่เพาะปลูกข้าวโพดฝักอ่อนเพิ่มขึ้นอย่างมาก โดยเฉพาะในครัวเรือนเกษตรกรที่มีพื้นที่ถือครองขนาดเล็ก เนื่องจากข้าวโพดฝักอ่อนเป็นพืชที่ให้มูลค่าเพิ่มต่อหน่วยพื้นที่ในระดับที่สูงกว่าอ้อย และยังสามารถปลูกได้

หลายครั้งในรอบปี ทำให้เกษตรกรมีรายได้มากขึ้น เกษตรกรรายเล็กเหล่านี้จึงปรับเปลี่ยนระบบการผลิตมาเป็นระบบข้าวโพดฝักอ่อน ที่มีความเฉพาะเจาะจงในการผลิต สำหรับครัวเรือนเกษตรซึ่งมีพื้นที่ทำกินขนาดกลาง จะมีการผสมผสานการปลูกข้าวโพดฝักอ่อนและการปลูกอ้อย เนื่องจากข้อจำกัดในด้านแรงงานที่มีอยู่ในครัวเรือนและความเหมาะสมของแปลงปลูก ซึ่งทำให้ไม่สามารถเปลี่ยนจากพื้นที่ปลูกอ้อยมาเป็นพื้นที่ปลูกข้าวโพดฝักอ่อนทั้งหมดได้

ในส่วนของเกษตรกรกลุ่มนายทุนหรือหัวหน้าโควต้าอ้อย การพัฒนาระบบการปลูกข้าวโพดฝักอ่อนในพื้นที่ทุ่งลูกนก ก่อให้เกิดประโยชน์ 2 ประการ กล่าวคือ เกษตรกรลูกไร่ซึ่งเป็นเกษตรกรรายเล็กและมักมีหนี้สินผูกพันกับหัวหน้าโควต้าอ้อย จะมีความสามารถในการชำระเงินกู้ได้มากขึ้น โดยเกษตรกรจะมีรายได้เพิ่มขึ้นจาการปลูกข้าวโพดฝักอ่อน ขณะเดียวกันกลุ่มหัวหน้าโควต้าอ้อยจะได้รับรายได้จากการให้บริการเกษตรกรผู้ปลูกข้าวโพดฝักอ่อน ในด้านการเตรียมดินและการเตรียมแปลงปลูก ซึ่งการปลูกข้าวโพดฝักอ่อนสามารถปลูกได้ 3-5 ครั้งในรอบปี จึงทำให้กลุ่มหัวหน้าโควต้าได้รับรายได้จากธุรกิจการบริการเป็นจำนวนมาก

นอกจากข้าวโพดฝักอ่อนแล้ว ยังพบการปลูกไม้ผลและการปลูกผักชนิดอื่นๆ ในพื้นที่ทุ่งลูกนก เกษตรกรที่มีพื้นที่ทำกินขนาดเล็กบางครัวเรือนได้ปรับเปลี่ยนระบบการผลิตมาเป็นการปลูกผักเพื่อที่จะได้รับมูลค่าเพิ่มต่อหน่วยพื้นที่สูงที่สุด อย่างไรก็ตาม ระบบการปลูกผักเป็นระบบที่ต้องการความรู้ความชำนาญและประสบการณ์เป็นพิเศษ ซึ่งเกษตรกรในพื้นที่ทุ่งลูกนกจำเป็นต้องใช้เวลาในการเรียนรู้และสั่งสม จึงจะทำให้ระบบการผลิตผักเป็นไปอย่างมีประสิทธิภาพและสร้างรายได้ตามมุ่งหวัง นอกจากนั้นการปลูกผักยังต้องการเงินลงทุนหมุนเวียน (ต้นทุนผันแปร) ค่อนข้างสูง เกษตรกรผู้ปลูกจะต้องมีความรู้ด้านความแปรปรวนของราคาตลาดในแต่ละช่วงเวลา จึงจะสามารถคาดเดาและวางแผนระบบการปลูกผักที่เหมาะสม ไม่ก่อให้เกิดภาวะเสี่ยงได้

ครัวเรือนเกษตรที่มีแรงงานในครอบครัวน้อยเมื่อเทียบกับขนาดที่ดินทำกิน จะมีการพัฒนาการปลูกไม้ผลในระบบการผลิต ซึ่งได้แก่ มะม่วง ชมพู่ ฝรั่ง เป็นต้น โดยเกษตรกรส่งผลผลิตขายเฉพาะตลาดในท้องถิ่น

ระบบการเลี้ยงวัวเนื้อและวัวนมได้มีการพัฒนาขึ้นในพื้นที่ทุ่งลูกนก เกษตรกรจำนวนหนึ่งปรับเปลี่ยนระบบผลิตทางการเกษตรในลักษณะผสมผสานระหว่างการปลูกพืช (ข้าวโพดฝักอ่อนและ/หรือข้าว) และการเลี้ยงสัตว์ (วัวเนื้อ/วัวนม) โดยต้นข้าวโพดฝักอ่อนและฟางข้าวจะใช้เป็นอาหารสำหรับวัว

โครงการส่งเสริมการเลี้ยงวัวนมในพื้นที่ทุ่งลูกนก เป็นโครงการที่เกิดขึ้นจากนโยบายเพิ่มผลผลิตน้ำนมดิบในประเทศ และรณรงค์ให้เกิดการดื่มนมด้วยการผลิตน้ำนมมีคุณภาพและราคาถูก โครงการดังกล่าวเป็นโครงการความร่วมมือระหว่างหลายหน่วยงาน ได้แก่ องค์การส่งเสริมกิจการโคนม (จัดหาพันธุ์วัว) ธนาคาร

เพื่อการเกษตรและสหกรณ์การเกษตร (บริการสินเชื่อ) มหาวิทยาลัยเกษตรศาสตร์ (จัดอบรมให้ความรู้) และบริษัทเอกชน (รับซื้อผลผลิต)

สำหรับการเลี้ยงสุกรและการเลี้ยงไก่เนื้อ ซึ่งเป็นระบบการผลิตแบบมีสัญญาผูกพัน พบเฉพาะเกษตรกรบางรายในพื้นที่ทุ่งลูกนก

นโยบายการส่งเสริมการลงทุนของรัฐและนโยบายการการกระจายอุตสาหกรรมสู่ชนบท ส่งผลให้เกิดการพัฒนาภาคอุตสาหกรรมในเขตลุ่มน้ำแม่กลองนับแต่ปี พ.ศ. 2520 เป็นต้นมา ซึ่งเป็นการสร้างโอกาสในการมีงานทำให้แก่เกษตรกรในพื้นที่ทุ่งลุกนกเช่นกัน เกษตรกรสามารถประกอบอาชีพนอกภาคการเกษตรด้วยการเป็นคนงานในโรงงาน ค้าขาย ประกอบกิจการอู่ซ่อมรถหรือทำธุรกิจรับเหมาก่อสร้าง ครัวเรือนเกษตรกรที่มีกิจกรรมหลากหลาย (pluri-activities) คือมีทั้งกิจกรรมการผลิตทางการเกษตรและกิจกรรมนอกภาคการเกษตร จะมีรายได้ที่แน่นอนและมากกว่าการทำอาชีพเกษตรเพียงอย่างเดียว มักพบว่าเกษตรกรนำรายได้ที่ได้รับจากกิจกรรมนอกภาคเกษตรไปลงทุนในการทำการเกษตรเพื่อให้ครัวเรือนเกษตรสามารถสืบทอดกิจกรรมการผลิตทางการเกษตรต่อไป

3.3 เขตนิเวศวิทยาการเกษตรและระบบการผลิตทางการเกษตรที่สำคัญ

ปัจจุบันพื้นที่ทุ่งลูกนกนับเป็นพื้นที่ที่มีความหลากหลายในการผลิตทางการเกษตร : อ้อย ข้าวโพดฝักอ่อน ข้าว พืชผัก ไม้ผล วัวเนื้อ-วัวนม สุกรและสัตว์ปีก โดยอ้อยและข้าวโพดฝักอ่อนนับเป็นพืชหลักของพื้นที่ เกษตรกรประมาณ 60 % ของพื้นที่ตำบลทุ่งลูกนกปลูกข้าวโพดฝักอ่อน และประมาณ 50 % ปลูกอ้อย ในส่วนของพื้นที่เพาะปลูก มีพื้นที่ปลูกอ้อยอยู่ประมาณ 74 % ของพื้นที่ทั้งหมดของตำบลทุ่งลูกนก และมีพื้นที่ปลูกข้าวโพดฝักอ่อน ประมาณ 13 %

จากการศึกษาเชิงพื้นที่ (spatial analysis) เพื่อวิเคราะห์ลักษณะทางกายภาพ ชีวภาพ และการใช้พื้นที่ทางการเกษตรของพื้นที่ทุ่งลูกนก ทำให้ทราบว่าปัจจัยทางสภาพแวดล้อมทางภูมิศาสตร์ เป็นปัจจัยสำคัญของความแตกต่างของระบบผลิตางการเกษตร แม้ว่าเกษตรกรจะทำการปรับเปลี่ยนสภาพแวดล้อม (artificialization) เพื่อใช้ประโยชน์ในการผลิตทางการเกษตรตามที่ต้องการได้ แต่การปรับเปลี่ยนดังกล่าวก็ทำได้ในระดับที่จำกัด

พื้นที่ทุ่งลูกนกสามารถแบ่งเขตเกษตรนิเวศออกเป็น 4 เขต คือ

(1) <u>เขตตอนเหนือ/ตอนบนของพื้นที่ (Northern zone)</u>

บริเวณนี้เป็นพื้นที่ที่มีลักษณะเป็นพื้นที่ค่อนข้างดอน (upper land) เป็นเขตที่มีระบบการปลูกอ้อยเป็นพืชหลัก (sugarcane based farming system)

สภาพภูมิประเทศโดยรอบ จะเห็นเป็นแปลงปลูกอ้อยขนาดใหญ่ มีคลองส่งน้ำชลประทานพาดผ่านพื้นที่ทางตอนเหนือ-ตะวันตก และทางตอนใต้- ตะวันออก แต่ระบบเครือข่ายชลประทานยังพัฒนาไม่ดีเท่าที่ควร โดยเฉพาะคลองส่งน้ำสายรองและคลองซอย ทำให้แปลงเพาะปลูกไม่ได้รับน้ำอย่างทั่วถึง เกษตรกรส่วนใหญ่ในพื้นที่เขตนี้เป็นเกษตรกรรายใหญ่ ซึ่งมีพื้นที่เพาะปลูกจำนวนมาก มีระบบการผลิตที่เฉพาะเจาะจง (specialization) โดยมีอ้อยเป็นพืชหลัก เกษตรกรกลุ่มนี้เป็นกลุ่มหัวหน้าโควต้าอ้อย ซึ่งมักเป็นหุ้นส่วนในบริษัทธุรกิจการเกษตรโดยเฉพาะบริษัทผลิตและจำหน่ายน้ำตาล (โรงงานน้ำตาล) พื้นที่การเกษตรบางส่วนใช้ในการปลูกผักหรือข้าวโพดฝักอ่อน ซึ่งเกษตรกรผู้ปลูกมักจะเป็นเกษตรกรรายย่อยที่มีพื้นที่เพาะปลูกต่ำกว่า 6 ไร่

ทางตอนเหนือ-ตะวันออก ใกล้กับหมู่บ้านหนองกร่าง มีฟาร์มเลี้ยงหมูขนาดใหญ่ มีวัวเนื้อบ้างแต่ก็น้อยมาก ส่วนวัวนมไม่มีการเลี้ยงในบริเวณนี้

พื้นที่ทางทิศตะวันออก จรดกับหมู่บ้านนาแกและหมู่บ้านหนองศาลา เป็นบริเวณที่มีการพัฒนาระบบชลประทาน ทำให้การปลูกข้าวโพดฝักอ่อนเป็นไปได้ด้วยดี ทางทิศตะวันตก ซึ่งพื้นที่มีลักษณะเป็นลอนลูกคลื่น มีการปลูกข้าวในเขตที่ลุ่ม

ส่วนบริเวณด้านล่าง ซึ่งเป็นเขตติดต่อกับเขตกลางของตำบลทุ่งลูกนก เกษตรกรมีพื้นที่ทำการเกษตรขนาดเล็กกว่าเกษตรกรทางตอนเหนือ มีการปลูกอ้อยเป็นพืชหลัก แต่อยู่ในระหว่างการปรับเปลี่ยนกิจกรรมการผลิต โดยมีความหลากหลายเพิ่มขึ้น โดยเฉพาะการปลูกข้าวโพดฝักอ่อน การเลี้ยงวัวเนื้อและสัตว์ปีก ตลอดจนวัวนมมีการเลี้ยงบ้างในบริเวณใกล้ๆ หมู่บ้านนาแกซึ่งมีการพัฒนาระบบการปลูกข้าวโพดฝักอ่อนเมื่อไม่นานมานี้

(2) <u>เขตตอนกลางของพื้นที่ (Central zone)</u>

บริเวณตอนกลาง (ตอนใต้ของถนนสายกำแพงแสน-พนมทวน) ของตำบลทุ่งลูกนกนี้ นับเป็นบริเวณที่มีสภาพของพื้นที่ที่แตกต่างกัน (heterogeneity) ก่อให้เกิดกิจกรรมการเกษตรหลากหลายและกระจายอยู่ทั่วไปทั้งพื้นที่ ได้แก่ อ้อย ข้าว ผัก ไม่มีพืชชนิดใดโดดเด่นเป็นพิเศษ (เช่นทางตอนเหนือที่มีการปลูกอ้อยมาก) พบว่ามีการพัฒนาการปลูกข้าวโพดฝักอ่อนในเขตหมู่บ้านหนองขโมย ซึ่งเป็นพื้นที่ที่มีการพัฒนาการเลี้ยงวัวเนื้อ สำหรับวัวนมมีการเลี้ยงในบางครัวเรือน ส่วนการเลี้ยงหมูและการเลี้ยงไก่พบเกือบทุกครัวเรือน เป็นการเลี้ยงเพื่อบริโภคในครอบครัว

เกษตรกรมีพื้นที่ทำการเกษตรขนาดกลางและมีความหลากหลายในการผลิตทางการเกษตร สำหรับครัวเรือนขนาดเล็กมักเป็นเกษตรกรที่มีการปลูกข้าวโพดฝักอ่อนเป็นพืชหลัก

(3) <u>เขตตอนใต้-ตะวันตกของพื้นที่ (Western-South zone)</u>
เป็นบริเวณที่มีที่ลุ่มมาก ข้าวเป็นพืชที่โดดเด่นในบริเวณนี้ และสามารถปลูกได้ 2 ครั้งในรอบปี เนื่องจากมีระบบชลประทานที่มีน้ำสมบูรณ์ พบการปลูกอ้อย ข้าวโพดฝักอ่อนในบริเวณนี้เช่นกัน มีการปลูกผักบ้างใกล้ๆ กับหมู่บ้านห้วยปลากดและหมู่บ้านอ้อกระทุง

เกษตรกรส่วนใหญ่ในเขตนี้เป็นเกษตรกรที่มีพื้นที่ทำกินขนาดกลาง ปลูกข้าวเป็นพืชหลัก แต่ก็มีความหลากหลายในการผลิต คือปลูกพืชอื่นๆ ในระบบการเกษตรด้วย

เกษตรกรรายเล็กมีระบบการทำการเกษตรที่เฉพาะเจาะจง (specialization) โดยมีข้าวโพดฝักอ่อนและ/หรือผักเป็นพืชหลัก มีการเลี้ยงวัวเนื้อทั่วไปในพื้นที่ โดยพบในครัวเรือนเกษตรกรที่ปลูกข้าว สำหรับการเลี้ยงวัวนมมักพบในครัวเรือนเกษตรที่ปลูกข้าวโพดฝักอ่อน โดยเฉพาะในบริเวณหมู่บ้านทุ่งกระถิน ซึ่งเป็นหมู่บ้านที่ได้รับการสนับสนุนจากรัฐบาลในการส่งเสริมการเลี้ยงวัวนม หมู่บ้านไร่แตงทองมีการเลี้ยงหมูเพื่อขายส่งเป็นหมูเนื้อ ซึ่งก็เป็นการสนับสนุนจากภาครัฐเช่นกัน

(4) <u>เขตตอนใต้-ตะวันออกของพื้นที่ (Eastern-South zone)</u>
บริเวณพื้นที่ตอนใต้-ตะวันออกของทุ่งลูกนก นับเป็นบริเวณที่มีระบบการปลูกอ้อยเป็นพืชหลักเช่นเดียวกับที่พบในเขตตอนเหนือ ทำให้เห็นสภาพภูมิประเทศเป็นแปลงอ้อยติดต่อกันเป็นผืนใหญ่
เกษตรกรในเขตนี้ส่วนใหญ่เป็นเกษตรกรที่มีพื้นที่ทำกินขนาดกลางและขนาดใหญ่ มีการปลูกข้าวในบริเวณที่ลุ่ม โดยเฉพาะในพื้นที่บริเวณรอบๆ หมู่บ้านห้วยผักชี นอกจากนั้นพบการเลี้ยงวัวเนื้อและวัวนม พื้นที่ตอนใต้-ตะวันออกนี้มีการปลูกข้าวโพดฝักอ่อนเช่นกัน โดยระบบการผลิตข้าวโพดฝักอ่อนพบมากในกลุ่มเกษตรกรรายย่อยซึ่งมีพื้นที่ทำกินขนาดเล็ก

3. 4 ประเภทของครัวเรือนเกษตรและระบบการผลิตทางการเกษตร

จากการศึกษาด้านเศรษฐกิจสังคม (socio-economic analysis) เพื่อวิเคราะห์โครงสร้างครัวเรือนเกษตรในด้านต่างๆ เช่น การถือครองที่ดิน ขนาดที่ดินทำการเกษตร จำนวนสมาชิกในครัวเรือน จำนวนแรงงานทำการเกษตรของครัวเรือน ลักษณะการผลิตทั้งการปลูกพืชและการเลี้ยงสัตว์ เครื่องจักรกลการเกษตร รายได้และสภาวะหนี้สิน รวมทั้งกิจกรรมทางการเกษตรอื่นๆ ทำให้ทราบว่าความหลากหลายของระบบการผลิตทางการเกษตรที่พบในพื้นที่ทุ่งลูกนก มีสาเหตุมาจากความแตกต่างของครัวเรือนเกษตร (farmer differentiation) โดยเฉพาะความแตกต่างในด้านการครอบครองปัจจัยการผลิต (means of production) อย่างไรก็ตาม ความสน

ใจ ความสามารถและความต้องการเฉพาะบุคคลตลอดจนความเป็นไปได้ในการพัฒนาระบบการผลิตทางการเกษตร ก็เป็นเงื่อนไขสำคัญที่ก่อให้เกิดการเลือกระบบการผลิตที่แตกต่างกัน

ครัวเรือนเกษตรในพื้นที่ทุ่งลูกนก แบ่งออกเป็น 3 ประเภทใหญ่ (7 กลุ่มย่อย) ดังต่อไปนี้

ประเภทที่ 1 : เกษตรกรรายใหญ่ มีที่ดินถือครองในการเกษตรมากกว่า 50 ไร่ และปลูกอ้อยเป็นพืชหลักในระบบการผลิต (Big farm / Sugarcane monoculture)

เกษตรกรประเภทนี้พบมากในเขตตอนเหนือและตะวันออกเฉียงใต้ของพื้นที่ทุ่งลูกนก ซึ่งเป็นพื้นที่ค่อนข้างดอน (upper land) และไม่ค่อยได้รับน้ำจากระบบชลประทาน เป็นเกษตรกรที่มีพื้นที่การเกษตรต่อแรงงานในครัวเรือนมาก ระบบการผลิตทางการเกษตรจึงมีอ้อยเป็นพืชหลัก (monoculture) จัดเป็นระบบเกษตรที่ไม่ต้องใช้แรงงานคนในการปฏิบัติดูแลเท่าใดนัก (labor extensive farming) อย่างไรก็ตาม เนื่องจากมีพื้นที่ขนาดใหญ่ จำเป็นต้องมีการจ้างแรงงานภายนอกมาทำงานในฟาร์ม ทั้งที่เป็นแรงงานประจำและแรงงานชั่วคราว โดยจ้างเฉพาะช่วงที่มีงานหนัก (peak of work) เช่น ช่วงการปลูกอ้อย และตัดอ้อย

เกษตรกรประเภทนี้ มีความสามารถในการลงทุนระดับสูง จึงมีการจัดซื้อปัจจัยการผลิตที่เป็นเครื่องมือเครื่องจักรกลการเกษตรที่สำคัญในการปลูกอ้อยมาเป็นของตนเอง ได้แก่ รถแทรกเตอร์ขนาดใหญ่ รถพรวนดิน และรถบรรทุก (รถ 10 ล้อ)

เราสามารถแบ่งครัวเรือนเกษตรประเภทที่ 1 นี้ออกเป็น 2 กลุ่มย่อยคือ

<u>กลุ่ม 1.1</u> : เกษตรกรรายใหญ่มาก/ฟาร์มระบบนายทุน (Capitalist farm)

เกษตรกรกลุ่มนี้มีพื้นที่ถือครองในการเกษตรมากกว่า 100 ไร่ เป็นที่ดินของตนเอง มักเป็นกลุ่มหัวหน้าโควต้าอ้อยซึ่งมีเชื้อสายจีน ตั้งหลักแหล่งถิ่นฐานอยู่บริเวณตอนเหนือของพื้นที่ทุ่งลูกนกและอาจมีพื้นที่การเกษตรที่ใช้ในการเพาะปลูกอ้อยอยู่นอกเขตพื้นที่ทุ่งลูกนกด้วยเช่นเดียวกัน ในอดีตอันยาวนานนับชั่วอายุคน ครัวเรือนเกษตรประเภทนี้ได้มีการสะสมทุนทั้งที่เป็นเงินและที่ดิน มีประสบการณ์ในการปลูกอ้อยตั้งแต่ยุคเริ่มต้นของการนำอ้อยเข้ามาปลูกในพื้นที่ทุ่งลูกนก (ประมาณ 40 ปีมาแล้ว) ระบบการผลิตทางการเกษตรจัดเป็นฟาร์มในระบบนายทุนโดยมีอ้อยเป็นพืชหลัก เป็นครัวเรือนเกษตรที่มีกิจกรรมการผลิตเฉพาะทาง (specialization) มีพื้นที่เกษตรต่อหน่วยแรงงานครอบครัวสูงมาก จึงมีการลงทุนในด้านเครื่องมือ เครื่องจักรกลในการทุ่นแรง (รถแทรกเตอร์, รถบรรทุก) และมีการจ้างแรงงานเป็นจำนวนมาก สำหรับการใช้แรงงานในครัวเรือนเป็นลักษณะของผู้บริหารกิจการฟาร์ม คือเป็นผู้วางแผนและจัดการดูแลแรงงานจ้างทั้งที่เป็นแรงงานประจำและแรงงานชั่วคราว

เกษตรกรกลุ่มนี้ทำหน้าที่เป็นหัวหน้าโควต้าอ้อยซึ่งเป็นคนกลางระหว่างผู้ปลูกอ้อยในพื้นที่ทุ่งลูกและโรงงานผลิตน้ำตาลทราย โดยมีโควต้าอยู่ในระดับมากกว่า 10,000 ตันต่อปี ดังนั้นเครื่องมือเครื่องจักรกลการเกษตรที่มีในฟาร์ม นอกจากจะใช้ในกิจกรรมการผลิตของตนเองแล้ว ยังนำมาใช้บริการแก่ผู้ปลูกอ้อยรายอื่นๆในพื้นที่ซึ่งมักเป็นเกษตรกรรายย่อย (ลูกไร่) และในกรณีที่เกษตรกรรายย่อยขาดแคลนเงินทุนในการจัดซื้อปัจจัยการผลิต เช่น ปุ๋ย ยากำจัดศัตรูพืช น้ำมัน ฯลฯ เกษตรกรรายใหญ่กลุ่มนี้จะเป็นผู้จัดหาให้บริการด้านสินเชื่อและปัจจัยการผลิตดังกล่าว

วัตถุประสงค์ในการดำเนินกิจกรรมการผลิตของครัวเรือนเกษตรกรประเภทนี้ คือ การได้รับผลตอบแทนสูงสุดจากการลงทุน ทั้งที่เป็นการลงทุนในภาคเกษตรและนอกภาคการเกษตร ดังนั้นจึงพบว่าเกษตกรบางรายได้มีการดำเนินกิจการรับจ้างบรรทุกดินและทรายจากบ่อดิน/บ่อทรายที่มีอยู่ในบริเวณพื้นที่ทุ่งลูกนก และพื้นที่ใกล้เคียงเข้าสู่กรุงเทพฯ โดยกิจกรรมนอกภาคเกษตรนี้นับเป็นแหล่งรายได้ที่สำคัญของเกษตรกรกลุ่มนี้

<u>กลุ่ม 1.2</u> : **เกษตรกรรายใหญ่/ฟาร์มระบบธุรกิจ (Business farm)**

เกษตรกรกลุ่มนี้มีพื้นที่ถือครองขนาด 50-100 ไร่ โดยทั่วไปมักเป็นเจ้าของที่ดิน เป็นกลุ่มหัวหน้าโควต้าอ้อยขนาดกลาง คือ มีโควต้าอ้อยประมาณ 5,000 ตันต่อปี ระบบการผลิตทางการเกษตรจัดเป็นฟาร์มในระบบธุรกิจโดยมีอ้อยเป็นพืชหลัก เป็นครัวเรือนเกษตรที่มีกิจกรรมการผลิตเฉพาะทาง (specialization) มีการลงทุนในด้านเครื่องมือ เครื่องจักรกลการเกษตรเช่นเดียวกับเกษตรกรกลุ่มแรก (กลุ่มที่ 1.1) แต่ในสัดส่วนที่น้อยกว่า ในด้านการใช้แรงงาน มีทั้งการจ้างแรงงานประจำและแรงงานชั่วคราว แต่ก็เป็นการจ้างในจำนวนที่น้อยกว่ากลุ่มแรกเช่นกัน ข้อแตกต่างที่สำคัญระหว่างฟาร์มระบบนายทุนและฟาร์มระบบธุรกิจคือ แรงงานในครัวเรือนของฟาร์มระบบธุรกิจนี้ จะมีส่วนร่วมในการทำงานด้านการเกษตรโดยมีการปฏิบัติกิจกรรมการผลิตทางการเกษตรด้วยตนเอง

นอกเหนือจากการทำฟาร์ม ครัวเรือนเกษตรกรประเภทนี้มีกิจกรรมนอกภาคการเกษตรเช่นกัน คือ การให้บริการด้านเครื่องจักรกลการเกษตร (การเตรียมดิน, การขนส่ง) การให้บริการปัจจัยการผลิตล่วงหน้าและให้บริการสินเชื่อแก่เกษตรกรรายย่อย (ลูกไร่) โดยมีจำนวนลูกไร่ที่รับบริการน้อยกว่าเกษตรกรประเภทแรก (ฟาร์มระบบนายทุน) ทั้งนี้รายได้ที่ได้รับจากการให้บริการดังกล่าว ทำให้เกิดความคุ้มทุนจากการลงทุนด้านเครื่องจักรกลการเกษตร อย่างไรก็ตาม ผลจากการที่ราคาอ้อยตกต่ำติดต่อกันหลายปี เกษตรกรภายในกลุ่มนี้เริ่มสนใจกิจกรรมการผลิตทางการเกษตรที่หลากหลาย (diversification) โดยต้องการพัฒนาระบบการปลูกพืชและระบบการเลี้ยงสัตว์ที่เหมาะสม สามารถปรับให้เข้ากับปัจจัยการผลิตที่ตนมีอยู่

ประเภทที่ 2 : ครัวเรือนเกษตรขนาดกลางและขนาดเล็ก/ฟาร์มระบบครอบครัว (Small and Middle Family farm)

เกษตรกรประเภทนี้พบหนาแน่นในเขตตอนกลางและเขตตะวันตกเฉียงใต้ของพื้นที่ทุ่งลูกนก ซึ่งเป็นพื้นที่ที่มีระบบเครือข่ายชลประทานที่ดี ขนาดพื้นที่ทำกินอยู่ในช่วง 6-50 ไร่ สภาพการถือครองที่ดินมักเป็นที่ดินของตนเอง เป็นครัวเรือนเกษตรที่มีที่ดินทำการเกษตรต่อแรงงานครอบครัวในระดับปานกลางถึงระดับน้อย เกษตรกรบางครัวเรือนอาจต้องจ้างแรงงานภายนอกมาช่วยกัน โดยเป็นการจ้างแรงงานชั่วคราวมาเฉพาะช่วงที่กิจกรรมการผลิตต้องการแรงงานจำนวนมาก (peak of work)ไม่มีการจ้างแรงงานประจำมาทำงานในฟาร์ม

ความสามารถในการลงทุนของครัวเรือนเกษตรประเภทนี้ค่อนข้างจำกัด แต่ได้รับสิทธิประโยชน์จากการบริการสินเชื่อของรัฐ (โดยมีที่ดินถือครองของตนเอง เพื่อใช้ในการค้ำประกันการกู้ยืมสินเชื่อจากภาครัฐ) ในด้านเครื่องมือเครื่องทุ่นแรงไม่สามารถลงทุนซื้อเครื่องจักรกลการเกษตรขนาดใหญ่ที่มีราคาแพงได้ (รถแทรกเตอร์, รถบรรทุก) จึงใช้บริการในด้านการเตรียมดิน การเตรียมแปลงเพาะปลูก และการขนส่งผลผลิตทางการเกษตร จากกลุ่มหัวหน้าโควต้าหรือกลุ่มพ่อค้าคนกลาง และเนื่องจากพื้นที่ถือครองมีขนาดไม่ใหญ่มากพอที่จะคุ้มต่อการลงทุนซื้อเครื่องจักรกล แม้เกษตรกรบางรายจะมีเงินทุนเพียงพอ แต่ก็ตัดสินใจเลือกรับบริการมากกว่าจะลงทุนซื้อเครื่องมือเครื่องทุ่นแรงขนาดใหญ่เป็นของตนเอง

ต้นทุนคงที่ (ค่าเสื่อมราคาจากเครื่องจักรกลการเกษตร) ในระบบการผลิตของครัวเรือนเกษตรกลุ่มนี้จึงค่อนข้างต่ำ ทำให้เกษตรกรกลุ่มนี้มีความคล่องตัวและความยืดหยุ่น (flexibility)ในระดับสูง สามารถปรับตัวเลือกทิศทางการผลิต และเลือกระบบการผลิตที่เหมาะสมกับโครงสร้างครัวเรือนเกษตรของตนเอง เกษตรกรแต่ละรายสามารถเลือกระบบการผลิตหลากหลาย ไม่ว่าจะเป็นระบบการปลูกพืชหรือระบบการเลี้ยงสัตว์ที่แตกต่างกันตามปัจจัยการผลิตที่แต่ละครัวเรือนมีอยู่ เช่น ความสามารถในการจัดหาแรงงาน ทุน ทั้งนี้เกษตรกรได้คำนึงถึงองค์ประกอบอื่นๆ เช่น การเปลี่ยนแปลงด้านผลตอบแทนทางเศรษฐกิจ รายได้เปรียบเทียบระหว่างผลผลิตต่างชนิด การได้มาซึ่งปัจจัยการผลิต (ปุ๋ย, สารเคมีกำจัดศัตรูพืช) ความคล่องตัวของระบบตลาด และความเสี่ยงในการดำเนินกิจกรรมการผลิต

คุณลักษณะที่สำคัญของเกษตรกรประเภทนี้จึงได้แก่ ความหลากหลาย (diversity) ทั้งในระดับครัวเรือนเกษตรกร และในระดับระบบการผลิตทางการเกษตร ความแตกต่างในด้านสภาพภูมิประเทศของพื้นที่ทำกินแต่ละแปลงของเกษตรกรแต่ละครัวเรือน เป็นปัจจัยสาเหตุและข้อจำกัดในการเลือกระบบผลิตทางการเกษตร โดยเฉพาะระบบการปลูกพืช โดยกฎเกณฑ์ทั่วไปแปลงเพาะปลูกที่อยู่ในเขตที่ดอน และได้รับน้ำจากระบบชลประทานไม่เพียงพอ เกษตรกรจะมีการปลูกอ้อย หากพื้นที่ได้รับน้ำชลประทานสม่ำเสมอตลอดปี เกษตรกรจะเลือกปลูกข้าวโพดฝักอ่อน ซึ่งเป็นพืชอายุสั้นสามารถเก็บเกี่ยวได้ 4-5 ครั้งในรอบปี และหากแปลงปลูกอยู่ในเขตที่ลุ่ม มีการระบายน้ำไม่ดี เกษตรกรจะมีการทำนาปลูกข้าวในบริเวณที่ลุ่มนี้ สำหรับการพัฒนาระบบการเลี้ยงสัตว์จะขึ้นอยู่กับความสามารถในการลงทุนของครัวเรือนเกษตร หากมีเงินทุนเพียงพอ (เงินทุนของตนเองหรือสินเชื่อจากธนาคาร) ก็อาจลงทุนเลี้ยงวัวเนื้อหรือหมูขุนในกรณีที่มีแรงงานในครัว

เรือนจำกัด แต่หากมีแรงงานครอบครัวมากพอก็สามารถเลี้ยงวัวนม ซึ่งเป็นสัตว์ที่ต้องการการดูแลเอาใจใส่มากกว่าการเลี้ยงวัวเนื้อหรือหมูขุน

โดยทั่วไปแล้ว ครัวเรือนเกษตรที่มีพื้นที่ทำกินขนาดใหญ่มักจะมีอ้อยอยู่ในระบบการผลิต สัดส่วนของพื้นที่ปลูกอ้อยจะมีมากในครัวเรือนที่มีที่ดินทำกินมาก (ขนาดพื้นที่อ้อยผันแปรตามขนาดพื้นที่ถือครองทำการเกษตร) ในขณะที่การปลูกข้าวโพดฝักอ่อนซึ่งเป็นพืชที่ต้องการแรงงานในการปฏิบัติดูแลมากกว่าอ้อย จะพบในครัวเรือนเกษตรที่มีพื้นที่ขนาดเล็กกว่า

ระบบการผลิตทางการเกษตรที่หลากหลาย (diversification) ของครัวเรือนเกษตรกลุ่มนี้ เป็นผลมาจากการผสมผสาน (combination) ระบบการปลูกพืชและระบบการเลี้ยงสัตว์เข้าด้วยกัน (ข้าว, อ้อย, ข้าวโพดฝักอ่อน, วัวเนื้อ, วัวนม ฯลฯ) ซึ่งระบบเหล่านี้เข้ากันได้ดี (compatible) และบางระบบเกื้อกูลซึ่งกันและกัน (complementary) (เช่น ระบบการผลิตที่มีการปลูกข้าวโพดฝักอ่อนและการเลี้ยงวัวนม-วัวเนื้อ โดยต้นข้าวโพดฝักอ่อนเป็นอาหารหยาบให้แก่วัวนม-วัวเนื้อ และมูลสัตว์เป็นปุ๋ยให้แก่ข้าวโพดฝักอ่อน) ซึ่งส่งผลให้ครัวเรือนเกษตรที่มีระบบการผลิตที่หลากหลายนี้ สามารถเพิ่มประสิทธิภาพแรงงานโดยสามารถปรับเปลี่ยนหรือจัดลำดับขั้นตอนการผลิตให้สอดคล้องกับความต้องการแรงงานของกิจกรรมแต่ละประเภท เกิดภาวะความเสี่ยงน้อยลงเนื่องจากมีหลักประกันจากกิจกรรมหลากหลาย และสามารถมีรายได้ต่อเนื่องสม่ำเสมอตลอดปี

ในพื้นที่ทุ่งถูกนกพบว่าเกษตรกรบางรายในกลุ่มนี้ พยายามที่จะริเริ่มทำกิจกรรมค้าขายผลผลิตการเกษตรด้วยตนเอง โดยเกษตรกรได้สะสมทุนในระดับที่สามารถลงทุนซื้อรถบรรทุกขนาดเล็ก (รถ pick-up) เพื่อใช้ในการรวบรวมผลผลิตทางการเกษตรทั้งของตนเอง ญาติพี่น้องและเพื่อนบ้านใกล้เคียง และขนส่งผลผลิตดังกล่าวสู่ตลาด เป็นการลดการถูกกดราคาจากกลุ่มพ่อค้าคนกลางและทำให้มีรายได้เพิ่มขึ้น

เราสามารถแบ่งครัวเรือนเกษตรประเภทที่ 2 นี้ออกเป็น 3 กลุ่มย่อย คือ

<u>กลุ่ม 2.1</u> : ฟาร์มขนาดกลางปลูกอ้อยเป็นพืชหลัก (Sugarcane monoculture/ Family farm)
ครัวเรือนเกษตรกลุ่มนี้ มีที่ดินทำการเกษตรประมาณ 10-20 ไร่ ต่อหนึ่งหน่วยแรงงานครอบครัว มักมีแปลงเพาะปลูกอยู่ในเขตที่ไม่ได้รับน้ำชลประทานสม่ำเสมอ จึงทำให้เลือกระบบการปลูกอ้อยเป็นระบบการผลิตหลักของครอบครัว การขาดแคลนน้ำและการขาดแคลนแรงงานครอบครัวในการเพาะปลูก ทำให้ไม่สามารถเลือกปลูกพืชที่มีมูลค่าเพิ่มสูงกว่าอ้อย เช่น ข้าวโพดฝักอ่อนได้

ความแตกต่างของเกษตรกรกลุ่มที่ 2.1 (ฟาร์มขนาดกลางปลูกอ้อยเป็นพืชหลัก) กับเกษตรกรกลุ่มที่ 1.2 (เกษตรกรรายใหญ่/ฟาร์มระบบธุรกิจ) คือ กลุ่มนี้มีความสามารถในการลงทุนน้อยกว่า จึงไม่สามารถเป็นเจ้าของเครื่องจักรกลการเกษตรขนาดใหญ่ จำเป็นต้องรับการบริการจากหัวหน้าโควต้าอ้อยในด้านการเตรียมดิน

(การเตรียมแปลงปลูกอ้อย) และการขนส่งอ้อย ในบางกรณีเกษตรกรบางรายรับบริการปัจจัยการผลิตล่วงหน้าและสินเชื่อจากจากหัวหน้าโควต้าอ้อยด้วย

วิวัฒนาการของระบบการผลิตทางการเกษตรของเกษตรกรขนาดกลางที่เกิดขึ้นเมื่อไม่นานมานี้ คือ มีเกษตรกรบางรายแบ่งพื้นที่ทำกินส่วนหนึ่งเพื่อใช้ในการปลูกข้าวโพดฝักอ่อน โดยมีการขุดบ่อบาดาลเพื่อสูบน้ำมาใช้ในการปลูกข้าวโพดฝักอ่อน และมีการจ้างแรงงานนอกฟาร์มมาช่วยงาน แนวโน้มการผลิตเชิงหลากหลาย (diversification) สำหรับเกษตรกรกลุ่มนี้โดยการนำข้าวโพดฝักอ่อนเข้ามาเป็นกิจกรรมหนึ่งในระบบการผลิตทางการเกษตร มีสาเหตุมาจากการพัฒนาเครือข่ายระบบชลประทานในพื้นที่ทุ่งลูกนก จากราคาที่จูงใจของข้าวโพดฝักอ่อน และจากความเป็นไปได้ในการจัดหาแรงงานจ้างชั่วคราวในพื้นที่

<u>กลุ่ม 2.2</u> : ฟาร์มขนาดกลางปลูกพืชหลายชนิดและมีการเลี้ยงสัตว์ในระบบการผลิต (Polyculture – Animal/ Family farm)

ครัวเรือนเกษตรกลุ่มนี้มีสัดส่วนพื้นที่ทำการเกษตรต่อหน่วยแรงงานครอบครัวน้อยกว่าเกษตรกรกลุ่มที่2.1 (ฟาร์มขนาดกลางปลูกอ้อยเป็นพืชหลัก) คืออยู่ในช่วงประมาณ 3 – 20 ไร่ แปลงเพาะปลูกอยู่ในพื้นที่ที่มีการพัฒนาระบบเครือข่ายชลประทานดี จึงมีสภาพการใช้น้ำที่สะดวก ทำให้สามารถพัฒนาการปลูกข้าวโพดฝักอ่อนซึ่งเป็นพืชที่ต้องการแรงงานในการดูแลเพิ่มขึ้น และเป็นพืชที่ให้มูลค่าเพิ่มสูงกว่าอ้อย เกษตรกรกลุ่มนี้มีการใช้พื้นที่ส่วนหนึ่งของพื้นที่ทำการเกษตรในการปลูกข้าวโพดฝักอ่อน การวางแผนปลูกข้าวโพดฝักอ่อนให้ได้พื้นที่ปลูกสูงสุดขึ้นอยู่กับจำนวนแรงงานครอบครัวที่มีอยู่และสภาพของระบบน้ำในแปลงปลูก สำหรับพื้นที่ทำกินส่วนที่เหลือ เกษตรกรจะไว้ใช้ในการปลูกอ้อย ในแปลงเพาะปลูกที่มีน้ำอุดมสมบูรณ์ เกษตรกรสามารถปลูกข้าวโพดฝักอ่อนได้ตลอดทั้งปี หากครัวเรือนเกษตรกรสามารถจัดหาแรงงานรับจ้างชั่วคราวสำหรับกิจกรรมการผลิตที่สำคัญซึ่งต้องใช้แรงงานมาก (peak of work) ซึ่งได้แก่ ช่วงการถอดยอดและการเก็บฝักข้าวโพด จะทำให้ครัวเรือนเกษตรกรนั้นสามารถปลูกข้าวโพดฝักอ่อนในพื้นที่เพิ่มขึ้น และมีจำนวนครั้งของการปลูกในรอบปีมากขึ้น (เพิ่มจาก 2 – 3 ครั้งเป็น 4 – 5 ครั้งต่อปี) เทคนิคการแบ่งแปลงเพาะปลูกเป็นแปลงย่อยๆและการปลูกข้าวโพดฝักอ่อนเหลื่อมเวลากัน โดยมีช่วงการปลูกในแต่ละแปลงห่างกัน 7 – 10 วัน ซึ่งต้นข้าวโพดของแต่ละแปลงจะเจริญเติบโตต่างกัน จะทำให้เกษตรกรสามารถดูแลแปลงเพาะปลูกได้อย่างทั่วถึง เป็นการใช้แรงงานในครัวเรือนได้อย่างมีประสิทธิภาพมากขึ้น

สัดส่วนในการใช้พื้นที่ปลูกพืชแต่ละชนิดของครัวเรือนเกษตรแต่ละรายมีความหลากหลายมาก โดยความสัมพันธ์ระหว่างขนาดของพื้นที่ต่อแรงงานครอบครัวเป็นปัจจัยสาเหตุ ครัวเรือนที่มีพื้นที่ทำกินต่อหน่วยแรงงานครอบครัวน้อยก็จะเลือกปลูกข้าวโพดฝักอ่อน ในกรณีที่เกษตรกรมีพื้นที่แต่มีแรงงานครอบครัวจำกัดก็สามารถเพิ่มพื้นที่การปลูกข้าวโพดฝักอ่อนได้จากการหาแรงงานนอกครัวเรือนมาช่วย ซึ่งเกษตรกรจำเป็นต้องมีเงินทุนในการจ่ายค่าจ้าง และในพื้นที่นั้นจะต้องมีแรงงานรับจ้างให้เรียกใช้บริการได้เป็นประจำ การ

ช่วยเหลือด้านแรงงานด้วยระบบเอาแรงระหว่างญาติพี่น้องและเพื่อนบ้าน สามารถช่วยแก้ปัญหาการขาดแคลนแรงงานในช่วงที่มีความต้องการแรงงานสูงได้เช่นกัน

เกษตรกรกลุ่มนี้ไม่มีความสามารถในการลงทุนด้านเครื่องจักรกลการเกษตร การเตรียมดินปลูกพืชและการขนส่งผลผลิต จึงเป็นการรับบริการจากกลุ่มหัวหน้าโควต้าหรือกลุ่มพ่อค้าคนกลางในพื้นที่

เกษตรส่วนหนึ่งในกลุ่มนี้มีเงินทุนเพียงพอที่จะพัฒนาระบบการเลี้ยงสัตว์ ได้แก่ การเลี้ยงหมูขุนซึ่งมีบริษัทธุรกิจเอกชนเข้าร่วมดำเนินการและร่วมลงทุน (contact farming) การเลี้ยงวัวเนื้อหรือวัวนมซึ่งต้องการทุนที่เพิ่มขึ้นตามลำดับ

ระบบการผลิตที่ผสมผสานระหว่างการปลูกข้าวโพดฝักอ่อนและการเลี้ยงวัวนม เป็นระบบการผลิตที่ให้มูลค่าเพิ่มและผลตอบแทนสูง โดยเกษตรกรที่สามารถพัฒนาระบบข้าวโพดฝักอ่อน – วัวนม จะต้องเป็นเกษตรกรที่มีแรงงานครัวเรือนพอเพียงคือ อย่างน้อย 2 – 3 คน เงินทุนเป็นปัจจัยสำคัญอีกประการหนึ่งเนื่องจากการเลี้ยงวัวนมต้องการเงินลงทุนสูง ในกรณีที่เกษตรกรขาดเงินทุนของตนเองสามารถขอรับบริการด้านสินเชื่อจากธนาคารเพื่อการเกษตรและสหกรณ์การเกษตรได้ โดยต้องมีที่ดินในการค้ำประกัน สำหรับรายได้ที่ได้รับจากระบบการผลิตแบบผสมผสานระหว่างข้าวโพดฝักอ่อนและวัวนมมากกว่าระบบการปลูกข้าวโพดฝักอ่อนเพียงอย่างเดียวถึง 2 เท่า

เกษตรกรที่มีแรงงานครัวเรือนน้อยและมีความสามารถในการลงทุนน้อยกว่าจะพัฒนาระบบการผลิตข้าวโพดฝักอ่อน – วัวเนื้อแทนระบบข้าวโพดฝักอ่อน – วัวนม เนื่องจากการทำงานมีความเข้มข้นด้านแรงงานน้อยกว่า การลงทุนด้านการเลี้ยงต่ำกว่า และความต้องการต้นข้าวโพดฝักอ่อนทั้งด้านปริมาณและคุณภาพเพื่อเป็นอาหารสำหรับวัวเนื้อมีน้อยกว่าเมื่อเปรียบเทียบกับวัวนม แม้ระบบข้าวโพดฝักอ่อน – วัวเนื้อ จะให้รายได้ในระดับปานกลางคือ ต่ำกว่าระบบข้าวโพดฝักอ่อน – วัวนม แต่เกษตรกรก็ได้รับผลตอบแทนมากกว่าการปลูกข้าวโพดฝักอ่อนเพียงอย่างเดียว

<u>กลุ่ม 2.3</u> : ฟาร์มขนาดกลางปลูกพืชผสมผสาน มี/ ไม่มีระบบการเลี้ยงสัตว์ (Polyculture with/without Animal/ Family farm)

เกษตรกรกลุ่มนี้มีการปลูกข้าวในระบบการผลิต เป็นครัวเรือนเกษตรที่มีพื้นที่ทำกินในบริเวณที่ค่อนข้างลุ่ม (low land) ซึ่งอยู่ในเขตตะวันตกเฉียงใต้ของพื้นที่ทุ่งลูกนก เป็นพื้นที่ที่มีระบบชลประทานเข้าถึงแต่พื้นที่บางแปลงมีปัญหาด้านการระบายน้ำ เกษตรกรที่มีพื้นที่เพาะปลูกในบริเวณที่มีการระบายน้ำดี จะสามารถปลูกอ้อยหรือปลูกข้าวโพดฝักอ่อนได้ โดยสัดส่วนการใช้พื้นที่ในการปลูกพืชแต่ละชนิดขึ้นอยู่กับปัจจัยด้านขนาดของพื้นที่ สภาพการชลประทาน และจำนวนแรงงานที่มีในครัวเรือน

การทำนาในพื้นที่นี้สามารถทำได้ 2 ครั้งในรอบปี โดยในช่วงฤดูนาปีซึ่งมีปริมาณน้ำมาก เกษตรกรจะใช้ข้าวพันธุ์พื้นเมืองในแปลงนาที่มีการระบายน้ำไม่ดี แต่หากแปลงนาอยู่ในพื้นที่ที่สามารถควบคุมระดับน้ำได้ เกษตรกรจะเลือกปลูกข้าวพันธุ์แนะนำลูกผสมซึ่งให้ผลผลิตสูง สำหรับการทำนาในฤดูนาปรัง เกษตรกรใช้ข้าวพันธุ์แนะนำลูกผสมซึ่งเป็นพันธุ์ไม่ไวแสง จึงสามารถปลูกได้ตลอดทั้งปี

โดยทั่วไปครัวเรือนเกษตรกลุ่มนี้มักเป็นเจ้าของที่ดิน แรงงานที่ใช้ในการทำนาเป็นแรงงานในครอบครัว มีปัจจัยการผลิตด้านเครื่องทุ่นแรงได้แก่ รถไถนา เครื่องสูบน้ำ เป็นของตนเอง ในกรณีที่ไม่มีเงินลงทุนซื้อรถไถนาเป็นของตนเองก็สามารถเช่ารถไถนาจากเกษตรกรรายอื่นในพื้นที่ได้ สำหรับการเก็บเกี่ยวข้าวและนวดข้าว เกษตรกรจะใช้บริการจากรถเกี่ยวและนวดข้าวซึ่งเป็นของคนต่างถิ่นเข้ามาบริการในพื้นที่ทุ่งลูกนก

เกษตรกรในกลุ่มนี้สามารถพัฒนาการเลี้ยงสัตว์คือวัวเนื้อและวัวนมในระบบการผลิตทางการเกษตรของตนเอง ทั้งนี้ขึ้นอยู่กับปัจจัยด้านแรงงานครอบครัว และความสามารถในการลงทุน

<u>ประเภทที่ 3</u> : ครัวเรือนเกษตรขนาดเล็กมาก/ฟาร์มระบบครอบครัว (Very small family farm)

เกษตรกรประเภทนี้พบเป็นจำนวนมากในเขตตอนกลางและพบกระจายอยู่ทั่วไปในพื้นที่ทุ่งลูกนก มีพื้นที่ถือครองขนาดเล็กมากคือระหว่าง 1-6 ไร่ จากภาวะหนี้สินซึ่งมีสาเหตุส่วนหนึ่งมาจากการที่อ้อยมีราคาตกต่ำ ครัวเรือนเกษตรกลุ่มนี้ได้ขายที่ดินทำกินของตนเองบางส่วน เกษตรกรบางรายในกลุ่มนี้ต้องเช่าที่ดินทำการเกษตรจากผู้อื่น เพิ่มจากที่ดินที่ตนมีอยู่

การครอบครองที่ดินและเงินทุนเป็นปัญหาสำคัญที่เกษตรกรกลุ่มนี้ประสบ เมื่อพิจารณาถึงแรงงานครอบครัวจะพบว่ามีจำนวนมากเมื่อเปรียบเทียบกับขนาดที่ดินถือครอง นั่นคือมีแรงงานส่วนเกินซึ่งสามารถออกไปทำงานนอกฟาร์ม ซึ่งเป็นทั้งงานในภาคเกษตรและนอกภาคเกษตรเพื่อเพิ่มรายได้ให้แก่ครัวเรือน

เราสามารถแบ่งครัวเรือนเกษตรประเภทที่ 3 ย่อยๆเป็น 2 กลุ่มย่อยคือ

<u>กลุ่ม 3.1</u> : ฟาร์มขนาดเล็กมากมีระบบการผลิตแบบใช้แรงงานเข้มข้น (Babycorn monoculture/ Family farm)

ครัวเรือนเกษตรกลุ่มนี้มีพื้นที่ทำกินขนาดเล็กมากคือน้อยกว่า 3 ไร่ ต่อแรงงานครอบครัว และเป็นพื้นที่สามารถรับน้ำจากระบบชลประทานได้ดี จึงเลือกระบบการผลิตทางการเกษตรที่เข้มข้นในด้านการใช้แรงงานครอบครัว (labour intensive farming) ได้แก่ การปลูกข้าวโพดฝักอ่อน โดยมีจำนวนครั้งของการปลูกถึง 5 ครั้งในรอบปี เกษตรกรบางรายมีการเช่าที่ดินเพิ่มในการปลูกข้าวโพดฝักอ่อนเพื่อใช้แรงงานครอบครัวให้เต็มที่ ในขณะที่เกษตรกรบางรายนอกจากจะทำการผลิตในฟาร์มของตนเองแล้ว ยังมีอาชีพรับจ้างทำการเกษตรให้กับเกษตรกรรายอื่น เช่น รับจ้างปลูกข้าวโพด รับจ้างเก็บข้าวโพด และรับจ้างทั่วไป รายได้หลักของ

ครัวเรือนที่ได้จากการผลิตในฟาร์ม และรายได้เสริมที่ได้จากการทำงานรับจ้างในพื้นที่ มีเพียงพอที่จะทำให้อยู่ภาคเกษตรต่อไปได้ โดยรายได้ที่ได้รับจากการขายแรงงานรับจ้างในภาคเกษตรมีสัดส่วนประมาณ 30-50% ของรายได้สุทธิครัวเรือน

เกษตรกรกลุ่มนี้ไม่มีเงินทุนและไม่มีโอกาสได้รับบริการสินเชื่อจากธนาคาร เนื่องจากมีที่ดินถือครองจำนวนน้อยไม่เพียงพอต่อการค้ำประกันสินเชื่อ ดังนั้นจึงขาดโอกาสการลงทุนด้านการเลี้ยงสัตว์ เกษตรกรบางรายจำเป็นต้องรับบริการ เงินกู้จากพ่อค้าคนกลางหรือนายทุนในพื้นที่เพื่อนำไปซื้อปัจจัยการผลิตในการปลูกข้าวโพดฝักอ่อน เกษตรกรรายที่มีพื้นที่เพาะปลูกในเขตที่ลุ่ม (มักมีพื้นที่น้อยกว่า 1 ไร่) จะทำนาปลูกข้าว โดยผลผลิตที่ได้จะไม่มีการขายแต่จะเก็บไว้เพื่อการบริโภคในครัวเรือน

<u>กลุ่ม 3.2</u> : ฟาร์มขนาดเล็กมากปลูกอ้อยเป็นพืชหลักและขายแรงงาน (Sugarcane monoculture/ Laborforce in non-agriculture)

ครัวเรือนเกษตรกรกลุ่มนี้เป็นกลุ่มที่มีเงื่อนไขข้อจำกัดในการผลิตทางการเกษตร กล่าวคือมีขนาดที่ดินทำกินเล็กมากคือ น้อยกว่า 3 ไร่ต่อแรงงานครอบครัว และเป็นพื้นที่ที่ไม่ได้รับน้ำจากระบบชลประทาน ทำให้ไม่สามารถพัฒนาการปลูกข้าวโพดฝักอ่อนในระบบการผลิตทางการเกษตรได้ เนื่องจากข้าวโพดฝักอ่อนเป็นพืชที่ต้องการน้ำสม่ำเสมอตลอดปฏิทินการเพาะปลูก เกษตรกรกลุ่มนี้จึงเลือกที่จะปลูกอ้อย ซึ่งเป็นระบบการผลิตที่ใช้แรงงานน้อย (labor extensive farming) แต่เป็นพืชที่ก่อให้ขาดรายได้เพียงปีละ 1 ครั้ง ในพื้นที่เพาะปลูกขนาดเล็กอ้อยไม่สามารถทำรายได้เลี้ยงครอบครัวเกษตรกรได้ นอกจากเกษตรกรจะต้องหารายได้เพิ่มจากการทำงานรับจ้างในภาคการการเกษตรแล้ว สมาชิกส่วนหนึ่งในครัวเรือนจำเป็นต้องหางานที่มีรายได้สม่ำเสมอทำนอกภาคการเกษตร เช่น เป็นคนงานรับจ้างในโรงงาน เป็นคนขับรถบรรทุก เป็นต้น ซึ่งพบว่ารายได้นอกฟาร์มเป็นรายได้หลักของครอบครัว โดยมีสัดส่วนมากกว่า 50 % ของรายได้สุทธิครัวเรือน

<u>ประเภทที่ 4</u>. กลุ่มไร้ที่ดิน (Landless)

เป็นกลุ่มที่เกิดจากกระบวนการล่มสลาย (elimination process) ของเกษตรกรรายเล็กในวิวัฒนาการของระบบชุมชนเกษตรกรรมของพื้นที่ทุ่งลูกนก (เนื่องมาจากเป็นครอบครัวที่มีที่ดินทำกินน้อยและมีลูกมาก เมื่อมีการแบ่งมรดกที่ดินจึงถูกแบ่งย่อยเป็นขนาดเล็กมากไม่เพียงพอต่อการประกอบอาชีพการเกษตร) และเป็นกลุ่มเกษตรกรที่ไม่มี “ทางเลือก” นอกจากเป็นแรงงานรับจ้างให้แก่เกษตรกรรายใหญ่

เกษตรกรบางรายในกลุ่มนี้ต้องการเช่าที่ดินจากผู้อื่นเพื่อประกอบอาชีพการเกษตรและอยู่ในท้องถิ่นต่อไป แต่มีเกษตรกรบางรายที่ต้องการหลุดออกจากวิถีชีวิตเดิมคือ ออกจากภาคการเกษตรเพื่อทำงานเป็นแรงงานในภาคอุตสาหกรรม ซึ่งพวกเขาคาดหวังว่าจะได้รับค่าจ้างและรายได้ที่ดีกว่าการมีชีวิตอยู่ในภาคการเกษตร

3.5 ความสัมพันธ์และการแลกเปลี่ยนภายในชุมชนทุ่งลูกนก

ในอดีตครัวเรือนเกษตรกรมีความแตกต่างกันน้อยจากวิถีการผลิตแบบพึ่งพาธรรมชาติและเพื่อการยังชีพ การดำรงชีวิตเป็นไปอย่างเรียบง่าย ความสัมพันธ์ในชุมชนเป็นไปในลักษณะของการพึ่งพากันและกันด้วยวัฒนธรรมชนบท การลงแขกเอาแรงกันในช่วงฤดูการเก็บเกี่ยวเป็นการแลกเปลี่ยนด้านเวลาการทำงาน แม้บางครั้งอาจมีการขอยืมเครื่องมือเครื่องใช้ในการเกษตรหรือปัจจัยการผลิตอื่นๆ แต่ก็เป็นไปในลักษณะที่ไม่คิดมูลค่า ปรากฏการณ์นี้เกิดขึ้นในพื้นที่ทุ่งลูกนกเมื่อ 30 - 40 ปีที่แล้วมา

วิวัฒนาการของชุมชนทุ่งลูกนกในด้านระบบการผลิตทางการเกษตรได้ส่งผลให้ความแตกต่างทางชนชั้นระหว่างครัวเรือนเกษตรกรเพิ่มขึ้นเป็นลำดับ ปัจจุบันนี้ความสัมพันธ์ในชุมชนมีระบบเศรษฐกิจเงินตราเป็นตัวกลางในการแลกเปลี่ยน การจ้างแรงงาน การเช่าเครื่องจักรกลการเกษตร ระบบการกู้ยืมเงิน เกิดขึ้นจากการที่เกษตรกรมีความสามารถในการเข้าถึงและครอบครองปัจจัยการผลิตที่แตกต่างกัน เกษตรกรรายใหญ่ถือครองที่ดินทำกินจำนวนมาก มีเงินทุนและเครื่องจักรกลขนาดใหญ่ (เกษตรกรประเภทที่ 1) ได้ดำเนินธุรกิจการให้บริการแก่เกษตรกรรายย่อย (ส่วนใหญ่เป็นกลุ่มผู้ปลูกอ้อย) ซึ่งมีพื้นที่ทำกินจำกัดและมีความสามารถในการลงทุนต่ำ (เกษตรกรประเภทที่ 2 และประเภทที่ 3) การจัดหาปัจจัยการผลิตล่วงหน้า (ปุ๋ย, ยา, น้ำมันเชื้อเพลิง) การให้บริการรถไถเพื่อเตรียมดิน การจัดหาแรงงานในการปลูกอ้อย/แรงงานในการตัดอ้อย และการให้บริการรถบรรทุกเพื่อขนส่งผลผลิตอ้อยเข้าสู่โรงงาน ค่าใช้จ่ายต่างๆ เหล่านี้เกษตรกรรายย่อยจะต้องจ่ายให้แก่เกษตรกรกลุ่มนายทุน โดยมีอัตราดอกเบี้ยในระดับที่ค่อนข้างสูง ในบางกรณีเกษตรกรรายย่อยจำเป็นต้องขอยืมเงินค่าใช้จ่ายในการดำรงชีวิตด้านอื่นๆ จากกลุ่มนายทุนหัวหน้าโควต้าหรือเถ้าแก่อ้อย เมื่อคิดรายได้ช่วงปลายปีเกษตรกรบางรายเกือบจะไม่มีเงินเหลือเพื่อการลงทุนในปีต่อไป หากช่วงปีใดที่ราคาอ้อยตกต่ำมาก เกษตรกรผู้ปลูกอ้อยรายย่อย อาจจำเป็นต้องขายที่ดินเพื่อชดใช้หนี้สินที่มีอยู่กับเกษตรกรกลุ่มนายทุน

การพัฒนาระบบการปลูกข้าวโพดฝักอ่อนในพื้นที่ทุ่งลูกนก ช่วยทำให้เกษตรกรรายย่อยได้รับโอกาสในการสร้างมูลค่าเพิ่มจากที่ดินและจากแรงงานครัวเรือนที่มีอยู่ รายได้ที่มากขึ้นทำให้สภาวะหนี้สินเริ่มลดน้อยลง อัตราการพึ่งพาปัจจัยการผลิตและสินเชื่อจากกลุ่มเกษตรกรนายทุนผู้ปลูกอ้อยเริ่มลดลงตามลำดับ เกษตรกรที่ถือครองที่ดินขนาดเล็กและมีแรงงานครอบครัวจำนวนมาก จะเช่าที่ดินเพื่อทำการเพาะปลูกข้าวโพดฝักอ่อนจากกลุ่มเกษตรกรที่มีพื้นที่ทำกินขนาดใหญ่ หากยังมีแรงงานส่วนเกินที่เหลือจากการผลิตในฟาร์มของตน ก็จะเป็นแรงงานรับจ้างให้แก่ฟาร์มอื่นๆ ในพื้นที่ แรงงานรับจ้างด้านการเกษตรที่สำคัญของพื้นที่ทุ่งลูกนก ได้แก่ แรงงานในครัวเรือนเกษตรกรขนาดกลางและขนาดเล็ก (เกษตรกรประเภทที่ 2 และประเภทที่ 3) รวมถึงแรงงานจากกลุ่มไร้ที่ดิน (ประเภทที่ 4)

Figure3

3.6 ความสัมพันธ์และการแลกเปลี่ยนระหว่างชุมชนทุ่งลูกนกกับสังคมภายนอกชุมชน

การขยายตัวของชุมชนเมืองและการพัฒนาด้านอุตสาหกรรม ได้ก่อให้เกิดธุรกิจด้านการซื้อขายที่ดินและสิ่งก่อสร้าง (real estate) กลุ่มนักลงทุนด้านหลักทรัพย์ที่ดินและสิ่งก่อสร้างนี้เป็นกลุ่มที่มีความสำคัญต่อระบบสังคมเกษตรในพื้นที่ทุ่งลูกนก การกว้านซื้อที่ดินเพื่อการเก็งกำไร การก่อสร้างอาคารร้านค้าและโครงการหมู่บ้านจัดสรร เป็นสาเหตุที่ทำให้พื้นที่การเกษตรในพื้นที่ทุ่งลูกนกลดลงอย่างมาก ราคาที่ดินที่เพิ่มสูงขึ้นเป็นเหตุจูงใจให้เกษตรกรในพื้นที่ โดยเฉพาะเกษตรกรรายเล็ก ตัดสินใจขายที่ดินของตนเองและอพยพโยกย้ายไปหาที่ดินทำกินใหม่ในพื้นที่ห่างไกล

เกษตรกรรายใหญ่ที่มีระบบการทำฟาร์มในรูปแบบนายทุน (เกษตรกรประเภทที่ 1) ได้นำเงินทุนส่วนหนึ่งที่ได้จากการสะสมทุนภาคการเกษตร ไปลงทุนในกิจกรรมด้านอื่นๆ นอกฟาร์ม เช่น การเป็นหุ้นส่วนในกิจการโรงงานน้ำตาล หรือการให้บริการรถบรรทุกเพื่อการขนส่ง เกษตรกรรายใหญ่ทุกรายมีกิจกรรมนอกภาคการเกษตร เช่น บริษัทรับเหมาก่อสร้าง ธุรกิจที่ดิน/บ่อทรายหรือโรงงานทำพลาสติก เป็นต้น
กลุ่มพ่อค้าคนกลาง (middleman) ต่างท้องถิ่นเข้ามามีบทบาทในพื้นที่ทุ่งลูกนกในด้านการลงทุนเพื่อการผลิต โดยเฉพาะการผลิตแบบมีสัญญาผูกพัน ขณะเดียวกันก็ดำเนินกิจกรรมด้านการซื้อขายผลผลิตทางการเกษตร

ในด้านเครื่องจักรกลการเกษตรที่ให้บริการอยู่ในพื้นที่ทุ่งลูกนก พบว่ามีบางกรณีที่เป็นกิจการของนายทุนนอกพื้นที่เช่นกัน ได้แก่ รถตัดอ้อย ซึ่งเป็นของโรงงานน้ำตาลในจังหวัดกาญจนบุรี รถเกี่ยวและนวดข้าวของเกษตรกรรายใหญ่จากพื้นที่บางเลนซึ่งเป็นแหล่งผลิตข้าวที่สำคัญ มาให้บริการแก่ชาวนารายเล็กในพื้นที่ทุ่งลูกนก

การสร้างงานในภาคอุตสาหกรรมและบริการได้ทำให้จำนวนแรงงานรับจ้างด้านการเกษตรในพื้นที่ทุ่งลูกนกลดน้อยลง รายได้ที่สม่ำเสมอและมากกว่าการทำงานภาคการเกษตร ทำให้แรงงานส่วนหนึ่งในพื้นที่ทุ่งลูกนกออกไปทำงานรับจ้างทั้งที่เป็นงานชั่วคราวและงานประจำนอกพื้นที่ จากสาเหตุของการเคลื่อนย้ายแรงงานเกษตรสู่นอกภาคเกษตรนี้เอง ทำให้เกิดการขาดแคลนแรงงานท้องถิ่นในพื้นที่ ฟาร์มขนาดใหญ่ได้มีการจ้างแรงงานรับจ้างจากภายนอกซึ่งส่วนใหญ่เป็นแรงงานจากภาคตะวันออกเฉียงเหนือ

เกษตรกรในพื้นที่ทุ่งลูกนกไม่ว่าจะเป็นเกษตรกรรายใหญ่ทำฟาร์มในระบบนายทุนหรือระบบธุรกิจเกษตรกรขนาดกลางทำการผลิตในระบบครัวเรือน หรือเกษตรกรรายเล็ก ต่างต้องพึ่งพาสังคมภายนอกโดยเฉพาะ "การตลาด" ซึ่งเป็นทั้งแหล่งจัดหาปัจจัยการผลิตและแหล่งรับซื้อผลผลิตการเกษตร

3.7 แนวโน้มการเปลี่ยนแปลงของระบบสังคมเกษตรในพื้นที่ทุ่งลูกนก

วิวัฒนาการที่อาจเป็นไปได้ของระบบสังคมเกษตรในพื้นที่ทุ่งลูกนกได้แสดงไว้ในแผนภาพที่ 4(Figure. 4) วิวัฒนาการที่สร้างขึ้นในภาพ (projection) มีฐานคติที่ว่าการขยายตัวของชุมชนเมืองและการพัฒนาภาคอุต

สาหกรรมจะยังคงดำเนินต่อไป โอกาสในการลงทุนและทำงานนอกภาคการเกษตรจึงยังคงมีอยู่ในระดับหนึ่ง

ครัวเรือนเกษตรกรรายย่อย (เกษตรกรประเภทที่ 3) จะเข้าสู่กระบวนการล่มสลาย (elimination) เนื่องจากขนาดที่ดินถือครองที่เล็กมากไม่เพียงพอต่อการดำรงชีวิต แม้จะปรับเปลี่ยนระบบการผลิตมาเป็นระบบการผลิตการเกษตรแบบเข้มข้น (intensive farming) ที่ให้ผลตอบแทนต่อหน่วยพื้นที่และแรงงานสูง ความไม่แน่นอนของราคาผลผลิตทางการเกษตร ตลอดจนต้นทุนในการผลิตที่สูงขึ้นจากราคาปัจจัยการผลิตที่เพิ่มขึ้น ทำให้เกษตรกรกลุ่มนี้ประสบภาวะเสี่ยงและอาจกลายเป็นกลุ่มไร้ที่ดินทำกิน (landless) แนวโน้มที่จะออกจากภาคการเกษตรไปทำงานเป็นแรงงานรับจ้างในภาคอื่นๆ มีค่อนข้างสูง และหากสมาชิกในครอบครัวไม่สืบทอดกิจกรรมการผลิตทางการเกษตร ฟาร์มกลุ่มนี้จะหลุดออกจากภาคการเกษตรอย่างถาวรในอนาคตอันใกล้นี้

ครัวเรือนเกษตรกรขนาดใหญ่ (เกษตรกรประเภทที่ 1) จะได้รับผลกระทบจากการขาดแคลนแรงงานรับจ้างภาคการเกษตร ซึ่งอาจส่งผลให้อัตราค่าจ้างแรงงานสูงขึ้น การลงทุนด้านเครื่องจักรกลการเกษตรจะเพิ่มขึ้นเพื่อทดแทนแรงงานคน อย่างไรก็ตาม ฟาร์มขนาดใหญ่ที่จะดำรงอยู่ในภาคการเกษตรต่อไปได้ จะต้องเป็นฟาร์ที่ดำเนินกิจกรรมการผลิตทางการเกษตรที่ให้ผลตอบแทนหรือรายได้ในระดับที่ดีเมื่อเปรียบเทียบกับการเคลื่อนย้ายทุน (capital mobility) ที่มีอยู่ในปัจจุบันในกิจกรรมนอกภาคการเกษตร การแข่งขันด้านผลตอบแทนในการลงทุนระหว่างภาคเกษตรและนอกภาคเกษตรจึงเป็นดัชนีชี้วัดที่สำคัญของทิศทางการพัฒนาฟาร์มขนาดใหญ่นี้

ครัวเรือนเกษตรกรขนาดกลางและขนาดเล็ก (เกษตรกรประเภทที่ 2) จะมีพื้นที่ทำการเกษตรขนาดเล็กลงจากการแบ่งแยกที่ดินให้แก่ลูกหลานในครอบครัวรุ่นต่อๆไป ซึ่งจะส่งผลให้ระบบผลิตทางการเกษตรมีความเข้มข้นในด้านการใช้แรงงานมากยิ่งขึ้น (labor intensive farming) และมีความหลากหลายในการผลิตเพิ่มขึ้น (diversification) ฟาร์มเหล่านี้จะพัฒนาระบบการผลิตผสมผสานระหว่างการปลูกข้าวโพดฝักอ่อนและการเลี้ยงวัว (วัวเนื้อ/วัวนม) ซึ่งจะทำให้มีการใช้แรงงานครอบครัวอย่างมีประสิทธิภาพ จำนวนวัวที่เพิ่มขึ้นในฝูงถือเป็นรูปแบบหนึ่งของการสะสมทุน อาจมีการรวมกลุ่มกันของเกษตรกรและลงทุนร่วมกันในด้านเครื่องจักรกลการเกษตรซึ่งสอดคล้องกับระบบการผลิตที่มีอยู่ในฟาร์ม

สำหรับการให้บริการของฟาร์มขนาดใหญ่ในพื้นที่ทุ่งลูกนกจะมีข้อจำกัดมากขึ้น เนื่องจากราคาอ้อยมีแนวโน้มไม่เพิ่มขึ้น ผลตอบแทนที่ได้รับจากการปลูกอ้อยจึงน้อยลง ทำให้พื้นที่ปลูกอ้อยในพื้นที่ทุ่งลูกนกมีแนวโน้มลดลงโดยเฉพาะในครัวเรือนเกษตรขนาดกลางและขนาดเล็ก

5. อภิปรายผล

การเปลี่ยนแปลงของระบบชุมชนเกษตรในพื้นที่ทุ่งลูกนก เกิดขึ้นจากปัจจัยหลายประการ ได้แก่ ความต้องการผลผลิตทางการเกษตร ทั้งจากภายในและภายนอกประเทศ การพัฒนาระบบเครือข่ายการค้าและธุรกิจเกษตร การปรับเปลี่ยนสภาพพื้นที่ (artificialization) โดยเฉพาะการพัฒนาระบบชลประทาน การเปลี่ยนแปลงนี้เกิดขึ้นภายใต้ผลกระทบจากข้อจำกัดและโอกาสที่แตกต่างกัน ทั้งในด้านเกษตรนิเวศ (agro-ecological condition) และด้านเศรษฐกิจสังคม (socio-economic condition) โดยเฉพาะความแตกต่างของครัวเรือนเกษตรในด้านการครอบครองปัจจัยการผลิตที่สำคัญ (ทุน, ที่ดิน, แรงงาน) และการเข้าถึงระบบตลาดที่แตกต่างกัน

ความแตกต่างระหว่างชนชั้นในสังคม ได้เกิดขึ้นพร้อมๆ กับการเปลี่ยนแปลงของระบบชุมชนเกษตร ในช่วงแรก ระบบการผลิตเพื่อการบริโภคที่พอเพียง (autoconsumption) เป็นระบบการผลิตหลักในพื้นที่ทุ่งลูกนก การการแลกเปลี่ยนเงินตราถูกจำกัดเฉพาะวงและความไม่เท่าเทียมกันในด้านทรัพย์สินยังมีน้อย เมื่อพื้นที่ทุ่งลูกนกได้ถูกผนวกเข้ากับระบบการค้า ระบบเศรษฐกิจเงินตราได้เข้ามามีความสำคัญในการแลกเปลี่ยน การสะสมทุนได้เกิดขึ้นในครัวเรือนเกษตรบางกลุ่มและท้ายสุดได้ก่อกำเนิดเกษตรกร "นายทุน" ขึ้นในพื้นที่ ความแตกต่างทางสังคม (social differentiation) ที่เกิดขึ้นในพื้นที่ทุ่งลูกนกนี้ไม่ใช่สิ่งน่าประหลาดใจ เมื่อเราพัฒนาถึงทำเลที่ตั้งและสาธารณูปโภคที่ดีของพื้นที่ทุ่งลูกนก (ถนน, การคมนาคม, รถไฟ, ตลาด โรงงานแปรรูปผลผลิตการเกษตรและโรงงานอุตสาหกรรม) ซึ่งส่งผลให้กระบวนการผสมผสานเข้ากับระบบการค้า ทั้งในระดับชาติและระดับนานาชาติเป็นไปอย่างรวดเร็ว ภาคเกษตรในพื้นที่ทุ่งลูกนกยอมจำนนต่อระบบทุนนิยม กระบวนการสะสมทุนได้เกิดขึ้นกับครัวเรือนเกษตรกรที่ครอบครองปัจจัยในการผลิต และกระบวนการล่มสลายได้เกิดขึ้นกับกลุ่มที่เหลือ เช่นเดียวกับภาคเกษตรในพื้นที่อื่นๆทั่วโลกซึ่งกระบวนการทั้ง 2 นี้กำลังดำเนินอยู่

ความเป็นไปได้ของการพัฒนาอุตสาหกรรมเกษตรโดยเฉพาะการแปรรูปผลผลิตทางการเกษตร เกิดจากการได้รับโอกาสในการเคลื่อนย้ายทุนเอกชนเข้าสู่ระบบการค้า ธุรกิจเกษตร อุตสาหกรรมและการเก็งกำไร การเคลื่อนย้ายเงินทุนเหล่านี้เป็นผลมาจากการดำเนินการของบริษัทในประเทศและต่างประเทศโดยเฉพาะเครือข่ายนานาชาติ เช่นเดียวกันในหลายกรณีที่การค้าธุรกิจการเกษตร การขายปัจจัยการผลิต (ปุ๋ย, สารเคมี) อยู่ภายใต้การผูกขาดของพ่อค้าคนกลาง นายทุนท้องถิ่น ผู้ปล่อยเงินกู้ ซึ่งเกษตรกรมีความสัมพันธ์และมีพันธะสัญญาในการผลิตสินค้าทางการเกษตรในลักษณะโควต้า ในภาพรวม การเกษตรในพื้นที่ทุ่งลูกนก ณ ปัจจุบันนี้พึ่งพาระบบการตลาด ธุรกิจการเกษตรเป็นอย่างมาก ทั้งตลาดการค้าในประเทศและตลาดต่างประเทศ ซึ่งในกรณีนี้ภาคเกษตรเป็นภาคที่อ่อนแอและถูกโจมตีได้ง่ายจากความเสี่ยงทางการตลาด และจากการใช้สิทธิพิเศษของนักลงทุน

ในช่วงหลายปีที่ผ่านมา รัฐบาลได้แสดงบทบาทที่สำคัญในการสร้างสาธารณูปโภคพื้นฐานได้แก่ ระบบชลประทาน การรักษาความสม่ำเสมอของราคาผลิตภัณฑ์เกษตร หรือการจัดตั้งโครงการและสนับสนุนการเงินให้แก่โครงการพัฒนาการเกษตรต่างๆ ทำการปลูกพืชและการเลี้ยงสัตว์ เช่น โครงการส่งเสริมการเลี้ยงโคนม อย่างไรก็ตาม การสนับสนุนจากภาครัฐมีข้อจำกัดจากความตกลงและความร่วมมือทางการค้าระหว่างประเทศ (GATT, องค์การค้าโลก, ธนาคารโลก) การสนับสนุนจากภาครัฐในด้านการเกษตรได้มีการปรับเปลี่ยนจากหน้าที่การสั่งการซึ่งเป็นระบบเชิงอำนาจ มาเป็นหน้าที่ในการให้คำแนะนำให้ข้อมูล และให้ความช่วยเหลือดูแล ภาคธุรกิจเอกชนด้านอุตสาหกรรมอาหารจึงก้าวเข้ามามีบทบาทโดยตรงในทิศทางการพัฒนาการเกษตรพื้นที่ทุ่งลูกนก

จากระยะทางที่ไม่ห่างจากกรุงเทพฯ พื้นที่ทุ่งลูกนกเป็นพื้นที่ที่มีปฏิสัมพันธ์เกี่ยวข้องกับการพัฒนาเศรษฐกิจและชุมชนเมืองเป็นอย่างมาก ในด้านหนึ่ง พื้นที่ที่ใช้ในการเกษตรได้ถูกเปลี่ยนสภาพจากการเพาะปลูกเป็นการปลูกสร้างอาคารบ้านเรือน รองรับการขยายตัวของชุมชนเมืองกรุงเทพฯ และปริมณฑล และรองรับการเติบโตของภาคอุตสาหกรรม การซื้อขายที่ดินเพื่อเก็งกำไรได้เกิดขึ้นพร้อมๆกันกับการเจริญเติบโตของชุมชนและอุตสาหกรรม ที่ดินในการเกษตรที่ถูกซื้อไปได้นำไปใช้ในการพัฒนาภาคอุตสาหกรรม (ได้แก่การจัดซื้อดิน/ทรายขุดเพื่อนำไปใช้ในการก่อสร้างอาคาร) หรือเพื่อการเก็งกำไร ทำให้ที่ดินมีราคาแพง เกษตรกรรายเล็กไม่สามารถเป็นเจ้าของที่ดินได้ ในทางตรงกันข้าม เมืองและกิจกรรมของเมืองเป็นแหล่งจ้างแรงงานและก่อให้เกิดอาชีพแก่ครัวเรือนเกษตรกรในพื้นที่ทุ่งลูกนก ยิ่งไปกว่านั้น กรุงเทพฯ ภาคอุตสาหกรรมและอุตสาหกรรมเกษตรที่มีความสัมพันธ์แนบแน่นกับตลาดต่างประเทศ เป็นแหล่งกระจายสินค้าการเกษตรที่สำคัญของพื้นที่ทุ่งลูกนก

อย่างไรก็ตาม ไม่มีสิ่งใดจะรับประกันได้ว่า ถ้าเราปล่อยให้พลังด้านการตลาดชี้นำการพัฒนาทางพื้นที่ทุ่งลูกนก การเกษตรของพื้นที่นี้จะมีทิศทางการพัฒนาที่เหมาะสมสำหรับประชากรของทุ่งลูกนก สำหรับประเทศไทย โดยคุณลักษณะของพื้นที่ ทุ่งลูกนกสามารถมีการพัฒนาในหลายทิศทาง จึงเป็นการยากที่จะคาดเดาได้ว่าการพัฒนาแบบใดจะเป็นการพัฒนาที่เหมาะสม ในระยะเวลาอีกไม่กี่ปีภายหน้า พื้นที่ทุ่งลูกนกอาจจะสูญเสียที่ดินและกิจกรรมทางการเกษตรเพื่อรองรับการพัฒนาด้านชุมชนเมืองและอุตสาหกรรม หากไม่มีนโยบายใดๆ ที่จะหยุดยั้งการเจริญเติบโตของการเก็งกำไรที่ดินและพลังทางธุรกิจการค้า/การตลาดได้

เมื่อพิจารณาถึงความได้เปรียบเชิงเปรียบเทียบของพื้นที่นี้กับพื้นที่อื่นๆในประเทศ ดูเหมือนว่าการรักษาพื้นที่ที่มีศักยภาพทางการเกษตร เช่น พื้นที่ทุ่งลูกนก จะเป็นการเดิมพันที่สำคัญ โดยเฉพาะอย่างยิ่ง จากสาเหตุของการที่ได้มีการลงทุนอย่างมหาศาลในด้านการปรับเปลี่ยนระบบนิเวศเกษตรโดยเฉพาะระบบชลประทานให้เหมาะสมต่อการผลิตทางการเกษตร วัตถุประสงค์หลักเชิงยุทธศาสตร์ในการรักษาพื้นที่ทุ่งลูกนก คือ การให้หลักประกันต่อความถาวรและความยั่งยืนของการเกษตรที่ประสิทธิภาพ เพื่อตอบสนองต่อความต้องการที่

เพิ่มขึ้นของตลาดทั้งภายในและภายนอกประเทศ การพัฒนาภาคอุตสาหกรรมหรือการพัฒนาชุมชนเมืองของพื้นที่แห่งนี้ต้องการการใคร่ครวญอย่างลึกซึ้งโดยจะต้องไม่ทำให้ภาคการเกษตรเสียหาย ดังนั้นจึงจำเป็นต้องสนับสนุนให้การพัฒนาภาคอุตสาหกรรมและภาคเกษตรเป็นไปอย่างสอดคล้องในทิศทางที่ประสานประโยชน์ซึ่งกันและกัน ความเติบโตก้าวหน้าในระยะหนึ่งของการพัฒนาภาคใดก็ตามจะต้องส่งผลเชิงบวกต่อการพัฒนาอีกภาคหนึ่งในอีกระยะหนึ่ง

6. ข้อเสนอแนะ

วิกฤติเศษฐกิจในช่วงที่ผ่านมาได้ให้ภาพที่ชัดเจนถึงความอ่อนแอของกระบวนการพัฒนาภาคอุตสาหกรรมและการเติบโตของภาคเมือง ขณะเดียวกันศักยภาพทางการเกษตรของพื้นที่ทุ่งลูกนกได้แสดงให้เห็นอย่างเด่นชัดภายใต้ภาวะการณ์ของปัญหาและวิกฤติเศรษฐกิจว่าเป็นมรดกของแผ่นดินที่มีค่าซึ่งไม่ควรละเลยทอดทิ้ง สิ่งอันพึงปรารถนาคือการพัฒนาภาคเกษตรให้สามารถเป็นหลักประกันในชีวิต ข้อเสนอแนะและแนวทางปฏิบัติที่จะทำให้ภาคการเกษตรเข้มแข็ง ไม่ก่อให้เกิดการอพยพย้ายถิ่นแรงงานจากภาคชนบทเข้าสู่ภาคการพัฒนาที่อ่อนแอ ต้องพึ่งพาปัจจัยภายนอก และขึ้นต่อวิกฤติของสถานการณ์โลก มีดังต่อไปนี้

6.1 ข้อเสนอแนะทั่วไป

1. นำกฎเกณฑ์มาตรการที่จะช่วยป้องกันพื้นที่ทางการเกษตรของพื้นที่ทุ่งลูกนก และป้องกันที่ดินจากการซื้อ – ขาย เพื่อเก็งกำไรมาใช้ (ได้แก่ แผนการใช้ที่ดิน, การวางระบบและดำเนินการด้านผังที่ดิน, การเก็บภาษีในอัตราสูงสำหรับที่ดินที่ไม่ใช้ประโยชน์)
2. สร้างระบบการคุ้มครองจากภาครัฐ โดยมีการกระจายที่ดินทางการเกษตร มีการปลดปล่อยที่ดินให้เป็นอิสระเพื่อให้ที่ดินไม่ตกอยู่ในมือของกลุ่มคนจำนวนน้อย (เช่น กฎหมายป้องกันการสะสมที่ดินจำนวนมาก และกฎหมายการใช้สิทธิซื้อที่ดินก่อน โดยภาครัฐ : pre – emption)
3. ปรับปรุงระเบียบข้อบังคับ (regulation) ในการเช่าที่ดิน อัตราค่าเช่าที่ดิน สัญญาการเช่าที่ดินระยะเวลาอย่างต่ำในการเช่าที่ดิน การประยุกต์ใช้ภาษีมูลค่าเพิ่ม ซึ่งจะทำให้เกษตรกรผู้เช่าที่ดินสามารถลงทุนระยะยาวในพื้นที่เช่า และได้รับผลประโยชน์คุ้มค่าจากการเช่าที่
4. สนับสนุนระบบการลงทุนและลงแรงช่วยเหลือกันระหว่างเกษตรกร ประกันและจำกัดผลประโยชน์ของผู้ให้บริการ (หรือบริษัทที่ให้บริการ) เช่นการบริการด้านการขนส่งผลผลิต สร้างเงื่อนไขที่จะไม่ก่อให้เกิดสถานการณ์ของการพึ่งพาแบบผูกขาด (monopoly)
5. สนับสนุนกิจการค้าและธุรกิจที่เกิดจากเกษตรกรหรือกลุ่มเกษตรกร (ธุรกิจชุมชน–เศรษฐกิจชุมชน) เพื่อเป็นการจำกัดการสร้างผลประโยชน์ของพ่อค้าคนกลาง
6. จัดสร้างระบบโครงสร้างในการพบปะแลกเปลี่ยนและเจรจาต่อรองระหว่างผู้ผลิตและผู้ซื้อเพื่อสร้างพันธะสัญญาที่ก่อประโยชน์อย่างยุติธรรมต่อทั้ง 2 ฝ่าย

7. ประกันระบบสินเชื่อที่จัดบริการให้แก่เกษตรกรรายเล็ก โดยผ่านระบบการจัดการของชุมชนหรือท้องถิ่น
8. พัฒนาระบบข่าวสารข้อมูลการเกษตรและการส่งเสริมการเกษตร (ห้องสมุดในพื้นที่)
9. จัดการให้เกิดการเจรจาต่อรองเพื่อให้มีการใช้ทรัพยากรน้ำที่มีประโยชน์มากขึ้น มีการรักษาสภาพเครือข่ายระบบน้ำชลประทาน (การจัดการในระดับชุมชน) จัดวางผังและก่อสร้างคลองและคูส่งน้ำที่เหมาะสมและดำเนินการพัฒนาคลองระบายน้ำอย่างต่อเนื่อง
10. ปรับปรุงพัฒนาคุณภาพดิน ความอุดมสมบูรณ์ของดิน (ปุ๋ยหมักจากสัตว์, การปลูกพืชตระกูลถั่ว)
11. ส่งเสริมให้เกิดความสนใจในระบบการผลิตที่ผลผลิตส่วนหนึ่งเก็บไว้เพื่อการบริโภคในครัวเรือนในครอบครัวเกษตรกร

6.2 ข้อเสนอแนะสำหรับครัวเรือนเกษตรกรประเภทต่างๆ

<u>ประเภทที่ 1</u> : ***ครัวเรือนเกษตรกรรายใหญ่มีการปลูกอ้อยเป็นพืชหลัก***

1. ปรับปรุงให้ข้อมูลความรู้ที่เกี่ยวข้องกับผลกระทบที่จะเกิดขึ้นจากความผันแปรระดับนานาชาติพัฒนาวิธีการคิด การวิเคราะห์เกี่ยวกับการเปลี่ยนแปลงของราคาอ้อย
2. พัฒนาข้อมูลความรู้ที่จะส่งผลให้เกิดการเพิ่มผลผลิตอ้อยต่อหน่วยพื้นที่ที่คุ้มค่าต่อการปลูกเป็นการผลิตอ้อยที่ประณีตมีการดูแลบำรุงรักษามากขึ้น มีการใช้เครื่องจักรกลที่เหมาะสมกับสภาพการปลูกและให้ประโยชน์สูงสุด โดยไม่ลงทุนมาก
3. ช่วยเหลือในการแปลงทุนหรือปรับกิจการเข้าสู่ภาคอุตสาหกรรมเกษตร

<u>ประเภทที่ 2</u> : ***ครัวเรือนเกษตรกรขนาดกลางมีระบบการผลิตแบบครอบครัว***

1. มีการผสมผสานกิจกรรมการปลูกพืช–เลี้ยงสัตว์ และปฏิทินการทำงานที่เหมาะสมกับแรงงานของครัวเรือนและชุมชน
2. สำหรับการเลี้ยงโคนมที่เกี่ยวข้องกับการปลูกข้าวโพดฝักอ่อนอย่างมากนั้น ควรมีการสร้างโรงงานผลิตนมและการแปรรูปนมขึ้นในพื้นที่อย่างรวดเร็ว ซึ่งการจัดตั้งโรงงานและกระบวนการแปรรูปน้ำนมนี้จะเป็นการสร้างงานให้แก่เกษตรกรในประเภทที่ 3
3. พยายามแนะนำพืชตัวอื่นๆที่พื้นที่ทุ่งลูกนกมีความได้เปรียบเชิงเปรียบเทียบให้แก่เกษตรในพื้นที่ โดยตระหนักถึงการพิจารณาระบบชลประทานที่มีอยู่ในพื้นที่
4. คำนึงถึงข้อจำกัดในการใช้เครื่องจักรกลการเกษตร หาแนวทางในการพัฒนาเครื่องจักรที่เหมาะสมเพื่อไม่ให้เกิดปัญหาการขาดแคลนแรงงาน

ประเภทที่ 3 : ***ครัวเรือนเกษตรกรรายย่อยถือครองที่ดินขนาดเล็ก***

1. แนะนำการเลี้ยงโคเนื้อซึ่งอาจมีปัญหาด้านการขาดแคลนที่ดินที่จะนำมาค้ำประกัน พัฒนาระบบธนาคารโคในหมู่บ้าน
2. พัฒนาระบบสินเชื่อ ให้ความช่วยเหลือในด้านสินเชื่อเพื่อการจัดซื้อเครื่องสูบน้ำ โดยให้ชุมชนในหมู่บ้านร่วมกันทำ แทนที่จะเป็นการได้รับความช่วยเหลือหรือรับการบริการจากหัวหน้าโควต้าและพ่อค้าคนกลาง
3. สนับสนุนให้เกิดการพัฒนาระบบเกษตรที่มีมูลค่าเพิ่มสูงขึ้น โดยการให้ความรู้ความเข้าใจในการผลิตและสร้างระบบการตลาดที่มีเสถียรภาพมารองรับผลผลิต

ประเภทที่ 4 : ***กลุ่มไร้ที่ดิน***

1. สนับสนุนให้เกิดการใช้ที่ดินสาธารณะให้เกิดประโยชน์
2. ให้ความรู้ในด้านการประกอบอาชีพ

References

Adulavidhaya, K., Tongloj, O., 1985. Migration and agricultural development of Thailand : Past and Future. in : Urbanization and migration in Asian Development, National Institute for Research Advancement, Tokyo.

Alexandratos, N., 1995. World Agriculture towards 2010. An FAO Study, Chichester, FAO, John Wiley and Sons, U.K..

Ashakul, T., 1988. Migration : Trends and Determinants. Promotion of Analysis and Consideration of Population Consequences of Development Planing and Policy in Thailand, Thailand Development Research Institute, Bangkok.

Chiengkul, W., 1983, The effects of capitalist penetration on the transformation of the Agrarian structure in the central region of Thailan : 1960 – 1980. Chulalongkorn University, Bangkok.

Doras, 1996. Agricultural and irrigation patterns in the Central Plain of Thailand,Preliminary analysis and prospects for agricultural research and development,Doras Project, Kasetsart University, Bangkok.

Dufumier, M., 1996. Les projets de developpement agricole : Manuel d'expertise. Editions Karthala, Paris.

Feder, G., Onchan, T., Chalamwong, Y., 1986, Land policies and farm productivity In Thailand., John Hopkins University Press, Baltimore MD..

Feeny, D., 1982. The Political Economiy of Productivity : Thai Agricultural Development 1880-1975. University of British Columbia Press, London.

Garin, M., 1989. " Thailande : un cinquieme tigre aliatique ? " in : La Nouvelle Asie Industrielle, Enjeux, Strategies, Perspectives, Presses Universitaires de France, Paris.

Ingram, J.C., 1971. Economic change in Thailand 1850-1970. Standford University Press, California.

Jansen, C., 1990. Thailand : the new industrialized country ?. Institute of Social Studies,Hake.

Kasetsart University, Thammasat University, Mahidol University,1978. Baseline survey report of Mae Klong integrated rural development program area : 1974. Kasetsart University, Bangkok.

Lelart, M., 1976. " L'endettement du paysan et le credit rural en Thailande". Etudes Rurales, No. 61, Paris.

Mazoyer, M., Roudart, L., 1997. Histoire des Agricultures du Monde du Neolithique a la Crise Contemporaine. Editions Seuil, Paris.

Molle, F., Srijantr, T., 1999. Agrarian Change and Land System in the Chao Phraya Delta. Doras –Delta Research Report No 6, DORAS Center, Kasetsart University, Bangkok.

Nartsupha, C., Prasartset, S., 1978. The Political Economy of Siam, 1851-1910. The Social Sciences Association of Thailand, Bangkok.

Nartsupha, C., Prasartset, S., Chenvidyakarn, M., 1981. The Political Economy of Siam, 1910-1932. The Social Sciences Association of Thailand, Bangkok.

Siamwalla, A., 1986. Thailand's agricultural future : What are the questions ?. Thailand Development Research Institute, Bangkok.

Siamwalla, A.,Setboonsarng, S., Patamasiriwat, D., 1991. Thai Agriculture : Resources, Institutions and Policies. Thailand Development Research Institute,Bangkok.

Srijantr, T., 1998. Transformations du System Agraire de Thung Look Nok (Plaine Centrale) et Perspectives de l'Agriculture Thailandaise. These de doctorat, Institut National Agronomique Paris – Grignon, Paris.

Taillard, C., 1995. " Les dynamiques paysannes en Asie : l'exemple de la Thailande ". In : Haubert, M., (sous la dir.), Les paysans peuvent-ils nourrir le Tiers Monde ?,Publications de la Sorbonne, Paris.

Takaya, Y., 1971. History of irrigation for agriculture in Thailand. In : Physiography of Rice land in the Chao Phraya Basin of Thailand, The South-East Asian Studies, Kyoto.

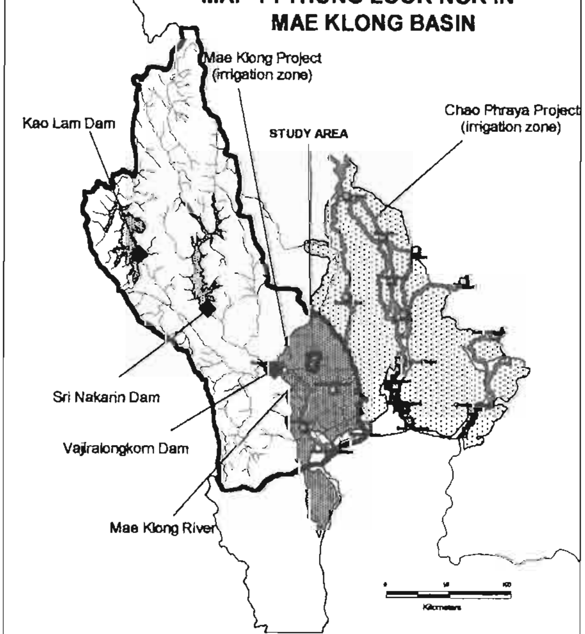
Takaya, Y., 1987. Agricultural development of a tropical delta : A study of the Chao Phraya delta. Center for South-East Asian Studies, Kyoto University, University Of Hawaii Press, Honolulu.

Tanabe, S., 1994. Ecology and practical technology peasant farming systems in Thailand.National Museum of Ethnology, White Lotus Press, Osaka.

Trebuil, G., Castella, J., Srijantr, T., Naritoom, C., 1993. Transformations desFiliere maraichere en Thailande : Apport de la recherche systeme aux producteurs Pour la maitrise des innovations techniques et organisationnelles. Innovations et Societes, Rapport de seminaire, Montpellier.

Tables and figures

MAP 1 : THUNG LOOK NOK IN MAE KLONG BASIN



MAP 6 : ZONING OF THUNG LOOK NOK

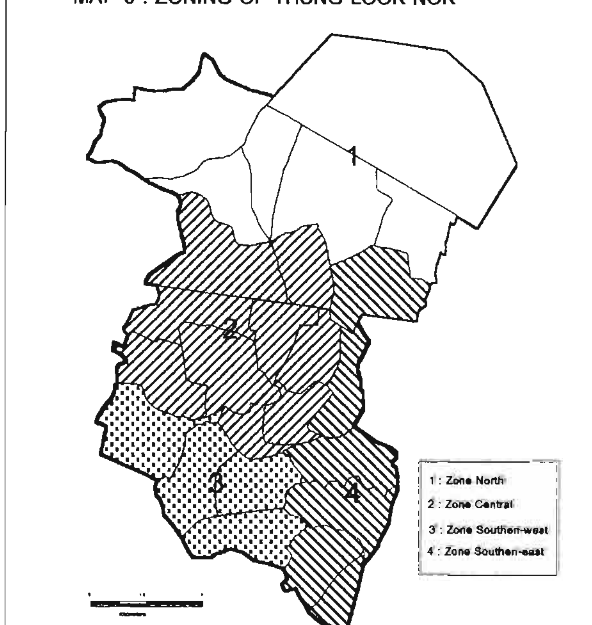


FIGURE 1. : FARMER TYPOLOGY IN THUNG LOOK NOK (*FARM AREA AND DISTRIBUTION OF EACH TYPE*)

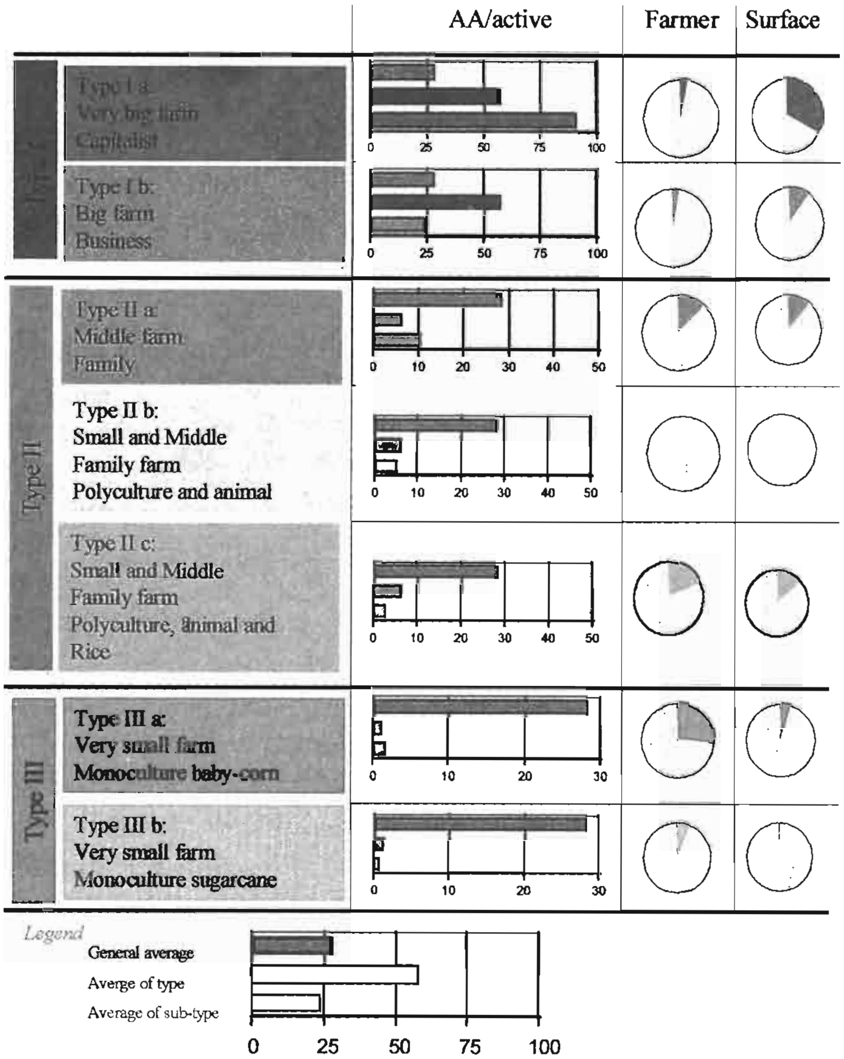
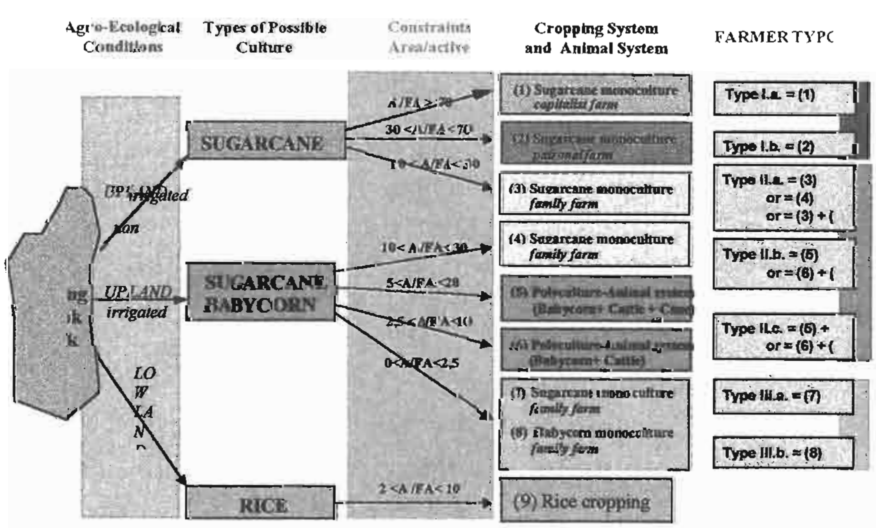
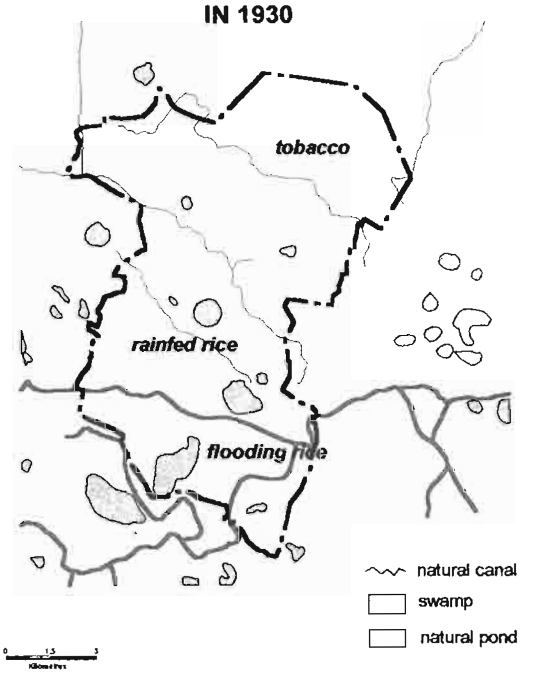


FIGURE 2. : RELATION BETWEEN PRODUCTION SYSTEM AND FARMER TYPOLOGY

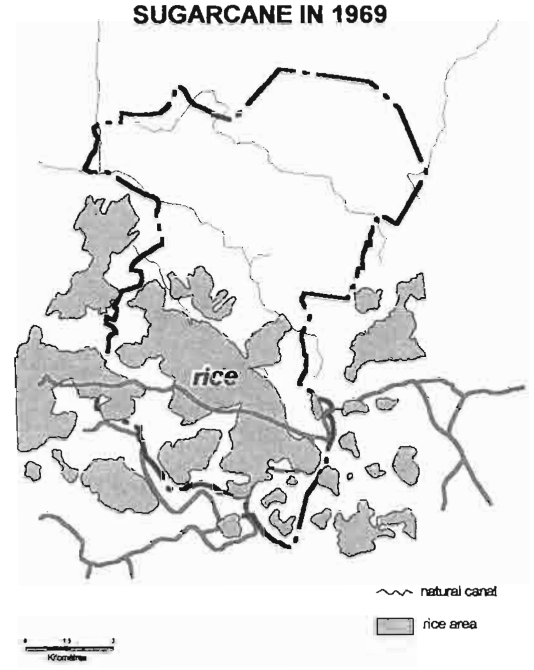


*A/FA = Area /Family Active(rai)

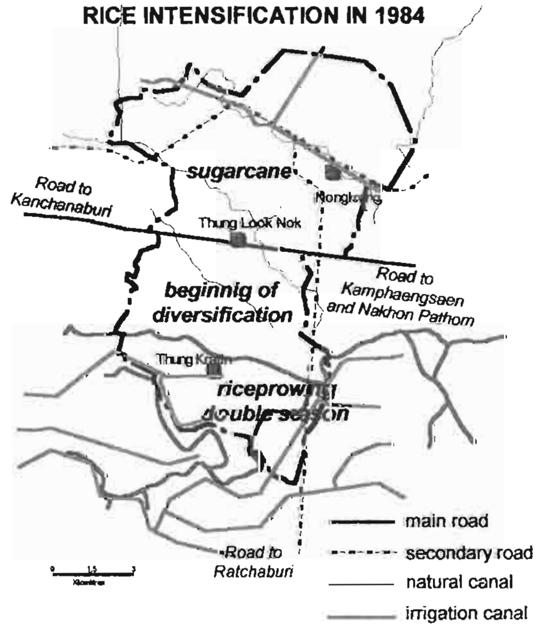
MAP 2 : RICE AND TOBACCO CULTIVATION IN 1930



MAP 5 : EXPANSION OF RICE AND SUGARCANE IN 1969



MAP 6 : AGRICULTURAL DIVERSIFICATION AND RICE INTENSIFICATION IN 1984



MAP 7 : LAND USE MAP IN 1994

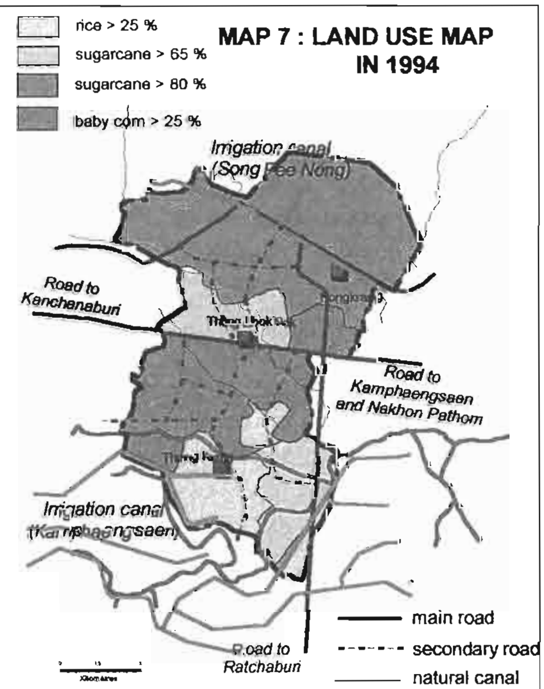


Figure 4: Perspective of possible changes in Thung Look Nok

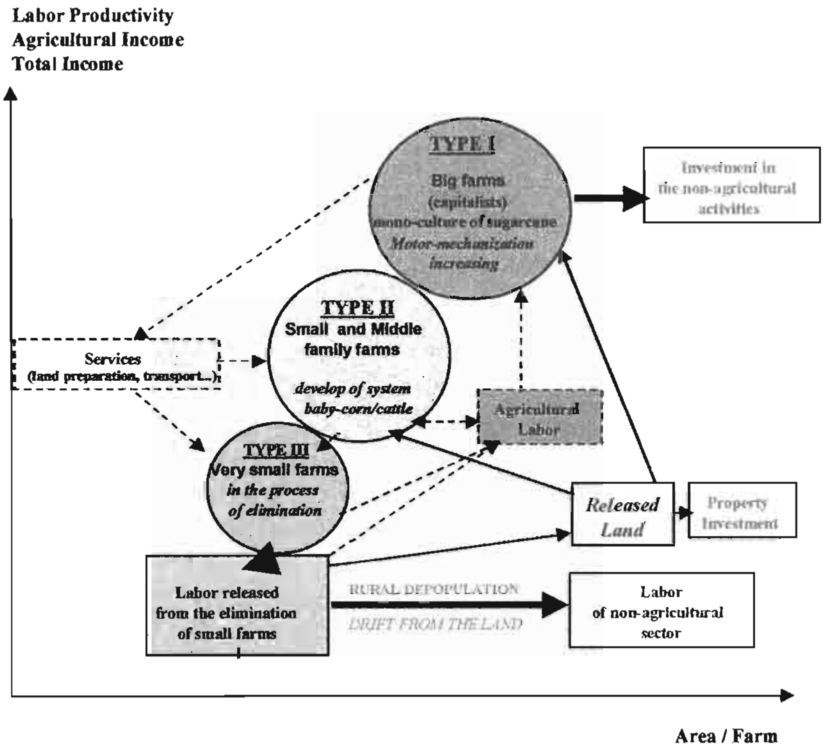


Figure 3

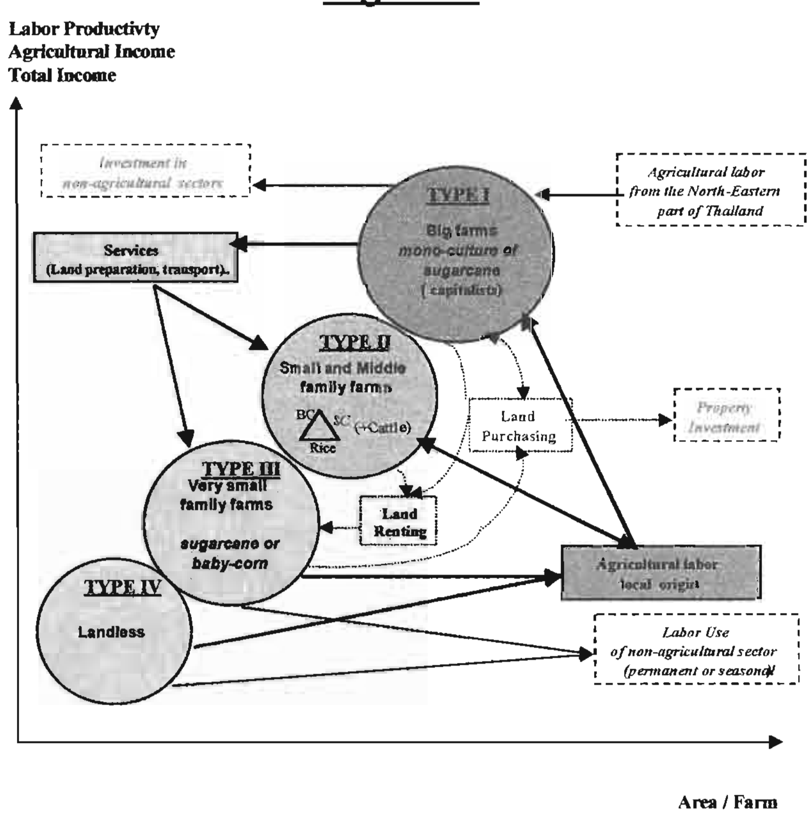


TABLE 1 : Farmer Typology in Thung Look Nok Area

Types and sub-types of farm	Agricultural Area of farm	Agricultural production system	% of farmer	% of area
TYPE I: Big farm : Sugarcane monoculture	**(AA>50 rais)**	**Sugarcane monoculture + Activities of Head of quota**	**6%**	**43%**
Type I.a : Very big farm capitalist	(100 rais<AA)	Sugarcane monoculture **Activities of Head of big quota**	3%	33%
Type I.b : Big farm business	50 rais<AA<100 rais	Sugarcane monoculture **Activities of Head of small quota**	3%	10%
TYPE II: Middle and small family farm	**(6 rais<AA<50 rais)**	**(Poly)culture (-animals)**	**60%**	**47%**
Type II.a : Middle family farm Sugarcane monoculture	(20 rais<AA<50 rais)	Sugarcane monoculture	13%	12%
Type II.b : Small and middle family farm : Polyculture and animal (cattle)	(6 rais<AA<50 rais)	Sugarcane and Babycorn associated or non with cattle	27%	20%
Type II.c : Small and middle family farm : Polyculture, animal (cattle) and rice	(6 rais<AA<50 rais)	Combination of polyculture-animal and rice Rice - Sugarcane Rice - Babycorn Rice-Sugarcane-Babycorn	20%	15%
TYPE III : Very small family farm	**(1 rais<AA<6 rais)**	**Monoculture in babycorn or sugarcane**	**33%**	**6%**
Type III.a : Very small farm Baby-corn monoculture	(2 rais<AA<6 rais)	Sugarcane monoculture	27%	5%
Type III.b : Very small farm Sugarcane monoculture	(1 rais<AA<6 rais)	Babycorn monoculture	6%	1%

TABLE 2 : Economic Parameter of Agricultural Production System in Thung Look Nok

Cropping/ Animal System	Equation of VA/family active	intermediate Cost (baht/rai/ year)	Fixed Cost (baht/rai/ year)	Area (max/family active)	Area (max/total active)	VA/ family active	VA/rai	Agricultural Income (max/family active)
• S1	2850 a/fa - 152000	1650	152000	300	25-30	703000	2343	448000
• S2	3590 a/fa - 67400	2070	67400	100	12-17	291600	2916	186000
• S3	3380 a/fa - 800	1950	800	12	12	39760	3313	39760
• Babycorn (BC)	8400 a/fa - 900	4400	900	4	4	32700	8175	32700
• BC+ Beef	10900 a/fa - 5400	9300	5400	3.5+7 Beef	3.5+7 Beef	32750	9357	32750
• BC + Dairy Cow	15500 a/fa - 6900	12800	6900	3+3 Dairy Cow	3+3 Dairy Cow	39600	13200	39600
• R1	2826 a/fa - 1900	1814	1900	10	10	26360	2636	26360
• R2	2644 a/fa - 1900	1276	1900	10	10	24540	2454	24540
• R3	2274 a/fa - 600	2274	600	15	15	33510	2234	33510
• R4	2184 a/fa - 600	1736	600	10	10	21240	2124	21240

S1 = Sugarcane/Very big farm – Capitalist
S2 = Sugarcane/Big farm – Business
S3 = Sugarcane/Family farm
R1 = Rice: 2 crops/year, HYV + HYV / with motorculture
R2 = Rice: 2 crops/year, HYV + Trad. variety / with motorculture
R3 = Rice: 2 crops/year, HYV + HYV / without motorculture
R4 = Rice: 2 crops/year, HYV + Trad. variety / without motorculture
a/fa = area / farmily active
VA = Value Added

Panel 5

Rural-urban interactions: the Delta and Bangkok Metropolitan area

The cultural factor in rural-urban fringe transformation: land livelihood and inheritance in western Nonthaburi

Marc Askew[1]

Abstract: *This paper addresses issues relating to patterns of lifestyle, livelihood and landscape change in two sub-districts (Tambon) of Nonthaburi province, one of the five inner provinces fringing the Bangkok Metropolitan Area, collectively comprising the so-called Bangkok "mega-urban region". I argue that strategies of survival on the part of gardeners (chao suan) and rice-farmers (chao na) in Bang Gruay and Bang Bua Thong respectively have, over the past three generations played as important a part in the underlying transformations of these areas as have the patterns of metropolitan area expansion. The smallholding economy of Nonthaburi's agriculturalists, particularly the gardeners, has always been intimately tied to the economy of the metropolis, and their production strategies have developed in response to changing market conditions. Well before the urban frontier of housing estates and factories encroaches into formerly rural landscapes, these households had become occupationally diversified, incorporating work patterns and networks tied into the metropolitan economy. Land is the crucial resource in the task of household reproduction, and access to new opportunities for status and livelihood have been historically tied to the accumulation, preservation and transmission of land. Increasing land prices and new settlements in these districts have been appropriated towards these ends. The capacity to strategically deploy land in the quest for income and status underlies the ways that families in these districts negotiate with, and participate in the ecological and social transformations around them. Studying farming and gardening families from a dynamic historical perspective through a succession of generations, we also find that these livelihood strategies have been tied not only to the exigencies of survival, but also to the quest for status among neighbours and wider fields of cultural capital shared in Thai society and the metropolis. Today, in the context of an increasing commodification of symbols and conspicuous consumption characteristic of the wider society, these traditional status concerns have made a significant impact on local areas in the ways that space and traditional institutions such as temples are utilised and displayed. We have seen that these local societies still exhibit features commonly associated with classically "rural" society, in particular strong and dense webs of kinship and place-specific reciprocity. But notwithstanding these characteristics, the households in these villages have never been insulated from*

[1] Senior Lecturer, Department of Asian and International Studies, Victoria University of Technology, Melbourne, Australia.

the wider society: the assumption that they are victims of external agents of change, exemplified in the metaphor of the threatening urban frontier, is a mistaken one.

1 Introduction

In 1970 the province of Nonthaburi was described in a guide to Thailands' 73 provinces as a distinctively agricultural area. Conveniently located on the northern and northwestern boundaries of the Bangkok Municipal area, it was recommended to weekend travellers from the city as a place famous for its Turian gardens; here they could tour a traditional landscape of placid canals and rice fields, and make merit at old and renowned temples (Supha 1970: 114-116). Above all, the province was identified by the image of its many small orchards worked by sturdy Thai gardening families (chao suan)(Yani 1995: 83). But within two decades of this guide's portrayal of rusticity, the province experienced a radical transformation in its economic base and its landscape. Throughout the 1980s manufacturing companies, attracted by cheap land and available labour, located plants in the western districts of the province. Contiguous with the official northern boundary of the Bangkok Metropolitan Administration, the eastern part of Nonthaburi (which straddled both banks of the Chao Phraya River) became a favoured site for housing estate projects. Beginning in the 1980s, expanding road and highway networks to the north of the BMA opened formerly inaccessible agricultural land, now attractive to the burgeoning housing industry. From the early 1990s, housing estates (mubanchatsan) spread across the river to the western side of the province as new state highway projects cut across the province. Due to the construction boom, residential land uses comprised 23% by 1990 (compared to 12% six years earlier), a figure far in excess of the other four provinces bordering the BMA (Banasopit et. al. 1990: 34; Somkiat 1989:40). By 1995, agriculture accounted for just 4.22% of Nonthaburi's Gross Provincial Product, despite the fact that agricultural activities still dominated overall landuse (71%). By contrast, manufacturing contributed 29 per cent and construction activity 11 per cent to the province's economy. Trade and services were Nonthaburi's principal economic sectors (Planning Office, Nonthaburi Province 1996: 12).

By the 1990s, Nonthaburi's annual population growth rate exceeded all other provinces in Thailand (Alpha Research 1994:24). In the wake of these population changes, the Ministry of the Interior belatedly reclassified sections of former rural districts to sanitary districts (sukhaphiban) and upgraded existing sanitary districts to municipal status, with the result that by 1990, 40 per cent of the province's population resided in these officially-designated 'non-rural' areas (thesaban) (NSO 1993).[1] In 1996, the preamble to the amended master plan for the province commented that parts of Nonthaburi were now indistinguishable from Krung Thep, and despite the persistence of considerable agricultural activity among household in its western districts, the role of the province was to act as a receiving area (rongrab) for the expanding population and burgeoning economic activities of the metropolis (Planning Office, Nonthaburi Province 1996: 5)

In recent years the transformation of the 'urban fringe' of Bangkok and other Asian cities has attracted the increased attention and study of policy-makers, planners, regional geographers and a variety of other social science researchers. A number of prominent geographers have identified the mixed and dynamic functions of these spaces as a new regional phenomena heralding the break-down of distinctively 'rural' and 'urban' geographies. The ecological and economic spaces formerly defined as 'urban fringes' are now generally viewed as interacting components of new 'mega-urban' regions of Southeast Asia - territorial formations with multiple and contrasting land uses forming an economic space combining both rural and urban characteristics (McGee 1989; Ginsburg 1991). It is argued that this new hybrid regional form in Southeast Asia owes its primary origins to the driving force of global investment flows following regional and global industrial restructuring and state driven export-oriented industrial policy (Douglass 1995; Greenberg 1994). There have been a number of propositions among scholars emphasising the internal diversity of these complex areas and the possibility that traditional village settlements may persist while serving dormitory functions (Greenberg 1994; Webster 1995). Recent research, however, shows that local as well as global investors are determining the distribution and concentration of land uses (Parnwell and Luxmon 1997). Nonetheless, these more refined depictions of Bangkok's extended metropolitan regions have told us little of the social dynamics and communities within this complex an dynamic space - they have focussed largely on surface distributions with only passing attention to the localised socio-economic dynamics of landscape production. The few detailed social studies conducted in these mega-urban regions of Southeast Asia show that ordinary local people have played a crucial role in shaping the changes taking place (Allen 1994; Brookfield, Hadi and Mahmud 1991).

Studies of the rural-urban fringe are dominated by the metaphor of 'invasion', applied to the process whereby industrial and residential extensions of the metropolis encroach into the countryside. Among regional and environmental planners, much attention has been given to the impact of industrial land uses on urban fringe agriculture, with the prevailing assumption being that agriculturalists would somehow continue farming (in favour of selling their land to housing developers) if their land was not degraded (Anuchat and Ross 1992:17).[2] This is a rather simplistic assumption which proves to be wrong. In fact, responses of agricultural households to changes in their immediate environment need to be seen in the context of broader long-term household strategies in an environment of social and economic change. As this chapter aims to demonstrate, the conversion of land to non-agricultural uses is only a final phase of a longer process of agricultural decline and the changing expectations of agricultural households.

At the local level, it is easy to portray the people of the fringe areas as victims of the incursion of the city. The sheer ecological and visual change to former rice-farming and orchard areas is dramatic. Housing estates, freeways, factories, department stores and modern transport are juxtaposed dramatically with rice-fields, canals and small village settlements. As one gardener of Bang Kruai District, Nonthaburi, remarked to me : 'sangkhom muang khao ma kin mot lery' ('urban society has come in and consumed everything'). Yet this is only part of the story. Together with his neighbours, this same gardener attended a public hearing on the new master plan for Nonthaburi (in 1996) and vehemently opposed the classification of his land as 'rural and agricultural' on the grounds that the land values of his holdings would be depressed. The same gardener vowed that his children would never work in agriculture: his eldest daughter was studying marketing at a private university and on graduation she would marry her boyfriend and live with him in a new housing estate in one of Bangkok's suburbs across the river. This highlights something about the ways that these households and their members participate in a complex process of change and consumption. The characteristics of this process are distorted when the expanding urban frontier is used as a territorial metaphor to encompass broader processes of social change, as if the city has been imposed on an innocent and unchanging rural populace. In territorial terms, agricultural settlements may be apparently surrounded or absorbed into a new 'urban' landscape, but the fundamental changes in household strategies have contributed to such transformation long before such physical encroachment commenced.[3]

This chapter is based on ethnographic and survey research which I conducted in two sub-districts of Nonthaburi province in the period 1995-6. This research combined the compilation of family histories and participant observation, and aimed to investigate how agricultural smallholders perceived and acted in their changing environment, both outside and within their immediate surroundings. I was particularly interested in gaining insights into how people explained their own decisions, and how cultural understandings and idioms could help highlight the strategies driving land use and disposal. A key theoretical approach guiding this research was that local socio-economic 'actors' play an important part in the overall process of change. In this I follow the work of those few geographers who have investigated the interplay between agency and structure in rural-urban fringe dynamics. These researchers propose that the re-shaping of these regions should be studied at two levels: first the societal/state/economy level, where forces of change have a key role in structural changes, such as transportation systems and industrial policy development; and secondly (but not less importantly), at the local level, where the larger processes are mediated by localised factors and land-uses, traditions and patterns of culture. A critical area of study in this local context is land, its function and meaning for landowners and users. This chapter argues that strategies promoting household livelihood and reproduction on the part of gardeners (chao suan) and rice-farmers (chao na) have, over the past three generations, played an important a part in the underlying transformations of these areas. These strategies are informed by practices which can be characterised as the critical 'cultural factor' underlying the transformation of the landscape - they reflect long-standing traditions of status accumulation and household reproduction among rural households in Thailand and in Thai society generally. This 'cultural factor' is not distinct or separable from economic processes - it is a dynamic which actually endows income generation and property with social meaning. Despite the large-scale forces which impinge upon agricultural areas and seemingly 'flatten' the landscape into a territory of investment and exchange value, local households and individuals act with an inherited set of understandings to accumulate symbolic capital and reproduce household status through recognisable cultural idioms. As agents in the very transformative process which engulfs them, these housholders need to be acknowledged as central players in the making of a new landscape of consumption in the Bangkok mega-urban region.

2 Bang Khanun And Phimonrat: Settlements In Transition

The two sub-districts (tambon) of bang Khanun and Phimonrat are located in the districts (amphur) of Bang Kruai and Bang Bua Thong respectively, on the western side of the Chao Phraya river. They represent the diverse and complex landscape within which agricultural households pursue their livelihoods today. Bang Kruai is an old orchard area, and Bang Bua Thong a rice-growing district. These settlements once formed part of the richest agricultural region of the Chao Phraya delta, a traditional farming ecology based on rain-fed crops sustained by the seasonal inundation of natural and man-made water channels. The rich alluvial soils of the delta have sustained settlements for centuries. In the Bang Kruai district, in the south of the province, ethnic Thai village settlements devoted to fruit and rice cropping seem to existed from at least the early sixteenth century (La Loubere;). As elsewhere in the delta, small villages clustered along the natural levees of the river banks and routes of canals, with their garden and rice watered by the seasonal flooding of the river. From this period the pattern of settlement in the south was relatively dense, as is evidenced by the large number of wat dating from the sixteenth century, pointing to the existence of communities capable of producing a surplus to be translated into the important task of merit making.[4] The villagers of Bang Khanun were linked into a web of economic exchange extending from small markets to the large market town of Talad Khwan, which later assumed importance as an administrative center under the name of Muang Nonthaburi during the 17th century (Terwiel 1989: 89, 121-122).

Until the late nineteenth century, however, the regions beyond the main waterways focusing on the Chao Phraya were unpopulated and inaccessible unless settlement was made feasible by extending canals, a process often undertaken on a modest scale by communities themselves (Tanabe 1977: 27). Areas to the north and centre of Nonthaburi have a varied settlement history. Mon refugees (who migrated in a series of waves from the 17th through to the 18th century) were encouraged to farm the sparsely populated districts around Pakret and Pathumthani (formerly Sam Khok) from the 17th century. By the early nineteenth century these clusters of Mon villages had become the most substantial settlements between Nonthaburi and the old capital of Ayutthaya to the north (Terwiel 1989:122). To the west of the Chao Phraya river, settlement began to spread from the Bang Bua Thong canal, pioneered from the 1840s by Lao war captives and later prisoners taken from the defeated Malay sultanate of Pattani. The Phimonrat canal, originally a small modified natural stream leading to the west from Khlong Bang Bua Thong, was settled first by Lao households (probably from the 1850s). They were joined in later decades by larger groups of Malay families who had first been settled in the Pakret area. They built their homes on the banks of this modified natural stream, cleared the surrounding forests for rice-cropping, and established familiar religious institutions to sustain their communities.

The central provinces bore the brunt of the transformation of the Thai economy in the nineteenth century. This transformation involved the expansion of rice production and other export products for trade on the world market, according to treaties imposed by the British, and later other western powers (Chatthip 1984:36-50; Douglass 1984). The push towards an export-oriented agricultural economy in the central plains gave the impetus to population settlement, land clearing, and state-directed canal building (Tanabe 1977: 51-61). The communities of Bang Khanun and Phimonrat were enmeshed in this broader process which saw expanding production and an increasing monetisation of the peasant economy. In the1860s major state projects such as the new Mahasawat Canal (linking Bang Kruai to Nakhon Chaisi in the west) opened further land for settlement in the Bang Khanun area. At the turn of the century, the small stream used by the farmers of Phimonrat was widened in order to facilitate settlement and allow for the easier transportation of rice to Bangkok. As Tanabe has noted, government projects designed to facilitate transportation for an export-oriented rice economy were of themselves not sufficient to ensure population settlement. Large tracts of these newly excavated areas were given to noblemen and royal family members, but they experienced difficulty in attracting Thai peasants. The expansion of cultivation was rather spurred by the decline of the corvee labour system and the dismantling of the pre-capitalist sakdina system of population and labour control which gave greater opportunities for peasants to search for and attain smallholdings of their own (Tanabe 1977: 1977:61). Even before land titles were issued in the late 1890s, farmers could acquire rights to cultivate new land, which included the right to sell or mortgage holdings (Wales 1934: 121-122). Pioneer farmers eagerly embraced opportunities for proprietorship in a new market economy. Indeed, the increasing formalisation of the system of registering land from 1874 seems to have been prompted by an escalation in disputes over land claims by smallholders (Sharp and Hanks 1978: 77). In Phimonrat the first major wave of settlement and land acquisition seems to have occurred between the mid-1890s until well into the first decade of the twentieth century. Recollections of elderly farmers of Phimonrat indicate that some of these settlers held rice-fields of up to 150 rai.

From the later decades of the nineteenth century the livelihoods of the peasant households of Phimonrat and Bang Khanun were linked to broader markets through an expanding group of rice-trading middlemen and rice-millers. Production was almost exclusively devoted to rice among Phimonrat households, while in Bang Khanun families engaged in both market-oriented fruit growing as well as rice cultivation. In the latter area the growth of a metropolitan consumer market in Bangkok led to peasant households converting rice-fields to orchards to the point where, by the 1940s, little rice-land remained in the Bang Kruai district. This may have also been a response to the progressive reduction of landholdings through family inheritance. Although relying increasingly on a money economy for their livelihood, these households were sustained by patterns of subsistence production, using local food resources as a basis for household sustenance. In Bang Khanun, women commonly sold or bartered orchard surpluses at local canal-based markets to supplement family needs. Customary practices of labour exchange were common in both areas until well into the twentieth century. Patterns of communality were reinforced by a physical isolation imposed by slow water-borne transportation.

Economic differentiation emerged increasingly throughout the 1920s and 1930s as a result of differential rates of land acquisition and indebtedness. Chatthip Nartsupha and Michael Douglass have outlined the high degree of landlessness characteristic of the central region, as well as the emergence of conspicuous inequality between large and small landowners.

An increasing availability of cash income enabled some rice-farmers to engage in conspicuous consumption (expensive merit-making activities and marriage ceremonies) and consumption of luxury foods as well as leisure activities (including gambling)(Chatthip 1984: 15; Douglass 1984: 66-68). For whatever cause, indebtedness and the need for cash led increasing numbers of farmers to borrow money from neighbouring villagers or local rice-millers on the security of their land. This pattern is also evident from family histories compiled in Phimonrat and Bang Khanun.[5] Those households without land worked as hired labour for land-owning neighbours. Larger landowners also drew on the services of labourers from the Northeastern region. In contrast to present-day labour arrangements, these men were hired on a yearly basis.

Old Bang Khanun residents recall that visits to Bangkok were rare among family members well into the 1940s, taking place once or twice a year for the purchase of essential supplies unobtainable locally (mosquito nets, for example). Phimonrat farmers rarely ventured beyond the market and district office of Bang Bua Thong, a journey on foot which took the best part of a day to accomplish. As illustrated by the cases in the discussion below, engagement in a wider status system was taking place well before WWII among some families in these settlements. However, the years after World-War II ushered in a period of accelerated change in both the social horizons of households and their connections to an increasingly diversified labour market and economy. The processes outlined by Sharp and Hanks for the village of Bang Chan in Minburi in the post-WWII years are broadly representative of the changes occurring in Bang Khanun and Phimonrat (Sharp and Hanks 1978: 225-226). The period saw a diversification of income sources among villagers into petty trade, transport and construction, as well as expanding opportunities for education and the status resources of white collar work for the children of the better-off households. The nature of the villages was changing as a result. Some households had little to do with agriculture. New arrivals purchased small plots from farmers to build houses. Children of farmers and gardeners (who pursued occupations in government service or other non-agricultural work) built houses next to their parents, contributing to an increasing densification of village settlement. These were added to the existing house plots of farm labourers, who, although having no rice land or orchards, generally owned their homes. By the 1990s, as seen in the following section, a high proportion of village home-owners could not be equated with agricultural livelihoods, despite the fact that many could claim kin connections with, and may be living next door to, agriculturalists who worked the fields and orchards beyond the canal banks.

By the 1950's motorised boats transported goods to markets and also transported the increasing numbers of family members in urban -related occupations to Bangkok. The eastern side of the province bore the brunt of ecological transformation during the 1960s and 1970s as commerce, housing and industry expanded northward from central Bangkok along newly constructed road and highway networks. But on the western side, including Bang Khanun and Phimonrat, radical change in the local living and working environment of agricultural households was delayed until new bridges were constructed across the Chao Phraya River from the seventies. Today, the Bang Kruai district is linked both to the metropolis and its surrounding districts by both canals (the traditional transport routes) and newly constructed roads. The Rama VII bridge joins Bang Kruai to the eastern side of the province. Bang Bua Thong, to the north of Bang Kruai, was formerly reached only by canals and a few minor roads, but has been made accessible by the recent construction of the north-south Talingchan-Suphanburi Highway. In 1983 a new bridge crossing the Chao Phraya River connected the Bang Bua Thong district via Rahanathithibet Road, to the eastern side of the province and beyond. Both Ban Kruai and Bang Bua Thong districts are characterised by an increasingly diverse land use, since road construction has influenced patterns of land sale and conversion to commercial or residential use.

In Bang Bua Thong, the mid 1980s saw light manufacturing establishments locating in a number of tambon bordering Phimonrat. In 1994 the total number of establishments at district level numbered 193, employing over 3,500 people. Most of these firms were small, with only 2 employing over a hundred people (Department of Town and Country Planning 1994: 110). The bulk of recent population growth and new housing development lies to the east of Tambon Phimonrat, close to the town of Bang Bua Thong, but by 1992-3 land purchases in a number of villages heralded the arrival of housing estates in the immediate vicinity. By 1995 there were seven housing projects nearing completion, focusing on the land close to the highway, but also scattered to the westward along the road recently cut through the rice-fields on the initiative of the local Tambon Council, headed by Phimonrat farmers. Entering Tambon Phimonrat from the eight-lane Talingchan-Suphanburi highway in mid-1995, one passed huge advertisements proclaiming the modern lifestyles available in Muban Bang Buathong Phase 4 and Wirotville, the latter featuring large units in 'Satai Roman' (Roman Style) for '<u>khon mi radab</u>' (people with class). Further eastward, crossing a bridge over one of the small lateral canals, a less congested landscape opened out to reveal farmers ploughing their fields, some of them wedged between new mubanchatsaan. Signs indicating the names and official numbers of the <u>muban</u> (villages) stand next to new entrance lanes (wide enough for vehicles) recently cut through to the villages lining the canal 500 metres walk from the road. On the canal there is a busy commuter traffic of motorised boats plying between the villages and the town of Bang Bua Thong- mainly comprising housewives going to and from the town market and school children- but the road had clearly become an alternative focus of activity, with a variety of shops and small petrol pumps servicing passers-by.

In Bang Khanun too, signs of the new wave of housing estates in 1995 were conspicuous, with three estates under construction on the <u>tambon</u> border, and another one inside the <u>tambon</u> boundary already completed and open for inspection. With its road yet-to-be widened, the area still appeared verdant with its thick canopies of coconut palms and densely planted orchards of banana, jackruit and mangosteens. Yet hand-painted signs advertising land sales betrayed this apparent isolation. While most gardeners still lived in homes along the Bangko Noi canal or its subsidiary streams, new white-stuccoed homes were noticeable, announcing their owner's modern lifestyles with driveways and fancy gates. As in Phimonrat, a steady commuter traffic comprising a diverse assortment of song thaews, motorbikes, decrepit bicycles and Hi-Lux vans highlighted the contrasting incomes and livelihoods of the local people. Most strikingly symbolic of the recent orientation to the roadway was the newly-constructed gateway to Wat Bang Khanun, welcoming visitors with its shining gilt and mirrored glass tiles. Next to it a noodle stall conducted a healthy business with elderly women merit-makers and garden laborers. The following sections of this chapter explore the emergence of these hybrid local landscapes in relation to the evolving and adaptive livelihoods, family strategies and status concerns of local households.

3 Land, Labour And Income

The gardeners of Bang Khanun practice a livelihood that seems little changed since the days of their forebears. Their densely planted orchards, seemingly small forests of Coconut and Betel palms, Jackfuit, Turian, Pomelo, Bananas and other fruit varieties, rely on the monsoonal rains to periodically the channels of their low-lying plots. Many gardeners commonly plant a variety of fruit crops which ripen throughout the year, in order to assure a continuous income. This pattern of cultivation, known as lom luk (literally meaning 'up and down'= seasonal) reflects, to an extent, the traditional concern of gardeners to ensure household subsistence, self-reliance and flexibility. This method contrasts with tree-fruit specialisation, known as yun ton. The cultivation of fruit orchards has always been oriented to markets, but gardening has also the advantage of producing food for daily consumption. This is one reason given by many gardeners for the fact that their lifestyle, when compared to rice-farmers, is extremely comfortable, involving steady work all year round in contrast to the intense periods of seasonal labour demanded of rice-farmers. Nonetheless, within this approach is a canny business assessment of the vagaries of market prices and the seasons, the perennial factors creating uncertainty for agriculturalists.

Despite the apparent simplicity of planting practices, they reflect a keen awareness of the gardener's orientation to the market, and the fruit varieties planted by the chao suan have evolved accordingly. It is thus common to find a pattern of planting combining plants of a very old age (Turian, coconuts and betel palms), together with recently planted fruit crops such as oranges, pomelo and limes, a response to the expanding demand for these in the growing metropolis. Another reason for the development of these crops is the increasing age of the gardeners, most of whom are now aged 50 and above. The harvesting of tree fruit demands considerable exertion as well as expenditure on the hiring of labour, assets which many elderly gardeners do not have, unless their children continue to work the orchards as a vocation. So changing the mix of crop types has been one adaptation to changing conditions. Yet another reason is to replace the fruit trees damaged by major floods, particularly that of 1983 and the most recent, and most devastating flood of 1995. Traditional tree crops such as the Turian take a long time to mature fully (7 years to full maturity). Moreover, many Turian trees have died through the effects of floods, and environmental changes brought about through air and water pollution in the metropolis have led to a severe decline in the fruit yield of these traditional tree crops. Today gardeners of limited means prefer to invest in crops which will assure a quick return and yield saleable fruit throughout the year.

The average size of garden holdings is small, generally between 2 to 4 rai (0.8-1.6 acres/). Gardeners say that some twenty years ago it was possible to make a reasonable living from 2 rai but this is now no longer the case, due to increases in labour costs, cost of fertiliser, pesticides, food and family expenses. The size of the holdings today also reflects a progressive pattern of land division through inheritance which has gradually reduced family holdings over the generations. In 1990, average incomes of gardening households (40,000-50,000 baht) were lower than the province per capita income (62,797 baht), and substantially lower than estimated average incomes for households in the greater Bangkok region (82,764 baht)(NSO 1997). Gardeners' annual incomes were not substantially higher than those of workers in skilled trades in the same district, and substantially lower than average incomes of government employees (70,000 baht) (NRDC Data Base 1990; Agricultural Office, Bang Kruai District 1994: 26).

Yet these average income figures can be misleading. Some gardeners can enjoy extremely high incomes through specialisation of crops, but this demands a greater investment and risk than many have the capacity or the will to take. This is one of the key distinctions between orchard operators in Bang Khanun, reflecting disparities in income and approach. The better off gardeners are those who either concentrate on producing tree fruits (such as oranges, Turian, Jackfruit, Mangosteen and Satorica) which enjoy higher prices in the market. Others grow fruit tree cuttings which are in great demand in the provinces where fruit growing has expanded; or focus on the expanding urban consumer market for flowers, such as roses or orchids. Profits from these endeavours grown on the limited holdings of 3 to 4 rai can yield annual incomes in excess of 100,000 baht per year.

The characteristics of agriculture and incomes in Phimonrat contrasts strikingly with those in Bang Khanun. In contrast to Bang Khanun, where the majority of gardeners own their land (82%), less than half of the rice farming households of Phimonrat own all the fields they work. Moreover, a quarter of these households own holdings of less than 10 rai, which is insufficient to produce an adequate income from rice-farming alone. Ten rai of rice-land harvested twice a year yields an estimated net income of just 22,000 baht, which is just over half the annual income of factory workers in the district. Those who work 20 rai of rice-land are not substantially better-off than full-time factory workers either (averaging 44,000 baht per year as compared to 40,000 baht). On these estimates, only a third of Phimonrat farmers (those with over 30 rai) earn incomes above the average of regularly-employed wage-workers (NRDC Data Base 1990; Agricultural Office, Bang Bua Thong District 1994: 23-24). It is thus hardly surprising that many rice-farmers also work as hired agricultural labour or in other occupations, notably those relating to the building industry. Family histories reveal a pattern of ever-reducing landholdings due to the division of land for inheritance. And, as with other rice farming communities, smallholders have faced problems of increasing debt through the need to invest ever-larger amounts of money into buying or hiring machinery, paying for fertiliser and hiring labour for planting and harvesting. Increasingly, loss of land has been the result (for which also see Chantana 1993: 6). There are numerous cases of rice-farmers mortgaging their holdings to the local rice-miller or to better-off farmers in the area, and eventually losing title to this land through their inability to repay debts. Indeed in the case of one village, all the farmers grow rice on land which they once owned, but now rent from the local rice-miller due to indebtedness.

From the early 1970's, many Phimonrat households turned to fruit trees to supplement their vulnerable and declining incomes. It made sense to utilise the slack period after harvest for extra money, and planting a variety of fruit crops in small sections of a farmer's holding offered the advantage of gaining supplementary income throughout the year. Gradually, some rice-farmers in Phimonrat devoted their efforts completely to fruit cultivation, since more income could be gained from cultivating less land, even though the initial investment was higher than rice per rai. For example, from planting one rai of land with mango trees, a farmer could eventually earn an annual income of an estimated 19,200 baht, or over seventeen times the amount that could be earned from planting the same area with rice (1,100baht) (Agricultural Office, Bang Bua Thong District 1994: 23). It was a rational response to the constraints imposed by small landholdings and the transformed family occupational structure where fewer children (and often none) were engaged in the agricultural enterprise.

Administratively defined as 'rural' the two tambon under consideration here are grouped into wider districts (amphur), which comprise adjacent 'municipal' (thesaban) and 'sanitary' (sukhapiban) sub-districts. These classifications and boundaries primarily reflect evolving patterns of population density and the ways the state has mapped them. To highlight the specific characteristics of the households in the two tambon, it is useful to view occupational and workplace features at this amphur level first, since this reflects the immediate environment of the households, including the market towns, the housing estates with new populations, and the key transportation nodes where a diverse service industry has recently grown. Viewed at this level, we see that many households of amphurs Bang Kruai and Bang Bua Thong pursue non-agricultural occupations within Nonthaburi province or further afield in other parts of the metropolitan region. In 1990, according to Ministry of the Interior surveys, households with members solely engaged in agriculture comprised just 21.7% of households in Bang Bua Thong and 29.6% per cent in Bang Kruai. (Amyot 1994: 160). Considered at a district level, the role of agriculture as a sole income-earning activity is clearly less important than household livelihood based on non-agricultural wage and salary-earning. In Bang Bua Thong, factory work is an important source of income for household members, with a greater proportion of women engaged in industrial labour. In Bang Kruai, the workforce is more diverse, and in contrast to Bang Bua Thong where the majority of wage and salary earners find work within the district, most non-agricultural workers of Bang Kruai (79% of males and 82% of women) travel into the metropolitan district to work (Amyot 1994: 162).

Not surprisingly, the proportion of Phimonrat and Bang Khanun households engaged in agriculture are somewhat higher than the district averages. In Tambon Ban Khanun, families categorised by local officials in 1994/5 as 'agricultural households' represented only 188 of a total of 550 families (34%), while in Tambon Phimonrat 51% were counted in this category (Agricultural Office, Nonthaburi 1995: File No. 4; Agricultural Office, Tambon Bang Bua Thong 1994: 19).[4] These 'agricultural households', are defined as those families owning or renting farm land with household heads engaged in agriculture. In fact, despite this designation, these families have a varied occupational structure linking members to the non-agricultural sectors of industry, commerce and government service both in the inner metropolitan area or their own region. Table 7.1, derived from my survey data in 1995, shows that agricultural activity provides varied proportions of income for different families, and is the sole support of only a minority of households living in the villages of these tambon.

TABLE 1 PROPORTION OF TOTAL HOUSEHOLD INCOME DERIVED FROM AGRICULTURE, HORTICULTURE AND AQUACULTURE, HOUSEHOLDS IN TAMBONS BANG KHANUN AND PHIMONRAT. 1995.

	None	>20%	20%-49%	50%-79%	<80%	Total No.
Bang Khanun	50.8%	11.4%	8.1%	6.5%	22.9%	70
Phimonrat	35.0%	7.2%	4.1%	9.2%	44.3%	102

Source: Author's 1 in 5 household survey, 3 villages Bang Khanun, 4 villages Phimonrat, 1995

An occupational survey of families in the two tambon in 1995 showed that in Phimonrat villages only 26.6% of households headed by agriculturalists had all adult children following the occupations of their parents, while 44% of these 'agricultural households' had no adult children in these occupations. For Bang Khanun, the proportions were 14.7% and 41.1% respectively. Yet a significant proportion of these farm operator-headed families had adult children distributed across the employment sectors. Thus in Phimonrat a further 24% of these households had at least one adult child sharing in their parent's enterprise, while in Bang Khanun, farm-operator-headed families with at least one adult child working the family orchard comprised forty-four per cent of all surveyed agricultural households.

Clearly, families continue to engage in agriculture at a variety of levels in these villages in the context of an overall decline in rice-farming and gardening across the generations. The significance of agriculture in terms of its role in supporting household livelihood is determined by the capacity of households' landholdings, their access to labour and capital inputs, and the market. As will be illustrated below, these patterns need to be assessed in the context of continuities and changes in the function of land as a multiple resource, and by viewing the household as a dynamic historical agent deploying resources towards the acquisition of status as much as survival. This approach thus focusses not on the conventional question of the viability of agriculture on the rural-urban fringe, but on the cultural practices of households.

4 Land and status

The sale and conversion of land to new residential, industrial and commercial uses is one way of portraying the central dynamic which transforms the landscape of the urban fringe. Viewed from particular localities and family histories, it is rarely that simple, either as a process or an outcome. To comprehend patterns of land disposal, we need to appreciate that landholdings have many meanings and functions for households. In common with peasant households in Thailand, families in Phimonrat and Bang Khanun have traditionally utilised land as a multiple resource - for survival, for profit and accumulation, and for social capital (eg. in the marriage market). While today land no longer provides the sole income for a large proportion of households, and non-agricutlural work often offers individuals and families better incomes, it still constitutes the key historical foundation for economic advancement and has determined to a large extent contemporary patterns of differentiation among households

Possession and transmission of land through inheritance has played the preeminent role in determining life chances and status. In both Bang Khanun and Phimonrat, local people have a keen awareness of the property holdings of their neighbours and measure their status accordingly. Traditionally, land gave wealthier families the capacity to reproduce and expand landholdings and status through further land purchase, arrangement of favourable marriages of their children, and the education of their offspring. In Bang Khanun, a household's capacity to afford education for sons (and later, daughters) provided them with access to work in government service (rap ratchakan), an occupation which still continues to be held in high esteem for its status and security benefits. Family histories in Bang Khanun show how wealthier families in the 1930's were investing in sons' education for government service, with the result that the occupational profiles of their households diversified, even though the core household remained committed to an agricultural way of life. The case of Lung Pherm ('Uncle Pherm', 82 years old when I interviewed him in 1995) illustrates this process. Lung Pherm was born into a gardening family which was considered to be very well-off. His father and mother held land in two sub-districts, comprising 33 rai of both riceland and orchards. After his marriage at the age of twenty in 1935, his father gave him 20 rai of orchards. He and his wife later purchased a further 10 rai of orchard land in Bang Khanun, where they moved to live. On his father's death, Lung Pherm inherited a further 13 rai of orchard land, raising his total holdings to 43 rai. Lung Pherm's wife bore eleven children. Of these, two sons followed their father's occupation as gardeners, while two entered government service, one as a military officer and another as a school teacher. Three of his daughters also received secondary and college education and entered government service. The youngest of these daughters studied to university level and entered teaching. Another daughter finished her secondary schooling, married a gardener and maintains an orchard in another district. Lung Pherm's orchard land allowed him to generate enough income to educate his children while maintaining an adequate living, also allowing his to distribute land to those sons and daughters who continued in agriculture. In addition to two sons who continued gardening and the unmarried daughters who stayed with their parents, one of the sons in government service often returned to the orchards to assist in the family enterprise.

As suggested in the case above, the process of dividing land for inheritance could affect the fortunes of succeeding generations engaged in gardening because landholdings were progressively reduced. In this sense the practice of diversifying families' occupations into various non-agricultural sectors could be seen as a strategy of survival as much as status acquisition and maintenance. Nonetheless, the initial possession of larger holdings and the income derived from them ultimately framed the opportunities of children and grandchildren to maintain their economic status, whether in agriculture or not. The case of Lung Suthin is instructive here. Lung Suthin (68 years of age) is the retired headmaster of the local school of Wat Bang Khanun. His parent's total orchard holdings of 10 rai had generated sufficient income for them to support his and his sister's vocational education, yet they seem never to have considered the abandonment of gardening. On completion of his teacher training, he returned to Bang Khanun to work at the local school and in 1948 married a woman from the neighbourhood where he had grown up. He and his wife used their orchard to supplement the modest government income from his teacher's salary. They lived and worked on a holding of 5 rai of orchard land inherited from Lung Suthin's parents. Lung Suthin maintained a lifestyle of both gardener and kharatchakan, and is still highly respected in the community. Like women in the neighbouring garden families, his wife pursued the traditional role of mae kha (female vendor), selling the garden surplus at the nearby floating market. Given their large number of children, neither occupation, on its own, would have been enough to maintain their growing family. But when combined, these incomes permitted both the maintenance of the family's livelihhood and the advancement of the childrens' life chances through education. They raised a large family of eleven children, and were able to support their education through secondary school and technical or commercial colleges. Only his youngest son continues the occupation of gardener on Lung Suthin's garden land. He is a chemistry graduate who made a deliberate choice to return to gardening to be with his parents and pursue an alternative lifestyle to his peers who work in commerce and industry. He stresses that the land is moradok (family inheritance), and thus should be maintained and nurtured.

Bang Khanun residents who consider themselves poor in comparison with their neighbours, explain the origins of their condition in terms of their parent's lack of land, or the absence of inheritance. Mrs Chum (aged 37 years) for example, emphasizes that she and her two sisters and four brothers attended school for only four years because her parents had no orchard land and could not generate enough income to pay for any further education. Until the time of her marriage she worked in the small orchard of her maternal grandmother and worked as a daily labourer on neighbour's holdings. Life improved for Mrs Chum and her husband when her grandmother died and bequeathed to her a house and orchard holdings of 2 rai. She, her husband and her sisters have divided the crops between lom luk and roses. They do not grow the roses in enough quantities to sell as single flowers, but rather use them to make garlands which are then sold at the large market of Pak Khlong Talad in Bangkok. The orchard produce brings them a bare income of around 3-4,000 baht per month. Given the limited family income, Mrs Chum does not expect her children to be educated beyond the early years of secondary school.

Similarly among the Muslim rice-farming families of Phimonrat, fortunes have been based on transmission of and access to land, as well as the capacity of landholdings to sustain livelihood. The stories of men and women who are now without farming land indicate that the progressive reduction of landholdings and the continued uncertainties of incomes from these small farm holdings were fundamental constraints to the maintenance of livelihood and economic status. Pu Abdullah (grandfather Abdullah) is 81 years of age. His father was a large landholder of 150 rai of riceland. Grandfather Abdullah was one of four children who received an inheritance of around 35 rai each. While this was a medium sized rice farm, Grandfather Abdullah became progressively indebted to the point where he lost this land to those neighbours to whom he owed money. He then worked as a farm labourer for neighbouring rice-farmers and later tried his hand as a vendor in inner Bangkok. With little education and no land, his seven children worked as farm laborers or vendors. For others with insufficient land, farm labouring (rab chang) was combined with cultivation of their own fields. This was the case with Mrs Si Ar, who inherited half of her parent's small farm of 16 rai.

Grandfather Abdullah's situation contrasts with the fortunes of the two brothers Ibrahim and Ismael in the neighbouring village of Ban Rongsuat. Their father had inherited 30 rai of riceland from his parents and had purchased a further 24 rai from relatives in the area. Together, they inherited this total landholding of 54 rai. This farmland enabled them to maintain a standard of living which they describe as 'dikwa chon noi' ('a little better than poor') and 'better than eating salt' (mai dong kin klua). Yet this land represented not only a livelihood (kan tham ha kin) but also important cultural capital. In 1988 they sold 10 rai of this land (at 15,000 baht per rai), and with the proceeds paid off their debts to the local rice-miller and financed the costs of a pilgrimage to Mecca. They gradually converted 10 rai of rice land located closest to their home into orchard, and rented the remaining land to farmers from a neighbouring village. Rented at 500 baht per rai, they receive a total rental income of 20,000 baht annually, in addition to at least twice that amount derived from their newly expanded orchard of coconuts, Jackfruit, Mango, Limes and Pomelo. Both men were able to afford schooling expenses for their children to at least the level of senior secondary school. Their sons follow occupations of hairdresser, radio technician, jeweller and religious teacher. Of their daughters, one is and nurse and another a hairdresser, while the others still study at school.

Among the communities of the rural-urban fringe, land continues to play the fundamental role as an economic foundation for household strategies and the acquisition of cultural capital. However, agriculture is less-and less the basis of occupations. However, it should be noted that, occupational diversification has a long history - especially among Bang Khanun households - and was evident as early as the 1930s among families of means. The further trend towards occupational diversity within lower-income families more recently is the result of an expansion of livelihood possibilities accompanying change in the economy generally, particularly over the last three decades. From the level of the household, it is important to acknowledge that this process is one in which households have played an active part. The households of Ban Khanun and Phimonrat are marked by a major contrast in the lifestyles between generations. While an older generation of grandparents and parents are largely wedded to agricultural vocations, many are adamant that they do not wish their children to enter agriculture. There is a general consensus among parents that there is no future in agriculture (mai kao na), and besides, it involves hard manual work (tham ngan nak). An extremely important consideration among parents is to ensure security for their childrens' futures. The uncertainties of agriculture determined by the external market, fluctuating climatic conditions and disasters (especially floods), provide a fragile basis for a secure life in old age. It is not surprising then that in responding to a survey question about preferences for childrens' occupations, the highest proportion of household heads specifying desired occupations for their children stressed that government service was the most desirable. Government service represented comfortable work with regular income (sabai), and it was secure with the assurance of a pension on retirement (man khong)(see table 7.2). Thus, in considering decisions of households to dispose of land on the urban fringe, these already existing orientations and expectations of farming and gardening families need to be acknowledged. Long before the asphalt met the rice fields, farming households have been in transformation.

TABLE 7: ASPIRATIONS FOR CHILDREN'S OCCUPATIONS AMONG PARENTS IN AGRICULTURE, BANG KHANUN AND PHIMONRAT, 1995

Work type	% HH Preferences	No.
Achieve high educational qualifications*	22.0%	38
Business (self-employment)	3.4%	6
Career with regular salary	13.9%	24
Government Service	29.0%	50
Professional	2.3%	4
Let children decide	29.0%	50
Total	100%	172

Source. As in Table 7.1

*Note: These respondents did not specify occupations but stressed the importance of children achieving the highest possible qualifications as preparation.

5 Responses to change: the uses of land

As has been well documented, the adverse environmental impact of the advancing urban frontier of housing, industry and commercial activity on agricultural land has clearly played a critical role in rendering an already fragile agriculture virtually untenable as a basis for household livelihood (Banasopit et al. 1990: 51-52). Although fewer households now rely completely on agriculture as an income source, environmental changes have impacted negatively on the last generation of full-time farmers and gardeners. Thus, viewed strictly from the perspective of agriculture, urban expansion is entirely negative. In Phimonrat, nearby housing development and industry have polluted canal water and brought pests (such as mice) to ravage the remaining rice fields. Farmers reminisce that there were once about twenty species of fish to be caught in the local canal, as well as shrimps, which formed part of their diet and subsistence. In the eastern half of Phimonrat -closest to the highway where housing estates have made the greatest incursion - fewer and fewer rice farms are viable. Most rice farming is practiced to the west, where less land has been sold. In Bang Khanun, polluted river and canal water has had a major impact on the health of fruit trees which once flourished. Gardeners argue that the marked decline in Turian yeilds over the past two decades is due to changes in air temperature, air pollution in the metropolis, and the continued vibrations caused by traffic using nearby roads.

Yet agriculturalists actively participated in the changes to their own environment. In Bang Khanun and the surrounding district, gardeners had been quick to take advantage of new technology by attaching engines to their boats, a trend which added to increasing water pollution through the release of oil and petrol into the canal water. In Bang Khanun and Phimonrat over the last five years, farmers have donated land for the construction of subsidiary roads to connect their settlements to the expanding road network. While adding many conveniences (allowing better access to services, markets and hospitals, for example), these initiatives opened these districts to an expanding housing industry. In describing the development of roads in their areas, agriculturalists invariably use the term 'progress' (khwamcharoen) in a positive way to describe recent changes

Moreover, the changing patterns of settlement have also been welcomed by many households. In Phimonrat for example, while farmers may individually complain that the canals have been polluted, they also stress that the factories which began operations in nearby tambon from the early 1980s afforded employment opportunities for their children close to home. In the household surveyed in Phimonrat, the greater proportion had members working in factories. Prior to this development, changes were already underway in the Muslim families of Phimonrat. While formerly it was customary for daughters to stay at home until marriage, factory work offered the potential to add to families' incomes. Daughters began working in the industrialising district of Prapadaeng (southeast of the BMA) in the 1970's. But the new factories in the Bang Bua Thong district allowed Muslim girls to work closer to home, which was a major advantage to parents, ever concerned to protect their daughters' sexual virtue. Pa Mo (Auntie Mo) has two daughters who once worked in Prapadaeng, but now work in a nearby umbrella factory. She expresses a general view of the factories among her neighbours by noting 'diowni sabai' ('now we are comfortable'). The factories are now an established part of the landscape and the livelihood of family members, including household heads. In one village (Ban Ronkrachom) the village headman works as a guard at a nearby factory and communicates with his assistants by mobile telephone. In addition, the advent of factories in Bang Bua Thong presented new opportunities for families who live nearby to supplement their incomes by selling food to factory workers.

5.1 Alternative uses of land

From the mid-1980s an increasing demand for land for housing led to an escalation of land prices in the provinces surrounding Bangkok. Agricultural land also increased in market value in the areas now made accessible to developers through the expanding road networks. In Phimonrat in 1985 the average selling price for a rai of land was 30,000 baht, which rose to between 70,000-100,000 baht in the following five years. By 1995 prices per rai had soared to 2 million baht, and to 3 million baht for land located close to roads. In Bang Khanun the price per rai had been around 50,000 prior to the land boom, but by the mid-1990's prices were equivalent to those in Tambon Phimonrat. In this environment, one response of farmers and gardeners was simply to sell all their holdings. In such cases this did not mean that the householders abandoned agriculture. Among households where agriculture was still actively practiced, (particularly among farmers and gardeners who had not reached an age when they could not work), profits from land sale were often used to purchase land in other provinces where agricultural land was cheap. Some farmers in Phimonrat moved to Rayong, in Chonburi province, to continue farming. In Bang Khanun too, Chonburi is a favoured site, since the province had become the major fruit producing region of the country, and land was still affordable. Others shifted to Suphanburi province to the west of Nonthaburi.

The landscape to the east of Phimonrat may at first glance give the impression of a wholesale desertion of the area by its former occupants. However, the movement of farming families and the uses of their land was determined by calculations concerning its most effective deployment. Notably, very large housing estates of over a hundred units are not conspicuous in the district because of the difficulty faced by developers in assembly sufficient land banks of individual holdings. The land for the largest housing estate near the main highway was able to be purchased easily because the whole parcel was owned by the Christian church at Bang Bua Thong. Further to the westward, along the Bang Bua Thong Sai Noi Road (which local farmers had originally opened) the housing estates are generally smaller. This points to a pattern of land sales where the original owners have often not dispensed with all of their land, but only individual parcels.

The logic of a landholder selling only part of his/her rice-fields is based on a strategy of maximising the uses of assets for the household, particularly preserving sections for passing on to children and retaining still-productive or otherwise useful land. Thus Hadji Dawo planned to sell 17 rai of his holdings which were already surrounded by a housing estate. However he was preserving the remaining 8 rai for his 6 children to inherit. Selling sections of land in the climate of high land prices prevailing from the late 1980s to the mid-1990s offered farmers the advantage of paying their debts while preserving sections of their land for continued production, as we saw in the case of the two brothers Ibrahim and Ismael above. Lung Yaya sold 2 rai of his 11 rai holdings in 1989 at 800,000 baht per rai in order to liquidate debts incurred to a neighbour and the agricultural cooperative. With the 1 million baht remaining to him, he arranged for a pilgrimage to Mecca with his wife (50,500 baht) and made improvements to his house. He kept that land which he had converted to orchard, and with family help in the orchard and supplementary payments from his adult children, he is still able to maintain an adequate income.

For some Phimonrat people who had struggled all their lives to make ends meet, the chance to sell their insufficiently productive land during the land boom gave them new opportunities. Mrs Si-a, mentioned earlier had farmed 8 rai with her husband, but both had also needed to work as farm labourers to gain additional income. In 1994 they sold this 8 rai to a property developer known to their son, who was a driver for a construction company. With the proceeds of the sale (8 million baht) Mrs Si-A purchased a truck for her eldest son to establish him as an independent transport contractor, and deposited the remaining funds in the bank, with plans to later build a new house on a small plot of land inherited by her husband in a neighbouring tambon. Such strategies are of course not available to completely landless families, but to some extent, land sale has increased the status of some economically marginal households in Phimonrat. In Phimonrat, the partial sale of holdings over the decade to 1995 has commonly been used to repay debts, fund children's education, rebuild homes and purchase vehicles (see Table 7.3).

5.2 New Income-generating activities

A more common approach to complete or partial land sale in Bang Khanun and Phimonrat has been the reorientation of income-generating activities towards the new opportunities presented by changes in these districts. More road traffic and more housing settlements with diverse populations has created an environment conducive to a range of family business activities which support overall household livelihood. On the border of Tambon Bang Khanun, where a sealed road has been upgraded to carry traffic to the amphur office, families have shifted the locations of their homes and opened small noodle stalls to cater to the amphur staff and to local people who travel to the amphur office and the hospital located behind it. Larger, more specialised concerns include restaurants attached to houses. Some gardeners have leased sections of their properties close to the road for outsiders to construct restaurants, but most often these are run by family members, relatives, or their friends.

Some families which found themselves favourably located to new patterns of activity and traffic movement in the area have deployed their landholdings in ways that have assured complementary income sources both from outsiders and for family members. At the bridge where the road crosses the Bangkok Noi canal leading to the Bang Kruai District offices, one family has succeeded in attaining conspicuous success in the following way. Garden land near the banks of the canal was developed for the building of a four-storey apartment block to accommodate the increasing number of office workers employed in the western suburbs of the BMA as well as amphur officials. A relative from Bangkok purchased this land. The strip of land between the apartment and the canal was reserved and leased to other relatives who opened a canal-side restaurant which succeeded in attracting considerable custom. The land behind the apartment block was retained by the family, who built a new two storey home as well as a small building adjacent to the apartment car park which they operate as a laundry and small grocery. In this case the family have completely abandoned gardening and the remains of the old orchard can be seen behind the walls which surround their land. Deeper into Bang Khanun, several families have benefited from partial land sale and built new suburban-style modern homes near the newly-widened road which leads into the orchards of Bang Khanun. These homes have been designed to include shops facing the road, which are operated by the wives of the gardeners. Households and individuals with less capital have also begun to locate small noodle shops along the narrow road leading into Bang Khanun.

TABLE 7: USE OF FUNDS FROM THE SALE OF AGRICULTURAL LAND IN TAMBON PHIMONRAT, 1985-1995

SALES IN VILLAGES BAN KHAISAM AND BAN RONGSUAT.

Owner's					
Qty Sold	Qty Remaining	Use of holdings	Reason for sale/	Occupation	remaining.Use of funds
Rice-farmer					
11 rai	20 rai	Rice growing	Pay debts		
Rice-farmer					
10 rai	10 rai	Idle land	Too old to work	funds for retirement	
Teacher					
1 rai	House Plot	Domestic use	Children's education		
Ag. Labourer					
200 wa	1 rai	Orchard	Building new house		
Gardener					
1 rai	3 rai	Orchard	Children's education/Pay debts		
Rice farmer					
2 rai	House Plot raise capital.	Domestic use	Land surrounded by housinge estate*/		Ag. Labourer
Rice-farmer					
30 rai	30 rai	Rice growing	Children's education/	Pay debts	
Gardener					
10 rai	5 rai	Orchard	Children's education		
Rice-farmer					
10 rai	5 rai truck.	Orchard	Paydebts/Building new house /pick-up		Gardener
Storekeeper					
2 rai	10 rai	Orchard	Children's education/ Gardener		Pay debts
Rice-farmer (rt'd)					
14 rai new house	2 rai	Given to children	Children's education/	Purchased house plot and built	
Gardener					
3 rai	25 rai	Orchard	Pay debts		

Source: As in Table ...

*Note: Sale funds were used to rent 65 rai of rice land in a more convenient location.

In Phimonrat a similar pattern of entrepreneurial activity has developed along the new road through the sub-district. Some newly-prosperous local families have completed rebuilt homes next to the road and opened stores attached to their residences. More typically, however, most local business concerns are fairly modest. For example, one family, whose old ricelands abut the road, operate a small petrol pump in addition to an eating house and general store which attracts business from both locals and the increasing number of passers-by, including building contractors, truck drivers and construction labourers. Behind the store the family have established a large pond for commercial fish breeding. Behind this fish pond they still maintain about 8 rai of riceland. These various enterprises have been developed for different members of the family to maintain. Another case of this family division of labour can be seen in the use of the brothers Ibrahim and Ismael's now-disused riceland land bordering the road. They have kept the roadside land for the use of two of their married sons who formerly worked in Bangkok. One son, who works as a radio technician, has built a small wooden home incorporating a room which is used by his wife as a hairdressing shop. Another son works with his wife in the adjoining building selling meals to Muslim neighbours.

The logic of this diversification of land uses among households in Bang Khanun and Phimonrat is to maximise the longer-term income generating potential of families, often in combination with agriculture. This is a pattern which highlights major generational differences within families, where parents and grandparents still pursue agriculture because it is the only occupation they know, while their children engage in lighter forms of work associated with petty trade and small business. The retention of family landholdings also reflects a prevailing concern of parents for their children's future. While windfall gains may be made by selling land, many parents with children who have yet to finish their education want to keep sections of their land to build homes for their children. In Phimonrat people frequently exchange tales of newly enriched neighbours who sold all their landholdings and spent the proceeds unwisely on expensive consumer items. They see these stories of misfortune as salutary lessons from which to learn more durable strategies of using their land resources. They see a major source of future income for their children in the construction of rental accommodation for the increasing population in the locality. Hence, there is a generally-shared view that family landholdings must be preserved wisely for the twin purposes of future sale for capital accumulation and sustainable income generation for children in the future.

6 The future of the village and its functions

6.1 Defining 'the village'

In the context of current changes towards the so-called 'mega-urban region' configuration, we need to ask: how viable are villages as settlement forms, and how meaningful are they as a cultural spaces for their inhabitants? As numerous anthropologists have argued, the use of the term 'village' is problematic in relation to studying agrarian societies in both the past and present. In Thailand, administrative boundaries of officially-designated muban have borne little correspondence to significant socio-economic networks and cultural practices of peasants (Kemp 1982: 102-103; Sharp and Hanks 1978: 140-141). In Phimonrat and Bang Khanun, as elsewhere in Thailand, administrative designations do not confine the relations sustained by households, economically or socially. Within any one muban, for example, fields and gardens have long been owned and worked by households in other muban, and kin networks extend well beyond such artificial geographical limits. Among the settlements of Phimonrat, relationships extend across administrative boundaries and natural features which are used as boundary markers for bureaucrats. For example, although Ban Rongsuat (Muban No. 5, Tambon Phimonrat) was divided physically into two sections by the widening of the Phra Phimonrat Canal shortly after WWI, the two halves of the original village were integrated by religious and kin connections. Five years ago the canal became a tambon boundary when Tambon Phimonrat was created. Such namings and boundary inscriptions are therefore meaningless if we continue to conceptualise 'the village' as a social network.

Having acknowledged this point about the limitations of administrative and territorial definitions of the village, and the fact that households and individuals have always maintained various relationships and networks outside the bounds of these local settlements, the villages may nevertheless be defined as relatively distinctive clusters of households who once engaged in common agricultural pursuits, but which now derive their principal identity from intersecting kinship relationships. In this they share characteristics in common with rural settlements far more distant from the metropolis (Kemp 1982: 111-112). The traditional rural village gained its character because of the mutual reinforcement of social organisation, territorial organisation, and economic organisation. Clearly in both of the areas under study here, the economic factors binding households to village settlements are extremely weak, in the sense that common work orientations in the 'life paths' of family members are declining. If defined in the sense of an integrated socio-economic subsystem, the villages in Phimonrat and Bang Khanun have already ceased to function in the traditional sense, as have most villages in Thailand. Such changes have resulted from transformations at both the societal and the household decision-making level, as local people have attempted to maximise income generating and status generating activities (e.g. Sharp and Hanks, 1978; Tomosuki 1995). Villages no longer signify a space shared by households bound principally by a common livelihood devoted to agriculture. The diversity of sources of income, particularly in the money economy, the scale of geographical movement among household members, their consumption patterns and expectations, have so diverged from the traditional patterns that equated the village with models of the rural community and economy that the very terminology used to describe and analyse villages in the contemporary period are being seriously questioned (Rigg 1994). How then can we define the villages of Bang Khanun and Phimonrat in relation to these changes? Are they merely blandly functional dormitory settlements, a representation suggested by some regional geographers? I suggest that when these local settlements are viewed as sites of social and cultural process, a number of important changes and continuities can be observed.

6.2 Kinship and the idiom of reciprocity

The villages of Bang Khanun and Phimonrat can still be characterised as locality-based communities whose members share close affective bonds among families through length of residence. This factor remains significant in determining the identity of these settlements, regardless of the occupational fragmentation of many households. In both Phimonrat and Bang Khanun, local people live with neighbours who are either direct relatives, or fictive kin (pi-nong nab tue gan : brothers and sisters who respect each other). Despite the decline of mutual assistance in farming (long khaek, or ow raengkan), the idiom of kinship tends to define relations between neighbours: 'rak kan muan yat' (love each other like family) is an expression often used by residents for their neighbours, and this social system is also recognised by outside officials. A common heritage in farming or gardening and its work culture is a key foundation for this sensibility, and such bonds are most strongly felt among connection of the individual to any particular temple is determined by relationships between the temple and his or her family. A wat occupies a special place in the life of a family if it is associated with the cremation of parents and grand-parents. The place of cremation establishes a significant existential space for the individual and family, even if they leave that locality in later life. On the anniversary of the deaths of parents, it is customary for the children to make merit at those wat where their parents were cremated. It is easy to see that in the case of well-established and continuous village settlements, this association of ancestors with descendants is reinforced in each generation. A common answer to questions about why people attended Wat Ban Khanun to make merit was 'po- mae kert yu thini, dai yu thini' ('My mother and father were born and died here'), or 'banphoburut kert yu thini' ('My ancestors-forebears were born here'). So, the reinforcement of family association establishes the wat as a significant space. In the case of men and women aged in their late fifties and older, these associations are critical to their identity with the area as a place. Most will confess to not feeling comfortable making merit at other wat - 'Mai sabai chai', unless that activity is part of a merit-making pilgrimage (Thot Phapha). For males the association is reinforced by their customary ordination at the village wat. Thus, at Wat Bang Khanun, the men who led the chanting every wan pra (Moon Day) had all been ordained at the temple as young men for the customary rains retreat period of three months (pansa). This form of attachment is independent of the abbot or the monks currently attached to the wat. In Tambon Ban Khanun and the surrounding tambon, each wan phra will see elderly villagers spending the day in the sala following the eight precepts to make merit. The wat is thus a site for the reproduction of key traditions associated with place and also life-cycle. At the beginning of the morning of the wan phra ceremony elderly women, their daughters and grand-daughters, sit at the rear of the sala preparing food for the monks; the men will set up the mats for the monks, sweep the floor, check microphones and arrange for the collections of donations after the feeding of the monks. The senior men and young men in the congregation will take the plates of food to the monks after the initial chanting and lead the congregation in the collective chants which follow. After departure of the abbot and monks from the sala, the men will distribute the food to the congregation who remain. The food at Wat Ban Khanun is prepared in traditional manner served in dishes made from banana leaves (bai tong). Of this the women are very proud, and claim that very few wat will prepare food in this manner.

A key relationship between village and wat is thus merit-making focused on family members, but such a relationship not only connects individuals to the wat, but establishes important horizontal links binding the community together. For key ceremonies, such as ordination, merit is generally made publicly. Additionally the wat is the site for the key rite of cremation, and cremation is a public event where social obligations are displayed and thus where the respect relation is reinforced. In addition, cremations and the social activities preceding and concluding the activities demand a great deal of preparation. It is here where neighbours and friends honour obligations and assist in activities ranging from food preparation to organising music and the entertainments. During the time of this study Grandma Phap, an old lady of 82 years died and was cremated at Wat Ban Khanun. Both she and her husband had been born in the district. They had eleven children and their kinship network encompassed many Tambon in Nonthaburi. Her husband Yai Pherm, the older generation. Nonetheless there is also a pattern of mutuality in social practice which still reinforces and actualises this model of local society. This is most clearly seen in the ways that kinship ties link families of different economic status. In this face-to-face society, the poor and landless relate to more fortunate neighbours through idioms of reciprocity and obligation which blunt the otherwise sharp edges of inequality between groups. Thus Pa Jin (Auntie Jin), a landless widow in Bang Khanun, lives on the orchard land of a elderly teacher who lives in another district with her married son. Pa Jin has an arrangement with this owner whereby she can live on the land and work the orchard, in exchange for giving the owner half of the produce of the orchard. During the floods which ravaged the district, the district headman (kamnan) paid local labourers above the average rate (300baht instead of the usual 200 baht), because, he explained, he knew all of them and felt sorry for them.

However, it is often the case that assistance to less fortunate neighbours is also assistance to kin, since the Thai definition of yat (family) is extremely wide. It encompasses not only blood relations, (however distant) but close family friends. Such linkages give to patterns of daily social interaction the appearance of familiarity and intimacy, even though individuals are always conscious of the economic status of their neighbours. Particularly among the older generation, their forms of verbal address - characterised by direct and often rough speaking and jocularity - combined with the custom of most men and women to dress in plain traditional rural clothing, might even suggest that there were few status distinctions. This is not the case. In the following section of this discussion I focus on religious life and ritual and suggest that status distinctions in these communities are generated through traditional practices which express both the continuity of traditional cultural capital and the appropriation of new symbols of modernity.

7 Religion, locality and cultural capital

Among the communities of Bang Khanun and Phimonrat, it is possible to treat religious life and practices as akin to a prism through which to view the ways that new social expectations are worked out in symbolic ways. We have already seen something of the ways that households have responded to economic change and environmental transformations in the long and the short term. We can view these as expressions of identity and status which affect the configuration of the local landscape in the context of wider social and economic changes in Thai society. Religious life in the close-knit local societies of Bang Khanun and Phimonrat has also contributed to transformations in the environment, for while in the ritual context it continues to affirm locality-based identities and networks, it also draws on wider influences and symbols which promote new distinctions between people and communities.

Social relations as well as existential commitments to locality are still important features of local life in Bang Khanun and Phimonrat. They have an integrative and 'place-making' function and are reinforced strongly by religious activity. We can see such a process at work in the way that the Thai Buddhists of Bang Khanun related to their wat. In general, the informed me that they could count at least ten families in the village as direct kin, and this encompassed probably half of the regular attendees of the wat. Thus this ceremony, which occupied five days, activated the relationships binding wat, kin and locality. Each day the food alone cost 10,000 baht, but if volunteer labour was not available this would have been much more expensive. It is at such ngan that villagers express the difference between their society and urban or city society. Here they make their own food, they do not hire caterers. Relatives and neighbours are mobilised to assist in activities which express key loyalties and collective values. The ceremonies attract a wide range of social groups from the local villages and their is little in the way of social exclusivity, except for the provision of a separate seating area for visitors from outside the locality.

But the major wat ceremonies also involve a display of hierarchy and status as well as communality. In large ceremonies such that of Grandmother Phap, a large number of well-to-do friends and relatives attended from outside the community. Many of them were friends and associates of her children, including businessmen, military officers and local officials. But the most significant aspect of hierarchy was the expense of the ceremony and the local knowledge that Grandmother Phap had been a prominent donor of money to the temple. During her life she had paid for the bell tower and the reception building constructed for temple rituals. Her worldly resources has been translated into social capital which was publicly recognised as symbolising her ability to gain merit and advance into the next life with advantage.

It has long been recognised that the hierarchy of Buddhist merit accumulation in Thai society mirrors hierarchy in the mundane world. As Hanks pointed out: '...the effectiveness of thousand baht outweighs the widow's battered coin'. (Hanks 1964: 1248). Although conspicuous merit making by the rich has always been a feature of Thai society, its impact on the cultural geography of localities has never been so dramatic as in contemporary Thailand. A new iconography of wealth and modernity has been translated into the religious landscape of temples, and it is marked by a concern to display modernity and affluence in architecture and decoration. No more do the wat of Nonthaburi contain the simple and unassuming structures which served the gardener's forebears. New buildings constructed with the donations of newly enriched and old established families alike gleam with iridescent blues, greens and reds on their gables. Old and decrepit preaching and ordination halls often stand juxtaposed with the freshly built products of merit making. Families now donate newly fashionable images, such as the Chinese Bodhisatva Kuan Yin to the old temples of the district. More conspicuously, there is a concern to make the wat landmarks in their areas by constructing large new buildings and images, a process notable in many parts of Bangkok and Thailand generally. While the specific projects may originally be the ideas of abbots, they channel the willing energies of residents in their merit making. Some structures owe their origins to individual merit-makers, such as the spectacular new two-story preaching hall at Wat Keao Fa (of the village of Ban Phra That, Tamon Bang Khanun), built from the money gained from a gardener's recent land sale. Other efforts at merit making may be more collective in nature, such as the project of the abbot of Wat Chalor to construct a new ordination hall in the form of a giant Suwannahong: a royal barge with a mythic swan image at the prow. This tall swan head towers over the nearby district announcing visually the distinctiveness of the temple. The original ordination hall which holds the wat's old Buddha images dates from the mid-Ayutthaya period (17th century). It has been left to decay in the wat grounds and presents a stark contrast to the glistening spectacle of the new landmark.

The landscape of Bang Kruai, as exemplified in its temples, is developing an orientation towards featurism, a phenomenon which is consonant with the economic changes within the district: that is, the abandonment of agriculture, the onset of consumerism among local and new residents, and a demand for conspicuous spectacle which is a rural version of urban sophistication. Prosperity and merit-making have reinforced each other to build a new religious landscape. However, the foundations of this process are rooted in villager's traditions of enhancing merit. The use of wealth and cash from land sales and other sources on non-farm income are channelled by traditional impulses. While poorer gardeners may still live a simple life without many of the luxuries enjoyed by wealthier neighbours, they nevertheless participate in the creation of this new geography of consumption by sharing a collective vision of 'khwamcharoen'(progress, advancement), in their aspiration towards improving their temples. For those richer residents whose new wealth from land sales is visibly signified by pick-up trucks, two-storied homes and ornamental gateways, they are ensuring a degree of merit which balances their good fortune, and in the process they are upgrading their temple's appearance to reflect their status.

In the Muslim communities of Phimonrat the twin characteristics of religious life -its tendency to reinforce communality and place identity as well as to reinforce socio-economic distinctions- are also noticeable, although they express themselves in somewhat different ways compared to the Buddhists of Bang Khanun The Surao (mosque) expresses the religious brotherhood with distinguishes these communities from those of the Bhuddists in the other villages. The obligatory Friday rituals of prayer are followed by virtually all households, and reinforce the bonds of place identity, despite the increasing diversity of livelihoods and lifestyles. Support for the maintenance of the surao has long been held as an index of religious worth and social esteem among community members. From the earliest history of the Muslim villages in Phimonrat, wealthier farmers donated land for religious use. At least 30 rai of the land around the surao in Ban Rongkrachom was in fact donated by landowners and is now used to accommodate landless households at nominal rentals. These features of the local society and its intimate relation to central Islamic values encourage a sense of fellowship and communality apparently overriding distinctions in wealth.

Yet at the same time new trends serve to emphasise distinctions in the community on the basis of religious practice. There has always been an emphasis on channelling family resources towards the religious education of males in households, and one of the sources of a family's greatest pride has been to have a son who has studied in religious schools in Pattani (southern Thailand) or Malaysia and returned to teach religion in the community. Increasingly, however, the tendency has been for families with enough means to send children, including daughters, to study overseas in the Islamic heartland of the Middle East. This is one (although not the only) source of change in religious practice, whereby wealthier families are turning towards stricter forms of Islamic practice. Many villagers now make a distinction between those households which follow strict Islamic precepts (nab thu sasana Islam khreng khrat) and the majority who still follow a more relaxed style, formerly common to Thai Muslims. Invariably, followers of the new fundamentalism are those who have been influenced by their own children, some of whom have returned to teach at the local religious school. These families are well-to-do by local standards. Parent's economic resources have thus been channelled into religious education which, in turn, accesses prevailing trends in the Islamic world, acting to differentiate the lifestyles of these wealthier households from those of their neighbours.

8 Conclusion

While state policy and market forces have played a critical structural role in transforming the functions and physical landscape of Bangkok's expanding mega-urban region, the process of change and its particular local and sub-regional configurations have also been strongly influenced by household strategies on the part of gardeners and rice-farmers. The smallholding economy of Nonthaburi's agriculturalists, particularly the gardeners, has always been intimately tied to the economy of the metropolis, and their production strategies have developed in response to changing market conditions. For the last half-century rice-farming households in Phimonrat have shared with their counterparts in other central provinces the experience of major problems associated with rising costs of production, fluctuating rice prices, reduced land-holdings through inheritance patterns, and debt. Well before the urban frontier of housing estates and factories encroaches into formerly rural landscapes, these households had become occupationally diversified, incorporating work patterns and networks tied into the metropolitan economy.

Land is the crucial resource in the task of household reproduction, and access to new opportunities for status and livelihood have been historically tied to the accumulation, preservation and transmission of land. Increasing land prices and new settlements in these districts have been appropriated towards these ends. The capacity to strategically deploy land in the quest for income and status underlies the ways that families in these districts negotiate with, and participate in the ecological and social transformations around them. The diverse mix of economic activities and household enterprises in these areas highlight these interacting patterns of change. Commitment to agriculture is restricted to an older generation who may look back nostalgically on a simpler past, but urge their children to pursue alternative employment.

Studying farming and gardening families from a dynamic historical perspective through a succession of generations, we also find that these livelihood strategies have been tied not only to the exigencies of survival, but also to the quest for status among neighbours and wider fields of cultural capital shared in Thai society and the metropolis. Today, in the context of an increasing commodification of symbols and conspicuous consumption characteristic of the wider society, these traditional status concerns have made a significant impact on local areas in the ways that space and traditional institutions such as temples are utilised and displayed. We have seen that these local societies still exhibit features commonly associated with classically 'rural' society, in particular strong and dense webs of kinship and place-specific reciprocity. But notwithstanding these characteristics, the households in these villages have never been insulated from the wider society: the assumption that they are victims of external agents of change, exemplified in the metaphor of the threatening urban frontier, is a mistaken one. They have actively participated in the social and economic transformations of their society, and shaped their material and symbolic environment in the process.

NOTES

1. According to local government guidelines prevailing until the restructuring of local administration under the 1997 constitution, sanitary districts could be formed when a place contained a population of no less than 1,500 people or 100 dwelling units within a 5 square kilometre area. Municipalities (aside from cities) required settlements of over 10,000 with a population density of at least 3000 people per square kilometre. There are cases of sanitary districts which are extremely large and municipalities which are quite small in terms of total population- thus the sanitary district of Pakret contains a population of over 116,000, representing 75% of the amphur's population, and covering 48% of its total area (42 square kilometres). By contrast, the municipality of Bang Bua Thong comprises a population of just over 10,000, representing only 15% of its amphur population. In the absence of any official statistical measure denoting urban areas in Thailand, demographers and urban researchers generally consider that both of these administrative units should be counted as 'urban'. Using these criteria the urban populations of the component districts of Nonthaburi range from a high in the east of the province of 89% (Amphur Muang) to lower levels in the west (eg. Bang Kruai:41%; Bang Bua Thong 15%) (Leman Group 1994: 11-13).

2. This assumption of invasion and encroachment as a principal cause of agricultural decline is clear in the following judgement by Anuchat and Ross (992:7): 'It is apparent that urban expansion in Bangkok will result in the loss of most of te fertile agricultural lands, as farmers are forced to give up their farms and sell their lands to more profitable urban projects'. A more balanced interpretation of the processes underlying land conversion on the rural-urban fringe in the BMR is offered by Banasopit et.al. (1990: 40-66). They note that while the destruction of agricultural land through negative urban environmental impacts is the most visible cause of land conversion, the fundamental cause lies in the fact that prices to be gained from selling land are far in excess of the returns farmers can expect from farming, particularly rice-growing. Low agricultural incomes are thus a key factor.

Anthropological studies of people on the urban fringe tend to perpetuate the image of a passive and vulnerable rural world, transformed by external forces. Thirawet's study of farming families in the Pakret district of eastern Nonthaburi in the late 1970's succeeded in showing something of the ways that people exploited the possibilities of urban expansion through diversifying occupations and selling of the topsoil of their ricefields to building contractors. Yet even so, it is notable that their strategies are portrayed as essentially defensive tactics, and their practices are described as an "adaptation" to new conditions, as if the process of urbanisation was externally driven, and not tied into broader patterns of social change (Thirawet 1979). The recent rise of concern for endangered communities and traditional culture in Thailand has also contributed towards the conceptual bifurcation of urban and rural cultures, adding nostalgia to the persistent sociological myth of the integrated, spatially-bounded village (Yani 1995).

4. Traditionally, the well-to-do would construct temples for conspicuous merit-marking, and several wat of Bang Kruai are known to have been established according to this practice. However the

majority of these temples are small, and were the product of collective effort among ordinary villagers. Even today, the Bang Kruai district, (although the smallest in area in the province) boasts the second -largest number of wat (46) in Nonthaburi. To the number of functioning wat we also need to consider the large number of deserted wat (wat rang) in the tambon of Bang Kruai district, including Bang Khanun, as indicators of previous population settlement and economic activity.

5. In Tambon Phimonrat one wealthy family of Ban Khaisam (Muban 4.) gained its wealth through lending money and repossessing land when the loans were unpaid by neighbours. Another source of credit was the local rice miller. In Tambon Phimonrat the local rice milling family (surname Bunbrakob) have extensive land holdings based on the same process of progressive accumulation of pawned land. Such has been the level of indebtedness of rice farmers in Muban 8 that actually none of the land is owned by the families who live there. All 400 rai of the village riceland is owned by the Boonbrakob family. The families who were once owners now rent the rice fields.

6. These figures do not match data compiled by the National Rural Development Committee village surveys (Ministry of the Interior), which suggests that different definitions of 'agricultural household' have been used. This is significant, because the 'farm operator' category used by the Ministry of Interior seems to count as active agriculturalists those who are simply resident proprietors. In the case of Bang Khanun, this gives rise to an overestimate of active gardening families (over 80% of all households) and probably counts retired gardeners as well. It certainly gives a misleading impression that these families are solely devoted to agriculture as a livelihood. To evaluate the comparative accuracy of the Ministry of Agriculture and Ministry of Interior estimates, I compiled an inventory of house plots and orchard holdings (used, disused and transferred through sale or inheritance) in three villages of Tambon Bang Khanun. The results showed that the Ministry of Agriculture figures corresponded most closely to the situation on the ground. For example, in Muban 1 (Ban Bang Khanun), 43 orchards were worked by resident households, while a further 28 were owned and cultivated by households in neighbouring muban. The Ministry of Agriculture figure for local households engaged in agriculture in this muban (42) was thus virtually the same. In addition there were 55 houseplots occupied by village residents with no orchards, and only three of the households owning these houseplots operated orchards in other muban. The Ministry of Agriculture figure of 95 non-agricultural households is reasonable, even though it is nearly double the figure of non-orchard houseplots, because many homes include more than one household.

9 References

Agricultural Office, Bang Bua Thong District (1994) Neowthang kanphatthana kankaset radab tambon [Trends in agricultural development at the tambon level] Nonthaburi: Agricultural Extension Office, Ministry of Agriculture. [In Thai]

Agricultural Office, Bang Kruai District (1994) Neowthang kanphatthana kankaset radab tambon [Trends in agricultural development at the tambon level] Nonthaburi: Agricultural Extension Office, Ministry of Agriculture. [In Thai]

Agricultural Office, Nonthaburi (1995) Annual Tambon Data. Typescript files.

Alpha Research (1994) Thailand in Figures, Bangkok: Alpha Research Co.

Allen, A. (1994) 'Environmental transformation on the rural-urban fringe: Yogyakarta, Indonesia', paper presented to the Asian Studies Association of Australia Biennial Conference, Perth, Australia, 13-16 July.

Amyot, J. (1994) The structure of employment of the rural population of the central region of Thailand, Bangkok: Chulalongkorn University Social Research Institute.

Anuchat Poungsomlee and Ross, H. (1992) Impacts of modernisation and urbanisation in Bangkok: an integrative bio-social study, Nakhon Pathom: Institute for Population and Social Research, Mahidol University.

Banasopit Mekvichai et. al.(1990) Urbanization and environment: Managing the conflict, Bangkok: Thailand Development Research Institute.

Brookfield, H., Hadi, A.S., and Mahmud, Z. (1991) The city in the village. The in-situ urbanization of villages, villagers and their land around Kuala Lumpur, Malaysia, Singapore: Oxford University Press.

Bryant, C. (1995) 'The role of local actors in transforming the urban fringe', Journal of Rural Studies 11,3: 255--267.

Chantana Banpasirichote (1993) Community integration into regional industrial development: A case study of Klong Ban Pho, Chachoengsao, Bangkok: Thailand Development Research Institute.

Chatthip Nartsupha (1984) Setthakit muban Thai nai adit [The economy of the Thai village in the past] Bangkok: Samnuk Phim Srang Sarn. [in Thai]

Department of Town and Country Planning (1994) Raingan wichai phua kanwang lae chat tham phang muang ruam Muang Nonthaburi. Prabprung thi 1. [Research report for the comprehensive planning of Nonthaburi. First Revision]. Bangkok: Department of Town and Country Planning, Ministry of the Interior. [In Thai]

Douglass, M. (1984) Regional integration on the capitalist periphery: The central plains of Thailand, The Hague: Institute of Social Studies.

---(1995) "Global interdependence and urbanization: Planning for the Bangkok mega-urban region', in T.G. McGee and I. Robinson (eds.) The mega-urban regions of Southeast Asia, Vancouver: University of British Columbia Press: 45--77.

Ginsburg, N. (1991) 'Extended metropolitan regions in Asia: A new spatial paradigm', in N. Ginsburg, B. Koppel and T.G. McGee (eds.) The extended metropolis: Settlement transition in Asia, Honolulu: Hawaii University Press.

Greenberg, C. (1994) 'Region-based urbanization in Bangkok's extended periphery', Ph.D dissertation, University of British Columbia.

Hanks, L.M. (1962) 'Merit and power in the Thai social order', American Anthropologist 64: 1247--1261.

Leman Group (1994) Metropolitan regional structure study. Sectoral study no. 1. Urbanization and human settlement, Bangkok: National Economic and Social Development Board.

NRDC Database (1990) Household, Incomes and landholding data from the National Rural Village Survey (Ko Cho Cho 2 Kho). Re-tabulated at the tambon level for Nonthaburi Province for the author by Dr. J Amyot,Chulalongkorn University Social research Institute.

National Statistical Office (1993) Housing and population census for 1990. Nonthaburi Province. Bangkok: Office of the Prime Minister.

National Statistical Office (1997) 'Average household monthly incomes and expenditure by region: 1981-1996.' Comparative data sheets. Statistical Data Bank and Information Dissemination Division, NSO, Thailand.

Kemp, J. (1982) 'Kinship and locality in Hua Kok', Journal of the Siam Society 70, (1&2): 101--113.

McGee, T.G. (1989) `Urbanisasi or kotadesasi? Evolving patterns of urbanization in Asia', in F.J. Costa et. al. (eds.) Urbanization in Asia. Spatial dimensions and policy issues, Honolulu: Hawaii University Press: 93--108.

Parnwell,M. and Luxmon Wongsuphasawat (1997) `Between the global and the local: Extended metropolitanisation and industrial decision making in Thailand', Third World Planning Review 19 (2) : 119--138.

Planning Office, Nonthaburi Province (1996) Phangmuang ruam Nonthaburi. Prabprung thi 1. [Comprehensive plan for Nonthaburi Province. 1st revision] Bangkok: Department of Town and Country Planning, Ministry of the Interior.[In Thai]

Rigg, J. (1994) "Redefining the village and rural life: Lessons from Southeast Asia", Geographical Journal 160 (2): 123--35.

Sharp, L. and Hanks, L.M., (1978) Bang Chan. Social history of a rural community in Thailand, Ithaca: Cornell University Press.

Somkiat Soontornchai (1989) Kansuksa phua kamnot neowthang kanwang phaenphatthana phun thi thesaban Muang Nonthaburi [A study to establish planning guidelines for the development of Nonthaburi municipal area], unpublished Masters of Urban Planning dissertation, Chulalongkorn University, Bangkok.

Spencer, D. (1993) Landowners and the urbanising countryside: A structure and agency approach, Reading: University of Reading.

Supha Lusri (1970) Chetsip sam changwat. Lem 4. [Seventy-three provinces. Vol. 4] Bangkok: Thai Watthanaphich Press. [In Thai]

Tanabe, S. (1977) `Historical geography of the canal system in the Chao Phraya river delta', Journal of the Siam Society, 65, 2: 23--72.

Terwiel, B. (1989) Through travellers' eyes. An approach to early nineteenth century Thai history, Bangkok: Editions Duang Kamol.

Tomosugi, T. (1995) Changing features of a rice-growing village in central Thailand. A fixed- point study from 1967 to 1993, Tokyo: Centre for East Asian cultural Studies for UNESCO.

Webster, D. (1995) `Mega-urbanization in ASEAN: New phenomenon or transition phase to the "Los Angeles world city"?', in T.G. McGee and I. Robinson (eds.) The Mega-Urban Regions of Southeast Asia, Vancouver: University of British Columbia Press: 27--41.

Yani Sonpraphai (1995) `Kansupnuang kanplianplaeng thang sangkhom lae watthanatham chao suan changwat Nonthaburi' [Continuity and sociocultural change of gardeners in Nonthaburi], unpublished M.A. dissertation, Silpakorn University. [In Thai]

Rangsit in transition: urbanisation and cultural adaptation in central Thailand[1]

Sowatree Nathalang[2]

Abstract: *This study attempts to describe and analyse the phenomenal and social change particularly the urbanisation of Rangsit, district of Pathumthani province north of Bangkok under the ruling 'modernisation and development' paradigm. By observing the macro level economic forces on one hand and focussing upon the micro level field study of three communities in the area on the other namely an 'Old Chinese' community, an old Muslim community, and a 'modern workers' community the study comes to some findings that: ethnic identity, if remained important during the past decades is presently less significant; that Muslim religious distinction still continues to influence collective identity; and that, for Rangsit people at large a sense of locality still counts significantly in the whole process of 'glocalisation'- a phenomenal confluence of globalisation and localisation.*

1 Background and research question

The social fabric of Thailand in the nineties was undergoing comprehensive and perplexing change at a rate so rapid that many new and complex conditions of life have emerged, particularly for the people living within the dense social networks of the country's urban centres. Thailand has, for many centuries, been an open society. Lately over the thirty-year period from 1960 to 1990, the change has been understood largely through a 'modernisation and development' paradigm as an urban centre and the neighboring provincial towns (e.g. Bangkok, Samut Prakan, Nonthaburi, and Pathum Thani) have recently become a connected cosmopolitan area to which people - from near and far - have moved in for a variety of reasons. Many are migrants from other parts of Thailand; others come from outside the Kingdom, seeking new social and economic opportunities. The urban setting has become a meeting ground where people from many different cultural backgrounds come into contact. Due to the expansion of this area, the agricultural landscape has been transformed by the establishment of new industrial plants, new residential areas, and new business centres. As a result, many novel cultural traits have emerged. The majority of people have become accustomed to the mainstream 'urban life style' and seek to take advantage of the novel situations emerged in the society around them.

[1] Synthesised from Ph.D. thesis submitted to Postgraduate School of Anthropology, Macquarie University, Sydney, 1999.

[2] Lecturer of Sociology & Anthropology Dept., Faculty of Social Sciences, Kasetsart University.

Much social change in Thailand has been attributed to urbanisation accelerating over recent years as a direct impact of globalisation. In anthropological sense, the study of peoples' management of change is critical to the examination of Thai socio-economic development. Most research studies undertaken on urbanisation in Thailand have focussed mainly on physical factors such as population and economic growth, city planning, and environmental change. However studies focussed on cultural and spiritual aspects, including the changing functions of social institutions, are seldom undertaken. It is desirable, therefore, not only to examine different groups' modes of living but also to study changes as they occur, and continue to occur, within the cultural environment. This approach will provide a better understanding of changing beliefs and values, methods of adjustment, and the problems faced by those who are forced by circumstances to change their way of life in order to survive in the new urban context. This study serves to some degree to be indicative, if not entirely representative, of the cultural consequences of urbanisation in Thailand during the period 1960s to 1990s.

The Rangsit area comprises a sprawling cluster of communities located at the site which, for centuries, was used for subsistence rice farming. A modern irrigation system introduced during King Chulalongkorn's reign (1868-1910) gradually transformed the whole area into commercial rice farms; in later decades it became a zone for multi crop plantation. Being situated at the gateway to the upper part of Central Thailand - connecting with the northern and the northeastern provinces where the huge flow of raw materials for commercial and industrial purposes are brought down to the premier city of Bangkok the Rangsit area has rapidly become an area of convergence for people from almost every walk of life. The rapid and sometimes bewildering pattern of economic and cultural change that has occurred during the past decades has transformed the Rangsit area into a new urban centre where the old and new lifestyles of its people are intertwined in a somewhat perplexing manner.

Up until the 1970s, Rangsit remained largely an agricultural area. As is the case for much of Thailand, the pace of change from an agrarian to an industrial society was extraordinarily rapid when compared with the gradual cultural change that took place in England, Europe and to a lesser extent the settler colonies. Yet this rapid change occurred in many Asian countries, creating, in its wake, a variety of responses -not only social tensions but also excitement, satisfaction, and new opportunities. How people perceive life, how they perceive change, how they value or undervalue their traditional ways of life, how they make their decisions and adjustments and how they see themselves in a context of changing lifestyles is deserving close observation and micro study.

Recently, a pilot study undertaken by the Institute of Thai Studies, Chulalongkorn University, Rangsit Centennial, documented the changes which have occurred in the Rangsit area especially during the last few decades (since 1957). It is a multidisciplinary study focussed on physical, medical and health care, as well as economic, social, and cultural issues. It reveals, to some degree, that the major factors conducive to change in the area are its location, transportation, and the price of land. Due to its location (as a northern suburb of Bangkok), the Rangsit area can help absorb the rapid growth of the metropolis. Transportation is more accessible and the land prices are relatively low when compared with those of Bangkok and its environs. The old slum settlements, which housed communities of peasants, fruit gardeners, and traders, along with some recent settlers, have been transformed; new settlements have emerged in industrial zones and in housing estates. Industrialisation and urbanisation have strong impact upon the Rangsit area in such a way that residents are not only powerless to resist change, but also unable to protect themselves from the varieties of rapid modernisation (Institute of Thai Studies 1995). It seems, therefore, critical for this study to undertake a micro study of the Rangsit area, with emphasis on the period of transition from agriculture to industry. My research is a continuation of the aforementioned pilot study, exploring the emerging conditions of life among three specific communities. The study provides an ethnography of the peoples' patterns of living and interaction during the period of transformation.

There have been few other studies of communities living in similar areas. One exception is that of Thiravet Pramuanratkan 1979 (discussed in Askew 1994:73) who focussed on the dissolution of the village as the urban fringe underwent transformation in Nonthaburi province. This study focussed on a single village in the 1970s and tended to see the changes involved in the transformation from village to urban zone in a largely negative aspect namely the loss of a village way of life and the entry into wage labour taken as the primary issue.

The present study aims to extend and develop a focus on the urban development question by examining three different kinds of community against the background of the macro level changes including those produced by the 'boom' years (1980s-1990s) in Rangsit. It combines an anthropological with a sociological approach, and incorporates a strong impact of the processes of globalisation and consumerism which were much less apparent at the times of earlier studies.

In anthropological terms, I will qualitatively analyse aspects of cultural and social transformation in the Rangsit area. I will study the effects of urban growth and expansion, and the way in which people have responded to these processes. The study will demonstrate the dynamism of the socio-cultural context in this area, and how changes in cultural aspects and the need for rapid adaptation can affect individual and their community lives both negatively and positively.

I will investigate how people perceive their respective communities and how social institutions function - for example, the family, the community, and the religious bodies. I will also question how personal networks of kin and neighbours, those in patron-client relations, and local figures of influence are placed in the changing environment. Actually, I explore the chosen communities to learn about their relationships and cultural identities according to ethnic groupings and patterns of settlement. The study will examine the dramatic changes in economic patterns and opportunities, and how people have been able to grasp these opportunities, embracing the 'modern way' and even the 'post-modern way'.

2 Methodology

The study begins by exploring some of the relevant literature pertinent to urbanisation and social and economic change in Southeast Asian countries in general, and in the Bangkok context in particular. A social and economic development summary will be provided.

Fieldwork in the locations under study was conducted using Qualitative Research Methods within a time frame of approximately twelve to fourteen months. The communities under scrutiny include the workers' community which is located at *Khlong* 6, the Chinese community (old settlement) at *Khlong* 7 situated on the Rangsit-Nakornnayok Road – Thanyaburi district, and the Muslim-Malay village at *Khlong* 1 which is located on the Phaholyothin Road – Khlongluang district. Members of these three communities provided the specific ethnographic information; their long acquaintance with urban Bangkok in general and Rangsit in particular provides a general basis for understanding the patterns observed.

Fifty questionnaires were distributed in order to gain a general overview of the Rangsit area and its peoples. Respondents included government officers, schoolteachers and local monks, wage labourers, shopkeepers and owners (both from shopping malls and outside), and commuters to and from Bangkok and other cities. Because of the high population density in the workers' community, a second set of questionnaires were issued to address general issues pertinent to the location. The surveys were undertaken to facilitate the selection of key informants before the launching of in-depth interviews.

The study focuses on the process of change in the area, addressing the decline of rice farming, the growth of industries and migration, and the social consequences for community life. Questionnaire surveys and in-depth interviews collected general data such as household composition, employment, income, and level of education. Households were classified into groups according to their income, occupation, 'class', and ethnicity. In-depth interviews and unstructured questionnaires were utilised for the collection of information pertinent to informants' attitudes toward urban issues. Oral histories yields insightful information in data collection. Views and opinions of other persons well versed on the topic were also sought.

2.1 Rangsit Area: the three communities

The term 'Rangsit area' refers to a largely agricultural area located in Pathum Thani province (the central Thai region).[3] In an economic sense, the geographical area of Rangsit has recently been broadened to cover the outlying districts of several neighboring provinces. These include the Wangnoi district of Ayudhaya province, the Nongkae district of Saraburi, the Ongkarak district of Nakornnayok, and the Bangnampreaw district of Chachengsao. The original four districts of Pathum Thani - Dhanyaburi, Klongluang, Lumlukka, and Nongsua - now constitute geographically the inner part of the Rangsit area (Institute of Thai Studies 1995). For this reason, the population density is considerably higher than in the outlying areas.

In presenting the findings of the study, two interesting concepts are sought out and incorporated, one is the Glocalisation and the second is the new concept of the city named Desakota.

[3] The spelling of the name of the province refers to the Provincial Map of the Royal Thai Survey Department.

2.2 The "Glocalisation" concept

This concept is now very interesting and much talked about among scholars as an explanation of the practical world-wide cultural struggle situation, including what happened in Thailand. Radically, the concept of "Glocalisation" comes from the two main paradigms: "Globalisation" and "Localisation". Thai society has blended many various cultures emerged in the mainland Southeast Asia. Therefore, acculturation and cultural adaptation are the crucial elements affecting Thai culture. By the mid-nineteenth century, on ward, Thai culture has experienced a somewhat "alien" culture brought in by Imperialism spreading over the whole of Southeast Asia. This in later days leads to the dichotomy between the so called local culture and global culture.

Culturally, it is understood that there are approaches explaining the relationship of such cultures namely cultural imperialism and cultural hybridisation. On one hand, the school of cultural imperialism suggests that the Western based global culture it destroys local culture. Under the economic beneficial and political condition of the colony, global culture makes local culture collapsed. On the other hand, the school of cultural hybridization notes that every culture, by its nature, cannot be "pure" but hybrid. This is because of the dynamism of culture, which is diverse and different. In other words, culture is dynamic, adapted and acculturated.

Glocalisation explains the situation of cultural adaptation of Rangsit people during the time frame under the study. It reveals the survival strategies they learn amidst the changes they have to cope with.

2.3 *Desakota*: a new concept of city

Due to the rapid urbanisation process that has occurred during the last few decades, most Asian metropolitan regions have experienced enormous population growth. Cities have extended outward from their original boundaries. Development in fringe areas has resulted from the decentralisation of industries from the core areas of the metropolitan cities. The shift of employment opportunities from core areas of metropolitan cities to fringe areas has resulted in a marked expansion of the areas of Asia's major metropolitan cities.

The rapid expansion that has occurred on the periphery of the major cities is creating a new form of rural-urban socio-economic admixture. This mixed development of rural-urban land utilities, i.e. industrial, residential, commercial and business activities, differs from the traditional concept of rural and urban areas. Where once agriculture was the main source of income, land has undergone transition into non-farming employment areas.

There are evidences of intense rural-urban interaction extending thirty to fifty kilometres - perhaps more - beyond the urban core, due to improved road networks. The ready availability of relatively cheap modes of transport, and increased numbers of motor vehicles, has facilitated faster movement of people, commodities and capital.

According to McGee (1991), the ideas marking the new regions of extended urban spaces surrounding the core cities in many Asian countries have been placed into new and interesting patterns called *Desakota*, a term derived from the two Indonesian words for *Desa* (village) and *Kota* (town/city).[4] The ideas seem to embrace overall patterns of urbanisation at a global and regional level, predicting a continuing increase in the proportion of the world's urban populations (McGee 1991:3). The *desakota* regions are characterised by an intensive admixture of agricultural and non-agricultural activities, which occur side by side. These regions are neither urban nor rural, but exhibit features of both. Thus, the core concept of *Desàkota* is an intense mixture of agricultural and non-agricultural activities developed upon a single economic and social plan in close proximity to large urban centres (McGee 1987).

A *desakota* region is a complex entity which encompasses cities (with their typically urban forms of land usage) and their compact, densely settled rural hinterland, areas closely enmeshed with the urban economy. It typically includes the regions within the transport corridors that link the major urban areas of Asia (Forbes 1996:96).

Greenberg (1994), commenting upon region-based urbanisation in Bangkok's extended periphery, notes that a pattern of extended urbanisation has emerged around Bangkok (Greenberg 1994:ii). He argues that the synergetic conditions that operate in the Bangkok region define the relationship between economic growth and spatial expansion. His study shows a form of settlement system characterised by an intense land-use mix, where agriculture, industry, housing, and recreation all enhancing impacts upon each other. He mentions not only the material environment of the outer city (reflected in its golf courses, for example), but also the ways of thinking about the environment, the 'human purpose', and implications of the consumption of space. He suggests that the urban landscape of the outer city is explained or characterised by a synthesis of the layers of capitalist sediment. Furthermore, the uneven development in the Extended Bangkok Metropolitan Region (EBMR) has generated a 'mass marginalisation' tied closely to the capitalist concept of searching for cheaper land adjacent to rivers and canals in order to develop industry. According to the 1990 census, Pathum Thani province, while as yet only four per cent urbanised, is becoming one of the premier industrial production zones in Southeast Asia (Greenberg 1994:280-281).

Javaid (1990) notes that the emerging developments on the periphery of metropolitan cities differ from the conventional developments of metropolitan areas in several respects. These include the coverage and diversity of growing economic activity, as well as a much higher degree of mixture of rural-urban land uses. The EBMR incorporated a new spatial form that differs from the conventional well-defined urban system. Such regions include a large urban core, semi-urban zones, and extensive zones of rural-urban land uses situated along the major arterial routes, and labelled the *Desakota Region*.

[4] The term *Desakota* was adopted after McGee observed the spatial process emerging in Java. The use of a non-western term evades Eurocentrism, which is prevalent in much of the Asian development literature (Greenberg 1994:34). The term was used in Thailand to describe the Extended Metropolitan Region (EMR) phenomenon and its process (Parnwell and Wongsuphasawat 1997:123).

3 Changes and adaptation

This study has examined the period of rapid transformation of the Rangsit area north of Bangkok, and explored the process of development in the region over the past century. By focussing on the macro-level economic forces, on the one hand, and presenting a micro-level analysis of three distinct communities on the other, it has attempted to assess the explanation of various theories commonly applied to the urban process in the social sciences. Early theories of the city, and the 'modernisation and development' paradigm, have been particularly influential in the way many social scientists, including those in Thailand, have tried to comprehend the apparently dramatic changes in Thai society. These approaches contrast the urban and the rural, associating 'traditional' forms of social life and values with the rural, as against the 'urban/modern' forms of life, which are seen to threaten the former as industrialisation and development proceed. More recent approaches, drawn from a variety of disciplines including anthropology, sociology, geography and the new urban cultural studies, stress instead the emergence of complex forms of dependency and interdependency in zones characterised by a complex mix of economic activities and opportunities.

Rather than assuming that it is inherently difficult and challenging for individuals to adopt new ways of life, to pass from a 'rural/traditional' way of life to an urban/modern one, or that one way of life necessarily supplants another, these approaches point to the dynamic interplay of forces brought to bear in any given context, permitting elements of a variety of lifestyles to mingle in the same time and space, or even in the same person. This study presents the case of Rangsit as an excellent example of the kinds of complexity found in the 'fringe' zones of the developing world.

Such zones are characterised by diversity, plurality and variability, unlike the remote rural village or the established urban centre. The problems involved in researching such an area at first hand are enormous. In order to make the task manageable, three distinct living sites were chosen for study. Two were old communities which had been profoundly affected (though in different ways) by the hectic pace of change since the 1960s; the third is a site typical of the new 'communities' of the fringe zones, where individuals, couples and families from all over the Kingdom and beyond it are drawn together and reach accommodation with a whole new way of life. Largely economic factors, especially those of supply and demand, come to bear on them in terms of housing, labour, consumer goods and other features of late modernity.

I have used a qualitative research methodology based both on interviews and participant observation, to examine these three case study communities. They represent a 'snapshot' of old and new communities at a particular moment in time – at the period bridging the 'boom' and 'bust' of the late 1990s.

The transformation of the area from rice-growing and cash-crops to a vast array of industrial consumer and mercantile activities has created a mixture of land use and a variety of urban spaces which are used by those from across the area and indeed outside it. These include not only the morning and evening markets, so characteristic of Thai communities everywhere, but also the phenomena of concerts, of shopping malls such as Future Park, and the recreational park, the "Dream World". These provide public sites for daily consumption and recreation needs.

Thus, a significant feature of the study is the depiction of Rangsit as an important new urban area in Thailand. Its role as a principle area of rice export has been transformed into one focused on industry. Service industry is included in the new phase of Rangsit's development, leading to the growth of residential areas that support Bangkok's expansion, and a concomitant need for cheaper accommodation for those in the lower income group. Such a transformation creates different modes of consumption and production. The contemporary context of a global capitalist society is expressed in the diverse experiences and practices found in the area. But values among the old and new generations are not totally opposed, both seeking means of maintaining their best potentials within the urban process. The involvement of the new generation in a capitalist society leads, out of necessity, to a 're-identification' of their ethnicity that is less concerned with ethnic origins and ethnic consciousness.

The urban process also leads to other social phenomena such as consumerism and individualism. Consumer goods are playing their roles in people's daily lives resulting in behaviour and value patterns that sometimes challenge their cultural identity - most evident in the case of the Muslims. The primary function of cultural centres, including schools and religious institutions, is to respond to the people's needs within a consumer culture. Broader relationships between the communities affect the ways in which people practice their religious rituals, for practices are not necessarily observed solely by one ethnic group. However, Muslim rituals still determine ethnic solidarity, though the trend is declining especially among the new generation. Education in schools corresponds to the needs of a consumer culture, with educational institutions equipping their students with the basic knowledge that will prepare them to cope with the demands of global capitalism.

Urbanisation in Rangsit is a consequence of changes in the socio-economic structure, both at the micro and macro level. Looking back over Rangsit history, social transformation is evident in changes in both form and content. The main pattern of relationships among people can be seen in the form of patron-client relations. In the past, the middleman (called *Nai Hoi)* was the one who organised agricultural labour forces drawn from the North and Northeastern areas to the central plain including Rangsit. At present, labour forces - comprising mostly alien workers who migrated illegally from neighboring countries mainly Myanmar and Cambodia who work as poorly-paid employees in factories or shops - are brought into the area by a group of people who act as agents. Relationships between landlord and tenants are transformed from rice tax and labour commitments to contract, as seen in the Muslim community, for example. The form of rent is transformed from rice field renting to accommodation rental. The ethnic role interchanges - for example, Muslims who used to be rice-growing tenants become landlords, and Buddhists who used to be landowners in the past become tenants, especially among those on a lower income. Patron-client relationships are reflected in terms of relationship among members of various communities. Religious leaders and community leaders gain a higher status within their communities, for although they are not really the 'privileged' class, they are definitely to be people of some importance.

With reference to the interaction between people and their social institutions, in the past, the temple has been the first educational institution, facilitating cultural activities undertaken in traditional rituals and festivals. The temple was a common meeting place, a place where young adults met by chance while participating in festivals (*Ngan Wat*). In some cases, this interaction led to marriage. When the importance of education was realised after World War II, the temple was replaced by school education as a formal institution. The temple of which original function is one of moral development, depending on individual needs. In the 90s, people, rather than meeting at the temple, tend to meet at more modern places like shopping malls, pubs or restaurants (for the upper middle class), and the morning and evening markets (*Talaad nad*) (for those on lower incomes and the lower middle class). The traditional social institutions have in some aspects been replaced by modernity and consumerism. These transformations in people's relationships, and interaction with social institutions, are relevant to the changing context of the Thai social system as a whole. This is related also to the degree of importance people attach to their cultural identities.

I have found in the study that amidst the rapid change, some aspects of cultural identity are preserved at a certain level in some areas, as witnessed among the Muslims at *Khlong* 1 community. Their religious norms have a positive effect on communal solidarity at a certain level. However, this form of preservation may be challenged by outsiders as well as by a global culture that seems to represent the main stream of development.

The workers' community indicates a pattern of urban lifestyle for the lower income group. This form of 'community' is composed of people who link and interact with each other through daily consumption needs, not by ethnic origin or background. Individualism is particularly evident in such environments, but many, nonetheless, maintain strong kin ties with their home villagers and continue to return there for annual events.

In final analysis, we see that people in the communities under scrutiny, in fact in the whole Rangsit area, have adjusted themselves to fit in well with the global capitalist culture. On one hand, this indicates 'human and social potentiality' to adapt their social lives to survive amidst changes. On the other hand, it may be said that some people may lose their 'cultural roots' and become confused regarding their identity.

Diverse patterns of behaviour are reflected in the old and new communities, as well as in their respective 'generation gaps'. Aged adults from the 'old world', who come from rural origins or who have stayed for a long period in specific rural areas, may have become attached to their rural lifestyles. When they are required to live in a new community (like the workers' community), or even simply in a new context (among the Chinese), they must find means of adjustment, making compromises, in order to fit into the current social sphere. The new generation's lifestyle is largely a consequence of the urban process. Priorities are seeking job opportunities and enhancing consumerism. The decline in kinship ties and ethnic identity lies outside of their sphere of immediate interest.

All of these factors are a consequence of the urban process which brought change to the 'nature' of the Rangsit area. An area composed of people from different ethnic backgrounds, Rangsit is almost a 'mosaic', linking Bangkok with other parts of the country. Since its inception, it has played an important role in the economic demands at the national level. As people have settled in Rangsit, scattered communities have sprung up. Rangsit is now composed of various groups of people, some of whom are local residents, and others - who came later - being commuters from elsewhere.

The dynamics of the people who commute, as well as the migrants, have resulted in Rangsit not fitting into the mould of a traditional community. The impact of globalisation may intrude upon people of the area without resistance - as a type of 'community power' that we can assume exists in some villages in rural areas. The lifestyle of the people in Rangsit is, in general, not much different from that found in the world's principle cities. The people share similar values in accordance with the global capitalist culture. However, the 'culture of community', such as that found among the Muslims, is still maintained at a certain level.

An important factor that has contributed to the lack of a sense of locality in Rangsit is the lack of people's solidarity. Even though this may be found at the level of the small community, it concerns only the community member's needs. The type of solidarity found at the macro level, that will match the traditional meaning of community, has not yet been found. Whether any concept of 'community' can or should be applied to the kind of diverse, pluralistic and dynamic area such as is found in Rangsit is open to debate. Traditional ideas of 'community' as a bounded locality with closely knitted relations among its members may be quite out of alignment with the social and cultural needs of cities of the future. People may form 'communities' across localities, or in virtual space, through the use of mass media and new technologies such as the Internet. There has been an effort to promote Rangsit (in the form of the Rangsit Anniversary Exhibition displayed in a shopping mall 13 March 1998) by a consortium of private organisations in the area. They have traced the historical background, of the area, showing the importance of land development that has been more for *business* purposes than to motivate people's sense of community. Rangsit is a huge area with complex forms of land use. In other words, the 'urban space' itself, as well as an individualist approach to the urban way of life, does not promote people's interaction. Neither does it motivate people to associate with each other in the interests of creating a 'community'. Some educational, religious, and social institutions in the area still serve as a way of uniting people at the individual level. In this sense Rangsit is not markedly different from most postmodern multicultural world cities.

This study examines the effects of globalisation on people's lifestyles. At another level, the concept of 'glocalisation' is introduced, in order to suggest that a sense of locality does remain important in many contexts. A growing urban area like Rangsit has never been able to mobilise sufficient power to resist global capitalist culture, even if its inhabitants wanted to do so. It is quite impossible to retard the rapid growth in the area. On the contrary, growth persists as long as the 'development paradigm' is formally supported by the State and business. However, a certain level of commitment to the local area, its pleasures and opportunities, does cushion the supposed effect of globalisation.

The study emphasises not only the dynamism of the socio-cultural context of the area, reflected in the people's adaptation, but also recognises the differences between groups. For an increasing number of people, ethnicity is less important than the necessity for earning and job opportunities. Those who are good earners can disassociate themselves from the lower income workers who represent the majority base in Thai society. The latter group constitutes the 'power of dynamism' in the Rangsit area, enabling Rangsit to fulfil its function as an area of production for the country. The workers' group appears to have less social and economic power at both local and national level. Hence, the middle class who are entrepreneurs have gained much more profit from their share of 'natural and social resources' in the Rangsit area.

In the current climate of economic crisis, all are affected. All members of society have to contend with the financial crisis. Low-paid migrant workers may be able to return to their agricultural roots. Those who remain unemployed in the cities, live in the vague hope of getting a job somehow. Social problems caused by unemployment and the 'over growth' of capitalism still persist. This is a common phenomenon found in urban centres throughout the developing world. For many of the middle class, the economic crisis could take them back to basics by stimulating their awareness of how they have been exploited by consumerism and materialism.

Finally, this study has tried to show that people as represented in Rangsit have been capable and willing to deal with the process of constant change throughout the modernisation period. Whether recruited as labourers from the distant Northeast in order to develop the rice-fields of Rangsit, or by turning their hands and minds to a bewildering variety of small-scale entrepreneurial activities, the people have taken up whatever opportunities were offered, and, if they failed, turned to different strategies as new possibilities arose. Far from being conservative peasants in a once stable subsistence village, the present population in the Bangkok peri-urban regions has undergone decades of opportunistic adjustments as the macro-level capitalist world-system has exerted overwhelming impact on their everyday lives. While the more traditional values essential for maintaining the social order are still observed, changes are occuring among the urban Thai in the personal competence sphere, with higher concern for independence and achievement. The Thai world view seems to be one of harmonious coexistence combined with the pragmatism of adaptability and flexibility (Pongsapich 1985). The resilience and capability of the people in the face of constant change can be noted as one of the aspects of people's adaptability. Hopefully, whatever is the end results of the current financial and economic crisis, this same flexibility and adaptability will continue to help remedy the situation people confronted in the face of the ever increasing challenges at the dawn of the 21st century.

References

Askew, Marc (1994) *Interpreting Bangkok: The Urban Question in Thai Studies.* Bangkok: Chulalongkorn University Press.

Forbes, Dean (1996) *Asian Metropolis: Urbanisation and the Southeast Asian City.* Melbourne: Oxford University Press.

Greenberg, Charles (1994) *Region based urbanization in Bangkok's extended periphery.* Unpublished Ph.D Thesis. University of British Columbia (Canada).

Institute of Thai Studies (1995) *Roipee Khlong Rangsit (Rangsit Centennial); a Pilot Multidisciplinary study for the Golden Jubilee of the King.* Chulalongkorn University.

Iqbal, Javaid (1990) *Verification of the 'Desakota' Concept, Assessment of Land-use and Environmental Problems and Related Policy Implications: Case Study of the Northern Corridor, Bangkok, Thailand.* Unpublished M.A.Thesis, Bangkok: Asian Institute of Technology (AIT).

McGee (1987) *The Southeast Asian City.* London: G.Bell.

McGee (1991) 'The Emergence of Desakota Regions in Asia: Expanding a Hypothesis', in *The Extended Metropolis: Settlement Transition in Asia,* ed. by Ginsburge, Koppel and McGee. Honolulu: University of Hawaii Press, pp.3-25.

Nathalang, Sowatree (1999) *Rangsit in Transition: Urbanisation and Cultural Adaptation in Central Thailand.* Unpublished Ph.D. Thesis. Sydney: Macquarie University.

Parnwell, M.S.G. and L. Wongsuphasawat (1997) 'Between the Global and the Local Extended Metropolitanization and Industrial Location Decision Making in Thailand, *Third World Planning Review,* 19 (2): 119-138.

Pongsapich, Amara (1985) *Traditional and Changing Thai Worldview,* Bangkok: Chulalongkorn University Social Research Institute and Southeast Asian Studies Program of the Institute of Southeast Asian Studies, Singapore.

A regional study of Klong Rangsit : its historical development from rural characteristics into urban area in northern Bangkok

Rachaniwan Vechaphurt, Porntip Karjanasunthorn, Sripen Durongdej

พื้นที่ศึกษาบริเวณคลองรังสิต : การเปลี่ยนแปลงจากลักษณะชนบทเป็นเมืองในบริเวณตอนเหนือกรุงเทพมหานคร*

Abstract: *The objective of this study is to observe the changing socio-economic aspects over one decade (1989-1999) in the Rangsit area. It is observed that not only the landuse has changed from agriculture (rice paddy fields and orange orchard or fish ponds) into housing projects, but that people from the urban area have moved to reside in this area. The life style also changed a lot from a simple life, for example finding wood for fuel and vegetables from the side road or net fishing along the canal. The new moving people live in urban style as white collars, stay in brick houses while some well-off households have cars. Infrastructures are established to serve the needs of these settlements, for example electricity to the housing projects. The main road is widened, the pipe system and supply with sanitation is distributed among the housing projects.*

The method used in this study included both observations in the field, interpreting satellite data, and interviews. The social movements, economic status and education levels are evidenced. The researchers are also concerned about the environmental problems.

บทนำ

1. ประวัติ

เดิมอำเภอเมืองรังสิตขึ้นอยู่กับเขตพระมหานคร เรียกว่า ทุ่งหลวงเป็นป่ารก ที่ดินอุดมด้วยธาตุ ซึ่งเหมาะแก่การประกอบอาชีพเกษตรกรรม แต่ขาดน้ำอันเป็นปัจจัยสำคัญ ไม่มีน้ำไหลผ่าน พระบาทสมเด็จพระจุลจอมเกล้าเจ้าอยู่หัวทรงมีพระราชดำริแก้ไข จึงโปรดให้ขุดคลองเมื่อ พ.ศ.2433 เป็นต้นมา โดยมีพระบรมวงศ์เธอพระองค์เจ้าสายสนิทวงศ์เป็นประธาน และได้ทรงพระราชทานนามว่า "คลองรังสิตประยูรศักดิ์" คลองนี้เริ่มขุดจากริมแม่น้ำเจ้าพระยาที่ตำบลบ้านใหม่ อำเภอเมือง จังหวัดปทุมธานี ไปทาง

* ผู้บรรยาย รศ.รัชนีวรรณ เวชพฤติ ภาควิชาภูมิศาสตร์ คณะสังคมศาสตร์ มหาวิทยาลัยเกษตรศาสตร์ กรุงเทพฯ

เขตจังหวัดนครนายก มีคลองซอยห่างกันประมาณ 60 เส้น มีคลองซอยทั้งหมด 17 คลอง โดยเรียกชื่อตามลำดับคลองจากคลอง 1 ถึงคลอง 17 ทำให้มีน้ำไหลจากภูเขาบรรทัดผ่านแม่น้ำนครนายกลงมาจนถึงคลองรังสิต ที่อำเภอองค์รักษ์ และมาจดแม่น้ำเจ้าพระยาที่ตำบลบ้านใหม่ ตรงวัดเทียนถวาย ซึ่งก่อให้เกิดประโยชน์อย่างมหาศาลในการประกอบอาชีพทางเกษตรกรรมแก่ชาวนาชาวไร่อย่างยิ่ง พระบาทสมเด็จพระจุลจอมเกล้าเจ้าอยู่หัวทรงมีปณิฌานแน่วแน่ที่จะพัฒนาทุ่งหลวงให้เจริญก้าวหน้าในอนาคต จึงได้จัดตั้งอำเภอธัญบุรี และอำเภอคลองหลวง อำเภอหนองเสือ และอำเภอลำลูกกา ในปี 2445 รวมเป็นจังหวัดธัญบุรี ต่อมายุบไปรวมกับจังหวัดปทุมธานี สภาพปัจจุบัน อำเภอคลองหลวง อยู่ใกล้กับกรุงเทพมหานคร ทำให้มีการขยายตัวในภาคอุตสาหกรรม และที่อยู่อาศัยมากขึ้น เพราะการคมนาคมสะดวก จึงมีการเคลื่อนย้ายแรงงานจากจังหวัดต่าง ๆ เข้ามาทำงาน ตามโรงงานเป็นจำนวนมาก จำนวนประชากรวัยทำงานจึงเพิ่มมากขึ้นตามการขยายตัวทางด้านอุตสาหกรรม ทำให้น่าเป็นห่วงปัญหาแรงงานในภาคเกษตรกรรม เพราะพื้นที่การเกษตรถูกแบ่งไปสร้างโรงงานอุตสาหกรรม และที่อยู่อาศัยมากขึ้น ประชาชนในวัยทำงาน โดยเฉพาะผู้ที่มีอายุ 15 ปีขึ้นไป เพื่อโตขึ้น หรือจบการศึกษาภาคบังคับแล้ว จะเข้าทำงานตามโรงงานอุตสาหกรรมหมด แรงงานทางภาคเกษตรกรรมจึงมีจำนวนน้อย ลักษณะชุมชนแยกได้ดังนี้

ลักษณะชุมชนภาคเกษตรกรรม ซึ่งเป็นชุมชนส่วนใหญ่ เป็นชนพื้นบ้านแต่ดั้งเดิม ภาษาพูดเป็นภาษาไทย มีความผูกพันเหมือนพี่เหมือนน้อง มีขนบธรรมเนียมประเพณีที่เหมือน ๆ กัน มีความเป็นอยู่คล้าย ๆ กัน

ลักษณะชุมชนในเขตอุตสาหกรรม ส่วนมากจะอพยพมาจากต่างจังหวัดทุกภาคของประเทศไทย มีความเป็นอยู่แบบตัวใครตัวมัน เวลาสวนมากจะทำงานอยู่ในโรงงานอุตสาหกรรม

2. พื้นที่ศึกษา อยู่ในเขตพื้นที่ 3 อำเภอ ได้แก่

2.1 อำเภอธัญบุรี มีการปลูกบ้านและทำสวน เช่น สวนส้ม และเนื่องจากมีถนนสาย รังสิต-นครนายกผ่าน ทำให้เกิดธุรกิจบ้านจัดสรร โรงงานอุตสาหกรรม ทั้งมีแนวโน้มจะเพิ่มขึ้นในอนาคต ส่งผลถึงการเปลี่ยนแปลงด้านการประกอบอาชีพของราษฎร คือ ประชากรวัยหนุ่มสาวมักหันเหไปทำงานตามโรงงานอุตสาหกรรมซึ่งถึงแม้จะเสี่ยงต่อการติดเชื้อจากสารเคมีต่าง ๆ ที่ใช้ในโรงงาน แต่ก็ทำให้มีรายได้เพิ่มขึ้น และแน่นอนในขณะที่ราษฎรวัยกลางคนและผู้อาวุโสยังคงประกอบอาชีพกสิกรรมตามบรรพบุรุษ ตัวแปรเหล่านี้ชี้ให้เห็นถึงการเปลี่ยนแปลงจากย่านเกษตรกรรมมาเป็นย่านอุตสาหกรรมและชุมชนที่อยู่อาศัยขนาดใหญ่ ของอำเภอพื้นที่ธัญบุรีในอนาคต

2.2 อำเภอหนองเสือ เป็นอำเภอที่ค่อนข้างกันดารอยู่ติดกับอำเภอหนองแค จังหวัดสระบุรี คำว่าหนองเสือ หมายถึงชุมโจรเนื่องจากอยู่ไกลเจ้าหน้าที่และเป็นเขตต่อแดนกับจังหวัดอื่น ลักษณะเป็นที่เป็นที่ราบต่ำลงมาจากภูเขาใหญ่ ในเขตจังหวัดสระบุรี และนครนายก

2.3 อำเภอลำลูกกา อยู่ทางทิศตะวันออกของจังหวัดปทุมธานีห่างจากจังหวัดที่ว่าการอำเภอลำลูกกา ประมาณ 35 กิโลเมตร ลักษณะภูมิประเทศโดยทั่วไปเป็นที่ราบลุ่ม อยู่ในเขตชลประทานหลวง พื้นที่เป็นดินเหนียวเหมาะแก่การทำนา ทำสวน ปลูกพืชผักต่าง ๆ มีน้ำอุดมสมบูรณ์ตลอดทั้งปี

3. สภาพแวดล้อม

เนื่องจากจังหวัดปทุมธานี เป็นพื้นที่รองรับการขยายตัวของกรุงเทพมหานคร ตามแผนพัฒนาเศรษฐกิจและสังคมแห่งชาติที่มีนโยบายจะชลอการเจริญเติบโตของกรุงเทพมหานคร โดยมุ่งให้เมืองในเขตปริมณฑล อันได้แก่ ปทุมธานี สมุทรปราการ นนทบุรี นครปฐม และสมุทรสาคร เป็นพื้นที่รองรับการขยายตัวจากกรุงเทพมหานครในระยะแรกรวมทั้งทำหน้าที่สกัดกั้นประชากรที่จะมุ่งเข้าสู่กรุงเทพมหานครด้วย ดังนั้นจะเห็นได้ว่าชุมชนเมืองในภาคกรุงเทพมหานครและปริมณฑลนั้นมีบทบาทสำคัญในการพัฒนากรุงเทพมหานครให้เป็นไปอย่างมีประสิทธิภาพ ปทุมธานีซึ่งเป็นจังหวัดที่มีอาณาเขตติดต่อกับกรุงเทพมหานครและมีกิจกรรมต่าง ๆ เกิดขึ้นอย่างต่อเนื่อง จึงมีการขยายตัวของชุมชนเพิ่มขึ้นอย่างรวดเร็ว

การเพิ่มจำนวนโรงงานอุตสาหกรรมอย่างรวดเร็ว ทำให้มีการขยายตัวของชุมชนการเกิดชุมชนใหม่มีการเคลื่อนย้ายแรงงาน เข้ามาทำงานในโรงงานต่าง ๆ ทำให้สภาพชีวิตความเป็นอยู่ของคนในท้องถิ่นเริ่มเปลี่ยนแปลงในทุกด้านจากสภาพความเป็นอยู่ของสังคมชนบท เป็นสังคมเมืองกึ่งชนบท และเป็นสังคมเมืองในที่สุด ขณะที่มีการเปลี่ยนแปลงอย่างรวดเร็วของโครงสร้างเศรษฐกิจและสังคมดังกล่าว ปัญหาที่ตามมาก็คือเรื่องที่พักอาศัยแหล่งเสื่อมโทรม ปัญหาสิ่งแวดล้อม สุขภาพอนามัย การสาธารณสุข และคุณภาพชีวิตของคนงานเหล่านี้ รวมทั้งความสงบเรียบร้อยของชุมชน

4. เนื้อหาที่เกี่ยวกับงานวิจัย

4.1 วัตถุประสงค์

1. เพื่อสำรวจการเปลี่ยนแปลงการใช้ที่ดินระหว่างปี 2537-2542 บริเวณคลองหนึ่งถึงคลองสิบ

2. เพื่อศึกษาการเปลี่ยนแปลงเศรษฐกิจและสังคมของชุมชน

3. เพื่อศึกษาปัญหาและผลกระทบจากการเพิ่มขึ้นของประชาชนเมืองต่อสิ่งแวดล้อมที่เกิดขึ้น เช่น ระบบการเก็บขยะ ระบบน้ำทิ้ง การจราจรที่เพิ่มขึ้น

4. เพื่อหาแนวทางในด้านการให้การบริการระบบสาธารณูปการ และสาธารณูปโภค เพื่อให้เหมาะสมกับการตั้งถิ่นฐานของประชากรในเขตนี้

4.2 ประโยชน์ที่คาดว่าจะได้รับ

1. ทำให้ทราบภาพรวมของการใช้ที่ดินในปัจจุบันและแนวโน้มต่อไปในอนาคต ข้อมูลที่ได้จะสามารถนำไปประยุกต์ใช้ในการวางแผนกำหนดแนวทางในการพัฒนาพื้นที่ต่อไป

2. ทำให้ทราบถึงสาเหตุการเปลี่ยนแปลงทางเศรษฐกิจและสังคมของชุมชนซึ่งสามารถนำข้อมูลมาประกอบการตัดสินใจเพื่อแก้ไขปัญหาในพื้นที่

3. ทำให้ทราบถึงปัญหาและผลกระทบต่างๆ ที่มีต่อชุมชน อันเนื่องมาจากการเปลี่ยนแปลงการใช้ที่ดิน โดยเฉพาะจากการสร้างบ้านเรือนอย่างหนาแน่น

4. เพื่อนำผลการศึกษามาเสนอหน่วยงานที่เกี่ยวข้อง เช่น จังหวัด และอบต.

4.3 ขอบเขตการศึกษา

การศึกษาเบื้องต้นเกี่ยวกับการเปลี่ยนแปลงการใช้ที่ดิน สภาพเศรษฐกิจและสังคมของชุมชนตลอดจนการเปลี่ยนแปลงสภาพความเป็นอยู่ของชุมชนจากภาคเกษตรกรรมไปสู่ความเป็นเมือง

พื้นที่ที่ทำการศึกษา ได้แก่ พื้นที่บริเวณคลองรังสิต ศึกษาตั้งแต่คลองหนึ่งถึงคลองสิบ จังหวัดปทุมธานี

ศึกษาสภาพการเปลี่ยนแปลงระหว่างปี 2537 - 2542

4.4 วิธีการศึกษา

การศึกษาใช้วิธีการรวบรวมข้อมูลลที่เป็นเอกสารและข้อมูลที่เป็นแผนที่จากหน่วยราชการที่เกี่ยวข้อง และจากการค้นคว้าในห้องสมุด และอีกส่วนหนึ่งได้จากการสำรวจภาคสนาม มีการสัมภาษณ์โดยใช้แบบสอบถามโดยคณะผู้ศึกษาร่วมกันออกสัมภาษณ์ประชาชนในพื้นที่

4.5 ข้อกำหนดการใช้ที่ดิน

1. การใช้ที่ดินในชนบท ส่วนใหญ่เป็นการใช้ที่ดินเพื่อการเกษตร เช่น ที่นา ที่ปลูกพืชไร่ ที่ปลูกต้นไม้ และไม้ยืนต้น ที่ป่า เป็นต้น กระทรวงเกษตรและสหกรณ์ได้แบ่งประเภทการใช้ที่ดินในเนื้อที่ถือครองทำการเกษตรออกเป็นรายละเอียด ดังนี้

1.1 ที่อยู่อาศัย
1.2 ที่นา
1.3 พืชไร่
1.4 ไม้ผลและไม้ยืนต้น
1.5 สวนผักและไม้ดอก
1.6 ที่รกร้างว่างเปล่า
1.7 ทุ่งหญ้า เลี้ยงสัตว์
1.8 ที่อื่นๆ เช่น เลี้ยงปลา ทำพาณิชยกรรม หัตถกรรม เป็นต้น

2. การใช้ที่ดินในเมือง แบ่งออกเป็นรายละเอียดได้มากประเภทกว่าการใช้ที่ดินในชนบท ในพื้นที่ที่มีขนาดเท่ากัน เช่น พื้นที่ 1,000 ไร่ การใช้ที่ดินในชนบทอาจทำการเพาะปลูก แต่พืชเพียงอย่างเดียว คืออาจใช้เป็นที่นาเท่านั้น แต่ถ้าเป็นการใช้ที่ดินแบบเมืองจะมีหลายประเภท เช่น ที่อยู่อาศัย ร้านค้า ร้านบริการต่างๆ เพราะอาชีพในเมืองมีหลายชนิด ในเนื้อที่ไม่มากเหมือนการเพาะปลูก ดังมีรายละเอียดดังต่อไปนี้

2.1 เป็นที่อยู่อาศัย
2.2 เป็นที่ค้าขาย

2.3 เป็นที่ตั้งโรงงานอุตสาหกรรม
2.4 เป็นที่ศาสนสถาน
2.5 เป็นที่สาธารณูปโภคและสาธารณูปการ
2.6 เป็นที่ตั้งสถานที่ราชการและสถาบัน
2.7 เป็นย่านโรงเก็บสินค้า
2.8 เป็นที่ตั้งปศุสัตว์
2.9 เป็นที่ตั้งสถาบันการศึกษา
2.10 เป็นที่พักผ่อนหย่อนใจ
2.11 เป็นบริเวณถนน ตรอก ซอย
2.12 เป็นบริเวณแม่น้ำ ลำคลอง บ่อ
2.13 เป็นบริเวณพื้นที่เกษตรและที่ว่าง

ความหมายของเมือง สุวันนา (สายัณห์, 2533 : 21) ให้ความหมายของเมือง คือ บริเวณที่มีประชากรตั้งถิ่นฐานรวมกันอยู่หนาแน่นเป็นชุมชนและประชากรส่วนใหญ่มิได้มีอาชีพ เป็นเกษตรกร หากแต่ประกอบอาชีพในการอุตสาหกรรม หรือการใช้บริการ อาชีพเหล่านี้ทำให้คนต้องมาอยู่ในบริเวณศูนย์กลางหนึ่ง เพื่อสะดวกแก่การติดต่อกับลูกค้าหรือให้บริการ จึงทำให้มีสิ่งก่อสร้างอยู่ใกล้ชิดแออัด มีถนนหนทางติดต่อกันทั้งภายในเมืองและระหว่างเมืองอื่น ๆ จึงเกิดลักษณะที่ต่างไปจากชนบท

สมชาย (สายัณห์, 2533 : 21) ให้ความหมายของเมือง คือ กลุ่มการตั้งถิ่นฐานของประชากรที่มารวมกลุ่มกันในบริเวณใดบริเวณหนึ่ง ซึ่งประชากรส่วนใหญ่ประมาณ 2/3 มีอาชีพที่มิใช่เกษตรกรรม

4.6 ผลงานวิจัยที่เกี่ยวข้อง

1. จารุวรรณ (2530) ศึกษาเรื่องการเจริญเติบโตของชุมชนในจังหวัดปทุมธานี กรณีศึกษาการใช้ประโยชน์ที่ดินของชุมชนประชาธิปัตย์และคลองหลวง ซึ่งเป็นชุมชนที่มีการขยายตัวอย่างรวดเร็วในช่วง 10 ปีที่ผ่านมา พบว่าชุมชนทั้งสองยังขาดการวางแผนการใช้ประโยชน์ที่ดินที่เหมาะสม จึงเกิดปัญหาความขัดแย้งของกิจกรรมประเภทต่าง ๆ เช่น สถาบันการศึกษา และโรงงานอุตสาหกรรม เป็นต้น การศึกษานี้ได้ทำการศึกษาตั้งแต่สภาพทั่วไปของชุมชน ลักษณะการขยายตัวของชุมชน ตลอดจนพื้นที่ที่มีศักยภาพเหมาะสมสำหรับกิจกรรมแต่ละประเภท ผลสรุปของการศึกษา คือ รูปแบบการใช้ประโยชนที่ดินที่เหมาะสม โดยคำนึงถึงสภาพแวดล้อมเป็นหลัก

2. ธนพรรณ (2538) ศึกษาเรื่องผลกระทบทางเศรษฐกิจสังคมของการเปลี่ยนแปลงจากภาคเกษตรกรรมสู่ภาคอุตสาหกรรม : กรณีศึกษากรณีอำเภอคลองหลวง อำเภอธัญบุรี จังหวัดปทุมธานี พบว่าเศรษฐกิจทั่วไปของประชากรในท้องถิ่นที่มีโรงงานอุตสาหกรรมเข้ามาตั้งดีขึ้น มีทางเลือกในการประกอบอาชีพมากขึ้น แต่การมีกรรมสิทธิ์ในที่ดินพบว่า ปัจจุบันจำนวนถือครองที่ดินมีสัดส่วนมากกว่าเมื่อ 10 ปีก่อน แต่ขนาดที่ดินลดลง และส่วนใหญ่ใช้เป็นที่อยู่อาศัย ส่วนสภาพสังคม พบว่าประชากรส่วนใหญ่

มีความพึงพอใจกับสภาพทางกายภาพของสังคมปัจจุบัน แต่ขณะเดียวกันก็มีปัญหาสิ่งแวดล้อม ปัญหาชุมชนแออัด และปัญหาสังคมอื่น ๆ ซึ่งเป็นสิ่งที่เกิดขึ้นภายหลังการมีโรงงานอุตสาหกรรมในพื้นที่ศึกษา

5. การวิเคราะห์ข้อมูล

การเก็บข้อมูลแบ่งออกเป็น 2 ช่วงคือ

- คลองหนึ่งถึงคลองห้า (2536-2541)
- คลองหกถึงคลองสิบ (2537-2542)

มีการเก็บข้อมูล 4 ครั้ง ได้แก่

ครั้งที่ 1	2536-2537	(คลองหนึ่ง-คลองห้า)
ครั้งที่ 2	2538-2539	(คลองหก-คลองสิบ)
ครั้งที่ 3	2540-2541	(คลองหนึ่ง-คลองห้า)
ครั้งที่ 4	2541-2542	(คลองหก-คลองสิบ)

6. ข้อมูลทั่วไป

ลักษณะพื้นที่ที่ศึกษาในครั้งนี้มีอาณาเขตตั้งแต่คลองหนึ่งถึงคลองสิบในบริเวณการปกครองของอำเภอลำลูกกา ธัญบุรี คลองหลวง และบางส่วนของหนองเสือ ทั้งนี้มีอาณาบริเวณติดต่อดังนี้

ทิศใต้ ติดกับกรุงเทพมหานคร เขตบางเขน จังหวัดมีนบุรี อำเภอหนองจอก

ทิศเหนือ ติดกับสระบุรี เขตอำเภอหนองแค จังหวัดพระนครศรีอยุธยา อำเภอวังน้อย

ทิศตะวันตก อยู่ในเขตจังหวัดปทุมธานี โดยมีถนนวิภาวดีผ่านจากทิศตะวันออกเฉียงใต้ไปทิศตะวันตกเฉียงเหนือ

ทิศตะวันออก ติดกับจังหวัดนครนายก

จะเห็นได้ว่า บริเวณริมถนนวิภาวดีมีแนวโน้มการใช้ที่ดิน เปลี่ยนไปจากที่นามาเป็นตึกแถว บริเวณที่ติดกับกรุงเทพฯ จะกลายเป็นที่อยู่อาศัยสำหรับผู้ที่เดินทางไปในเขตเมือง โครงการบ้านจัดสรรเกิดขึ้นหลายแห่งในบริเวณอำเภอลำลูกกา รวมทั้งโรงงานอุตสาหกรรม เป็นต้น สวนที่ตั้งของบริเวณทิศเหนือและตะวันออกจะยังคงสภาพเป็นที่นา สวนส้ม การใช้ที่ดินเป็นแบบชนบท ที่ตั้งบ้านเรือนจะอยู่ริมคลองอาศัยน้ำคลองเป็นที่อุปโภค บริโภค

ตัวอย่างตารางข้อมูลที่สัมภาษณ์จากประชากรบริเวณพื้นที่ศึกษา (คลองหนึ่งถึงคลองห้า) ปี 2540 ย้อนหลัง 5 ปี

1.1 ข้อมูลสังคมแสดงเหตุผลเกี่ยวกับการย้ายถิ่น

1. สาเหตุการย้ายออกไปอยู่ที่อื่น

โดยพิจารณาเฉพาะจำนวนที่มีสมาชิกย้ายออก เพราะฉะนั้นจำนวนรวม = 31

ตารางที่ 1 แสดงสาเหตุการย้ายออกไปอยู่ที่อื่น

สาเหตุการย้ายออกไปอยู่ที่อื่น	จำนวน	ร้อยละ
เพื่อประกอบอาชีพใหม่	15	48.39
ศึกษาต่อ	6	17.14
แต่งงาน	11	31.43
อื่น ๆ	0	0
รวม	**31**	**100**

จากตารางที่ 1 พบว่า ประชากรที่อาศัยอยู่ในตำบลคลอง 1 – คลอง 5 นั้น จะมีสาเหตุของการย้ายออกไปอยู่ที่อื่นโดยส่วนใหญ่ คือ เพื่อไปประกอบอาชีพใหม่ มีจำนวนร้อยละ 48.39 ส่วนสาเหตุรองลงมาคือ การย้ายออกเพราะแต่งงานแยกครอบครัวไป มีจำนวนร้อยละ 31.43

2. ท่านคิดจะย้ายไปอยู่ที่อื่นหรือไม่

ตารางที่ 2 แสดงการคิดจะย้ายไปอยู่ที่อื่น

การคิดย้ายที่อยู่อาศัย	จำนวน
ไม่คิดจะย้ายที่อยู่	81
คิดจะย้าย	19
รวม	**100**

ตารางที่ 3 แสดงเหตุผลที่ไม่คิดจะย้ายที่อยู่

เหตุผลที่ไม่คิดย้ายที่อยู่	จำนวน	ร้อยละ
มีหลักฐานที่มั่นคงแล้ว	41	50.62
มีรายได้และอาชีพที่ดีอยู่แล้ว	20	24.69
การศึกษาของบุตรหลาน	1	1.23
การคมนาคมสะดวก	7	8.64
อื่น ๆ	12	14.81
รวม	**81**	**100**

ตารางที่ 4 แสดงเหตุผลที่คิดจะย้ายที่อยู่

เหตุผลที่คิดย้ายที่อยู่	จำนวน	ร้อยละ
ต้องการเปลี่ยนอาชีพใหม่	1	5.26
การคมนาคมไม่สะดวก	2	10.23
ไม่พอใจเรื่องสิ่งแวดล้อม	5	26.31
อาชญากรรม	1	5.26
อื่น ๆ	10	52.63
รวม	**19**	**100**

จากตารางที่ 2 พบว่า ประชากรที่อาศัยอยู่ในตำบลคลอง 1 – คลอง 5 ส่วนใหญ่ไม่คิดจะย้ายไปอยู่ที่อื่น ซึ่งมีจำนวนถึงร้อยละ 81 อาจเนื่องจากประชาชนส่วนใหญ่มีนิสัยรักถิ่นฐานที่อยู่ อยู่ไหนก็มักอยากอยู่ที่นั้นต่อไป ถึงแม้จะไม่มีความแน่นอนก็ตาม จากตารางที่ 4.19 ส่วนเหตุผลของการไม่คิดจะย้ายไปอยู่ที่อื่นๆ ก็คือ เพราะมีหลักฐานมั่นคงแล้ว มีจำนวนร้อยละ 24.69

จากตารางที่ 4 ส่วนประชากรที่คิดจะย้ายที่อยู่ไปอยู่ที่อื่นนั้นมีจำนวนเพียงร้อยละ 19 โดยเหตุผลที่คิดจะย้ายที่อยู่นั้นมีหลากหลายที่ระบุมาซึ่งมีจำนวนถึงร้อยละ 52.63 เช่น เนื่องจากไม่มีที่ดินเป็นกรรมสิทธิ์ของตนเอง หรือเนื่องจากโดนไล่ที่ดินที่อยู่เหตุผลรองลงมาคือ การไม่พอใจเรื่องสิ่งแวดล้อม มีจำนวนร้อยละ 26.31 อาจเนื่องมาจากพื้นที่ในปัจจุบันมีความเจริญมากขึ้น มีโรงงานอุตสาหกรรม และบ้านจัดสรรมากมาย มีสภาพแออัดมากขึ้น และเกิดมลพิษต่อสิ่งแวดล้อม เช่น น้ำเสีย อากาศเสีย

4. การเปลี่ยนแปลงที่อยู่อาศัยเพราะเหตุมีการพัฒนาที่ดิน ในช่วง 5 ปีที่ผ่านมา (เช่น การมีโรงงานอุตสาหกรรม, บ้านจัดสรร, ศูนย์การค้า เป็นต้น)

ตารางที่ 5 แสดงการเปลี่ยนแปลงที่อยู่อาศัยเพราะเหตุมีการพัฒนาที่ดิน

การเปลี่ยนแปลงที่อยู่อาศัย	จำนวน
ไม่มีการเปลี่ยนแปลง	44
มีการเปลี่ยนแปลง	56
รวม	**100**

จากตารางที่ 5 พบว่า ประชากรที่อาศัยอยู่ในตำบลคลอง 1- คลอง 5 นั้น ต้องมีการเปลี่ยนแปลงที่อยู่อาศัยเพราะเหตุมีการพัฒนาที่ดิน โดยมีจำนวนร้อยละ 56 จากประชากรทั้งหมด และในส่วนที่ไม่มีการเปลี่ยนแปลงมีจำนวนร้อยละ 44

5. ผลกระทบต่อครอบครัวจากการเปลี่ยนแปลงที่อยู่อาศัย

ตารางที่ 5 แสดงผลกระทบจากการเปลี่ยนแปลงที่อยู่อาศัยต่อครอบครัว

ผลกระทบจากการเปลี่ยนแปลงที่อยู่อาศัยต่อครอบครัว	จำนวน
ไม่มี	37
มี	63
รวม	**100**

จากตารางที่ 5 พบว่า ประชากรที่อาศัยอยู่ในตำบลคลอง 1 - คลอง 5 นั้น ได้รับผลจากการเปลี่ยนแปลงที่อยู่อาศัยมีจำนวนถึงร้อยละ 63 ส่วนผลกระทบที่เกิดขึ้นมีทั้งดีและไม่ดี ผลดีคือ เส้นทางคมนาคมสะดวกขึ้น ได้รับสาธารณูปโภคครบครัน และทำให้การประกอบอาชีพสะดวกขึ้นมากกว่าแต่ก่อน ส่วนผลเสียก็คือ เมื่อหมู่บ้านพัฒนามากขึ้น ความเจริญก็ขยายตัวเข้ามาในหมู่บ้าน เกิดบ้านจัดสรร เกิดโรงงานอุตสาหกรรม ทำให้ชาวบ้านต้องขายที่ดินบ้าง ต้องย้ายออกไปบ้าง บางครอบครัวก็โดนไล่ที่ และยังประสบปัญหามลภาวะเป็นพิษทางอากาศ เช่น ฝุ่นละอองและควันต่างๆ เป็นต้น จากแหล่งอุตสาหกรรม

และการขนส่ง ซึ่งมีเส้นทางคมนาคมที่สะดวกและยังมีผลกระทบต่อการทำอาชีพเกษตรกรรมด้วย ชาวบ้านส่วนหนึ่งก็ขายที่ให้กับเจ้าของโรงงาน เจ้าของบ้านจัดสรร สนามกอล์ฟ ซึ่งสิ่งเหล่านี้ต้องใช้น้ำมากในการทำกิจกรรม จึงมีผลกระทบต่อชาวนาชาวสวนมาก ส่วนการเปลี่ยนแปลงที่อยู่อาศัยไม่ก่อให้เกิดผลกระทบนั้นมีจำนวนร้อยละ 37 ของประชากรทั้งหมด

1.2 แสดงสภาพแวดล้อม

1. แหล่งน้ำดื่ม น้ำใช้

ตารางที่ 6 แหล่งน้ำดื่ม น้ำใช้

แหล่งน้ำดื่ม น้ำใช้	จำนวน
น้ำฝน	37
แม่น้ำลำคลอง	7
น้ำบาดาล	31
น้ำประปา	14
อื่น ๆ	11
รวม	**100**

จากตารางที่ 6 พบว่า ประชากรที่อาศัยอยู่ในตำบลคลอง 1 - คลอง 5 นั้น ส่วนใหญ่แหล่งน้ำดื่ม น้ำใช้ ได้จากน้ำฝนมีจำนวนร้อยละ 37 เนื่องจากน้ำฝนเป็นน้ำที่ได้จากธรรมชาติ สะดวก และไม่ต้องซื้อหา และก็ใช้กันมาตั้งแต่สมัยก่อน ที่จะสูบน้ำบาดาลหรือต่อท่อประปา รองลงมาคือ แหล่งน้ำดื่ม น้ำใช้ที่จากน้ำบาดาลมีจำนวนร้อยละ 31 โดยจะมีแหล่งจ่ายน้ำบาดาลประจำตำบลให้บริการ และการใช้น้ำประปามีจำนวนร้อยละ 14 ส่วนแหล่งน้ำดื่ม น้ำใช้อื่น ๆ เช่น การซื้อน้ำสะอาดเป็นถังมาบริโภค มีจำนวนร้อยละ 11 ส่วนแหล่งน้ำใช้ที่ได้จากแม่น้ำลำคลอง มีเพียงจำนวนร้อยละ 7 เพราะน้ำในคลองนั้นสกปรกมากขึ้น ไม่ได้ใสสะอาดเหมือนเดิม

2. การบำบัดน้ำเสีย

ตารางที่ 7 แสดงวิธีการบำบัดน้ำเสีย

การบำบัดน้ำเสีย	จำนวน
ระบายลงดิน	49
ปล่อยลงคลอง	31
ท่อระบาย	7
บ่อพัก	13
รวม	**100**

จากตารางที่ 7 พบว่า ประชากรที่อาศัยอยู่ในตำบลคลอง 1 - คลอง 5 นั้น ส่วนใหญ่มีการบำบัดน้ำเสียโดยระบายลงดินมีจำนวนร้อยละ 49 รองลงมาคือการปล่อยลงสู่คลองมีจำนวนร้อยละ 31 และการทิ้งลง

บ่อพักและท่อระบายน้ำ มีจำนวนร้อยละ 13 และ 7 ตามลำดับ จะเห็นได้ว่าชาวบ้านส่วนใหญ่ไม่รู้จักวิธีการบำบัดน้ำเสีย เมื่อใช้น้ำเสร็จแล้วก็ทิ้งตามธรรมชาติ เช่น ลงดิน ลงคลอง ซึ่งน้ำเสียเหล่านี้ เมื่อลงสู่แหล่งน้ำธรรมชาติ จะทำให้เกิดน้ำเน่าเสียได้ ทำให้คุณภาพน้ำต่ำกว่าที่ควร ก่อเกิดเชื้อโรคเจือปนในน้ำและอาจส่งผลเสีย การติดโรคระบาดได้ ถ้าประชาชนนำน้ำมาใช้ดื่มกิน

3. การกำจัดขยะ

ตารางที่ 7 แสดงวิธีการกำจัดขยะ

การกำจัดขยะ	จำนวน
เทศบาล, สุขาภิบาล หรือ อบต. จัดเก็บ	57
กำจัดเอง เช่น เผาขยะ	43
รวม	**100**

จากตารางที่ 7 พบว่า ประชากรที่อาศัยอยู่ในตำบลคลอง 1 - คลอง 5 นั้น ประชาชนส่วนใหญ่ทิ้งขยะในที่ทางเทศบาล สุขาภิบาล หรือ อบต. จัดไว้ให้ โดยจะต้องเสียค่าบริการในราคาถูก และเป็นการสะดวกไม่ต้องเสียเวลาในการกำจัดเอง โดยมีจำนวนร้อยละ 57 และการกำจัดโดยการเผาขยะเอง มีจำนวนร้อยละ 43 ซึ่งการเผาขยะทำให้เกิดผลเสียและเกิดมลภาวะได้ อีกทั้งถ้าขยะที่เผาเป็นพวกโฟมพลาสติก ก็จะมีสาร CFC ทำลายโอโซนได้

4. ความแตกต่างของความสะดวกในการเดินทางเมื่อ 5 ปีก่อนกับปัจจุบัน

ตารางที่ 8 แสดงความแตกต่างของความสะอาดในการเดินทาง

ความแตกต่างของความสะอาดในการเดินทางเมื่อ 5 ปีก่อนกับปัจจุบัน	จำนวน
ไม่แตกต่างกัน	26
เมื่อ 5 ปีก่อนมีความสะดวก**มากกว่า**ปัจจุบัน	10
เมื่อ 5 ปีก่อนมีความสะดวก**น้อยกว่า**ปัจจุบัน	64
รวม	**100**

จากตารางที่ 8 พบว่า ประชากรที่อาศัยอยู่ในตำบลคลอง 1 - คลอง 5 นั้น จาก 5 ปีก่อนกับปัจจุบันนี้ประชาชนจำนวนร้อยละ 64 แสดงความคิดเห็นว่าการเดินทางมีความสะดวกน้อยกว่าปัจจุบัน เป็นผลมาจากการขยายความเจริญหรือการพัฒนามากขึ้น ส่งผลให้การเดินทางสะดวกมากขึ้น เนื่องจากมีการตัดถนนเพิ่มมากขึ้น และเพียงจำนวนร้อยละ 10 เท่านั้นที่บอกว่าเมื่อ 5 ปีก่อนมีความสะดวกมากกว่าปัจจุบัน และจำนวนร้อยละ 26 บอกว่าไม่แตกต่าง อาจเนื่องมาจากบ้านอยู่ติดถนนเดิมอยู่แล้ว ทำให้ไม่เห็นความแตกต่าง หรืออาจเป็นเพราะไม่ต้องเดินทางไปไหนมาก เนื่องมาจากมีอาชีพที่ประกอบกิจการอยู่ที่บ้านหรือการทำการเกษตร จึงลดการเดินทางในการไปทำงานได้ทางหนึ่ง

1.3 ข้อมูลสภาพเศรษฐกิจ

1. การเปลี่ยนแปลงอาชีพหลักเมื่อ 5 ปีก่อนกับปัจจุบัน

ตารางที่ 9 แสดงการเปลี่ยนแปลงอาชีพหลัก

การเปลี่ยนแปลงอาชีพหลัก	จำนวน
ไม่มีการเปลี่ยนแปลง	70
มีการเปลี่ยนแปลง	30
รวม	**100**

จากตารางที่ 9 พบว่า ประชากรที่อาศัยอยู่ในตำบลคลอง 1 - คลอง 5 นั้น เมื่อ 5 ปีก่อนจนถึงปัจจุบัน มีประชาชนเปลี่ยนแปลงอาชีพหลักเพียงร้อยละ 30 โดยเมื่อก่อนมีการทำการเกษตรกันมาก เมื่อความเจริญขยายเข้ามา เกิดการขยายที่ดินแล้วหันไปทำอาชีพอื่น และจำนวนร้อยละ 70 ไม่เปลี่ยนแปลงอาชีพหลัก

2. การเปลี่ยนแปลงอาชีพหลักทำให้มีรายได้เพิ่มขึ้นหรือไม่

โดยพิจารณาเฉพาะผู้ที่มีการเปลี่ยนแปลงอาชีพหลัก ฉะนั้นจำนวนรวมจึงเท่ากับ 30

ตารางที่ 10 แสดงระดับรายได้จากการเปลี่ยนแปลงอาชีพหลัก

ระดับรายได้เมื่อเกิดการเปลี่ยนแปลงอาชีพหลัก	จำนวน	ร้อยละ
เท่าเดิม	9	30
ลดลง	12	40
เพิ่มขึ้น	9	30
รวม	**30**	**100**

จากตารางที่ 10 พบว่า ประชากรที่อาศัยอยู่ในตำบลคลอง 1 - คลอง 5 ที่มีการเปลี่ยนแปลงอาชีพหลัก ส่งผลให้ชาวบ้านมีรายได้ลดลง เป็นจำนวนร้อยละ 40 อาจเนื่องมาจาก ช่วงนี้ภาวะเศรษฐกิจของประเทศไม่ดี ทำให้รายได้ของชาวบ้านลดลง ของใช้ต่าง ๆ ขึ้นราคาแต่เงินเดือนหรือรายได้กลับเท่าเดิม และจำนวนร้อยละ 9 ได้รับรายได้เพิ่มขึ้นและเท่าเดิมจากการเปลี่ยนแปลงอาชีพหลัก

3. ขนาดการถือครองที่ดิน

โดยพิจารณาเฉพาะผู้ที่มีกรรมสิทธิ์ในที่ดิน ทั้งเมื่อ 5 ปีก่อนถึงปัจจุบัน ฉะนั้นจำนวนรวมจึงเท่ากับ 52

ตารางที่ 11 แสดงขนาดการถือครองที่ดินของผู้ที่มีกรรมสิทธิ์ในที่ดิน เมื่อ 5 ปีก่อนจนถึงปัจจุบัน

ขนาดการถือครองที่ดินของผู้มีกรรมสิทธิ์ในที่ดิน เมื่อ 5 ปีก่อนจนถึงปัจจุบัน	จำนวน	ร้อยละ
เท่าเดิม	31	59.61
ลดลง	18	34.61
เพิ่มขึ้น	3	5.78
รวม	**52**	**100**

จากตารางที่ 11 พบว่า ประชากรที่อาศัยอยู่ในตำบลคลอง 1 - คลอง 5 นั้น โดยดูจากผู้ที่มีกรรมสิทธิ์ในที่ดินเมื่อ 5 ปีก่อน และยังมีกรรมสิทธิ์มาจนถึงปัจจุบันนั้น ส่วนใหญ่ขนาดการถือครองที่ดินยังมีขนาดเท่าเดิม มีจำนวนร้อยละ 31 และมีร้อยละ 18 ที่มีขนาดการถือครองที่ดินลดลง อาจเป็นเพราะแบ่งขายที่ไปบ้าง หรือแบ่งให้ลูกหลานเป็นที่ทำมาหากิน และอยู่อาศัยบ้าง ส่วนการมีที่ดินเพิ่มขึ้นมีจำนวนเพียงร้อยละ 3 เนื่องจากซื้อที่ใกล้เคียงเพิ่ม

การทดสอบสมมติฐาน

ในการศึกษารูปแบบการใช้ที่ดินในบริเวณคลอง 1 - คลอง 5 อำเภอคลองหลวงโดยตั้งสมมติฐานทดสอบในการศึกษาดังนี้

1. มีความสัมพันธ์ระหว่างการเปลี่ยนแปลงที่อยู่อาศัย เพราะเหตุการพัฒนาที่ดินกับการเปลี่ยนแปลงอาชีพหลัก
2. มีความสัมพันธ์ระหว่างการมีกรรมสิทธิ์ในที่ดินเมื่อ 5 ปีก่อนกับการมีกรรมสิทธิ์ในที่ดินในปัจจุบัน
3. มีความสัมพันธ์ระหว่างการเปลี่ยนแปลงที่อยู่อาศัย เพราะเหตุมีการพัฒนาที่ดินกับความสะดวกของการเดินทางเมื่อ 5 ปีก่อนกับปัจจุบัน
4. มีความสัมพันธ์ระหว่างระดับรายได้กับการเลือกเดินทางไปรักษาพยาบาล

การทดสอบสมมติฐานในการศึกษา

สมมติฐานในการศึกษา

สมมติฐานที่ 1 มีความสัมพันธ์ระหว่างการเปลี่ยนแปลงที่อยู่อาศัย เพราะเหตุมีการพัฒนาที่ดินกับการเปลี่ยนแปลงอาชีพหลัก

ตารางที่ 5.1 แสดงความสัมพันธ์ระหว่างการเปลี่ยนแปลงที่อยู่อาศัย เพราะเหตุการพัฒนา

ที่ดินกับการเปลี่ยนแปลงอาชีพหลัก

การเปลี่ยนแปลงที่อยู่อาศัยเพราะมีเหตุการพัฒนาที่ดิน	การเปลี่ยนแปลงอาชีพหลัก		รวม
	ไม่มีการเปลี่ยนแปลง	มีการเปลี่ยนแปลง	
ไม่มีการเปลี่ยนแปลง	35 (30.8)	9 (13.2)	44
มีการเปลี่ยนแปลง	35 (39.2)	21 (16.8)	56
รวม	**70**	**30**	**100**

Chi - Square = 5.45 D.F = 1 Sig = 0.05 ค่าวิกฤติ = 3.84

ในการหาความสัมพันธ์ระหว่างการเปลี่ยนแปลงที่อยู่อาศัยเพราะเหตุมีการพัฒนาที่ดินกับการเปลี่ยนแปลงอาชีพหลัก พบว่า มีผู้มีการเปลี่ยนแปลงที่อยู่อาศัยเพราะเหตุมีการพัฒนาที่ดินกับการเปลี่ยนแปลงอาชีพหลักมากกว่าผู้ที่ไม่มีการเปลี่ยนแปลงที่อยู่อาศัย คิดเป็นร้อยละ 16.8 ส่วนผู้ไม่มีการเปลี่ยนที่อยู่อาศัยจะมีการเปลี่ยนแปลงอาชีพหลัก เป็นส่วนน้อย คิดเป็นร้อยละ 16.8

จากทดสอบหาค่า Chi - Square พบว่า ผู้ที่การเปลี่ยนแปลงที่อยู่อาศัยเพราะเหตุมีการพัฒนาที่ดิน มีความสัมพันธ์กับการเปลี่ยนแปลงอาชีพหลักอย่างมีนัยสำคัญทางสถิติที่ 0.05 เป็นการยอมรับสมมติฐานที่ตั้งไว้ อันเนื่องมาจากเพราะที่อยู่อาศัยเปลี่ยนแปลงไป มีการพัฒนาที่ดินในรูปแบบใหม่ในปัจจุบัน เช่น จากแต่ก่อนมีแต่พื้นที่เกษตรกรรมประชาชนจึงประกอบอาชีพทำการเกษตรกรรม บ้านจัดสรรมากขึ้น พื้นที่เกษตรกรรมน้อยลง ประชาชนจึงเปลี่ยนแปลงอาชีพหลักจากเกษตรกรรมมากขึ้น มีความสัมพันธ์ระหว่างการมีกรรมสิทธิ์ในที่ดินเมื่อ 5 ปีก่อนกับการมีกรรมสิทธิ์ในที่ดินในปัจจุบัน

สมมติฐานที่ 2 มีความสัมพันธ์ระหว่างการมีกรรมสิทธิ์ในที่ดินเมื่อ 5 ปีก่อนกับการมีกรรมสิทธิ์ในที่ดินในปัจจุบัน

ตารางที่ 5.2 แสดงความสัมพันธ์ระหว่างการมีกรรมสิทธิ์ในที่ดินเมื่อ 5 ปีก่อนกับการมีกรรมสิทธิ์ในที่ดินในปัจจุบัน

การมีกรรมสิทธิ์ในที่ดินเมื่อ 5 ปีก่อน	การเปลี่ยนแปลงอาชีพหลัก		รวม
	ไม่มีกรรมสิทธิ์	มีกรรมสิทธิ์	
ไม่มีกรรมสิทธิ์	29 (18.9)	16 (30.6)	45
มีกรรมสิทธิ์	3 (23.1)	52 (37.4)	55
รวม	**42**	**68**	**100**

Chi - Square = 35.45 D.F = 1 Sig = 0.05 ค่าวิกฤติ = 3.84

ในการหาความสัมพันธ์ระหว่างการมีกรรมสิทธิ์ในที่ดินเมื่อ 5 ปีก่อนกับการมีกรรมสิทธิ์ในที่ดินในปัจจุบัน พบว่า ประชาชนที่มีกรรมสิทธิ์ที่ดินเมื่อ 5 ปีก่อนก็ยังคงมีกรรมสิทธิ์ที่ดินอยู่ในปัจจุบันมากกว่าผู้ที่ไม่มีกรรมสิทธิ์ในที่ดินเมื่อ 5 ปีก่อน คิดเป็นร้อยละ 37.4 ส่วนผู้ที่ไม่มีกรรมสิทธิ์ในที่ดินเมื่อ 5 ปีก่อนจะมีกรรมสิทธิ์ในที่ดินคิดเป็นร้อยละ 30.6

จากการทดสอบ Chi - Square พบว่า การมีกรรมสิทธิ์ในที่ดินเมื่อ 5 ปีก่อนมีความสัมพันธ์กับการมีกรรมสิทธิ์ในที่ดินในปัจจุบันอย่างมีนัยสำคัญทางสถิติที่ 0.05 เป็นการยอมรับข้อสมมติฐานที่ตั้งไว้

สมมติฐานที่ 3 มีความสัมพันธ์ระหว่างการเปลี่ยนแปลงที่อยู่อาศัย เพราะเหตุมีการพัฒนาที่ดินกับความสะดวกของการเดินทางเมื่อ 5 ปีก่อนกับปัจจุบัน

ตารางที่ 5.3 แสดงความสัมพันธ์ระหว่างการเปลี่ยนแปลงที่อยู่อาศัย เพราะเหตุมีการพัฒนาที่ดินกับความสะดวกของการเดินทางเมื่อ 5 ปีก่อนกับปัจจุบัน

การเปลี่ยนแปลงที่อยู่อาศัย เพราะเหตุมีการพัฒนาที่ดิน	**ความสะอาดของการเดินทางเมื่อ 5 ปีก่อนกับปัจจุบัน**			**รวม**
	ไม่แตกต่าง	**5 ปีก่อนมีความสะดวกมากกว่าปัจจุบัน**	**5 ปีก่อนมีความสะดวกน้อยกว่าปัจจุบัน**	
ไม่มีการเปลี่ยนแปลง	12	3	29	44
	(9.68)	(3.96)	(30.36)	
มีการเปลี่ยนแปลง	10	6	40	56
	(12.32)	(5.64)	(38.84)	
รวม	**22**	**9**	**69**	**100**

Shi - Square = 1.49 D.F = 2 Sig = 0.05 ค่าวิกฤติ = 5.99

ในการหาความสัมพันธ์ระหว่างการเปลี่ยนแปลงที่อยู่อาศัย เพราะเหตุมีการพัฒนาที่ดินกับความสะดวกของการเดินทางเมื่อ 5 ปีก่อนกับปัจจุบัน

จากการทอสอบ Chi - Square พบว่า การเปลี่ยนแปลงที่อยู่อาศัยเพราะเหตุมีการพัฒนาที่ดินไม่สัมพันธ์หรือเกี่ยวข้องกับความสะดวกของการเดินทางเมื่อ 5 ปีก่อนกับปัจจุบัน คือว่า การเปลี่ยนแปลงที่อยู่อาศัยไม่มีผลต่อความสะดวกของการเดินทางโดยมีระดับนัยสำคัญทางสถิติที่ 0.05 ดังนั้นจึงปฏิเสธข้อสมมติฐานที่ตั้งไว้

สมมติฐานที่ 4 มีความสัมพันธ์ระหว่างระดับรายได้กับการเลือกการเดินทางไปรักษาพยาบาล

โดยพิจารณาจากรายได้ต่อเดือนของครอบครัวทั้งหมด แล้วแบ่งช่วงรายได้เป็น 3 ช่วง ได้แก่ ระดับรายได้ต่ำ คือ ต่ำกว่า 3,000 – 6,000 ระดับรายได้ปานกลาง คือ ช่วง 6,000 – 16,000 และระดับรายได้สูง คือ ช่วง 16,000 20,000 ขึ้นไป

ตารางที่ 5.4 แสดงความสัมพันธ์ระหว่างระดับรายได้กับการเลือกเดินทางไปรักษาพยาบาล

ระดับรายได้	สถานพยาบาลที่เดินทางไปรักษา					รวม
	อนามัย	โรงพยาบาลในจังหวัด	โรงพยาบาลในกรุงเทพฯ	ซื้อยากินเอง	คลีนิก	
ต่ำ	16 (13.26)	10 (8.67)	6 (8.67)	11 (8.67)	8 (11.73)	51
ปานกลาง	9 (8.06)	6 (6.29)	7 (6.29)	5 (6.29)	10 (8.51)	37
สูง	1 (3.12)	1 (2.04)	4 (2.04)	1 (2.04)	5 (2.76)	12
รวม	**23**	**17**	**17**	**17**	**23**	**100**

Chi – Square = 11.5 D.F = 1 Sig = 0.05 ค่าวิกฤติ = 15.51

ในการหาความสัมพันธ์ระหว่างระดับรายได้กับการเลือกเดินทางไปรักษาพยาบาล จากการทดสอบค่า Chi – Square พบว่า ระดับรายได้ไม่มีความสัมพันธ์กันหรือไม่เกี่ยวข้องกับการที่จะเลือกเดินทางไปรักษาพยาบาลที่ใด คือ ว่า รายได้ไม่ว่าจะสูงหรือต่ำ แต่ประชาชนอยากที่จะเลือกไปรักษาพยาบาลในสถานบริการที่เชื่อถือได้และมีคุณค่าเพราะทุกคนก็จะเป็นห่วงสุขภาพถึงแม้ว่าจะมีรายได้น้อยแต่ก็อยากจะเลือกบริการที่ดีที่สุดและรวดเร็วประหยัดเวลา โดยมีระดับนัยสำคัญทางสถิติที่ 0.05 เป็นการปฏิเสธสมมติฐานที่ตั้งไว้

2. คลองหกถึงคลองสิบ (ย้อนหลัง 5 ปี)

1. ข้อมูลสังคม : แสดงการย้ายถิ่น

จากตารางที่ 1 พบว่า ประชากรที่อาศัยอยู่บริเวณคลองหก – คลองสิบที่มีความคิดว่าจะย้ายไปอยู่ที่อื่นส่วนใหญ่มีเหตุผลเนื่องมาจากต้องการเปลี่ยนอาชีพใหม่ จึงทำให้ต้องเปลี่ยนที่อยู่อาศัยไปด้วย ร้อยละ 51.4 รองลงมา คือ เนื่องมาจากไม่พอใจในเรื่องสิ่งแวดล้อม ร้อยละ 30.5 เนื่องมาจากการคมนาคมไม่สะดวก อยู่ไกลร้อยละ 10.5 และอื่น ๆ ร้อยละ 7.6

ตารางที่ 12 แสดงความแตกต่างกันของที่อยู่อาศัยระหว่างเมื่อราว 5 ปีก่อนกับปัจจุบัน

ความแตกต่าง	จำนวน	ร้อยละ
ไม่แตกต่าง	124	41.3
เมื่อราว 5 ปีก่อนดีกว่าปัจจุบัน	12	4
เมื่อราว 5 ปีก่อนแย่กว่าปัจจุบัน	164	54.7
รวม	**300**	**100**

จากตารางที่ 12 พบว่า ประชากรที่อาศัยอยู่บริเวณคลองหก - คลองสิบ คิดว่าที่อยู่อาศัยเมื่อ 5 ปีก่อนแย่กว่าปัจจุบันมีมากเป็นอันดับ 1 ร้อยละ 54.7 อันดับ 2 คิดว่าไม่แตกต่างกัน ร้อยละ 41.3 และสุดท้ายคิดว่าเมื่อ 5 ปีก่อนดีกว่าปัจจุบัน ร้อยละ 4

ตารางที่ 13 แสดงผลกระทบจากการเปลี่ยนแปลงที่อยู่อาศัย

ผลกระทบ	จำนวน	ร้อยละ
ไม่มี	63	21
มี	237	79
รวม	**300**	**100**

จากตารางที่ 13 พบว่า ประชากรอาศัยอยู่บริเวณคลองหก - คลองสิบ ส่วนมากมีความเห็นว่าการเปลี่ยนแปลงที่อยู่อาศัยมีผลกระทบครอบครัวของเขา ร้อยละ 79 ซึ่งส่วนใหญ่จะเป็นผลกระทบในแง่บวก และอีกร้อยละ 21 คิดว่าการเปลี่ยนแปลงที่อยู่อาศัยไม่มีผลการทบต่อครอบครัวของเขา

2. ข้อมูลสิ่งแวดล้อม

ตารางที่ 14 แสดงแหล่งน้ำดื่มน้ำใช้

แหล่งน้ำดื่มน้ำใช้	จำนวน	ร้อยละ
น้ำฝน	92	30.7
แม่น้ำลำคลอง	165	55
น้ำบาดาล	30	10
น้ำประปา	13	4.3
รวม	**300**	**100**

จากตารางที่ 14 พบว่า ประชากรที่อาศัยอยู่บริเวณคลองหก - คลองสิบ ส่วนมากใช้น้ำจากแม่น้ำลำคลองในการนำมาใช้อุปโภค บริโภค ร้อยละ 55 ใช้น้ำจากน้ำฝน ร้อยละ 30.7 ใช้น้ำจากน้ำบาดาล ร้อยละ 10 และใช้น้ำประปา ร้อยละ 4.3

ตารางที่ 15 แสดงการบำบัดน้ำเสียของประชากร

การบำบัดน้ำเสีย	จำนวน	ร้อยละ
ไม่มี	297	99
มี	3	1
รวม	**300**	**100**

จากตารางที่ 15 พบว่า ประชากรที่อาศัยอยู่บริเวณคลองหก - คลองสิบ ส่วนใหญ่ไม่มีการบำบัดน้ำเสียมากถึงร้อยละ 99 และมีการบำบัดน้ำเสียเพียงร้อยละ 1 ซึ่งจะเป็นร้านอาหารใหญ่ ๆ เท่านั้น

ตารางที่ 16 แสดงความแตกต่างของความสะดวกในการเดินทางระหว่างราว 5 ปีก่อนกับปัจจุบัน

ความแตกต่าง	จำนวน	ร้อยละ
ไม่แตกต่าง	42	14
เมื่อ 5 ปีก่อนมีความสะดวกน้อยกว่าปัจจุบัน	258	86
รวม	**300**	**100**

จากตารางที่ 16 พบว่า ประชากรที่อาศัยอยู่บริเวณคลองหก – คลองสิบ ส่วนใหญ่คิดว่าเมื่อ 5 ปีก่อนมีความสะดวกในการเดินทางน้อยกว่าในปัจจุบัน ร้อยละ 86 และมีผู้ที่เห็นว่าความสะดวกในการเดินทางเมื่อ 5 ปีก่อนกับปัจจุบันไม่แตกต่างกัน ร้อยละ 14

ตารางที่ 17 แสดงความแตกต่างในการให้ความร่วมมือกับทางราชการในการพัฒนาหมู่บ้าน

ความแตกต่างในการให้ความร่วมมือกับทางราชการ	จำนวน	ร้อยละ
ไม่เคยให้ความร่วมมือ	21	7
ให้ความร่วมมือจนถึงปัจจุบันไม่แตกต่าง	198	66
เมื่อ 5 ปีก่อนมีมากกว่าปัจจุบัน	9	3
เมื่อ 5 ปีก่อนมีน้อยกว่าปัจจุบัน	72	24
รวม	**300**	**100**

จากตารางที่ 17 พบว่า ประชากรที่อาศัยอยู่บริเวณคลองหก – คลองสิบ ส่วนมากแล้วให้ความร่วมมือกับทางราชการ ในการพัฒนาหมู่บ้านไม่แตกต่าง คือ ให้ความร่วมมืออย่างสม่ำเสมอถึงร้อยละ 66 ให้ความร่วมมือมากกว่าเมื่อ 5 ปีก่อน ร้อยละ 24 และมีผู้ที่ไม่ให้ความร่วมมือเลยตั้งแต่อดีตจนปัจจุบัน ร้อยละ 7 และปัจจุบันให้ความร่วมมือน้อยลง ร้อยละ 3

3. สภาพเศรษฐกิจ

ตารางที่ 18 แสดงการเปลี่ยนแปลงอาชีพหลักเมื่อ 5 ปีก่อนกับปัจจุบัน

การเปลี่ยนแปลงอาชีพหลัก	จำนวน	ร้อยละ
ไม่เปลี่ยนแปลง	209	69.7
เปลี่ยนแปลง	91	30.3
รวม	**300**	**100**

ข้อสรุปและข้อเสนอแนะจากบริเวณพื้นที่ศึกษาคลองหกถึงคลองสิบ

1. สรุปข้อมูลด้านสภาพสังคม

จากผลการวิเคราะห์ข้อมูลจะเห็นได้ว่า ประชาชนส่วนใหญ่มีภูมิลำเนาเป็นคนท้องถิ่นมีจำนวนสูงถึงร้อยละ 75.3 โดยมีผู้ย้ายมาจากที่อื่นเพียงร้อยละ 24.7 ผู้ที่ย้ายมาจากที่อื่นมีระยะเวลาในการย้ายเข้ามาอยู่ไม่เกิน 5 ปี มีจำนวนร้อยละ 54.1 สาเหตุที่ย้ายเข้ามาเพราะเพื่อประกอบอาชีพใหม่มีจำนวนร้อยละ 43.7 และที่อยู่เดิมทำมาหากินฝืดเคืองมีจำนวนร้อยละ 37.3 โดยสรุปแล้วผู้ให้สัมภาษณ์ย้ายมาอยู่

ที่นี่เป็นเพราะความเจริญของท้องถิ่นมีจำนวนร้อยละ 54.1 และในช่วง 5 ปีที่ผ่านมา ประชาชนส่วนใหญ่ไม่มีสมาชิกย้ายออกมีจำนวนถึงร้อยละ 82.75 ส่วนที่มีสมาชิกย้ายออกเพียงร้อยละ 17.25 โดยย้ายออกเพื่อประกอบอาชีพใหม่มีจำนวนร้อยละ 42.85 และจากการสัมภาษณ์ความคิดเห็นว่าจะย้ายไปอยู่ที่อื่นหรือไม่นั้น ส่วนใหญ่จะตอบว่าไม่คิดย้ายออกไปอยู่ที่อื่นมีถึงร้อยละ 76.0 โดยให้เหตุผลว่า มีหลักฐานมั่นคงแล้ว มีจำนวนร้อยละ 46.70 สำหรับผู้ที่ตอบว่าคิดจะย้ายออกไปอยู่ที่อื่นมีจำนวนร้อยละ 24.0 โดยให้เหตุผลว่าต้องการเปลี่ยนอาชีพใหม่มีจำนวนร้อยละ 51.4

เมื่อราว 5 ปีก่อนกับในปัจจุบัน ที่อยู่อาศัยของผู้ตอบแบบสอบถามเมื่อ 5 ปีก่อนมีสภาพแย่กว่าปัจจุบัน มีจำนวนร้อยละ 54.7 และที่ตอบว่าไม่มีความแตกต่างกันมีจำนวนร้อยละ 41.3 และการเปลี่ยนแปลงที่อยู่อาศัยมีผลกระทบกับครอบครัวทั้งในด้านดีและด้านไม่ดี โดยที่ด้านดีมีจำนวนร้อยละ 79.0 และด้านไม่ดีมีจำนวนร้อยละ 21.0

ส่วนการสอบถามความต้องการให้โอกาสการศึกษาของบุตรหลาน ประชาชนส่วนใหญ่เปิดโอกาสให้บุตรหลานเลือกศึกษาตามความสามารถที่จะเรียนได้ ส่วนเรื่องการเลือกบริการรักษาพยาบาลจากสถานบริการนั้น จะเลือกไปรักษาจากร้านขายยาทั่วไป คือ ซื้อยารับประทานเอง มีจำนวนร้อยละ 29.0 แหล่งน้ำดื่มน้ำใช้ของประชาชนบริเวณนั้น จะใช้น้ำฝนมีจำนวนร้อยละ 55.0 และไม่มีการบำบัดน้ำเสียเลย

ด้านความสะดวกในการเดินทาง เมื่อ 5 ปีก่อนเปรียบเทียบกับปัจจุบัน ประชาชนได้รับความสะดวกในการเดินทางมากขึ้นมีจำนวนร้อยละ 86.0 ส่วนเรื่องการให้ความร่วมมือกับทางราชการในการพัฒนาหมู่บ้านของตนนั้น ประชาชนส่วนใหญ่จะให้ความร่วมมือดีเสมอมามีจำนวนร้อยละ 66.0

2. สรุปข้อมูลด้านสภาพเศรษฐกิจ

จากการวิเคราะห์ข้อมูลจะเห็นได้ว่า โดยส่วนใหญ่ประชาชนไม่เปลี่ยนแปลงอาชีพหลักในช่วง 5 ปีที่ผ่านมา คือมีจำนวนร้อยละ 69.7 ส่วนที่มีการเปลี่ยนแปลงอาชีพมีเพียงร้อยละ 30.3 และผู้ที่เปลี่ยนแปลงอาชีพหลักแล้วมีรายได้เพิ่มขึ้นจำนวนร้อยละ 70.3

ด้านค่าใช้จ่ายในครอบครัวเฉลี่ยต่อเดือน 5 ปีก่อนกับปัจจุบัน สิ่งที่เพิ่มขึ้นคือ ค่าอาหารร้อยละ 76.7 ค่าเสื้อผ้าเครื่องนุ่งห่มร้อยละ 75.7 ค่าพาหนะร้อยละ 74.3 ค่าพักผ่อน/ บันเทิง/ใช้จ่ายทางสังคม ร้อยละ 36.7 ค่าใช้จ่ายจำเป็นในครัวเรือนและค่าน้ำ/ไฟฟ้า/โทรศัพท์ และสาธารณูปโภคอื่นๆ มีจำนวนเท่ากันคือ ร้อยละ 100.0 ค่าการศึกษาเล่าเรียนบุตรร้อยละ 83.0 และการลงทุนเกี่ยวกับอาชีพร้อยละ 87.6 ส่วนสิ่งที่เหมือนเดิมคือค่าเช่าบ้าน ค่ารักษาพยาบาลและค่าซื้อบ้าน/สร้างบ้าน/ผ่อนบ้าน โดยคิดเป็นร้อยละ 69.7 58.0 และ 69.7 ตามลำดับ

ในเรื่องของการมีกรรมสิทธิ์ในที่ดิน เมื่อ 5 ปีก่อนประชาชนส่วนใหญ่ที่มีกรรมสิทธิ์ที่ดินเป็นของตนเองมีร้อยละ 25.0 และปัจจุบันมีผู้มีกรรมสิทธิ์ในที่ดินเป็นของตัวเองเพิ่มขึ้นเป็นร้อยละ 26.3

ข้อเสนอแนะ

1. รัฐควรกำหนดแผนการใช้ที่ดินให้เหมาะสมกับประเภทของการใช้ประโยชน์ที่ดิน มีการแบ่งเขตพื้นที่สำหรับเขตอุตสาหกรรม พาณิชยกรรม สถานบริการ โดยเฉพาะสถานที่เพื่อการอยู่อาศัย ควรมีการแบ่งให้ชัดเจน เนื่องจากประชาชนบางส่วนยังมีการตั้งถิ่นฐานไม่เป็นหลักแหล่ง บางรายมีการปลูก

สร้างบ้านเรือนในที่ดินของรัฐและเอกชน เนื่องจากขาดความรู้ความเข้าใจในเรื่องการมีกรรมสิทธิ์ที่ดิน ทำให้เกิดปัญหาการไล่ที่ขึ้นมาภายหลัง และเกิดความไม่เข้าใจกันระหว่างราชการกับประชาชน ดังนั้นรัฐบาลควรเผยแพร่ความรู้ในเรื่องการถือครองที่ดินให้ประชาชนมีความเข้าใจด้วย

2. ประชาชนที่อาศัยอยู่บริเวณคลองส่วนใหญ่มีฐานะยากจน และมีความเป็นอยู่ที่ลำบากมากกว่าประชาชนที่อาศัยอยู่บริเวณริมถนน ดังนั้นจึงควรมีการสนับสนุนทางด้านเกษตรกรรม โดยส่งเจ้าหน้าที่ของรัฐมาให้ความรู้ในด้านการเกษตรเกี่ยวกับการใช้ปุ๋ย การบำรุงรักษาและควรเร่งขยายปรับปรุงสาธารณูปโภคให้กับชุมชน เช่น ขยายเขตบริการน้ำประปา เพิ่มจำนวนโทรศัพท์ รวมทั้งขยายบริการรถโดยสารประจำทางให้เพียงพอกับความต้องการของประชาชนในชุมชนด้วย

3. การประกอบอาชีพของประชาชนทั้งในบริเวณริมถนน และริมคลองส่วนใหญ่มักจะเน้นการประกอบอาชีพหลักเพียงอย่างเดียว ซึ่งรายได้ที่ประชาชนได้จากการประกอบอาชีพหลักมักไม่เพียงพอกับค่าใช้จ่ายในชีวิตประจำวัน โดยเฉพาะสภาพเศรษฐกิจในปัจจุบันที่สินค้าอุปโภคบริโภคมีราคาแพงขึ้น ควรจะมีการส่งเสริมอาชีพเสริมให้ประชาชนมีรายได้เพิ่มขึ้นนอกจากการประกอบอาชีพหลักเพียงอย่างเดียว ซึ่งจะช่วยลดปัญหาด้านอื่น ๆ ที่จะตามมา เช่น แรงงานอพยพ การกู้หนี้ยืมสิน ปัญหาอาชญากรรมเป็นต้น

4. จากการศึกษาพบว่าปัญหาที่เกิดขึ้นในปัจจุบัน มีแนวโน้มจะเพิ่มขึ้นถ้ามิได้มีการวางแผนป้องกันไว้ก่อนคือ ปัญหาสิ่งแวดล้อม ได้แก่ น้ำเสียจากบ้านเรือน โรงงานอุตสาหกรรม ปัญหาขยะมูลฝอยและปัญหาฝุ่นละอองจากการก่อสร้างต่าง ๆ ปัญหาเหล่านี้อาจส่งผลต่อสุขภาพอนามัยของประชาชน ดังนั้นหน่วยงานที่เกี่ยวข้อง เช่น อุตสาหกรรมจังหวัด เทศบาล ตำบล สุขาภิบาล สาธารณสุขอำเภอ ควรจะร่วมมือกันเพื่อแก้ไขปัญหาที่มีอยู่ในปัจจุบัน และวางแผนป้องกันปัญหาที่จะเกิดขึ้นในอนาคต เพื่อให้ทันเหตุการณ์ เพราะปัญหาเหล่านี้มักเกิดจากชุมชนที่มีการขยายตัวทางอุตสาหกรรม พาณิชยกรรม และบริการอย่างรวดเร็ว

เอกสารอ้างอิง

กนก วงษ์ตระหง่าน. 2525. การเกิดและการขยายเมืองกรุงเทพฯ : การศึกษาทางการเปลี่ยนแปลง. เอกสารหมายเลข 21 ประกอบการสัมมนา, สถาบันวิจัยสังคมจุฬาลงกรณ์มหาวิทยาลัย.

จำนรรจา ชัยโชติชย์. 2532. การศึกษาเอกลักษณ์ของการใช้ที่ดินย่านศูนย์กลางธุรกิจการค้าใจกลางเมืองกรุงเทพฯ กรณีศึกษาแขวงสีลม-สุรวงศ์ และพื้นที่ที่เกี่ยวข้องเขตบางรัก. วิทยานิพนธ์ปริญญาโท.

ฉัตรชัย พงศ์ประยูร. 2527. ภูมิศาสตร์เมือง. สำนักไทยวัฒนาพานิช, กรุงเทพฯ.

ชัชย์ ปลอดดี. 2530. การศึกษาการเปลี่ยนแปลงการใช้ที่ดินในเขตชานเมืองชั้นนอกกรุงเทพกรณีเฉพาะเขตหนองจอก. วิทยานิพนธ์ปริญญาโท, จุฬาลงกรณ์มหาวิทยาลัย, กรุงเทพฯ.

เบญจวรรณ อารีสมาน. 2530. การปรับปรุงชุมชนในเขตเทศบาล. ข่าวสารสำนักผังเมือง ฉบับที่ 49. กรุงเทพ.

ปราณี นันทเสนามาตร์. 2523. การศึกษาการเปลี่ยนแปลงของอำเภอเมืองสมุทรปราการ. วิทยานิพนธ์ปริญญาโท. จุฬาลงกรณ์มหาวิทยาลัย, กรุงเทพฯ.

พรวรรณ สุรนันท์. 2522. การเปลี่ยนแปลงทางเศรษฐกิจและสังคมในชุมชนเขตลาดกระบังศึกษากระบวนการและผลของการขยายชุมชนไปสู่ชานเมือง. วิทยานิพนธ์ปริญญาโท, กรุงเทพฯ.

ภัทรียา จิตเอื้ออารีย์. 2528. การศึกษาเพื่อวางแผนการใช้ที่ดินเขตราษฎร์บูรณะ กรุงเทพฯ. วิทยานิพนธ์ปริญญาโท, จุฬาลงกรณ์มหาวิทยาลัย, กรุงเทพฯ.

เพิ่มยศ เจริญวงศ์. 2530. การศึกษาเพื่อวางแผนทางการวางแผนการใช้ที่ดินเขตชั้นกลางของกรุงเทพฯ ด้านฝั่งธนบุรีพื้นที่กรณีศึกษาเขตภาษีเจริญ. วิทยานิพนธ์ปริญญาโท, จุฬาลงกรณ์มหาวิทยาลัย, กรุงเทพฯ.

ศุภมิตร มโนพิทักษ์. 2526. การวางแผนการใช้ประโยชน์ที่ดินเขตชานเมืองของกรุงเทพมหานคร. รายงานผลการวิจัย. มหาวิทยาลัยมหิดล, กรุงเทพฯ.

สุรีรัตน์ ณ นคร. 2526. การศึกษาการเปลี่ยนแปลงการใช้ที่ดินและผลกระทบทางเศรษฐกิจสังคมที่มีต่อการเกษตรเขตหนองแขม. วิทยานิพนธ์ปริญญาโท. มหาวิทยาลัยเกษตรศาสตร์, กรุงเทพฯ.

สุวัฒนา ธาดานิติ. 2523. การใช้ที่ดินทางเกษตรกรรม. เอกสารประชุมวิชาการเรื่องกรุงเทพ 2545, โครงการศูนย์นครศึกษา. สถาบันวิจัยสภาวะแวดล้อม, กรุงเทพฯ. 50 น.

______________. 2532. แนวความคิดและทฤษฎีที่เกี่ยวข้องกับเมือง. กรุงเทพฯ. 113 น. (โรเนียว)

______________. 2533. เอกสารประกอบการสอนวิชานาครภูมิศาสตร์. มหาวิทยาลัยเกษตรศาสตร์, กรุงเทพฯ. 45 น.

เสาวลักษณ์ ไสยวรรณ. 2525. การศึกษาพัฒนาพื้นที่เพื่ออยู่อาศัยในเขตอำเภอเมืองนนทบุรี. วิทยานิพนธ์ปริญญาโท. จุฬาลงกรณ์มหาวิทยาลัย, กรุงเทพฯ.

อำพัน รุ่งวรรณวงศ์. 2526. การศึกษาเพื่อประกอบการวางแผนการใช้ที่ดินในพื้นที่ชานเมืองทางด้านตะวันตกของกรุงเทพมหานคร กรณีศึกษาเขตบางขุนเทียน. วิทยานิพนธ์ปริญญาโท. จุฬาลงกรณ์มหาวิทยาลัย, กรุงเทพฯ.

อภิศักดิ์ โสมอินทร์. 2522. ภูมิศาสตร์ชนบท. อภิชาติการพิมพ์, มหาสารคาม. 135 น.

Alexander, J.W. 1963. Economic Geography. Prentice Hall, New Jersey. p. 491-492.

Amedeo, D. and R.G. Golledge. 1975. An Introduction to Scientific Reasoning Geography. Wiley and Sons, New York.

Chrisholm, M. 1972. Rural Settelment an Land Use. Hutchison University Library, London.

Golony, G. 1976. New Town in city : New Urban Venture, In New Town Planning Principles and Practice. A Wiley Interscience Publication New York. 266 p.

Goodall, B. 1978. Urban Land Use Patterns, In the Economic of Urban Areas, Pergaman Press, Oxford. 102 p.

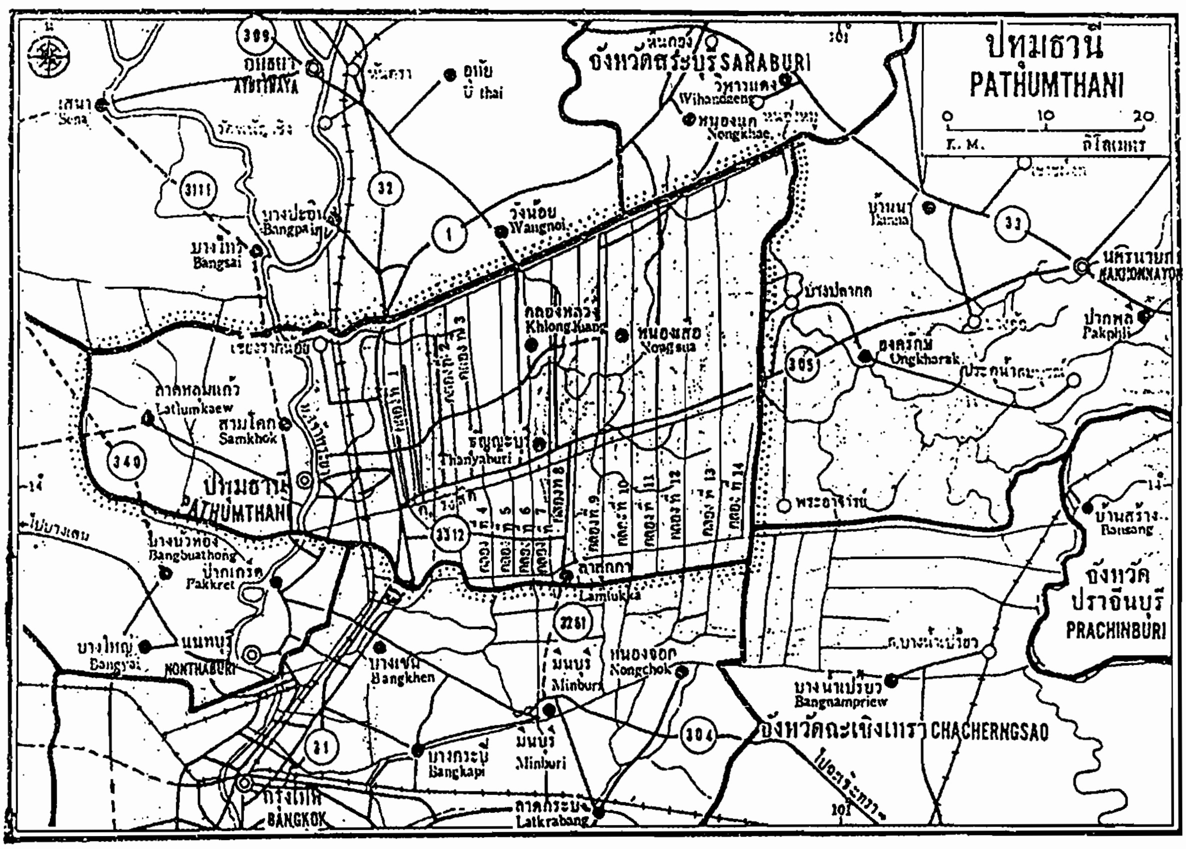
Hudson, J.C. 1969. A location Theory for Rural Settelment. Annals of the Association of American Geography. pp. 361-381.

Mocine, R. 1956. Suburban Development Problem, In Planning 1955 : American Society of Planning Officials, Illinois. 83 p.

Needham, B. 1977. How Cities Work : An Introduction. The Pergamon Press, Oxford. 132 p.

Northam. R.M. 1975. Urban Geography. John Wiley and Sons. New York. 78 p.

Ottensmann, J.R. 1975. The Changing Spatial Sturcture of American Cities. Lexington Books, London. pp. 63-86.



ที่มาของข้อมูล รายงานประจำปี ของจังหวัดปทุมธานี พ.ศ.2542 หน้า 1.

The impact of socio-economic changes on land use changes

Orasa Suksawang[1] and Hideharu Morishita[2]

Abstract: *This paper illustrates the disparity patterns of both spatial and non-spatial development in Pathumthani province. The objectives are to analyze the land use changes between 1989 and 1999 from the Landsat images of 1989 and 1999; to examine the cluster formation of the villages based on the changes of socio-economic development between 1996 and 1999 applying multivariate analysis; and to explore the association between the changing patterns of land use and socio-economic development. Analysis tools used are Erdas Imagine V8.3 for image processing while Arc View 3.1 and MapInfo for GIS analysis; SPSS for statistical analysis and MS Excel for data handling. It was found that the central area of the province had higher value of developed ration in area size of each Tambon both in 1989 and 1999, however the west site of the Chao Praya river became higher compared with the east. The grouping patterns of the villages were clearly clustered in relation to the socio-economic development and land use changes.*

1 Introduction

Normally, in provincial development planning process, there is an attempt to reduce the inequality development between urban and rural area as well as among the villages in the rural area. However, this is hardly achieved in practice since an interaction between the spatial and socio-economic performance in the development process is dynamic and hardly observed its pattern in a short period. This results in a difficulty to manage the desired growth in the province. This paper aims to examine the changing patterns of land use and socio-economic development as well as their associations. The findings help understand the development problems and provide information for policy making and development planning in the future.

[1] Lecturer, Kasetsart University, Thailand

[2] Associate Professor, Aichi Gakuin University, Japan

2 Land use changes in Pathum Thani from 1989 to 1999 (Morishita, 2000)

2.1 Objectives

When we look at the last decade regarding with the development in Bangkok and the surroundings, there were many developments existed even the Baht crisis has happen.

This part reveals the changing of the 10 years' land use spatially using Remote Sensing (RS) technology with Landsat Data and Geographical Information Systems (GIS) with Digital Maps.

2.2 Methodology

To know the situation in 1989 and 1999, and the difference of the two periods, a several steps of processing have applied as shown in Fig.1.

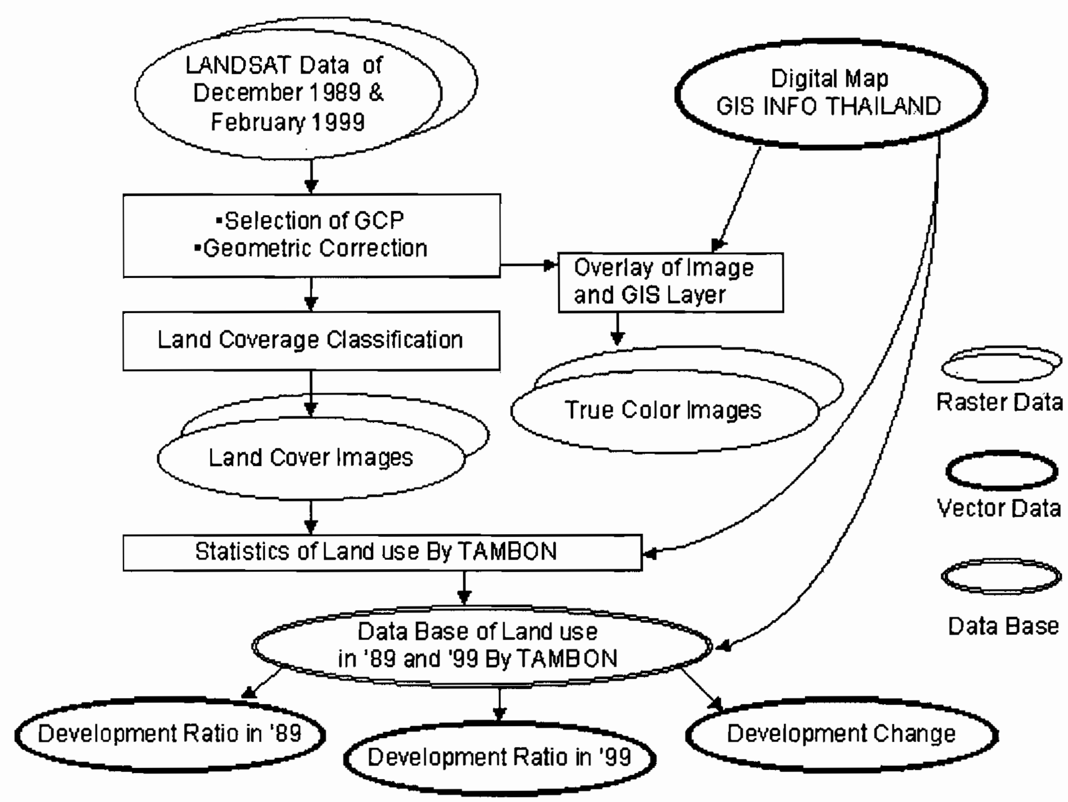


Fig.1 Flow Chart of Processing

2.3 Selection of GCP and geometric correction

Satellite data were corrected geometrically using Ground Control Points (GCP) taken form Digital Map named "GIS Info Thailand", which data format is for ARC/INFO. The following is information pertaining to the Digital Map:

1. **spheroid:** Everest
2. **projection:** UTM Zone 47
3. **vertical datum:** Indian Datum
4. **horizontal datum:** Mean Sea Level at Ko Lak

Around ten GCPs were selected for this purpose. First order polynomial transformation equation was used to rectify the data set. Tambon boundary, streams and major road of Digital maps were used to get the GCPs.

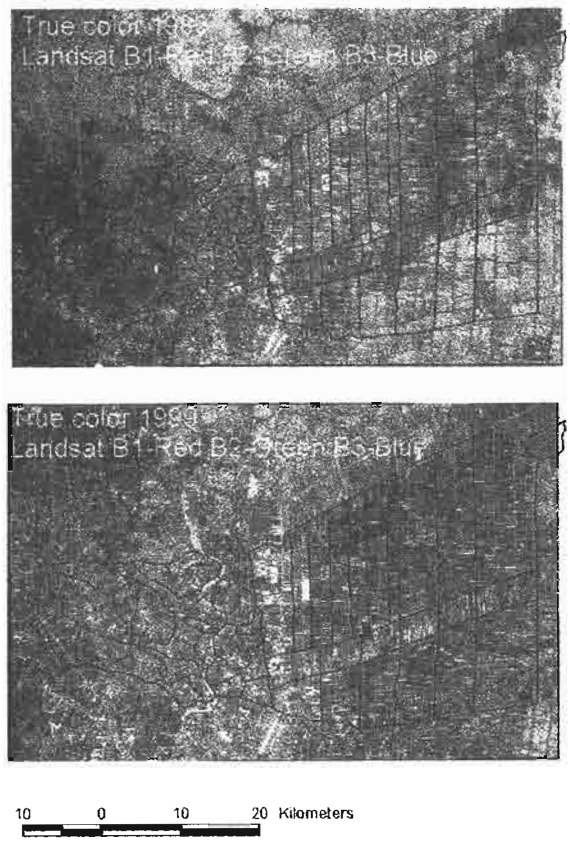


Fig2. True Color Image in '89 and '99

Fig.2 shows overlay of Landsat True color image and Pathumtani Tambon boundary. The upper image is in December 1989, and lower one is in February 1999. The images use Band 1,2 and 3 of the satellite image, and put Red to Band 1, Green to Band 2 and Blue to Band to show true color images.

2.4 Land Coverage Classification

Table 1 Category of Classification

Class	Land cover	Remarks
1	Water body	Water in 1989 & Water in 1999
2	Water & Agriculture	One image is Water and another is Agriculture.
3	Agriculture	
4	Developed Area	

Unsupervised classification was applied to create the land cover image. It is more computer-automated. The patterns are simply clusters of pixels with similar spectral characteristics. After classified the image into 10 classes, merge similar ones into one, and put the land cover categories. Table 1 shows the categories.

After the classification, land cover image of each year was created. Fig.3 shows the output. Fig.3(left) shows land cover in 1989, and Fig.3(right) shows it in 1999.

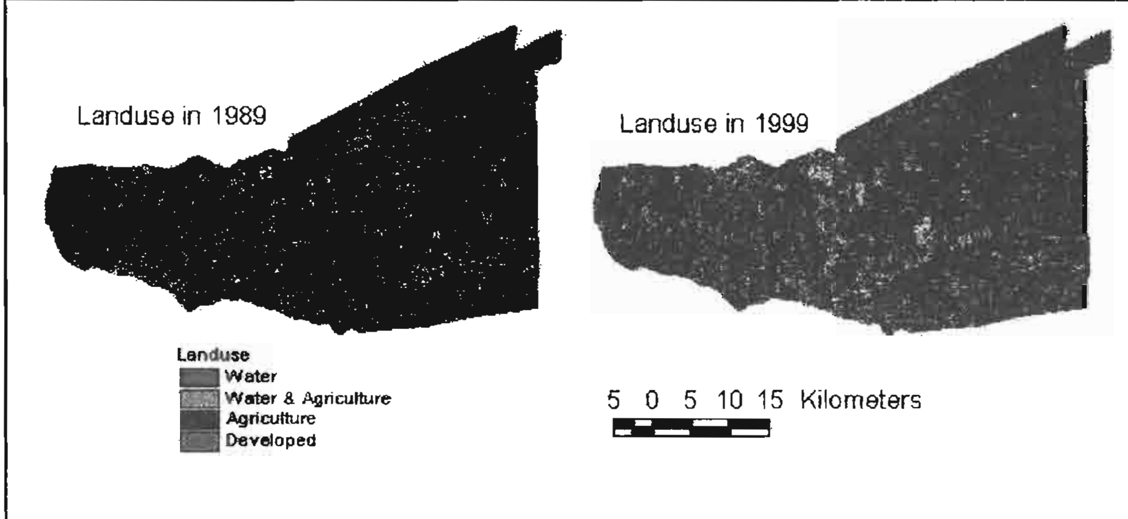


Fig.3 Land cover image

2.5 Statistics of land use by tambon

The area size of each category of land use by Tambon was calculated. The procedure is as follows:

- Apply overlay analysis of land cover image and Pathumtani Boundary Digital map
- Count the pixel number of each category of each Tambon
- Calculate the area size from the pixel number

By this processing, a database on the land use in '89 and '99 was build. This database includes items that are shown in the Table 2.

Table 2 Items of in the Database

No	Items	Remarks	No	Items	Remarks
1	ZONE	Zone Number	11	WTR89	Water in 89
2	Id	Id number of polygons in Digital Map	12	UNCLS99	Unclassified area in 99
3	PROV	Province's Number	13	WTR99	Water in 99
4	Amp	Amper's Number	14	NEWDV99	New developed area during 89 to 99 (DVL99-DVL89)
5	tam_cd	Tambon's Number	15	AGR89	Agriculture area in 89
6	AREAV_HA	Area size from GIS data	16	AGR99	Agriculture area in 99
7	AREAR_HA	Area size from IMAGE	17	DVL89	Developed area in 89
8	WTR89_99	Water body (89 and 99)	18	DVL99	Developed area in 99
9	DVL89_99	Developed area both of 89, 99			
10	UNCLS89	unclassified area in 89			

3 Land use change between 1989 and 1999

Use the database that is mentioned the previous part and Tambon boundary data, development ratio maps by Tambon are made. The ratio is calculated by the following equation:

Ratio in 19XX = (Developed Area Size in 19XX) / (Area size of the Tambon)*100

Fig.4 shows the result. Fig.4 (a) is development ratio in '89. The maximum ration is about 10.1% in "Khlong Nung". Tambon names in Fig.4 (a) show the best five at that time. Fig.4 (b) also is in 1989, but to compare the ration in 1989 with it in 1999, the interval of legend is different from Fig.4 (a).

In 1999, most tambons have increased the developed area size, especially west part in Pathumtani has changed more compare with the east part. "Khlong Nung" and "Khu Khot" where are located in the central part of Pathumthani are categorized in 25 to 30% in area size, which is the highest category.

Fig.5 shows development area increase ratio from 1989 to 1999. In Fig.5, (a) shows the increased ration during 10 years by tambon's area size, and (b) shows it by developed area in '99. These are calculated used following equation;

(a) Increase Ratio[%] = (Developed area from '89 to '99)/(Area size)*100

(b) Increase Ratio[%] = (Developed area from '89 to '99) / (Developed area in '99)*100

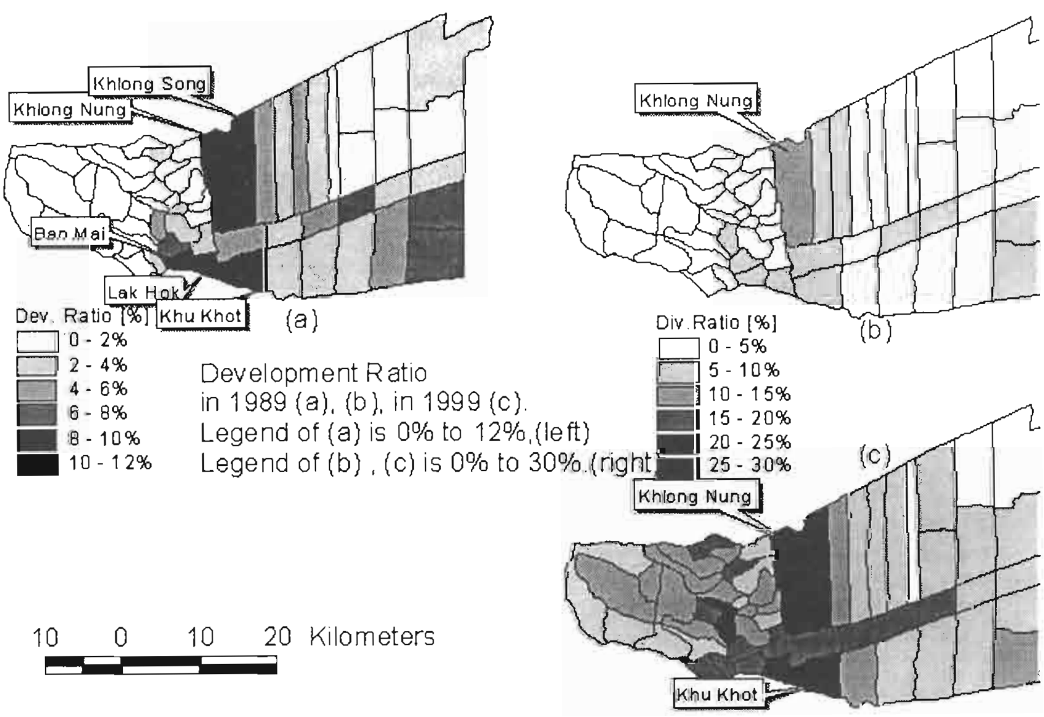
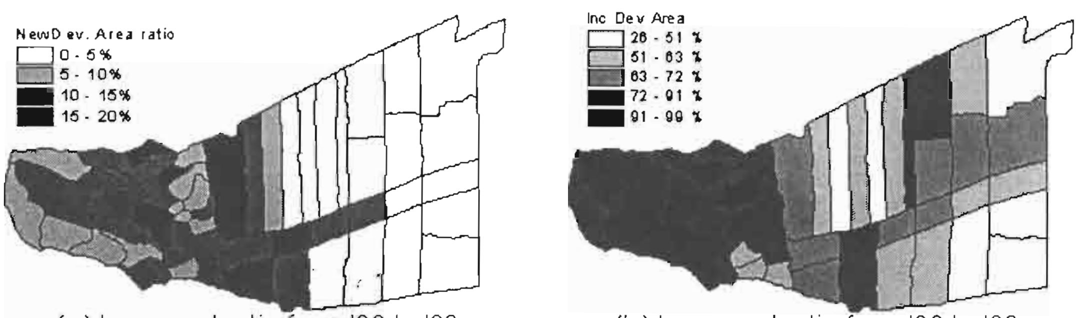


Fig.4 Development Ration in 1989 and 1999

From Fig.5(a), it is clear that tambons in west and central part of Pathumtani are aggressive to development, but its of east are not. Fig.5(b) shows the ratio of developed area compared with in 1999. Even the absolute developed area size are not large in tambons of west parts, it show high percentage in Fig.5(b).



(a) Increased ratio from '89 to '99 in the Tambon

(b) Increased ratio from '89 to '99 compared with developed area in '99 in the Tambon

Fig. 5 Increase Ratio of Developed Area from 1989 to 1999

Appendix

1. Date:
   (1) LANDSAT TM : Dec. 1989 and Feb. 1989 for Land cover distribution map provided by the NRCT.
   (2) Pathumthni province Digital Map for GIS from "GIS INFO THAILAND"
2. Tools
   (1) Erdas Imagine V8.3 for image processing
   (2) Arc View 3.1 for creating maps
   (3) MS Excel for attribute data handling

4 Village development changes between 1996 and 1999 (Suksawang, 2000)

4.1 Objectives

The ultimate objective of this part is to study the changes of village development pattern in Pathumthani province between 1996 and 1999. The development changing patterns are described by 53 variables covering demography, quality of life, income, occupation, agriculture, water resource for agriculture and household industry.

The working objectives are to classify the villages into 2 groups based on various sets of variables and examine the relationships between village clusters and the land use changing patterns.

4.2 Methodology

Population frame is the total villages of PathumThani in 1996 accounting for 529 villages. Unit of study is village.

Samples are villages which have data of 1996 and 1999 accounting for 487 villages.

Variables included in this study are as follows:

1) Demography (6 variables)

Changing of total birth, total death, male birth, male death, female birth, and female death to total pop ratio from 1996 to 1999

2) Quality of life (7 variables)

Changing of households having electricity, telephone, water supply, radio, television, consuming water from river, and consuming water from irrigation to total households from 1996 to 1999.

3) Income group (7variables)

Changing of households having income <6,000 baht, 6,000-9,999 baht, 10,000-19,999 baht, 20,000-29,999 baht , 30,000-49,999 baht, 50,000-99,999 baht , >100,000 baht to total households from 1996 to 1999.

4) Occupation (3variables)

Changing of 1st important occupation households , 2nd important occupation households and 3rd important occupation households to total households from 1996 to 1999.

5) Water resource for agri (2 variables)

Changing of households using water from river for agriculture, and using water from irrigation for agriculture to total households from 1996 to 1999.

6) Agriculture (2 variables)

Changing of households growing trees, vegetables, raising duck and hens to total households from 1996 to 1999.

7) Household industry (4 variables)

Changing of total households earning household industry, households earning 1st important , 2nd important and 3rd important household industry to total households from 1996 to 1999.

4.3 Data collection

Data for analysis consists of village map and attributes. The village map wascreated by voronoi method from two basemaps: point map of village head andarea map of tambon boundary with 1:50,000 provided by the Ministry of Science, Technology and Environment. Attributes are secondary data of variables mentioned in 2.3, done by the National Statistical Office.

4.3.1 Tools

Village mapping was created by MapInfo and Gamma softwares.

Data Processing and statistical analysis by SPSS and MapInfo.

Thematic Mapping was created by MapInfo Software.

4.3.2 Analysis techniques

Multivariate analysis : K-Means Cluster

4.3.3 Data processing for analysis

Steps of data processing are shown in Fig. 6

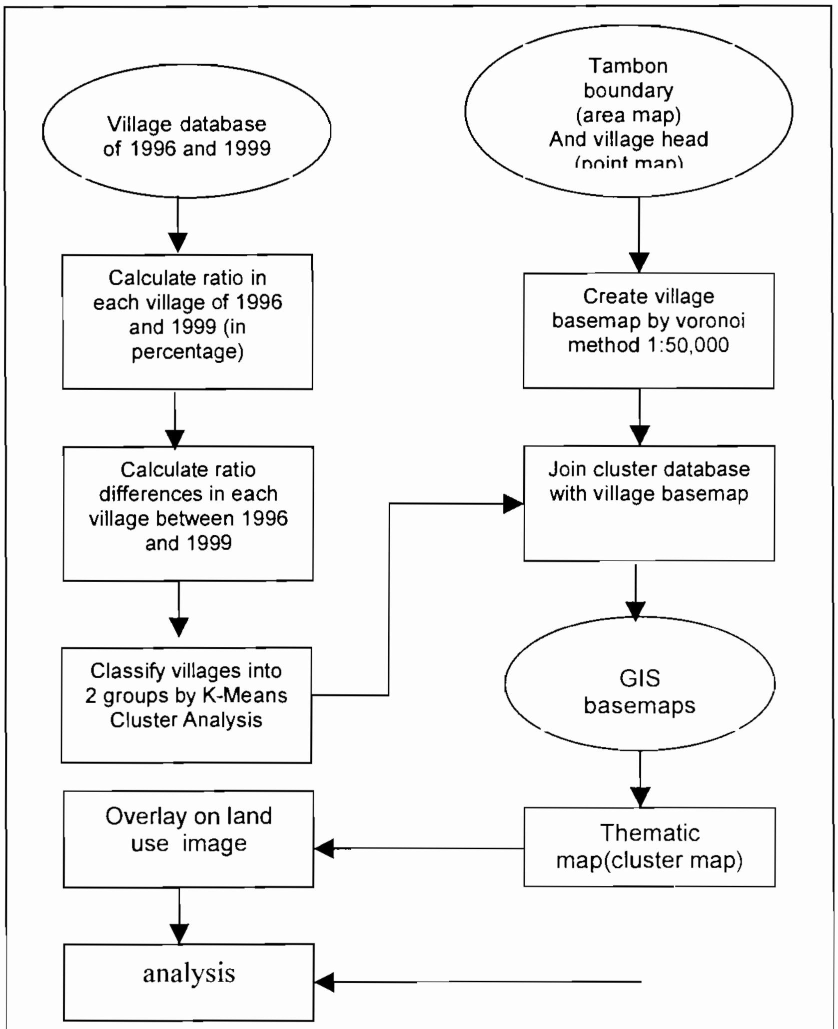


Fig.6 Data processing for analysis

4.4 Findings

4.4.1 Village classifications based on variable sets

Fig. 7 shows the different patterns of village clusters classified into 2 groups based on multi-variables comprising the ratio changes in demography, quality of life, income groups, occupation, water resources for agriculture, growing trees, growing vegetables, duck and hen raising and household industries, between 1996 and 1999. It was found that the villages were classified in response to the land use changing patterns.

1. **Demography** : When classifying the villages into 2 groups based on demographic variables. It was found that the ratio values of all variables increased in group1 while decreased in group2.

2. **Quality of life** : The two variables' values-the ratio of households accessing telephone and water supply -in group 1 increased while there were increases in all variables' values in group2.

3. **Income group**: The ratio of households earning more than 50,000 baht per year decreased in group1 while increased in group2.

4. **Occupation**: The ratio of the first occupation households increased in group 1 while decreased in group2. However, the second and the third ones decreased in group1 while increased in group2.

Water resource for agriculture : The ratio of households using water from river and from irrigation for agriculture increased in group1 while decreased in group2.

Agriculture (trees): The ratio of the 2^{nd} and the 3^{rd} tree areas decreased while others increased in group1. There was an increase in the ratio of the 3^{rd} tree areas while others increased in group 2.

Agriculture (vegetables): There were little increases in all variables in group1 while only the 2^{nd} and the 3^{rd} vegetation areas increased in group2.

Agriculture (ducks and hens) : The ratio of households raising hens and ducks increased in group1 while decreased in group2.

Household industry : The ratio of households doing household industries increased in both groups.

However, the increases in group2 were larger than that in group1.

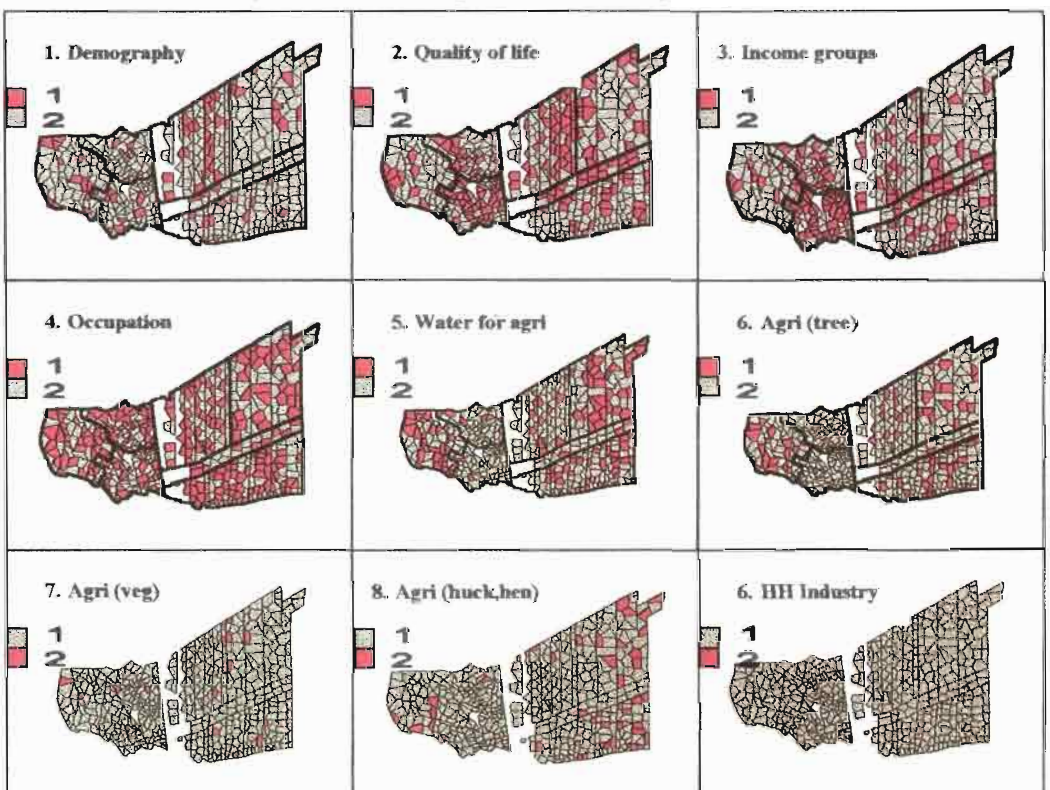
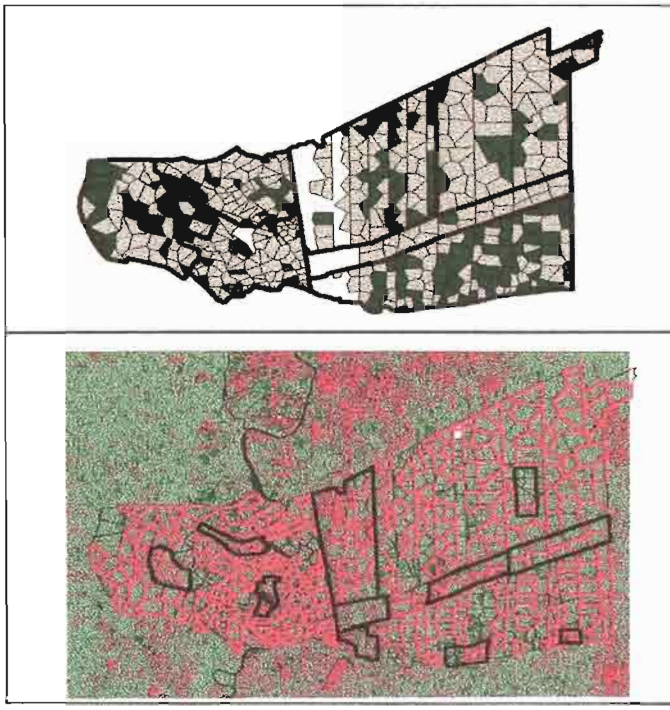


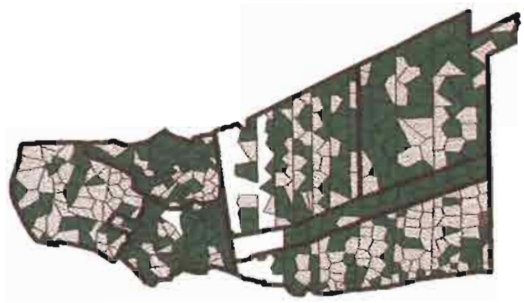
Fig. 7 Different patterns of village clusters based on various sets of variables

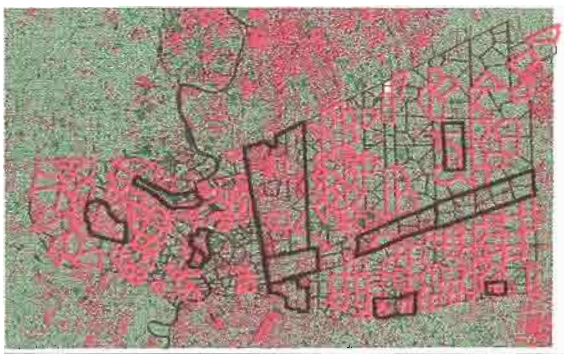
3.2 Overlay of village clusters on land use map



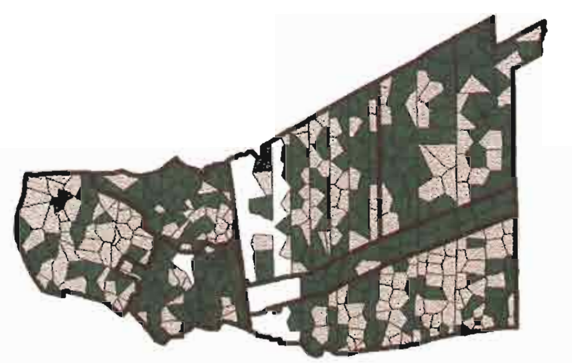
The differences found between the two groups when classified by 21 variables, including demographic, quality of life, income and occupation variables; were the ratio changes of male birth, income group of 10,000 -19,000b and 30,000-49,000b, 1st occupation group and household approaching to telephone and water supply. The ratio of male birth, income group of 30,000- 49,000b, 1st occupation group and households accessible to water supply decreased in group1 while increased in group2. The ratio of income group of 10,000-19,000 b, decreased in both groups, however the decreasing rate of the group1 was less than that of group2. The ratio of households accessible to telephone also increased in both groups, however the increasing rate of group 2 was larger than that of group 1.

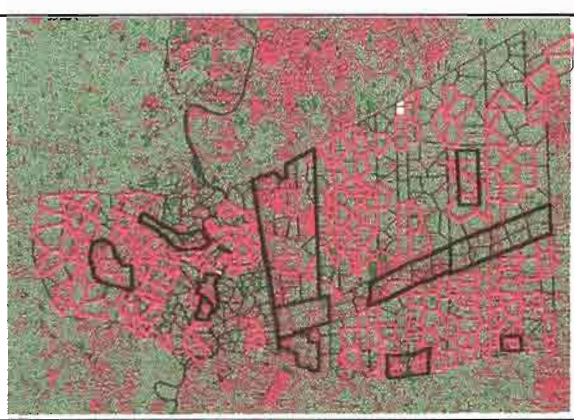
The differences found between the two groups when classified by 43 variables, including demographic, quality of life, income, occupation and agriculture variables, were the ratio of income group from 10,000- 19,000 b to 60,000-90,000b , 2nd occupation group and households approaching to water supply, 1st and 2nd paddy rice areas, primary tree areas, households cultivating 1st and 2nd paddy rice and secondary tree. There were increases in the ratio of income group between 30,000-49,000 b and ratio of areas for primary trees while they were decreases in group2. The ratio of areas for 2nd paddy rice decreased in group 1 while increased in group 2.





The differences found between the two groups when classified by 45 variables including demographic, quality of life, income, occupation , agriculture variables and water resource for agriculture were the ratio changes of income group from 10,000- 19,000b to income group of over 100,000 b, except the group of 30,000-49,000b, households having radio, television, water supply, 1st and 2nd paddy rice areas and households, primary tree areas and households, secondary tree households and households consuming water from river and irrigation canals for agriculture. There were decreases in the ratio of households having television and areas for 2nd paddy rice in group1 while there were increases in group2 . However there were increases in the ratio of primary tree areas, households consuming water from river and irrigation canal in group1 while there were decreases in group2.





The differences found between the two groups when classified by 45 variables including demographic, quality of life, income, occupation , agriculture variables. The pattern changes are found in similar with that in being classified by 45 variables

Acknowledgements

To the following organizations

1. The KU Research and Development Institute for research financial support.
2. The National Research Council of Thailand for supporting the Landsat 5 images of Pathumthani Province in 1989 and 1999.
3. The Ministry of Science, Technology and Environment for supporting the base maps of Tambon boundary and point map of village head in Pathumthani.
4. The National Statistical Office for supporting the database of village survey of Pathumthani in 1996 and 1999.

References

Morishita, Hideharu. (2000). "Land development in Pathumthani Province 1989-1999". In the 1st year Research Report of Decision Support System for Provincial Development Planning, a Case Study of Pathumthani Province, vol.2. 2000.

Suksawang, Orasa. (2000). "Village Development in Pathumthani Province 1989-1999". In the 1st year Research Report of Decision Support System for Provincial Development Planning, a Case Study of Pathumthani Province, vol.2. 2000.

Thon Buri : conservation of agricultural area and urban development

Siriwan Silapacharanan[1]

Abstract: *The Bangkok area on the western bank of Chao Phraya a River so called "Thon Buri" is now divided into 11 districts in which covers 450 square kilometers. The urbanization of the area started the reign of King Rama VII. The land uses in the past were mixed orchards, vegetable plantations and rice fields. Settlements aligned the river banks and canals. The urbanization of Thon Buri affected the conflict between agricultural conservation and urban development. The main problems are: 1) The lack of development guidelines from urban development agencies. Consequently, urban sprawls occurred due to laisser-faire private investments. 2) The service of infrastructure and facilities tend to solve existing problems and not to lead urban development: 3) The urban environmental problems are mainly wastewater and solid waste in which are treated inefficiently: 4) Deteriorated agricultural areas in mixed orchards, Flower and vegetable plantations and aquaculture land. The problems of sea water intrusion, wastewater from urban areas, the lack of enriching agricultural lands affected the reduction of products while the investment cost becoming increased. In conclusion, these problems should be solved to conserve agricultural lands to produce food for Bangkok Metropolitan Area.*

[1] Chulalongkorn University

Dynamics of Ayutthaya region

Suriya Veeravong and Amara Pongsapich[1]

Abstract: *This paper attempts to present a picture of the development process of Ayutthaya during 1970-2000 using longitudinal data collected systematically every 10 years in the years 1969/70, 1979/80, and 1989/90. Data for the year 2,000 has yet to be collected and will provide a continuation to the on-going data collection process.*

The studies showed how Ayutthaya, which was traditionally believed to be the center of rice culture of Thailand, was forced to shift from an agrarian society to an urbanized/industrialized society. In the process of searching for an alternative means of livelihood, Ayutthaya was recovered as a historical and cultural center. The famous ancient city has been revived and recognized as a World Heritage. Ayutthaya became an urban tourist town as well as an industrialized satellite area of Bangkok where 4 industrial estates are established. As the people adopted an urban way-of-life, the urge to maintain its local identity and means of livelihood lead to the formation of a civic group in Sena District. Members of the group call themselves Khlong Khanom Chin Community as a symbolic representation of who they are and as a reminder of their goals in achieving sustainable development at the local level where their community is located.

1 Introduction: myth of Ayutthaya prosperity as center of rice culture

Chulalongkorn University Social Research Institute (CUSRI) launched "the Ayutthaya Project" in 1969. Traditionally, and at the time the project was launched, it was believed that the Ayutthaya Province, being located in the Chao Phraya River Basin, was a very fertile alluvial plain area. The project selected Ayutthaya as a typical central plain province and the center of rice culture. The area was covered with a network of rivers and canals. CUSRI carried out labor utilization and time allocation surveys in 1969/70 in 3 villages where researchers were living in the villages to collect daily information (Amyot, 1976). The 3 villages were: Ban Khayai and Ban Tapnam of Bangpahan District and Ban Chung of Nakhon Luang District. In 1980 another survey was conducted in 12 villages including the original 3 villages. And, again in 1990 the third survey took place. Although separate survey for the year 2000 has not been conducted, this paper attempts to provide a picture of socio-economic and cultural changes over 40 years. Data for the year 2000 is based on the village

[1] CUSRI, Chulalongkorn University

profiles collected by the Community Development Department and observation of the present situation made by researchers.

2 Brief village profiles

Villages Thapnam, Khayai, and Ban Chung were old villages about 100 years old. Being located in alluvial plain, houses were easily flooded during September-November. Traditionally, houses were lined along canals and waterways. Now with the Asian Highway and village roads, houses are lined along the roads. House style also changed from one story with high posts to keep from water during rainy season to 1 or 2 story houses built on the ground. Modes of transportation changed from waterways to roads.

Obvious changes during the past 30-40 years are shifts from agriculture to non-agriculture activities. Basic data for 1969-1989 for the 3 villages are included in Table 1.

TABLE 1: BASIC INFORMATION ON THE 3 VILLAGES

	Khayai		Thapnam		Ban Chung	
	1969	1989	1969	1989	1969	1989
Total households	134	116	65	71	85	81
No. of agri households	59	34	45	48	62	48
% agri households	44.0	32.6	69.2	67.6	72.9	59.3
Total land holding (rai)	1560	860	1665	1500	1673	1379
Average land holding/hh.	11.6	7.4	25.6	21.1	19.7	17.0
Total agri land (rai)	1442	775	1580	1485	1604	1315
Average agri land/hh.	24.4	22.8	35.1	30.9	25.9	27.4

Source: Suriya, 2000

3 2. Physical conditions affecting way-of-life of Ayutthaya farmers

Before CUSRI started the project, in 1968 there were 9 irrigation projects set up within the Chao Phraya River Basin. In 1982 there were 11 projects (Kobkul, 1982). Most of the projects of the system served the dual purpose of irrigation and drainage. Although all districts of the province received some irrigation water, it was not possible to grow more than one crop of rice a year except in a very few locations. The main function of the systems were to offset the effects of variation in rainfall from year to year, supplementing rainfall when it was insufficient and draining away surplus water to prevent excessive flooding when it was too abundant. During 1969-1980, research findings indicated that such was not the case. Most farmers still cultivated rainfed agriculture, transplanting or broadcasting--depending on the location--and faced the risk of the crops being flooded.

The research team found that with the construction of new irrigation systems, pattern of water flows had changed and farmers of Ayutthaya were faced with flood problem. Furthermore, the belief that soil in Ayutthaya was fertile was proven wrong as well. The 1977 report of the Department of Land Development indicated that 11 out of 16 districts were facing acid soil, 12 out of 16 districts were facing yearly flooding, and 2 districts had both acid soil and flooding (Amara, 1985).

Being located at the end of the line of the irrigation systems, during 1970s and 1980s, Ayutthaya suffered water shortage during deficient years and flooding in the years of excess rainfall. Part of the problems facing Ayutthaya during that period was partly due to the government policy to keep water from flowing into Bangkok. Dikes and gates were put up north of Bangkok, forcing water to remain in the Ayutthaya area. During 1990s the flood and drought problems have been abated and lost importance. One reason was because the government found an alternative solution to keep water out of Bangkok. Another reason being the fact that agriculture has declined in importance in Ayutthaya.

The construction of the irrigation systems, in effect, caused damage to crops in Ayutthaya during the 1970s more than it improved production. Average yield during 1976-1980 was 293.6 kg./rai causing many farmers to leave their land uncultivated and farmers became wage laborers instead of remaining in the agricultural sector (Amara, 1985). However, in 1990 Watana Woonkietirat reported an increase in a more positive trend. Increase in production during 1980-1990 may be due to improved water distribution system since the concerned government agencies had the opportunity to make corrective measures in solving excess and deficient water supply for the farmers.

TABLE 2: PADDY PRODUCTION IN KHAYAI AND THAPNAM VILLAGES, 1969-1989

Village	**1969/70**			**1989/90**		
	No. Hs	**Av. size**	**Prod.(kg./rai)**	**No. HHs**	**Av. Size**	**Prod.(kg./rai)**
Khayai	55	25.5	319	37	18.7	436
Thapnam	49	34.6	301	49	26.2	356

Source: Watana Wongkietirat, 1998:37

Meanwhile, farmers made adjustments as well. Ayutthaya was known to be a province with second highest percentage of landless farmers. The Land Rent Act 1974 and the Land Reform Act 1974 did little to help landless farmers in Ayutthaya. Landless farmers turned to non-farm activities instead of continuing to rent land for cultivation. Farmers with poor quality soil also sold their land out. Detailed study of land sold in Khayai and Tapnam villages in 1989/90 indicated that land without transaction had average production of 406 kg./rai whereas land with transaction had average production of 298 kg./rai (Watana Wongkietirat, 1998:39). Size of land holding also decreased quite drastically. Table 3 shows decrease in land holding in Khayai approximately 45 percent, Ban Chung 17 percent and in Thapnam approximately 10 percent.

TABLE 3: CHANGE IN TOTAL LAND HOLDING 1969-1989

Village	1969/70	1989/90	No. rai change	% change
Khayai	**1560**	**860**	**-700**	**-44.8**
Thapnam	1665	1500	-165	-9.9
Ban Chung	1673	1379	-294	-16.9

Source: Suriya, 2000:12

Village Khayai had largest incidents of land transaction due to the fact that the village is located where the Asian Highway passed. During 1986-1990, the beginning of the economic boom, land speculation and land transactions were observed and should have been seen as a warning sign of economic crisis to be followed a few years later. A piece of land near the Asian Highway of approximately 100 rai in size changed hands 4 times within a month. The price went up to 600,000-700,000 baht per rai. The broker earned 5 percent for each transaction.

Low productivity and low income also caused shift in occupation. Number of agriculture households decreased 42 percent for Khayai and 23 percent for Ban Chung. For Thapnam, there is a slight increase in number of agriculture households with an increase of 6.6 percent.

TABLE 4: CHANGE IN NUMBER OF AGRICULTURE HOUSEHOLDS (1969/1989)

Village	No. of households		No. change	% change
	1969/70	1989/90		
Khayai	59	34	-25	-42.4
Ban Chung	62	48	-14	-22.6
Thapnam	45	48	+3	+6.6

Source: Suriya, 2000:12

The shift from agriculture to manufacturing and service sectors became apparent during 1980s which coincided with the Fifth National Development Plan when poverty alleviation was the objective of the plan. During this period, villages were classified into poor, medium, and advanced villages. Because of limited budget, the government implemented poverty eradication programs and projects with priority given to poor villages. Most of villages in central plain provinces were identified as non-poor and were left with no special assistance programs. It was obvious to the research team that classification criteria used by the government at the time were not appropriate. Many of the villages in Ayutthaya deserved to be given special assistance support.

4 3. Urbanization and industrialization of Ayutthaya

CUSRI report of the 1979/80 data indicated that development of Ayutthaya was basically made difficult mostly because of physical conditions (Kobkul, 1982). None of the attempts of the government to help solve each specific problems, i.e., irrigation, land rent, land consolidation can be identified as successful (Pinit, 1982). Unless a village is situated in a favorable environment where agricultural production can be predicted on the basis of inputs injected into the field, villagers had no hope in agriculture. Non-farm activities must be generated to help solve the problem, at least partially (Amara, 1985).

The case of Ayutthaya differed from that of other provinces located in the upper Central Region of Thailand where irrigation water can be controlled and production was predictable. The government had not considered Ayutthaya a special case and accepted the stereotype, which presented Ayutthaya as a prosperous province in the central plains. All provinces in the central plains were classified as non-poor areas requiring no special assistance from the government. In fact, the National Economic and Social Development Board planned for Ayutthaya to be developed through investment of the private sector. But statistics already showed that during the 1970s, very little industrial investment was made in Ayutthaya. Not enough jobs were generated to induce the people of Ayutthaya to remain in the province and out-migration became very high during the 1980s.

Some private firms in the agricultural sector gave credits to farmers in the form of contract farming. But because of very low yields or because of the unpredictable water supply, private firms found it very difficult to maintain the program. Our research findings indicated that with the physical, social, and legal limitations, private firms had little chance of surviving in this set-up unless they took a very harsh stand on the contract made with the villagers. That is, if the villagers could not pay back their credit advances, land would be taken away. However, when private firms took legal action against the villagers, they found that villagers suffered greater hardships than the private firms did and the situation became socially unacceptable. The firms could survive socially only when they were willing to adjust their profit to an optimum point where both the firms and the farmers could make profit. But because of the unfavorable physical conditions, the optimum point could not be identified.

It became obvious during the 1980s that agriculture was not the best mode of production for the people of Ayutthaya and alternative solutions were sought. Two alternatives identified were tourism and industrial development. The government agreed to landuse re-zoning and declared areas in Bang Pa-in and Bang Sai Districts as industrial development zone with special investment incentives. At present, there are 4 industrial estates in Ayutthaya, i.e., Bang Pa-in, Bang Sai, Tharua, and Wang Noi. Table 5 shows shift in production from agriculture to manufacturing in terms of number of labor force and manufacturing firms. From 1976-1990 change in number of all types of enterprises was 66 percent with highest changes in commerce and manufacturing sectors.

TABLE 5: CHANGE IN LABOR FORCE AND MANUFACTURING FIRMS IN AYUTTHAYA PROVINCE (1976-1990)

Production type	No. labor force		% change	No. enterprises		% change
	1976	1990		1976	1990	
Manufacturing	21,665	25,754	+15.89	507	989	+48.74
Commerce	3,399	11,357	+70.07	195	2,067	+90.57
All types	29,929	42,630	+29.79	1,268	3,777	+66.43

Source: Napat, 1998:50

It became clear that Ayutthaya has been transforming from an agriculture province to an industrial town, a satellite of Bangkok. Interviews of female labor force in industrial sector indicated positive responses more than negative. They appreciated the opportunity for both males and females to join the manufacturing sector to bring back cash income for the families. Ayutthaya has moved into market economy and urban way of living can be observed everywhere. Negative impacts of industrialization in terms of occupational health and way of life as a result of having to work in alternate shifts have been mentioned. But overall it was believed that the positive benefits outweigh the negative impacts (Napat, 1998). In addition, impact of industrialization on environment is also being observed negatively.

It is undeniable that workers in manufacturing firms in Ayutthaya came from other provinces as well. In the villages studied, not everyone enter the firms. Many villagers coped with the changing socio-economic conditions by finding alternatives. Table 6 shows shifts in occupation and income sources of people in Khayai and Thapnam. Shift in occupation was seen much more clearly when one looks at source of income. Income from non-farm activities increased from 76.5 to 94.1 percent between 1969-1989 for Khayai and from 13.6 to 65.4 percent for Thapnam.

TABLE 6: CHANGE IN INCOME PER HOUSEHOLD IN VILLAGE KHAYAI AND VILLAGE THAPNAM (1969-1989)

Village/income	1969/70		1989/90	
Income/hh	**baht**	**%**	**baht**	**%**
Village Khayai				
Total income	28,226	100.0	67,518	100.0
• Farm	6,644	23.5	4,009	5.9
• Non-farm	21,582	76.5	63,508	94.1
Village Thapnam				
Total income	14,561	100.0	69,224	100.0
• Farm	12,587	86.4	23,720	34.6
• Non-farm	1,974	13.6	45,504	65.4

Source: Watana Wongkietirat, 1998:42

At the same time, in terms of labor force involved in agriculture and wageworkers in factories, changes in the 3 villages can be seen in Table 7. Traditionally, manufacturing in Ayutthaya was mostly in the form of rice mills. But with government promotion, many different types of firms have been established both within the industrial estates and outside. Manufacturing firms where people in the 3 villages studied worked include electronic, garment, and footwear factories.

Changes can be seen most clearly in Ban Chung with 28.2 percent decrease in agriculture and 16.7 percent increase in manufacturing.

TABLE 7: CHANGES IN OCCUPATION OF LABOR FORCE IN AGRICULTURE AND MANUFACTURING SECTORS DURING 1969/70 AND 1989

Village	**Agriculture**			**Manufacturing**		
	1969/70	**1989**	**% change**	**1969/70**	**1989**	**% change**
Khayai	30.7	19.9	-10.8	-	12.8	+12.8
Thapnam	68.1	61.6	-6.5	-	10.2	+10.2
Ban Chung	81.0	52.8	-28.2	1.2	17.9	+16.7

Source: Suriya, 2000

In addition to manufacturing firms, many villagers turned to brick making, especially in Khayai, where brick making was observed during the first phase of the study in 1969/70. Brick production had been taken place in Khayai as an off-farm secondary occupation for many years. During 1980s with construction boom, brick manufacturing in Ayutthaya was expanded and was seen in Thapnam where brick making was not observed during the first phase of the study.

5 Ayutthaya as a cultural center and a tourist town

Our report based on the 1969/70 and 1980 data also recommended tourism as an alternative development strategy for Ayutthaya. In 1988 a Tourism Master Plan for Ayutthaya and Its Vicinity was completed. Historic sites were identified and travelling loops to visit the different sites were recommended (CUSRI, 1988). Ayutthaya was also honored with the recommendation of UNESCO as one of the Historical World Heritage site.

Locating only an hour away from Bangkok, Ayutthaya is now known as one of the historical and cultural center of Thailand. A few business people willingly invested in hotels to attract tourists who prefer to be outside of Bangkok. Boat trips from Bangkok to Ayutthaya also became popular tourist attraction. Local crafts promoted include clay dolls (*tukkata sia kaban*), woven baskets, mobile woven fish (*pla taphian*), and aranyik knives. In addition, the royal craft center in Bangsai, Sun Silapa Chip Phiset, became a must for tourists visiting Ayutthaya. Traditional Thai houses are known to be a product of Ayutthaya. People who wanted to build a Thai house come to Ayutthaya either in search of the famous Thai house builders or to buy a finished house to be reassembled.

The making of traditional Ramayana mask (*hua khon*) is now being revived (Watana Jutawiphat, 1998). A small apprentice center has been opened to attract young artistic students to join in to learn the crafts and keep the trade alive. Ayutthaya has indeed recovered its traditional fame of being the cultural center and the ancient capital of Thailand.

6 Coping strategies and social impact on people and communities

Population structure of the 3 communities during the past 30 years showed no change in gender ratio. In terms of age groups, smaller percentages of younger cohorts are reported. This means larger number of people older than 65 are left in the villages. A proportion of young people left Ayutthaya to continue their study and find work in Bangkok. Table 8 shows percentage of people older than 45 living in the 3 villages in 1969/70 and 1989. The increase of more than 20 percents for both male and female in all 3 villages indicated clearly that problems of the elderly living in villages without their children will become vital issues for future social planners. The data also indicates that of those older than 65 years old, 61.3 percent of females were single while only 16.7 percent of males were single. Average size of households in the 3 villages was maintained at 4 persons and did not change during the 30 years. Percentage of extended families also was maintained at 30-40 percent in each village.

TABLE 8: PERCENTAGE OF PEOPLE OLDER THAN 45 YEARS OLD IN 1969/70 AND 1989

Village	Male			Female		
	1969/70	1989/90	% change	1969/70	1989/90	% change
Khayai	11.8	32.5	20.7	15.0	37.5	22.5
Thapnam	9.9	34.4	24.5	11.5	36.1	24.6
Ban Chung	10.8	31.5	20.7	17.6	41.5	23.9

Source: Suriya, 2000.

In terms of education attainment, in 1969/70 almost everyone older than 11 years had 4-year education only. Compare with the present, the situation has changed. Not only had compulsory education been extended to 6 years in 1989/90, and 9 years in 1999/2000, the villagers also realized that secondary education has become an important asset in terms of job attainment in some of the manufacturing firms. Table 9 shows increasing trend in education attainment in the villages. One needs to keep in mind that many of the young people also left home to continue their education in Bangkok.

TABLE 9: EDUCATION SITUATION IN 1969/70 AND 1989/90

Village	Secondary		Vocational		Tertiary	
	1969/70	1989/90	1969/70	1989/90	1969/70	1989/90
Khayai	5.8	7.6	2.4	3.3	-	5.5
Thapnam	2.1	5.3	-	3.9	-	-

Source: Watana Wongkietirat, 1998:19-20.

It is clear from the table that trend in higher education attainment can be observed. With the 1999 National Education Act, it can be predicted that education will be recognized as an important factor for future means of livelihood. However, eventhough figures in Table 9 shows an improving trend, the figures are not impressive. Based on the 1990 labor force survey of the National Statistical Office, in Ayutthaya there were 4,127 children aged 13-14 working. Of these 1,987 were males and 2,140 females. And in addition there were 29,878 youth aged 15-19 years old, 14,513 males and 15,365 females who were working in Ayutthaya. Among children 13-14 years old, 50 percent worked for private enterprises and 45 percent worked in home enterprises. Similarly, among youth 15-19 years old, 60 percent worked for private enterprises and 35 percent worked in home enterprises (Nitaya, 1998). It is not clear from the NSO data whether work at private enterprises and home enterprises are different or not. However, a qualitative study of children in homebased work in Ayutthaya carried out in 1996 indicated that many of the children who worked went to school at the same time. Enterprises where children worked included home industries making wide varieties of product ranging from dried fish preservation, paper artificial flowers, and computer keyboard assembling. Parents usually appreciated the efforts made by children to bring in extra income either on a full time or part time basis. These working children were not considered being exploited and work conditions were not hazardous (Nitaya, 1998).

7 Local organizations, local governance, and civic groups

In 1969/70 in the 3 villages studied, local organizations were seen in the forms of agricultural cooperatives and Bank of Agriculture and Agricultural Cooperative groups. Later on, other groups included agricultural housewives, credit groups, cremation groups, etc. These were groups organized by government officers, mostly in the Ministry of Agriculture as part of the community development activities being promoted at the time. The study in 1989/90 found that these groups were neither active nor productive. People have been recruited to join the different groups only to show that government officers had made attempts to form such groups. Many villagers belonged to many groups, most of which were not operating. Bad experiences in group organizations had negative effects on the attitude of the people and confirmed the belief that Thai people were individualistic and could not be organized. But such belief is being proven otherwise.

However, village scouts and Thai Volunteers for National Protection (*Thai Asa Pongkan Chart*) formed during the 1976-1979 to counter student movements continued to operate.

These groups will last as long as objectives and activities are revived regularly. Thus, group organizations can function if the needs arise and remain to be necessary.

In terms of local governance, tambon councils have been in existence for a few years before the Decentralization Act was promulgated in 1994. Tambon councils gradually became upgraded to be tambon administrative councils (TAO) according to the law. A case study of Khlong Sakae TAO in Nakhon Luang district was carried out in 1996. Khlong Sakae TAO was one of the first tambon councils to be formally recognized (Kobkul, 1998).

It became clear that shift in social and power relations had been made. Traditionally, social relations were established in the form of patron-client. In Ayutthaya especially, where landlessness and incidence of absentee landlord was high, patron-client relations were in multiple pairs with one of the pair being between landlord and landless farmer. A farmer was a client to the landlord, a client to a money lender, and a client to the rice mill owner. All these relations gradually disappeared. The establishment of cooperative groups as well as commercial banks and the Bank of Agriculture and Agricultural Cooperatives gradually replaced the role of middlemen and money lenders in providing funds for farmers. Occupational shift from landless peasants to factory wage earners also lead to the disappearance of landlords.

Nevertheless the study still found local leaders to be powerful. Village leaders are still considered to be those powerful persons who acted as patron in some ways. Traditional stereotype of village headmen being socially powerful persons is changing and economically powerful persons are joining local political sphere more and more. At the tambon level, tambon heads are also economically and politically powerful. Social relations at the village and tambon level had certainly shifted from kinship networks to economic and political networks. Hierarchical linkage between village-tambon-provincial-national politicians are observed. Money politics is accepted as a norm.

The role of TAO in self governing is something new to the public. Most villagers in the case study did not quite know the implication of the change from tambon council to tambon administrative organization. They had yet to realize that in the near future they need to take care of their communities and environment, using the financial resources made available for them through government allocations and local tax collection. At the moment, it is clear that local governance is inevitable and the people will have to make adjustment to take care of the decentralization policy and good governance policy promoted in the 1994 Decentralization Act and the 1997 Constitution.

At the same time civic groups and civil society organizations are emerging in Ayutthaya as well. Village Sakhlee in Sena District is an example. Strength of Sakhlee community became evident during 1980s when a school teacher was recognized as one of the local leaders who had been promoting integrated farming as one of the community development activities. Group members and group activities expanded to include 3 neighboring tambons. The group is in search of a development strategy which will lead to self-reliance and sustainable development. It is now recognized as one of the leading civic group to be replicated. Newly formed groups came to observe activities and listen to lessons learned. The group now decided to adopt the name "khlong khanom chin" community in recognition of the name of the canal where the group is now formed and located. This is an example of an indigenous grassroot organization with its own objectives and goals to work towards sustainable development.

8 Conclusion

This paper attempts to present a picture of the development process of Ayutthaya during 1970-2000 using longitudinal data collected systematically every 10 years in the years 1969/70, 1979/80, and 1989/90. Data for the year 2,000 has yet to be collected and will provide a continuation to the on-going data collection process.

The studies showed how Ayutthaya, which was traditionally believed to be the center of rice culture of Thailand, was forced to shift from an agrarian society to an urbanized/industrialized society. In the process of searching for an alternative means of livelihood, Ayutthaya was recovered as a historical and cultural center. The famous ancient city has been revived and recognized as a World Heritage. Ayutthaya became an urban tourist town as well as an industrialized satellite area of Bangkok where 4 industrial estates are established. As the people adopted an urban way-of-life, the urge to maintain its local identity and means of livelihood lead to the formation of a civic group in Sena District. Members of the group call themselves Khlong Khanom Chin Community as a symbolic representation of who they are and as a reminder of their goals in achieving sustainable development at the local level where their community is located.

References

Amara Pongsapich. 1985. "The Unsolved Problem of Ayutthaya" in Ayutthaya Summary Report Bangkok: CUSRI.

Amyot, Jacques. 1976. Village Ayutthaya: Social and Economic Conditions of a Rural Population in Central Thailand Bangkok: CUSRI.

Chulalongkorn University Social Research Institute. 1980. Ayutthaya Village Report Bangkok: CUSRI.

Chulalongkorn University Social Research Institute. 1988. Tourism Master Plan for Ayutthaya and Its Vicinity Bangkok: CUSRI.

Kobkul Phutharaporn. 1982. "Physical and Technological Problems of Ayutthaya" in Ayutthaya Research Project Report Volume 4: Physical Characteristics and Technological Application Bangkok: CUSRI.

Kobkul Samakki. 1998. "Local Power Structure at Tambon Level" Ayutthaya Research and Development Project Bangkok: CUSRI.

Napat Sirisambhand. 1998. "Industrial Expansion and Female Labor Force: The Case of Nong Jik Village" Ayutthaya Research and Development Project Bangkok: CUSRI.

Nitaya Kathaleeradabhand. 1998. "Child Labor in Homebased Work" in Ayutthaya Research and Development Project Bangkok: CUSRI.

Pinit Lapthananon. 1982. "Land Holding in Ayutthaya" in Ayutthaya Research Report Volume I: Problems Related to Land Bangkok: CUSRI.

Suriya Veeravong. 2000. "Socio-economic and Cultural Changes in Rural Central Plain Area: the Case of Ayutthaya" mimeo.

Watana Juthawiphat. 1998. "Khon: a Cultural Dimension" Ayutthaya Research and Development Project Bangkok: CUSRI.

Watana Wongkietirat. 1998. "Change in Land Use and Labor Force in Rural Communities in Ayutthaya (1969-1989)" Ayutthaya Research and Development Project Bangkok: CUSRI.

Transformation of Bangkok and concomitant changes in urban-rural interaction in Thailand in the 19th and 20th centuries

Porphant Ouyyanont*

Abstract : *This paper focuses upon the origins of Bangkok's emergence as a leading Thai city from the early 19th century. A key theme is to account for the transformation of Bangkok from a port- city dominated by Chinese migrants to a manufacturing center based on cheap labor. It is suggested that demographic change transformed the economy from one where indigenous labor was relatively expensive to one where it was relatively cheap.*

1 Introduction

Bangkok holds a unique place in economic history. The city grew from a traditional dynastic foundation in 1782 to the modern primate "megalopolis" of today. This paper explores this transformation, and notes in particular the way in which the growth of Bangkok influenced, and was influenced by, the rural provinces.

We can trace Bangkok's growth through three phases: that of a royal fortified city based on tribute; that of a commercial port growing through trade and immigration; and that of an industrial urban center based on cheap labor. Crucial in the process were three factors: (1) Bangkok's role as a government center, (2) the overall growth of Thailand's population, and (3) the physical development of Bangkok from a city based on water (river and canals) to one based on land. As we will see, key periods of transformation occurred in two particular periods, roughly from 1890 to 1920, and again from around 1960-1980s.[1]

* School of Economics, Sukhothai Thammathirat Open University, Nonthaburi, Thailand 11120 Email ecasopor@samsorn.stou.ac.th The author is grateful to Professor Malcolm Falkus, Department of Economic History, University of New England, Australia, for his helpful comments on an earlier draft of this paper, and grateful too, to anonymous referees and Professor FUKUI Hayao, for their comments. Sole responsibility for the views expressed here, of course, rests with the author. I should like to acknowledge with gratitude financial support for research from the National Council Research of Thailand and the Japan Society for the Promotion of Science (JSPS).

1)It is my pleasure to acknowledge my debts to two key works by Malcolm Falkus which introduced me to the subject of this article, [Falkus 1991 ; Falkus 1993]. As for works related to this issue, see for example the following: [Ingram 1964], [Ingram 1971 in chapter 10] and [Sompop 1989 in chapter 6].

2 Bangkok before the 1850s

By about 1820 Bangkok had surpassed other Thai-speaking centers in terms of size and commercial significance. We might even speak of "primacy", although this was as much a product of the small size of provincial centers as it was of Bangkok's eminence.

If the size of Bangkok cannot be estimated with confidence, even more uncertain are estimates for other centers. Such data as we have suggest beyond doubt that from an early period no other Thai-speaking center approached Bangkok in size or economic significance. Yet Bangkok's population contained no more than 50,000 to 100,000 around the 1850s [Terwiel 1989: 233].

Prior to around 1850 Bangkok was essentially a medium-sized royal capital.

However, even in this early phase there were elements which pointed the way forward. One element was the growing significance of foreign trade in Bangkok's economy. Until around the middle 19th century, some of the principal Siamese exports were obtained by suay (tribute taxes, especially in kind).Until the early 1820s, foreign trade was largely under royal monopoly. China was the main trading partner. The royal trade monopoly and the China trade combined to concentrate activity in Bangkok. Hong Lysa argued that "Foreign trade was a lifeline of Thonburi and early Bangkok"[Lysa 1984:48] and the contribution of international trade as a chief source of the state revenue remained throughout the first half of the 19th century [Vella 1957:22]. A second element, related to the first, was significant links between Bangkok and the provinces emanating through the collection of suay. Suay cardamoms, for example, were sent from Nakhonchampasak, Ubonratchtani, Kalasin, Rattanaburi, Suwanapum, Khemmarat, Mukdaham, Surin, Chacheongsao, Pratabong, PrachinBuri, Yasothon, Wattananakorn, Saraburi, ChumPhon, NakhonSawan, Ratchburi and Roi-Et [Boonrawd 1975:91-92]. A list of major products for export in the 1820s and 1830s shows that forest products constituted the largest items including sticlac, sapanwood, cardamoms, bark, and so on. Thirdly we have the sizeable significance of immigrant communities, especially the Chinese. From the very outset Chinese influence was strong in Bangkok. A Chinese settlement had been moved to make away for the construction of the royal compound on Rattanakosin Island in 1782, and this settlement soon became the commercial hub of the capital (Sampeng) [Tomosugi 1993: 16]. The Thonburi period saw the arrival of many Chinese, and opportunities opened up by canal and temple construction and shipbuilding attracted a flow of Chinese immigrants which gave Bangkok resources of labor, skills and enterprise [Skinner 1957:20-27].

Bangkok's trade expanded and the port of Bangkok developed as the nation's major center of internal, coastal and foreign trade. Bangkok was one of a number of great Asian port cities which developed in response to opportunities offered by growing trade, and we may compare Bangkok with other great ports such as Singapore, Batavia, Saigon and Bombay. During the period of 1829-51, the number of Siamese ships calling at Singapore was as follows [Sarasin 1977:209]:

Year	Number of Junks
1829-30	31
1832-33	37
1835-36	23
1838-39	23
1841-42	28
1844-45	22
1847-48	20
1850-51	63

The number of junks entering Bangkok at various years in the second quarter of the 19th century , according to Malloch were :

1825: 265	1836: 302	
1826: 249	1843: 314	
1827: 275	1850: 332	Source: [Malloch 1852:65]:

Taken together, these figures show a lively, and overall growing, foreign trade in the first half of the 19th century. Three points are worth emphasis. First, foreign trade was a significant part of Bangkok's commercial development long before the Bowring Treaty in 1855 "opened" Siam to foreign trade with the West. Secondly, through growing contact with Singapore, Bangkok was open to products and ideas from the West long before the formal Treaty of 1855. Thirdly, Bangkok developed as an Asian commercial port, with a dominant part played by Chinese products, merchants and ships. This strong Chinese influence on Bangkok's character and development was to remain as a legacy long after the Chinese trade itself declined in importance.

Suay not only constituted the largest portion of Siam's exports, but was also significant for royal construction activities in Bangkok, such as temples, palaces and canals. The growth of such construction generated a demand for non-agricultural employment, chiefly, of Chinese; drew resources from the provinces; and induced Bangkok to tighten its administrative control over the townships.

Suay helped finance the growth of Bangkok at the expense of the countryside. Table 1 indicates that the growth of construction activities in Bangkok directly related to the supply of suay increased significantly from the late 18th century.

Table 1 Some Major Public Works in Bangkok, 1782-1851

Item	Detail	Number
1. Number of Temples	Rama I (1782-1809)	6
	Rama II (1809-1824)	10
	Rama III (1824-1851)	83
2. Number of Palaces	Rama I (1782-1809)	29
	Rama II (1809-1824)	49
	Rama III (1824-1851)	72
3.Canal Construction	Rama I(1782-1809)	7.1
(Kilometres)	Rama II(1809-1824)	9.1
	Rama III(1824-1851)	62.2

Sources: 1. and 2. calculated from [Chula. University 1991 : 26-68]. 3. [Robert V. Hubbard 1977 :28-37].

Note: The figures show the number of temple, palace, and canal projects in each reign; they are not cumulative numbers.

Table 1 above also shows that construction activity in Bangkok increased significantly between 1809 and 1851, especially in the period of the Third Reign (1824-1851). Some 83 new temples and 72 palaces were built and 62.2 kilometres of canals were dug. These construction projects were financed not only by suay from the countryside but also by profits from foreign trade.Exports to neighbouring countries earned considerable revenue for the Treasury.[2] Contemporary Thai sources indicate that revenue from the foreign trade was 2,759,600 baht in 1795, 610,000 baht in 1816 and 4,599,600 baht in 1837 [Suvit 1982:192]. While the profits from trade increased, the revenue from corvee taxes tended to decline in relative importance from around 1830. Trade and the associated construction activity also stimulated the use of money in the Thai economy. King Rama III, in addition to constructing 83 new temples, set aside a considerable sum for restoring and improving over 30 others (19 of which, we know, cost around 104,000 baht).

3 Bangkok 1850s-1932

By the 1850s, Bangkok was a city in transition, changing from a moat and fortified city into a large commercial city. Before 1851, Bangkok was mainly concentrated within the area of the city walls with the palace as its centre. After 1851, the year in which Rama IV (1851-1868) came to throne, there were gradual changes in the city landscape. After the Bowring Treaty was signed in 1855, the growth of the city gradually accelerated. One of the most important aspects of the Treaty was that it allowed private business, mostly western and Chinese, to develop the economy, rather than the state monopoly involved in international trade. As a result, more westerners came to live in Bangkok and set up trading firms as well as a few industries. The growth of business generated demand for land for construction and some residential areas.

The trade liberalisation of the Bowring Treaty influenced economic changes in Bangkok, because the development of Bangkok was tied to foreign trade. Bangkok developed essentially as an outward-looking port city, handling virtually all the kingdom's exports and imports. Rice exports, which were 75 per cent of the value of total exports in the decade before 1914, grew from around 10,000 tons annually in the 1860s to around 500,000 tons in the 1890s and to over 1 million tons by the 1920s [Falkus 1993: 148].

Since Bangkok was the most important port in Thailand, foreign trade had a considerable impact upon general economic activity in Bangkok. Shipping, warehouses, rice mills, saw mills all developed in step with foreign trade. Trade also brought capital, technology and labour to Bangkok.

---

[2] An interesting work, based on Thai archival sources, calculates revenue from the profit from international trade. [Suvit 1982].

Bangkok's population in the 19th century was much smaller than often suggested. Indeed, at the time of the Bowring Treaty in 1855, Bangkok's population would be numbered in tens, rather than hundreds of thousands, much of this population river dwelling and transient. The major changes came only from about the 1880s and 1890s, with a marked acceleration of population growth (much of it caused by Chinese migration) and an expansion of permanent land dwelling. Around the time of the first world war, Bangkok's population stood at some 360,000, heavily concentrated in districts around the royal Palace and commercial river areas. It is thought that perhaps half of the population was composed of Chinese migrants [Porphant 1997:258].

We should not exaggerate the impact of the Bowring Treaty on Bangkok's development. Bangkok had a significant involvement in international trade before the treaty in 1855. There are many studies of pre-1855 Siam, both in Thai and western languages[3], which show that indeed there were a many forces boosting Bangkok's development in this period. Especially in the 1820s and 1830s, Siam's "expansive" and "export-oriented" economy [Terwiel 1989:236] led to the development of the capital city.

Although we should not exaggerate the economic role of the Chinese, their role needs emphasis. Ethnic Chinese formed the core business and labouring classes in Bangkok. They provided the main commercial class in the city, acted as middlemen in business transactions with the rural interior, and were a substantial component of Bangkok's entire population. The Chinese contributed roughly half of the city's overall growth rate before the 1950's. [Skinner 1957: 199-209].

During the 1860s and 1870s sailing junks and square -rigged vessels still dominated Bangkok's trade, but thereafter the triumph of the steamship, especially the British steamship, was swift. Foreign trade not only brought business development to Bangkok, but also brought many foreign ideas which in turn led to the improvement of Bangkok.

Although the size of Bangkok's western communities was relatively small, they were responsible for many changes. For example, in 1861 the western consuls complained of ill health because there were no roads for making excursions in their horse-drawn coaches, and put pressure on the government to construct a road in the capital. "New Road", or Chareonkrung Road, was then constructed. This, the first and for long the most significant commercial artery in Bangkok originated in the 1860s at the behest of the new resident western community. The road at once became the hub of commercial Bangkok and remained so until the 1950s, the headquarters of many of the principal trading houses, banks, and other enterprises, and containing most of the leading hotels. There were also developments from the 1880s brought by western technology which went hand in hand with city roads and streets, for example, tramways, electricity, the telegraph, and the telephone. In the 1880s a Danish consortium introduced a horse-tramway, electrified and extended in 1893. British and Danish merchants formed the first railway company, which ran a narrow-gauge track from Bangkok to Paknam from the early 1890s. In 1898 Danish capital took

3) See [Nidhi 1982; Sarasin 1977; Cushman 1975; Hong 1984; Skinner 1957; and Evers 1987: 751-771]

over an ailing American electricity supply company, later amalgamated with the tramway company, and continued in operation until taken over by the Thai government in 1950.

City and port grew together, and contemporary maps show how important was the river to city development. The headquarters, warehouses, private wharves of the western trading companies, the rice and saw mills and their wharves, the custom house, and the principal consular buildings were all concentrated along the banks of the river, principally on the eastern side but also on the Thonburi side. The old commercial port was centred on the wharves of the Bangkok Dock Company, a private company launched in 1865 with British capital. Early in the twentieth century the Company embarked on improvements and extensions; it then maintained two dry docks and three slipways and had extensive engineering works, as well as the principal wharves and storage facilities. Bangkok grew in elongated fashion along the river, with little extension away from the river until well into the twentieth century. Such extensions as there were tended to be along canals cut from the main river, and in this way grew such well-known present-day thoroughfares as Silom, Sathorn, and Rama IV roads [Falkus n.d:14-15].

As foreign trade flourished, more than 15 canals linking Bangkok and the central hinterland were dug between 1860-1910. Canals facilitated trade, above all the rice trade.[4] Canals contributed to the growth of Bangkok and there was a close link between canals and foreign trade. Trade necessitated the digging of canals. From the 1880s, commercial rice production expanded rapidly in the provinces adjacent to Bangkok, especially in Ayutthaya and Chachoengsao, which were centres of fertile rice growing. Such development went hand in hand with Bangkok's expansion. Bangkok gradually extended to the north when the Prem Phrachakorn canal was dug in 1869-70. This canal provided a route between Bangkok and Ayutthaya extending 51.3 kilometres [N.A.R.5 M.of Agriculture (Department of Canals) 34/791)] and encouraged people to settle in the northern part of Bangkok, [Chai 1976:282] because it facilitated transportation and communication to Ayutthaya. Also Bangkok extended further to the east after the 21.5 kilometre Nakhon Nuang Khet Canal (1876), and the 28.7 kilometre Pravet Burirom canal (1878) were dug because both canals shortened and provided more rapid communication and transportation between Bangkok and Chachoengsao which was the centre of rice growing on the Bangpakong river [N.A.R.5 M.of Agriculture (Department of Canals) File no 34/791 (1909)]. Waterways dominated rice transport until the 1940s. In 1929, the Ministry of Commerce recorded that 786,901 kwien[5]

---

[4]) The Bangkok Calendar noted in 1871:

The great canal Klawng Padoong gave at once great expansion and life to suburban interests. Not far from the same time, the still longer canal Hua-Lampong going eastward through thousands of acres of the richest-paddy fields to the head of the Big-bend, was cut... Such a convenience and privilege had never before been enjoyed by the residents of Bangkok. This canal shortened the distance from the Big-bend to Bangkok more than one half. The canal Mahaswas, leading from Bangkok-noi to Tacheen River, near the town of Nakawn-Chaisee [Nakhonchaisri], a distance of about 20 miles, and thence to Pra-Pra-Tom, 7.5 miles, was completed soon after. The canal also going to Tacheen River a distance of 17 miles, was made in the latter part of the same reign, and shortens the distance to the part of the great Sugar district by full 24 hours of travel [Bangkok Calendar 1871: 151].

[5])A kwien (cart) is a Thai capacity measure equal to 15 piculs or 2,000 litres.

of rice arrived in Bangkok by water as compared to 121,656 by rail [N.A.R.7, M of Commerce 8.1/1929]. Even in the 1930s, despite the existence of a railway network amounting to some 4, 000 miles, more than 80 percent of exported rice was carried by water from the interior to the rice mills.

Bangkok's growth brought important changes for the provinces, and in turn the provinces influenced Bangkok's development. Influence was never uniform, however. We may note, for example, that before the first World War, the major source of Bangkok's rice supplies (on which the city grew as a commercial rice port) came from the central provinces. But this did not mean that other provinces were unimportant. Even before 1850 we have the significance of suay from distant regions (including the northeast),while from around the 1880s both northern teak and southern tin were significant in different ways.

Teak brought largely European capital and enterprise to Thailand, with Bangkok becoming the centre of saw-milling (with both Chinese and European mills) and the headquarters of the firms engaged in the industry. The sawn timber was exported entirely from Bangkok. Revenue from teak royalties became controlled from Bangkok and the formation of the Royal Forestry Department in 1896 was an important step in the modernisation of the forestry industry. Tin was mined in the south and exported (largely as ore) from the south. However, tin royalties became an important part of government revenues [Tej 1977: 71], and the main tin regions were among the first to come under direct Bangkok control following the reforms of Prince Damrong [Tej 1977: 61-3].

The period around 1890 saw some crucial developments. Significant were reforms to centralise administrative control in Bangkok. Formerly semi-independent provinces such as Chiang Mai, Lampang and Phuket, were brought within Bangkok's orbit through the appointment of governors from Bangkok, centralised tax collecting, and other measures. These changes have been fully discussed by Tej Bunnag [Tej 1977: 61-63] and are not elaborated here. In addition to the political dimension there was an economic one. Bangkok was to become a modern capital in other senses. Growing wealth from the rice trade, from centralised taxes , and from the influx of Chinese migrants, provided resources for a notable extension of the city. This expansion had its physical expression in the construction of new canals and city streets. The streets were of considerable importance since, for the first time, Bangkok began to lose its all-embracing connection with water and became a land- based city. Land -based activities, including building construction, tramways, electricity, gas-lighting and other urban developments followed. By 1910 the shape and aspect of the city had been transformed.

We may note that from the early 1890s onwards there was an even more a rapid rate of areal expansion when compared to the previous period as the city absorbed more of the surrounding countryside. Changes were now caused by the construction of roads rather than canals. During the period of 1890-1925, around 135 roads were built. Roads brought the expansion of trade and business and increased the size of the residential area .[6] We

6)For example,between 1890 and 1910, large areas outside the city walls, formerly used for growing rice, Chinese cabbage, green onions, mangoes, betal nuts, were developed as commercial, residential and industrial should emphasise that the changes took place as more roads were built. Before 1890 most residential areas were on the banks of the Chaophraya river and canals, but from the 1890s settlements developed further afield. This was the beginning of the residential and commercial quarter in the inner area, and the urban area expanded. Such transformation was helped by the introduction of western vehicles such as trams,bicycles, and later automobiles, from the late 1880s.

The major changes came from about the 1880s and 1890s, with a marked acceleration of population growth (much of it caused by Chinese migration) and an expansion of permanent land dwelling. As long as the area of Bangkok was confined, and the population small, city regulation could be maintained within the traditional Siamese social structures, with Bangkok being, in effect, a royal domain. But increasingly the strains of a burgeoning capital led to new forms of administration which had, nonetheless, to keep control in royal hands.

Thus the growth of Bangkok brought pressure for greater administrative regulation and new sources of revenue raising. The 1890s was a critical decade in the evolution of Bangkok as a true metropolitan centre and political capital, and among the many important changes of that era was the formation of a new Ministry overseeing Bangkok in 1892.[7] The Ministry of the Capital controlled a great deal of the revenue and expenditure concerned with Bangkok's development between 1892 and 1922, and worked closely with the Crown Property Bureau which was active in developing new areas of Bangkok, erecting houses [Sayomporn 1983; Thaweeesilp 1985; Chollada 1986] and in other ways promoting change in the capital. In this way, Bangkok's growth remained closely tied to its royal status.

---

areas, including Tung Woalumpong [currently Hualumpong], Tung Samsen [currently Samsen district], Tung Phayathai [currently Phaya Thai district], Tung Bangkapi [currently Bangkapi district], Suan Dusit [currently the area around Suan Dusit Palace], and Tung Sompoy [where ??]. The very names suggest the encroachment of the city on cultivated fields. [Tung in Thai means field and Suan means garden].

[7])The effects of the administration under the Ministry of the Capital on the growth of Bangkok between 1892 and 1922 were several. When the Ministry of the Capital was established, it was necessary to decide which districts should be included within the new jurisdiction especially the sanitary areas which covered the thickly populated parts of the city. In 1897/98, the first sanitary law was made to apply only to the area of the walled city. In 1922, the law was extended to PadungKrungkasem canal. Within this territory the Ministry of the Capital assumed responsibility for all arrangements affecting public health, urban construction, problems caused by the construction of roads, and other matters. The chief tasks included the removal and disposal of rubbish drainage, construction and cleaning of canals, construction and cleaning of public streets, supply of water, lighting of streets, maintenance and control of public markets, maintenance of hospitals, maintenance and control of slaughterhouses, enforcement of rules for the sanitary condition of private residences, the execution of laws relating to public health, and the detection and suppression of crime. The Ministry controlled the police, supervised the pawnshops, and issued licenses for a number of regulated activities. In short, the Ministry had a wide range of responsibilities, and the Ministry's role was clearly part of an attempt by the Siamese authorities to give Bangkok an administrative structure in keeping with a modern capital city.

The Privy Purse Bureau (PPB)[8] was also crucial to Bangkok's development . Bangkok's new streets were often laid out as part of row house (hong taew) construction for royal investment especially between 1890 and 1920.

As roads were built the price of land increased, and this attracted the elite and the PPB to invest in land and land related business such as market places and row houses. A survey of land prices in Bangkok in the first decade of the 20th century shows that the price of land was highest in the areas where roads were cut (Table 2).

Table 2 Price of Land in Bangkok ,1905-1911 Unit : Baht per square wa

Year	I: Land adjacent to road cutting [name of roads]	Year	II: Land not adjacent to road cutting
1905	20	1905	12
	Charoenkrung		Tumbon Silom
1905	293	1908	2
	Suriwong		Tumbon Silom
1908	160	1909	20
	Rajawong		Tumbon Silom
1910	450	1910	30
	Rajawong		Tumbon Rimboonklongsilom
1910	300	1910	50
	At the angle of Sampeng Road and Trok Kaosarn		Tumbon Tanon Pahurud
1910	170	1911	59
	Chakkrawat		Tumbon Trok Sibbia
1910	400	1911	2
	Sampeng		Tumbon Bangprakaew
1911	300	1911	6
	Luang		Tumbon Bangrak
1911	160	1911	18
	Charoenkrung		Tumbon Wat Yuan Khumloki
1911	300	1911	12
	Talard Kaosarnsampeng Road		Tumbon Banknanghong
1911	500	1911	12
	Rajawong		Tumbon Bangprakok
1911	350	1911	98

[8])The PPB was formally established as an independent department within the Ministry of Finance [Phraklang] in 1890. Prior to this, the PPB or formerly the Phra Klang Khangthi was established during the reign of King Rama II. It was known as *"Ngoen Khang-thi"* ' but its name was changed to *"Phara Khlang Khang-thi"* during the next reign.This organization was the king's personal institution. He was able to manage money to allocate to his own interests. During the reign of King Rama IV, 5 percent of the total state revenue, around 2,000 chang (160,000 baht), was regularly allocated to the PPB, together with the extra revenue from the land tax, another 2,000 Chang (16,000 baht) [Thaweesilp 1985 : 124-128]. In 1890, 15 percent of the total revenue was allocated to the PPB [N.A.R.5 M. of Finance 9.1-1 (1892)].

	Songward		Tumbonnawat Sungwejwisayaram
		1911	35
			TumbonSarn Chaokao
		1911	50
			Tumbon Rimtanonluang
		1911	60
			TumbonTalard Nanglerng
		1911	4
			Tumbon Tung Banmai
		1911	2-6
			Tumbon Bangsua
		1911	2
			Tumbon Samsen at The Northern Part
		1911	10
			Tumbon Hualumpong
		1911	20-30
			Tumbon Trok Wat Phrayakrai
		1911	2
			Tumbon Bangpong

Source: [N.A.R.6 M. of the Capital 15.2 no1(1909); N.A.M. of the Capital 15.2no.2 (1909-1910); and N.A..M of the Capital 15.2 no3 (1913)].

Figures for land prices indicate that prices rose considerably along roads such as Charoenkrung, Sampeng, Rajawong. When we compare well and poorly- situated land, the price of land in some adjacent areas varied by as much as 250 fold. For example, in 1911 price of land at Talard Kaosam Sampeng road was 500 baht per square wa, while price of land was 2 baht per square wa at the northern part of Tumbon Samsen. Bangkok's commercial development expanded whenever roads were cut, for instance along the edge of the south Charoenkrung road, Siphraya, Bangrak, Silom, Suriwong,Sampeng and Pomprab. Trading companies and merchant residences were mostly located along the main roads. Thus the traditional city plan of Bangkok which consisted of city moats and a complicated network of canals underwent a marked change to land-base building after the 1890's.

The Privy Purse Bureau and Bangkok's Development

The PPB acquired land in various ways. It was able to occupy public land, including unused land belonging to government Ministries, unused palaces, and unused land conferred on government officials [Orathip 1981: 10-13 ; Chollada 1986:114-192].

Land was also obtained through reclaimed mortgage, and the PPB frequently lent money on mortgage. Major customers of the PPB who mortgaged land and real estate were Chinese tax-farmers, aristocrats and senior bureaucrats. When borrowers were not able to pay their debts, the properties were transferred to the PPB. For example, a plot of the PPB land around Tawejnareamitre Bridge (5,321 square wa) had previously belonged to

Chaophraya Tawej who failed to pay a debt of 40,000 baht in 1910 [N.A.R.5. M. of Finance 9.2/14, no 76/1003]. Chaophraya Surawongwattanasuk bought land beside Talard Hualumpong (23,159 square wa) and mortgaged it with the PPB for 160,00 baht. Chaophraya Surasakmontri bought land (23 rai) and a house at Tumbon Saladaeng, and mortgaged it with the PPB for 2,755 Chang and 42 baht (220,442 baht) [N.A.R.5. M of Finance 8.1/39 (1897)]. In both cases, the properties were transferred to PPB when the mortgagees were unable to repay the loan.

The PPB could also directly buy land from ordinary people and always had the advantage in terms of obtaining information on road cutting, the price of land, the advantage of land location and so on. In this way the PPB acquired many plots of land established at good locations and commercial centres. As a result, the PPB investments in markets and row houses grew in the quarter century before 1910 in the main commercial centres such as Bangrak, Rajawong, Suriwong, Patumwan, Pahurad, Sampeng, Samsen,and Banglumpoo. As a result of occupying and buying land in various parts of Bangkok, the PPB then controlled both prime commercial land and valuable cultivated land. Table 3 shows PPB landholdings in 1902.

Table 3 Land Owned by the PPB Classified By Commercial Districts in Bangkok in 1902

Amphur	Tumbon	Land Acquisition(rai)
Sampeng	Pomprabsatroopai, Samyawd, Samphuntawong,	
	Chakkrawat, Patumwan	1,831
Bangrak	Sathorn, Bangkwang, Ban Tawai	458
Within the City Wall	WatChanasongkram, Prarajawang, Sumrarnraj, Pahurad	86
Dusit	Bangkunprom, Nang Lerng, Samsen	1,708
	Total	**4,085**

Source: [N.A.R.5 M. of Agriculture 6/6153 (1903)]

As the largest and most important land owner in Bangkok, the PPB was a contributing factor to the growth of Bangkok, influencing road cuttingand land use., Road building was heavily influenced by the King and the PPB,and road construction and row houses went hand in hand. For example, the Privy Purse Bureau would advance money to purchase a plot of land to build row houses,and then demand road cutting nearby or through the land to increase the price of land and properties. As recorded in King Chulalongkorn's handwriting in 1901 [Office of the Prime Minister 1970 : 129]:

Chakkri Mahaprasas

4 November 1901

No 26/1001

Dear Prince Nareesworarit

In dealing with a purchase of a plot of land to construct a road and the buildings [row houses] at the back of Talad Sao Chingcha, this should be done as soon as possible. The construction of the row houses is almost completed in this year.... So road construction in this area should be completed very soon. The expenditure for purchasing land has been charged to the Privy Purse Bureau, while the cost of road construction is financed by another department [Ministry of the Capital].

(Signature)

Chulalongkorn.

We should consider further the impact of road construction on row house investment. Throughout the years 1890-1932 the PPB was the largest owner of row houses, which were usually constructed along both sides of newly-cut roads. Row house investment was closely related to land investment by the PPB, and construction was undertaken along major roads in the main commercial districts, in Sampeng, Yaowaraj, Pahurud, Charoenkrung, and Fuangnakorn.The first available figure for row house building can be obtained from the postal census survey in 1883. Unfortunately, some parts of the postal roll in the National Library in Bangkok are missing. The available data for row houses on Fuangnakorn Road indicate that 83 of 315 households resided in the Privy Purse Department's row houses and 94 of them dwelt in private tenements[Tomosugi 1993 :27 and 29].

We have scattered market transactions which give a picture of growing activity in the twenty years or so before 1910:

In 1892, the PPB had 63 row houses for rent collection along the edge of Bumrung muang road. In 1899,the PPB bought the markets and 134 row houses of Krommuan Putharesthumrongsak whose mortaged properties were transferred to the Ministry of Finance .[N.A.R.5. M. of Finance 9.4 ng/11 (1900)].

In 1899, the PPB bought a group of buildings belonging to the Oriental hotel along the bank of the Chaophraya river. Total value was 375,000 baht [N.A.R.5. M.of Finance 9.4 ng /11 (1900)].

In 1900, the PPB had 215 row houses around the edge of Samsen Road, and 239, 133 and 17 row houses around the edge of Sangheenok road, Duangduan Nok (Sukhothai road), and Daokang road respectively. [N.A.R.5. M. of Finance 4.1/24 (1903)].

In 1902, the PPB constructed 140 row houses at Sampeng, Pahurud, Plublachai, Chakkrawat, and Hualumpong [N.A.R.6 M. of Finance 1/64 (1912)].

In 1902, there were some 616 row houses constructed by the PPB in Suan Dusit area [N.A. Office of Royal Secretariat N.58/272 no. 120/1172 (1902)].

In 1909, the PPB had a plan to construct hundreds of row houses around Tumbon Samsen [N.A.R.5. M. of Finance 4.1/24 (1903)].

In 1910, the PPB bought 20 row houses at the edge of Charoenkrung road from Kromkhunsabprasart Suphakit at a price of 96,000 baht [N.A.R.5. Office of Royal Secretariat n.s. 1.3/ (1910)].

We should emphasise that the Ministry of the Capital was a branch of royal supervision, rather than the sort of urban government independent of royal control which evolved in London and other European cities in earlier times. Thailand was an absolute monarchy until 1932 and absolutism had implications for Bangkok as well as for Siam's progress in general. The linking of Bangkok's administrative structure with royal interests produced both a physical and economic stamp on Bangkok which has had an enduring effect on the city's development.

4 Bangkok:1932-1950

After the impressive growth of Bangkok between 1890 and the1920s there was a slowing down. The interwar period, marked by the political convulsion of 1932, stagnation and lower prices in the world market, and the great depression of the 1930s, brought an end to vigorous growth. This did not lessen Bangkok's primacy though, and the revolution of 1932 strengthened Bangkok's importance in some respects.

The 1932 revolution overthrew the absolute monarchy and the subsequent evolution of the political system produced a state and bureaucratic apparatus which could provide a focus for national development. After 1932 new Thai elite groups emerged, and the "bureaucratic capitalists" with close military ties, and links also with powerful Chinese business groups, oriented the economy towards Thai economic nationalism and state- led enterprise. Such changes gave an"inward " direction to Bangkok's economy, which was strengthened by the ending of the last vestiges of the 19th century"unequal" treaties in 1926/27. A base was laid for metropolitan -based finance and enterprise which grew after 1945 [Falkus 1993 :151]. The Communist victory in China in 1949 was also of significance. Chinese remittances from Thailand to China dropped sharply and long- term investment by Thai-Chinese in Thailand was encouraged as links with their former homeland were severed [Falkus 1995: 28].

Above all, political and economic changes saw Bangkok develop from a " port-capital" to a more inward-looking "metropolis" with an increasing role as a financial and business centre, the beginnings of state-led industrial enterprise, and a more significant centre for Thai, as opposed to Chinese, migrants [Falkus 1993: 151].

During the world depression, exports and imports fell. Demand for labour stagnated and deteriorating economic conditions led to falling numbers of Chinese migrants. From 1938 Chinese immigration to Thailand dropped as South China ports were disrupted by the Japanese. Fewer migrants left China for fear they might not be able to return, while there was an upsurge in departures from Thailand. During the war years, migration virtually ceased. In 1946-7, a sharp revival was then cut short by immigration restrictions[Skinner 1957:176].

The war and immediate post war years was a significant period in Bangkok's development as a megalopolis. One feature was migration to the city where jobs were more available and wages higher than in the provinces. While economic activities in general were curtailed a great number of farmers deserted their farms to seek employment in Bangkok.[9] Very rapid inflation led to economic dislocation and often hardship,especially in the years 1943-47.

We have already seen that Bangkok's primacy was clearly established prior to the 20th century. Bangkok's primacy did not mean rapid population growth or the emergence of a modern industrial city. There was no large industrial base or influx of rural migrants to the city. Furthermore, prior to 1950, Bangkok's proportion of Thailand's population increased only gradually. Bangkok contained perhaps 4-6 percent of the total between 1913-1929, and may have fallen a little by 1947, when it stood at 4.4 percent.

5 Bangkok After 1950

By 1960 Bangkok was in the process of a transformation taking it from a moderately-sized metropolis of some 1 million in 1950 to a large diversified and growing industrial city of some 3 million by 1970. By the late 1980s Greater Bangkok had grown to more than 8 million. Bangkok's proportion of Thailand's total population rose steadily over the years, from under 5 per cent in the 1940s to about 7 per cent by 1960, 9 percent in 1970, 11 percent in 1980, and 14 percent in 1990.

The overwhelming dominance of Bangkok has created an unusual distribution of the urban and rural population. In 1947 Bangkok's population was 20 times the size of the second largest city, Chiang Mai. In 1960, the ratio with respect to Chiang Mai 's population was 26 to one, in 1970 35 to one, and in 1980 55 to one [Falkus 1993:144] Now Bangkok contains over 8 million while Korat, the second largest city, contains around 300,000. In the 1980s, Bangkok accounted for 70 percent of the nation's telephones, generated 70 percent of its income tax, generated 75 percent of the annual value of Thai manufactures, contributed 30

9) The Bank of Thailand reported the situation of Thai farmers in the war and intermediate post war years :

Low earnings on farms due to a comparatively slow rise in the price of paddy until 1946 has caused large numbers of cultivators to move to more remunerative occupations especially in urban areas. Great loss of farm animals by Japanese spoliation, infectious disease and smuggling, as well as prevalence of crime were also contributory causes of low rice production in 1945, and to a smaller extent in 1946. Some of these detracting circumstances still remained in 1947. Teak exploitation became disorganized during the war, resulting in great loss of extracted logs and the halving of production. Much damage was caused to mining equipment and rubber plantations through neglect and disuse. Direct damage by aerial bombing was done to business buildings, industrial plants and electric power stations. Restoration of most of the damage was still delayed in 1947 and will take time. [B.O.T. n.d.: 3].

percent of Gross National Product, and handled more than 80 percent of Thailand's sea-borne foreign trade.

Bangkok exerted an increasingly dominant influence on nearly every aspect of Thai economic, social and cultural life. For example the spread of television, the cinema, and the Bangkok-centred school curricula, enhanced the status of Bangkok and of the "Bangkok language", and cemented the cultural superiority of the capital. Ambitious country youngsters rarely saw their futures within the confines of their local areas, but rather looked to the opportunities presented by Bangkok.

From around 1980 Bangkok's role changed yet again, as a major regional capital of a "tiger" economy. By this time the capital was experiencing many problems associated with environmental degradation, large slum communities, traffic congestion, and so on. Such problems have been accompanied by a growing realisation that the Thai economy has been centralised in Bangkok, and active steps should be taken to spread development and the benefits of growth to regional centres.

Bangkok increasingly attracted migrants from the rural sector, stimulated by rapid population increase. The 1950s and 1960s saw significant rural to urban migration, and migration continued to account for much of Bangkok's population growth in the 1970s [Paritta 1993:26]. After 1950, 40-50 percent of the increase in Bangkok's population resulted from rural in-migration, and the net number of in-migrants to Bangkok doubled from 1955-60 to 1965-70. [Sternstein 1979 : 30]. From the 1980s, however ,the movement to Bangkok slowed down, but movement to the central region rose significantly.

Migrants as a proportion of Bangkok's population were 7.3% in 1960, , 11% in 1970, and8 % in 1980. The majority of migrants to Bangkok in the period 1955-80 came from the central region, but their percentage declined from 61.82 % in 1955-60 to 42.37 in 1975. By contrast the percentage of migrants from the northeast increased from 20.35 % to 35.11 %. [Paritta 1993: 28]. By 1980 northeastern migrants ranked first and their proportion has continued to increase.

The 1960s was a crucial period in the shaping of modern Bangkok. Expansion began in the 1950s, but at this stage the overall shape and appearance of the pre-war city still remained intact. From the early 1950s, the old European business area along Charoenkrung road was pushed out from the river along Silom and Suriwong roads, and finally joined with Rama IV road to form the fastest growing area in Bangkok. The expansion of other business districts was noticeable along Ploenchit, Petchaburi and Asoke roads. Old roads were re-surfaced, widened, reconstructed and provided with modern facilities for sanitation and traffic control . Roads were built or upgraded to improve access to the new port at Klong Toey and to Don Muang airport. Settlement in outer districts such as Bangkane, Din Daeng, Phrakanong, Samut Prakarn, Pathum Thani and Prapradang increased in importance, and also demanded the improvement and construction of new roads.

Newspapers of the time noted the changes in the city, the various new buildings, road widening schemes, new bridges and so on [Siam Rath Thai Weekly Review, November 23, 1958]. The bicycle pedicab disappeared from the central streets in 1959, a sure sign of the progress of the city.

Despite this expansion, in 1960 the shape and economic functions of Bangkok would have been familiar to those acquainted with the pre-war city. The rice trade still dominated commercial activity, canals still played a role in day-to-day transport and living, and New Road still formed an identifiable "city centre".

From 1960, the pace quickened. In 1961, the start of the first National Economic Development Plan (1961-66), a number of canals were filled to build roads, including Silom, and Hua Lumpong (Rama IV). In the early 1950s, there were still nearly 100 functioning canals in Bangkok and Thonburi, [Thebchu 1975 : 55-62 based on Government Gazette, Various Years] but by 1970 only one-third remained, with some reduced to small conduits in the middle of major roads. The disappearance of canals in the 1960s was a feature of the period.

As the size of the city expanded in the 1970s, the inner part of Bangkok surrounded by the old city wall slowly lost its population as people moved away to other sections of the city. The old business district along Charoenkrung and Yaowaraj roads also suffered a decline in relative importance as new trade centres emerged at Patunam, Rajaprasong, Siam Square, Suriwong, Saphankwai, Wong Wien Yai in Thonburi, Phrakanong and Banglumpoo. By the early 1980s, the city absorbed more and more of the surrounding countryside and Nonthaburi, Pakkred, Pathumthani, Rangsit and Samut Parakarn became an integral part of Bangkok.

The growth of Bangkok's built up area is given in the Table 4. In the 1970s and 1980s the rate of aerial expansion accelerated; in 1981 the built -up area covered 330 sq. km. and in 1988 was increased to 620 sq.km.[Falkus 1993 :156]

Table 4 Bangkok: Growth Rates of Built-Up area and Population

Year	Area	Population
1936-53	2.6%	1.6%
1953-71	5.8%	5.5%
1971-88	7.4 %	4.1%

Source: [Falkus 1993: 157]

Factors Affecting Bangkok's Growth

How do we explain the very large aerial expansion of Bangkok's built-up area? Four factors have been significant. One has been the rapid growth of Bangkok as a financial, commercial and tourist centre.US military involvement in the Vietnam War in the 1960s developed Bangkok's service industries. The financial, commercial and tourist industries experienced rapid growth, and construction followed in their wake. The presence of the U.S. military in Vietnam in the 1960s induced an influx of foreign direct investment boosting the growth of industry in Bangkok. Tourism added to the expansion of services and construction. Among reasons for the increase in tourism were the stable political atmosphere[especially in the 1960s] and the development of Bangkok as a crossroads of international air transportation. The hotel industry and the retail industry both expanded rapidly on tourist demand. With a natural concentration of these sectors (such as hotels and department stores as well as offices) in the inner city areas, land prices soared. In turn, populations living in the central areas grew slowly or even declined, the most rapid growth thus concentrated in intermediate or outlying zones [Falkus 1993:157]. Secondly, particularly important was a major burst of construction activity during the Sarit period: new suburbs developed and hotels and other commercial building sprung up. At the same time, the new port at Klong Toey, opened in the 1950s, greatly enhanced Bangkok's role as a trading centre, and opened up a new area of the city for development . Thirdly, a growing number of industrial plants created diversified jobs for unskilled labourers who migrated from the provinces. The rural migrants constituted a substantial component of the city's population. Often, growing industries were established on the fringe of the city to take advantage of low land prices and the urban public utilities. A very rapid growth of industry not only encouraged the urban area to expand but also generated demand for building construction for offices and housing.

Fourthly, we must add that the lack of urban planning and multiplicity of overlapping municipal authorities meant that new land for expansion could often be acquired and developed in a quite undisciplined and uncontrolled fashion.

Crucial in this phase of Bangkok growth was the development of cheap labour industrialization. Here we will investigate a theme suggested by Malcolm Falkus to explain the evolution of the labour market in twentieth century Thailand [Falkus 1991]. In developing this theme, we present new archival evidence to shed light on the relative wage movements in the urban and rural sectors and suggest that the key factors influencing the movements were rural population growth on the one hand, and the growth of job opportunities in Bangkok respectively. From around the 1950s, these two forces combined to encourage a significant flow of Thai rural labour to Bangkok for the first time: hitherto Bangkok had grown rapidly on natural increase and Chinese immigrant labour.

The author's study of Bangkok [Porphant 1994] has confirmed that prior to the Second World War there was only limited growth of the major city, Bangkok, and during the interwar years Bangkok 's population hardly kept pace with the overall growth of Thai population. From around 1950 the position changed, and Bangkok grew markedly faster the overall population growth. The key problem to be explained here is the nature and timing of the change.

Before we look at the models underlying change in labour supply and demand , we will examine evidence on relative wages in the rural and urban sectors.

Table 5 distills existing wage data over the period 1904- 1970. It is apparent that between 1904-1931 (unfortunately we have no data for 1913-24) there was no clear trend in real wages, upwards or downwards.

Table 5 Wage Rates for Unskilled Labourers per Region, 1904-1970 (baht per day)

Years	Bangkok (1)	Bangkok (2)	Rural Areas (3)	Rural Areas (4)
1904	.50			66
1905	.50-.75			.89
1906	.75			2-3
1907				1.10
1908				6
1909				.93
1910				.93
1911				.94-1.10
1912		.87		1.10
1913		.82		
1914		.75		
1915		.75		
1916		1.00		
1917		1.00		
1918		1.00		
1919		1.00		
1920		1.00		
1921		1.00		
1922		1.00		
1923		1.00		
1924		1.00		
1925		1.00		.80
1926		1.00		.76
1927		1.00		.80
1928	.75	1.00		.80
1929	1.0	1.00		1.10
1930	1.0	1.00		.94
1931		.80		.75-1.10
1932	.50	.80	1.8	
1933		.80	1.00-2.00	
1934		.80	1.20-1.70	
1935		.80	1.5	
1936		.80	1.5	
1937	.50-.60	.80	1.00-1.25	
1938	.80	.80		
1939	.64-1.00		1.20-2.00	
1940			2.00	
1941			2.00	
1942			1.50-2.00	
1943	1.00-1.50	1.27	1.50-2.00	1.50-2.00
1944		1.96		
1945	4.00	2.46	2.50	
1946	4.00	5.22		
1947		8.80		
1948	10.00-15.00			
1949	12.00	12.00-15.00		7.54
1950				7.90
1951	16.80		10.00	6.91
1952	16.80			7.92
1953	19.80			8.08
1954	19.80		10.00	

1955	25.00-30.00		8.00
1956	21.00	15.00	8.00
1957	21.00	11.00	
1958	20.00		
1964	22.00		10.00-12.00
1965	20.60		10.00
1965-67	21.00-22.10		8.00-10.00
1970	23.30		10.00
1971	23.30		9.00-12.60
1972	21.00		
1973	24.11		
1974	27.32		
1975	33.90		25.00
1976	33.85		14.00-30.00
1977	n.a		15.00-30.00
1978	36.36		15.00-35.00
1979	41.68		n.a
1980	49.20		36.30
1981	59.00	45.00-52.40	
1982	61.50	52.00-58.3	
1983	n.a	n.a	
1984	n.a	n.a	
1985	80.0	55.90-73.00	
1986	84.0	56.00-73.00	

Sources: [N.A.R.5. M. of the Capital 23.5/1 (1906)], [N.A.R.5. M. of the Capital 22.3/2 (1907)], [N.A. R.5 M.of the Capital 5.8/25 (1910)], [N.A. R.7 M. of Interior 26.5/79 (1928)], [N.A. M. of Education 0701.7.1/13 (1929)], [N.A. M. of Education 0701.7.3.1/15 (1929-30), [N.A. Office of the Prime Minister 0201.75/11 (1933-36)], [N.A. M of Education 0701.28.3/2 (1937-38)], [N.A. (2) Office of the Prime Minister 0201.75/38 (1947-49)], [N.A. M. of Education 0701.26.3/2 (1947)], [N.A. Office of the Prime Minister 0201.75/5 (1948-54)] , [N.A. M. of Education 0701.23.3 (1949)]. , [N.A. M. of Education 0701.2.6.3/12 (1953)]., [N.A. M. of Education 0701.26/25 (1954)]., [N.A. M. of Education 0701.26.3/16 (1954)]., [N.A. M. of Education 0701.23.3/13 (1954)], [N.A. M. of Education 0701.26.1/24 (1954)].,

[Railways Authority of Thailand, (1951 - 1957) Various Issues],
[Bureau of Labour Statistics :1959 : 14].
[Usher n.d. 13].
[Department of Labour 1964; 1966; 1967, 1970,1971].
[Ingram, 1964 :115]
[Department of the Secretary-General of the Council of Ministers, Various Years]
[Bank of Thailand, n.d]
[N.A. M.of Education 0701.26.1/24 (1954)]
N.A.M. of Education 0701.26.1/25 (1954) ;
Bureau of Labour Statistics :1959 : 14].
[Central Statistical Office 1954]
[Usher 1966 :441].
[World Bank 1980 : 55].
[Ministry of Agriculture 1964].
[Nipon 1981 :75]
[Porphant 1996:74 and Porphant 1998 : 82-83]
[Pradit 1990 :53-54]

Note: According to column **Bangkok (1)**, wages for construction workers in public projects in Bangkok
According to column **Bangkok (2)**,wages for unskilled labourers in Bangkok.

According to column **Rural Areas (3)**,wages for construction workers in public projects in the provincial areas.
According to column **Rural Areas (4)**, wages meant farm wages for hired farm labourers in the provincial Areas.

In some years wages for hired farm labourers were very high. Thus in 1906 wage rates for hired labourers were about 2 to 3 baht a day and in 1908 jumped to 6 baht plus a share of the crop on some farms in Rangsit. The high level of rural wage rates compared to those of unskilled coolies in Bangkok suggests that demand for labour in the central plain exceeded supply. According to Johnston:

Agricultural wages increased rapidly during this period (the 1890s), from a pre-boom rate of one to two baht per day, up to as high as three baht a day in 1907 and a seemingly incredible rate of six baht per day, plus a share of the crop on some Rangsit farms in 1908. Even at these rates, the demand for agricultural labour exceeded the available local supply [Johnston 1981 : 113].

Table 5 shows that in 1932 general labourers in Songkhla earned 0.75 baht per day [Damrong Rajanuparb 1990 : 17]. In 1933, unskilled workers in construction on public projects in Chiang Rai earned 1 baht a day, and the daily wage for unskilled labourers in construction projects was 1.20-2.00 baht [N.A. M. of Interior 2.3.9/2 (1933-34) ; N.A M. of Interior 2.3.9 /1 (1933-34)]. In 1934, the daily wage stood at 1.2 baht for unskilled labourers in public construction in Songkhla, and 1.20-1.50 Baht in Samut Prakarn [N.A. M of Interior 2.3.9 (1933-34)]. Between 1935 and 1936, unskilled labourers in Ranong earned 3 baht a day [N.A. M.of Interior 2.3.9/9 (1934-35)]. In 1937, daily wages on public projects in Sukhothai were 2 baht a day [N.A. M. of Interior 5.12/298 (1941)]. In 1939, unskilled labourers in road construction at Betong Songkhla earned 1.20 baht per day [N.A. (3) Office of the Prime Minister 0201.22/14 (1943)], while unskilled labourers in public construction projects at Sukhothai earned 2 baht per day [N.A. M. of Interior 5.12/298 (1939)]. In 1940-1, daily wages for general workers in a public construction in Saraburi were recorded at 0.60 baht [N.A. M. of Education 0701.26.1/15 (1940-41)], while daily wages for unskilled labourers in a public construction project in Trang in the same period were 2 baht [N.A. M. of Interior 5.12/2.86 (1941)]. In 1942, wages for unskilled labourers were 1.5-2 baht in Saraburi, 1.5-2.0 baht in Kanchanaburi and 1.00-1.50 baht in Nakhon Pathom [N.A. (3) Office the Prime Minister 0201.75/13 (1943-51)]. In 1944, the daily wage for unskilled labourers in railway construction in Ratchaburi was 1.5 baht per day [N.A. (2) Office of the Prime Minister 2.4.1.7/30 (1944)].

Between 1904 and around 1950, then, money wages for unskilled workers in Bangkok seem to have been no higher, and generally were lower, than money wages earned by unskilled workers in the provinces. By the 1950s circumstances had changed. As we have seen, rural unskilled wages now lagged behind urban unskilled wages.

From 1950 onwards, wages of unskilled labourers in Bangkok were significantly greater than those earned by rural hired farm labourers and employees engaged on private and government projects in the provinces (Table 5). Wages for unskilled labourers in the department of railways in Bangkok in the early 1950s were 16.80 baht a day [Railways

Authority of Thailand, (1951-1957) Various Issues] while farm labourers in Bangchan village in 1951-3 were paid 7-8 Baht a day [Kamoll 1955:195]. In 1951, the wage for unskilled labourers for cleaning the temple in NakhonSawan province was 10 baht a day [N.A. M. of Education 0701.26.1/21 (1951)]. In 1954, the wage for unskilled labour in the department of railways in Bangkok was 19.10 baht per day, while the wage offered for repairing a temple in Phitsanulok province was 10 baht a day [N.A. M.of Education 0701.26.1/24 (1954)]. In the same year, the wage for unskilled construction workers repairing the National Museum in Bangkok was 30 baht a day [N.A. M. of Education 0701.23.3/13 (1954)], while construction workers repairing the temple in Nakhon Si Thammarat earned 15 baht a day [N.A. M. of Education 0701.26.1/25 (1954)].Throughout the whole period 1951-1970 Bangkok wage rates for unskilled workers remained above those in rural areas. For example, wage rates for highway construction labourers in Bangkok ranged between 20.60 and 23.30 baht a day between 1964-70, while wages for hired farm labourers in the central plain were 8.00-12.00 baht a day over the same period (Table 6). From 1980 though, nominal wage differentials between Bangkok and the provincial areas were not substantial, and lack of clear and significant wage differentials suggests that migration served to link the labour markets in Bangkok and the provincial areas quite efficiently[Bertrand 1980 :480-511].

6 Analysis: Before 1950

Why should rural unskilled wages have been above those of unskilled urban wages before 1950 ? The basic answer lies in the relatively high returns to rural labour in agriculture, and the undeveloped urban sector with few job opportunities.

High wages in the provincial areas were caused by the relatively high productivity of Thai agriculture in relation to labour input. According to Falkus,

The relatively favoured situation of the Thai peasant should be seen in international perspective. In 1883 wages in Thailand were apparently three times higher than wages in Japan. The underlying factor was the relatively high productivity of Thai agriculture in relation to labour input... Around 1900 a farmer in Japan had to work twice as long to gain a similar amount of rice as his counterpart in Central Thailand. Thai yields were also well ahead of those in Java before the Second World War [Falkus 1991:61].

The high labour productivity in Thai agriculture was made possible through the abundance of land. Although rice yields per rai were very low, output per worker per hour worked was very high. Lower labour productivity in rice farming in Japan and Indonesia was attributed to the excessive supply of farm labourers in relation to land, which outweighed the effect of using more advanced biotechnology than Thailand[Sompop 1989:170].

Prior to the 1950s, the country was sparsely populated and relatively little urbanised. Thailand's population in 1855, according to Bowring, was probably around 4.5 - 5.0 million, while the revised census figure for 1911 was 8.3 million. These figures yield a growth rate over the period 1855-1911 of around 1 percent per annum. Although neither the 1855 or 1910-11 estimates can be considered reliable, such a gentle rate of growth seems credible in view of the fact that there were no invasions and wars, and some improvements in medical care introduced by western missionaries. From 1911 to 1947, the population doubled to 17.4 million, growing at an average rate of 2.1 percent per annum.

The abundant land encouraged agriculture with existing traditional techniques, and the number of hectares of cultivated land per worker increased. Feeny's estimates show that the paddy area per person (land man ratio) which in 1905/06 was .164 hectare/person grew at an average annual rate of 1.19 percent during the period of 1905/06-1941 [Feeny 1982:45].[10] Population pressure was not severe, and the average peasant family could sustain a reasonable livelihood while still enjoying significant leisure time[11]. The preferences for rice farming and village living can be explained by the fact that Thailand was underpopulated with an abundant supply of land. Labour in rural Thailand before 1950 was relatively fortunate in terms of income earning and the high opportunity cost of moving [Falkus 1991: 59]. Sompop found that throughout the period 1905 to 1925, a broadcast rice farmer with 8 hectares of land (roughly the average size of a paddy farm in the central plain in the interwar years) usually had an annual income well in excess of coolie labourers in Bangkok [Sompop 1989: 168]. In addition, the peasant still had access to food sources such as fish, crabs, frogs, fruit and vegetables found in the rivers, rice fields and forests. The general picture must be one of relatively high rural incomes. High opportunity cost of moving was a crucial factor in keeping Thai labour engaged in rural agriculture. Rice remained the single most important product, the largest source of employment, and the largest source of foreign exchange earning. Under these circumstances, Chinese immigration played an important role in developing the non-farming occupations in Thailand, especially in Bangkok (see next section) and the influx of Chinese immigrants helped keep down unskilled urban wages.

Although the focus of this paper is upon changing supply conditions for rural labour in Thailand, a word or two may be said about demand for labour. The nature of the Thai economy, both in Bangkok and the provinces, meant that the market for labour was little developed before the 1950s. In the rural sector, wage labour was characteristic only of the central region , while in Bangkok much of the paid labour force(in factories, in transport, in port activities, in shops) came from the Chinese community. The limited formal labour market is one reason why satisfactory wage data are so hard to find.

We may be confident that in the post Second World War years a growing demand for labour in Bangkok, associated with various factors such as government policy and declining Chinese immigration, took place. Before the war, though, labour demand was limited by the slow pace of Bangkok growth and by the impact of the world depression. We should, of

[10])From 1905/6 to 1924-25 the paddy area per person grew at 2.45 percent per year and then declined at .21 per cent from 1924/25 to 1941. He also found that land /man ratio(using the area in major crop grew at a similar rate as it was in the case of paddy areas [Feeny 1982: 44-45]

[11])An anonymous referee perceptively pointed out that high leisure preference may explain that the Thai peasant's reluctance to move to urban occupations. To this extent real wage differentials tell only part of the story. However, it is not easy to explain why leisure preference should have declined markedly after 1950, and real wage differentials seem to give a more coherent (though admittedly partial) explanation.

course, emphasise the extent to which Bangkok's commercial sector depended upon unskilled Chinese labour.[12]

The interplay of supply and demand factors resulted in the characteristic of the labour market discussed here : a limited flow of rural labour to Bangkok before the Second World War,but an enhanced flow thereafter.

The Implication for Bangkok's Growth prior to 1950

Under these circumstances the limited flow of labour from rural to urban is hardly surprising. No large influx of rural migrants to Bangkok occurred prior to 1950. China, with its enormous population and unsettled economic and political conditions, provided a large flow of cheap labour to Thailand and other Southeast Asian countries. Skinner found that unskilled wages in Bangkok had long been higher than in any other ports in East Asia [Skinner 1957:116]. Skinner noted " Chinese laborers [in the 1880s] in Siam could earn wages double those prevailing in South China ports and live both better and cheaper than in his own country" [Skinner 1957: 117]. Hence, the inducement to Chinese coolies to migrate to Bangkok was great. The Chinese played an important role in Bangkok's population growth. The numbers of Chinese in-migrants at the Bangkok Port were around 16,000 a year in the 1880s, 25,000 in the 1890s, 60,000 between 1900 and 1920, and over 100,000 a year in the 1920s. In the 1930s and afterwards, with the depression, the war, and quota restriction, arrivals decreased to 45,000 a year in the 1930s and 31,000 a year in the 1940s.[Skinner 1957: 173].Bangkok's population was around 365,000 in the early 1910s [N.A. R.6. M. of the Capital 27/3 (1909-1914)] and 780,000 in 1947. As we have seen the limited internal flow of rural labour to Bangkok was reflected in the relatively low, and near-constant, ratio of Bangkok's population to the total.

Also, there was little industrial development in Bangkok prior to 1950. Industry in Bangkok at this time was practically limited to the preparation of agricultural produce, the building trades, utilities, and a few factories making consumer goods for local use. Compounding the situation was the isolation of much of rural Thailand from Bangkok, for there were no roads linking Bangkok and the provincial areas until the late 1940s.

The other side to the coin of an "inflexible" supply of Thai labour for Bangkok was the great and continued significance of the Chinese. The most important industries in Bangkok were rice mills, shipping, and saw mills, mostly in the hands of Chinese. The Chinese provided most of the heavy industrial labour force, particularly in rice mills, on the quays and in construction, and also provided most of the craftsmen (carpenters, masons, fitters and other skilled occupations). They were also the chief trading class and were responsible for much of the secondary industry such as small foundries, ice factories and so on. They were also, as everywhere, the market gardeners.

---

[12]) Thai and Chinese labour were by no means substitutable, Chinese entrepreneurs continuing to show a marked preference for Chinese employees (a preference which contained long after the end of heavy in - migration after 1949).

7 Analysis: After 1950

What factors promoted the change ?

One change was rapid population growth. The rate of growth of Thailand's population, which had averaged 1.9 percent per annum in 1937-47, accelerated to 3.2 percent in 1947-1960, then fell to 2.8 percent in 1960-70 and 2.7 percent in 1970-80, taking Thailand from a sparsely populated country with an extensive land frontier to a heavily settled country. In 1929 the Thai population was just 11 million in, 1947 it was around 18 million, in 1970,34 million in 1980, 44 million , and today some 60 million. Thailand's population density was 34 persons per square kilometres in 1947 and increased to 51,67,92,109 in 1960,1970, 1980 and 1990 respectively (Table 6). These high growth rates put pressure on rural incomes and wage rates, and led to increases in poverty, tenancy, indebtedness,[13] and a decline in rice output per person in some regions. There was also a growing disparity in income levels between rural and industrial occupations, and especially between Bangkok and the provincial regions.[14] Such differentials must have been significant in encouraging migration from the provinces to the city, which in turn kept down urban wages. The gap, moreover, grew over time. In 1975 the average income in Bangkok was double that of the nation as a whole; in 1986 the figure had increased two -and a-half-fold. In the former year average incomes in the northeast were 37 percent of those in Bangkok, in the latter year they were 23 percent [Falkus 1995: 30].

Table 6 Population of Thailand , 1911-1990

Year	Population of Thailand (millions)	Annual Growth Rates (%)	Density (persons per sq.km.)
1911	8.3	-	16
1919	9.4	1.4	18
1929	11.5	2.2	22
1937	14.7	2.9	28
1947	17.5	1.9	34
1960	26.3	3.2	51
1970	34.4	2.8	67
1980	44.8	2.7	92
1990	56.3	2.3	109

Source: [Thailand Statistical Yearbooks ,Various Years ; N.A. R.6 M. of the Capital 27/3 (1909-1914); and Ministry of Interior, Various Issues]

Low productivity in rice production constrained rural wages and incomes. Between 1959 and 1966, the area under rice cultivation expanded. The north had the highest growth rate of 4.1 percent per annum, followed by 3.5 percent in the northeast as compared with less than 2 percent for the central region and 2.8 in the south[Pasuk 1980:197]. The high growth

13) For a fuller discussion see [Ammar 1979 ; Udis 1958].

14)There are a number studies on income distribution in Thailand [see Oey :1979 ; World Bank 1980b Somchai 1987 ; Medhi 1988 :967 ; Ikemoto 1991].

rate of rice land for cultivation in the north and northeast was caused by the increase of population and the expansion of national highways linking the countryside. In the central plain, the area under paddy increased partly because of an extension of irrigated land in the region. Rice yields (based on area planted) were among the lowest of the major rice-producing nations in the world. The average for the northeastern areas was just 140 kilograms per rai in both 1957/58 and 1958/59, while the average for the entire country was 175 and 198 [N.A.M.of Finance (1) 1.3.3.2/4 (1960)].In 1958 one survey showed that in the populous northeastern provinces of Roi-et,Sisaket,and Nakhon Phanom,the average output of rice was well below that necessary to sustain an acceptable level of subsistence [Falkus 1993:161].

A feature of the 1950s and 1960s was the impact of the rice premium policy which was imposed to encourage agricultural exports and keep down urban rice prices. This is a complex topic ,but most writers [for example Ammar 1989; Bertrand 1969; Silcock 1967:231-257] conclude that the policy resulted in a significant transfer of income from the rural to urban sector.[15] Virabongsa (1972) concluded that the abolition of the rice premium would have increased paddy output by 2.1 per cent and the paddy cultivated area by 1.4 per cent annually between 1953-1969 [cited in Rungsan 1987: 209]. Sarun (1978) showed that if the rice premium was eliminated paddy output and cultivated area would have increased by 0.9 and 0.8 percent annually respectively [cited in Rungsan 1987: 210). Chesada (1978) estimated that the domestic price of rice would have risen by 38 percent and paddy output and overall farm income would have increased by 30 percent [cited in Feeny 1975:113]. The rice premium obstructed the modernisation of the agricultural rice sector since it distorted the rate of return from rice farming. It led to lower rice productivity because the rice premium reduced the attractiveness of the use of fertilizers, pesticides, chemical inputs, and mechanization.[16] This resulted in the slow growth of rice and the rapid growth of t exported upland crops such as maize, kenaf, and cassava. The share of paddy land in total cultivated areas declined throughout the post war period, from 88 percent in 1950 to 68 percent in 1965 [Bertrand 1980:21].[17]

In addition to population growth and low rural productivity wage differentials between the city and the provincial areas were also increased by the reduction of Chinese immigrants following the Second World War. From May 1947 only 200 migrants were allowed to enter annually, which tended to raise wages in Bangkok.

---

15) A comprehensive survey of the recent literature on aspects of the economic impacts of the rice premium on the Thai Economy is contained in Rungsan [Rungsan 1987].

16) Per capita fertiliser use in Thailand was very low. In 1962-63 it was 1.8 lbs per capita which was only 4.8, 5.8 and 6.9 percent of the comparable levels for Japan (37.4 lbs per capita),Taiwan (30.8 lbs per capita), and Korea (25.9 lbs per capita) respectively [Bertrand 1969: 181].

17) Bertrand also estimated that the rice premium resulted in a substantial disincentive measured by market returns to land that undervalued rice by some 50-70 percent The rice premium led to market returns to land that were generally around 100-300 baht per rai, substantially below what could be obtained from biannual upland crops [Bertrand 1980:71-79].

Regional wage differentials were also caused by rapid urban expansion. Following World War II Bangkok experienced rapid growth in light manufacturing and, more particularly, in service industries, including construction, public utilities, retail and wholesale trade, and entertainment.

Especially from around the 1960s there was a distinct urban bias in the nature of Thailand's development. Government policies enshrined in the development plan of 1961 supported import-led growth and laid emphasis on investment in manufacturing industry. These policies promoted Bangkok at the expense of the countryside, often drawing the best human resources away from the villages. Also in the 1960s, the expansion of tourism together with the presence of U.S. military personnel boosted the service sector of Bangkok. The Vietnam War had a major stimulating effect on the Thai economy through a growing inflow of foreign capital. The construction of American bases and related infrastructure such as highways and spending by American servicemen on leave reached a total equivalent to around 30-40 percent of total Thai exports in the late 1960s [Boonkong 1974:215]. Jobs were by no means solely or even mainly in the industrial sector, but were spread across a wide range especially in services. Demand for labour increased considerably. Manual jobs in the service sector constituted most of the non-professional urban jobs especially in the 1960s. Over the 1960s, the share of construction in Bangkok's labour force increased from 2.10 to 5.21 percent (21,245 to 72, 007 employed workers), transport from 5.36 to 6.26 percent (54,290 to 86,588 employed workers), and other services from 22.36 to 28.34 percent (46,840 to 63,510 employed workers) [NSO 1960 ; 1970]. The 1960s in particular was a time of immense physical change in Bangkok under the rebuilding enthusiasm of Field Marshal Sarit.

In 1986, for the first time, exports of manufactured goods exceeded those of agricultural goods. Rice ,which had been 65 % of the value of total exports in 1953, was but 20 % in 1969, and 8 % in 1988. Manufactured goods, only 1.2 % of exports in 1960, were 28.3 % in 1980 and 40.2 % in 1988[Falkus1991:59]. Also, the jump in foreign investment was dramatic. In the years 1980-7 net foreign direct investment averaged 6 million baht with a low of 3.8 billion baht in 1980 and a high of 9.6 billion baht in 1984. In 1988,the figure was 27.6 million baht and in 1989 39.4 billion baht, with over half going into industrial sector. [Falkus 1995 :24]. Much investment was directed to export-oriented manufacturing rather than import substitution, overwhelmingly in the Bangkok area, and new industries continued to locate near fringe of the city to take advantage of low land prices and access to ports and trunk roads. Tourism added to the expansion of services and construction. Bangkok's service sector has been increasingly geared to the reception of overseas visitors, andtourism became the largest export earner from the 1980s until the present . Employment in Bangkok in the 1980s grew faster than in the rest of the country, with an annual growth rate of 6.5 % in the BMA and surrounding five provinces compared to 3.5 % for the Thai workforce [Askew 1993:25].

The Implication for Bangkok's Growth After 1950

After the Second World War, with the rapid overall population growth, a pool of "cheap" rural labour developed which could supply the industrial and service sectors in Bangkok, on which further growth depended. Wages in Bangkok rose compared to the provincial areas.

Bangkok's population has increased at a rate at least double the national average since 1950 (Table 7).

Table 7 Population of Thailand and Bangkok's Growth , 1911-1990

Year	Population of Thailand (millions)	Annual Growth Rates	Population of Bangkok- Thonburi (millions)	Annual Growth Rates
1911	8.3	-	0.34	-
1919	9.4	1.4	0.43	3.3
1929	11.5	2.2	0.68	5.8
1937	14.7	2.9	0.53 (excluding Thonburi)	-
1947	17.5	1.9	0 .78	4.7
1960	26.3	3.2	1.80	9.3
1970	34.4	.2.8	2.61	4.4
1980	44.8	2.7	5.15	8.8
1990	56.3	2.3	6.84	3.1

Source: [Thailand Statistical Yearbook Various Years ; N.A. R.6 M. of the Capital 27/3 (1909-1914); Ministry of Interior, Various Issues.]

Given the many factors encouraging industrial productivity in Bangkok (for example, technology transfer through foreign capital, Sino Thai entrepreneurship, pro-capitalist policies by the government, and so on), low urban wages raised the profit rate in the modem sector in Bangkok, and encouraged the expansion of an industrial sector which relied heavily on cheap labour. Falkus noted that:

Yet one only has to consider the structure of Thailand's growing manufacturing sector, concentrating on labour-intensive commodities such as textiles, clothing, or leather goods as well as the highly labour-intensive character of much of Bangkok's fast-developing building and construction and service sectors (including port facilities and tourist-related occupations), to realize the crucial importance of labour supplies. Certainly much of the growth of Thai manufacturing exports from the 1960s was based on abundant supplies of cheap labour [Falkus1991:65].

Labour productivity in the modem sector was higher than in the agricultural rural areas. The non-agricultural sector grew faster than the agricultural, and agriculture declined strikingly both in terms of its share in total employment and in its contribution to GDP. During the period 1960-90, agricultural production grew around 3 percent annually, while industrial production rose 12-13 percent annually. Agriculture's share of GDP continued to drop. Agriculture, which had contributed 50.1 percent of GDP in 1951 ,contributed 29.9 percent in 1970 and only 12.4 percent in 1990 ,while manufacturing's share had continued to rise over these years moving from in 10 percent in 1951, 17.1 percent in 1970 and 39.2 percent in 1990 . Yet rural employment remained high with 87.4 and 80 and 60 percent of total employment in 1960, 1970 and 1990. Industrial growth was heavily concentrated in the Bangkok metropolitan area, with around 80 percent of total industrial output concentrated there in 1990.

In addition to permanent migration to Bangkok, there was also a considerable seasonal migration, dictated in part by the seasonal nature of agricultural activity. A further factor encouraging labour mobility was the post-Second World War expansion of the provincial road network and concomitant rise of truck and bus services. Even as late as 1940 there was not a single trunk road linking Bangkok to other provinces. The furthest distance a motor vehicle could travel comfortably from the centre of Bangkok was no more than 20 miles. The Nonthaburi road built in 1931 stretched from Rama V road through Bangsue to Nonthaburi province with a total length of 6.4 kilometres. The Samutprakarn road built in 1933 ran from Ploenchit road in Bangkok to Bangduan district [Anonymous 1977:320-324]. In 1950, the total length of national highways was nearly 4,000 miles, of which 500 miles, all within a 150 mile radius of Bangkok, were paved. Thereafter the pace quickened and in 1966 over half the state highway network of 7,000 miles was paved, and a substantial network of provincial "feeder" roads had come into existence [Falkus 1991: 66].

By the 1960s, major road routes radiated from Bangkok to all parts of the country. The Petchkasem highway and its feeder lines connected the capital city to the south. The Paholyothin highway and its tributaries linked the major northern provinces with Bangkok. The Friendship highway branched out from the northern route into the northeast. The Sukhumvit highway connected the Eastern provinces with Bangkok. Another important route was the Bangkok-Aranya Pradhes road to the Cambodian border.Roads encouraged a stream of rural migrants to Bangkok, making the real cost of migration lower in terms of expenditure per trip, and also making it easier for migrants to enter Bangkok's labour market on a seasonal basis.

The glitter of Bangkok always held the promise of a better life, even if the reality for many migrants was the urban slum (it was in the 1960s that slums first became a significant social feature of Bangkok). Bangkok became a magnet of aspiration for rural folk. Its image was built up through radio, television, cinema and the stories of returning migrants. So different was Bangkok to other places, with its palaces, department stores, modern shops, paved streets that in the words of one writer, "The magic spell of Bangkok is cast" among the rural dwellers [Paritta 1993:31] Rural-urban migration was a form of human capital investment, transferring the labour surplus of the low productive rural sector into the more productive urban sector.

8 Conclusion

Bangkok has played a dominant role in the economic development of Thailand, its primacy established from around the 1820s. Bangkok has held a concentration of the nation's wealth, has been centre of domestic and international trade, the seat of government, and the most populous urban centre in Thailand. Factors affecting Bangkok's "primacy" varied through time.

Between 1820-1850s, the three key elements which contributed to Bangkok's primacy, the control of suay and manpower, the port and river, and the role of Chinese immigrants, were interrelated. The collection of suay produced a flow of commodities which could be sold abroad. In fact, suay was for much of the period the main source of exportable commodities (especially forest products). Because foreign trade was a royal monopoly, and because suay was a royal privilege, the expansion of foreign trade necessarily enhanced both royal interests (the King himself, his family and close associates) and Bangkok. Labour and enterprise were supplemented by immigrants, mainly Chinese, who played a major role in Bangkok from the start. In all, then, Bangkok was far from stagnant before the 1850s, and grew in population, wealth and area.

Between the 1850s and 1932, the role of Bangkok grew. During the second half of the 19th century Bangkok's development was strongly influenced by Siam's absorption into the international economy and saw growing western influence. Foreign trading companies were established , and certain modern amenities began to make their appearance in the city. Labour flowed from China in increasing numbers at a time when the Siamese countryside was still underpopulated. We also brought out the significance of the period from around 1890 to 1911 in Bangkok's development. Key elements here include the rice trade, Chinese immigration, and the activities of the Privy Purse Bureau and groups of foreign investors. Especially, we discussed the important role played by the Privy Purse Bureau in Bangkok's development . We concluded that Bangkok's new streets were often laid out as part of row house construction for royal investment. For much of the 1920s, the physical spread was limited, although at the end of the decade there was a revival of activity.

Around the time of the First World War, Bangkok's population stood at around 360,000. By contrast, around 1880, Bangkok's population was very different. It was smaller, less Chinese was concentrated on the river areas. Only after the 1890s was land settlement pushed significantly beyond the immediate river boundaries.

Land settlement and population growth, coupled with political change which saw Bangkok develop as a modern capital for Siam with centralized revenue collection and centralized power, encouraged administrative changes for the capital. Important was the establishment of the Ministry of the Capital (1892). This Ministry ensured that Bangkok would be administered as part of state (royal) interests, and may thus be seen as part of a process of centralization initiated by Prince Damrong in the 1890s.

After 1932, political and economic changes saw the city develop from a " port-capital" to a more inward-looking"metropolis" with an increasing role as a financial and business centre, the beginnings of state-led industrial enterprise, and a more significant centre for Thai,as opposed to Chinese's migrants. The 1960s and subsequent years saw the rapid industrialization of Bangkok and an influx of immigrants from an increasing populous and accessible countryside. By the 1980s Bangkok had becoming a flourishing modern city and the capital of one of the new Asian "tigers". Cheap labour underpinned this industrial and commercial expansion.

It will be clear from the above discussion that Bangkok's growth brought important changes for the provinces, and in turn the provinces influenced Bangkok's development. Influence was never uniform, however. We may note, for example, that before the first World War, the major source of Bangkok's rice supplies (on which the city grew as a commercial rice port) came from the central provinces. But this did not mean that other provinces were unimportant. From the 1960s, regional interaction took on a different form, with Bangkok drawing large supplies of cheap rural labour (above all from the northeast),and also with Bangkok capital developing may significant agro-industries, mining enterprises, forest industries, and so on, in virtually every province.

Our discussion of Bangkok's economic role does not pretend to exhaust the topic, and much remains to be uncovered by further research and analysis. What we have attempted here is to account for in outline form the genesis of the economic growth and national dominance of what is widely recognised as one of the world's leading" primate" cities.

References

(1) Documents from Bangkok National Archives

Citations to the archives begin with "N.A.". The citation " N.A. R.5. M. of the Capital 14/4 (1899)" refers to the Fifth Reign and the Ministry of the Capital involved and the accompanying number classified to a specific series and file. The citation " N.A. M. of Finance 0301.1.1/139 (1931)" refers to the date and file number for the archive of the Ministry of Finance.

(2) Newspapers

Bangkok Chronicle, 22 March ,1941

Siam Rath Thai Weekly Review, 23 November , 1958

(3) Published Works

Ammar Siamwalla 1979. Rice in the Thai Economy. Bangkok: The Social Science Association of Thailand (in Thai).

Ammar Siamwalla and Suthad Setboonsarng 1989. Trade, Exchange Rate and Agricultural Pricing Policies in Thailand Washington, D.C.: the World Bank

Anonymous. 1977. Royal Duties of King Rama VII. Bangkok: Ruang Rueng Silp Publishing Office (in Thai).

Askew, Marc 1993 The Making of Modern Bangkok: State, Market and People in the Shaping of the Thai Metropolis, The 1993 TDRI Year-End Conference, Who Gets What and How?: Challenges For the Future.

Bertrand,TJ 1969. Rural Taxation in Thailand. Pacific Affairs.Vol 42, No 2. (Summer 1969),pp.178-188.

Bertrand,TJ 1980. Thailand: Case Study of Agricultural Input and Output Pricing. Washington,D.C.: the World Bank.

Chai Ruengsilp 1976. The History of Thailand : Social Aspects, B.E. 2352-2453. Bangkok: Amarin Publishing Office.

Chatthip Nartsupha and Suthy Prasartset. 1981a. The Political Economy of Siam 1851-1910. Bangkok: The Social Science Association of Thailand.

Chatthip Nartsupha, Suthy Prasartset and Montri Chenvidyakarn. 1981b. The Political Economy of Siam 1910-1932. Bangkok: The Social Science Association of Thailand.

Chatthip Nartsupha 1990. The Village Economy of Thailand in the Past. Bangkok: Sangsan Press (in Thai).

Chulalongkorn University 1991. The Composition of Physical Growth of Bangkok. Bangkok: Chulalongkorn University Press.

Crawfurd, John 1977. Journal of an Embassy to the Courts of Siam and Cochin China. Kuala Lumpur: Oxford University Press.

Evers ,Hans-.Dieter, Rudiger , Korff and Suparb Pas-Ong 1987. Trade and State Formation: Siam in the Early Bangkok Period, In Modern Asian Studies, Vol.21, part IV, October, pp. 751-771.

Falkus, M. n.d. The Port of Bangkok.

Falkus, M.1991. The Economic History of Thailand. In Australian Economic History Review, 31(1), edited by G. D. Snooks, A. J. S. Reid, and J. J. Pincus. pp.53-7. Special Issue: Exploring Southeast Asia's Economic Past.

Falkus,M.1993. Bangkok: From Primate City to Primate Megalopolis. In Megalopolis : The Giant City in History, edited by Theo Barker and Anthony Sutcliffe, pp. 143-165. London :the Macmillan Press.

Falkus, M.1995. Thai Industrialization: An Overview. In Thailand's Industralization and Its Consequences, edited by Medhi Krongkaew, pp.13-32. London:the Macmillan Press.

Feeny, D.1982. The Political Economy of Productivity, Thai Agricultural Development 1880-1975. Vancouver and London: University of British Colombia Press.

Hubbard, R. V. 1977. Canal Construction in the Chao Phraya River Central Thailand. In the History of Inland Waterway Development in Thailand. Michigan: The Department of Geography, University of Michigan, Ann Arbor.

Ikemoto,Y.1991. Income Distribution in Thailand : Its Change,Causes,and Structure. Tokyo : Institute of Developing Economies.

Ingram, J. C. 1964. Thailand's Rice and the Allocation of Resources , In the Economic Development of South-East Asia, edited by Cowan, C.D. pp. 102-126. London: George Allen and Urwin.

Ingram,J.C. 1971. Economic Change in Thailand,1850-1970. Standford:Standford University Press.

Junko Koizumi 1992. The Commutation of Suai from Northeast Siam in the Middle of the Nineteenth Century. Journal of Southeast Asian Studies 23(2) (September),pp. 276-307.

Lysa Hong 1984. Thailand in the Nineteenth Century: Evolution of the Economy and Society . Singapore: Institute of Southeast Asian Studies.

Malloch D.E. 1852. Siam: Some General Remarks on its Productions,and Particularly on its Imports and Exports,and the mode of transaction Business With the People.Calcutta: J.Thomas Baptist Mission Press.

Medhi Krongkaew and Pawadee Thongudai 1988. Unbalanced Growth between Agricultural and Industrial Development. In the Thai Economy on the Path of Peace and Justice,(Vol II),edited by Rungsan Thanapornphan and Nipon Puapongskorn, pp. 937-974. Bangkok: The Faculty of Economics, Thammasat University (in Thai).

Nidhi Aeusriwong 1982. Bourgeoisie Culture and Literature of Early Bangkok. Bangkok: Thaikhadi Research Institute, Thammasat University [in Thai].

Nipon Poapongskorn. 1975. Land Acquisition in Thailand. In Agricultural Economics ,edited by Rungsun Thanapornphan , pp.308-445. Bangkok : Kled Thai Press.

Nipon Poapongskorn. 1981. Wage : the Story of the Poor. Thammasat University Journal, 10 (3) : 72-107.

Oey Meesook. 1979. Income, Consumption and Poverty in Thailand,1962/63 to 1975/76. World Bank Staff Paper No. 364,November.

Office of the Prime Minister 1970. A Collection of King Chulalongkorn's Manuscripts. Bangkok, no 3, Part I.

Paritta Chalermpow Koanantakool 1993. Urban Life and Urban People in Transition. In the 1993 Year- End Conference, Who Gets, What and How? Challenge for the Future.

Pasuk Phongpaichit. 1980. Economic and Social Transformation of Thailand,1957-1976. Bangkok : Chulalongkorn University Research Institute.

Pasuk Phongpaichit, Chris Baker. 1995. Thailand Economy and Politics. Kuala Lumpur : Oxford University Press.

Porphant Ouyyanont.1996. Wages in the Thai Economic History. Thammasat Economic Journal, Vol .14, no. 1 March

Porphant Ouyyanont. 1997. Bangkok's Population and the Ministry of the Capital in Early 20th Century Thai History. Southeast Asian Studies, Vol.35,no 2,September.pp. 240-260.

Porphant Ouyyanont.1998. Bangkok as Magnet for Rural Labour: Changing Conditions:1900-70. (Southeast Asian Studies), Vol.36,no 1 ,June pp 78-108.

Pradit Chasombat 1990. Regional Industial Labour Market, Bangkok : Thailand Development Research Institute.

Rungsan Thanapornphan 1987. The Economics of Rice Premium Bangkok: Thammasat University Press [in Thai].

Sarasin Viraphol. 1977. Tribute and Profit; Sino- Siamese Trade 1651-1853. Cambridge : Massachusetts, Harvard University Press.

Shigeharu Tanabe 1994. Ecology and Practical Technology :Peasant Farming Systems in Thailand, Bangkok:White Lotus.

Silcock,T.H. 1967. The Rice Premium and Agricultural Diversification. In Thailand : Social and Economic Studies in Development, edited by T.H. Silcock, pp.231-257. Canberra: Australian National University Press.

Skinner, G.W. 1957. Chinese Society in Thailand : An Analytical History. Ithaca: Cornell University Press.

Sompop Manarungsan 1989. Economic Development of Thailand 1850-1950, Response to the Challenge of the World Economy. Bangkok: Institute of Asian Studies, Chulalaongkorn University .

Sternstein,L. 1979. Thailand: Internal Migration and the Development of the Capital District, In Migration and Development in Southeast Asia : A Demographic Perspective, edited by Robin J.Myor. Kuala Lumpur : Oxford University Press.

Sternstein ,L. 1982. Portrait of Bangkok. Bangkok :Bangkok Metropolitan Administration.

Suvit Theerasawas 1982.The Economic and Political History of Thailand Since Taksin Reign to the Third Reign, 1767-1851. Bangkok: the National Research Council of Thailand [in Thai].

Tej Bunnag 1977. Provincial Administration of Siam, 1892-1915. Kuala Lumpur: Oxford University Press.

Terwiel, BJ 1989. Through Travellers' Eyes : An Approach to Early Nineteenth Century Thai History. Bangkok: Editions Duang Kamol.

Terwiel, BJ. 1991. The Bowring Treaty: Imperialism and the Indigeneous Perspective. Journal of Siam Society ,Vol 79, part 2,pp. 40-47.

Thebchu Tubtong 1975.Bangkok in the Past. Bangkok : Aksornbundit Press [In Thai].

Thai University Research Associates 1975. Urbanization in the Bangkok Central Region. Bangkok: the Social Science Association of Thailand.

Thailand. Bank of Thailand. n.d. An Economic Survey of Thailand 1946-47.

Thailand. Ministry of Agriculture. 1964. Report on Economic Survey of Rice Farmers in Pathom Province during 1955-56, Bangkok .

Thailand. Ministry of Interior. Report of Manucipality Operation : Bangkok and Thonburi (Various Years).

Thailand. Central Statistical Office. 1962. 1970 Population Census,Whole Kingdom [in Thai].

Thailand. National Statistical Office. 1973. 1970 Population and Housing Census,Whole Kingdom.

Thailand. National Statistical Office. 1992. Key Statistics of Thailand [in Thai].

Thailand. Railways Authority of Thailand Wage and Salary Act (1951-1957) Various Issues, (in Thai).

Thailand. Department of Labour. 1964. 1966. 1967. 1970.1971. Yearbook Labour Statistics.

Thailand. Department of the Secretary-General of the Council of Ministers, Central Service of Statistics 1917-1954. Statistical Yearbook of Thailand 1916-1953 (Title Varies), Vols 1-21, N.S. 1-2 Bangkok

Thammasat University 1983. The Faculty of Economics, Thailand is Bangkok?, papers presented to Annual Symposium Conference.

Thaweesilp Subvattana 1985. The Role of Privy Purse in Economic Investment, 1900-1932. In Thammasat University Journal, Vol 14, no 2 ,pp. 122-159.

Thompson, V. 1947. Labor Problems in Southeast Asia. New Haven: Yale University Press.

Thompson, V. 1967. Thailand: The New Siam. New York: the Macmillan.

Udis Narkswas 1958. Rural Indebtedness of Farmer and the Rice Trade in Central Thailand,1957-1958,Bangkok: The Ministry of Agriculture (in Thai).

United Nations. 1948. The Economic Survey of the Far East.

U.S.A.Bureau of Labor Statistics. 1959. U.S. Embassy Wage Survey of 12 Companies in Thailand .

Usher, Dan. 1966. Income as a Measure Productivity in Thailand: Alternative Comparisons of Agricultural and Non-agricultural Productivity in Thailand. In Economica. November, pp.430-441.

Usher , Dan. n.d. Wages,Land Rents,Land Prices and Interest Rates. Available at Thailand Information Center,Chulalongkorn University.

Vella,Walter 1957. Siam under Rama III,1824-1851 New York : J.J.Austin Incorporated Publishers.

Wilson, Constance. M. 1989. Bangkok in 1883: An Economic and Social Profile. Journal of the Siam Society 77(2):49-58.

World Bank. 1980a. Thailand: Toward a Development of Full Participation. Washington: A Country Report.

World Bank. 1980b. Income Growth and Poverty Alleviation. Washington D.C :World Bank Country Study.

Zimmerman, C. 1931. Siam: Rural Economic Survey, 1930-31. the Bangkok: Bangkok Times Press.

(4) Dissertations

Boonkong Hunchangsith. 1974. Economic Impact of the US Military Presence in Thailand,1960-72".Ph.D thesis: Claremont University.

Boonrawd Kaewkhanha 1975. The Collection of Suay During the Early Ratanakosin Period (1782-1868) , M.A. thesis, Chulalongkorn University [in Thai].

Cholluda Wattanasiri. 1986. The Privy Purse and the Business Investment, 1890-1932. M.A. thesis: Silapakorn University [in Thai].

Kamoll Janlekha Odd. 1955.A Study of the Economy of Rice Growing Villages in the Central Thailand. Ph. D Thesis: Cornell University.

Orathip Tessiri.1981. Land Holding in Thailand from 1901 to 1932: A Case Study of Monthon Krungthep. M.A. thesis: Chulalongkorn University [in Thai].

Sayomporn Tongsari.1983. The Impact of the Building of Roads in Bangkok During the Reign of King Rama V (1868-1910): A Study in the Area within the City Walls, the Northern and the Southern Parts of the City. M.A. thesis: Silapakorn University [in Thai].

Somchai Jitsuchon. 1987. Sources and Trend of Income Inequality : Thailand 1975/76 and 1981 M.A. Thesis: Thammasat University.

Thaveesilp Subvattana.1978. Rice Production and Rice Trade in Central Thailand from the Reign of King Rama V to the Reign of King Rama VII. M.A. thesis: Chulalongkorn University [in Thai].

Panel 6

The Delta in the national and regional contexts

Measurement of technical efficiency in Thai agricultural production

Wirat Krasachat[1]

Abstract: *The primary purpose of this study is to measure technical efficiency in Thai agricultural production during the period 1972 to 1994. Unlike past studies, this study decomposes technical efficiency into its pure technical and scale components. The data envelopment analysis (DEA) approach and annual data from 1972 to 1994 for four regions in Thailand are used. The empirical results suggest that there are significant possibilities to increase efficiency levels by increasing farm size. In addition, the availabilities of new land and the diversity of climate, natural resources, etc., could have had an influence on technical efficiency in Thai agricultural production.*

Keywords: *technical efficiency, pure technical efficiency, scale efficiency, data envelopment analysis, Thai agriculture*

1 Introduction

Thai agriculture has experienced rapid growth over the past three decades. During the periods 1963 to 1975, 1975 to 1985, and 1963 to 1985, the annual growth rates of gross value added averaged approximately 4 per cent (Onchan and Isvilanonda 1991, p. 60). Although the agricultural sector recorded a negative growth rate of 2 per cent in 1987, due to the drought crisis, agriculture still grew at a high average rate of nearly 4 per cent per annum during the 1980s (Asian Development Bank 1990) and 3 per cent per annum from 1990 to 1995 (Bank of Thailand 1998).

There are at least three causes for worry concerning the future development of the agricultural sector in Thailand. First, in the past, the relatively high growth rate of the agricultural sector in Thailand was achieved mainly through the expansion of cultivated areas (by deforestation). This pattern of growth can no longer continue since Thailand reached its land frontier two decades ago. Therefore, a new strategy for agricultural development has been used in recent years with emphasis placed on increasing agricultural land productivity. New technology inputs, such as modern varieties of plants, fertilisers, irrigation, mechanisation and chemicals, have been widely adopted. Second, although, the contribution of technology inputs towards sustainable output growth has been recognised,

[1] Department of Agricultural business Administration, King Mongkut's Institute of Technology Ladkrabang, Bangkok 10520, Thailand, Email: kkwirat@kmitl.ac.th

yield in Thai agriculture has generally been rather low, and declining in some cases such as rice and corn, the most important crops. For example, their yields decreased from 1988 to 1990. Compared with some selected Asian rice-growing countries, the yield of rice in Thai agriculture was the lowest in 1990 (Ministry of Agriculture and Cooperatives 1996). Third, Thai agriculture differs regionally due, primarily, to the differences in geographical area, such as climate and natural resources, and thus production characteristics. For example, as indicated in Puapanichya and Panayotou (1985), mungbeans and soybeans are of particular significance to the Northern Region, while kenaf, rubber, and rice are very important to the Northeastern, Southern and Central Regions, respectively. These regional differences may cause different technical efficiency among regions. This is because most government intervention policies at national level might unequally impact producers in different regions as indicated in Schertz et al. (1979). In addition, Thailand has experienced cheap land and labour, little agricultural research and no shortage of food for many years. Because of the above factors, economists and policy makers have raised the question of the technical efficiency of Thai agricultural production.

The main purpose of this study is to measure technical efficiency (decomposed into its pure technical and scale components) at aggregate level in Thai agriculture. To estimate efficiency scores, the DEA method is applied to panel data comprising 23 years of annual data (1972 to 1994) on the four regions in Thailand. Previous studies have investigated cost efficiency and its components at both the farm and aggregate levels in Thai agriculture (e.g., Tantavaruk 1985, Chayaputi 1993, Krasachat 2000). However, this study, to our knowledge, has been the first application of DEA in order to measure technical efficiency and its components at the aggregate level in Thai agriculture. This enables more detailed understanding of the nature of technical efficiency in Thai agricultural production.

This paper is organised into five sections. Following this introduction, the analytical framework is described. Next, data and their sources are described. The last two sections cover the empirical findings of this study, and conclusions and suggestions for further research.

2 Analytical framework

Coelli. (1995), among many others, indicated that the DEA approach has two main advantages in estimating efficiency scores. First, it does not require the assumption of a functional form to specify the relationship between inputs and outputs. This implies that one can avoid unnecessary restrictions about functional form that can affect the analysis and distort efficiency measures, as mentioned in Fraser and Cordina (1999). Second, it does not require the distributional assumption of the inefficiency term.

According to Coelli, Rao and Battese (1998), the constant returns to scale (CRS) DEA model is only appropriate when the farm is operating at an optimal scale. Some factors such as imperfect competition, constraints on finance, etc. may cause the firm to be not operating at an optimal level in practice. To allow for this possibility, Banker, Charnes and Cooper (1984) introduced the variable returns to scale (VRS) DEA model. In this study, technical efficiency is calculated using the input-oriented variable returns to scale (VRS) DEA model. Following Fare, Grosskopf and Lovell (1985), Coelli, Rao and Battese (1998) and Sharma, Leung and Zaleski (1999), the VRS model is discussed below.

Let us assume there is data available on K inputs and M outputs in each of the N decision units (i.e., regions). Input and output vectors are represented by the vectors x_{it} and y_{it}, respectively for the i-th region in t-th time period. The data for all regions may be denoted by the $K \times NT$ input matrix (X) and $M \times NT$ output matrix (Y). The envelopment form of the input-oriented VRS DEA model is specified as:

$$\begin{aligned} &\min_{\theta,\lambda} \theta, \\ \text{st} \quad &-y_{it} + Y\lambda \geq 0, \\ &\theta x_{it} - X\lambda \geq 0, \\ &N1'\lambda = 1 \\ &\lambda \geq 0, \end{aligned} \qquad (1)$$

where θ is the input technical efficiency (TE) score having a value $0 \leq \theta \leq 1$. If the θ value is equal to one, indicating the region is on the frontier, the vector λ is an $NT \times 1$ vector of weights which defines the linear combination of the peers of the i-th region in t-th period. Thus, the linear programming problem needs to be solved NT times and a value of θ is provided for each region in the sample.

Because the VRS DEA is more flexible and envelops the data in a tighter way than the CRS DEA, the VRS TE score is equal to or greater than the CRS or 'overall' TE score. The relationship can be used to measure scale efficiency (SE) of the i-th region as:

$$SE_i = \frac{TE_{i,CRS}}{TE_{i,VRS}} \qquad (2)$$

where SE = 1 implies scale efficiency or CRS and SE < 1 indicates scale inefficiency. However, scale inefficiency can be due to the existence of either increasing or decreasing returns to scale. This may be determined by calculating. an additional DEA problem with non-increasing returns to scale (NIRS) imposed. This can be conducted by changing the DEA model in equation (1) by replacing the $N1'\lambda = 1$ restriction with $N1'\lambda \leq 1$. The NIRS DEA model is specified as:

$$\begin{aligned} &\min_{\theta,\lambda} \theta, \\ \text{st} \quad &-y_{it} + Y\lambda \geq 0, \\ &\theta x_{it} - X\lambda \geq 0, \\ &N1'\lambda \leq 1 \\ &\lambda \geq 0, \end{aligned} \qquad (3)$$

If the NIRS TE score is unequal to the VRS TE score, it indicates that increasing returns to scale exist for that region. If they are equal, then decreasing returns to scale apply.

Note that efficiency scores in this study are estimated using the computer program, **DEAP** Version 2.1 described in Coelli (1996).

3 Data

The empirical application in this study considers aggregate data from each of the four regions of Thailand for the period 1972-94. Inputs are classified into six groups: fertiliser, hired labour, capital, operator labour, unpaid family labour and land. The data for quantities of labour are based on annual surveys conducted by the National Statistical Office (1997).

The data for quantities of fertiliser are derived from several occasional publications of the Ministry of Agriculture and Cooperatives. Regional data on fertiliser usage are not available in fourteen of the years. The missing data are extrapolated from the whole Kingdom data.[2]

Output is aggregated into a single index of agricultural output to avoid any further complexity in modelling. The output index includes the ten major crops. They are rice, kenaf, cotton, cassava, groundnuts, soybeans, mungbeans, sugar cane, corn and sorghum. Livestock is a sector which has been very important for Thai agriculture for a long time. Unfortunately, there are no livestock product data available. Thus, the livestock products are not included in this study. Particular regions have higher livestock output, and thus their low indexes reflect to some extent the problem of undervaluation. The data for quantities and prices of crops are also taken from the *Agricultural Statistics of Thailand Crop Year.* Note that the actual prices of ten major crops are used. Due to lack of regional price data, the average Whole Kingdom farm price of each crop is used.

Similar to output, capital is aggregated into a single index to avoid any further complexity. The capital index includes the three primary types of capital. They are farm machinery, water pumps and threshers. The figures for quantities of capital are collected from the *Agricultural Statistics of Thailand Crop Year* published annually by the Ministry of Agriculture and Cooperatives (1996). The imported capital prices are obtained from the *Annual Statement of Foreign Trade Statistics* (Ministry of Finance 1995).

As mentioned above, pooled data are used for this study. Thus, multilateral comparisons among the four regions are an important issue in this study. However, because of the disadvantage of the Tornqvist index in multilateral comparisons resulting from its failure in the transitivity property, the Caves, Christensen and Diewert (CCD) multilateral index is used to construct any price indexes which involve more than one commodity.[3] Following a number

[2] Following Setboonsarng and Evenson (1991), the missing data are acquired by multiplying the national numbers by an average share of numbers of each region to national numbers which are calculated from the data available.

[3] See more discussion on index number methods in Krasachat (1997).

of studies (e.g., McKay, Lawrence and Vlastuin, 1980; Wall and Fisher, 1987), implicit quantity indexes are obtained by dividing the current value of each input and output by their corresponding CCD price index.

Land use, in this study, comprises land under rice, field crops, fruit trees and vegetables, grass land, idle land, other land and housing areas. Land use data are available in the *Agricultural Statistics of Thailand Crop Year.* Eight years of regional land use data are missing. Thus, missing data on land use are extrapolated from the Whole Kingdom data.

4 Empirical results

Technical and scale efficiency scores of Thai agricultural production were calculated using equations (1) and (2) at the sample means of the regional data comprising the two sub-periods of 1972-77 and 1978-94.[4] Table 1 indicates that the mean values of overall technical, scale and pure technical efficiency of all regions are less than one in the two periods and in all regions. The comparatively poor performance in terms of overall technical and scale efficiency is in the Southern Region. This may be due primarily to the differences in soil quality, irrigation and climatic conditions. Most parts of the Southern Region are not irrigated, while large areas in the Central and Northern Regions are irrigated. The mean values of overall technical efficiency range from 0.378 to 0.961 during the period of 1972-77, and they range from 0.214 to 0.962 during the period of 1978-94. The mean values of scale efficiency range from 0.382 to 0.985 during the period of 1972-77 and from 0.270 to 0.988 during the period of 1978-94, while those of pure technical efficiency range from 0.891 to 0.988 during the period of 1972-77 and from 0.781 to 0.973 during the period of 1978-94. These empirical results suggest four important findings. First, there are significant possibilities to increase efficiency levels in Thai agricultural production, especially in the Southern Region. The average overall technical inefficiency for the Whole Kingdom could be reduced by 22 per cent during the first sub-period and by 29 per cent during the latter period by operating at optimal scale. Second, the results also indicate that scale inefficiency for the Whole Kingdom makes a greater contribution to overall inefficiency. Third, because all values of efficiency scores for the Whole Kingdom of the first sub-period are higher than those of the latter sub-period, this implies that the reduced availability of new land (in the latter sub-period) appears to have affected efficiency in Thai agriculture. Finally, the results indicate the diversity of the scores of efficiency among regions. This suggests that the considerable variability of regions in climate, natural resources, irrigation, etc., can have different impacts on efficiency in Thai agricultural production in different regions.

The scale efficiency results are summarised in Figure 1. The DEA results suggest that, of 92 observations, 23 per cent operated at their optimal scale, 23 per cent operated above their

[4] Patamasiriwat and Suewattana (1990) suggested that the patterns of growth of Thai agriculture can be divided into two periods. As mentioned earlier, before 1978, the relatively high growth rate of agriculture was achieved mainly through the expansion of cultivated areas by clearing the forests. Since 1978, this pattern of growth could no longer continue because Thailand had reached its land frontier. Therefore, new technology inputs such as fertiliser, modern varieties of crops and water have been widely used in this latter period.

optimal scale and 54 per cent operated below their optimal scale. This indicates that the largest increase in overall technical efficiency could be achieved by eliminating the problem of increasing returns to scale, while eliminating the problem of decreasing returns to scale would increase overall technical efficiency to a lesser extent. This implies, from an agricultural policy viewpoint, that if production efficiency of Thai agriculture is to be improved, increasing farm size would be better than decreasing the size of farms.

When comparing the scale efficiency results among regions, the results indicate that, during the 23 years, for 87 per cent or 20 years farms in the Northeastern Region operated above their optimal scale, for 70 per cent or 16 years farms in the Northern Region operated below their optimal scale, for 57 per cent or 13 years farms in the Central Region operated at their optimal scale and for 100 per cent or 23 years farms in the Southern Region operated below their optimal scale. These results indicate evidence of the variation of scale efficiency among regions.

Temporal Efficiency Changes

The changes in the efficiencies of Thai agriculture over time are reported in Table 2. They were estimated at the sample means of the periods 1972-77, 1978-83, 1984-89, 1990-94 and 1972-94. The analysis indicates that there is a decline in overall technical, scale and pure technical efficiencies. The reasons for these decreases could be due to the reduced availability of new land since 1978, or may be a consequence of imperfect competition in output and input markets, as a result of intervention by the government in certain markets in Thai agriculture, as mentioned earlier.

Although the analytical results in general indicate that there exist advantages in increasing farm size, it would be better to use them to focus on efficiency improvement at the regional level due to a wide diversity of efficiencies from region to region in Thai agriculture. Jaforullah and Whiteman (1999) indicated that there is a positive relationship between the availability of extension services and farm technical efficiency. An increase in the rate of diffusion of technology and optimal farm management practices encouraged by extension services and programs should increase the technical efficiencies of the inefficient farms in Thailand.

5 Conclusions and suggestions for further research

An input-oriented DEA model was used for estimating overall technical, scale and pure technical efficiencies in Thai agriculture.

The results indicate that efficiency scores of some regions were considerably low. This implies that there is significant scope to increase efficiency levels in Thai agriculture. In addition, they also indicate that differences exist in the values of technical efficiency and its components between the periods of 1972-77 and 1978-94 and among regions. This implies that the availabilities of new land and the diversity of climate, natural resources, etc., could have had an influence on technical efficiency in Thai agricultural production.

The results in general indicate advantages in increasing farm size in the Thai agricultural sector. However, extension services should be used to increase the technical efficiencies of the inefficient farms in Thailand. In addition, there exists a decline in overall technical, scale and pure technical efficiencies.

The analysis presented in this paper can be improved in a number of areas. Some areas of further research should be considered. These include: comparing stochastic and DEA frontier analyses; and investigating technical efficiency and productivity changes in Thai agriculture.

References

Asian Development Bank. 1990. Asian Development Outlook 1990. Manila.

Bank of Thailand. 1998. Monthly Bulletin, 1997-1998. Bangkok.

Banker, R. D.; Charnes, A. and W.W. Cooper. 1984. 'Some models for estimating technical and scale inefficiencies in data envelopment analysis'. Management Science 30, 1078-92.

Caves, D.W.; Christensen, L.R. and W.E. Diewert. 1982. 'Multilateral comparisons of output, input, and productivity using superlative index numbers'. Economic Journal 92, 73-86.

Chayaputi, P. 1993. 'An efficiency analysis of major non-glutinous rice production in a pump irrigation area in the Northeast Region: a frontier production function study'. Journal of Agricultural Economics Research 15 (47), 59-72.

Coelli, T.J. 1995. 'Recent developments in frontier modeling and efficiency measurement'. Australian Journal of Agricultural Economics 39, 219-45.

Coelli, T.J. 1996. A Guide to DEAP Version 2.1: A Data Envelopment Analysis (Computer) Program. CEPA Working Paper 96/08, Department of Econometrics, University of New England, Armidale.

Coelli, T.J.; Rao, D.S.P. and G.E. Battese. 1998. An Introduction to Efficiency and Productivity Analysis. Kluwer, Boston.

Fare, R.; Grosskopf, S. and C.A.K. Lovell. 1985. The Measurement of Efficiency of Production. Kluwer-Nijhoff, Boston.

Fraser, I. and D. Cordina. 1999. 'An application of data envelopment analysis to irrigated dairy farms in Northern Victoria, Australia'. Paper presented to the 43rd Annual Conference of the Australian Agricultural and Resource Economics Society, Christchurch, January 20-22.

Jaforullah, M. and J. Whiteman. 1999. 'Scale efficiency in the New Zealand dairy industry: a non-parametric approach'. Australian Journal of Agricultural and Resource Economics 43(4), 523-41.

Krasachat, W. 1997. The Dynamic Adjustment of Structure and Demand for Labour in Thai Agriculture. Ph.D. thesis, University of New England, Armidale.

Krasachat, W. 2000. 'Cost efficiency in Thai agricultural production'. Paper presented to the North American Productivity Workshop, Union College, Schenectady, New York, June 15-17, 2000.

McKay, L.; Lawrence, D. and C. Vlastuin. 1980. 'Input demand and substitution in the Australian sheep industry'. Review of Marketing and Agricultural Economics 48(2), 57-69.

Ministry of Agriculture and Cooperatives. 1996. Agricultural Statistics of Thailand Crop Year 1971/72-1995/96. Centre for Agricultural Statistics, Bangkok.

Ministry of Finance. 1995. Annual Statement of Foreign Trade Statistics. Department of Customs, Bangkok.

National Statistical Office. 1997. Report on Labour Force Survey (Round 3), Whole Kingdom, 1971-94. Bangkok.

Onchan, T. and S. Isvilanonda. 1991. Technology and Productivity: A Comparative Study of Thailand and Japan, A Research Report. Centre for Applied Economic Research, Kasetsart University, Bangkok.

Patamasiriwat, D. and S. Suewattana. 1990. 'Sources of growth of agricultural production 1961-85: analysis based on Thailand Development Research Institute model'. Thammasat Economic Journal 8(1), 43-69 (in Thai).

Puapanichya, K. and S. Panayotou. 1985. 'Output supply and input demand in rice and upland crop production: the quest for higher yields in Thailand', in Food Policy Analysis in Thailand, ed. T. Panayotou, Agricultural Development Council, Bangkok, pp. 23-99.

Schertz, L.P. et al. 1979. Another Revolution in U.S. Farming?, Agricultural Economic Report No. 441, U.S. Department of Agriculture, Washington D.C.

Setboonsarng, S. and R.E. Evenson. 1991. 'Technology, infrastructure, output supply, and factor demand in Thai agriculture'. in Research and Productivity in Asian Agriculture, eds R.E. Evenson and C.E. Pray, Cornell University Press, Ithaca, pp. 206-216.

Sharma, K.R.; Leung, P-S. and H.M. Zaleski. 1999. 'Technical, allocative and economic efficiencies in swine production in Hawaii: a comparison of parametric and nonparametric approaches'. Agricultural Economics 20(1), 23-35.

Tantavaruk, S. 1986. The Palm Production Analysis: A Case of Palm Owner Planting in Krabi Province, 1985. Master thesis, Kasetsart University, Bangkok.

Wall, C.A. and B.S. Fisher. 1987. Modelling a Multiple Output Production System: Supply Response in the Australian Sheep Industry. Research Report No. 11, Department of Agricultural Economics, University of Sydney, Sydney.

TABLE 1: MEAN TECHNICAL AND SCALE EFFICIENCY SCORES OF THAI AGRICULTURE

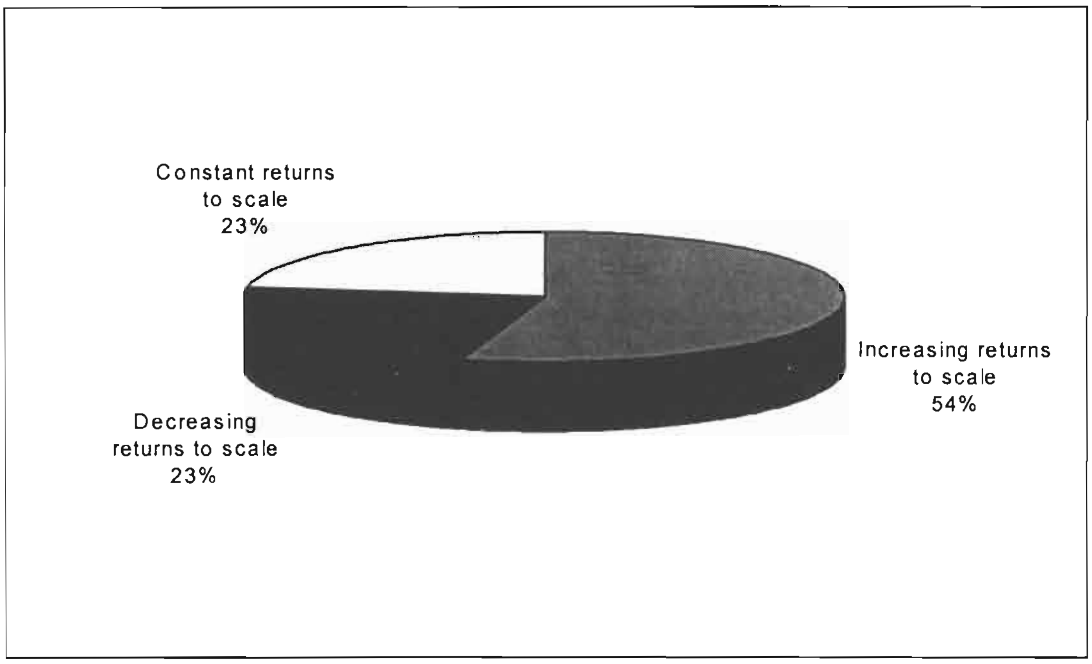
Regions	Periods	Overall technical efficiency	Scale efficiency	Pure technical efficiency
Northeast	1972-77	0.836	0.937	0.891
	1978-94	0.735	0.779	0.947
North	1972-77	0.961	0.978	0.982
	1978-94	0.912	0.981	0.929
Central	1972-77	0.957	0.985	0.970
	1978-94	0.962	0.988	0.973
South	1972-77	0.378	0.382	0.988
	1978-94	0.214	0.270	0.781
Whole Kingdom	1972-77	0.783	0.820	0.958
	1978-94	0.706	0.755	0.907

TABLE 2: CHANGES IN EFFICIENCIES OF THAI AGRICULTURE

Periods	Overall technical efficiency	Scale efficiency	Pure technical efficiency

1972-77	0.783	0.820	0.958
1978-83	0.735	0.765	0.949
1984-89	0.714	0.760	0.907
1990-94	0.662	0.737	0.858
1972-94	0.726	0.772	0.921

FIGURE 1: THE SCALE EFFICIENCY OF THAI AGRICULTURE



Still "Technology-Transfer" After All These Years: A Search for Thailand's Post-crisis Sustainable Transformation[1]

Opart Panya[2]

Abstract: In this paper, I will apply a system thinking approach to demonstrate a better way to understand changes and developments that have occurred in rural Thailand. It allows the use of both the social and natural science perspectives to view the problems and develop interventions within.

Drawing from my previous fieldwork experiences in Thiland's poverty-stricken Northeast and the case studies currently available on rural communities located in the Thailand's Chao Phraya Delta, I argue that the lack of systems thinking is one of many problems retarding our effort to develop an alternative and more sustainable agriculture.

"Every division we make is a result of how we think. In actuality, the whole world is shades merging into one. But we select certain things and separate them from others – for convenience, "

David Bohm, *On Dialogue* (1996)

1 Introduction

Agricultural research and development for Thailand must be approached from the perspectives of her planned changes and discontinuities. In the past forty years in particular the pace of changes has been so accelerated and society became highly complex that most of the sectors of Thai could hardly build up new knowledge to keep pace with new problems. Thus most ideas of science and technology was imported by urban technocrats and practitioners and then imposed upon the regional and rural population. As will be discussed, the short period of time witnessed Thai facing cultural decay and environmental degradation and finally economic crisis. I propose here for Thailand "community-first agriculture." Before undertaking any new interventions, either through science or technology, a learning process

[1] This is an adapted version from the earlier one presented at the 14th International Federation of Social Science Organization (IFSSO) Conference entitled "Interface of the Social Science with Science and Technology," held during 17-19 November 1999 at Naresuan University, Phitsanulok, Thailand.

[2] Opart Panya, Ph.D, is an assistant professor at Faculty of Environment and Resource Studies, Mahidol University, Thailand. *teopy@mahidol.ac.th*

should be given to the rural people to re-build the sense of community and regain their mental strengths.

2 The decade that was

How a country became rich today and turned "poor" tomorrow is beyond anyone's imagination. This is but a discontinuity for a country known for her stability and strength. History shows, for example, that the then Siam successfully avoided being colonized, while her neighboring countries one by one fell to the 19th colonial Powers. Half a century later she came out from the Second World War unscratched. The strength shown by Thai society lies not on the use of forces but on application of flexibility and adaptability.

The collapse of the "bubble" economy at the turn of this century is beginning to change the old view of "Siam" society. How capable we Thai people are in coping with the current crisis will be a great challenge for the whole Thai society. Some critics have put forward the idea that strength is not true characteristics of Thai society. For example, leading Thai scholar Sippanon Ketthad, in his opening address delivered at a national conference, strongly argues that Thailand "is not an intellectual and rational society" (TRF 1999: 23). So cruel though it may seem, this economic crisis can perhaps be the best thing that happened to Thailand. This is the opportunity for the Thai to re-assess their real weaknesses and strengths, so that Thai society as a whole can be better prepared to live in a "new" world—a real, rapidly changing and highly complex world.

3 Dealing with the creeping catastrophes

Thailand's immediate recovery will largely depend on the strength of the rural sector, where the majority of the people live and since the 1960s has been dominated by the mainstream, modern agriculture. The other sectors, once recognized as "miracles", are in deep trouble. The Thai industry has been ailing and the financial sector crippled. Together they have caused the country an estimate of US$90 billions indebted[3] and nearly over half a million people unemployed (see Withayakorn Chiangkul et al. 1998:15 and Lauridsen 1998).

Looking closer at the rural sector, however, the future is far from certain. It looks as though a society weakened by poverty and resource problems is about to embark upon a larger world full of competition and domination of the stronger societies. Despite the country's impressive economic growth prior to the crisis, an estimate of eight million people is living under the poverty line. Of those, six million live in the rural area. Rural poverty, thus, will remain a critical problem for economic recovery. On top of that, environmental degradation caused by the mainstream, modern agriculture will create a bigger problem. The world market for agricultural production will not only be competitive but highly political. The coming century will welcome the New World Order and the agricultural production from all over the world will be regulated and controlled by international mechanisms, such as the GATT and WTO. With the rise of various social and environmental movements both at the global and grassroots levels,

[3] Calculated for August 1997, one month after devalue of the Baht.

environmental issues can be used as a criterion for granting access to the international market.

Regarding the environmental situation in rural Thailand, five decades of well-intended developments have brought about degradation of natural resources and cultural decay in rural Thailand. Thailand has lost nearly 80% of natural forest in the past forty years and half of the mangroves (3 million *rai* total) in ten years. Marine resources in both the Gulf of Siam on the south) and the Andaman Sea on the west have been over exploited. Important watersheds have been damaged by government-permitted timber industries followed by encroachment of poor farmers, who in turn, sold to the business sector for building tourist resorts and golf courses. All major streams and rivers, particularly those in the Central Plain, were heavily polluted with chemical residues used in both agriculture and industries (OEPP1999).

The most significance impact of development was the decay of the social environments. Economic of development combined with the discourse on national security has uprooted the rural community culture. Bangkok-based Ministries have made decision virtually on all directions and rates of change for the whole country. Gradually, the livelihoods of the rural inhabitants have become deeply embedded in the Thai State, centered on Bangkok, the capital city. Thailand, generally seen as rich and strong for her cultural diversity, has been transformed into a unified national community based on Bangkok's cultural dominance. What actually happened then was the rural inhabitants lost the community spirits and local cultures. This particular issue is the central theme and will be addressed in the course of this paper.

Environmental issues caused by agricultural practices will become the weakness spot of the rural sector. Agriculture, once conceived of as a way of life in rural Thailand, was promoted to adopt the practices following the mainstream "green revolution." Introduction of cash crops such as cotton, cassava, and maize has encouraged rural farmers to tie their livelihoods with foreign markets. Agriculture has increasingly become involved with risks and uncertainties. Decision on prices and annual import quotas of cassava, for example, was generally made in Italy by the EU.

Land degradation and extensive use of chemical fertilizers and pesticides are two main characteristics of the current practices of the mainstream, modern agriculture in Thailand. Fertile lands are used for short-term gains. Soil erosion and fertility loss in turn makes farmers to use more cash investment for purchasing chemical fertilizers and pesticides. Under the market and climatic uncertainties, small farmers often ended up loosing lands to larger holders through heavily burden debts (Thaweekiet 1997). This is the starting point of a "vicious" cycle of rural poverty in Thailand.

4 Inadequate views of the world

The Thai situation, as just been portrayed, is what might be called 'dealing with the creeping catastrophes," a situation which crises gradually creep in without people realizing it. We normally did not see environmental problems until they were there. The problems are multi-facets and thus too complex for a single worldview and discipline to come up with all the answers. Most critically is that we are limited by our own ability not to see the "wholeness" or "connections" of the components underlying the problems. The environmental problems do not exist by themselves. They are directly related to agricultural practices. The mainstream, modern agriculture is in turn associated with a certain development discourse, and the economic development discourse is shaped by the economic culture of Thai society as a whole. In other words, economics, environment and society are interconnected; each cannot be understood in isolation.

It is the inadequacy in seeing the 'whole' or the 'pattern' of the problems that is the main theme of this paper. The focus will be on agricultural development, drawing from my research experience in Thailand. Unless we shift our mode of thinking from the fragmented "phenomena" or "objects" to the relationships, our ability to deal with the "creeping" catastrophes is in question.

Having looked at the crisis that Thai society has encountered and having envisioned its complicated future, we will see that we need a new way of thinking and looking at things. Fifty years are long enough to find out that Thai society is not as strong as it has been perceived. How many more years does it take until we know that a new way of thinking is needed?

In this paper, I will deal specially with this issue. I will examine the farmer's way of "thinking": why the farmers do things the way did for many years. I will draw on the experiences of a group of farmers who planted rice three times a year and kept repeating it years after years. But before I go on, let me discuss in brief a conceptual framework and methodology to be employed in my examination.

5 Systems thinking: an alternative view of the world

Due to limited space and time, my review of systems thinking will be rather brief. A great deal of elaboration of the concept can be found in Gerald Weinberg's *An Introduction to General Systems Thinking* (1975). In addition Fritjof Capra, in his *The Web of Life: A New Synthesis of Mind and Matter* (1997), on which my discussion is largely based, provides an excellent review of the development of systems thinking and made a synthesis of this with the emerging chaos theory.

According to Weinberg (1975:52), systems thinking is "a way of looking at the world" or "a point of view." Well established into the Second World War, systems thinking has evolved as a competing model of the world to that of the modern science, generally known as the "Cartesian" paradigm (see Capra 1977; Heisenberg 1971). The latter, having long influenced on every branch of the scientific disciplines to this day, claims that it can describe the world as similar to the clockwork. All smaller components can be taken apart, unfolded and put back again.

Systems thinking, on the other hand, is the shift from the parts to the whole, from "objects" to "relationships" or the network. Alexander Bogdanov, Ludwig von Bertalanffy and Norbert Wiener have all been credited for their contributions to the development of systems thinking (see Capra 1997). The "ecosystems" concept has made a remarkable application of systems thinking. In an ecosystem, for example, it can be conceived of as a system of network or relationship of organisms interacting through a series of feedback "loops" (see below). The behavior of the 'whole' (system) is qualitatively different from that of the total sum of its parts.

From a system perspective, nothing can be understood in isolation. Changes initiated by a small, single part can create a great deal of non-linear effect on the system. The "butterfly effect" is a famous metaphor for this. It was a half-joking assertion that a small portion of cloud stirring up the air (an image with two wings of a butterfly) over Peking can cause a big storm a month later in New York (see Lorenz 1963).

Agencies involved in rural development will benefit from applying systems thinking into their operations. Each agency will overcome the institutional boundary and be able see the other parties involved as a whole, operating in a multi-stakeholder approach. Mutual trusts and respects of others, particularly of the farmers, will arise as a result. The community on which the agencies work will eventually move towards "synergism," a qualitative change characterized as form of self-controlling or self-organization. In living in the world that changes rapidly, some social elements and organizational structure of every party involved in development needs to be re-adjusted to be better prepared for new problems as well as opportunities. "Self-organization," as Capra (1997:85) asserts, "is the spontaneous emergence of new structure and new forms of behavior in an open systems far from equilibrium."

For the rural villagers, who are generally seen on the receiving end of development, working in partnership with other fellow villagers and outsiders will open themselves up for a new kind of learning. Friendly and horizontal interactions will enhance the farmer's learning skills, involving consultation and deliberation of ideas (both giving and receiving information). The villagers will gain not the traditional "knowledge" as they used to receive from the traditional teaching method, but the ability to learn "how to learn." In their old version of the World, they were used to teaching rather than learning and were reduced to mere receivers of "answers" ready made or "packaged" technologies being delivered by outside experts. The new form of learning allows farmers to see themselves as part of a larger network, as a giver and a taker at the same time, forcing them to alter their way of thinking in coping with new problems.

In my recent research experience (see Opart Panya 1999), carefully chosen techniques used in brainstorming of ideas were appreciated, especially by the small and "powerless" segment of the community. I have witnessed in most part of the country the gradual changes in individual personalities and social alignments. Eventually, new groups and networks were formed, new local initiatives developed, and most significant of all, the community prides that were long lost have been regained (see Opart Panya and Pichet Nong Chang 1999).

6 Feedback loops: a new language for change

In the mainstream development, the major concern was to make quantitative changes, i.e., growth in GDP, increase of household income, increase of crop yields and farm productivity, and so on. All of these can be measured and validated by facts and figures, aided by "scientific" methodologies readily available. It would have been appropriated in a fragmented, Cartesian worldview.

But we are to deal with a "system," of which the environmental problems are inseparate parts, we must shift our focus, from its component parts to their relationships, networks and alignments. Qualitative changes, therefore, must be treated as properties of the system, and there is no way that the "facts and figures" can adequately capture system's changes. We, therefore, need a new language. Systems thinking differs fundamentally from the conventional mode of analysis. "Analysis means taking something apart in order to understand it; systems thinking means putting it into the context of a larger whole," as Capra (1997:30) puts it.

The original concept of "feedback" is owed to cybernetics, a field concerned with self-controlled mechanical systems. Lately, it is conceived of as the underlying mechanism for change and survival of living systems, all of which are built in to regulate the systems. Briefly, feedback loop is a circular arrangement causally connecting all components in a system. It feeds information both ways, from one to the next and back to the initial cause. If the loop continues, as called "positive feedback," it is generally characterized as a phenomenon known as a vicious cycle. In contrast, if somehow the information runs back as "check and balance" to the original source, it is called negative feedback. It is the negative feedback that scientists are most interested in, because it shows how living systems under the unstable environments maintains itself and changes.

I will now apply the systems thinking concept discussed above to the main problem generally occurring in agricultural development. As will be demonstrated, agricultural system is a system of a network of component parts, including humans (individual actors), the geo-biological environments and market. Each of these components also exists as sub-systems, consisting of sub-groups of the elements. The sub-systems are all nested within a larger system, in this case, of rice cultivation. Together, they make rice cultivation as a system of networks connecting all required components.

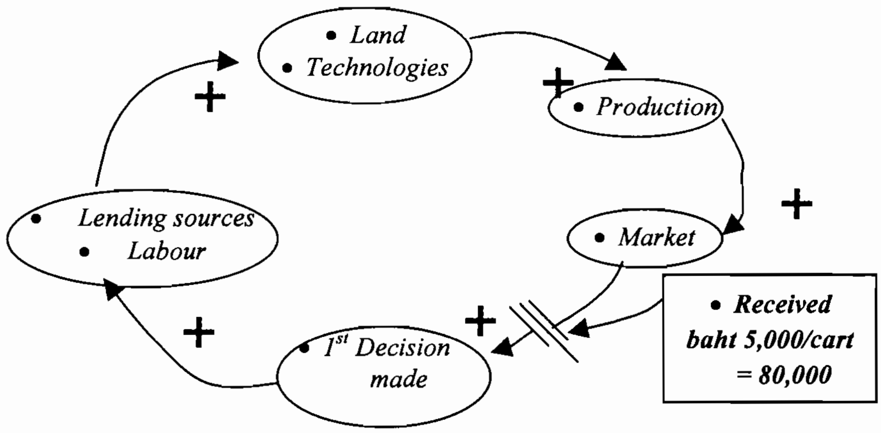
7 The "mental" model and agricultural problems

Systems approach's main concern is to describe how the "whole" system or network works, changes and maintains its pattern of organization in the unstable environment. Priority of systems thinking is not to find solutions, but to focus on how problems (pattern) occur. The advantage of systems thinking has over the traditional, fragmented and linear approach is that has the ability to capture the deep root of problems.

The following demonstration is based on my previous research in Thailand's poverty-stricken Northeast—*E-san* (see Opart Panya 1995). But the bulk of information is drawn from two student field-works, both of which I was involved as a programme manager. The first study, a six-month fieldwork in 1996, focused on a Tambon (8 villages) south of the city of Pitsanuloke. It followed in 1998, looking particularly at a sustainable issue of the existing wet-rice agriculture a Tambon in Manorom district of Chainat province. Both reports are available at Faculty of Environment and Resource Studies, Mahidol University.

As will be demonstrated, small changes in the loops of in network patterns can induce self-correction, larger-scale changes. *Figure 1* below depicts a simplified rice cultivation system or cycle. With availability of water (mostly from underground) and a sophisticated broadcasting technique, a large number farmers in Thailand's Central Plain have been doing three cycles or crops a year. As *Figure 1* shows, the feedback loops, hypothetically being both positive and negative, can explain the root cause of our thinking about problems. Here we shall see that problems sometimes reside in our head by our own creation.

Figure 1: A vicious cycle (+ feedback loops) of modern agricultural problems, see text for explanation



+ = positive, reinforcing feedback, leading to a vicious cycle

- = negative feedback, evaluating or checking each step of action to be taken *= delays*

Data from a survey shows that economically they were not "better off" than those with single and double cropping.[4] Their total production has increased, but the capital expenses involved were relatively high, estimated up to 40%. The rice they grew was not the variety for local consumption but for foreign markets. They were reported to have bought rice for family use from the other regions of Thailand, where it produced better suitable varieties for their tastes and flavors. Worse, they have struggled with pests they have never had before and required the use of chemical pesticides more and more every year. "I fainted and felt black-out in the paddy field many times," as a female farmer reported.

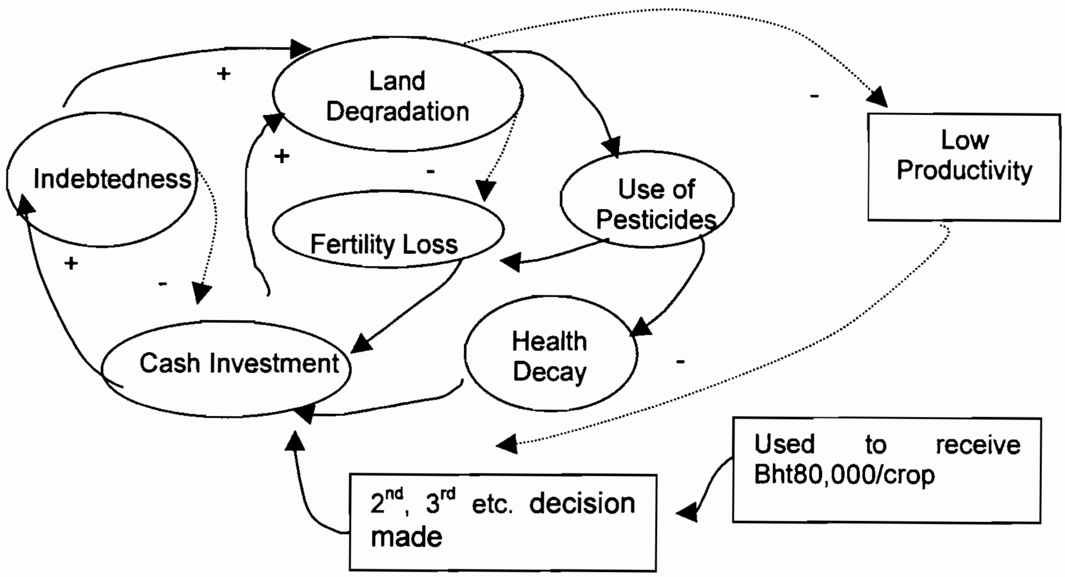
The question most people would ask is this. How, with all these problems, do the farmers keep doing this three times a year? As shown in the *Figure 1*, it all started with a huge profit they made at the first attempt a few years ago. Rice cultivation has recently become an easy task than that in the past; mechanized plows were available locally, several lending sources easily accessible. It is even easier to have access to paddy lands, as a number of shadow landholders have increased resulted from the "bubble" economy favoring the higher-income population. The landlords were eager to lend lands to the triple croppers, because they could get the money out all year round (rent prices are determined by a number of cropping).

The problem lies understanding in the pattern of the loops. All elements of the "whole" system of rice cultivation (in the first and most favorable year, at least) are connected with positive feedback loop (+). Each reinforced the next elements until it reaches the end of the

[4]. The research site is in Manorom district of Chai Nat province. This is part of fieldwork of M.Sc students and study report is available at Faculty of Environment and Resource Studies, Mahidol University.

cycle, making a cultivation of paddy rice appears an attractive and favorable way of making a living.

Figure 2: Starting An Environment-Poverty Cycle (simplified)



8 Starting a "vicious" cycle of rural poverty

The subsequent years were different, however. Here we will see that multiple "loops" occur, making circles around each of the component. They can be viewed as the sub-systems (with connected elements) nested within a larger "whole" system of rice cultivation. A small change taken by a single component can create a large effect on the whole system. Fore example, the price began to drop in subsequent years, because they were dependent on the highly competitive foreign market. They also needed more cash input: the soil lost its fertility and in need of fertilizers. All year round cultivation allowed rice pests to continue the food cycle and thus increased their population. Heavy use of chemical pesticides caused health decay. In a small sub-district in Pitsanulok, for example, a report shows that up to 70% of the farmers who were taken blood samples are found to have in their blood the chemical substances above the standard set by the Public Health Department.[5] All of these conditions led to additional expenses for health care, and this, in turn, forced the farmers to take out more loans in the next cropping.

Generally, the farmers would have hardly noticed these minor "cycles" or loops. This is because the "past"--"the-good-old-days," might come into play in decision making of the subsequent cropping. It appeared as though they operated under the "old" mental model, which they used to receive a considerably high return of 80,000 Baht.

[5] Reports were undertaken, under close supervision from Programme Committee, by two different groups of graduate students in M.S. Programme in Environmental Planning for Community and Rural Development. Both are available at Faculty of Environment and Resource Studies, Mahidol University

it can become a more useful tool in agricultural extension and research. It allows the people involved in agriculture—farmers and experts alike, to evaluate their own "model" of nature against the real "nature" (rice-cultivating system). Scientists in particular rarely question the method (i.e. Cartesian worldview) they used in constructing their "model" of reality and nature. What is identified as specific objects or "realities" depends, as Capra (1997:40) asserts, on "the human observer and the process of knowing." By applying systems thinking approach demonstrated here, the people are forced to adjust their "mental" model of reality to the real situation out there. "Learning," as has been demonstrated, is about shifting oneself between seeing "parts," to the "wholeness " of the existing reality.

Most people have a "distorted" view of the world, as they can only see the "parts" of the system, and thus lose sight of interconnections and a non-linear cause and effect from within. By simply following each "loop," problems will emerge. Start from the circles around the sub-systems and work up to the larger scale of the connected whole. The positive "loops" (+) mean the situation is likely to repeat itself, and if allowed to continue, may run into serious problems.

The negative feedback loops are what should be looked at. When negative loop (-) is found, simply go back to the original source and be critical about it. This is a place where the system is "asking": "what can be done about it?" Such a step is what it is referred to as "learning" taking place. Consequently, it calls for some "changes" and "alterations" to be formulated. When the (sub) system needs pesticides (see Figure 2), the negative loop would signal for alternatives. Two options will be available, either using the chemical or the organic pesticides. But if every thing else is impossible, we might look at perhaps changing the whole "paddy cultivation" system. For the farmers, this means giving up or forgetting about the 80,000 Baht return and they might start looking for new cropping patterns. In the drought-prone Northeast Thailand, some interesting cropping patterns centered on rice have initiated by the rural farmers. This includes "beans-after-rice," "sesame-before-rice," and recently popular *Kaset phasom phasan),* a pond-based, integrated agriculture (see Opart Panya and de Pater 1992: KKU 1989). What all these patterns required was a shift in their thinking—diversifying the use of their land from a single, mono-cropping of rice to diversified agricultural systems. A systems change may look like this:

Alternative A: [*Rice* + *Beans*] + [*Off-farm Employment*]

Alternative B: [*Sesame* + *Rice*] + [Off-farm Employment]

This brings to the concluding section of the paper.

Should these set of related problems were evaluated (learned), they would have used the negative feedback (-) to help them formulate a set of alternatives. By focusing on each loop at the time, they would certainly have come up with a set of alternatives from which they could choose. For example, the loops with the dashed arrows (Figure 2) indicate that "evaluation" is needed. Practically, negative feedback (-) is a warning "signal" for the farmers to review the previous actions. It is like asking; "can something be done here?" On the soil's fertility lost, for example, they could have used organic, green manure as an alternative, so that they did not have to borrow money for purchasing chemical fertilizers, which resulted in borrowing more money for the investment. But of course, they could not think about the green manure, because, if they did, they would have to cut down the number of cropping or to devote some portions of the paddy land for manure making. This, however, required a long-term perspective by the farmers, and most often than not, they opted for a short-term solution—a continued use of chemical fertilizers. The chemical fertilizers and pesticides used generally killed most microorganisms, which in turn effected soil structure and fertility. Farmers were well aware that they needed to increase the amount of fertilizers every year.

Finally, the "whole" system or cropping pattern now appears as a network of the component parts. Changes and improvements can occur at two levels: 1) by "correcting" or modifying the relationships of those small components and 2) by "changing" the "whole" system (see application below). The second one involves a shift of the entire cropping pattern. This comes to another important concept referred to as "delay" (\\ as in Figure 1), interruptions of the flow of influence or intervention. Due to the time-space available, it will be very simplified. More details and applications of this concept are available in Peter Senge's widely read *The Fifth Dimension* (1990). Basically, every loop has a "delay" action, depending on the intervening factor. For example, rain coming too early or too late can cause damage to a particular component leading to failure of the whole cycle. The above exercise suggests that before making decision for the following cycle, farmers need to intervene intelligently. They are best to really look at the whole system again. Their decisions should be based not on the "ideal" return alone (or using the best year's profit), but on "practical" prediction. This involves "learning" to understand the whole system of land-use and their own potential capabilities.

9 The problems within: applications:

In agricultural extension and research, the focus on "technology" and the conventional transfer-of-technology (TOT) approach has recently come under heavy scrutiny (see for example, Scoones and Thompson 1994). Agricultural specialists have too much attention to what is not in the farmer's head (i.e. what knowledge and technology that are lacking). Even the farming system and recently popular "farmer first" (Chambers 1989) approaches have not made much progress in capturing the larger picture of agriculture. The farmer-first is too confined with "indigenous" knowledge and "local wisdom", the so called *Phum Panya Chaoban,* and attempted to make "science" out of them. It sometimes had a notion of being too local specific that could be easily taken as anti-development. Both conventional TOT and Farmer-first are concerned mainly on "knowledge" in a sense that it is ready made either in the heads of the experts or of farmers.

In the systems thinking approach, on the other hand, emphasis is placed on the processes and system's patterns of behavior (i.e. repetitive or innovative). As has been demonstrated, often lack a vision of the world in which they live (see for example, Freire 1970). Here, pure knowledge and self-awareness is insufficient to create desired changes, as changes themselves often meet with resistance from both within and without. They need to engage themselves in some activities. In so doing, they will be forced to "learn" to organize themselves into groups and networks to sustain the "will" to change and adapt to a changing condition.

As skills in working as groups and in networking are enhanced, they can now with some level of confidence move on to "learn" that they can create their "community" as a realistic world on which they so wish to live together with the others. Shared vision is an image of the future, reflecting the people's livelihoods, their relations with, and values given to the physical nature which surrounds them. Agriculture, then, can be seen as a "sub-system" nested within the shared image of the community in which they wish to live. The role of scientists and students of development is to adequately understand such a "whole" community-and-nature and applying agricultural knowledge within. Sustainable agriculture cannot exist without capable and sustainable society and nature, of which they are part.

Such an exercise is probably too complicated for the traditional communities to be undertaken without outside help. Skilled facilitators are needed to provide systematic learning techniques appropriated to the nature of the communities. It involves enhancement of skills to manage the changes, over which they felt having little or no control (i.e. nationalization, globalization). The process involves "learning" about themselves, the community they wish to leave, and importantly their relations to the local environments and the world outside. They may have to, for example, "think globally" and at the same "act locally" in order to maintain their collective identity, strength stability in their communities. Shared vision of the community is a means to build people's capacities in coping with a complex and constantly changing world.

10.4 Using participatory and interdisciplinary research

Advance in molecular biology today has proved that an integrated approach from diverse disciplines is a key to an adequate understanding of living systems. In literature, there is a trend towards a synthesis of the knowledge gained from both the physical and social sciences. In environment, for example, the concept of "ecosystems" has been developed as an interdisciplinary framework to study interactions of both living organism and non-living systems. It has increasingly been debate for a shift of paradigm from the conventional Cartesian worldview to a holistic and integrated approach referred to as "the life sciences" (Capra 1997). The world as seen today can not be understood as a clock-like machine, but as a living and changing system, just like a mythical image of Gaia—the ancient Greek goddess of the Earth (Lovelock 1972).

In development, there is a need to explore the possibility of building participatory and inter-disciplinary approaches. Several participatory action research techniques have recently been developed and proved to be effective in land-use planning and community-based forest management. Farmers and specialists are encouraged to work together to find out about the conditions of the local resource base and about their communities. Participatory planning and

10 Community-first agriculture

Agriculture development, as has been demonstrated, is about learning to shift the mental model, from a distorted (fragmented) to holistic view of nature and reality (network of relationships). It involves a continual evaluation of one's fragmented view of the world against the present state of nature. Learning, in this sense, is the ability to make a connection between nature-society (wholeness) and the individuals (parts).

It has been unfortunate, as emphasized earlier, the rapid change created by the "mainstream" development has uprooted the rural communities. As society as a whole has been dominated by the Bangkok hegemony (which is always influenced by the West), the same population lost their rural identities and community prides (see for example, Opart Panya, 1995). Conceivably, the rural inhabitants have been removed from rural societies and they gradually see themselves separate from their communities, from nature of which they are part, and from the fellow Thais (strong "I-We" division).

10.1 Community-nature re-building

To adequately understand the problems of Thai agriculture, it must not begin by taking agriculture out of the fragile physical environment, the traditional livelihoods, and of worldviews of the rural people. Rather it should try to put agriculture back into the community, where ecosystems and agricultural livelihoods are all integrated. Agricultural development, thus, depends on how capable the rural people are in dealing with the others, their communities, a hostile and highly competitive world, and with a fragile environment. But since the rural people have for so long been made powerless from feeling separated from of the others, the rural communities, and nature, there is an urgent need to "heal" them first. That is that we need to help them regain the sense and pride not only of their local identities but also of the national identities, and of belonging to the world humanity as well.

10.2 Beginning with consultative and deliberative styles of learning

How do we begin, since we deal with shifting the people's distorted and abused mental model of changes, realities and the environments? Community-nature re-building must be used as an entry point. Community implies collectivity. Learning, thus, must be re-conceptualized as sharing the beliefs and experiences with others, as opposed to transmitting "ready-made" knowledge from the perceived experts to passive recipients or a teacher-to-student type. Learning thus begins with building basic skills in exercising their mind, including the ability to express-and-hold back ideas, listen to others, contemplate on certain issues, ask the "right" questions, and to control emotion. Traditional "village" forums and informal roundtables are some good examples and have recently been widely used for the exercise (see Opart Panya, 1999).

10.3 Learning self discovery and determination

Learning alone is not enough, however. They should be provided with real activities in order to learn how to coping realities. People with long experience of oppression and powerless

References

Capra, Fritjof. 1997.The Web of Life: A New Synthesis of Mind and Matter. London: Flamingo.

Chambers, Robert. 1989. Farmer First: Farmer Innovation and Agricultural Research. London: Longman.

Conway, G. 1985. "Agroecosystem Analysis," in Agricultural Administration 20:31-55.

Freire, Paolo. 1970 Pedagogy of the Oppressed. New York: Continuum.

Heisenberg, Werner. 1971 Physics and Beyond. New York: Pergamon.

Khon Kaen University (KKU). 1987 Proceedings of the 1985 International Conference on Rapid Rural Appraisal. Khon Kaen: Rural Systems Research and Farming Systems Research Projects.

Lauridsen, Laurids S. 1998 "Thailand: Causes, Conduct, Consequences," in Jomo K.S. (ed.), Tigers in Trouble: Financial Governance, Liberalisation and Crises in East Asia. London: Zed Book, pp. 137-157.

Lovelock, James. "Gaia as Seen Through the Atmosphere," in Atmospheric Environment Vol. 6, pp. 579.

Office of Environmental Policy and Planning (OEPP). 1999. The State of Thailand's Environment 1997. (in Thai), Bangkok: Ministry of Sciences and Technology.

Opart Panya. 1999. Grassroots Governance Initiatives: Experiences from Rural Thailand. Ottawa: Institute on Governance.

Opart Panya. 1995 "Change from Within: Adaptation and Self-determination in Three Rain-fed Communities of Northeast Thailand." Ph.D. Thesis, Victoria University, New Zealand.

Opart Panya. 1992 "Farmer Response to a Grassroots Approach to Forest Management," in Pacific Viewpoint 33(2): 151-158, October 1992.

Opart Panya and Phichet Nongchang (Eds.) 1999 Sang ban wan mai (Building New Home for New Dawn). Bangkok: Local Development Institute.

Opart Panya and Cathrien de Pater. 1992 "Conservation and Economic Development Through Community Forestry" Mid-term Evaluation Report, Save the Children, Nakhon Sawan, Thailand, October 1992.

Rambo, A.T. 1991 The Human Ecology of Rural Resource Management in Northeast Thailand. Khon Kaen: Khon Kaen Press.

Senge, Perter M. 1990 The Fifth Discipline: The Art and Practice of the Learning Organization. New York: Currency Boubleday.

Scoones, Ian and J. Thompson (eds.) 1994. Beyond Farmer First: Rural People's Knowledge, Agricultural Research and Extension Practice. London: Intermediate Technology Publications.

Thailand Research Fund (TRF). 1999 Research Community (in Thai). Vol. 27 (September).

Thaweekiet Prasercharoensuk. 1997. "The Impact of IMF Acceptance on Thai People and Recommendations for People's Options" (in Thai). In Withayakorn Chiangkul, et. al (eds.) Thai Economic Crisis: Impacts from Accepting IMF Conditions and People's Way Out (In Thai). Bangkok: Thailand Research Fund. pp. 192-250.

Weinberg, Gerald M. 1975. An Introduction to General Systems Thinking. New York: John Wiley and Sons.

Withayakorn Chiangkul et. al. 1997. Wikrit sethakit Thai phon kratop jak karn rap nguenkhai IMF lae thangork samrap prachachon (Thai Economic Crisis: Impacts from Accepting IMF Conditions and People's Way Out). Bankok: Thailand Research Fund.

management actions by all stakeholders involved is a way to build the learning community (see Opart Panya 1992).

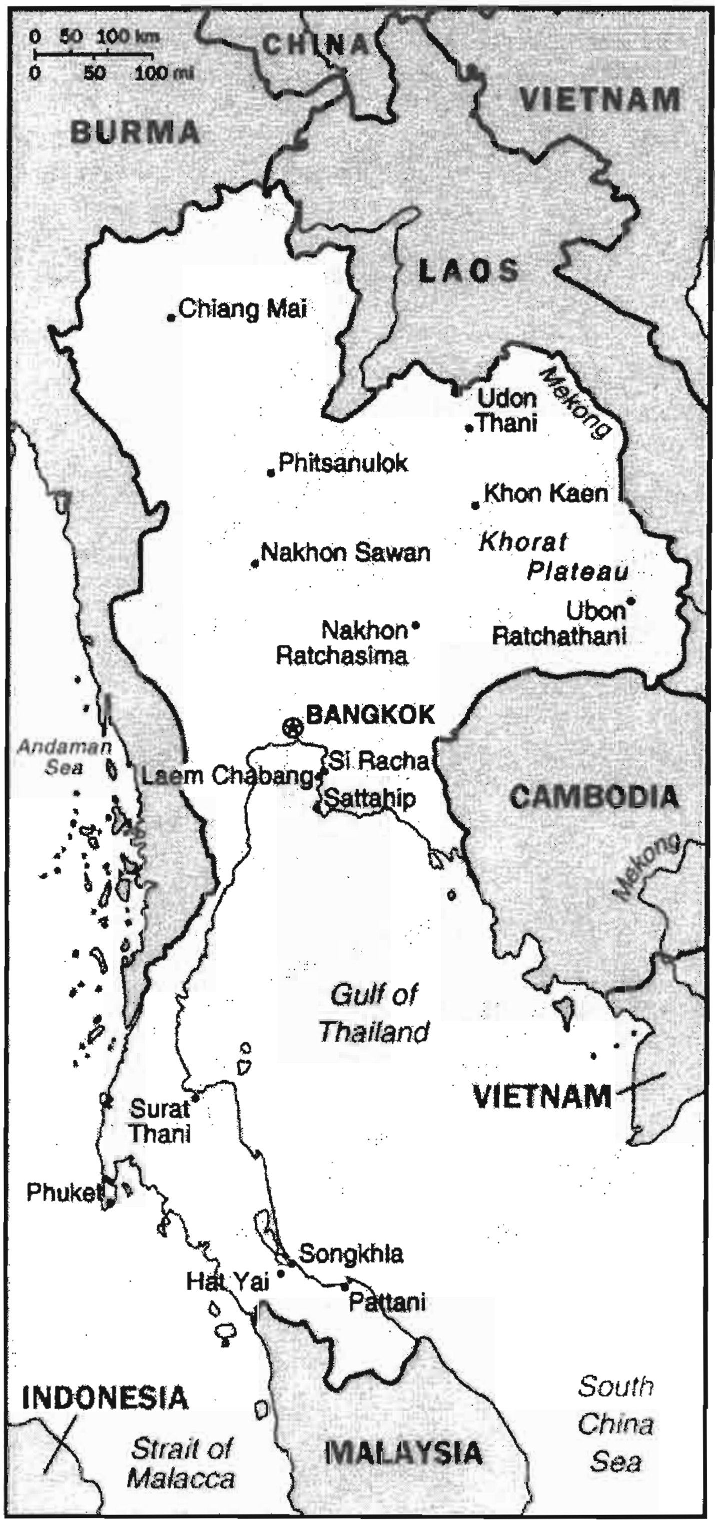
In environment-agriculture, the conceptual and methodological developments have been slow and in need for urgent improvements. Two equally important concepts have begun to take shape. They include 1) human ecology (Rambo 1991), and 2) "agro-ecosystem" (see for example, Convey 1985), both of which have their roots in systems thinking. The two concepts are similar in that they incorporate the complex relationships between society and nature. The approaches, however, fail to capture human's cultural systems, i.e. hegemony, oppression, exploitation, and capacity building. Humans are treated in these systems not much different from other living organisms. But at least this area provides the opportunity to build on them and make them work.

11 Conclusion

The rural society, on which Thai society as a whole depends, in overcoming the present crisis, needs be re-conceptualized. The view of its being simply a collection of individuals, which is confined to the clearly marked boundary, should be abandoned. So should the notion that rural society is an autonomous system separated from the national and World systems. Rather, the rural society is a social network nested within the national community, which is influenced by the World system. Its relationships with the physical environments and other societies cannot be understood as a linear connection. How the rural people see themselves and their relationships with the environments and other communities depend on cultural values and meanings shared by the whole national community. Certain political systems shape certain sets of cultural values and meanings. Those who have been oppressed, disempowered and culturally dominated (as in Thai society), their views of the world are fragmented and static. They will see themselves separated from the community, the environments and from the rest of humanity. This seems to be characteristics of Thai society as a whole.

To strengthen the rural communities, such as those in Thailand, they need first and for most a community healing process; they should be encouraged to re-build the sense of "community," rediscover who they really are, their relationships with other communities and with nature.

As trained researchers and scientists, our role is of critical importance. What we do not want to see it happen is that a few more distorted views of the world being imposed upon them. Our job is to assist them to learn how to re-build their social network within the community, re-establish their relationships back to nature, and allow them to feel that they live in the same world of which they are inseparate part. We must try to work along with them in the process of re-building their real "communities" and at the same time "learn" from them. This way we can re-assess our preconceptions, working methods, and our paradigms, on which we based, against the real world out there. After all, how we see and feel about the world is subject to our inner, mental model of the world.



Thailand:

Studv Areas

Core and frontier: comparison of agricultural development between Northeast Thailand and the Chao Phraya delta

Yasuyuki Kono [1]

Abstract: *The present paper tries to compare agricultural development in Northeast Thailand and the Chao Phraya Delta since the last century or the beginning of this century from the viewpoint of "core" and "frontier" of the region. Comparative study of the implication of land suitability to agricultural production in actual agricultural development reveals that local cores and frontier distribution is deeply affected by land suitability to agricultural production, but national-level cores and frontier distribution is thought to be one of the determinant factors of actual agricultural development. This denies a simple viewpoint of "core" and "frontier" and suggests diversified viewpoints for a long-term analysis of agricultural development.*

Full paper not provided

[1] Kyoto University, CSEAS

The Chao Phraya delta in perspective: a comparison with the Red River and Mekong deltas, Vietnam

Dao The Tuan[1], François Molle[2]

Abstract: *The deltas are the major rice bowls of Asia. They combine high population densities with intensive agriculture. Agricultural activities are strongly shaped by the hydrologic regime, its floods, low flows in the dry-season and the tidal effect. Their historical development seen in terms of settlements, cultural origin and socio-political formation are nevertheless contrasting. This paper attempts to highlight a few commonalities of the Red River, Mekong and Chao Phraya deltas, together with their main discrepancies. It thus provides a comparative perspective on the Chao Phraya delta and helps sketching out its particularities.*

The comparison between three Southeast Asian deltas will help us understand the peculiarities of the development of the Chao Phraya delta. The Red river delta belongs to the category of high population density deltas (over 300 inhabitants per km^2), covers 250,000 km^2 with 12 million inhabitants. While the Mekong and the Chao Phraya deltas belong to the category of less highly populated deltas.

The Red river and the Mekong rivers originate from the region where other great rivers of Asia as the Yang Tse Kiang, the Si kiang, the Salaween, the Irrawadi and the Brahmaputra also have their origins. It is also the region where cultivated rice probably originated (Chang T.T.,1976, Watabe, 1977). This region, according to Dao The Tuan (1997), is a centre of highest diversity of rice cultivars.

This region is inhabited by ethnic groups which belong to the Thai, Tibeto-Burman and Mon-khmer groups. The mountainous regions had the administration form of intermontane basin called Muong, governed by chiefs called Chao muong. The North Vietnamese Tai ethnic groups contributed to the formation of the Vietnamese nation. The first Thai kingdom on the territory of Northern Thailand was the kingdom of Lanna founded by the Yuan (a group of Thai) in the XIII century (Ishii, 1978). In the lower Mekong, inhabited by Mon-khmer ethnic groups, the kingdom of Funan spread from the I to the VI century and developed agriculture and trade (Malleret, 1962). We don't know if there were relations between these ethnic groups and states in the past, but there were migration waves of Thai ethnic groups from Yunnan to Laos, to Thailand and to the mountainous regions of North Vietnam, especially

[1] Director of the Agrarian Systems Department, Vietnam Agricultural Science Institute, Hanoi, Vietnam.

[2] Researcher at IRD (Institut de Recherche pour le Développement) /Kasetsart University; odoras@ku.ac.th

after the Mongol invasion of the XIII century, and further to the apogee of the Khmer empire which extended from Thailand to the delta of Mekong in the XIII century. From the XVII century the lower Mekong basin was colonised by the Vietnamese together with the Khmers.

People living in Southeast Asia have developed varied agrarian systems according to the ecological conditions of their environments (Kaida 1991). Most of the time they have used adaptive strategies to natural parameters (soil, relief, rainfall, flood, etc...) but gradually endeavoured to modify these conditions by different engineering and technological innovations (dikes, canals, lifting devices, genetic crop improvement, etc). According to O'Connor (1995) in the early era (700 A.D.) Mon, Khmer, Cham and Pyu ruled the southern part of mainland Southeast Asia. These ethnic groups were garden-farmers in uplands or flood-managing farmers in lowlands. People living in the Northern part of Southeast Asia, such as *Thai, Vietnamese* and *Burmese* specialised in wet rice agriculture and are known to be skilled irrigators. These people expended to the South and conquered three of the largest rice bowls of Asia: the Mekong, Chao Phraya and Irrawady river deltas.

1 The evolution of the agrarian systems of the Red River delta

The Red river delta is in reality the delta of two rivers: the Red river and the Thai Binh river, with an area of 15 000 km2. The apex is located at Viet Tri and the base follows the cost from Yen Hung (Quang Ninh province) to Kim Son (Ninh Binh province).

According to historians (History of Vietnam, 1983) the settlement of the delta began 4000 years ago with the birth of the Van Lang state, at the epoch of Hung kings, with Lac Viet (Mon-khmers) and Au Viet (Thai) tribes.

The Vietnamese agriculture began in the middle region of the Red river delta, probably at the Phung nguyen period, the early bronze period in the first half of the II millennium B.C., as shown by paddy husks found at the low layers of archaeological sites. Archaeologists think that the Red river delta settlement began 4000 years ago because sites of the Phung nguyen period were found in the delta, but we think that the lower delta was exploited later, during the Dong son period (I millienum B.C.).

In the following period, the exploitation of the delta was made possible by the construction of dikes as a protection against floods. At the beginning of our era, at Phong Khe district, dikes against the floods already existed. But only from 1077 onward was the construction of dikes undertaken on a large scale. In the XIX century, the dike system of the Red river delta was still being developed but it was completed only during the French period. Due to the presence of dikes, the natural sedimentation of silts in the delta was altered and the relief remained very heterogeneous. The breaking of dikes which happened frequently changed the relief of delta. The dike system also created difficulties for the drainage, and the delta is divided into polders ("*casiers*") which retain water. All the improvements to the drainage system implemented since the French period until now have not been able to solve the problem totally.

When the delta began to be exploited, irrigation was practised thanks to the tidal effect. This method was used by Nguyen Cong Tru to colonise the coastal area in the XIX century and is still in use in the present time. The digging of canals began in the Ly dynasty, such as the canal To lich (Ha noi) in 1192. During the Tran dynasty the To Lich canal (1256 and1281) and the Thien duc canal (Duong river) (1390) were completed. Irrigation in the delta was practised through the lifting of water from ponds, tanks, canals, lakes. Irrigation systems by gravity were built only later, during the French period, in the middle region (examples are the Kep system (Bac giang), Cau river system, the Vinh Yen system). The pumping station at Phu Xa (Son Tay) was the first pumping system and demonstrated that this method is cheaper than the former. From 1931 onwards, the construction of dikes near the sea cost, in order to reclaim land from the sea, and the drainage system of some *casiers* were implemented. In 1945, the area served by irrigation in the delta amounted to 377 000 ha, or 34 % of the area of rice fields of the delta. After the liberation of the delta in 1954, irrigation expanded mainly by the pumping method.

The exploitation of the delta was done by devising various modes of cultivation attuned to the different ecological settings. Coyaud (1950) distinguished the following types of cultivation according to different elevations:

- Summer crop non stable,
- Summer crop stable,
- Winter crop non stable, summer crop stable,
- Winter crop non stable,
- Winter and summer crops stable,
- Winter crop stable, summer crop non stable,
- Winter crop stable,
- Winter crop non stable,
- Flooded area, no rice cultivation.

In general in high and medium fields practised summer rice during the rainy season. The fields were embanked to retain water. This is the method of rainfed lowland. On low fields, when there was not yet protection, during the rainy season the fields were flooded. The flood in the Red river came abruptly, without regular timing like in the Mekong, so it was impossible to plant floating rice as in the south. It is possible only to plant rice during the dry season after the receding of water by retaining water. This crop is called *Chiem* or winter rice. In this delta the winter is relatively fresh so it needs to have cold tolerant varieties. These varieties are also tolerant to drought, to acid and saline soils. They are short duration varieties but the vegetative period lasts 6 to 7 months due to the low temperature.

In the XIX century we have some records about the population of the Red river delta. From 1847 to 1923 the population increased 3,83 times or 1,6 % per year. The population in 1931 was 6,500,000 in the rural area and only 350,000 in the urban area. After 1931 the increase was only 1% per year due to out-migration. Comparing the population of 1995 with that of 1930 we see that the population density after more than 60 years increased more than 2 times.

Vietnam is one of the countries in Southeast Asia which had a centralised state relatively early. It was explained by the fact that there were needs of struggle against natural calamities and foreign invasion. It was a hydraulic state with an Asian mode of production, or Oriental despotism. The ideology of this administration system was Confucianism, influenced by the Chinese system.

The social system in the Red river delta corresponds to what E. Wolf has labelled "closed corporate communities" (Rambo, 1973). The villages of Northern Vietnam have many characteristics which coincide with this system:

1. The village in the north Vietnam is a cluster of houses, bordered by a hedge of lived bamboo. The village was a microsociety formed in a process of peasants' struggle against natural calamities and foreign invasions.

2. But villages had a certain autonomy, the State did not control directly village affairs. Village affairs were managed by a council of notables. Peasants had little or no contact with upper administrations. Villages established their own laws that were even stronger than the king's laws. The duties (taxes, corvée and military service) were distributed to communes, which deal with villagers.

3. The peasant of the Red river delta have a high peasant mentality; he is strongly attached to his land, dreams of increasing it, thanks to whatever saving he can achieve. The differentiation of land ownership was regulated by the spirit of communitarism which is very developed in the villages of the North. The system of communal land was conserved and even protected by the State. The land was regularly distributed to eligible villagers. The cottage industry was controlled by trade guilds. Religious activity in general served to impede the accumulation of capital. There were limitations for outsiders to become members of the community.

4. Production was primarily for subsistence purposes. The land tenure system was typical of a subsistence economy. Small scale trading of surpluses is carried on in the peasant market system. Due to the lack of land, animal husbandry and cottage industries are also developed to compensate for the limitation of income drawn from agriculture.

Regarding land property, we know the situation of the beginning of the XIX century through the Cadastre of Gia Long. If we compare the situation of these cadastres with that of given by Henri (1930) we can assess historical changes. While at the beginning of the XIX century landowners in Ha Dong and Thai Binh had on the average 1,9 and 7,3 ha, in 1931, when the population had increased about 4 times, the average property was only 0,7 and 1,3 ha.

While there was formerly no data of landless peasants, after Gourou (1936), landless peasants amounted to 51% of registered males (of 18 to 60 years).

We calculated the Gini coefficient which show the level of equity within landowners and found that this coefficient after a century increased from 0,4 - 0,5 to near 0,6, which means that the differentiation increased.

The area of communal land in the Red river delta in 1930 was 26 %.

According to Gourou (1936), the area of rice fields of the Red river delta in 1930 totalled 1,100,000 ha, to which 100,000 ha of upland crops should be added. The cropping area was broken down in the followings types:

Ricefields with one winter crop: 250,000 ha

Ricefields with one summer crop: 350,000 ha

Ricefields with two crops: 500,000 ha

Thus, the area under winter rice was 750,000 ha and that under summer rice was 850,000 ha. From 1930 to 1950 fields double cropped with rice increased by 30 %.

Comparing the situation of 1930 with that of 1985, rice land decreased by 18 %. Rice double-cropping did not increase compared with 1930, probably due to different definitions. But in 1930 the land double cropped with rice made up 45% of the total rice land and reached 59% in 1985.

TAB.1 : THE EVOLUTION OF THE AGRARIAN SYSTEM OF THE RED RIVER DELTA

	Rural population	Arable and permanent crops land		Food production		Food crops yield
	Million	Million ha	M2/n	1000 t	Kg/h	T/ha
1930	6,5	1,2	1846	1,8	277	1,5
1998	14.2	0,783	551	6.2	439	4.4
Growth rate	1,1	-0,6	-1,8	1,8	0,7	1.6

During the past 65 years the population of the Red river delta increased only twofold, because of the war and of out-migration to mountainous areas or to the south. The agricultural land was reduced by one third, and the land per capita decreased 3 times. But due to intensification, food production increased more than 3 times and the food per capita increased close to 1.65 times. Concurrently, the peasant's income increased 1,5 time. Equity increased, especially after the land reform in 1954, but later started to slightly decline.

After a period of collective agriculture from the beginning of 60's to the end of 80's, the system returned to the peasant household and to market economy. Surveys made in the beginning of 90's showed that farmers in the Red river delta had enough food to eat, but a high percentage were still under the threshold of reproduction. The number of commercial farmers was very low, while most were in the intermediate group between self-sufficiency and production for the market. The most important constraint for the development of the household economy nowadays in this region is the lack of market.

During the process of intensification the area under winter rice increased due to the development of irrigation. The yield of winter-spring rice increased due to the use of high yielding varieties. The area under summer rice slightly decreased due to the change of some flooding area into fish ponds. The area of upland food crops such as maize and tuber crops varies: it increased before 1990 due to the development of winter cropping season but later decreased due to the lack of market for vegetables and pork.

When the population density rose, the man land ratio increased, the part of rice in the gross income decreased, and the part of cash crops increased accordingly. The gross income per capita increased until reaching a density of 1000 h/km2, and subsequently decreased. The land area cannot provide enough employment for peasants and this triggered two processes: migration and the development of non-agricultural activities.

Migration is not a new process in the delta. In the 1930s, emigration accounted for the removal of about 15,000 persons per year. The organised migration from the delta helped reduce population pressure. Temporary migration to the cities in search of jobs is increasing. It was estimated that 13 % of the rural labour force emigrated for this purpose.

Another process occurring in the densely populated area is the development of non-agricultural activities in order to compensate for the lack of income. This process already existed long time ago. In the thirties the number of peasants involved in these activities was 250,000, or 6,8% of the active population. The most important activities are handicraft, food processing and commerce, especially the latter two. Many handicrafts production are constrained by the lack of market.

So we can conclude that in the Red river delta when the population pressure increased, the expansion of arable land was limited, irrigation was developed in order to increase the cropping intensity, firstly to grow two rice crops, later to develop winter crops. When the potential of the development of agricultural activities was limited, people emigrated or developed non-agricultural activities.

2 The evolution of the agrarian systems of the Mekong delta.

The Mekong plain is a vast low-lying area, which comprises the Mekong delta in Vietnam, most of the lowlands of Cambodia, a small part of southern Laos and a small part of eastern Thailand. The plain is 800 km from the north to the south and 600 km from the east to the west. The area of the whole delta is about 7.2 million ha, including 4 million ha in the Vietnamese part.

The Mekong delta part of Vietnam covers 12 provinces of South Vietnam (Cochinchina). This part of Vietnam is a delta formed by two rivers: the Mekong and the Dong Nai. The largest branch of the river is called Hau Giang (fleuve posterieur) and the second river branch, called Tien Giang (fleuve anterieur), divides the region into two subregions : the Transbassac and the Cisbassac.

Archaeological discoveries and ancient Chinese texts show that 2000 years ago there was a kingdom named Funan, extending in the Mekong delta. A site near the village of Oc eo was excavated during World war II. Aerial photographs revealed traces of an ancient hydraulic network. But the occurrence of Funan is still debated without definitive conclusion. In the 6th century this area was invaded by the Khmers which found the Tchen La kingdom. But the Khmers only developed the terraces of the old Mekong delta, named «Dry Tchen la», leaving the young delta, named "Water Tchen la" in an unexploited situation.

Before the settlement of the Vietnamese, this region was inhabited by a few communities of Khmers, living in Soc, villages located on the levees of the rivers. In 1296 a Chinese ambassador Chau Da Quan reported that this region was covered by dense forests and large savannahs without any big trees. In 1818 when the mandarin Nguyen Van Thoai received an order to construct a canal from Long Xuyen to Rach Gia, he declared that this area had not yet been trodden by any human foot (Brocheux, 1995).

In the middle of the XVI century, Nguyen Hoang left the kingdom of the North (Dang Ngoai-Outer kingdom) to Central Vietnam and his son found the South kingdom (Dang Trong-Inner kingdom). They began the «March to the South» (*Nam tien*) by the settlement of Central and South Vietnam. The South kingdom was a kingdom founded on a military system with the aim of fighting with the North. In order to strengthen the military force, foreign trade was developed. This kingdom was more open and more market-oriented. The ideology of the political system was Buddhism instead of Confucianism.

At the end of the XVII century, settlements reached Dong Nai and Gia Dinh in the northern border of the delta and the colonisation of the young delta began. In 1757 they reached Chau Doc the furthest point on the West of the delta. At that time a group of Chinese came and established in My Tho, Vinh Long and Sa Dec; in 1715, another group founded the settlement of Ha Tien.

The conquest of the delta was done by digging canals such as Vinh Te and Long An Ha, and founding *don dien* (military settlements). The canal network was improved and completed by the French colonial regime since 1875. From 1900 onwards, a new program was implemented where both functions of canals were prioritised: canals were a means to access the area of settlements, and (through the construction of drainage channels) a means of rendering the land arable (Brocheux, 1995).

In the XIX century we don't have data on population for the delta. We can take data of the whole Cochinchina. The population of the West of Cochinchina in 1908 totalled 863,987.

The Mekong delta social system resembles Erich Wolf "open peasant system" (Rambo, 1973), with the following characteristics:

1. Villages in the south were organised from former military colonies, and were loose communities. Boundaries of the community were poorly demarcated. Villages were of the ribbon type, with individual houses strung along a canal or a road, often for distances of several kilometres. The physical dispersion and the relatively high rate of immigration all militated against the development of a sense of village solidarity.

2. Land was privately owned and freely alienable. Communal land was very limited. The bulk of the cultivated land was owned by large absentee landlords and worked by tenant farmers. The peasantry was strongly differentiated. Although these village were organised by northerners the village communitarism was weakly developed.

3. Villages are not isolated from the national society. Peasants are exposed to the presence of outsiders in the form of merchants, government officials and police...

4. Production is for the market with dependence on the outside capital inputs. Tenants were dependent on the large landlords for the provision of working capital.

The settlement of Cochinchina began in the eastern part in the 16th century, after peasant rebellions in the North (1511-1522). Only after 1698 did the kingdom of Dang Trong of the Nguyen lords extend its administrative control on this area. At that time there were already 40,000 households. The organised colonisation started in this period. Before this period reclaimed land belonged to individuals. In South Vietnam the formation of villages and communes was based on the private ownership of land, different from that of the North where the village community was formed on the basis of the communal land property. In the XVII and the XVIII centuries, the colonisation was achieved by soldiers, many military farms were founded, and this land belonged to the State. Villages also established village land acquired by the village with its own resources, for common services.

In 1836 the Emperor Minh Mang decided to make a cadastre of the 6 provinces of Cochinchina in order to collect a land tax. From the cadastres of 124 villages of Cochinchina we calculated the Gini coefficient in order to determinate the level of differentiation of peasant households. The Gini coefficient of cantons in the Mekong delta were ranging from 0.6 to 0.8, while that of the Red river delta was in the 0.4 - 0.6 bracket.

Data of land ownership during the French domination given by Henri (1932) show that the differentiation of peasants was at the same level than earlier in the XIX century. The number of landowners in South Vietnam was 255,047. The number of registered males was 1,100,000, so the number of landless was 845,000 (2/3 of registered). In 1929-30, large-scale holdings predominated in West Cochinchina (Mien Tay). Family-held private property and communal land had always coexisted in the Vietnamese village, but the percentage of communal fields was only 3 %.

The mode of farming, as described by Henri was predominantly indirect, or tenant farming, with the exception of Rach Gia and Chau Doc where direct farming or mixed farming (some land in direct cultivation, some rented out) was more popular. Managers of the delta could not employ gangs of agricultural workers, leaving them with no alternative but to rent land to *ta dien*. The *ta dien* was not a real sharecropper paying his rent with a portion of the harvest, as in other countries. This system was found only in Chau Doc where landowners received 2/3 of the harvest. In general, the landowner provided the land and added livestock, advances of rice and paddy as food and seed, and a sum of money as credit. The *ta dien* supplied tools and labour and he paid a part of his harvest as a rent. The most common situation was the landowner renting his land to a land broker who recruited the *ta dien*. The profits of the land broker were a part of the land rent and the interest of the advances that he granted to the *ta dien*. The land rent was from 8 to 30 gia of paddy according to the quality of land (a gia equals to 40 litres). The advance should be repaid two gia of paddy for one and 3 gia of paddy for one piaster (Brocheux, 1995).

After the August revolution in 1945 many institutional changes occurred. In 1946-47, land which previously belonged to the French and French collaborators was redistributed and land rents were reduced to 25 %. In the south, in 1955-56, a land reform occurred under Ngo Dinh Diem regime which restricted rents and maximum land ownership to 100 ha. Again in 1970, land reforms occurred both in territories controlled by the Provisory Revolutionary Government and by the Nguyen Van Thieu Government. Following the liberation of South Vietnam, collectivisation was introduced in 1978 but had little time to take root as de-collectivisation was initiated in 1981 with the Decree No. 100 and the process took place throughout the whole country between 1980-1988. All these reforms contributed to making the land distribution more equitable.

Peasant households in the Mekong delta are more commercial than that of the Red river.

In the XVI century when the first Vietnamese's settled in the east and the west of Cochinchina, there were two types of fields:

- the upland fields (*son dien*, literally mountainous fields),

- the lowland field (*thao dien*, literally herbaceous fields). The cultivation of upland fields was done with the slash and burn system, as in the present mountainous areas. The cultivation of lowland fields depended on the swamping of the field. In less swampy fields, the soil needed to be ploughed before planting, and in the more swampy fields the cultivation could be done without ploughing (no-tillage system).

After the conquest of Cochinchina by the French in 1868, rice production was developed to a higher level. At that time the rice area was already 350,000 ha. A permanent commission was named in 1875 to improve and complete the canal network between Saigon and the Bassac river. After 1884 dredgers were used, and the digging and maintenance of canals were improved. From 1886 to 1930 the drainage work allowed the reclamation of 1,425,000 ha of land. Roads were constructed on the excavated material (embankments), and followed the canals. With the development of the canal system, the rice area increased and in many regions the no-tillage system evolved to the ploughing system.

The rice area of the Mekong delta increased very rapidly during this period:

1880: 522,000 ha

1910: 1,528,000 ha

1930: 2,443,000 ha

In 1901, floating rice varieties were introduced from Cambodia and allowed to make use of the flooding area of the Long Xuyen quadrilateral of An giang province and the plain of reeds. In 1930, the different types of rice culture in the Mekong delta were estimated by Y. Henri (1932) as follows:

	Cochinchina	Mekong delta
- Rainfed single transplanting rice:	1 649 740	1 369 720 ha
- Double transplanting rice:	392 470	392 470 ha
- Floating rice:	217 550	217 550 ha
- Total:	2 259 760	1 979 740 ha

The export of rice grew from 360,000 ton in average during the period 1875-1884 to 1,454 000 ton in the period 1925-1929. In 1925 Vietnam overtook Burma and became the first rice exporter of the world, reaching a maximum of 1,797,682 ton in 1928. After this year, rice production was depressed by the world crisis and export lowered to 1,064,000 ton in 1938.

In 1941 the General governor of French Indochina organised a conference to discuss how to improve the rice production: rice landlords asked for the construction of big irrigation systems and the water management technical services asked for the digging of drainage canals.

In 1944 the areas of the different types of rice cultivation in Cochinchina were as follows:

- Single transplanting rice: 1 541 000 ha
- Double transplanting rice: 436 000 ha
- Direct seeding rice 411 000 ha
- Total: 2 388 000 ha (Coyaud, 1950).

TAB. 2. THE DEVELOPMENT OF THE MEKONG DELTA IN RECENT TIMES

	Rural population	Arable land and permanent crops		Rice production		Rice yield
	Million	Million ha	m2/h	1000 t	Kg/h	T/ha
1930	3,2	2,0	6250	2,6	812	1,4
1998	12.0	2.55	2125	15.3	914	4.1
Growth rate	2,0	0,3	-1.6	2.6	0,02	1.6

During the last 70 years the population of the Mekong delta increased almost fourfold, the area per capita decreased 3 times, but is 5.3 times higher than that of the Red river delta, while the food production per capita is 2.6 times higher. The income per capita increased 1.5 times more than that of the Red river delta and is 1,2 time more than the later.

After the retreat of the French army, the production had to be restored after a long period of war. In 1957 the rice area was restored to 1,964,594 ha and the rice production reached 2,545 000 ton. Ten years later in 1967 the area was only 1,647,938 but the production was 3,190,000 ton. In 1974 the production almost reached 5 million ton. With the American aid, from 1965 to 1975 a great number of 4-wheel and 2-wheel tractors, a great amount of chemical fertilisers and pesticides were imported and high yielding rice varieties provoked the green revolution. After 6 years, 30% of the rice area was cropped with these varieties. Two new types of rice cropping systems were introduced:

- Two high yielding rice: winter- spring and summer-autumn on well irrigated areas.

- high yielding (summer-autumn) and traditional rice on medium flooded area where double transplanting rice was practised. Double transplanting rice was reduced from 250 000ha to 90 000 ha.

Traditional rice remained in the flooded area with floating rice and in the semi-flooded area with the double transplanting rice. The single transplanting area covered 1,5 million ha on rainfed area, especially in regions affected by saline water. During this period the construction of irrigation systems was not yet undertaken and water was lifted by hundreds thousand of small pumps.

Only after the liberalisation in 1975 was implemented in the delta a program of water management. 15 systems of dikes against flood were constructed in the upper part, a network of 75 big canals with hundred medium and thousand small ones drain water for leaching the acid sulphate area and providing non saline water. Several gate systems on the coastal area protect agricultural land from the intrusion of saline water. More than 100 electric pumping station and more than 2200 big and medium pumps serve the irrigation work. The area of irrigated summer-autumn rice increased 2 times. The irrigated area grew up to 350,000 ha, or by 60%. The change of cropping system was characterised by the increase of winter-spring and summer-autumn rice and the decrease of the traditional summer rice.

The mechanisation of agriculture was also developed. In 1983 big tractors increased by 60 % and small tractors by 50 % compared with 1975. The provision of fertilisers especially of phosphorous and of pesticides also was improved. Especially the agricultural research and breeding work was conducted together with the introduction of high yielding varieties. All these improvements, together with the institutional reforms, induced a rapid development of the rice production which changed the country from a rice importer in the beginning of eighties to a rice exporter since the end of the eighties.

Recent surveys show that in the Mekong delta the rice surplus of farmers increased very rapidly in all types of households. The diversification process is going very slow, especially regarding the development of animal husbandry and non agricultural activities.

3 The evolution of the agrarian systems of the Chao Phraya delta

The Chao Phraya delta area is comprised of three main regions (Takaya, 1978): the old delta is the undulating part near the apex of the delta, Chai Nat; the flood plain, with an alternation of levees and deeply flooded backswamps; the young delta, the low-lying and flat area on the southern part. With an area of 1,810,000 ha, the Chao Phraya delta is slightly larger than the Red river one, but much smaller than the Mekong one.

Between 6000 and 3000 BC, most of the lower delta was covered by the sea. Ancient settlements were found on the margin of the lateral terraces. U-Thong, on the West, is believed to have flourished as early as 500 BC (Valliphodom, 1992), while many later sites of the Dvaravati period (first millennium AD), can be found both in the upper and the lower delta (most of the latter on moats and on the terraces margins, as most of the central area remained an inhospitable swamp) (Higham and Thosarat, 1998).

The major ethnic group in Thailand is the Thai, who were valley-dwelling wet-rice growers in the intermontane basins of North Thailand. The Lanna Thai kingdom founded in the XIII century exploited an intermontane basin, and the Sukothai kingdom founded in 1238 exploited a fan-terrace complex. Only the Ayutthaya kingdom, with the core area shifted to the old delta in the XVI century, began the colonisation of the delta. Watabe (1978) showed that the wet rice was first grown in the delta north of Ayutthaya from the XI to the XV centuries, expanded in the same area from the XV to XVIII centuries and spread rapidly to the young delta in and after the XIX century. During the Ayutthaya (1350) and the early Bangkok periods (end of XVIII century), more than 20 large-scale canals (canal linking the Chao Phraya and the Bang Pakong rivers, shortcuts in the meanders of the Chao Phraya) were dug by an army of corvée peasants. At the beginning of the XVIII century, the first two canals between Chao Phraya and Tha Chin rivers (Mahachai and Yong canals) were dug, principally for military and transportation purposes. The liberation of the corvée peasants (phrai) and debt slaves (that) that accompanied the dismantling of the old social order in the late XIX century allowed the peasants to migrate and supplied the labour force for the reclamation of the young delta. From the reign of the king Rama III (1824) a large number of Chinese immigrants settled in Bangkok, and their hired labour provided a working force for canal digging which proved much more efficient than corvée labour, significantly contributing to the reclamation of the delta.

The ancient states of the Thai-inhabited Muang of the intermontane basin of the southeast Asia were numerous and not centralised. The Lanna Thai kingdom founded in the XIII century by the Yuan of Northern Thailand was an example of this type. The water management was practised by the village (ban) or group of village (muang) community . In such condition there was no need to found centralised state. The landownership rested with the headman of the Muang. The land was distributed to serfs (5-25 rai) and slaves (5 rai) against contribution of corvée, services and rent in nature.

In the middle of the XIV century, with the foundation of the Ayutthaya kingdom, the canal excavation for the reclamation of the delta needed a state of an other type. The kingdom also developed trade activities. In the end of the XVIII century, when the capital was transferred to Bangkok, started the reclamation of the young delta, agriculture gradually shifted to an export-oriented rice monoculture (Ishii, 1978).

The social division during the Ayutthaya period and the early Ratanakosin can be simplified as follows:

- the free peasants, who were allowed to occupy, clear and cultivate unused land, and could sell or mortgage if they wished to do so. They were obliged to participate to public works and obligations and to pay different taxes.

- the so-called slaves, who most of time were prisoners of war or people who had chosen to attach themselves to a patron because of indebtedness.

- the nobles and patrons who were granted titles and land within the Sakdi na system.

Three labour sources were possible for landlords: 1) Corvée labour. The load of corvée system gradually decreased between 1780 and 1910. By the turn of the century, the corvée was abolished and replaced by a capitation tax, later eliminated in 1938; 2) Bondsmen labour. Bondmanship was abolished in the 1890's; 3) Wage labourers: In the second half of the last century the hire of Chinese labour was common, as was hired labour of Lao people in the 1890s.

The commercial rice monoculture developed in response to demand for rice from China and other Asian countries in the last half of XIX century, especially after the benchmark Bowring treaty. From the middle of the XIX century onward, canal excavation was mostly aimed at the expansion of riceland. Between the late XIX and early XX centuries, canal excavations proceeded rapidly following the legal confirmation of private ownership of adjoining land. While peasant settlers were granted the usufruct right of the land they cleared, most of the land reclaimed during the last century was granted by the king to royalty or noble officials. The first half of the XX century would witness the explosion of peasants colonisation.

Concession for land development to private companies in 1889 rapidly increased the speed of land reclamation, with the use of mechanisation. In 1905 the Royal Irrigation Department was established. Between the two World Wars, three projects were initiated, where diversion dams or regulators delivered water in canals which, for the first time, were fully irrigation canals. Main land development works were eventually carried out after World War II. In 1952 the Greater Chao Phraya Project was constructed for the irrigation of the northern part of the delta. The Greater Mae Klong Project, initiated in 1972, was further implemented on the western side of the delta. In the young delta, no gravity irrigation is possible because of the flatness of the area. Canal excavation in order to turn water available by pumping, construction of dikes for flood and salt water intrusion protection, were developed (Kasetsart University and ORSTOM, 1996).

In 1967 the rice acreage of dry season was only 3.7 % of the irrigable area in the Greater Chao Phraya Project. The introduction of high yield varieties, the construction of the Sirikit dam (1972) and the improvement of water control contributed to the rise of double rice cropping, with a total of 500,000 ha planted in 1979.

As a consequence of this gradual colonisation and "artificialisation" of the region, the delta society has much of the features attributed to frontier societies: a certain degree of independence from the grip of the central state, a propensity to evade social conflicts or responding to bankruptcy by moving further away, and the formation of villages with migrants from different origins and backgrounds, therefore with little "social glue". At the same time, the integration to the wider economy and national sphere was provided by the marketing of the rice production surplus. The description of the Thai society as "loosely structured", as coined by Embree in 1950, was reinforced by the Cornell-Thai Project research at Bang Chan, near Bangkok (Sharp et al.; 1953; Hanks; 1972; Phillips; 1970). This research team laid emphasis on the lack of strength and unity of the village as a social unit, on the absence of extended kinship groups, the lack of enduring rural social groups and of loyalty to the village, with co-operative labour exchange groups and other asocial arrangements based upon ad hoc dyadic ties with no duration.

The "loose structure" society was later challenged by sociologists carrying out village surveys in the North (Potter, 1976) and in the Northeast (Mizuno, 1978), who opposed it and attempted to show that rural villages were, on the contrary, as strongly structured as other Asian societies. Relevant to our present concern is the argument that the "loose structure paradigm has been linked to observations made in communities located in the Chao Phraya delta, near Bangkok, and that it could not readily apply to other different cultural regional settings. The historical and ecological contexts are often brought up as the main factors explaining differences in social structure.

The population of the Central plain in 1990 was almost 13,781 million habitants, 20 % of the total population of Thailand. 5,9 million live in Bangkok, and 2 million in the vicinity of Bangkok (four neighbouring provinces). In Bangkok and the vicinity the population density was 1374 h/km^2, against 276 h/km^2 in rural areas. From 1960 to 1990, the population of the Central plain increased more than 2 fold.

TABLE 3: POPULATION CHANGE IN THE DELTA

	1960	1970	1980	1990
Bangkok	2,136,435 -	3,077,336 3.7	4,697,071 4.3	5,882,411 2.3
Bangkok vicinity	786,410 -	1,032,792 2.8	1,421,448 3.2	2,077,890 3.88
Rural central plain	3,561,595 -	3,986,228 1.13	4,774,887 1.82	5,518,057 1.46
Total central plain	6,484,440 -	8,096,356 2.2	10,893,406 3.0	13,478,358 2,15

Immigration played an important role to offset the low population of the delta during the 1850-1940 period. A post-war recession in rice production and a demographic saturation of the delta, together with the development of upland agriculture, boosted out-migration in the late 1950s and the 1960s. The population of the rural delta is still on the rise, but its agricultural population is decreasing slowly at present, while all the natural growth and net migration flow have been transferred to non-agricultural sectors. The share of agricultural population was 70 % of the total population in 1960 and 40 % in 1990.

From 1960 the economic development of Thailand was very rapid, the income per capita increased very fast, but the differentiation also increased. In 1979 the urban class (12.5 %) had an average income 9 times that of farmers (68.5 % of the population) (Trebuil, 1987). The Gini coefficient of income distribution and the number of people under the poverty line increased, even in the rural Central Plain (Krongkaew et al., 1992).

The study by Molle and Srijantr (1999) of the land system in 6 rural provinces of the Chao Phraya delta showed that:

1. After an increase between 1950 and 1963 (+36 %), the number of agricultural holdings has been found to level off.

2. The relative stability in the number of farms associated with a significant overall loss of agricultural land means that the average farm size has been declining (4.8 ha in 1950, 3,5 ha in 1993).

3. Rice mono-cropping also declined (96 % in 1937, 90 % in 1963 and 70 % in 1993).

4. During the last 40 years, a great number of farms over 4.8 ha have disappeared.

5. The Gini coefficient of farm land distribution increased: 1950- 0.41, 1963- 0.46, 1978- 0.47, 1993- 0.52. This means that the landownership differentiation has increased but this cannot readily be translated into socio-economic terms as the productivity of land varies and very intensive cash production (peri-urban vegetables, aquaculture, orchids, etc) are done on small areas.

6. The class of full tenants and mixed holders have not grown, but the class of full owners now dominates, most of these emerging new holdings being associated with small farms areas.

7. Tenancy, expressed both in the number of farms renting all or part of their land or in percentage of farmed land, has been rising to a peak in the early 70's and has, overall, been slightly declining hitherto. Despite some slight ups and downs (War, 1970 crisis, etc.), the most striking picture arrived at is that of a certain stability of the tenanted farmland, since as early as the 30's.

8. The rental arrangements and the types of rents have been shown to greatly vary according to the relations between owners and tenants, the price of rice, the projected land use and, more generally, the level of water control. Molle (forthcoming) has shown that, contrary to common wisdom, land owner-tenants had been rather balanced, despite some historical crises.

9. Surveys in the early 80s show that 9 % of agricultural households were landless wage labourers. The Central region had a higher percentage: 9-30% and this population has been growing hitherto. However, this is concomitant to the rise of pluri-activity (multiple occupation concerns 57% of rural households), job opportunities in intensive productions and the ageing of farmers increasingly resorting to hired labour.

The agrarian system of the delta, after the crisis in the late 60s early 70s, was able to re-balance itself significantly. The crux of the matter was that, on one hand, surplus labour was able to be absorbed by non-agricultural sectors, while on the other hand, agriculture could continue its transformation towards higher intensification (one million rai of triple cropping in 1998 and 1999) and diversification (aquaculture, cash crops). These two trends, however, are conditioned by the price of rice, by the existence of markets for other production and, overall, by the availability of water (see Molle et al. *this conference*).

4 Comparison of the three deltas

The description of the three deltas allows us to make a comparison of their main features.

4.1 The natural environments

The natural condition of the Red river delta with its "mosaic environment" strongly differs from that of the two southern deltas which have a flatter relief. The relief of the former delta was altered in its evolution by the construction of dikes. The development and maintenance of the dikes required a higher degree of centralised power than in the two frontier deltas, where floating rice could be grown in flood prone areas and where individual water lifting, or tidal irrigation, allowed farmers to start cultivating without collective constraints.

The Mekong and Chao Phraya deltas also constituted harsher environments, swampy, unhealthy and with little available land to construct homesteads. This partly explains their late wide-scale colonisation. In the case of the Mekong delta, severe constraints also include soil acidity and salinity.

Rainfall patterns are similar but the Mekong delta enjoys a longer rainy season. It allows in particular rainfed rice cultivation in the first part of the rainy season, which is not possible in the Chao Phraya Delta where total amounts are lower and more irregulars.

Differences in hydrology and topography also made it possible to construct a diversion dam at the apex of the Chao Phraya delta, thus allowing gravity irrigation in the northern part, something unthinkable in the Vietnamese deltas where flows are too powerful and upstream regulation by dams limited.

4.2 Natural hazards

The Red river delta and the other two deltas are exposed to drastically different risks of being flooded: the Red river is one of the most dangerous rivers in the world while the Mekong and Chao Phraya have more predictable and less destructive floods. The Red river is extremely flood prone because of its small cachtment basin which is subject to erratic but very heavy rainfall, its extremely steep gradient and low elevation and flat relief. The flood control was achieved by the mean of the construction of dikes. The lover reaches of the Mekong river and Chao Phraya with its larger watershed (the dampening capacity of the Tonle Sap for the mekong), the greater regularity of its rainfall pattern and its less extreme gradient profile, are not subject to extreme flooding. The regime of the river is a single annual gradual rise and fall of the waters rather than the frequent and unpredictable cresting characteristic of the Red river. This situation allowed the two southern deltas to cultivate floating rice.

The Red river delta is also faced with typhoons, while these are infrequent to rare in the two other deltas. This raises the risk of crop loss and make higher investment in drainage necessary.

4.3 The settlements

The Red river delta was settled much earlier than the other two deltas, hence its higher population density, the higher man land ratio, the higher population pressure on resources and the higher intensification in farming methods. All these factors put the Red river delta in a more difficult situation for development.

The southern deltas with larger size and later colonisation have less population pressure and were reclaimed by canals digging. Settlement was hampered by the lack of communication and of convenient location for homesteads, especially in the most southern parts. Even in present times, a chief objective of canal development in the Mekong delta is to expand the land suitable to accommodate the growing population.

This geographical feature also explains the high occurrence of ribbon villages in the southern deltas, while those of the Red river are more of the cluster type. In the Chao Phraya delta, there is a vivid contrast between the southern settlements, established along the canal embankments, and some older and cluster-type villages of the north of the delta.

4.4 The social systems

The Red river delta had an early centralised state. The Mekong delta was colonised by a military new founded state for the struggle against the Northern state. While the Chao Phraya delta was the development from a Muang state in a new context of large land reclamation and market development.

The villages of the Red river delta are "closed corporate communities" while that of southern deltas are open peasant communities" (Rambo, 1973). Northern Vietnamese villages have more communal land and have a higher level of equity. In the southern deltas land is more privately owned, agriculture was developed for commercial purpose. Thus, the stratification of peasants is more acute.

While the Chao Phraya delta frontier society can be considered loosely structured with regards to corporate communities, it is not deprived of strong "structural regularities" centred on flexible, voluntary patterns of relationships between individuals. Social control is apparent in issues such as money borrowing or land rental contracts (Molle, *forthcoming*). However, the implementation of large scale state initiated irrigation infrastructure did not help in creating a sense of community, as happened in the north where villages united to build run-of-the-river communal irrigation schemes.

The Red River delta's history is marked by a strong bias in favour of centralised and collective options of development. The Chinese background was reinforced by the necessity to tame the floods (hydraulic state) and, later, by the communist ideology. In the Mekong delta, the influence of the central power was less, although the colonial period and the reunification were times in which the state attempted to increase its control. In the Chao Phraya delta, the independence of the peasants at the frontier was even higher.

4.5 The objective of production

Due to the limitation of its resources, rural production in the Red river delta is more subsistence oriented than in the southern deltas, where production is more market oriented. In the Chao Phraya, the reclamation has been tightly governed by the boom of the rice economy which has offered an outlet to the labour force freed from bondsmanship. Although there are speculations on the impact of the opening of subsistence-oriented peasant economies to capitalism and market economies, it is inadequate to look at the Chao Phraya delta within such a framework, as its formation and social fabric are inseparable from the rice economy itself.

From what has been said earlier, we see that there are more similarities than differences between the Mekong and the Chao Phraya deltas. But there also important differences:

1. If we take the population pressure on resource and man land ratio and the level of intensification (as allowed by the present land development), the Mekong delta may rank higher; but if we take the level of industrialisation, the urbanisation, the migration, the decline of agriculture ... the Chao Phraya delta appears to be far "ahead".

2. If we take the Gini coefficient on income and land distribution we observe that the differentiation in the Chao Phraya delta is higher than in the Mekong delta, in its turn higher than in the Red River delta. However, it has been shown (Molle and Srijantr, 2000) that the Chao Phraya was remarkable by the resilience of its agrarian system rather than by a critical worsening of its socio-economic situation.

If we consider wider economic and societal transformations, it is the Red river which appears to be in the most worrying situation. The very low development rate of off-farm job activities and the closure of the upland frontier, and the already very high level of intensification achieved do not provide sufficient opportunities for increasing and diversifying incomes. The Mekong delta fares better as it still has significant scope for intensification and even expansion of agricultural production, and as the dynamism of Saigon is creating some job opportunities. The Chao Phraya delta has weathered the agrarian crisis it underwent 30 years ago but it might now face a process of agricultural demise, together with growing environmental problems.

All three deltas have to maintain delicate balances between their rural and urban components, an equilibrium which is governed by several interlinked factors, including demography, migration or non-farm job opportunities, the price of rice and the market for other productions, improved water management and adequate government policies.

Acknowledgements

This paper is a preliminary version of a study carried out within the research project "Water Management, Land Development and Economic Diversification in Southeast Asian Deltas" funded by the European Union (INCO-DC).

References

Brocheux P. 1995. The Mekong delta: Ecology, Economy, and Revolution, 1860-1960, Univ. of Wisconsin-Madison.

Chang T.T. 1976. The origin, evolution, cultivation, dissemination, and diversification of Asian and African rices, Euphytica, 25 , 1976, 425-441.

Coyaud Y., 1950. Le riz, Archives de l'office indochinois du riz, No 30, 1950.

Dao The Tuan, Luu Ngoc Trinh, Le Thi Chau Dung 1997. La diversité génétique du riz cultivé dans le Sud-est asiatique, Cahiers Agricultures, 1997, Vol. 6, 531-4.

Dao The Tuan. 1985. Types of rice cultivation and related civilisations in Vietnam, East Asian Cultural Studies, 1985, V 24, No 1-4, 41-56.

Embree, J.F. (1950) Thailand : a loosely structured social system, American Anthropologist 52 : 181-193.

Feeny D., 1982.The political economy of productivity, Thai agricultural development, 1880-1975, Univ. of Bristish Columbia, 1982.

Gourou P., 1932. Deltas as population centres, Natural resources of humid tropical Asia, UNESCO, Paris, 1974, 439-456.

Gourou P. 1936. Les paysans du delta tonkinois, Les Editions d"'art et d'"histoire, Paris, 1936.

Hanks, Lucien M. 1972. Rice and Man, University of Hawaii Press, 173 p.

Henry Y. 1935 . Economie agricole de l'Indochine, Hanoi, 1932.

Higham, Charles and Rachanie Thosarat. 1998. Prehistoric Thailand, from early settlement to Sukhothai, River Book, Bangkok, 234 p.

Ishii Y., 1978. History and rice-growing, Thailand: a rice-growing society, The University Press of Hawaii, Honolulu, 1978, 15 -39.

Ishii, Y. (ed.). 1978Thailand: A Rice-growing society, Ed. Y. Ishii, The Univ. Press of Hawaii, Honolulu, 1978.

Kaida, Y. 1991. Irrigation landscapes and waterscapes in the rice land of tropical Asia, South East Asian Studies, Vol. 28, No 4, Kyoto University, pp. 124-135.

Kasetsart University and ORSTOM. 1996. Identification of agricultural and irrigation patterns in the Central Plain of Thailand : prospects for agricultural research and development, 220 p., DORAS Project, Bangkok

Malleret L., 1962. L'archeologie du delta du Mékong, tome III (texte), EFEO, Paris, 1962.

Mizuno, Hoichi. 1978. The social organisation of Rice-growing villages ; in Ishi, Y. (ed.) : Thailand : a rice growing society , pp. 88-114.

Molle, François. forthcoming. Social and economic patterns of landlord-tenant relationships in the Chao Phraya Delta, Thailand: an historical perspective.

Molle, Francois; S. Durongdej; C. Chompadist; A. Joannon and Y. Limsawad. 1999. Improvement of rice cultivation and water management in the flooded area of the Central Plain of Thailand : a zoning of rice varieties by using remote sensing imagery Kasetsart University, DORAS Center, Research Report n°5, submitted to NRCT, Bangkok, pp. 155.

Molle, François; Srijantr, Thippawan. 1999. Agrarian change and the land system in the Chao Phraya Delta, DORAS Project, Kasetsart University, Bangkok, Research Report n°6, 191 p.

O'Connor R.A. 1995. Agricultural change and ethnic succession in Southeast Asian states: A case for regional anthropology, The journal of Asian studies, Vol. 54, no 4, 1995, 968-996.

Phillips, Herbert P. 1970. The personality of the Thai peasant: the patterning of interpersonal behaviour in the village of Bang Chan, University of California Press, 230 p.

Potter, Jack M. 1976. Thai peasant social structure, Chicago, University of Chicago Press

Rambo T. A. 1973. A comparison of peasant social systems of the northern and southern Vietnam: A study of ecological adaptation, social succession and cultural evolution, Center for Vietnamese studies, Southern Illinois University at Carbondale, Monograph Series III, 1973.

Takaya, Yoshikazu. 1987. Agricultural development of a tropical delta : a study of the Chao Phraya delta. Monographs of the Center for Southeast Asian Studies. Kyoto University. ed. Vol. 17. University of Hawaii Press, Honolulu. 269 p.

Trebuil G., 1987. Sathing Phra: un système agraire en crise au sud de la Thailande, These de doctorat, INAPG, Paris, 1987.

Vallibhotama, Srisak. 1992. Early urban centres in the Chao Phraya valley of Central Thailand, in Ian Glover et al. (eds) "Earl metallurgy, trade and urban centers in Thailand and Southeast Asia, White lotus press, pp. 123-130.

Vo Tong Xuan, S. Matsui (eds.) 1988. Development of farming systems in the Mekong delta of Vietnam, Eds. Vo Tong Xuan, S. Matsui, HCM, 1988.

Watabe T. 1973. Alteration of cultivated rice in Indochina, Japanese Agricultural Research Quarterly, V.7, No 3, 160-163.

Natural environment

Red river delta	Mekong delta	Chao Phraya delta
Mosaic environment due to dikes	Almost flat due to natural sedimentation	Almost flat due to natural sedimentation
Most dangerous river of the world	Most benign river	Most benign river
Small catchment basin, steep gradient	Large watershed, low elevation, flat relief	Large watershed, low elevation, flat relief
Erratic and heavy rainfall	More regular rainfall pattern	Rainfall pattern with irregularities, especially during the early rainy season
Frequent typhoons	infrequent typhoons	Rare typhoons
Irregular and abrupt flooding with rapid rise of water	Regular flooding with regular annual gradual rise and fall of water	Relatively regular flooding with regular annual gradual rise and fall of water

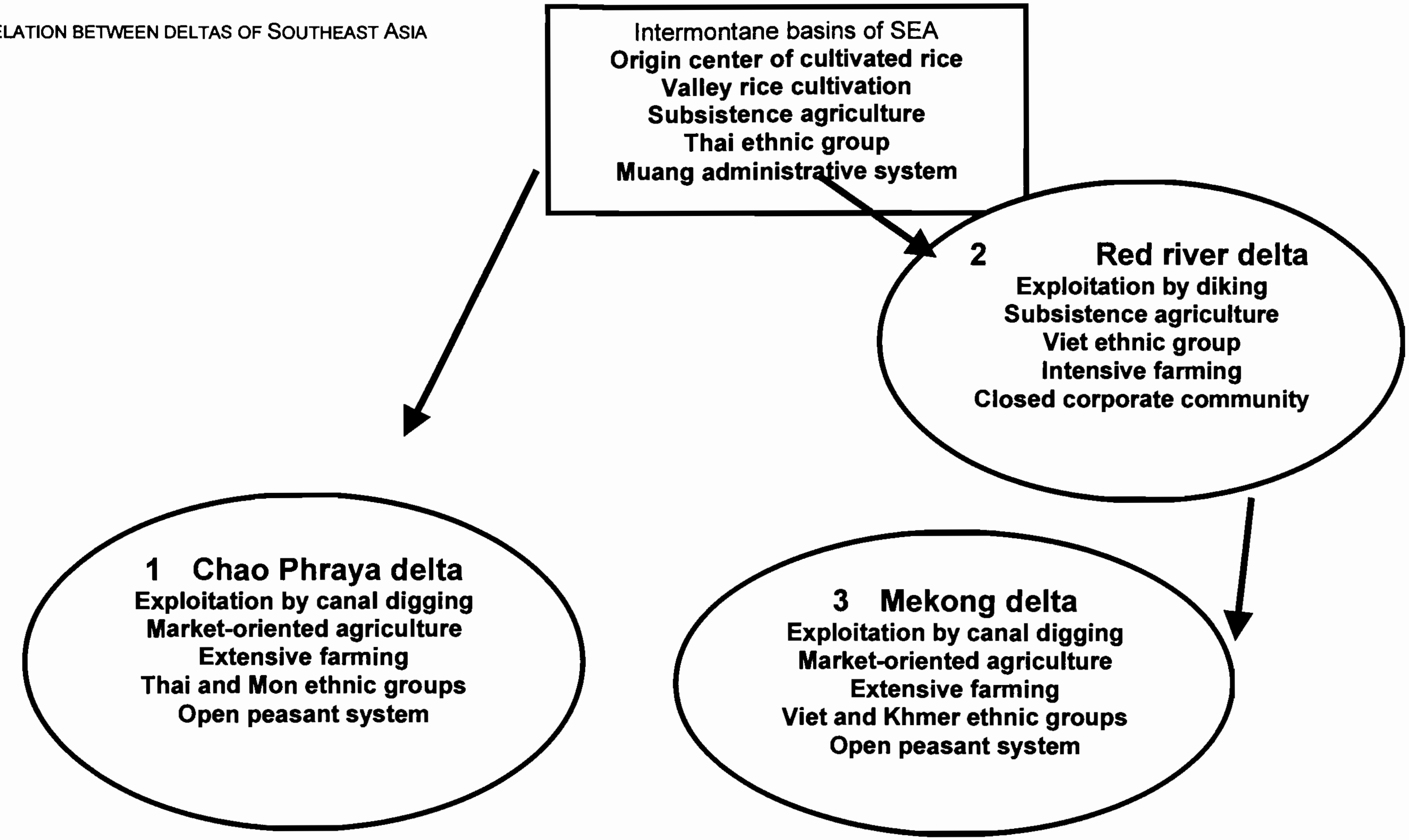
Settlement

Red river delta	Mekong delta	Chao Phraya delta
Early settlement (10th century)	Late settlement (18th century)	Late settlement (18th century)
High population density	Medium population density	Low population density
Lack of land for extension , intensive farming	Large area for extension, extensive farming	Large area for extension, extensive farming
Flood control by dikes and creation of heterogeneous landforms	Reclamation of land by canal digging and drainage	Reclamation of land by canal digging and drainage
Exploitation by intensive cultivation adaptation to different landforms	Exploitation by extensive method of cultivation	Exploitation by extensive method of cultivation

Socio-economic systems

Red river delta	Mekong delta	Chao Phraya delta
Needs of struggle against foreign invasion and flood control	Need of strengthening the Southern state and struggle against Northern state	Heritage of Muang slavery and Sakdina system
Early central state of oriental despotism type	Military and civil colonisation by soldiers and criminals	Civil colonisation by migrants and Chinese labour force
Strong influence of Confucianism	Strong influence of Mahayana Buddhism	Strong influence of Hinayana Buddhism
Strong village communitarism	Loose village communitarism	Loose village communitarism
Closed corporate community	Open peasant system	Open peasant system
Village autonomy	Less village autonomy	Relative village autonomy
Subsistence agriculture	Development of market economy	Development of market economy
High equity	Medium equity	Medium-low equity
Large out-migration	Large immigration from the North	Immigration, including from China, and outmigration from the 50s onward
Slow industrialisation and urbanisation, little job opportunities out of agriculture	Emerging industrialisation and urbanisation	Rapid industrialisation and urbanisation
Strong Chinese cultural influence	Strong Chinese economic influence	Strong Chinese economic influence

RELATION BETWEEN DELTAS OF SOUTHEAST ASIA



Changing faces of the Ayeyarwady (Irrawaddy) Delta (1850-2000)

Mya Than[1]

1 Introduction:

The Ayeyarwady River, the longest river and main transportation route in Myanmar, has flowed into the country for several milleniums witnessing the physical and socio-economic changes along its banks and delta. The purpose of this study is to explore and examine the changes that took place during the last one and a half centuries in the Ayeyarwady delta. That is, this study will discuss the political, social, economic and environmental changes that were taken place during the period from 1850 to 2000. It seems that political, particularly leadership, and environmental changes are more apparent than any other.

To evaluate these changes, this study will take the chronological approach. Since the period of study is long, it will be divided into four sections. The first section will describe and analyze the changes in the pre-British period (under the rules of Myanmar kings) up to 1852. Changes in the Ayeyarwady Delta during nearly one hundred years of colonial rule (1852-1947) will be assessed in the second section and the third section will examine the post-independence period (1948-2000). As the post-independence saw several changes in political leadership, it can be divided again into three sub-periods; democracy period, Burma Socialist Program Party (BSPP) period, and the present State Peace and Development Council period (SPDC).

For this study, the author has sourced mainly from the studies of J. S. Furnivall (1953), Willem van Schendel (1991), Michael Adas (1974), Cheng S. H. (1968), U Tun Wai (1961), McCrae and Prentice (1978), Mya Than (1984, 1987, 1990), Nishizawa (1991), and various IMF and World Bank reports, among others. Because the Ayeyarwady delta occupies most of the "Lower Burma" (as used by the British which refers to the area between Pyay and the Gulf of Martaban), these two terms will be used interchangeably in the first two sections.

The Ayeyarwady River: The Ayeyarwady is the main river of Myanmar/Burma, traversing the country from north to south (from Himalayan slopes to the Bay of Bengal) for about 1,350 miles. However, the river is navigable by steamers for about 900 miles up to Bhamo and by launches up to Myitkyina. It has its source at the confluence of two rivers, the Maykha (N'mai

[1] Institute of Southeast Asian Studies, Singapore

Hka) and Malikha (Mali Hka), both of which have their beginnings in the Himalayan slopes. They join about thirty miles north of Myitkyina to become the Ayeyarwady.

The melting snow from these Himalayan peaks brings about the phenomenom that the Ayeyarwaddy begins its early annual rise during the month of April at the heart of Myanmar's driest season. It is the main communication route of Myanmar as it flows southward through Myitkyina, Bhamo, Mandalay, Pakokku, Yenangyaung, and Pyay before it enters the vast delta at Hinthada. The river is joined by Chindwin, a main tributary, and Myitnge rivers below Mandalay. In its northern part, the river has three defiles.

The southwest monsoon rains reach the lower part of Myanmar around June and the upper part around April. These rains add to the already swollen river until October when its water level starts to fall. It reaches its lowest level between December and April. In the northern part of the river, the average rainfall during the months of April to October is about 80 inches, in the central dry zone only, 25 to 40 inches and in the delta area 100 inches or more.

During the low water season the level of the Ayeyarwady river drops 80 to 100 feet in the First Defile below Myitkyina, while over the 750 miles between Bhamo and Hinthada the drop is on average about 40 feet. "At Henzada (now called Hinthada - author), 150 miles from the sea (where Irrawaddy is four miles wide) the first branches of the delta break out east and west and from there south the whole country is flat and alluvial, with no defined or measurable rise and fall of the river" (Irrawaddy Flotilla, 1978, p.26).

It is to be noted that although the river has an exceptionally small contour drop of only some 500 feet in the 1350 miles from the beginning of the river to the sea, the current speed is maintained even during the low water season, often at modest levels where the river widens. However, the current is at a greater velocity where a narrowing of the natural banks occurs.

As the sedimentation of the river is very significant for agriculture, it is well described in McCrae and Prentice (1978) as follows:

"With huge sediment deposits suspended by the current, silt and sand dictate the nature of the river bed. The sand is of the finest texture and almost white in colour, but where the river is subject to the tidal influence of the delta area it can only be described as muddy, and seasonal flooding there accounts for the remarkable fertility of the delta paddy growing land. The quantity of alluvial deposit is so immense that delta extends further and further into the Bay of Bengal each year; geological evidence has shown that the town of Prome, now some 250 miles from the sea, was once close to the seaboard" (p. 26).

In the delta area, low water season defined creeks are transformed by high water into many vast, lake-like surfaces. Below Henzada (Hinthada) the ever increasing branches which form the delta spread east and west until, finally, across a land space of more than 100 miles between the Bassein (Pathein) River to the west and the Rangoon River to the east, the Irrawaddy pours out its muddy waters over a wide expanse of the ocean" (p. 26).

This process of sedimentation of the Ayeyarwaddy, to some extent, is contributing to the socio-economic changes in its delta area.

The Ayeyarwady Delta: The Ayeyarwady delta consists of the interminable and fertile plain of southern part of Myanmar which is 180 miles long and 150 miles wide. When the British occupied the lower part of the country in 1852, the delta was tall jungle and high grass. During the period, native colonists from the parched fields in the formerly Upper Burma became attracted by the delta and started clearing the jungle because of the regularity of its fertilizing rain and unfailing monsoon. Many of those pioneers died due to harsh conditions but their descendents benefited by staying. The colonial government encouraged the immigration from Upper Burma by adopting "*dama-u-gya*" system which had allowed any person to clear and cultivate any land to which no previous occupant laid claim. Thus the land became the private property of the cultivator which he could mortgage, sell or bequeath to his descendents. Actually, under the British rule there were five different systems of occupying land have been recognized. (For details, refer Furnivall, 1953, p. 51).

Most of the delta area falls under the present Ayeyarwady Division which lies west and northwest of Yangon, Yangon Division, and Pegu (Bago) Division. The Ayeyarwaddy Division includes the mouth of the Ayeyarwady River and the area upriver to Kyangin, south of Pyay and Pathein Distict spanning from the eastern side of the Rakhine Yoma (Arakan Yoma Range). Yangon Division includes former Hantharwady District, south of Yangon up to the mouth of the Ayeyarwady. The area between Bago Yoma and Sittaung River from the south of Taungoo up to the Bay of Martaban (Motetama) is known as the Bago Division.

Majority of the inhabitants in the Delta are Bamar (Burman). Minorities like Kayins (Karens) and some Rakhines (Arakans) and Shans can be found in the delta area. The dominant crops in the area are rice, sugar cane and jute and most of the agricultural processing industry is concentrated in this part of the country. In other words, the delta bustles with various types of commercial activities.

As far as the present farming system in the Ayeyarwady Delta is concerned, the World Bank study (August, 1999) described it concisely as follows:

"The Ayeyarwady Delta of southern Myanmar is a fragile and intricate ecosystem of mangrove swamps and tidal estuaries. Non saline arable areas are limited and becoming scarce due to the erosion of riverbanks, saltwater intrusion, and increasing soil salinity. Poor water control and drainage works contribute to periodic flooding and crop losses. Most poor households cultivate a single crop of traditional monsoon paddy. Better-off farmers able to grow early maturing, high-yielding varieties of paddy benefit from an additional winter crop such as groundnuts or soybeans. In the very few areas where irrigation facilities are available, summer paddy is grown. Marginal farm households cannot afford to use chemical fertilizer or manure and suffer from declining crop yields. In some townships such as Laputta, Bogalay and Mawlamyaingyun, it is estimated that more than half of the population is landless. Many marginal farmers engage in fishing and crabbing. Those who fish typically do not own fishing gear or boats and depend on fish traders for such resources. Some households raise pigs, chickens, or ducks. Others crop during the slack growing season by borrowing from more well-off farmers; loans are paid back through labour or through a portion of paddy crop. The effective interest rate charged by fish traders, rice traders and others in these loan arrangements typically amount to 10 per cent a month" (p. 40).

2 Feudal Delta (Until 1852)

The history of old Burma could be described as one long series of internecine warfare. There were independent kingdoms at Arakan (Rakhine), Pegu (Bago), Tavoy (Dawei), Prome (Pyay), Toungoo and Ava (Innwa). The stronger and dominant kingdom varied from time to time. Only under the King Anawrahta of Bagan (1044-1077), Myanmar was united for the first time. The second unification was occurred in 1539 under the Toungoo King Tabinshwehti, and the third and the last dynasty was founded by King Alaungpaya which lasted from 1755 to 1855 when the British occupied the whole country. This dynasty was known as the Konbaung Dynasty and its last king, Thibaw, was deported to India after the British conquest.

Economic system: During the period of Konbaung Dynasty, it is obvious that the political system was feudal which was different from the one that existed in Europe. "As in Europe, there was the usual obligation of the chieftain to produce the required number of men in times of war, and the same kind of tithes and dues that had to be paid by peasants to the overlord. But unlike the feudal society which existed in Europe or the caste system in India, the one in Burma was elastic in nature" (U Tun Wai, p.1). Another difference was that there was not the same connection between the land and serfs as in Europe. According to Furnivall (1936), under Burmese rule the relation between rulers and the ruled was personal. A man did not live in a village because he owned land there, but owned land because he lived in the village (p.85). Moreover, a man could migrate from one village to another, and still owe allegiance to the same captain (usually township chief – Myo Wun or Myo Sa). More importantly, the economic policy of Burmese kings was very akin to the mercantilist philosophy.

At the beginning of the 19th Century, it was estimated that the population in Lower Burma was about 1.2 million out of the country total of 4.7 million. In other words, the population of Lower Burma was only about one quarter of the total population (U Tun Wai, p. 5). This low level of population could be attributed to the internecine war since this part of the country used to be battlegrounds. As far as literacy is concerned, "The Burmese are a well educated people, at least the male part of the community, the boys throughout the empire being taught by the priests both to read and write" (ibid., p. 65).

It is interesting to note that Burmese kings did not encourage their subjects to emigrate. Even if men were allowed to emigrate, the women were not. On the contrary immigration was encouraged.

Agrarian system: There were four kinds of land during the feudal days; Crown lands (lands belonging to the king), lands held under various kinds of services tenures (similar to the land tenure of feudal Europe with the concept of overlord), waste land, and land under allodial title (dama-u-gya land for which the owner had to pay the share of the produce to the king).

People working on the crown land had to pay rent to the king and the right to collect rents were sold to the collector (Ayadaw-ok) who would collect for the king. "On land under various kinds of services tenure and allodial title, land revenue had to be paid to the king. On the latter it was one-tenth of the produce and payment was in kind"(ibid., p. 8).

During the feudal period, the main crops grown in Upper Burma were rice, wheat, tobacco, pulses, and maize whereas rice, sugar cane, cotton and indigo were grown in Lower Burma. As far as technique was concerned, it was better in Upper Burma than in Lower Burma, particularly the usage of irrigation due to poor soil and scarce rain fall. In the Ayeyarwady delta, the plough was seldom used; instead a rude harrow and the treading of cattle was used. Instead of transplanting, broadcasting method was used in the monsoon season. On the other hand, plough and transplanting methods were used in paddy cultivation due to availability of irrigation system.

Lifting of the ban on paddy exports helped the delta area increase in income. During the first years of the British annexation of the Lower Burma, Lower Burma exported rice to Upper Burma. But by1855-86, half of 127,000 tons of rice was exported to Upper Burma and the rest to overseas.

The agriculture system in this period, with the exception of cotton, was for domestic consumption and hence credit was not necessary. Credit was necessary only in the cases of crop failure due to droughts or warfare or wild pigs. In such cases, the neighbours in the village would be sources of credit (Furnivall, 1936, p. 118). Agricultural activities were mainly a domestic affair using family labour and in the case of transplanting and harvesting, farmers would help each other.

Industry: There was a flourishing ship building industry due to the existence of teak forests. U Tun Wai (1961), quoting Symes, mentioned that the cost of building a ship in Rangoon river was one third less than the cost in Ganges and about half that at Bombay (p.11). However, the technique used for the industry was very primitive and wasteful since the axe was used instead of the saw.

The salt industry also flourished in the delta area along the sea coast. In Upper Burma, the cotton industry and oil industry existed although techniques used were outdated. Most oil wells were located in Yenangyaung township from where oil was transported by boat to all parts of the kingdom.

One popular industry during the period was mining industry in which rubies, iron, lead, tin and zinc were produced. All the mining industry was located in Upper Burma. Processing of agriculture products such as rice, sugar cane and sessamum oil as expected was also found mostly in Upper Burma.

In short, most industries using primitive techniques were located in the upper part of the country and products were mainly for domestic market.

Economic conditions of the people: Let us start with the revenue system. Revenues were collected by chieftains by taxing the people in their jurisdiction and they, in turn had to pay the king as tributes. The king also obtained revenues from various duties, taxes on mines, oils, fisheries, salt, on exports and imports, land revenue and rent in the sense of one tenth of the produce.

For ordinary people, according to colonial officers such as Crawford, the standard of living in Myanmar at that time was better than India due to higher wages and lower cost of living (op.cit., p.27). However, housing conditions were inferior to those in Europe since Myanmar houses were constructed with bamboo and wood peculiarly adapted for countries subject to earthquakes and hot weather. To conclude, compared to Upper Burma, the standard of living in the delta area during the time of Myanmar kings was low. This was because most of the people in the delta area were subsistence cultivators, fishermen, salt manufacturers and dhani palm gatherers. Of course there were administrators but their community was quite small.

3 Colonial Delta (1852-1947)

As a result of the First and the Second Anglo-Burmese war, the British annexed Lower Burma in 1852 while the Upper Burma was still ruled by Myanmar kings. The last two Myanmar kings were King Mindon (1852-1878) and King Thibaw (1878-1885). In 1886, the British again annexed the Upper Burma after the third war between the two countries. The excuses were the growing influence of France on Myanmar, the massacres at the royal court regarding the accession of the throne, and the dispute between the king and the Bombay Burma Trading Company and the resulting fine, among others. The country gained its independence from the British in January 1948 after the Second World War. In between, Japanese occupied the country from 1943 to 1945.

The conquest of the British marked the end of feudal system in the Ayeyarwady delta. The political and economic institutions of Lower Burma were transformed as the area was rapidly drawn into a capitalistic, commercially oriented global economy (Adas, 1974, p. 28). Thus, the feudal lands had become the private property and the commercialization of the country's agriculture and globalization started to work. (For details, refer to Furnivall (1957) and U Tun Wai (1961).

Since the colonial rule lasted for about 100 years, it can be divided into two parts; the period from the annexation of Lower Burma to that of Upper Burma (1852-1885) and the period when the whole country was under the British rule until the country gained its independence (1886-1947). However, due to limited time, both sub-period will be examined at the same time.

Economic System: The British annexation of Lower Burma resulted in a significant change in the economic system in the delta. The Myanmar kings' had had a closed door system but now the country was thrown open to the outside world. The economic policy was for development and to a certain extent the principles of "free trade" as practiced in England were applied and economic forces were given full play. At the same time in Upper Burma, the Myanmar kings were still attached to mercantilist philosophy in spite of closer relations with Lower Burma and there were monopolies in trading. (U Tun Wai, p. 30). On the other hand, even though market economy was working, there existed monopolies such as Steel Brothers which handled three quarters of the total European rice trade.

With the opening of the economy and foreign trade, many banks were established in Myanmar; most of them were opened in seaports and Yangon. However, the money link between the cultivators and money market was served by Chettiers.

The feudal system in the whole country was came to an end as a result of the annexation of Upper Burma by the British in 1886. Along with feudalism, also gone were the mercantilist policy and economic controls such as state trading and price controls. Thus, the economy of the country was again integrated and the structure of the economy had changed significantly. A new type of economy known as plural economy in which foreigners played very significant role, started to take place in the Lower Burma. In short, the earlier stage of market economy was working in the whole country which was brought into closer contact with materialistic civilization (Ibid., p. 63). There was no change in overall economic structure between 1930 and 1940 just before the Japanese occupation.

The worst case for the Delta towards the end of the colonial period was the Japanese occupation period during the Second World War which resulted in very extensive damages. The whole economy was seriously affected due to British and Japanese scorched-earth policies. Furthermore, cultivators abandoned almost half of the land.

Agrarian System: The objective of the British government regarding the agrarian system was to strive to make rights to land easily attainable and at the same time to ensure that holdings came to be controlled by agriculturists and not by speculators and moneylenders. Under the British rule five different systems of occupying land have been recognized; (a) the squatter system, (b) the patta system, (c) the lease system, (d) the Grant system, and (d) the colony system (Furnivall, 1957, p. 51). Two dominant types of land system out of the five introduced during the period were patta system and squatter type. Under the patta system, the government granted tenure before the cultivator cleared his land. "Grants were made by local Thugyis, or district officers, depending on the size of the holding. Only persons who were able to prove that they are bonafide agriculturists could obtain patta grants" (Adas, 1974, p.32). On the other hand, "squatter' type land was similar to dama-u-gya system in the feudal days in which most cultivators became landholders by the act of clearing and cultivating a patch of jungle or scrub. Either form of tenure gave the landholder a permanent and heritable title to his land which he could sell, mortgage or transfer. To promote immigration into the Delta, the government waived payment of the capitation tax for the first two years after a migrant's arrival. (Ibid. p.34).

During earlier colonial period, land revenue was assessed at 10 per cent and then 20 per cent of gross produce. Then in later days it was changed to one half of the net profits, and net profit was defined as gross produce less cost of cultivation and cost of living (U Tun Wai, p. 69).

As a result of the colonization of the Delta, the cultivated land had increased from 600 thousand acres in 1852-53 to 6.7 million acres in 1902-03 and then to 8.9 million acres in 1922-23. This was the equivalent of ten times increase within the first 50 years of the colonial rule in Myanmar and 14.5 times within the first 70 years. This was due to increase in immigration from Upper Burma and expansion of rice cultivation. This was due to increase in immigration from Upper Burma and expansion of rice cultivation. At the same time, area of rice grew from 5.5 million acres in 1896 to 11.6 million in 1926 – more than two times increase in 30 years. A remarkable increase in rice cultivation area in the Delta was due to increase in population and export demand which was spurred by the opening of the Suez Canal, the outbreak of civil war in the US and the subsequent decline of the Carolina as a source of rice for Europe, and Sepoy Mutiny and famines in India in the 1870s.

In the earlier colonial period, agriculture techniques used in the Delta were inferior to those in Upper Burma. However, in the later years, techniques in the Delta were improved as many canals were constructed for irrigation and embankments were built by the government on the Ayeyarwady and Sittaung rivers to floods and soil prevention. During this period, ploughs were used in the Delta.

With the colonization of Delta, came commercialization of rice cultivation which was meant for market rather than domestic consumption. Subsequently, processing of agriculture products were carried out by rice mills, saw mills and sugar mills for which machinery were imported. However, due to migration of Indians labourers, unlike in the US, the development of processing industry was very marginal. However, it should be noted that all the Indians immigrants were not labourers. There were also capitalists, traders and money lenders too and this created problems in rural Myanmar.

One of the bad products of the colonization of the Delta was indebtedness. The failure of the government to create a class of peasants proprietors resulted in agriculture indebtedness. (Details of causes for indebtedness are discussed in U Tun Wai, p. 73-75, and Binns, 1948.) Here Chettiars, who were moneylenders, also played a part in this issue as they charged high rates of interests.

Industry: During this period the majority of industries were agriculture industries such as rice mills, saw mills, oil mills, and sugar mills. However, rice mills topped the industry in terms of numbers. It increased from 3 steam mills in 1867 to 26 in 1872 and then to 657 in 1929 with small increase in 1940. Of this, 19 were large mills employing more than 500 labourers in one shift. Rice milling was responsible for the employment of one-third to one-half of the industrial workers (Ibid, p. 19). This occurrence of processing industry created the division of labour and change from the old domestic economy. Sugar refining industry was the late comer during the colonial period. The output of sugar met the domestic consumption. Out of two sugar mills, one in the lower part of the country was owned by an Indian. In general, most firms in industry were owned by the British, and the Indians to a lesser extent controlled the industry and trade.

There was a significant improvement in transportation industry as well, especially, waterways, railways and roads which helped the economy grew. This also had changed the economy and social life of the population and gave foreigners the opportunity to exploit country's resources. Canals were constructed in the Delta; the Irrawaddy Flotilla Company ran its steamers along the Ayeyarwady River and between Yangon and cities like Prome, Henzada, Bassein and between various towns in the Delta. Railways lines were built in the Delta; from between Yangon and Pyay, Hinthada, Pathein, Bago, Mawlamyine, among others. Exports of agriculture products, mainly rice, shipped from Yangon, Pathein, Mawlamyine and Sitway (Akyab) ports.

Economic conditions of the people: During the earlier colonial period, when natural economic (barter) system was transformed into market (money) economy, Myanmar cultivators in the Delta were most probably well-off and prosperous. This was evident when U Tun Wai (1961) quoted Geary that "Lower Burma has advanced in prosperity with rapid growth usually associated with American cities" (p. 60). This rapid growth was because the paddy price rose from Rs16 per basket in 1852 to RS100-110 in 1900 while wages fell 20 per cent during the period between 1870 and 1930. However, as prices of basic goods increased during the period, industrial workers had suffered. This indicates that cultivators were better off than labourers. However, pioneers who turned the Delta into inhabitable localities had to struggle for survival and face epidemics, cattle disease, and fever. Since cultivators were more tempted to borrow money from Chettyars and when there were crop failures, indebtedness became a widespread phenomenon. At the same time, the index of imports and exports prices showed a rise of about 150 per cent.

During the Great Depression in the early 1930s, there was a decline in Indian immigration, decline in rice production (more because of the weather than the fall in prices), and a big decline in timber extraction. In the processing industry mainly rice mills in terms of operating mills and workers had not been affected much although there was a decline in charges. However, in saw mills, many workers were laid off. More importantly, because of the decline in prices and crop failures, many cultivators lost their land to the Chettiars because of heavy indebtedness. The amount of the total occupied area in Lower Burma held by nonagriculturists rose from 31 per cent in 1929-30 to nearly 50 per cent by 1934-35 (Adas, p.188). And as a result, the standard of living of cultivators fell.

These worsening agrarian conflicts led the peasant rebellion against the British government had occurred in the 1930s followed later by bloody anti-Indians riots.

Towards the end of the colonial period and before the Japanese occupation, the standard of living in towns in the Delta might have been rising as the cost of living (at least in Yangon) was declining. The cost of living index in Yangon showed that it fell from 100 in 1931 to 88 in 1938. Even though workers were protected by laws, there was no compulsory type of insurance for them.

One significant factor during the colonial period was that population in the Delta increased significantly. The density of population in the Delta rose from 45 per sq mile in 1852 to 152 in 1930. In Lower Burma, the population increased from 7.8 million in 1931 to 8.9 million in 1941. As noted before, the British and Indians had a major control in industry and trade and "There is not a single banking, insurance, shipping, manufacturing or import firm of any size that is owned or managed by Burmese" (Christian, 1942, p. 128).

As far as social activities were concerned Myanmar agriculturists enjoyed themselves by holding pagoda festivals, ox-cart races, *pwes* (theatres), and village feasts during religious activities such as *shinbyu*s (initiation ceremonies of Buddhist monks) and taking rest during the off-season. However, some of these were lacking in the Delta as a result of economic decline during the 1930s and the years following the Japanese Occupation.

4 Mixed-economy Delta (1948 – 1988)

Many political, social and economic development changes hav taken place since Myanmar gained its Independence from the British in January 1948. Civil war broke out soon after the Independence and many ethnic armed separatist movements occurred. There was a military coup in 1962 after a decade of democratic governments. The "Burmese Way to Socialism" was introduced and experimented since the military took over power in 1962 to 1988. A new "socialist" constitution was introduced in 1973 and general elections were held. Another military was carried out in 1988 and socialism was discarded since then. Free and fair elections were held in 1990 and the results are still yet to be announced as the Elections Commission is still working on ten years later.

During the period under the democratic governments, the administration was similar to that of the British. However, under the military rule, government appointed committees at various levels of administration with the exception of the period under Burmese Socialist Programme Party period where members of administrative bodies at various levels were elected.

Economic system: Economic systems also have changed. Up to 1962, mixed economy with dominant private sector was practiced. Despite of civil wars and political upheavals, economic growth of about 4-6 per cent was attained during the period under the democratically elected governments, that is, from 1948 to1961. However, the economic performance has declined during the period between 1962 to 1988, when the country experimented with the Burmese Way to Socialism, a cocktail of socialism, nationalism and Buddhism, .

As far as economic performance is concerned, the country's economy recovered, in terms of GDP index, only in 1959-60 compared with that of 1938-39. Paddy production and rice exports still lagged behind the pre-war level. The average annual growth rate of GDP from 1951-61 was 5.3 per cent and that of between 1962 and 1988 was 3.5 per cent. However, the growth rate of GDP between 1989 and 1999 averaged 5.9 per cent as the government policy changed to be market-oriented since 1988. The difference was due to market-hostile and trade prohibiting policies. However, there was no significant change in economic structure. The pre-war level of paddy production reached only in 1971-72 and the post war exports level still could not catch up with the 1938-39 level of 3.3 million ton.

Agrarian System: Since independence, successive Myanmar governments have introduced pro-socialist agrarian reforms with the aim of uplifting the well-being and standards of living of rural people in the name of equity with the slogan of "Land to the tillers". The post-independence agrarian reform started with the Land Nationalization Act of 1948. However, due to political hostilities during the period, the Act was not implemented. Then the government implemented an expanded version of the Act of 1948 in 1953-54. However, it was a disappointment. Contrary to the aim of the agrarian reform, the land owned by the non-agriculturists had even increased and it was obvious that the land reform did not benefit the poor small farmers. The implementation of the land reform had to stop in 1958-59 due to dissatisfaction among the peasantry. As a result, the socio-politico-economic position in the rural sector was not strong as in the colonial days. The conditions of the agricultural labourers was worse than that of tenants, although wages were about two times higher than in pre-war days. Technology was almost the same as in pre-war days and agriculture production was achieved through land expansion. The system benefited mostly the urban and rural bourgeoisie.

Under the rule of the military regime (1962-1988), many measures were introduced to raise the standard of living of the rural population and to protect them from losing the land or livelihood. Since 1963 the government introduced four laws and decrees were passed as measures towards the abolition of land ownership by tenanted owners. Moreover, a new constitution was promulgated. As in the 1948 Constitution, the 1974 Constitution confirmed that ownership of the land was vested in the State. However, the slogan of the agrarian reform in the military government changed from "Land to the tiller" to "Right to cultivate to the tiller" since the land belongs to the state. (For details, refer Mya Than 1984, p. 741-761). As in the past, average farm size was declining due to inheritance and population pressure. As a result, the profit margin became smaller for cultivators as the compulsory sale of the agricultural produce (particularly paddy) to the state was introduced,. During the period, agricultural workers were most of the time worse off than small farmers. However, during 1971-72, when the free market price of paddy was raised, they were better off than small owner-cultivators because agricultural workers were usually paid in kind.

Although there was no data on indebtedness, it was estimated that 60-80 per cent of the farmers were in debt. One reason was that government's credit was not enough to cover even the labour cost as the amount of credit was one third of the cost of cultivation. After raising the paddy price, the extent of indebtedness was not as acute as in the colonial days.

Land fragmentation also has taken place all over the years due to the land policy loopholes and the law of inheritance. However, land-man ratio is still better than in neighbouring countries.

In short, the state became the landlord since it monopolized the rice export and cultivators have to sell a certain percent of their produce to the state at the government fixed procurement price which is much lower than the government price.

Industry: During this period, the government followed an inward-looking import-substitution policy. In the Delta, many of private and government owned industries mushroomed, mainly around Yangon since independence. Processing industries such as rice mills, oil mills, saw mills, jute mills, textile and garment mills, pulps and paper mills, and so on. Even a glass factory was established near Pathein. There existed heavy industry in the Delta such as motor industry, oil and gas industry. However, most private-owned industries were nationalized in the 1960s along with banks and trading companies. In short, people in the Ayeyarwady Delta had more work opportunities than in colonial days.

Economic Conditions of the People: In terms of per capita income in constant price (1985-86 prices), it increased from 1095 kyats in 1961-62 to 1885 kyats in 1973-74 and again to 1905 kyats in 1999-2000. Compared to other developing countries in the region this increase in per capita income is not impressive. The social and economic conditions of the Delta up to 1962, had improved slightly, compared with the colonial period, as a result of the agricultural development. Also in the period between 1962 to 1988, social indicators such as literacy rate, school enrolment ratios, teacher-student ratios, number of hospitals and medical staff, infant mortality rate, life expectance, etc., showed some improvements due to the socialist policy which gave priority to social sector.

5 Market-oriented Ayeyarwady Delta (1988 – 2000)

5.1 Capitalists are coming !

After the mass demonstrations and riots, sparked by the demonetization of 25-, 35-, and 75-kyat notes without any compensation, the military again took over power in 1988 and named themselves as the State Law and Order Restoration Council (SLORC). Soon after the coup, the SLORC (later it was changed to the State Peace and Development Council (SPDC) in 1997) announced that it would open up the economy by transforming from the command control economy into the market-oriented system. It was obvious that the continued deterioration of the economy since 1962 became the motivating factor for Myanmar's economic transition. However, purely economic aspects of a nation's life are by no means the only motivating forces for the transition to a market-oriented economy. The international scene at the time – economic reforms in China, people's power movement in the Philippines, *perestroika* and *glasnost* in the Soviet Union and the Eastern Europe, the success of the newly industrialized countries (NICs) – all these must also have had some influence in uplifting the aspirations of the Myanmar people and determining the decision of their leaders (Myat Thein and Mya Than, 1995, p. 215). One of the most important measures taken by the SLORC was the official revocation in 1989 of the 1965 Law of Establishment of Socialist Economic System. Around the same time, there was the changing of the country's name from the "Socialist Republic of the Union of Burma" to the "Union of Burma" then to the "Union of Myanmar". However, many economic activities are still under government control.

With the opening of the economy, many investors, foreign and local, rushed into the Ayeyarwaddy Delta where many of not-fully exploited resources are located, such as agriculture, fisheries, forestry, processing industries, etc. And thus, the Ayeyarwady Delta shares the consequences of this transition process with other parts of the country.

Agrarian System: Along with the opening of the economy, many significant reform measures were introduced during the late 1980s, including decontrol of prices and domestic trade in rice and other crops and formalization of the border trade. "These reforms brought about impressive short-term supply responses from farmers, with average growth of over 7 per cent a year between 1992/93 and 1995/96" (World Bank, August, 1999, p. 50). However, during the second half of the 1990s, the reforms seemed to have lost steam as there was stagnation in paddy output and the yields. This stagnation was attributable to severe droughts and flooding, decrease in fertilizer use due to price increase, high and persistent inflation, lack of access to credit and continued suppressing of farm-gate prices (ibid, p. 50).

Liberalization of the agricultural sector gained back its momentum in the second half of the 1990s; farmers are relatively free to make their own cropping choices, liberalization in cultivation and export of some crops such as beans and pulses, reduction of fertilizer subsidies, and partial privatization of fertilizer provision. However, there remain many distortions in policy environment in the agriculture sector. The most glaring distortion is the compulsory sale of a portion of paddy production to the government at the price lower than the market price, which can be considered as implicit tax. Moreover, the philosophy of self-sufficiency in key food crops also contributed in banning on export of rice and other crops. In fact, continuation of the compulsory quota delivery of rice also inhibits the development of agriculture production.

A detailed study of how capitalists are working in the development of agriculture Ayeyarwady Delta will be presented below.

5.2 Capitalist agriculture in the Delta: a case study

The agrarian system in Myanmar has changed from subsistence economy to commercialization and recently to capital intensive system to some extent. Successive governments tried to introduce measures to improve agriculture production by using political, institutional, social, economic, and technical factors.

The present government applies land expansion method since the other option to use the yield-raising method needs foreign exchange which is scarce. Thus the government started the land reclamation program in 1998 to develop large tracts of land of about 22 million acres to be farmed by private entrepreneurs. The land includes deep water or wet land, coastal land, and dry zone land not under cultivation. In the Delta, which comprises Ayeyarwady Division, Yangon Division and Pegu Division, there are two types of such land, wet land and coastal land. This is remarkable and historic in the sense that big private business firms are being allowed to get involved in agriculture production. In other words, this is the first time that non-resident capitalists are being allowed to be directly involved in agriculture production.

As of June, 1999, a total of about 1.2 million acres have been allocated to some 80 business groups in the whole country (see Table I). That is, 35 per cent of total leased land is from the Delta, mostly from Yangon and Ayeyarwaddy Divisions. Up to February, 1999, there were 24 business groups which also include a local military unit and Yangon City Development Corporation. Most holdings are around 3000 to 5000 acres and the largest of which is 72,000 acres.

There are incentives given to these groups. According to Warr (2000, p. 232-233), the government provides assistance for these projects in the following ways.

- The land is made available in a 30 year lease, provided free of charge, under the condition that the land be developed for agriculture production within three years.
- The public work required for flood control, drainage, and irrigation are provided free of charges.
- Government agencies assist in supplying the heavy earth moving machinery used to create the level fields to be used for paddy production. They do this under contract with the developer, but at subsidized rates.

- The government assists in providing technical assistance in developing the project, free of charge.
- Local private banks are encouraged to provide loans to the projects on a preferential basis.
- Fuel required for project construction and land preparation is provided at the government price of 160 kyats per gallon.
- Project investors may export 50 per cent of the rice they produce and are exempted from the rice procurement program operated by the government agency, the Agricultural Produce Trading (MAPT).
- Preferential provision of telephone services, including cellular phones and land-based phone lines.
- Provision of security services to protect project staff and equipment, free of charge.
- Permission to import equipment, including water pumps, tractors, bulldozers excavators, duty free and without limit, and without the need to demonstrate foreign exchange earnings through approved channels.

The majority of those business firms involved in the program are real estate developers who were caught up in the bubble economy when the regional crisis occurred in 1997-98. Many critics are saying that this program is aimed to help the developers who are losing money due to the decline in prices of real estates. Some said banks are asked to provide loans at the interest rate of around 10 per cent whereas inflation is around 30-40 per cent. At the same time, the interest rate at the market is around 30-40 per cent on collateral basis. There have been rumors of selling of fuel provided by the government at the official price in the market where the price was about 2 – 3 times higher. According to local critics, there may be cheating of the production figures by buying paddy from the farmers and exporting to get much needed foreign earnings. Worries coming out of this program were that those firms have no experience nor basic knowledge of cultivation and are profit motivated.

Out of 24 business groups, as of February, 1999, involved in this program in Delta, 18 are in the Ayeyarwady Division and only 4 in the Yangon Division (Appendix I). The largest firms are Myanmar Billion Group (38,141 acres), Ayeyar Shwewar (36,695), Yuzana Group (21,880 acres) and Olympic Group (20,650 acres). The Billion Group's lands are located in Nyaungdon Island, Nyaungdon Township, Bawdi East in Pantanaw Township, and the west bank of Ayerwaddy in Naungdon Township, Ayeyarwaddy Division.

Table I: Myanmar's Land Reclaiming Scheme

Land Reclamation (acres)

Region	Total area leased June 1999)	Total area developed (June 1999)
Ayeyarwaddy Division	246,366	65,456
Yangon Division	58,368	22,134
Bago Division	101,890	6,835
Delta Region Total	**406,624**	**94,425**
Magwe Division	233,037	3,625
Dry Region Total	**233,037**	**3,625**
Tanintharyi Division	464,744	415
Coastal Region Total	**464,744**	**415**
Shan State	21,675	15,017
Kachin State	33,027	1,409
Kayin State	1,000	400
Upland Region Total	**55,711**	**16,826**
Union Total	**1,160,116**	**115,291**

Source: Warr, 2000, Table 6

Peter Warr discussed about the largest firm "Myanmar Billion Group" in the Appendix I of his chapter (p.236-237). He argued that in purely economic terms the social costs of the project exceed its social value in that the combined social opportunity cost of the publicity supplied or subsidized inputs used by the projects exceeds the value of the reclaimed land "produced", even if it is assumed that the land would have had zero social value in the absence of the project. "In addition, the social implications of the project are potentially significant. Local communities lose access to the wet lands being drained. In place of these wetlands, very large, capital-intensive agricultural enterprises are created which are more typical of Latin America than Asia. The long-term social and environmental consequences of these developments could be even more costly than the purely economic considerations.." (p. 234). (For details, please refer Appendix II).

The wetland project the author visited in February is located about 70 km south of Yangon. The firm operating there belongs to Yangon City Development Corporation. Land reclaiming process was almost finished at the time of the visit. The place used to be the natural reservoir located between the Hlaing River, a tribute of the Ayeyar River and the Bago Yoma (Pegu Mountain Range). Whenever the river floods, the reservoir collects the water or whenever there were heavy rains on the Bago Yoma, waters run into this reservoir so that there is no flood in the river. Once this reservoir is gone, the community is worried about coming flood from both the river and the nearby mountain range. This will definitely affect the environment as there may be permanent ecological damage caused by this land reclaiming projects.

For the villages around the place, this wetland provides them fish and fishery products and cheaper transportation mode. In the summer, when the water dries up in some parts of the wetland, farmers grow rice for their consumption and use small deepwater trees as fuel wood. Moreover, thatch which grows naturally provides them with roof for their houses. Now, the livelihood of the villagers around the area has gone as they become wage labour at the big enterprise in place of the wetland. Now, for fish and rice, they have to commute to nearby towns and buy them at high prices. Also they will have to buy fuel wood and thatch for their households which they may no longer be able to afford with their daily wages.

In short, many worry that there may be social conflict between the local groups now denied access to this wetland and the business groups which established large agricultural enterprises in near future. Since the impact of land reclamation on agricultural production takes time, it is early to assess the impact of establishing large enterprises in the Delta on agricultural development.

Industry: Since the present State Peace and Development Council (formerly the SLORC) opened up the economy, foreign as well as local investors are allowed to invest in the country. Since the Delta is endowed with natural resources and infrastructure is relatively better than other areas, many industries are established. To accommodate the investors several "industrial estates" are established providing better infrastructure. Processing industry, light industry, oil and gas industry, and even heavy industry are located in the Delta. Most of the foreign investment projects of US$7.2 billion (as of end January 2000) flow into the Ayeyarwaddy Delta. Most of these industries are labour-intensive. Moreover, some of state owned industries such as garment industry, food processing industry and entertainment industry (mainly cinema halls) are being nationalized in the Delta. This also indicates that capitalism is already starting to take place in the Delta.

Economic Conditions of the People: Myanmar is a low-income country, according to UN classification. However, because of abundance of natural resources and self sufficiency in basic food, most people do not think that Myanmar is poor. Since the introduction of a series of economic reforms in 1988, average income has increased in both urban and rural areas. The Delta is more fortunate than other parts of the country. When the government decontrolled the prices, cultivators were better off, especially those who cultivate cash crops. However, after reforms were slowed down in the mid 1990s, and during the late 1990s when the Asian Crisis hit the country, income of the people, particularly from urban areas were affected. Inflation is highly persist. However, the authorities had reacted with various measures such as a sharp increase in salaries of the government servants including the armed forces.

However, recently, UN reports indicated that there has been a lackluster performance of the social sector compared with other neighbouring countries which could be attributed to low budget allocations, including to some extent the poor allocation of the public expenditure that was designated for those areas. Household surveys conducted by the World Bank revealed that about 13 million people had expenditures below minimum subsistence levels in 1997.

However, people from the Delta are relatively fortunate than their countrparts in the other areas of the country in the sense that they are sitting on the "rice bowl" of the country. However, the shadow of the big capital-intensive agricultural enterprises is haunting them.

6 Conclusion: economic development vs environmental costs

As mentioned above, the Ayeyarwaddy Delta has changed its hardware as well as software sides; physical landscape and political, social, and economic systems through out the one and a half century period of study. Physical landscape has changed due to natural causes through erosion and salination, deterioration of marine ecosystem, and man-made deforestation. On the software side, the Delta witnessed Myanmar's feudal system, British and Japanese colonial system, nationalist democratic system, nationalist socialist system, and military authoritarian system. It also saw several types of economic systems experimented with and practiced on feudal tribute system, plural economy, commercialization and export-oriented free market system, mixed-economy, centrally planned command/controlled economic system, and market-oriented transitional economy.

There was, to some extent, an improvement in living standard of the people in the Delta due to increase in market price of rice in the 1990s. In 1993-94, according to the official statistics, income in terms of total crop value per rural population, the Delta, including Ayeyarwaddy Division, Yangon Division and Bago Division) out performed other states and divisions in Myanmar (Dapice, 1995, Appendix I).

However, in a study of a Delta village called Mayin near Bago, by Mya Than (1987), it was found that, between 1960 and 1980 the village has borne witness to some progress in fulfilling basic needs. But the author summarized that "if the aim (of the successive governments) was to increase real income and to create more employment opportunities then, thus far, Mayin's has been an unsuccessful story" (p. 87). Anyway, the standard of living of the inhabitants should have been better if not for exploitation of feudal lords, colonialists, foreign capitalists, landlords, and local capitalists; and economic mismanagement. Once the right policy reforms are implemented consistently with right sequencing and right coordination, more benefit for the Delta region as well as its inhabitants will be achieved.

What is more worrisome is the ecological damage caused by man-made environmental degradation such as deterioration of agricultural soil by soil erosion, forest depletion, and water pollution. According to the UNDP Report (1995), the huge areas of mangroves in the Ayeyarwady Delta have been totally destroyed, with untold damage to brackish water ecology and coastal fisheries, as well as heavy erosion of delta lands due to the constant shift of the river's channels (p. 42).

Dapice added in another study of his, "landless and land poor households in the Delta commented on increasing scarcity of fish, crabs, firewood, and even vegetables. Goods that had been collected "free", or for only an investment of time, were progressively less available. Water supply was also deteriorating, as increasing amount of fresh water were drawn out of wells, and increasingly rain was running off land that had been cleared of mangrove and other trees. Salty water intrusion was seen as an issue both for crops and drinking water" (1998, p. 9).

Unless proper measures are taken to prevent the further degradation of environment by over-logging (legal and illegal), over-fishing, improper mining, and misuse of water sources, the impact to the Delta and its inhabitants would be enormous and most probably irreparable. The government of Myanmar is aware of this situation and has tried to introduce several measures to protect environment. However, the IMF report noted that "while past piece meal efforts have contributed somewhat in preserving natural resources, these gains have been mostly offset by the rapid growth of the economy and the population. These problems threaten to swamp Myanmar's environmental policies and programs, and pose a major challenge for sustainable development in the future" (February, 1999, p. 57).

References

Adas, Michael, *The Burma Delta*, University of Wisconsin Press, Wisconsin, 1974.

Binns, B. O., *Agricultural Economy in Burma*, Government printing, Rangoon, 1948.

Burmese Socialist Program Party, *Myanmah Leyarmyay Thamaine* (Myanar's Agrarian History), Vol. I and II, Rangoon, June, 1971.

Cheng, S. H, *The Rice Industry of Burma (1852-1940)*, University of Malaya Press, Kuala Lumpur, 1968.

Dapice, D., "Accelerating Progress Among the Rural Poor in Myanmar", a report to the UNDP, September, 1995, New York, 1995.

Furnivall, J. S., *An Introduction to the Political Economy of Burma*, Third Edition, Burmese Advertising press, Rangoon, 1957.

IMF, Myanmar: Recent Economic Development, Washington, February, 1997.

Lin Wai Myaing, "Yaynetkwin Saba" (Deep Water Rice), in *Kyaw Hya Lan Hnun (Living Color)*, No. 45, February, 1999.

McCrae, A. and Prentice, A., *Irrawaddy Flotilla*, James Patton Ltd, Paisley, PA, 1978.

Mya Than, "Burma's Agriculture since 1962 – From Stagnancy to Breakthrough", in *Unreal Growth: Critical Studies in Asian Development*, by Ngo Manh-Lan (ed.), Hindustan Publishing Corporation (India), Delhi, 1984.

Mya Than, "Little Change in Rural Burma". In *SOJOURN*, Vol. 2, No. 2, 1987, ISEAS, Singapore, 1987.

Mya Than & Nishizawa, N.,"Agricultural Policy Reforms and Agricultural Development in Myanmar", in *Myanmar Dilemmas and Options*, edited by Mya Than & Tan, J.L.H., ISEAS, Singapore, 1990.

Nishizawa, N., *Economic Development of Burma in Colonial Times*, Research Report No. 15, Institute for Peace Science, Hiroshima University, Hiroshima, June, 1991.

U Tun Wai, *Economic Development of Burma: from 1800 till 1940*, Dept. of Economics, University of Rangoon, Rangoon, 1961.

UNDP, *Myanmar Human Development nitiative: An assessment*, 1995, New York, 1995.

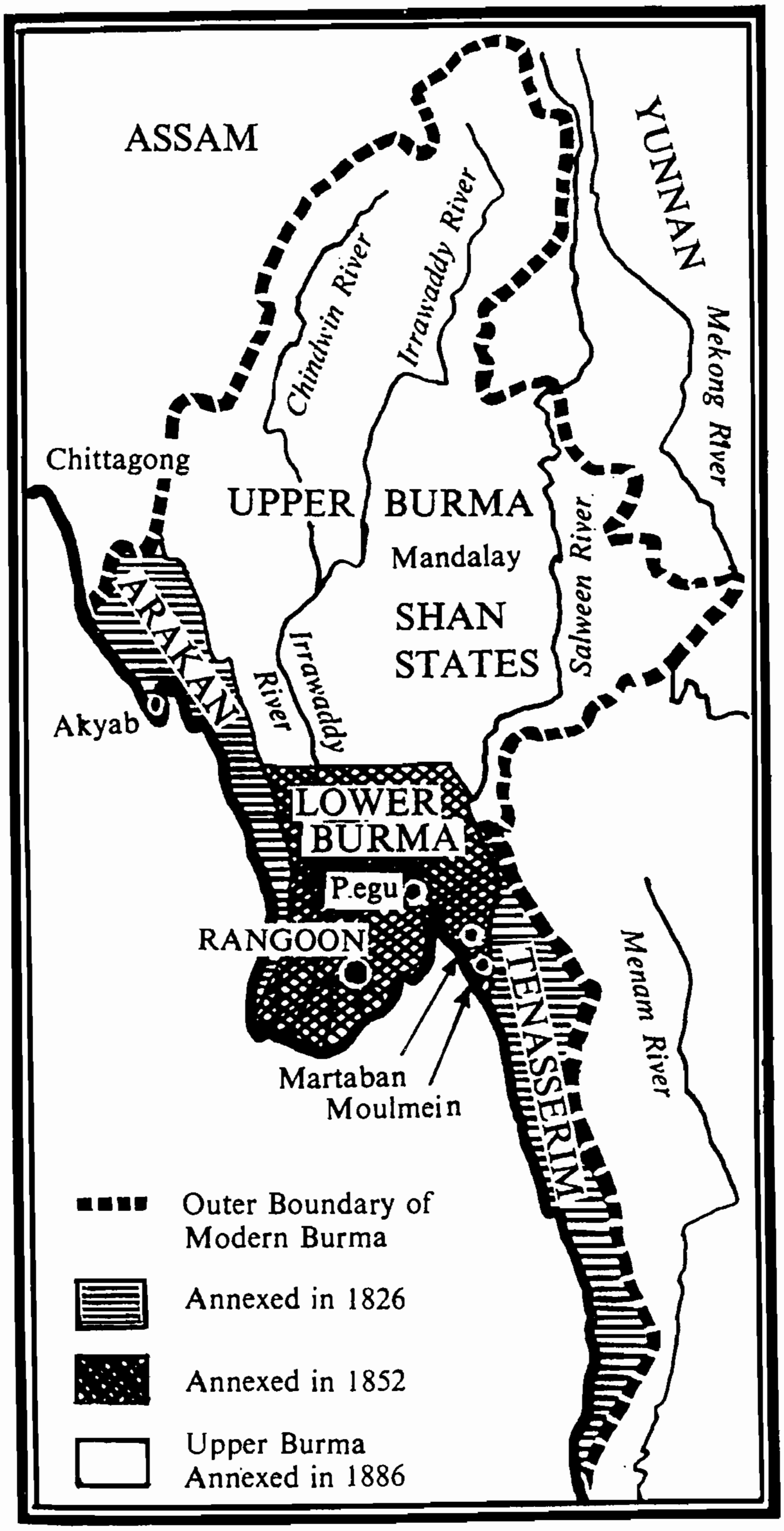
van Schendel, W., *Three Deltas: Accumulation and Poverty in Rural Burma, Bengal and South India*, Sage Publications, New Delhi, 1991.

Warr, P. G., The Failure of Myanmar's Agricultural Policies, in Southeast Asian Affairs 2000, ISEAS, Singapore, 2000.

Appendix I. Business Groups Granted for Cultivation in the Ayeyarwady Delta (As of February, 1999)

Enterprises	Township	Granted Acres
Ayeyarwady Division (Total)		**196,362**
1. Myanmar Billion Group	Nyaungdone	38,141
2. Yuzana Group	Pantanaw/Nyaungdone	21,880
3. Olympic	Pantanaw/Danubyu	20,650
4. Wawawin	Ma-U-Bin	13,880
5. SI Group	Nyanungdone/Danubyu	3,000
6. Ayeyar Shwewar	Thabaung/Yegyi Kyaungkone/Kangyidaunt	36,695
7. Seinthrafu	Ma-U-Bin	460
8. Myanmar Golden Star	Ma-U-Bin	5,600
9. Ochard	Nyaungdone/Ma-U-Bin	2,250
10. Shwenagamin	Ma-U-Bin	1,000
11. Arkar-Oo	Pantanaw	5,080
12. Myanmar Rice Traders Asson.	Pantanaw	5,082
13. Toetetaung Co.	Pantanaw	470
14. Golden Green	Kyaungkone	5,556
15. Klosein Co.	Ingapur	5,858
16. Military Unit	Thabaung	2,175
17. U Saw Win	Thabaung	1,000
18. U Tin Shwe	Ma-U-Bin	585
Yangon Division(Total)		**29,880**
1. Dagon Agriculture Group	Tikekyi/Htatabin	14,300
2. Yangon City Development	Tikekyi	1,500
3. Ministry of Interior	Tikekyi	2,000
4. Dagon Agriculture	Htantabin/Tikekyi	5,000
5. Golden Plough	Tikekyi	2,080
6. Steel Stone	Hmwabi/Tikekyi/Htantabin	5,000
All Areas Total		**225,242**

Source: *Kyawnyar Lanhnyun*, No.45, February 1999 and *Myanmah Alin* (10/2/99)



ap I. Myanmar in Colonial Days (McCrae and Pentice, 1978)

Appendix II. (Source: Warr, 2000, p. 55)

Box 4.3: The Costs of Reclamation the case of MBG

This project, being developed by a group of local entrepreneurs, covers a total of 72,000 acres, divided into two parts, one of 40,000 and the other 32,000 acres. The mission visited the first of these. Myanmar Billion Group (MBG) aims to develop the entire area within three years. The area is low lying wetlands and during the monsoon season it is submerged under more than 10 feet of water. The project involves draining the wetlands, building bunds and dykes to prevent inflow of water during the monsoon, leveling the fields for paddy production and installing irrigation facilities for dry season production.

One paddy crop of 1,729 acres was harvested in early 1999 and a similar sized crop is planned for the current year. Highly mechanized methods of cultivation are in use, including large, heavy duty tractors for cultivation, mechanical rice planters and weeders and mechanical rice harvesters. Because the drained soil is highly fertile, with high organic matter content, low levels of fertilizer input are sufficient to obtain high yields.

The private costs of the development, incurred by MBG, include (i) Cleaning and establishing bunds, 10,000 Kyats per acre, paid to Agricultural Mechanization Department of the Ministry of Agriculture and Irrigation, which arranged the work; and (ii) Further earth moving work conducted by MBG itself, including land leveling, consolidation and establishment of irrigation system, 70,000 Kyats per acre.

The social costs evaluated at market prices exceed these costs because the inputs are priced below market prices. For example, the earth moving work uses large quantities of diesel fuel, which is provided to the Agricultural Mechanization Department and the MBG project itself at below its market value. The bund establishment required 80,000 gallons of diesel for a 6,000 acre site, which implies that the social cost of the diesel fuel alone exceeded the private cost by 2133 Kyats per acre. Applying a similar calculation to the second item of cost above (incurred directly by MBG) suggests an additional divergence between social and private costs of around 15,000 Kyats per acre, a total of 17,200 Kyats per acre, raising the social cost of the land development at the site itself to at least 97,200 Kyats per acre. It should be emphasized that these calculations make no allowance for divergence between the accounting cost of machinery supplied to the government and its social opportunity cost, allowance for which would raise further the divergence between social and private costs.

In addition to the costs incurred on-site the Ministry of Construction, provides irrigation and drainage facilities to the project through the development of the Nyaundone Island area. The public investment in this development has to date been 645 million Kyats, with an output of 90,000 acres of cultivable land, including the MBG site described above. The cost per acre is thus 7,200 Kyats, of which 30 percent are again fuel costs, implying a market equivalent social cost of not less than 9,300 Kyats, again making no allowance for divergence between the accounting cost of machinery supplied to the Government and its social opportunity cost.

The above calculations imply that the aggregate social cost of developing the land for agricultural use is not less than 106,400 Kyats per acre, considering only the sources of social cost mentioned above and disregarding public provision of technical support, security, improved roads,and so forth. We now estimate the value of the project.

Suppose, initially, that in the absence of the project the social value of the land under development would have been zero. Under this assumption, the project creates usable agricultural land from an area which would have otherwise have been wasteland. Land of a quality similar to that developed by the project has a market value of 100,000 Kyats if directly adjacent to the sealed road. Land further distant from the road has a market value of 50,000 to 70,000 Kyats per acre depending on the distance. The agricultural land established by the MBG project includes areas close to and distant from the sealed road. The mean market value of this land would be thus no more than 85,000 Kyats per acre.

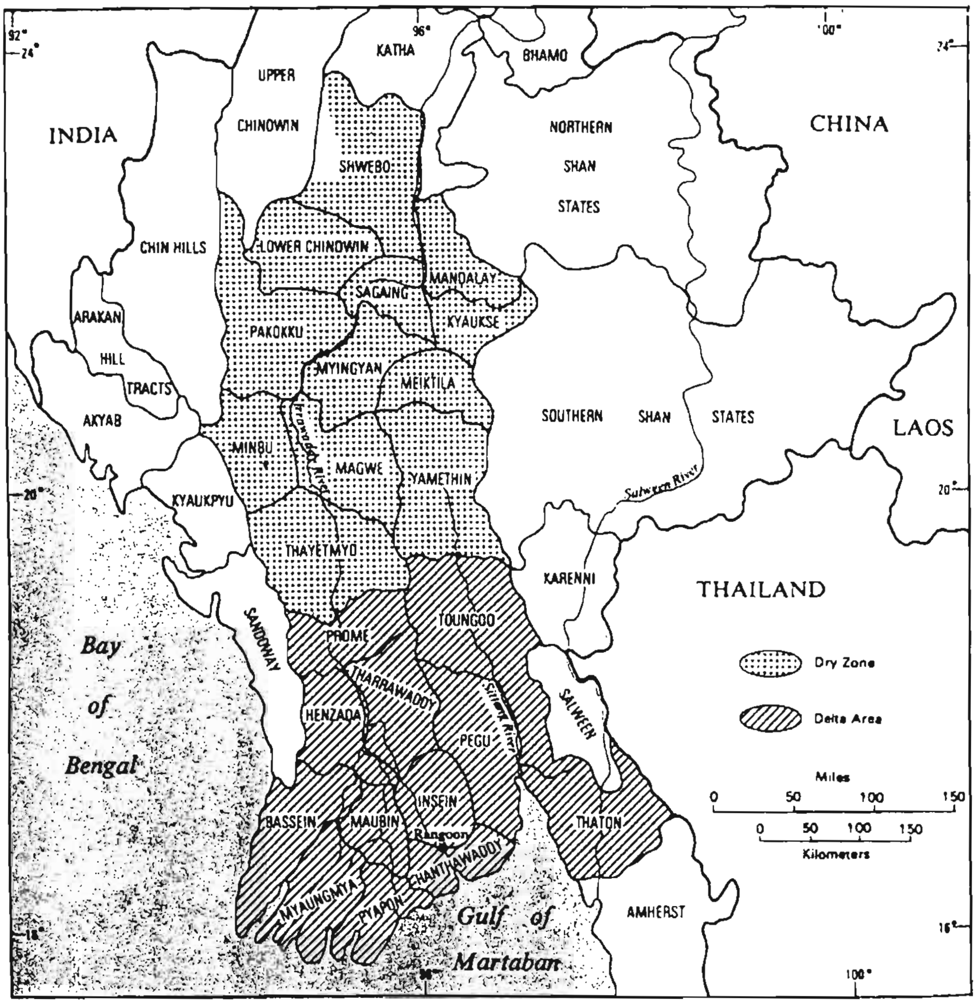
That is, the project 'creates' agricultural land worth, say, 85,000 Kyats per acre at a social cost of at least 106,400 Kyats per acre. The project is privately profitable because of the special privileges extended to the project, but without these implicit subsidies the project could not be viable. It should be recalled that the above calculations assume that in the absence of the project the land would have no value. This is clearly not the case. Allowance for the social value of the wetlands drained by the project, and therefore lost to the people Myanmar because of it, in terms of fishing, wildlife habitat, hydrological value in terms of water course movement and other ecological values, will increase the social cost of the project further, reinforcing the above conclusions.

Source: Bank mission with acknowledgment of assistance from the staff of the Myanmar Billion Group.

55

Map 2: Myanmar: Delta and Dry Zone Areas

Source: Adas, 1974, p 2.



University of Wisconsin Cartographic Laboratory

Map. 1. Political Divisions of the Province of Burma in the Twentieth Century. Source: J. R. Andrus, *Burmese Economic Life* (Stanford, 1948).

Agricultural change and transformations of the Mekong delta

Vo Tong Xuan [1]

Abstract and full paper not provided

[1] Can Tho University

Agrarian versus mercantile deltas: characterizing the Chao Phraya delta in the six great deltas in monsoon Asia

Yoshihiro Kaida[1]

Abstract: *Of the six great deltas in tropical Asia, the Chao Phraya delta, along with the Mekong and the Pearl River delta, may be characterized as a "Mercantile delta". The three others, namely, the Bengal, the Ayeyarwady and the Red River deltas, are, in contrast, characterized as "Agrarian deltas".*

The "mercantile" nature of the Chao Phraya delta are reflected in (a) the capital-led opening of riceland for rice trade in the late-19C, (b) the mono-rice culture in the early-20C, (c) the mono-crop garden culture for marketing, (d) weak communal ties, and (e) the recent rapid urbanization. The complex farming of "rice-fish-poultry-fruit mix" in the Chao Phraya delta was short-lived. The behavior of delta farmers and landowners are more opportunity-seeking and economy-minded as compared with peasants in the "Agrarian deltas".

The Mekong delta looks like following the development path of the Chao Phraya delta, and the Chao Phraya delta is chasing closely after the Pearl River delta with respect to landuse, agricultural intensification and commercialization, and to urbanization. In other words, the "imagescape" of the Chao Phraya delta in the near future can be found in the present Pearl River delta, whereas the present imagescape is the goal for the Mekong delta to catch up with.

1 Some characteristics of Asian Deltas

1.1 Large alluvial plains in tropical Asia

It is the rice culture that sustains the dense population in tropical monsoon Asia. The rice culture prevails in almost all agro-ecological zones in the tropical monsoon Asia, of which alluvial plains are particularly productive. Soils are generally fertile and hydrological conditions are suitable for rice cultivation in the alluvial plains. The alluvial plains, including fans, river-terraces and deltas, prevail in the rice cultural zones in Asia. It accounts for about one sixth of all land area in tropical Asia, whereas it occupies only one twentieth of land area world wide. The proportion of the alluvial plains is as much as one third of arable land in tropical Asia, while it is only one tenth world wide. In other words, one third of the world's total alluvial plains is in tropical Asia which shares only 7 percent of the world's land surface [Fukui]. Geological background of this skewed distribution of the alluvial plains in tropical

[1] Center for Southeast Asian Studies, Kyoto University

Asia lies in the fact that the Alpine orogenic movement was particularly vigorous in Asia; it made the mountains high and valleys deep, torrential monsoonal rains eroded mountain slopes and washed huge amounts of sediment loads down into valleys, making fans, river plains and river terraces, and large deltas in the river mouths.

1.2 High fertility of the delta

A typical alluvial plain is a delta. Taking Thailand as an example, the Chao Phraya delta which shares only 7 percent of country's rice acreage yields as much as 20 percent of total rice production, indicating high fertility of delta.

1.3 The Notion of "forest and sea" SEA vs. "peasantry" SEA

Southeast Asia may be subdivided into two major zones; continental and insular Southeast Asia. The continental Southeast Asia may be characterized by such key-words as monsoonal cycle of the rainy and the dry seasons, dry deciduous forest which turns green at the onset of the monsoon, great plains and rice cultivation. This is the land where small farmers till the land and grow rice over generations, and live in tightly knit village communities. This land was the cradle of classic and medieval "muang" which was the typical small patrimonial states.

On the other hand, typical key words to characterize the insular Southeast Asia include: tropical rain forest constituted by extremely diverse species of ever-green trees, a large number of islands in the Sunda shelf, productive seas and forests, rich coastal fauna and flora, which all result in the non-settled and shifting land use system. Regarding cultural and social characteristics of the insular Southeast Asia, anthropologists point out that the society is formed on the basis of infinite chains of binomial human relations and a country may not have an explicit boundary but has a center-periphery gradation of power which gradually diminishes in distance. "No permanence" may be the most important key word here. This part of Southeast Asia has occupied an important position in the east-west maritime trades in classic, medieval, modern and present world, because of its crucial location. This area has always been a part of world-wide network society. This region has been involved in the world-wide commerce on the basis of the wealth of seas and forests.

1.4 Agrarian vs. mercantile deltas

The great deltas in Southeast Asia are naturally located in the continental Southeast Asia. Their society and economy are, however, of typically insular type, namely, their economic system is based mainly on transactions with the external world, or in other words, "commercial sphere". The on-going rapid economic growth must have been attained by tuning the delta economies to the one of maritime and commercial activities. The rice lands in the delta have undergone continuous improvement to sustain intensified rice-based cropping systems. It is not certain, however, whether the present rice-based land use continues into future, or not. The rice growers here, in the delta, would opt to convert the land to any other uses when they judge rice farming is less productive and profitable. The delta farmer are opportunist farmers. The delta in Southeast Asian continent is a part of the maritime Southeast Asia that penetrates deep into the continent.

On the other hand, it is also true that the six great deltas in the monsoon tropics, namely, the Zhujiang in Guangzhou, the Song Koi, the Mekong, the Chao Phraya, the Ayeyarwady, and the Bengal, have their respective features and characteristics. The six delta may be classified into two sub-groups; (a) urban or commercial delta including the Zhujiang, the Mekong and the Chao Phraya, and (b) rural or peasantry delta including the Song Koi, the Ayeyarwady and the Bengal. The difference may reflect the difference in their reclamation process, which in turn is determined basically by their geomorphological features. This assumption will be elaborated in the following section taking two contrasting deltas, namely the Zhujiang and the Bengal delta.

2 The Zhujiang Delta

2.1 *Weitian* and *shatian*

There are two types of paddy lands in this delta. One is the "*weitian*" which has been developed from ill-drained and flood-prone marshes by enpoldering and drainage work. The other type is the "*shatian*" which has been reclaimed from shallow sea bottom by poldering technology. The boundary between the two runs along the archaic coastline in the middle to late eras of the Neolithic age, and runs in the middle part of the present Zhujiang delta. The "*shatian*" occupies about 60 percent of the delta and the "*weitian*" the rest.

The following three conditions facilitated the development of "*shatian*": (a) There are appropriate land-bound seasonal wind and off-shore current in the estuarine zones that helped push back to the estuaries a huge amount of sediment load that is drained from the Zhujiang river system, mainly the Xijiang river. This phenomenon has made the estuarine zones relatively shallow. (b) There are many rock-islets rising from the sea bottom in the estuarine zones. The rock-islets have supplied stones to build polder. Embankment. (c) There is a big city, Guangzhou, and more recently Hong Kong, in the region.

2.2 Process of empoldering *shatian* -- *yuyoulupohelicaoshe*

The process of poldering the "*shatian*" is exactly and beautifully expressed by a simple Chinese phrase, "*yuyoulupohelicaoshe*". It is a good time for the builders to start dumping stones along future sites of polder embankments when the sea bottom becomes shallow enough for bottom fish to been seen swimming ("*yuyou*"). The stone foundation is laid up to the low tide level so that tide can come in the polder bringing with it sediment loads and leaving them in the polder when it recedes. The sediments accumulate rapidly till boat ores hit the bottom ("*lupo*"), then water becomes shallow enough to allow cranes fly in, stand and feed themselves in the water ("*heli*"). Seeds of marsh grasses are broadcast to trap more sand and to stabilize sedimentation ("*caoshe*"). At the time when the mud surfaces at medium tide, the stone foundation is reshaped and soils are piled to make it water tight. The tide is allowed in and out for irrigation and drainage through sluice gates as salinity of the water in the estuarine zone is at a tolerable level. This is similar to the Indonesian coastal tidal irrigation (*pasang surut*).

2.3 Sanjiyutang

As the "*shatian*" extends further into the shallow sea, "*weitian*" as well as "*shatian*" that lie inland become increasingly ill-drained so as not to allow ordinary land use. Farmers devised "*jitang*" at this stage. Soils dug up from about 70-80 percent area are piled onto 20-30 percent area to make a combination of pond (*tang*) and land (*ji*). In the ponds fishes were reared, and on the elevated land mulberry (*sang*), sugarcane (*shu*), grasses (*cao*), or miscellaneous vegetables (*za*) were grown. The mulberries, sugarcane leaves, grasses and miscellaneous vegetables were all used to feed fishes, and bottom mud containing refuses of fish was applied to fertilize the crops. A typical land use on the basis of nutrient recycling was the "*sangjiyutang*", where mulberry leaves were fed to silk-worm, refuses from the silk-worm were dumped in the pond for fishes, and the bottom mud in the pond was returned to fertilize the mulberry.

2.4 Urban-oriented land use

The intensive land use as stated above was sustained and accelerated by high demands for the products by adjoining cities, especially Guangzhou and Hong Kong. The rock-islets that supplied stones for building the plodder embankments gradually became "land-locked" islets. The small towns at the foot of the rock-islet had an easy access to the cities via canal and road networks, and they were increasingly involved in the regional commercial transactions. The commercialization made the "*jitang*" even more productive in fish, silk, sugarcane, and various vegetables. In this way, this area, e.g.. Shundexian Tailiangzhen has become a well known center of silk industry by the mid 19th century. At the present time, small and medium towns are distributed ubiquitously all over the delta. Many of the towns have some unique marketable commodities of the locality, and they are all included in a wider market of Guangzhou, and the whole area is in the greater economic sphere of Hong Kong. The area that originated from "*weitian*" and "*shatian*" has developed suburban land use over centuries, and now the whole area is going to be transformed to urban environment at an alarmingly high rate.

The writer presumes that these land development projects were sponsored and participated by local merchants or groups of merchants who had obtained a kind of license or concession from the local government.

2.5 Contemporary urbanization

The urbanization of the Zhujiang delta is progressing at an alarmingly high speed. A large outlay is being made mainly by Hong Kong capitalists and overseas Chinese in Hong Kong, Taiwan, USA and Singapore many of whom originated from this delta. The overseas Chinese are enthusiastically investing capital in public works and donating public facilities such as roads, bridges, homes for elders and schools. To receive such external investment certain conditions must be furnished. They may include; (a) long and short-term, ambitious development plans made by Guangdon province and city corporations(*zhen*), with leading city being Guangzhou, (b) two special districts designed for leading rapid development of market economy, viz. Senchuan and Zhuhai, and (c) the presence of local counterpart entrepreneurs. Among the three conditions as indicated above, the third one is particularly interesting. The entrepreneurs who live or originate in the Zhujiang delta must have developed, over generations, an economic sense of "making best use of opportunities", which should be a typical attitude of maritime merchants. They must have used the "*weitian*" and "*shatian*" as paddy field when they thought rice farming was most suitable and profitable, used as "*sangjiyutang*" when they thought it was the most suitable, and as urban land use if they think it is the time of change. In short, the Zhujiang delta is a part of the maritime world.

The author, however, has some reservations in the present mode of land development, because (a) the planning is too straight forward, and (b) power of the decision making (planning) is vested to a small group, viz. leaders of city corporations (*zhen*).

2.6 Top-down development planning

The author observed a large "*shatian*" which had been reclaimed from shallow sea bottom over generations through the process of "*yuyoulupohelicaoshe*" was filled by sand gushing out from a huge outlet pipeline of a sand-pump in the matter of days and weeks. Off shore, one can see a number of dredging boats sucking sand and carrying it ashore, on the shore, one can see a huge sand-pump aboard a barge sucking the sand from the boat and vomiting it onto the "*shatian*". Probably all the "*shatiian*" that have been created over generations and over centuries will be disappearing to make rooms for roads, bridges, factories, apartments and shopping arcades, in the matter of years. Leaders of the city corporations (*zhen*) are more or less the same portfolio of the old people's commune (*renmingongshe*), who are accustomed to make decisions top-down. The leaders may think this way: what's wrong in making collective decision for land use that must be owned collectively by the commune, or today, city corporation(*zhen*). The writer saw most of the residents simply following the order of the leaders without knowing any details of the development plans.

As far as the author observed in many parts of the delta, bridges were spanning rivers and marshes too high and too long; roads were too wide and actually sporadic cars were seen running in a single lane out of 3 lane-installation; only one in three pre-fabricated factories were in operation; similarly only one in three finished shops in shopping plaza were open; and only one in four sky-scraping apartment units were inhabited. With very poor installation of air, water, sewage and garbage treatment, what a disastrous scene we would see when these facilities would be fully occupied and in full operation! This bubble economy on the basis of external capital outlay, standard and uniform planning and straight forward, top-down decision making, must surely burst in near future. Despite all these anomalies, general trend of development here, in the Zhujiang delta, will be towards commerce, trade and urbanization in the maritime world.

3 The Bengal Delta

3.1 Floodplain Delta

The Bengal delta is the world largest delta spreading over 9 million ha. Three magnificent international rivers formed this delta; the Jamuna river which originates in glaciers of the

Tibetan Plateau and running through Assam, one of the heaviest rainfall zones in the world; the Megna river that originates in the Meghalaya Plateau which has 20,000 mm (!) annual rainfall; and the great Ganges river that drains a large montane tract of northern India, through the extensive Hindhustan Plain and eventually empties itself into the bay of Bengal after 4,000 km travel. The edge of the delta is believed to extend deep in the Bay of Bengal far beyond Sri Lanka, and the depth of alluvium is somewhere about 14 km (!) at the river mouths. Major parts of this delta would better be termed as "floodplain" because this is made out of huge power of water and sedimentation, ingredient of which is mainly sand. If one uses the term delta for the Bengal delta, he would better call it a "sandy delta".

The floodplains are, geomorphologically, the remnants of old and new river courses, having criss-cross combination of natural levees and backswamps. Take any place in the delta, say, in Mymensingh floodplain, and stand at any one point in the paddy field. You will see greenery lines encircling you within a diameter of minimum 500 m and maximum 1 km, and you will see farm houses almost buried in the green forest. The statistical book indicates the forest coverage in this country accounts for only 7 percent, but seemingly you find the greens ubiquitous, within your reach. This must have been one of the most favorable conditions for early rice farmers to settle and start farming. A small group, probably close kins, could find an appropriate place to settle on a natural levee, and till the adjoining backswamp for rice cultivation. Fish might have been caught easily in rivers and marshes. The early settlers might have tilled the land and made living relatively autonomously.

3.2 Scattered, autonomous villages

Historians presume the early settlers in the Bengal delta must have been under control of *zamindar*, just as their counterpart peasants in the Chao Phraya depended heavily on delta developers, i.e., large landlords who invested a huge outlay of capital for reclaiming the delta for rice plantation. Here at the Bengal delta, the author presumes that the early settlers did not encounter any larger powers beyond local *zamindar*, who might have tried to control the peasants by providing protective guard in exchange for tax levying. The colonial power had nothing to deal with peasantry till the middle of 18th century. Ubiquitous combination of relatively small natural levees and backswamps might have provided easy precondition for the early farmers to settle, start farming and live in the villages in relatively autonomous environment.

LANDSAT imageries of the Chao Phraya delta show a great deal of lineaments, indicating artificial objects such as canals, embankments and roads, etc. In contrast, the ones of the Bengal delta lack any lineaments, but instead, full of active and inactive rivers, old river courses, intricate combination of levees and backswamps, and alarmingly high concentration of arable land; indicating almost all areas are under farming, either paddy cultivation or any other agricultural uses. About 70,000 hamlets are distributed all over the country, as though sesame seeds broadcast randomly on the floor. Actually, those 70,000 hamlets are no more cohesive neither to each other nor with higher administrative tiers to form a pyramidal administrative structure. They are independent horizontally as well as vertically. Each one of the hamlets is highly autonomous politically under relatively loose control by respective group of plural leaders, called *matabbors*. The hamlets tend to unite and coordinate to each other and form a loose federation to meet their common needs such as improving market places, secular as well as religious education, security and local law and order enforcement. Their linkage with upper tiers in the administrative ladder is very weak. The village economy is, or at least was, rather self-subsistent.

3.3 Prosperous Bangladesh in her rural amenity

Economic life in the Bengal delta is ranked among the poorest in the world, with GDP of only US$300 per capita per annum. About 80 percent of country's populace live in the villages, pushing rural population density staggeringly high, to over 1,000 per square km. The legend of golden Bengal has gone bye in the past 50 years. The gone-bye easy living in self-subsistent economy, relatively class-unconscious society, dislinkage with local government administration, and relative village autonomy, must be acting as the dragging force for economic development and upliftment of village life in the Bengal delta.

Where will future prosperous rural Bangladesh be? Will it be in an urbanized society? Will Bangladesh be able to find a way out of economic stagnation that locks the people and the country by industrial development and urbanization? The authors personal projection is that Bangladesh will be able to find its prosperity in the rural amenity that can be attained through strengthening local urban centers, interactions between villages and local, small urban centers, linkage between service administration and autonomous village community, while maintaining the present village autonomy, village traditional leadership and social systems. The prosperous future of economically impoverished Bangladesh lies in the amenity of rural life in which rural culture and life style of small independent peasantry are made revitalized and made more attractive.

4 The Chao Phraya Delta

4.1 Reclamation and Development

Organized reclamation of the deltas in Southeast Asia started almost coincidentally in the middle of nineteenth century in the three major deltas of the Mekong, the Chao Phraya and the Ayeyarwady, when the demand for rice from colonized neighboring countries increased. These countries were then characterized by monoculture of certain commercial and industrial crops such as cotton in the Indian subcontinent, rubber in the Malay peninsular, sugarcane in Java, rubber and coffee in Sumatra, coconut and sugarcane in the Philippine islands.

The key technology for opening the delta, especially the Young delta of the Chao Phraya river was canalization. This had three functions: provision of access to the inland by boat, provision of homestead land on the dug-out earth along the canals, and supply of domestic water. With the meeting of these three basic human needs, rice land expanded rapidly because soil and water conditions were basically suitable for extensive rice cultivation. Rice exports from Thailand increased sharply from a nominal 120 thousand tons before 1870 to a high of 1.5 million tons in 1929. All development works and the rice trade were monopolized by royalty, nobility, big merchants, and high-ranking government officials. Rice farming was practiced by owner farmers as well as tenant peasants who moved and settled in the delta to make a quick fortune. The farming system was rice monoculture under a quasi-estate farming system, although individual farmers and peasants were not necessarily employed as wage laborers.

The Chao Phraya delta saw a renewal of irrigation development after World War II, when Thailand received financial and technical assistance from the world community to boost its rice production in order to help cope with the world-wide food shortage. A large diversion weir was installed at the apex of the delta, at Chai Nat, from which five main canals conveyed water to hundreds of secondary and tertiary canals and to the blocks of rice land covering about 600,000 ha of the Upper delta. On the other hand, the hydrological environment of the 600,000-ha Lower delta was totally changed by enpoldering the formerly canalized tracts and supplying water constantly throughout the year through numerous gated canals and creeks. Thanks to the large annual budget of the state Royal Irrigation Department for operating and maintaining the new Chao Phraya irrigation system, farmers in the Upper delta now enjoy stable gravitational canal irrigation and by means of "water conservation" in the flood plains of the delta; and those in the Lower delta have adopted individual lifting irrigation of their flood-free farms, tapping the ubiquitous creeks that carry controlled, perennial water.

The engineering design of the post-war development of the Chao Phraya delta was not new. It simply followed a grand design that had been submitted to the government by a Dutch engineer back in 1902. The engineer, Van der Heide, came from Java, then a Dutch colony, to become the first director-general of the newly established Royal Irrigation Department and conducted a very intensive field survey for about a year, which culminated in his grand design for delta development. The grand design, however, was shelved, as it required a far larger budget than the government could afford. Instead, several individual smaller projects were undertaken, mainly in the Lower delta, under the leadership of a British engineer, Sir Thomas Ward, who succeeded Van der Heide as the second foreigner to become director-general.

To these European engineers, planning and design criteria of large-scale gravitational canal irrigation systems must have presented familiar engineering problems, because similar major irrigation projects had been undertaken elsewhere in the then colonized counties in the region. For example, British engineers had completed the Great Upper Ganga irrigation project in India during 1836-54, started the 1.5 million-ha Indus valley irrigation project in the Punjab from 1849, and developed other major Indian deltas such as the Krishna, the Goudavari and the Cauvery deltas since the middle of the nineteenth century. The predecessor of these large-scale projects through which engineers had gained their engineering know-how was the Nile delta development, which had started even earlier in the nineteenth century. All of these major irrigation systems helped boost crop production, intensify cropping patterns, and promote commercial cropping. Commercial crops included cotton in the Nile; cotton or sugarcane added to the original traditional patterns of wheat combined with millet, pulses or rice in the Indian deltas; and rotational cropping of rice and sugarcane in rice land in Java.

4.2 Lower Delta (young delta)

With the provision of these irrigation systems, the delta farmers have devised a new form of landuse, especially in the "controlled creek" area of the Lower delta. Along the controlled creeks and behind their homesteads, they have carried out a number of small earth works, digging deep furrows and pilling the earth removed in ridges about one meter high to make alternating furrows and ridges at the intervals of, say, 2-4 meters. On the ridges they plant banana, intercropping with slower-growing fruit trees such as mango, mangosteen, and coconut, etc. Some furrows maybe planted with rice, but basically they are used to rear water-fowl. Small ponds may be dug out near the house to keep fish, and larger ones may be dug further away in the swales of paddy fields for some commercialized cage culture of fish. Although this "homestead" landuse occupies less than 5 percent of the Lower delta, leaving the rest, of course, for rice cultivation, it has drastically changed the rural scene along such canals from one of a monotonous, treeless and desolate line of shacks to one of a more woody, shady, green landscape comprising rice land, fruit groves, and sheltered homesteads. I have named this landuse the "rice-fish-fruit and poultry complex" in the Lower delta. This was indicative of future landscape, I thought, in Southeast Asian deltas.

The above desirable "scenario" that I had expected to be written, however, has been aborted in half way. Since mid-1970s, canal transportation was replaced gradually by road transportation, and this trend has been accelerated after the 1980s. A large number of dirt roads were built through and behind the homesteads along the canals. The poldered "rice-fish-fruit and poultry complex" farming that had been flourishing since the 1970s were gradually converted to more commercialized and specialized monoculture of fish-culture, fruit-culture, vegetable-culture, or duck-cage-culture. Since the 1980s, fruit-culturist A grew only banana, farm B planted guava alone, C selected only orange, and D opted *casualina* (*tonsong*) planted all over his block. Some were specialized in large-scale fish-culture as their business. Many of these farms were found to be owned by absentee land owners such as retired government officials and office workers who live in Bangkok. Through the 1990s, the land owners rented out the land at relatively low rate to keep the land used until it was sold to real-estate business for nonagricultural uses.

Until the 1970s, industrial estates were found scattered along Papholyothin road, rout No.1, passing nearby the airport. Through the 1980s, and notably after 1990, the industrial estate zones sprawled out into a large tract of Lower delta along the road network, and they expanded rapidly into inland, especially in South Rangsit tract in the east and north of the airport. Sprawling Bangkok expanded and penetrated into the delta in all directions, and since the 1980s South Rangsit tract, in particular, has been urbanized dramatically. A survey conducted in North Rangsit zone at the end of the 1980s indicates that the areas of paddy land, poldered horticultural farms, factories or offices, and residential lots accounted for 45, 35, 15 and 5 percent, respectively.

A tremendously large volume of red-soil was transported into the delta from adjoining hills to make safe grounds to keep the factories and residential estates not to be submerged by flood water. Huge lorries were seen carrying a full load of red-soils on the roads along Rangsit and other main canals. Some home-estates dug huge ponds to get soils to fill up the ground and to provide attractive landscaping of homesteads with water body surrounding them

4.3 Upper delta (old delta)

Following the development of trunk canals system in the Upper delta, a further large investment was laid out in improving on-farm irrigation through such means as a dikes-and-ditches project and preliminary land consolidation trials. Most of the sloped land suitable for gravitational canal irrigation had been equipped with the irrigation and drainage by early-1980s.

With the provision of controlled water supply system, farmers reacted to the given conditions by converting traditional broadcast, deep water rice to transplanted modern rice varieties, especially new high yielding varieties named in RD series. Single rice cultural system in the rainy season has been converted to double rice system including irrigated dry season rice. Government tried to boost farmers' groups or associations to improve on-farm irrigation management and to adopt new technologies in rice farming. Transplanting rice was regarded as an indicator of modernization of farming. Intensive farming was thought to be a token of progress. A decade of the 1970s was a happy decade when both farmers and promoters of agriculture, including government officials, extension workers as well as researchers, were equally enthusiastic and cooperative to boost modern rice farming.

This ambition has been aborted in half way, too. Three reasons may be attributed to this. (a) Rice farmers in the delta must be cost-conscious as the rice price reflects price levels at international rice market directly, hence regulations of rice production is installed. (b) Water available in the delta for irrigating dry season rice was found to be much scarce than expected earlier despite water resources development projects that had been completed in the Chao Phraya river basin including the Phumiphol and the Sirikit dams. This was because water demand for up-stream extraction and nonagricultural uses downstream, especially Bangkok, had been increasing rapidly. (c) Even the remote villages in the Upper delta were gradually brought close to towns physically, economically and mentally following road construction implemented rapidly through the 1970s and 80s. I would like to elaborate the third point a little further because I think this was the main cause of the subsequent alteration of land and water-scapes of the delta.

Till the 1950s, there was only one trunk route passing through the delta in north-south direction, which was the Phapholyothin road from Bangkok through the Lower delta to Saraburi, and via Lopburi to Chai Nat through hilly tracts. Secondary roads were equally limited; one was from Wang Noi via Ayutthaya and along the right bank of the Chao Phraya river up to Chai Nat, and the second one was from Nakhon Pathom going in the north along the right bank of the Suphan river up to Chai Nat. Roads were only secondary means of transportation when water communication in the Chao Phraya river system was dominant.

The construction of tertiary road network was associated with the canals for gravitational irrigation implemented from 1957 through mid-70s. Either sides of the trunk, secondary and oftentimes even tertiary canals were provided with asphalted or dirt roads for operation and maintenance of the irrigation system. Some of the roads along main canals were upgraded to a part of national road network. By the time when the Asian Highway cut through the center of the delta in mid-1970, a good number of *songteo*, small pick-up trucks furnished with two lines of benches and canvas hood, had been seen preying on the roads in the delta carrying farm products as well as villagers to and from nearby town markets.

On the other hand, water communication in the delta has lost its efficiency by being blocked by numerous embankment, weirs and water-gates provided to facilitate irrigation, drainage and flood protection. By the end of the 1970s, it had been replaced by road transportation almost completely. A typical desolate scene of water communication may be witnessed at Samchook on the right bank of the Suphan river, that once flourished as a center of water communication through the river. While the old market place on the right bank is crumbling, a new market and a business center along a new road on the opposite bank are now evolving.

Since early 1980s, a villager in the remotest village in the delta may be able to reach Bangkok within 2 hours. This has contributed to redirect the villagers concern toward "towns", pushing and pulling the villagers toward towns, and thus leaving only few young farmers in the villages. The management of small farms has no other choice but turning back to labor-saving management than labor-intensive and land-efficient farming. Rice transplantation, which was once a symbol of advanced farm management, has vanished completely in the delta. Rice seeds are either sown directly on controlled wet-beds if good irrigation is furnished, or broadcast on dry rough soil, in the same way as far back till the 1960s, if poorly irrigated. Not a soul can be seen in the fields tending the farms right after ploughing and sowing until harvesting.

4.4 Delta periphery

The periphery surrounding the Chao Phraya delta is a large expanse of dry-foot crops zone. The northeast periphery was opened in the 1950s for maize production, which expanded rapidly in the 60s when Thai maize became one of the most profitable export commodities. The western fringe of the delta in the middle reach of the Mae Klong river was a traditional sugarcane zone, which also expanded dramatically in the 1960s and 70s to meet expanding sugar market. Throughout these peripheral zones road networks criss-cross. The delta periphery has now been engulfed in Bangkok's sphere physically, economically and psychologically. Probably no people living in the peripheral areas feel isolated from the center of prosperity.

Rice lands are seen scattered in the peripheral zones, too. Rice farmers used to wait for scarce and erratic rains till they can transplant seedlings, and nowadays, they plough the land, sow seeds on the rough surface, and wait for the rain. Rice is subsistent crop for their home consumption, but it is, at the same time, only one of the commercial crops in their commercialized cropping patterns.

4.5 The Chao Phraya delta as a mercantile land-and-waterscape

Not only the Lower delta in the periphery of Bangkok, but also the Upper delta as well as the delta periphery have all been engulfed in the Bangkok economic territory during the past three decades. Three main groups of actors may have played their respective roles in this recent "drama of Bangkokianization". The Thai merchants of mainly Chinese origin are important actors who have controlled transactions of delta commodities; including rice in the first place, and then any other commodities such as fish, vegetables, fruit, chicken, pork and other meat. Some of the merchants operate major rice mills, or manage their own large farms of vegetables, fruit, fish, poultry and swine. The same merchants have established joint-ventures of building industrial, commercial and residential estates, and some have invested in new factories and shops. Quite a few innovative entrepreneurs have established larger manufacturing companies by drawing foreign capital and technologies. Thai government supported the economic development by furnishing infrastructures including roads, bridges, water supply, electrification, tele-communication, etc. in the past three decades. The policy to boost this type economic development has never been changed.

The main actors, however, were delta farmers themselves. Delta farmers have selected different farming techniques according to the different environment and conditions, changed cropping patterns as needs arose, took different management strategies, and stepped out of farming when they thought it was the right time. The farmers in the Lower delta were particularly flexible in selecting their life styles. They do not commit to a particular plot of farm, a village or a region. They can take their own decision, and bear all the risks associated with the decision. It is a behavior of a person who has been living in the world of commerce, rather than in the agrarian society.

In the Lower delta, in particularly, farmland is a commodity for commercial transactions and speculation. Many of the owners of "rice-fish-fruit-poultry complex" farms whom I met in 1994 were Bangkok residents who were mentally prepared to quit the contracted-out farming business at any moment when they though it the right timing. The transfer of ownership of farmland from farmers to the hands of Bangkokians must have proceeded further by now. It would not be possible to try to preserve so-called peasant farming, because in the first place, there was no peasant, or small-holder owner farmer, in the Chao Phraya delta.

5 The imagescape of the six great deltas in the 21st century

It would not be possible to expect the similarly flexible behavior of Bengal delta peasants. The "agrarian moment" in the Bengal delta, including lineage-based blood relations, land-based society, traditional norm in the rural society, farming technologies, and cropping and farming systems prevailing in the society, is too large to make any meaningful changes. There are only very few people in the villages who are smart enough to change their behaviors, both in farming and life-style, according to new environment and conditions given to them. There are also very few people in the villages who can properly appreciate and encourage those pioneers who initiate the change. I do not intend to make any simple comparison in capability and flexibility to the change between the two ethnic groups, but I am interested in the heavy moment of life-style that has been molded in the past 100-200 years and unique unknown causes that made this difference between the two ethnic groups.

I am currently engaged in a rural development project in Bangladesh. A set of desirable strategies for rural development that have been squeezed out from this research project include:

(a) make good use of the traditional leadership available in the village,

(b) cultivate and boost the feeling of one-ness and solidarity of a small "unit" village community,

(c) Formulate an independent "union" of these unit communities by loosely organizing the individual communities,

(d) Establish a systematic linkage between this independent "union" and the government's local administration that delivers proper rural services, and

(e) Bring the villages closer to towns and bring the towns closer to the villages to promote diverse economic activities and, at the same time, rural amenities.

If and once I had been given a chance of conducting similar studies in the Chao Phraya delta, I would have drawn a very different scenario for the development.

The six great deltas in the tropical monsoon Asia have undergone respective paths to development under respective ecological and historical settings. They are commonly core zones that lead the country's economic development. Every feature of the respective countries including ecology, agricultural land use, products-mix, rural society, road and waterway transportation, trade and commerce, functions and structures of towns and cities, are all in transitional phase. The change occurs in the first place in the delta, the core region, that lead social, economic and political transformation of the country. The delta is the showcase in which the country's future is displayed.

Seemingly, the Mekong delta is tracking the path to prosperity that the Chao Phraya delta experienced a few decades ago, the Chao Phraya delta is likely following the path of the Zhujiang delta. The Bengal and the Ayeyarwady delta are probably trying to find an alternative approach to prosperity.

The Imagescape of the Chao Phraya delta into the year 2020

Thanawat Jarupongsakul[1] and Yoshihiro Kaida[2]

Abstract: *Today's Chao Phraya delta naturally differs from that of the past, the delta has continued to change momentarily. This paper would attempt to portray, schematically, the land of the delta in terms of its natural landscape and history of mankind development.*

From the past 3 decades, the country's development has been concentrated in promoting industry as a replacement of agriculture. As a result, there are more investment in various areas which reflecting a rapid growth of community and economy. Such a rapid urban expansion have caused the growth in the city only, especially for the city which has received support from the investment policy.

For the past couple of years, the Bangkok Metropolitan Region's economy has been consistently growing at over 11% per annum, 3% higher than the national economy, making Bangkok one of the fastest growing economies in the world. Resulting an increase in population number and buildings but the government can not provide basic infrastructure to meet the increase of demand. Besides, a rapid increase in population has caused a numerous problems, for instance; an increase of slum, unemployment, deteriorated urban environment, poor living condition and especially traffic congestion that causes great economic loss.

At this moment, the variation problem of Bangkok Metropolis have increasingly caused serious implications on social and economic development of the city. The unlimited monocentric growth of Bangkok Metropolis has also added up numerous problems in adjacent towns of Samut Prakarn, Pathum Thani, and Nonthaburi particularly on traffic congestion, pollution, inadequate utilities and social fare, improper landuse, and poor quality of lift, etc.

Besides the explosive growth of the Bangkok population, the migration of people from rural area to big cities is a major social and environmental challenge at present. It need hardly be said the where so many people live together particularly in the low-lying areas of coastal cities, the demands on the natural environment of urbanized areas are extremely high. Drinking water, construction materials, and optimal sites for a dense

[1] DLIS, Department of Geology, Chulalongkorn University, Bangkok, Thailand

[2] CSEAS, Kyoto University, Kyoto, Japan

infrastructure network are among the natural resources and conditions which can help to optimize social and environmental condition, but the availability of all of them is invariably limited. Uncontrolled of resources always to depletion of these resources and creates negative effects and uncontrolled waste disposals can pollute groundwater system or housing estates. The more densely an area is inhabited, the more severe the impact of hazards will be. One of the most important population centers in Thailand is the city of Bangkok which is just one metropolitan area vulnerable to inundation. The basis of sound environments has been largely ignored in planning and development of the coastal city as like Bangkok in view of these consideration, the current paper is intended to draw the imagescape of Chao Phraya delta in the 21st century. The outputs from this paper are the sectoral analysis from the point of view of land conditions of proposing the primary objectives of gaining some basic knowledge and compare.

1 Outline of the Chao Phraya delta

The Chao Phraya delta occupies the southern basin of central plain of Thailand. It is situated over a large structural depression up to 200 kilometers long from north to south and 50-150 wide from east to west. The plain is bordered on the west by Tenasserium range, on the north by the Nakhon Sawan depression, on the east by the Khorat plateau, forming a triangular shape with its south facing to the Gulf of Thailand. In the northern basin, four big tributaries, the Ping, the Wang, the Yom, and the Nan flow to the south and join one another at Nakhon Sawan to form the Chao Phraya river.

The Chao Phraya delta plain is characterized by a flat and low-lying plain approximately 40,250 square kilometers, consisting of young fluvial, brackish and marine deposits. Fan and terrace occupy marginal zone of the plain. A peneplain and structural terrace of marl deposit in the eastern part of the plain are the oldest landforms of the region. The topography of Chao Phraya delta can be devided into the Singburi plain and Bangkok lowland (TAKAYA, 1969). The elevation of Singburi plain varies from 5 to 15 meters MSL. with a mean slope of approximately 10 meters/100 kilometer. The surface of Bangkok lowland is flat to very slightly undulating and its floor lies less than to 5 meters MSL. with a mean slope of less than 4 meters/100 kilometers. The major drainage system of Chao Phraya delta consists of the Chao Phraya river and its distributary, Tha Chin river. Beside, the plain also receives waters from two rivers, the Mae Klong in the west and the Bang Pakong in the east. The mean annual flow of Chao Phraya river is about 917 cubic meters per second. The present growth rate of Chao Phraya deltaic plain toward the sea is about 4-5 meters per year.

In the Chao Phraya delta, the Quaternary and Tertiary sediments represent a complex sequence totaling more than 2,000 meters, of which only the upper most 200 meters is well known. Sedimentation was controlled throughout most of Tertiary and Quaternary time by a combination of tectonic movements both within the plain and in the adjacent mountains (NUTALAYA & RAU, 1981). The plain is situated over a large structural depression that has been filled with an assortment of clastic sediments chiefly of fine to medium grain size. This prism of sediment rests upon a basement complex that slopes south to the latitude of

Bangkok, where it is broken by an east-west trending horst block (Samut Sakhon horst). The north trending axis of the Chao Phraya depression is related to the north-south structural trend of the Paleozoic and Mesozoic fold belt of western Thailand. The sediments of Chao Phraya delta reach a thickness of at least 1,859 meters on 15 kilometer west of Bangkok, where a borehole reached upper Cretaceous granit. Thirteen other deep boreholes have been drilled in the lower central plain but few have penetrated bedrock. The data suggest that the Chao Phraya though has been tectonically active during most of Tertiary and Quaternary time, receiving alluvial and deltaic sediments when the adjacent ranges were uplifted.

Geophysical evidence suggest that in some areas the sequence of sediments may be more than 4,000 meters thick. Regional aeromagnetic and seismic data in the Gulf of Thailand indicate that the basement is highly irregular. The geomorphology of the central plain is strongly effected by the faulting and most river alignments and strike lines of hills along the margin of the plain are controlled by faults that probably cut the basement. The dominant direction of faulting is north-south, although three secondary directions are indicated. The Chao Phraya river is apparently controlled by normal faulting indicated by both borehole records and geophysical data in the Ayuthaya area.

The climate of the Central Plain of Thailand is the tropical lowland savana type with the maximum monthly rainfall in September of 295.8 mm. and the minimum of 2.8 mm. in November. The lowest temperature of record is 18°C in December and the highest of record is 36.5°C in April. The extreme recorded diurnal rang has reached 26.4°C. Fog is common between January and March but generally it occurs only during the early hours of daylight. The region is under the influence of the southwest monsoons, resulting in a wet season from the middle of May and October. The coolest seasons extends from November through February and the hot season extends from March to mid May.

The study of Chao Phraya delta has been mentioned by many researchers such as Takaya (1969) and (1972); Hattori (1972); Thiramongkol (1984 and 1987); Chonglakmani *et al.* (1983); Dheeradilok et al. (1984); Somboon (1988, 1990, and 1991); and Somboon and Thiramongkol (1992). From the detailed study at the Senanivate housing site (Somboon 1988) and the updated data from Somboon and Thiramongkol (1992), the seaward progradation of the Chao Phraya delta is usually characterized parallelly by beach accretion, ridges or dune deposits developing behind the active shoreline and overlying nearshore marine deposits. The delta results from progradation of prism-like terrestrially derived sediment sequence into the marine basin. In general, the morphology of deltaic plain changed in response to the incidence of sediment-laden floodwaters which promote vertical accretion, particularly on channel margins and to the effects of the vegetation which colonized the depositional terrain and the extent of continuing subsidence, due to compaction of underlying sediments. As compactional subsidence ensues, marsh growth continues, resulting in already extensive and commonly landscapes of the swampy areas in the deltaic plain (see Fig. 1). The landform of the Chao Phraya delta can be classified into 13 units as follows: Recent Tidal Zone, Recent Brackish Swamp Zone, Deltaic Plain of Marine Clay, Deltaic Plain of Brackish Clay, Floodplain, Lower Terrace, Middle Terrace, High Terrace, Fan Delta, Old Alluvial Fan, Peneplain, Terrace of Marl, and Mountain and Hills.

2 Land development history in the delta

Today's Chao Phraya delta naturally differs from that of the past, the delta has continued to change momentarily. This section would attempt to portray, schematically, the land of the delta in terms of its natural landscape and history of mankind development. In this context, the authors have utilized historical data, dated back to the Ayutthaya Period, in co-ordination with geomorphology to vividly explain the history and evolution of land development in the past.

In this topic, the evolution of land development is divided into 5 periods: (1) Before the land development period (Ayutthaya); (2) The opening up of land development period (Thonburi-Rama III); (3) The extension of land development (Rama IV); (4) The progressive epoch for land development (Rama V); and (5) Period of land development adaptation (after Rama V).

2.1 Before the land development period (Ayutthaya)

From early in the Ayutthaya period, trade was mostly, in the hands of Arab, Persian, Indian, and Chinese merchants, with whom the king's relationship appears to have been extremely close. Ayutthaya's air of an international trading port is well expressed by the seventeenth-century map of the City by Loubere de la (1693). From a geopolitical positions, the location of Ayutthaya is ideal for trading port. It lies at the junction of the upper flatland of floodplain and the lower deltaic plain (Fig. 1). In the rainy season, the Ayutthaya area is high enough to remain above the floodwater and can be considered to be dry land; but the lower deltaic plain becomes completely inundated, especially the swampy landscapes of Tung Tawan Tok, Tung Tawan Aok (Luang), Tung Nakhonnayok, Tung Dong Lakorn, Tung Bang Phrong, Tung Bang Khen, and Tung Minburi-Chachoengsao. Lastly, a part of these swampy landscapes do not offer a secure environment for human habitation. In this sense, Ayutthaya might be said to occupy the Southernmost tip of terra firma.

Takaya (1987) and Tanabe (1978) concluded that beyond the Ayutthaya area there were an upper flatlands belonged to the ancient community where farmers had dug small ditches to divert water from the river channels into their farm lands. Some parts of the areas had sufficient reserved water for paddy fields to enable annual rice-growing without the need of rain water. Within the whole delta in the lower part, there were few inhabitants except along the sides of the main river channels. Most of the newly excavated canals were provided for the purpose of transportation. Therefore, the land development for such area was named "Before and Land Development Period". Most of the development activities happened to be canal excavations to short cut the river courses, canals inside big cities, and canals to join rivers. Excavating labours were basically drawn from the king's conscription. Figure 2 demonstrates the excavation of canal between 1550-1767 during the Ayutthaya Period.

In the authors' opinion, the land development around the delta of Chao Phraya River in the Ayutthaya period could be classified as the pre-historical sequence where most of the development work were in the form of short cutting the river courses by canals and the linking canals to join the river as a mean to facilitate waterway traffics. In that period, very few people lived close to the canals, since most people preferred to live along the riversides beyond Ayutthaya. Most of the rice fields along the upper flatlands were the floating rice cultivated by direct seeding system (Tanabe 1978). The lands further south a Ayutthaya were permanently flooded and wild without inhabitants, except a few fisherman and orchard cultivations. Therefore, the swampy lowland at the delta was minimized in terms of agricultural importance, but held some meaning in terms of a natural defense line for military use.

2.2 The opening of the land development period (Period between Thonburi up to King Rama III)

After the fall of the Ayutthaya dynasty, Thonburi gained importance when King Taksin the Great decided to choose it as a capital in the year 1768. Meanwhile the beginning for the period of land development along the swampy lowland of the Chao Phraya delta had started, as it was the time when the Thai people began to depart their lands, at the upper parts of Ayutthaya, for the southern exodus and began their settlement along the swampy lowland of the delta in earnest. Land development between the periods of Thonburi and King Rama III (1768-1851) had been the beginning phase of land development, which was similar to that of the Ayutthaya period whereby most excavated canals to short cut the river courses, digging the city moats, and to join rivers together by canals for the purpose of convenient traffic movement in trade and defense. There were forced expatriation and migration of people to lay claims along the land close to the canals, for the purposes of settlement and some agricultural endeavors. Figure 3 shows details concerning the canals being excavated in his period.

It is noteworthy that at the beginning of King Taksin the Great up, to King Rama II, most land development along the swampy lowlands of the Chao Phraya delta consisted mostly of buildings and expansion of the capital city similar to that happened in the Ayutthaya era. During the reign of King Rama III, the development veered towards the excavation of long canals to connect rivers, which aim was for military, reason. During that time there were needs to expedite forces to suppress Vietnam's aggression on Cambodia which was under the protection of Thailand and also to expedite forces to fight Malaya (Malaysia). A policy was carried out to force resettlement of people, the outsiders: Mon, Cambodians and Champa Indians, as well as to persuade farmers from the outlying Bangkok suburb, to resettle and do rice farming along the new canals (Tanabe, 1978).

2.3 The extension of land development (during the reign of King Rama IV)

King Rama IV, reign during 1851-1868, saw Thailand being on the threshold of change after the Bowring Treaty. Internal trade and foreign trade prospected since them. The main agricultural produces for export were rice, sugar, pepper etc. The rice production also markedly increased. The excavation of canals at that time had facilitate the increase of area for paddy field as well as the sugar transportation from the main sugar-cane belt such as Nakhon Chaisri. Details of canal excavation at that time were shown in Figure 4.

During the reign of King Rama IV, land development along the swampy lowlands of Chao Phraya delta did not progress much. Canal excavation in this period was for the purposes of Bangkok expansion and for the expansion of transportation of various kind of good especially from the western side of the Chao Phraya River. The government carried out canal excavation for the clear target of changing wild land into farm land, as shown in the cases of the Maha Sawat canal in 1861-1865, the Pasi Charoen canal in 1867 and the Damneon Saduak canal in 1867-1868. These canals were excavated for transportation and irrigation use in the western side of the Chao Phraya River. Anyhow the irrigation purpose was not fully served because the canals were capable of supplying water only at the time of high tide and caused inundation in the canals. It is perceivable that even though the canals were for the increase of farming land but lands adjacent to the canals were usually given to the royalties and the high ranking officials, and such lands were usually left unattended without yielding any benefit. Therefore, the land development in this time was called "Era for Extension of Land Development", since hew farm lands along the canals were tilled by slave laborers under the control of the royalties or high ranking officials. Land development by canal digging in the progressive epoch should be done with free farmers emerging from the changing of administrative rules such example could be found at the final phase of King Rama the fifth's reign.

2.4 The progressive epoch for land development (during the reign of King Rama V)

In the reign of King Rama V (1868-1910), the king had created "the Canal Department" to look after canal excavation along the Chao Phraya delta and exceedingly real development happened. Since during his reign, Thailand had made more contacts with the foreign countries and agreements to buy rice to feed the colonial people were made. And this had enhanced the importance of communication and transportation. The government proclaimed "The Canal Premium Act" in 1870 to upkeep the canal traffic in good order for easily transportation. In 1877, new policy on canal excavation was emerged to cope with discarded lands along the new canal banks that did not increase any farming land. A new regulation for canal excavation was created and called "Announcement on Canal Digging" in 1877. Thailand had increased rice export to foreign countries and Thai rice of higher price was welcome by the consumers. Furthermore, land price along the canals near Bangkok that was suitable for farming had increased by better demand. Therefore, canal excavation project which formerly belonged to the government had changed into private sector's project with businesslike inclination. His majesty King Rama V had granted individuals or companies to dig or do repair works on the finished canals such as the Klong Phra Pimon and Klong Phraya Banlue. For the old canals after repairing, the government granted concession to individual to collect premium on passing boats including various management to keep the canals in good order. The significant company of private person at that time was the "Siam Canals, Land and Irrigation Company" which was established in 1888. It is perceivable that this period might be named "the Progressive Epoch for Land Development along the Chao Phraya Delta", particularly in views of the immense and unattended wild and flooded lands. Figure 5 summed up the excavation of various canals in this period.

It is remarkable that in this period, the land development along the Chao Phraya delta had been extended considerably and progressively. Paddy fields and prices of lands had increased. The government managed to excavate canals itself and concessions to excavate canals had been awarded to individuals with a view to increase paddy fields.

It was noticed that this period was rather different from the former periods in terms of policy change to allow the right of ownership holding along both sides of the newly excavated canals. There were land allotments distribution and staging claims to lands from people from up country. There was also a mass exodus of farmers from other regions and new group of farmers was formed, especially by the newly freed serfs and slaves. These farmers flocked the canal-side lands which was a new phenomenon of this period that gave rise to the free farmer groups.

This was the different farmers from the period of land development extension where the farmers were mere serfs of slaves under the control of the royalties and high court officials. Rice farming had been restricted and some plots of land were left to grow wild and unoccupied. This period also saw the new form of canal excavation which was very much different from the previous method where the government had to undertake the excavation and spend a lot of money on it. In this period, canal excavation had been entrusted to the individual and the government could save the expenses and at the same time could also levy taxes. Thus, farming land had considerably and rapidly increased, particularly on the vacant wet-lands along the east side of the Chao Phraya River.

Another distinctive promotional driving force towards progress and plentifulness in land development of this era had been the good earnings from paddy cultivation, and consequently a land rush fever entailed. Peoples migrated and laid claims to lands near the canals especially the big canals, for example, in the vicinity of Rangsit area. This was the era of land development progress along the swampy lowland of the Chao Phraya delta.

2.5 Period of land development adaptation (after the reign of King Rama V)

Land rush fever during the period of progressive land development had brought along many problems which had effected later canal excavation projects. The planned canal excavation projects were notably, the medium and small projects. Some project had to be stopped due to financial problems and withdrawal of investors. Some finished canals met with the lack of water, shallowness, insufficient control and unoperativeness. Mass of farmers had left their lands such as around the Rangsit canal vicinity. Furthermore, new gained lands form canal excavation lacked of good facilities because of its long distance away form the city (Johnston, 1975:85-86). It was noteworthy that all these problems originated from the expansion of cultivated land by depending only on canal excavation. Canal excavation in the period of prosperous land development progress was solely for the opening of new arable land which previously was wild to be turned into cultivated field. Very few finished canals were meant for irrigation purpose.

The era of land development improvement that portrayed a crucial period started at the final phase of King Rama V reign, but serious improvement of land development happened during the reign of King Rama VI and VII. The government had realized the importance and necessity of bringing modern technology to solve problems of the finished canals of the previous era and to transform them into the most efficient irrigation system for agriculture, especially for paddy fields along swampy lowlands of the Chao Phraya delta.

The introduction of modern irrigation technology began at the final phase of King Rama the fifth's reign around 1902. The King sought for expert engineers on irrigation to be advisors for the improvement of irrigation system around the swampy lowlands of the Chao Phraya delta. Mr. J. Homan Van de Heide, an irrigation engineer from Holland, was employed in June 1902. At the same time the Canal Department was set up to look after the improvement of canal excavation and water supply. Mr. Heide was later appointed as the first director of the Canal Department. In 1903, the report on the survey of the Chao Phraya delta was prepared and presented with the suggestion that paddy farming along the delta was still using an outdated agricultural method which solely depending on rain water. Yearly harvest yield depended mostly on the weather condition of each particular year. There were three sources of water supply for paddy fields along the Chao Phraya delta: the unpredictable rainfall volume; delayed flows from higher grounds especially from the upper flatland with river terraces around Ayutthaya and Ang Thong; and water overflow from main rivers with unpredictable yearly volume. Mr. Heide suggested that in case the government wish to make sure that yearly paddy field to be increased at a constant volume and also manageable, a modern and viable water supply system must be set up. Regular sufficient supplying waters through the canals must be provided. Mr. Heide gave the explanation that although some canals existed but their functions in irrigation was negligible and these canals drained away the rain waters. It was found out that water levels in the river always at low level during dry season before rain came. Once the rain came, the canals drained away the rain water into rivers and thus only a short duration of inundation existed (Heide, 1903: 18-26). Mr. Heide proposed to the government to urgently improve the water reserve system together with an efficient system of irrigation by building a dam across the Chao Phraya river at Chainat Province and supplied the conserved waters into the Suphan and the Noi rivers. A canal to divert water from the dam to Lopburi river should be excavated. Irrigation watergate or regulator to retain water in the canals from flowing into rivers should be built as well as regulator to keep away salty water. The likely target areas for irrigation system should be provided within three sub-projects, that is the eastern side of Chao Phraya river, the western side (large project), and the western side (small project) (Heide, 1903: 67-107). At that time the government was of the opinion that the improvement projects as suggested by Mr. Heide were quite good. However, no attention and due response came from the government because of financial constraint from the railway construction project including many other small and urgent projects that needs attention, such as the dredging of many canals that became shallow. These canals were Pasi Charoen, Damneon Saduak, Rajdamri, Pai Sinkto, San Saeb, Bang Kanark, Sam Rong and Praves Burirom. Other urgent works included watergate, navigation locks, and the construction of hydrographic stations to check and monitor water levels and discharges in various waterways. Around 1906, the Rangsit Project area was struck with a severe drought. Mr. Heide advised that a diversion canal from Lopburi river to join Rangsit area at canal No. 26 should be built. It seemed that many projects, one after another, as proposed by Mr. Heide had received no attention from the government. Therefore, Mr. Heide was fed up with the situation, and in

1909, he and his five engineer assistances resigned and went back to their country (Heide, 1906: 91-92).

During 1906 to 1913, at the beginning of King Rama the sixth's reign. A long drought of three year duration struck the country causing severe damages to paddy fields along the lowlands of the Chao Phraya river. Farmers were suffering, the cost of living was very high, and thieves were abundant than ever. His Majesty the King Mong Kutklao appointed one committee with H.R.H. Krom Luang Rajburi Direkrith, the Minister of Agriculture, as the chairman, to tackle the problem. The committee advised that there should be an urgent program to improve the irrigation works. They sought technical assistance from the British government who allowed Sir Thomas Ward, an irrigation expert, to come to study and plan the irrigation system for the country (Johnston, 1975: 288-289). After reviewing all the data, Sir Ward concluded in his report to the effect that, if Thailand was to be developed into an important rice producer of the world, there should be a technically correct way to build the irrigation infrastructures. Anyhow, at the initial stage, Sir Ward suggested that irrigation project shoulds be carried out in conformity with the financial condition of the country and be compatible with the prepared target areas. It was also suggested that the lowlands of Chao Phraya river should be appropriately divided into seven areas according to the irrigation potentiality, they were : Suphan river; Noi river; Lopburi river; Mae Klong river; Pasak river; the western river basin; and the eastern river basin (Takaya, 1987: 226-227). Since the government had allotted 22,750,000 Bahts for irrigation works, Sir Thomas Ward also proposed five urgent subprojects: Suphan Canal, South Pasak, East Petchaburi, Lampang and Monton Payap Irrigation Projects as well as the irrigation infrastructures to divert water from the upper flatlands in Ayutthaya to the seashores along both banks of the Chao Phraya River (Arsawai, 1987: 157-158). The Pasak Irrigation Project was the first choice and became one of the biggest irrigation work of the country.

Later on, works under the Canal Department was compiled and then a new "Irrigation Department" was established in September 1914, and Mr. R.C. Wilson was appointed as the director general. After the establishment of the department, irrigation works were substantially carried out. Later on, King Pok Klao had an opinion that the word "Irrigation" seemed rather misleading in describing the department's activities, and the name "Water Supply Department" came in as a supplanted on the 21st of March 1927. The main works on irrigation at this and the following periods were various sizes of irrigation projects (Fig. 6) which included the followings:

The South Pasak Project (1915-1924)

The Chiengrak-Bang Hia Project (1921-1931)

The Suphan Project (1921-1955)

The Nakhon Nayok Project (1933-1954)

The Greater Chao Phraya Project (1952-1957)

The Bhumibol and Sirikit Dam (1964/1975)

From a technical point of view, the south Pasak Project had created tremendous impacts on the flow or hydraulic regimes within the delta of the Lower Chao Phraya Basin in three aspects. Firstly, the lower areas such as the Rangsit area could then receive much more water from the upstream river reach by the diversion structure on the Pasak river in the north, and flow southwardly through irrigation canals (klong Rabhibhatana) by gravity in stead of receiving only rainwater and flooding or overflow water from the Chao Phraya on the west and Bang Pakong river (Nakhon Nayok river) from the east. Secondly, this was the first time that modern irrigation infrastructures such as regulators, gates and check structures were introduced in the irrigation areas. Thirdly, water which was intercepted or trapped in the lowland areas in the middle or lower part of the floodplain could now be drained to the Gulf of Thailand faster (for example, via Klong Chiangrak Noi-Klong Dan). At the same time these drainage water, which flowing through the saline soil in the coastal zone, would reduce the salinity level of the saline making that land became more suitable for agriculture.

In this period, the government had also constructed a system of sea dikes to prevent salt water intrusion and to reclaim land in Samrong, Bang Bo and Bang Plee areas for agriculture. Major effects from these changes in flow regime were the shifting of cultivation period and the types of crops that could be grown in the Lower Chao Phraya delta which could be witnessed in the North Rangsit and South Rangsit areas. The estimated irrigation areas in this period were about 2.8 million rai.

After the irrigation water became available in the lower part of the Chao Phraya Basin in the 1970s, farmers had then slowly changed from their traditionally practics of growing “floating” rice variety to a high yield one. (it is estimated that at present it covers an area of more than 18.8 million rai). It was also noted that many parts of the area were idle due to flooding during the wet season and some were therefore used as flood retention ponds.

Since the establishment of the Royal Irrigation Department in 1927, several water resources and irrigation development projects had been carried out by the Department through out the country. For the Chao Phraya delta, in 1933 the Nakhon Nayok Irrigation Project, the Sam Chuk and Makham Thao Project in Suphan River were implemented. It could be said these projects had major impacts on the irrigation development in the delta since they had incorporated new technology such as hydrological and geotechnical investigations and analyses and reinforced concrete design for major control structures. These new technology, to a certain degree, had some impacts on the river flows, water allocation, operation and management of basin’s water resources. However, the development activities in the Chao Phraya delta came to almost a complete halt during the Second world War period.

In the late 1940s, the Chao Phraya Barrage Project (Chainat Dam) was reviewed and appraised, and found suitable for international financing. After the end of the Second World War, the development works in the lower Chao Phraya delta resumed again, some with the technical and financial assistances from the external funding agencies such as the World Bank. One of the most important infrastructures implemented during this period was the construction of the diversion barrage on the main Chao Phraya river at Chainat. After more than fifty years since the idea of controlling river water by means of diversion structure was proposed by van der Heide, the Chao Phraya Barrage was constructed to divert water to irrigation canals and natural channels both on the left and right banks of the Chao Phraya river which covers most of the irrigable area in the lower part of the delta. The Project was designed for supplementing irrigation water to increase rice production in the wet season both for domestic consumtion and for exporting. The project area consists of more than 20 sub-projects all of which were connected by newly excavated and natural canals. All irrigation canals were unlined and natural drainage channels were incorporated in the design to reduce the project coast. By this nature, the Project itself was complex and was very difficult to operate and manage efficiently.

The Noi and the Suphan rivers were excavated and enlarged to serve as supply channels for the downstream irrigation areas on the right bank. While on the left bank, Chainat-Pasak Canal was excavated to deliver diverted water to Manorom, Takli, Lopburi and Saraburi irrigation areas upto Pasak river. Navigation locks, secondary canals, drainage canals and various canal control structures such as checks, gates and farm turn-out were also constructed in order to raise water level and divert water into the irrigation field. It was estimated that the areas which could enjoyed benefit from the Chao Phraya river water were increased upto almost 7.6 million rai.

To secure more water for utilization, two large storage dams namely, the Bhumibol Dam and the Sirikit Dam were later constructed on the main tributaries of the Chao Phraya upstream from the Chao Phraya Barrage. These dams were muti-purpose serving for irrigation, hydro-power generation, flood control, inland navigation, domestic and industrial uses, and for preventing salinity intrusion at the river mouth. These two dams were completed in 1964 and 1975 respectively.

Following the completion of the above two dams, it was then possible to control about 22 percent of the total water in the Chao Phraya Basin, and therefore it was possible to allocate water for dry-season cropping in the lower part of the Basin for over 2.5 million rai and to generate about 920 MW of hydropower. To promote water utilization, particularly for the dry-season cultivation, improvement works were made in some project areas, which were originally designed for supplementing irrigation water. These improvements included the introduction of ditches and dikes facilities and land consolidation works in the northern part of the Lower Chao Phraya Project. Since these work were new to the farmers, several pilot projects were implemented to demonstrate that if properly manage both rice and upland crops could be grown in the Lower Chao Phraya area. At the beginning it was difficult to motivate farmers to make use of the water in the dry season. Series of training programs and strengthening of the extension services were installed to promote and improve agricultural production particularly in the dry season.

As a result of these concerted efforts by various concerned parties, the dry-season rice area had increased over twenty percent in eight years after project was initiated, i.e., from 2.5 million rai in 1970 to 3 million rai in 1978. At the same time problems of water shortage and increasing conflicts among different water users in the dry season became more pronounce. While development of irrigation projects were taking place in the Chao Phraya basin, the development of other large-scale projects in the adjacent Mae Klong basin on the western region were also taken place.

Flood protection work in the lower part of the Chao Phraya basin was implemented by the government. Flood control facilities included construction of dikes along the Chao Phraya river banks to prevent overflow into the cultivating lands. Series of dikes on the eastern side of Bangkok together with permanent pumping facilities were constructed to prevent water flowing into residential areas and to drain rainwater into the river. Flooding of the city of Bangkok and the surrounding suburban areas occurred much more often during the last decade due to several reasons such as heavy local rainfall, changes of land use from agriculture to industrial and residential areas. These changes also had significant changes of flow regime within the lower Chao Phraya delta and in Rangsit area in particular.

Many pumping irrigation projects were also implemented in the Chao Phraya Basin. These projects could be classified as large- and small-projects. The large-scale projects were implemented, operated and maintained by RID, similar to other gravity schemes. These were also a number of pumping units, privately owned by individual farmers or cooperatives. At present, they are freely operated since at present there is no specific regulation governing such activities. In the future these units could create conflict among water users and could become more serious in the area where in the dry season river flow is low and there exist no upstream storage facility. In some areas, farmers pumped water from shallow wells to supplement water supply from the irrigation canals when it was inadeguate. Groundwater was also used for domestic and industrial purposes in the area around large towns and cities.

At present, the Chao Phraya river is the principal source of water supply for domestic and industrial uses in the basin. The Bangkok Metropolitan Water Works Authority (BMWA) who is responsible for providing water supply in Bangkok Metropolitan area is taking about 1,100 MCM per year from the Chao Phraya river for it water supply productions. Water supply of other towns and municipalities are mostly under the responsibility of the Provincial Water Works Authority (PWA), the present yearly requirement is estimated at 140 MCM. The total annual water requirement for domestic use in the basin is therefore about 1,250 MCM or about 8 percent of the total water requirement. Though the Chao Phraya Basin itself has good highway networks and extensive rural road and feeder road networks, inland waterways are one of the main routes for public transportation and had been used extensively in the lower part of the Basin both for public transports and large shipment of goods to and from Bangkok. Transportation of bulge cargoes such as commodity goods / agricultural products and construction materials, from the lower Northern area and the Central plain to the Port of Bangkok. Even though during the last decades, the network of highway systems have been very much improved, large shipments of agricultural products, construction materials and others by barges are still being used in the lower part of the Chao Phraya river.

In 1976, the Phitsanulok Irrigation Project, located downstream of the Sirikit Dam, was proposed and implemented. The project consists of a barrage across the Nan River near Phitsanulok and a system of irrigation canals covering an area of about 0.58 million rai. By opening up new scheme upstream, the downstream flow regime is also changes and the Chao Phraya River system itself become much more complex to manage.

A comprehensive overall basin study for the Chao Phraya Basin was carried out by RID in 1977 to determine the water resources development potential, development policy as well as operation guidelines and etc. for the Basin. The study revealed that the regulated water supply of the Basin was fully committed. Further development downstream which would lead to increased water use in the Basin have to be postponed until the amount of water use in the existing projects could be significantly reduced or new source of water supply could be developed. It was also found that the best way to reduce water use in the drought years was to control of the extent of dry-season areas. As a consequence from the findings, an operating guideline for the two reservoirs was adapted and put into practice. A large storage dam on the Yom had been proposed and now being under appraised. If it is implemented the project would also some impact on the flow regime of the Chao Phraya river downstream.

Since then several studies had been made on system improvement including modernization and rehabilitation of some sub-projects including the North Rangsit and South Rangsit projects. Attention have been given to the adaptability of the farmers and projects staff to the new technology. Nonetheless, improvement of infrastructures involve a large amount of money and with the shortage of professional personnel, prevailing in the country, the improvement or modernization of the Chao Phraya Irrigation Project has not progressed as envisaged. The irrigation efficiency varied widely from project to project from 15 to 20 percent in the wet season and 40 to 60 percent in the dry season, depending upon the physical condition of infrastructures and the availability of water supply.

To conclude this section it is obvious that the water management issues in the Chao Phraya delta would become much more complex and increasingly important in the near future and this in turn would have a definite impact, both positively and negatively, on the future land and water development of the Rangsit area.

3 Agricultural and water resources development in the Rangsit area

The type of land development in the Rangsit area is in conformity with the land development along the swampy lowland of the Chao Phraya delta. As explained previously, this study had made it possible to categorize the description of land development around Rangsit area into five periods according to the changing ecological habitat as follows: Before the opening up period (before 1889); The opening up period (1889-1924); The first transition period (1924-1957); The second transition period (1957-1977); and The third transition period (1977-present).

3.1 Before the opening up period (before 1889)

From the travel record documents of foreigners and missionaries who visited Thailand before 1827 and the journey of Mr. Smith S. Warrington in 1890, they mentioned about the Chao Phraya river from the district of Sam Kok (presently) up to Ayutthaya (Pallegoix, 1854: 84-85), which understandably was generally known as Tung Tawan Tok and Tung Tawan Aok (Luang) in the Rangsit area before the opening up (before 1889), and possible indicated as a vast expanse of plain with some swamps. Most plants in the area were various species of Graminae; *Arundo danax Linn; Cyperus spp.; Cyperus differmis Linn.; Cyperus malaccensis Lank.; Typha angustifolia Linn.; Aeschynomene indica Linn.; Themedia arundinacea Ridl.; Ormocarpum orientale Merr.; Saccharum procerum Roxb.; Colocasia esculentum Var.; Nymphaea nouchali Burm.; Nelumbo nucifera Gaertn.* In the shallow inundated area and high grounds, bushes and big trees were commonly found for instance, *Ficus maclellandii King; Erythrina suberosa Roxb.; Elaeocarpus hygrophilus; Juncellus inundatus Clarks.; Combretum quadrangulare Kurz; Streblus taxoides Kurz; Flacourtia indica Merr.;* Phraya Cholmark Wijarn when alive, had paid much interest in the “Samun” deer (Cervus schomburgki), - a species of swampy deer: endemic to the local only, had been hunted down to extinction within a short period. During his tenure as the director of the Water Supply Department, he tried to study by inquiring workmen and villagers. He related that his father while being the director of the Siam Canal, Land and Irrigation Company, had supervised irrigation works for paddy fields in the Rangsit area. He told his son that at those time the “Samun” deers were plentiful around the Rangsit area and he had even hunted them near the Chulalongkorn Regulator. In the flooding season, the “Samun” deers would avoid the flood water and went up to the higher grounds. Villagers would then went out by boats to easily hunt the deer by using spears. In summer, the villagers would dry its horns and filed off portion of the horns to lessen the weight and then put the horns on their heads, creeping up to the deers and easily stabbed them. The deer would not run away because they thought the villagers were ones of their own (Figure 7). “Samun” deers were so abundant around the Rangsit area up to the sub-district of Bang Plagrod and Tung Dong Lakorn in Nakorn Nayok where people usually riding water buffaloes to hunt the deer that ran away up to the high grounds in flooding seasons. Baffaloes could traverse muddy and water logged grounds easily while the deers had no strength for such condition (Laekhakula, 1992: 228-229). Besides “Samun” deers, groups of wild elephants were found wandering in the Rangsit area and the vicinity of both sides of the San Saeb canal (Laekhakula, 1992: 229 and Johnston, 1975: 100-101).

The ecological type of flooded basin along the Chao Phraya river usually offered the best habitat to many kinds of birds and animals. Various species of birds were *Anas sp.; Tachybaptus ruficollis; Phalacrocorax sp.; Nycticorax nyccticorax; Ardeola speciosa; Dupetor flavicollis; Porphyrio porphyrio; Gallicrex cinerea; Gallinula chloropus; Metopidius indicus; Amauronis phoenicurus.* As for the amphibians and reptiles that lived in the waterlogged basin of the Rangsit area before the appearance of canals should be *Bufo melanostictus; Occidozyga lima; Phrynoglossus laevis; Phrynoglossus martensii; Rana erythraea; Rana limnocharis; Rana macrodactyla; Rana rugulosa; Rhacophorus leucomystax; Kaloula pulchra; Microhyla heymonsi; Microhyla ornata; Cuora amboineusis;*

Hieremys annandalei; Malayemys subtrijuga; Pelochelys bibroni; Trionyx cartilagineus; Crocodylus siamensis; Varanus bengaleusis; Varanus salvator; Ramphotyphlops; braminus; Typhlops diardi; Acrochordus javanicus; Xenopeltis unicolor; Cylindrophis rufus; Python molurus; python reticulatus; Bungarus fasciatus; Naja kaouthia; Naja naja; Elaphe radiata; ptyas Korros; Trimeresurus albolabris; Trimeresurus gramineus.

It was shown that the eco-system of the Rangsit area before the appearance of canals, plentiful of various types of animals existed but later on some species of animals and plants were annihilated to extinction such as the "Samun" deers that existed in Central Thailand only.

The lost of "Samun" deers from the repercussion of land development when the flooded basin was opened up for paddy fields, is a good example. About 100 years ago once the "Samun" deers were profile along Bang Khen, Lak Si, Don Muang, Rangsit, Ayutthaya, Nakorn Nayok, Suphanburi etc. Despite its immensely vast stock, hunting had done away with their existence in Thailand and the world in a few years time.

3.2 The opening up period (1889-1924)

The era of opening up began in 1889 when the Rangsit Canal Project was launched by the Siam Canals, Land and Irrigation Company. Originally the Rangsit area was a waterlogged basin covered by various kinds of plants. It was permanently inundated. Later on, a canal was excavated, as shown in Figure 8, to drain water away and consequently the water logged ground became dry and soon paddy fields appeared. Paddy production in the Rangsit area at the openning up period was less successful. Mr. Heide spoke about the Rangsit Project as a very primitive and incompleted scheme because at that time the canals could not supply sufficient water to the paddy field and a damaging harvest resulted (Arsawai, 1987: 154). The difficulties with water supply for paddy fields had been heard regularly to the effect that nearly every year paddy field were damaged by too much or too little water supply. In 1906, the Rangsit Project was suffered from severe drought and the canals from the project were shallow as shown in Figure 9. This had driven away great number of farmers from Rangsit. In year 1906, it was reported that 1,000 families had vacated, and the continued migration still went on.

Another cause for the large migration of farmers was the problem of production failure from acidity in the soil as appeared in Figure 10 which showed that the lands were abandoned to be waterlogged basins in 1906 from the effect of acidity of the soil.

The most severe problem happened in 1908-1909 when flooded water inundated Rangsit basin and later on in 1909-1913 a three year drought in succession had caused heavy damage to paddy fields in Rangsit and thus caused great suffering to the farmers, cost of living was sky high, theives were exceedingly abundant everywhere. In 1914, the year that the concession to built canals in Rangsit ended, the canals, in a worse condition, were transferred back to the government. This had adverse effect upon rice production in this area. There was evidence indicating that of all the 400,000 rai of arable land, the actual ultilized land was only 40% and that was another period when mass migration from the

Rangsit area occured. The deterioration of the canal conditions not only restricted water supply to the paddy fields but also obstructed the transportation of rice to the markets. This had led the government to consider a substantial improvement of irrigation in this area. An urgent plan to develop the irrigation system was drawn and substantially in the form of the South Pasak Irrigation Project which was planned to supply water to the Rangsit area and nearby vicinity in 1915, and was finished in 1924. This was a significant turning point for the Rangsit area. The objectives of the South Pasak Irrigation Project could be concluded in two points: 1) to remedy water shortages in the year of small rain and to lessen the shallowness of the Rangsit canals; and 2) to indirectly solve the problem of soil acidity since water of the Pasak river had its own source of origin and running through limestone mountains in Saraburi, therefore contained better alkalinity than water from the Chao Phraya river.

3.3 The first transition period (1924-1957)

After the construction of the South Pasak Irrigation Project was finished in 1924, farmers within the area of Rangsit canals received more water supply. Problems concerning the shallowness of the canals occurred much less frequent. Moreover, the Rama VI Dam could help in receiving and supplying water to every part of the Rangsit canal area. Especially in droughty year, farmers in this area had sufficient water to grow rice.

During the first period of change, farmers in the Rangsit area could grow rice more easier than during the pioneer period. However, they still had to face problems of Chao Phraya river flooding over the banks, in years of abundant water. This phenomenon had in some years caused heavy damages to the paddy fields. Nonetheless, the South Pasak Project did not increase the cultivating land. It only helped in maintaining the production level of the district within the same land which was about 400,000 rai in 1925-1927.

The acid sulfate soil was a very important problem in those times. In some areas, where the soil was of high acidity, farmers had to leave the land empty and barren. Pendleton (1962) mentioned in a scientific report concerning the problem of acid sulfate soil in Rangsit and Ongkarak area, as:- "In paddy fields with acid sulfate soil problem, farmers had learned how to test the water in the field before cultivation when it was time to start the paddy cultivation, at the beginning of the rainy season, farmers were seen splitting betel nut salivary juice into the water to test whether the water was too acid to sow and transplant or not. If the splitting juice changed from red into black, that would indicate that water in the field was still too acid. Farmers would then wait for a while for rain to wash the acidity away from the soil. However, if the color of the salivary juice was still the same, it means that the acidity of water in the field had already been reduced. Sowing or transplanting could then begin".

The socio-economic factor of this period played an important role with the changes. For it was during this period that the two world wars occurred, thus creating a high demand for Thai rice in the world market. The price for Thai rice was very good, especially after the World War II had ended in 1945. Thailand was then recognized as an important food producing country to solve the problem of fool shortage after the end of the World War. Representatives of UN, Food and Agriculture Organization (FAO) visited Thailand in 1948 (Takaya, 1987: 237), with the purpose of giving advices to improve Thailand's agriculture.

The FAO suggested that big projects to develop water resources should be carried out since in the past this had been unpracticeable. The Thai government then proposed to develop eater resources project to be funded by loans from the World Bank. The construction of the Greater Chao Phraya Irrigation Project then began in 1952, with the loan from the World Bank. It was finished in 1957.

3.4 The second transition period (1957-1977)

The second period of change probably began with the construction of the Chainat Dam, which ended in 1957. The Chainat Dam, which was part of the Greater Chao Phraya Irrigation Project, significantly effected the areas around Rangsit canals. Water could then be supplied to the Rangsit area regularly. Moreover, the dam functioned as a small storage reservoir to prevent water part of flood of the Chao Phraya river from overflowing the banks and flooding into paddy fields in Rangsit area.

The lessening of floods in the late 1960s showed that change was occuring in the Rangsit area. During 1969-1974, some paddy fields were changed into orchards and gardens, to grow plants that yield higher profit. Investors from Bangkok and people of good economic status went into the Rangsit area to invest money in supporting farmers to extensively grow banana and orange orchards.

Yet, the less frequency of floods had some negative aspects as well. It caused more problems concerning the acidity in soil. Because of fewer floods, the upper layer of the soil that contained Pyrite as a soil component came into more contact with the air. Thus, oxidation of Pyrite occurred, causing the soil eventually become acidic. The attempts to develop and improve the soil began seriously in this period, especially in 1969, with soil specialists from abroad in cooperation with Thai. Such experts were: Moorman and Pons (1974), Pons and Van der Kevie (1969), Van der Kevie and Yenmanas (1972), Kawaguchi and Kyuma (1969), Attanandana and Ponnamperuma (1972), and experts from other agencies as well.

To reclaim the soil that become acid, the Department of Land Development had advised farmers and gardeners to use marl to lessen the acidity in the soil. In the first phase, the Department of Land Development distributed marl to farmers for free. The only expenses came from the transportation coast which each ton cost 50 baths.

Normally, the amount of marl added to the soil of highly acid areas such as in Thanyaburi district and Nong Sua district, would be about 2 tons per rai per every one or two year. While the amount of marl to be added to the areas with a low upto average level of acidity, would be one ton per rai per every one or two year. The turning point that caused important change in Rangsit canal area was the development of surface transportation according to the first National Economic Development Plan (1961-1966). Moreover, the Paholyodhin road which passed through the Rangsit area was built. And by the end of the second period of change, the Bhumibol and Sirikit dams were built. Both dams were built at the source of the Chao Phraya river. They were multipurpose dams which here used to produce electricity and supply water for agriculture and domestic and industrial purposes in Chao Phraya basin.

The significant outcome from the construction of roads and dams to produce electricity, was the proliferation of many new industries and factories along a section of the Paholyodhin road. Many modern factories with machinery were set up.

Such as jute mills factories, yarn factories, textile factories, textile dying factories, clothes factories, industrial chemical factories in this third period of change (1978-present) (National Statistic Bureau, 1979; 1982 and 1989).

3.5 The third transition period (1977-present)

Figure 11 showed that there were changes concerning the ecological system of Rangsit area. The data was collected from aerial photography and LANDSAT imageries, taken in various lapses of time from 1952 to 1994. It could be evidently shown that the area around Rangsit canals had changed enormously, especially from the aerial photography taken in 1952. It shows that the area previously exclusive to agriculture had been changing gradually into industrial zone, living quarters, golf courses and agricultural orchards, particularly, the area along the Paholyodhin road near Canal Number 1 area and the area around Rangsit-Nakorn Nayok road close to the main Rangsit Prayunsak canal.

The tendency for change seemed to be accentuated more and more each day. One hundred years ago, this area was the area that people sought to own to grow rice, which crops were considered highly profitable. That was the time already mentioned as "the Land Rush Era".

Therefore, the change that are currently happening in the area are not much different from the ones occurred during the land rush era. The only difference is perhaps in the purposes of land use.

At present, the Rangsit area is full of housing projects and manufacturing factories. The change of agricultural pattern from producing only rice to produce other kinds of economic plants, either orchard plants or vegetables. The change is most significant to the history of landuse of Rangsit area. The third period of change became evident 20 years ago. New occupational option for old time typical agricultural families was for employment in industrial factories. However the changes that occurred in this period had transformed Rangsit area into a new society. The rapid economic and social growth have created a tendency for environmental degradation in the Rangsit canal area, which will eventually effect the health and lives of the people. The Rangsit canal area had a rapid economic growth rate. In 1989, the average income per person per year was 100,293 bahts, which was 64% increase from 1958. The main economic activities of the area were agriculture, industries and commerce, (Pathumthani Provincial Office, 1994).

Because the Rangsit canal area is located not too far away from Bangkok with convenient traffic ways and close to Don Muang Airport, this had induced many investors to built factories there. The factories increased at the rate of 20% during 1970-1994. The period of the highest growth rate was between 1989-1994, when the growth rate was at 64%. From data of 1994, the Rangsit canal area which consisted of 4 main districts; Thanyaburi district; Lamlukka district; Klong Luang district; and Nong Sua district, had a total of 737 factories.

The industries can be classified into 9 groups; service industry 26.4%; wood conversion industry 3.5%; chemical and plastic industry 9.8%; agriculture industry 5.6%; construction industry 8.8%; food and beverage industry 6.9%; metal and non-metal industry 8.8%; and other industry 12.9%. The distribution of factories in Rangsit canal area is shown in Table 1 (Pathumthani Provincial Office of Industry, 1994).

Finally, even with all the changes as previously mentioned, the Rangsit area is still remain and important agriculture area. It's agriculture area consists of 482,281 rai. There are 74,560 farmers on total. The area has 14,912 households (Table. 1). The land ultilization of the area is of agriculture nature. The 80% of the agriculture area is under the irrigation project. The 7% of the agriculture area is outside the project. The residential areas constitute of 10%. The industrial area makes up 2% of the area and water source 1% (Department of Land Development, 1990).

4 The population in the Delta

The population of the Central Plain totals almost 14 million habitants in 1990, that it is approximately 20% of the total population of Thailand is concentrated in less than 6% of the territory. Most of this population (5.9 million) live in the Bangkok Metropolitan Area and, among the remaining 8 million people, two live in the vicinity of Bangkok, defined as the neighbouring provinces of Pathum Thani, Nonthaburi, Samut Prakan, Samut Sakhorn (Table 2)

This population is therefore distributed very unevenly over the Central Plain human density culminated in Bangkok and its vicinity (1374 habitants/km^2) but has an average of 276 habitants/km^2 in the remaining rural area, which is slightly higher than in other regions (for example 200 habitants/km^2 for the Northeast). This value of 276 is an average of densities by *changwat* which are generally comprised between 120 and 300 habitants/km^2. The less populated ones are Lop Buri (119), Chai Nat (137), Saraburi (153), whereas Sing Buri (269), Ayutthaya (271), Angthong (293), Nakhon Pathom (310) show higher densities. Details at *amphoe* level (map 2.12, data from 1990), show that all the area south of Ayutthaya and the flood plain have densities greater than 200, with growing urban concentration around Nakhon Pathom, Chonburi and Ayutthaya.

TABLE 2 : POPULATION IN THE CENTRAL PLAIN (1990) (KASETSART UNIVERSITY; ORSTOM, 1996)

1990	Whole Kingdom	Central Plain	Bangkok and vicinity	Central Plain without BKK and vicinity
Population (* 1000)	57,303	13, 781	7,692	6,090
Area (km2)	513,115	27,658	5,578	22,080
Density (ha/km2)	1,117	498	1,374	276
Agri ratio	60%	19%	-	37%

Source : Population census 1990 NSO

Population in the Central Plain increased more than twofold in the 1960-1990 period. In the same period, population in Bangkok has been multiplied by 2.75 but the growth rate over each of the three decades has shown a significant decline from 44% to 35% (Table 3 and Fig. 12). This means than saturation is taking place and the rate for the present decade is expected to decrease even more dramatically. On the contrary, no saturation can be evidenced concerning Bangkok's vicinity area, where the current growth is similar to the one observed in Bangkok for the 1960-1980 period.

If we now consider the whole of the Central Plain, growth rates by decade seem to have levelled off around a value of 30%. These growth rates are of course the combined result of natural growth and immigration flows. The annual growth rate has been declining a lot in Thailand and the yearly average rate of growth - for the whole country - is now as low as 1.5%. If we consider the Central Plain during the 1985-1990 period, with an average growth of 14.2, the observed overall population increase of 1.68 million habitants can approximately be divided between a share of 673,000, due to net migration flows from outer provinces (see next section), and a share of almost 1 million persons due to natural growth.

TABLE 3 : POPULATION EVOLUTION IN THE CENTRAL PLAIN (1960-1990) (KASETSART UNIVERSITY; ORSTOM, 1996)

Zone	1960	1970	1980	1990
Bangkok	2,136,435	3,077,336	4,343,074	5,882,411
Growth rate by decade	-	44%	41%	35%
Bangkok vicinity	768,953	973,784	1,278,737	1,809,195
Growth rate by decade	-	27%	31%	41%
Total Central Plain without Bkk+vicinity	3,579,052	4,045,236	4,917,598	6,089,852
Growth rate by decade	-	13%	22%	24%
Total Central Plain	6,484,440	8,096,356	10,539,409	13,781,458
Growth rate by decade	-	25%	30%	31%

Source : NSO population census

Change in population can be specified at *amphoe* level. Figure 12 shows the evolution of the population density during the 1960-1990 period. It can be observed that, 45 years ago, three areas presented a human density above 500 habitants/km^2 : Bangkok, the capital of the Kingdom, Ayutthaya, the first large settlement in the Central Plain and one area near the canal of Damnoen Saduak, in the Province of Ratchaburi.

From this point, three axis successively developed in the Central Plain. The first axis is located in the western part of the Central Plain, from Bangkok to Ratchaburi and Nakhon Pathom Provinces, where urbanization has become important since 1970. The second axis heads towards the eastern part, from Bangkok to Chachaengsao and Prachinburi. At last, a new trend seems to surface, with the development of the hinterland of Sing Buri, Ang Thong and Ayutthaya.

Three areas remain more rural in the Central Plain. The Nakhon Nayok area, where the density of the population is near 100 ha/km^2, the south of Suphan Buri and the south-west of Chai Nat. Not surprisingly, they also correspond to areas with higher ration of full owner farmers.

5 Urbanization pattern in the delta

Five main characteristics of urbanization in Thailand should be noted. First, despite the difference in size of population between BMA (the large city) and the four or five next largest cities, the pattern of spatial expansion of all the cities is similar. Ribbon development outside the boundaries of the cities that is the official municipality boundaries, is the main pattern occurring for industrial, trade and service activities.

Second, without either effective control measures or an effective mechanism for control. This unconstrained ribbon development will cause further problems for managing the cities, especially for managing the cities' environments.

Third, the changing patterns of the economy in different Changwat have implications for the urgent need of appropriate land use planning in the cities, so that the urban centers of the Changwat can be prepared to function well and support the changing economy.

Fourth, a decline in GPP share of agriculture in the selected Changwat and increase in the service and manufacturing sectors is evident. However, the increase of GPP in manufacturing is not prominent in all areas, except in the BMA and in Changwat along the periphery of the BMA.

Finally, at the same time that rapid urban growth makes a major contribution to the economy of Thailand, that same growth places a major burden on the urban environment. Air, water, and land use are the major natural resources affected by urban growth. In the unplanned city, the larger city, the more degraded is the urban environment. Air and water pollution grow rapidly. Garbage disposal becomes crucial in almost all major cities. Hazardous waste management has become among the most important issues. Water shortage in the urban community leads not only to conflicts in water usage between the cities and agriculture and between the various urban sectors, but it also leads in some areas to ground subsidence, most notably in the MBA. Even the visual ambiance of the urban landscape is threatened with replacement by the visual pollution of an unplanned agglomeration of factories, high-rise office buildings and condominiums, dense suburban housing, and crowded congested traffic. This unplanned tangle of construction threatens critical environmental areas with extinction.

The quality of the urban environment in the major cities is jeopardized by the high rate of increase of major urban activities, such as the growth of residential, commercial and industrial areas and the spread and increase of transportation activities (NESDB/UNDP/TDRI, 1990). While precise data are not available for the suburban areas of the BMA, information from the areas of BMA is indication of the problems.

5.1 Bangkok Metropolitan Area

Bangkok, the 200 years old capital of Thailand, with a population of about 7 million lies in the southern part of the central plain about 25 kilometers north of the Gulf of Thailand. The Bangkok area is situated on the floodplain east and west of the Chao Phraya river which meanders through the center of the city. The Bangkok metropolitan area (BMA) occupies an are of about 1569 sq. km. of flat low-lying land which is poorly drained, relying on a system of canals constructed over the age of city. Most elevation of the city is only 0.5 to 1.5 m. above mean sea level and the water table is at or near the surface throughout the year.

The development of Bangkok dates from the fall of Ayutthaya to the Burmese in 1767 after a fifteen-month siege. The battle irreparably destroyed the old capital reducing its population from one million to about 10,000. One of Thailand's most famous generals, Phya Taksin, led the remainder of the Thai army 90 km south into the swampland of the Chao Phraya river where a new capital was established in Thon Buri, occupying the west bank and floodplain of the Chao Phraya river opposite present day Bangkok. During the next ten years, Taksin reunited of Kingdom, expelled the Burmese and revived a central government (Office of the Prime Minister, 1980). In 1782, the official date of the founding of Bangkok, a successful coup was mounted to replace Taksin who had fallen seriously ill and the Thai throne was taken by Taksin's leading general, Phya Chakri, who became the first monarch of the present Chakri dynasty with the title of Rama I (Office of the Prime Minister, 1980).

Map of early Bangkok show that the city resembled 17th century Ayutthaya. All of its early structures were built on stilts or on raised mounds to avoid the annual inundation of the floodplain. The city was criss-crossed by canals and waterways and was referred to by Europeans as the "Venice of the East" (Office of the Prime Minister, 1980). The early city was dated with magnificant temples and was surrounded by a heavily fortified city wall.

As already noted, the small water bounded crescent of 2 sq. km. which included the Grand Palace with its magnificent grounds and one of the countries most revered temples, Wat Phra Keaw, was the heart of the new capital in 1782. A strip of land just outside the palace area and beyond it moat became the main Chinese commercial district in Bangkok. When the population reached 400,000 King Mongkut (Rama VI, 1851-68) ordered city expansion and the construction of another canal, klong Ong Ang (sometime referred to as klong Bang Lampoo) parallel to the inner moat (klong Lord) which permitted easier access to the crowded commercial center as well as giving the heart of the city more protection from the east. This took some stress of klong Lord which was already badly polluted and provided another 6 sq. km. for expansion. By 1900 Bangkok had grown concentrically away from this center toward the east in a fan-shaped pattern which gradually became elongated north and south along the Chao Phraya river. Major roads paralleled the river, which government structures and palaces of the nobility were located along its banks and nearly klong, especially klong Lord. Farther away from the Grand Palace area warehouse and wharves lined the river to service the trading ships which entered the kingdom from many nations. On the opposite side of the river in Thon Buri expansion was equally rapid mainly north and south along the bank of the river. Many canals were constructed which radiated outward from the commercial center both east and west of the river. The canals functioned as highways, providing access to the commercial centers. In the early years of Bangkok more than a hundred canals were dug. It was sometime before road construction, other than new road, began in earnest. Canal banks were lined with homes and shop houses while the land between was cultivated with fruit orchards and rice paddies. The river and klong (canal) system were naturally flushed by tidal action and, as a result, no sewage treatment system was developed in the early day. The city continues to rely on this system a present. With the increased demand for housing, land was subdivided and housing developments sprawled eastward into paddy fields. Bangkok's industries, hotels and suburban development mushroomed in the late 1960s and 1970s. This created a problem for the city as it was unprepared to treat the sewage generated by this large population and pollution became a serious problem. The problem was compounded by the fact that Bangkok's early residents depended on canal and river water for much of their basic needs. The city supplied treated river water to its central core up to about 1950. After that it was forced to develop groundwater supplies to provide adequate potable water to more outlying communities and industries which were situated beyond the limits of the water distribution system. There after, peripheral growth proceeded much more rapidly than the ability of the city to expand its water distribution system. Eventually, thousands of other wells were drilled by private industry, schools, government etc. This was to lead to major subsidence problems in the 1980s.

About 7 million people, 10 percent of the population of Thailand, live in the Greater Bangkok. This includes the adjacent populous provinces of Nonthaburi, Pathum Thani and Samut Prakan. The city was growing at an annual rate of about 4.3 percent during the period 1970 to 1980 although the rate of growth for rural Thailand was much less than this, about 1.8 percent over the period 1980-85 (Fig. 13). The national growth rate in 1985 was about 1.9 percent. Because of the job opportunities in the capital, the city is flooded with a migration of workers from the large rice-growing areas of the central plain, the north and the northeast, especially after every planting and harvesting season and in dry years when the up-country rice crop is lost or reduced. It is important to review the growth of the city from its 200 years ago to show how this has been constrained by the natural features of the land.

5.2 Some problems concerns in Bangkok areas

5.2.1 Crowded Congested Traffic

Traffic congestion is the most visible and most widely encountered problem in Bangkok. The root causes of the problem are rapid, unplanned growth, increasing automobile ownership and usage, and inadequate provision and utilization of transportation infrastructure. The long-term solutions to the problem are the adoption of rational strategies for growth, restrictions on automobile usage, and the more effective utilization and expansion of the transportation infrastructure within and around BMA.

5.2.2 Air Pollution

The problem of air pollution is becoming increasingly serious. Ambient monitoring data indicate substantial increases in all major pollution. Lead emissions from gasoline illustrate a clearly increasing trend. Lead from all sources combined, is potentially the most serious urban environmental health hazard. Monitoring data during 1983-1986 ranged from 0.1 to 1.0 micrograms per cubic meter (24 hour geometric means). Data obtained from 1987 to 1989 indicate a range of 0.6 to 5.45 micrograms per cubic meter. While reported blood lead levels are somewhat inconsistent (study results range from 16 to 40 ug per deciliter), even the lowest reported average is three times as great as that found in the United States and Western Europe. Lead at these levels is directed implicated as a major cause of strokes and mental retardation.

Increasing trends are also evident for suspended particulate matter (24 hour averages). The 1983-1986 data ranged from 0.09 to 0.19 milligrams per cubic meter, while the 1987-1989 data ranged from 0.09-1.25 milligrams per cubic meter. The National Environmental Board (NEB) standard is 0.1 micrograms per cubic meter.

Carbon monoxide monitoring also shows a significant increase during the period. Monitoring data from 1983 to 1986 were within the range of 1.0 to 9.5 milligrams per cubic meter, while the 1987-1989 range grow to 1.13 to 52.65 milligrams per cubic meter. The NEB standard is 50 milligrams per cubic meter for one hour.

While it is uncertain whether all the reported increases reflect actual increases in pollution levels or simply improvements in monitoring, there is absolutely no doubt that the pollution levels for these substances are well above the standards for healthy air quality.

5.2.3 Water Supply

About two third of Bangkok's water from the Chao Phraya river and the remainder is from groundwater resources. The present supply of the Metropolitan Water Work Authority (MWWA) is about 4.0 million cubic meter/day. Of this an average of from 1.25 to 1.4 million cubic meter/year was derived from aquifers beneath the city. The present city supply is sufficient to serve the needs of about 4.5 million people which is 45 percent of Bangkok's projected population of 10 million by the year 2000. By the year 2000, the Authority plans to be able to expand its output to 5 million cubic meters/day and cover an area of 815 sq. km. Its coverage in 1985 was about 300 sq. km.

Industries presently obtain all but about 5 percent of their water by drilling their own wells which they find more economical at present. This has resulted in over exploitation of groundwater in some areas and a rapid decline of the water table as known under the subsidence problem in Bangkok area. Moreover, many city wells have gone brackish because of the intrusion of saline water which have leaked out of the compressing clays.

The biggest problem facing the Authority is how to phase out its groundwater development, which it intends to do in 1987 by replacing it with surface water. A cabinet decision was made to phase out the use of artesian water in the Bangkok metropolitan area (BMA) and to control the rate of ground subsidence and improve the quality of water.

5.2.4 Wastewater Treatment

At present wastewater disposal is mostly by septic tank or by discharge into the nearest ditch or klong. These practices are gradually being phased out by laws and new regulations. Septic tanks are not efficient because of Bangkok's heavy monsoon rain. The water table during the rainy season (July-October) is perched near the surface of the Bangkok clay, and within 1-2 m of the surface for the rest of the year. Thus, during heavy rainstorm events in some areas wastewater from septic tanks and raw sewage is discharged to klong system or collects in low-lying streets and depressions. During floods the residual water rapidly becomes septic. Organic matter from kitchen, laundry and bath wastes also are discharged to the klong system. Although Bangkok's klong have been septic for some time there are signs that the flood prevention measures employed in 1983 and 1984 have improved the flushing action throughout certain parts of the system and, in spite of the problem of subsidence, some klong are draining better now than they have for some years. Fish are reappearing in the river. New water gates have been installed at the months of many klongs. Tidal flushing has become more efficient than in past years. The reliance of much of the population on surface water diverted from the Chao Phraya river above Bangkok and from the groundwater supply has placed less urgency on the treatment of klong waters but these are still a threat to the health of the people of Bangkok as water borne disease is prevalent in some area.

5.2.5 Solid waste disposal

The problem of the disposal of solid waste in Bangkok is not a new one; it emerged with rapid population growth and the city's industrial revolution. Fifty years ago the presence of piles of garbage in heavily populated areas was so common that they went unnoticed. There was no municipal garbage collection prior to about 1915. Most garbage was thrown into the river or klong system.

In recent years the Bangkok Metropolitan Administration has taken several steps to ensure more efficient collection of the city's solid waste. In addition to improving the efficiency of removing the waste from city collection routes it has installed a large number of garbage disposal containers in public centers and markets. Moreover, three composting plants in Bangkok, each with a capacity of 320 tons/day and one additional plant in Thon Buri with a capacity of 160 tons/day give the metropolis a current capacity of 1,120 tons/day.

In spite of these technologies for processing and disposing of solid waste, a substantial amount remains. Therefore, the metropolitan administration is considering the use of sanitary landfills for burying the waste not disposed of by other methods. The selection of a proper landfill site will require the expertise of a geologist and a hydrogeologist. The large pit which exist in a few places within the metropolis should be avoided if they are more than 10 to 15 m deep as there is considerable risk that the underlying aquifers, lying at a depth of from 15 to 20 m and lower would be polluted. Aquifers beneath Bangkok are hydraulically connected.

By the end of the century the United Nations has predicted that Bangkok will become one of the world's 24 most populous cities; a megalopolis of about 10 million from today's 6 million, a number which excludes the large population centers of Pathum Thani, Nonthaburi and Samut Prakhan lying outside the BMA. A solution to the problem of solid waste disposal for a city of this size is being sought. The BMA wishes to protect the beauty and charm of the city and recognizes that the proper collection and disposal of its solid waste is a problem of immense dimensions.

5.2.6 Engineering problems

The soft clay at the surface of the lower central plain is the most important surficial unit with respect to the very special problems. It presents for engineering design, construction and maintenance. By definition, soft clays are of low strength and high compressibility, and many are sensitive (liqueft during disturbances), although the Bangkok clay in only "slightly quick" and, hence, less likely to liqueft. Foundation failures have occurred in the Bangkok soft clay. Such failures are comparatively common in similar clay in other parts of the world. Surface loading in the form of embankments or shallow foundations inevitably results in large settlements. Thus, Thai engineers must use special precautions in designing foundations for large structures. The piling program required is related to the geotechnical properties of the sub-soils at the site. If the engineering properties of the clay are not considered properly, it invariably results in life-long maintenance of engineered facilities. Virtually all structures on soft clay except earth fills and very small light frame buildings have to be supported on deep foundations. This results in high costs.

5.2.7 Flooding

Generally, the flood season begins in September but rainstorms can cause immediate flooding at almost any time between May and October. The most severe floods occur in October when rivers draining northern Thailand bring their flood-swollen water into Bangkok. Moreover, the highest tides of the year occur at time and back water up into the Chao Phraya river slowing the discharge during its high flow period. Major klongs enter the city from the east, passing through the city on the way to the Chao Phraya river. Moreover, the east side of Bangkok is its most vulnerable side to rainstorms because most tropical storms are driven into Thailand from the South China Sea. These klong also receive runoff from the large suburban area sprawling east of the river and the rice fields beyond them. Hundreds of smaller klong feed water into major klong which pass through the heart of the city, crossing through the subsidence bowl. The klongs are at essentially zero gradients or are concave in some places. Tidal action sends water back into the klongs during high tide periods. Flood control structures, called water gates, are designed to prevent river water from intruding into the klong system. But when the city is flooded and the river is at its highest stage, the klong water must be lifted over the water gates before the city can be drained. Thus, exceedingly high capacity pumps are employed to do this. Even so, after heavy rainstorms the volume of water which must be drained is very large and the capacity of the system is such that flood waters may reside within the city long period.

5.2.8 Subsidence

Large scale groundwater withdrawal, mainly for municipal and industrial uses, has caused land subsidence in Bangkok region. Groundwater development began in 1954, with a daily pumpage of 8,360 cubic meters/day. Groundwater pumping by the Metropolitan Water Authority (MWA) increased to 447, 000 cubic meters/day in 1982, and private pumping was also increasing every year. By 1982 total daily groundwater pumpage was 1.4 million cubic meters.

Between 1978 and 1981 land subsidence rates were over 10 cm/year in the eastern suburbs and 5 to 10 cm/year in central Bangkok. Soil compression during this period in the top 50 m and in the zone between 50 and 200 m below the land surface, contributed 60% and 40% respectively to the total surface subsidence. Surveys in 1982 by Royal Thai Survey Department indicated that the lowest land elevation in Bangkok, 4 cm below mean sea level, was at a point in Ramkhamhaeng University.

Remedial measures for mitigation the groundwater crisis and land subsidence have been implemented since 1983 to control the groundwater pumpage and to slow down the rate of subsidence. The amount of groundwater pumpage for water supply and private use dropped sharply between 1983 and 1987, due to these control measures, but began rising again in 1988. This was because the unexpected nation economic growth, particularly affecting the Bangkok Metropolitan region, together with the city growth in area, caused a rising demand for water, outpacing the amount of public water supply. Annual private pumping has, therefore, kept increasing despite the strict control of requests for drilling new wells. By the end of 1988, 1989 and 1990, instead of decreasing the private pumpage increased 4.7%, 7.4% and 6.3% respectively, this together with the fact that the MWA is still pumping groundwater instead of phasing out in 1987, has affected the present aquifer system, and the scheme of management predicted by mathematical model simulation may have to be revised.

After the remedial measures for controlling groundwater pumpage were introduced in 1983, a recovery of water level was observed in central Bangkok and its eastern suburbs. This has contributed to the decreasing rate of land subsidence. Annual subsidence rates between 1988 and 1990 were 3 to 5 cm in the eastern suburbs and 2 to 3 cm in central Bangkok. Between 1989 and 1990, subsidence rates decreased to 2 to 3 cm in the eastern suburbs and 1 to 2 cm in central Bangkok. The elevation of the ground inside Ramkhamhaeng University was about 50 cm below mean sea level in 1989. Maximum land subsidence in the eastern Bangkok area from 1930 to 1990 was estimated at 160 cm.

Although the present rate of land subsidence is decreasing, it should be kept in mind that subsidence is still taking place in the Bangkok region, particularly in the industrial areas of Bang Phli, Rangsit and Samut Sakhon, where no surface water supply exists and more wells are being drilled. Consequently, the piezometric level in these areas has dropped significantly, indicating new areas of land subsidence.

5.2.9 Submergence

Submergence is another problem which has affected coastal cities like Bangkok which lie only one or two meters above sea level. It should be noted that current usage of the term submergence is relative and does not imply which process, downwarping or a eustatic rise in sea level, is responsible for the condition. Worldwide climatic change, for example, may have only have a mild effect of interior cities but may profoundly affect coastal settlements.

The Bangkok city is gradually sinking below sea level at a time when global warming may be raising water levels throughout the region. The idea that the global sea level will rise a few centimeters in the near future. Projected global warming could cause global average sea level to rise 50 to 100 cm by A.D. 2100. Local trends in subsidence and substantial rise in sea level would permanently inundate wet-lands and low-lands, accelerate coastal erosion, exacerbate coastal flooding, and increase the salinity of estuaries and aquifers. Up to 40% of land in Bangkok could be flooded with a one-meter rise in sea level. The importance of protecting the Bangkok areas so as the economic and social development of the growing population of Thailand can not be over-emphasized.

5.2.10 Loss of High Quality Agriculture Land

The loss of good agricultural land is inevitable wherever fertile soil is converted into building sites. Because cities were established to be near fertile agricultural areas, it is not surprising to find that the expansion of urban area almost always leads to the loss of some of the best agricultural land.

Almost all the soil series found in the BMA are extremely well suited agriculture. They are rate either as the most suitable or the second most suitable soils for paddy, fruit and vegetable production. Many areas with these soils have been converted to other uses such as industry of residential areas. The misuse of soils (use of high quality agricultural land for non-agricultural uses) occurs in every Changwat of the central plain area.

5.3 Urban problems in Thailand

For the past 3 decades, the country's development has been concentrated in promoting industry as a replacement of agriculture. As a result, there are more investment in various areas which reflecting a rapid growth of community and economy. Such a rapid urban expansion have caused the growth in the city only, especially for the city which has received support from the investment policy.

For the past couple of years, the Bangkok Metropolitan Region's economy has been consistently growing at over 11% per annum, 3% higher than the national economy, making Bangkok one of the fastest growing economies in the world. Resulting an increase in population number and buildings but the government can not provide basic infrastructure to meet the increase of demand. Besides, a rapid increase in population has caused a numerous problems, for instance; an increase of slum, unemployment, deteriorated urban environment, poor living condition and especially traffic congestion that causes great economic loss. And living in Bangkok has become a sad case in the eyes of the world.

At this moment, the variation problem of Bangkok Metropolis have increasingly caused serious implications on social and economic development of the city. The unlimited monocentric growth of Bangkok Metropolis has also added up numerous problems in adjacent towns of Samut Prakarn, Pathum Thani, and Nonthaburi particularly on traffic congestion, pollution, inadequate utilities and social fare, improper landuse, and poor quality of life, etc.

Besides the explosive growth of the Bangkok population, the migration of people from rural areas to big cities is a major social and environmental challenge at present. It need hardly be said that where so many people live together particularly in the low-lying areas of coastal cities, the demands on the natural environment of urbanized areas are extremely high. Drinking water, construction materials, and optimal sites for a dense infrastructure network are among the natural resources and conditions which can help to optimize social and environmental condition, but the availability of all of them is invariably limited. Uncontrolled of resources always to depletion of these resources and creates negative effects and uncontrolled waste disposals can pollute groundwater system or housing estates. The more densely an area is inhabited, the more severe the impact of hazards will be. One of the most important population centers in Thailand is the city of Bangkok which is just one metropolitan area vulnerable to inundation. The basis of sound environments has been largely ignored in planning and development of the coastal city as like Bangkok.

In view of these consideration, the current research is intended to study the potential sites for moving a future activities and development of Bangkok to suitable places. The outputs from this study are the detailed sectoral analysis from the point of view of land conditions with recommendations of proposing the primary objectives of gaining some basic knowledge and existing environmental geomorphic information, together with a landuse strategy of the studied sites. Attempts will be made to review, compile, analyze, and consider some significant environmental and geomorphological data which are relevant to planners and decision makers for the recognition, understanding, and realization of the potential natural resources and problems, which may lead to any benefit or any adverse effect on the current development projects and future development prospects within the studied site. And, an important evaluation should take place before planning new urban settlements of the resettlements in the future.

An attempt has been made by the Thai government in the Sixth and Seventh National Economic and Social Development Plants to promote the growth of principal cities in various regions of the country, such as Chiang Mai in the northern region, Nakhon Ratchasima in the northeastern region, and Songkhla in the southern region. This strategy aims at diversifying the growth and development to numerous regions so that it may assist in the control of growth and development of Bangkok Metropolis. However, no attempt has been made to create the so-called "Satellite Cities" of Bangkok to minimize the problem of the future megalopolis city as additional remedial measure or preparation of the potential sites for second capital of Thailand.

6 The satellite cities of Bangkok metropolitan region

Thailand is currently one of the fastest growing countries in the world. The effects of this growth include an intensification of development within the inner Bangkok and a horizontal enlargement of the metropolitan suburbs. Urban population has grown by over 6 percent a year and a huge boom in construction activity in Bangkok and its environs has changed the face of the metropolitan area dramatically. According to estimates based on the geographic definition of urban by NESDB/UNDP/TDRI (1990), the urban population of the BMA is projected to increase from 7.4 million to 12.6 million over the next twenty years. These uncontrolled expansions reflect the lack of proper land use planning, inadequate in provisions of infrastructure, and illegal encroachment in areas of traditional agricultural land. How can the BMA respond to these uncontrolled expansion of urban population within the next two decade. They can either try to move the capital city or to prepare the satellite cities for growth corridor of Bangkok metropolis. Decision-makers need to have some basic for establishing priorities when faced with the question of selecting suitable areas for development, especially if parts of the municipality are faced with either natural or man-induced hazards. City-planners will have to do more long-term studies for sustainable development.

The analyses and recommendations described in previous sections, as well as the background reports accompanying this study, have revealed a number of informations in the regional planning and management. Major impediments to urban and regional development in Thailand include the lack of institutional co-ordination among the various agencies involved in planning and implementing. The focus of this part is to briefly detail recommendations which can and should be taken, during the Eighth Plan and beyond, to improve urban management in Thailand. The focus below is on changes which will facilitate urban growth as well as some legal changes which may by necessary.

As illustrated in Figure 14, we have made recommendations for a broad decentralization of development in the Bangkok region to create a "Bangkok Multipolis" in which the contiguous Bangkok area would be only one of several major centers in the region. Four new major centers are proposed: Ratchaburi on the west, anchoring a western and southern development corridor; Chachoengsao on the east, providing a center for the eastern development corridor; Saraburi on the northeast, for the spread of development corridor in the northeastern region; and Suphanburi on the northwest, providing a center for the northern development corridor. The decentralization processes that might bring this multi-polar metropolis about is already under way, and may be seen especially in the spread of new industrial and residential development. Therefore, since creation of the four subcenters at some distance from Bangkok will require costly transportation infrastructure (high speed train and connected road networks system). They will serve as a magnet for a new wave of companies that can operate in decentralized offices. The move of government offices out of central Bangkok will also be facilitated. And the centers will help change of the new Bangkok from a sprawling, congested, randomly developed metropolis to a city with memorable streets and districts.

In the meantime, the contiguous area of Bangkok will continue to sprawl, and there is an immediate need to shape the encroachment boundary of development into more choerent and efficient pattern. The greater traffic volume passing through the BMA from these urban centers as well as from other cneters require the construction of effective transport networks within and around the capital city. Without construction of bypasses around the BMA as well as improvements in the distribution network within the region, the congestion problems of Bangkok will impede development in the rest of the country. The proposed networks emphasize connections between the Bangkok and the four satellite cities. There is also planning under way to rationalize the systems of mass transit to be installed in the Bangkok area.

References

Arsawai, S. 1987. History of Rangsit Canal: land development and its social impact during 1888-1918. Thammasat University Press, Bangkok (in Thai).

Attanandana, T. and Ponnamperuma, F.N. 1972. Amelioration of acid sulphate soils of Thailand. *Journal of Agriculture Science* 5(1), 17-24.

Chonglakmani, Ch., Ingavat, R., Piccoli, G. and Robba, B. 1983. The last marine submersion of the Bangkok area in Thailand. Menorie di Scienze Geologiche Vol. XXXVI, 343-352.

Department of Land Development. 1990. Landuse Planning of Pathumthani. Ministry of Agriculture (in Thai).

Dheeradilok, P., Chaimanee, N., Piccoli, G., and Robba, E. 1984. On the Quaternary Stratigraphy and Fauna of senanivate Housing Project Area, Bangkok Metropolis. Memorie di Scienze Geologiche Vol. XXXVI, 413-426.

Fukui, H. 1978. Paddy production technology, present and future, In: Thailand- a rice growing society, Monographs of the center for Southeast Asian Studies, Kyoto University, English Language Series No. 12. University of Hawai Press, Honolulu.

Gee, C.D. 1927. Administration Report of the Royal Irrigation Department of Siam for the Period 2457B.E-2468B.E. The Royal Irrigation Department.

Hattori, T. 1972. Some properties of recent sediments in the Bangkok plain of Thailand. Journal of Southeast Asian Studies 10, 321-334.

Heide, J.H. van der. 1903. General report on irrigation and drainage in the lower Manam Valley. Report to Ministry of Agriculture, Kingdom of Siam.

Heide, J.H. van der. 1906. The Economic development of Siam during the last half century. Journal of Siam Society, Vol. 3.

Ishii, Y. 1978. History and rice-growing, In: Thailand- a rice growing society, Monographs of the center for Southeast Asian Studies, Kyoto University, English Language Series No. 12. University of Hawai Press, Honolulu.

Johnston, D.B. 1975. Rural society and the rice economy in Thailand, 1880-1930. Unpublished Ph.D. Dissertation, Yale University.

Kambhu, M.L.X. 1949. Report on Irrigation Drainage and Water Communication Project of Chao Phraya River Plain. The Royal Irrigation Department.

Kasetsart University, ORSTOM. 1996. Agricultural and irrigation patterns in the Central Plain of Thailand: preliminary analysis and prospects for agricultural development. Bangkok, Thailand; DORAS Project, 224pp.

Kawaguchi, K. and Kyuma, K. 1969. Lowland rice soils in Thailand, In: Reports on research in Southeast Asian, Natural Science Series N-4. The Center for Southeast Asian Studies, Kyoto University.

Kavie, W. van der and Yenmanas, B. 1972. Detailed Reconnaissance Soil survey of Southern Central Plain Area, In: Report on soils survey no. 89. Department of Land Development.

Kemp, P.R. 1918. Some note on Cervus (Rucervus) Schomburgki. Journal of the Natural History Society of Siam Vol. III, No. 1, 1-9 p.

Laekhakula, B. 1992. "Samun" deer or Schomburgk deer, In the Cremation Volume of Dr. Boonsong Laekhakula, M.D. in June 6, 1992 at Wat Debsirin, pp. 223-236. Dansutra Press, Bangkok (in Thai).

Loubere de la, S. 1693. The kingdom of Siam. Reprinted on 1969, Oxford University Press, Kuala Lumper.

Moorman, E.R. and Pons, L.J. 1974. Characteristic of mangrove soils in relation to their agriculture landuse potential, In: paper submitted to International Symposium on Biology and Mangrove. Honolulu.

National Satatistic Burean. 1979. The Provincial Satatistic Record of Pathumthani. Office of the Prime Minister (in Thai).

National Satatistic Burean. 1982. The Provincial Satatistic Record of Pathumthani. Office of the Prime Minister (in Thai).

National Satatistic Burean. 1989. The Provincial Satatistic Record of Pathumthani. Office of the Prime Minister (in Thai).

NESDB/UNDP/TDRI. 1990. National Urban Development Policy Framework, Final Report Vol.1 and 2. Office of National Economic and Social Development Board (NESDB).

Nutalaya, P. and Rau, J.L. 1981. Bangkok: the sinking metropolis. EPISODES 4, 3-8.

Office of the Prime Minister. 1980. Thailand into the 80's. Royal Thai Government, 300p.

Pallegoix, J.B. 1854. Description du Royaume Thai ou Siam, In : Reprint Edition, Vol. 1, 1969. Farnborough, England, Gregg International Publishers.

Pathumthani Provincial Office. 1994. Summary Report of Pathumthani. Ministry of Interior (in Thai).

Pathumthani Provincial Office of Industry. 1994. The Industrial Record of Pathumthani. Ministry of Industry (in Thai).

Pendleton, R.L. 1962. Thailand aspects of landscape and life. Moredith Press, Dos Noines and New York, USA.

Pons, L.J. and Kevie, W. van der. 1969. Acid sulfate soils in Thailand: studies on the morphology, genesis and agricultural potential of soils with cat clay. Soil Survey Reports No. 81, Land Development Department.

RID. 1986. The 84· Anniversary of Royal Irrigation Departmnet. Royal Irrigation Department, Ministry of Agriculture.

Smyth, H.W. 1898. Five years in Siam from 1891-1896, Vol. 1. John Murray, London.

Somboon, J.R.P. 1988. Paleontological study of the recent marine sediments in the lower central plain, Thailand. *Journal of Southeast asina Earth Science* 2(3/4), 201-210.

Somboon, J.R.P. 1990. Geomorphology of the Chao Phraya delta. Unpublished Ph.D. dissertation, Kyoto University.

Somboon, J.R.P. 1991. Salinazation in the Holocene fan-delta of Maekhlong river, Thailand. Journal of Southeast Asian Studies 29(1), 49-63.

Somboon, J.R.P. and Thiramongkol, N. 1992 Holocene highstand shoreline of the Chao Phraya delta, Thailand. Journal of Southeast Asian Earth Science 7(1), 53-60.

Takaya, Y. 1969. Topographical analysis of the southern basin of the central plain Thailand. Journal of Southeast Asian Studies Reprint, Series N-2, 293-300.

Takaya, Y. 1972. Quaternary outcrops of the southern part of the central plain, Thailand. Journal of Southeast Asina Studies 10(2), 298-320.

Takaya, Y. 1987. Agricultural development of a tropical delta: a study of the Chao Phraya delta, In: Monographs of the center for Southeast Asian Studies, Kyoto University, English language Series No. 17. University of Hawai Press, Honolulu.

Tanabe, S. 1978. Land reclamation in the Chao Phraya delta, In: Thailand: a rice growing society, Monographs of the center for Southeast Asian Studies, Kyoto University, English language Series No. 12. University of Hawai Press, Honolulu.

Tanabe, S. 1994. Ecological and Practical Technology, Peasant Farming Systems in Thailand. White Lotus Co. Press.

Thiramongkol, N. 1984. Geomorphology of the lower central plain, Thailand, In: proceeding of 3rd meeting of the working group on Geomorphology of rivers and coastal plain, 113-117p. Department of Geology, Chulalongkorn University, Bangkok.

Thiramongkol, N. 1987. Neotectonism and rate of uplift in the eastern margin of the lower central plain of Thailand. In: proceeding of the workshop on Economic Geology, Tectonics, Sedimentary Processes and Environments of the Quaternary in Southeast Asia (Edited by N. Thiramongkol), pp. 35-44. Deparment of Geology, Chulalongkorn University, Bangkok.

Watabe, T. 1978. The development of rice cultivation, In: Thailand: a rice growing society, 3-14p., Monographs of the center for Southeast Asian Studies, Kyoto University, English language Series No. 12. University of Hawai Press, Honolulu.

Wright, A. and Breakspear, O.T. 1908. Twentieth Century Impressions of Siam: Its history, people, commerce, industries, and resources. Lloud's Greater Britan Publishing Company, Ltd, 1908 Reprinted by White Lotus Co., Ltd, Singapore.

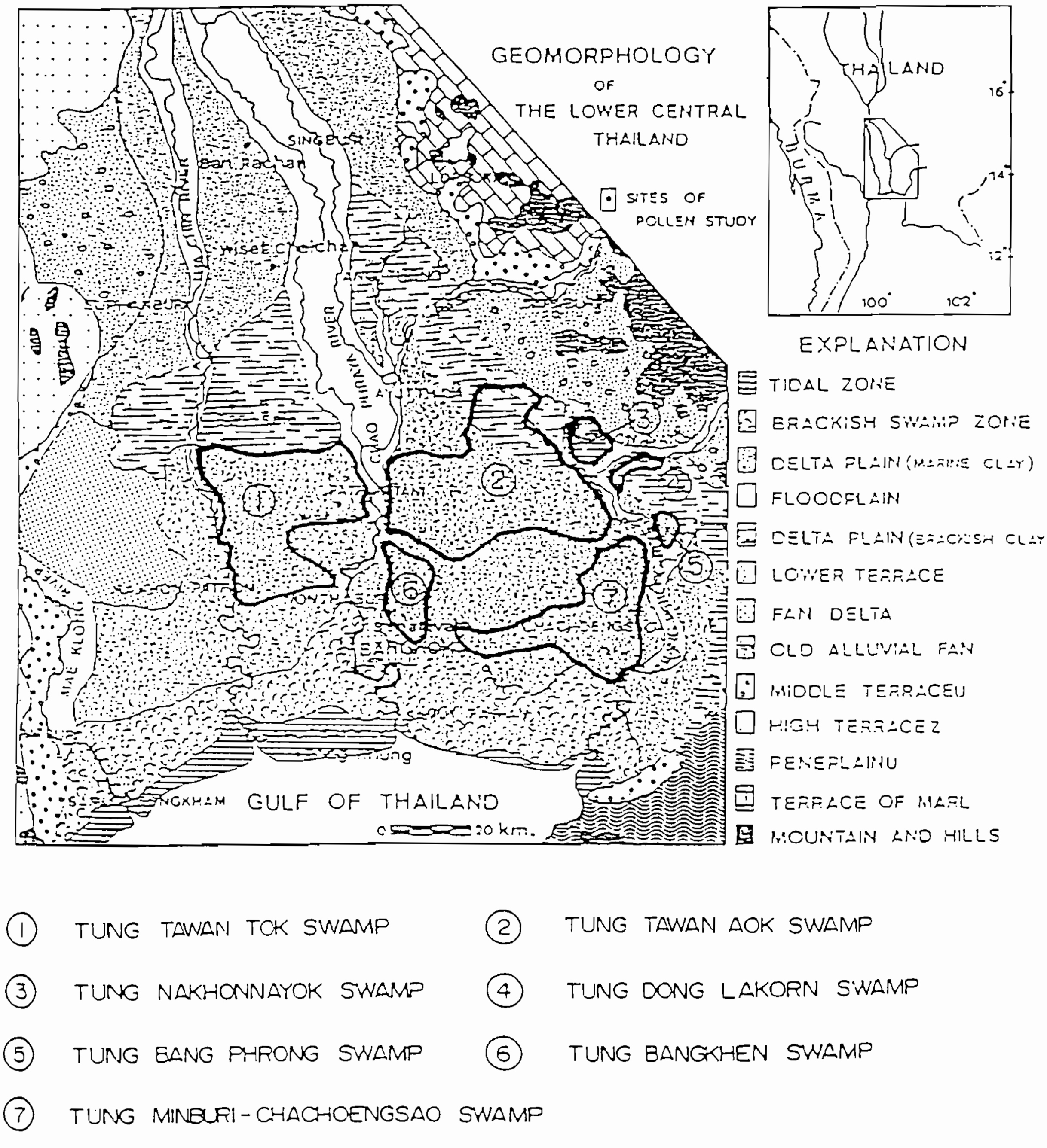


Figure 1. Geomorphology of the Chao Phraya delta (after Somboon, 1990)

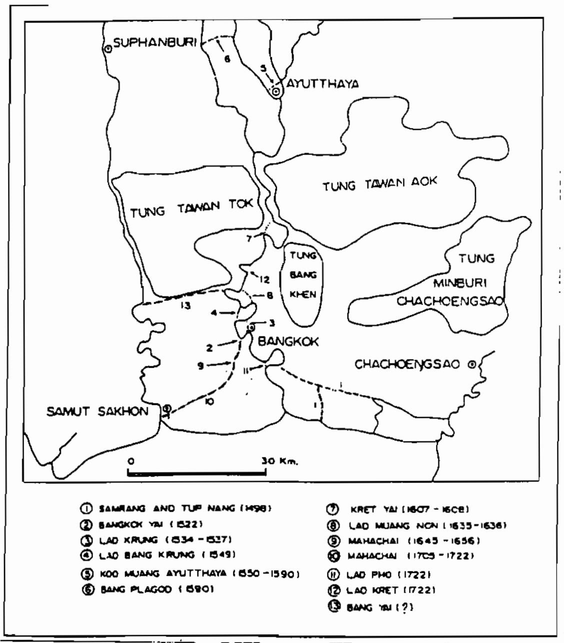


Figure 2. The canal digging between 1550-1767 in the period before the land development history (modified after Takaya, 1987).

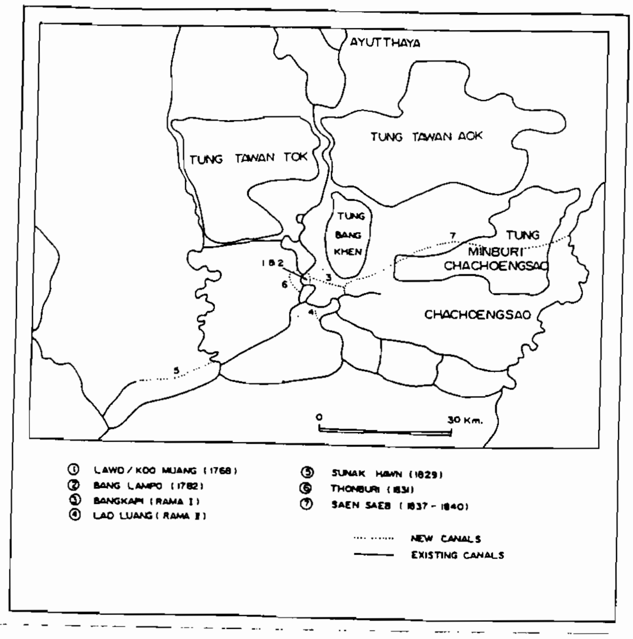


Figure 3. The canal digging between 1768-1851 of the opening epoch for the land development (modified after Takaya, 1987).

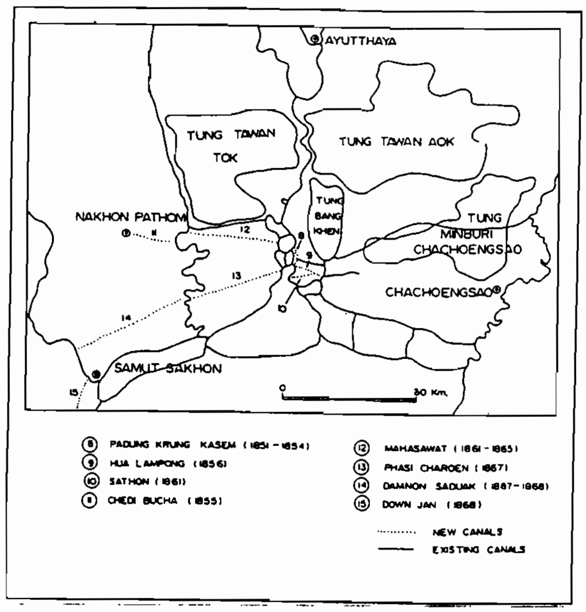


Figure 4. The canal digging between 1851-1868 of the extension for land development (modified after Takaya, 1987).

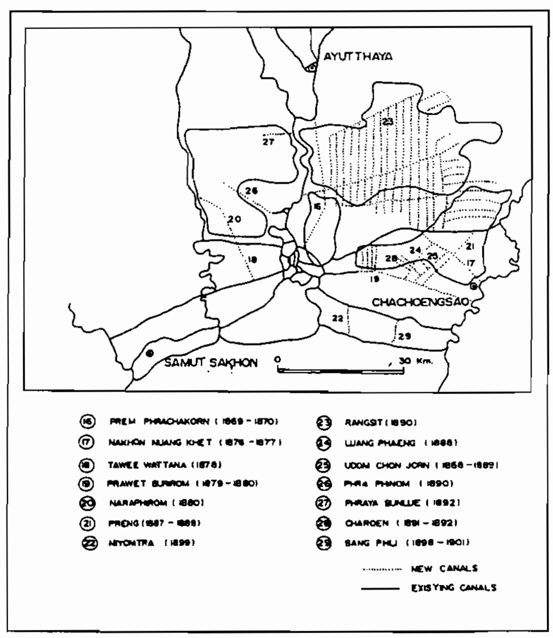


Figure 5. The canal digging between 1868-1910 of the progressive epoch for land development (modified after Takaya, 1987).

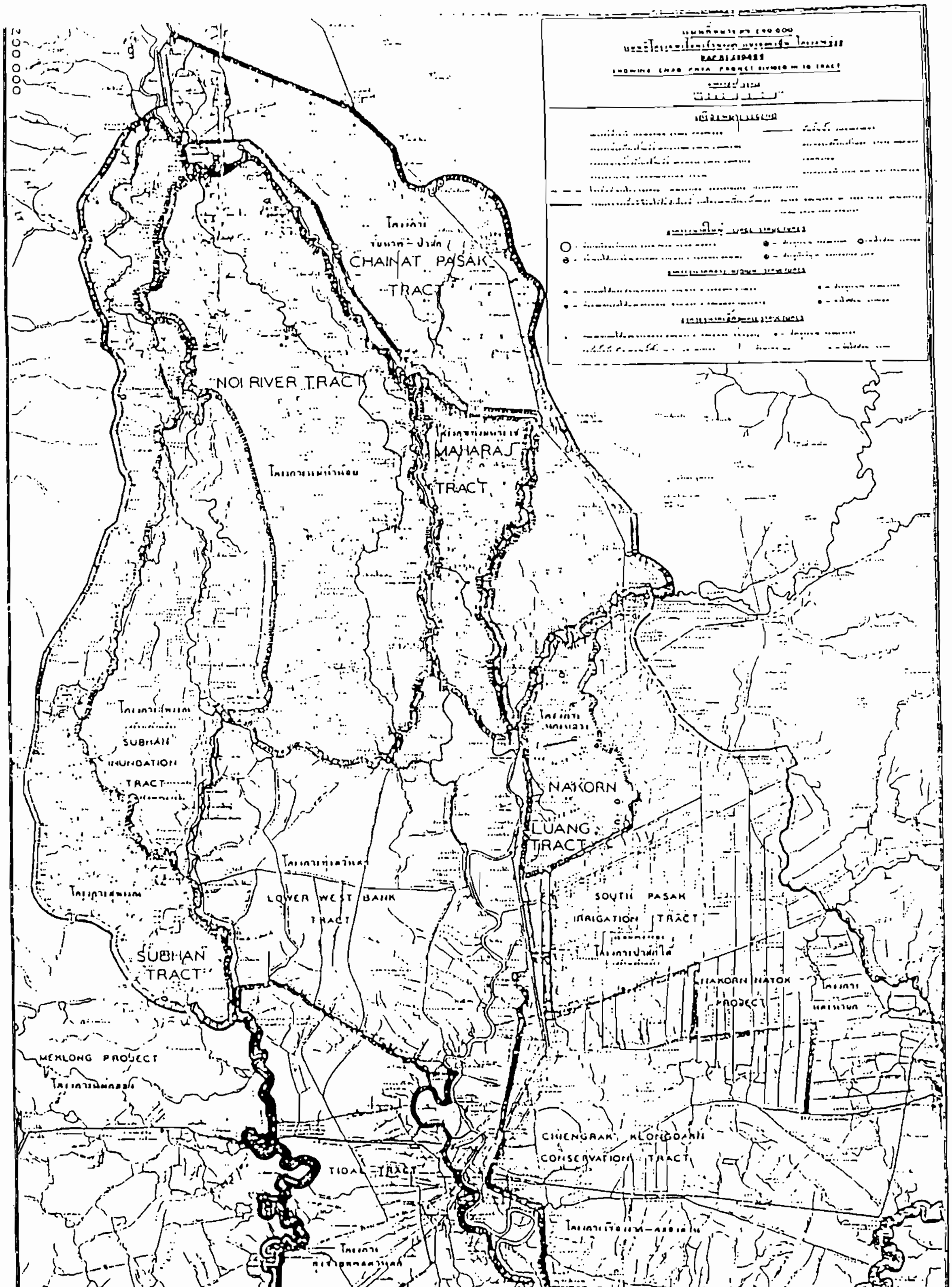


Figure 6. The main works on irrigation of the period of land development (RID 1986).

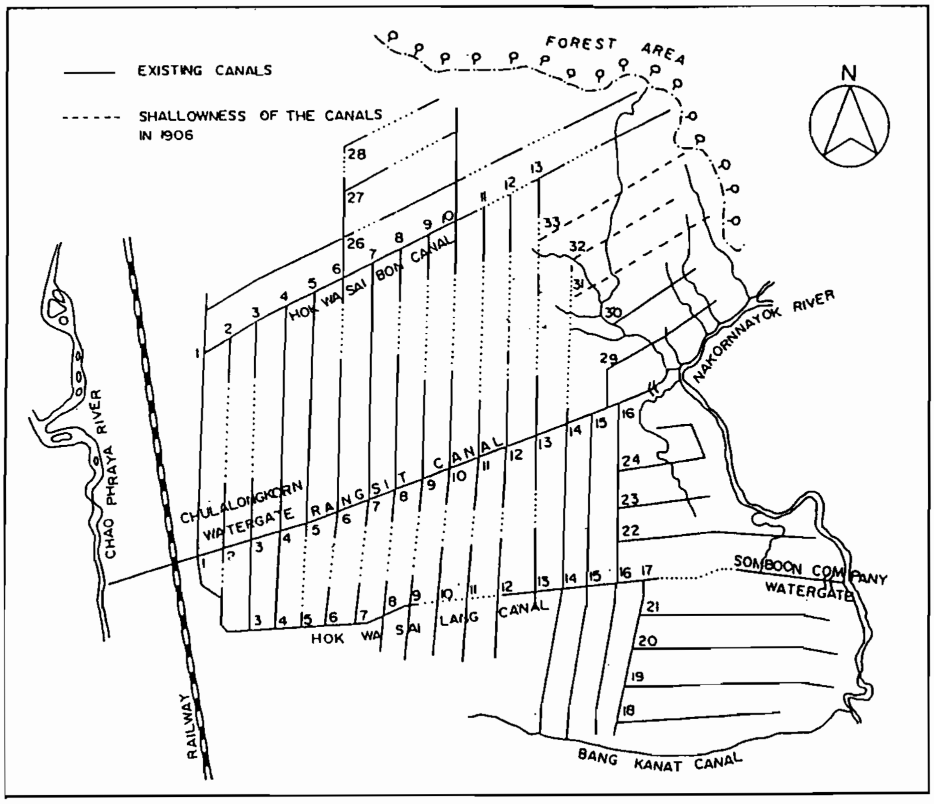


Figure 9. The shallowness of the Rangsit canals in 1906 (after Arsawai, 1987)

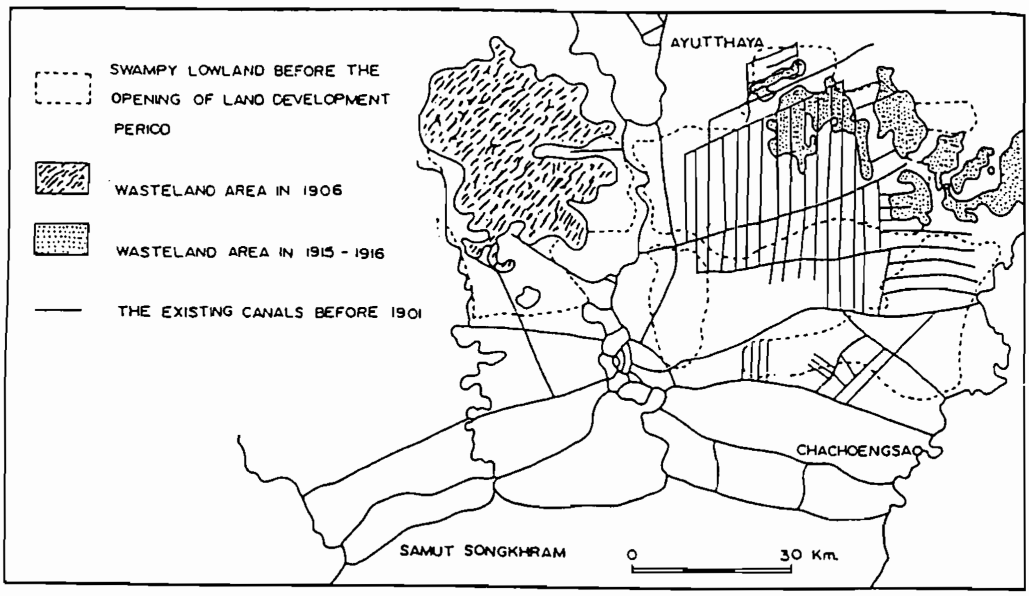


Figure 10. The wasteland area of acid surfate soils problem in 1915-1916 (modified after Takaya, 1987 and Topographical map of Thai Royal Army, 1916)

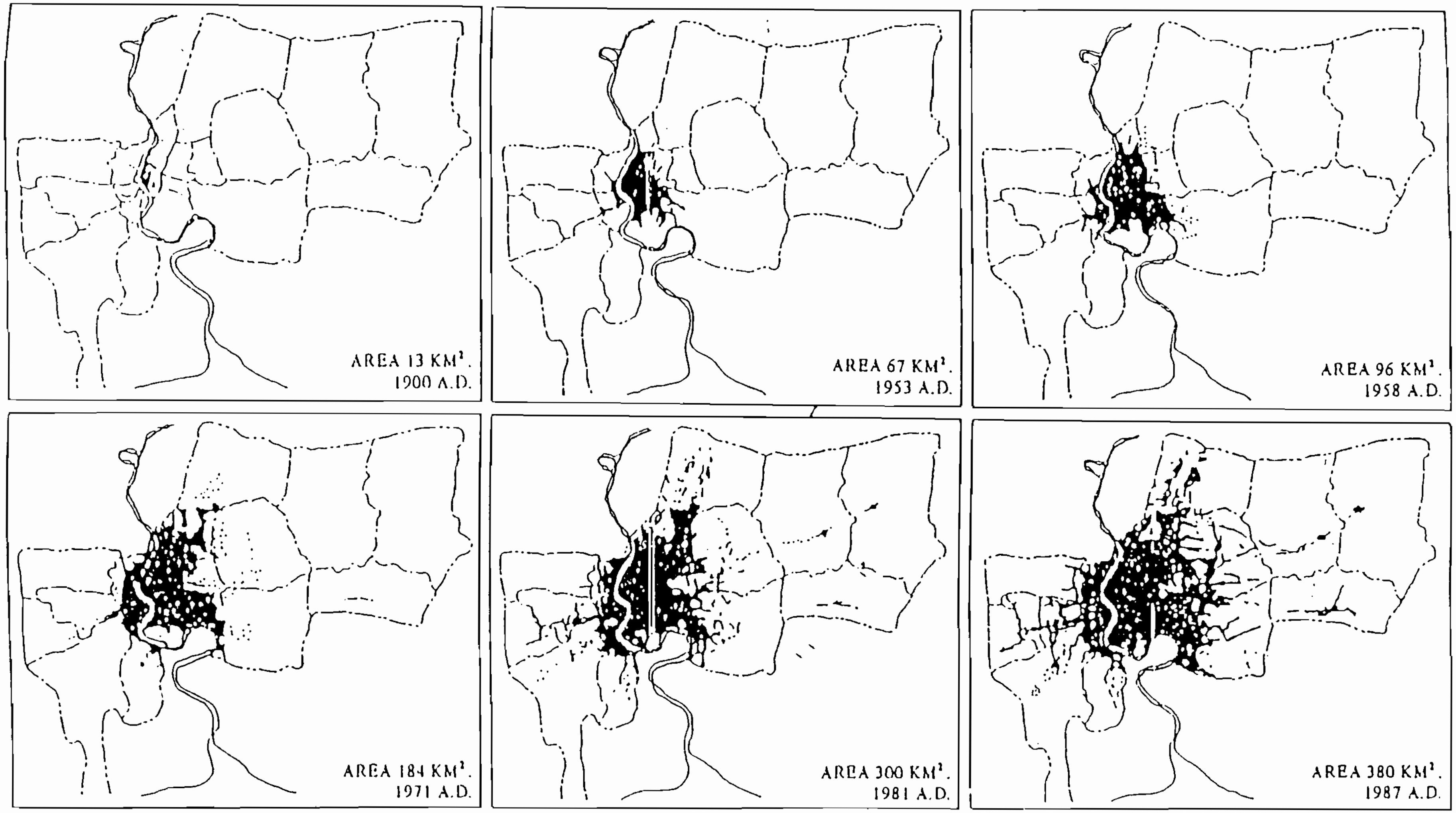


Figure 13. The growth of Bangkok in A.D. 1900-1987 (sethanunt, 1990).

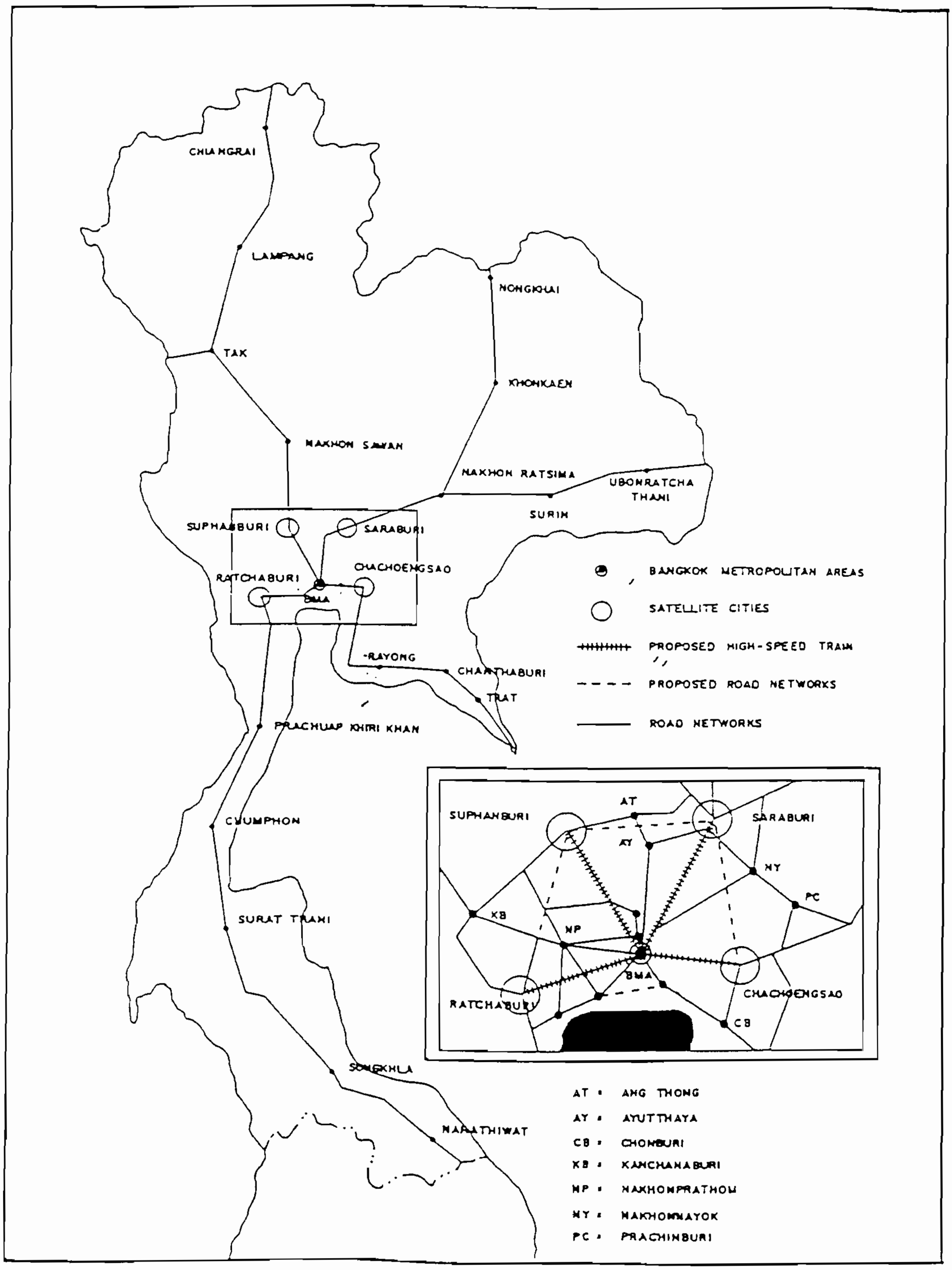


Figure 14. Policy implication and recommendation for the Bangkok Multipolis.