Ecological Destruction, Health, and Development

Advancing Asian Paradigms

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VOLUME 8

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Preface

During the last five decades, Asian peoples and communities have experienced revolutionary change in their living environments due to war, economic development, and the accelerated movement of people. The scale of change was most striking in Southeast Asia, where rather traditional lifestyles had existed in harmony with rather intact natural environments. In the course of the swift buildup of the nation-state and modern economy, nature and ecological resources were exploited on a tremendous scale, sometimes devastatingly. In our grass-roots studies of environments and communities of Asia, we have witnessed these swift changes that have been particularly accelerated by the overwhelming spread of a market-oriented economy and culture. We have also observed contrasts and conflicts in many respects between the value systems of local communities and those of modern civilization.

Forests were felled and encroached upon, crop fields heavily dosed with fertilizers and pesticides, foreign crops and fish introduced, livestock crammed into hustling cages and dosed with antibiotics, and epidemics caused by new pathogens spread in unimaginable ways at accelerated speeds. Large-scale migration, both organized and spontaneous, caused ethnic minorities in the mountains to be mingled with lowland dwellers, and denuded steep slopes to give rise to mud and stone flows in the valleys and flash floods in the deltas. Vast peat swamps, which were the last green resources in Asia by the late 1960s, were cut, drained, and changed into barren acid-soaked lands, producing nothing. Conflict between traditional communities and incoming populations fermented and often erupted into uncontrollable violence. Vietnam, Laso, and Cambodia were further afflicted by the disasters of war, some of which are still manifesting themselves as genetically embedded abnormalities.

Increasing concern with the endangered global environment inspired scientists and policy-makers to seek solutions through technological matching and legislative regulations. This approach, however, is not integral, not democratic, and consequently will not be effective, since it represents one side of a coin, that is, the top-down approach. It should be counteracted by a bottom-up approach, that is, field-based holistic study of ecological cause and sequence, clarifying by local knowledge, aiming at achieving grass-roots form of development and setting aside the influence of outside actions and norms. This kind of study is nowadays called a participatory ecological study of environment and community and has been pursued most ardently by ecologists working in the field of area studies.

This is the background for the International Seminar entitled 'Changing People-Environment Interactions in Contemporary Asia: An Area Study Approach' held on November 15-17, 2001, in Kyoto. In order to illustrate the broad range of environmental problems we face, the program was organized into three sessions and eight sub-sessions comprising thirty-one papers. Session 1, 'Confrontation and Environment,' comprised two sub-sessions. They were 'Ecological Issues in Transmigration Policy and Development of Coastal Wetlands of Indonesia' and 'Ecological After-Effects of Agent Orange Spraying in the Vietnam War and Post-War Food Security.' Session 2, 'Dynamism of Health and Ecology,' comprised three sub-sessions: 'Global Aspects of Disease Study', 'Infectious Diseases', and 'Environmental Health.' Session 3, 'People's Strategies in Eco-Resources Management,' comprised three sub-sessions: 'Development Policy in Vietnam's Northern Mountain Region', 'Environmental Policy and Land Resources Management in Laos', and 'Eco-Technological Approach for Alternative Development.'

The organization of this book essentially reflects the aims of the Seminar, but its structure has been altered slightly by adding some articles and editing and reaggranging the read papers: three sessions were reorganized into four Parts: short inset articles and photographs were inserted to make the book more understandable and visual, and an index was added. A brief introduction summarizes each Part, explaining its themes and conclusions and highlighting each article. The content of each Part is as follows.

Part One, 'Ecological Destruction caused by Modern Technologies,' takes up two striking affairs that symbolize the trend in thoughts and deeds of the last five decades in order to learn lessons for the future. First is the large scale destruction of peat swamp forests for development in Indonesia carried out under the transmigration policy; second is the human and environmental disaster caused by widespread spraying of defoliants and herbicides during the Vietnam War.

Part Two, 'Health, 'presents reports and discussions on medically-oriented human ecology and the accelerated spread of diseases and human populations under globalization. Specific topics of discussion include projected ageing of populations and increases in age-related disorders in Asia, pandemic spread of infections from Asia and infections endemic to Asia; unprecedented environmental disasters caused by emerging biological and chemical agents; and global and multi-dimensional analysis of human health.

Part Three, 'Eco-Resource Management in the Development Process,' focuses on the indispensable roles played by local communities in conserving diverse ecological systems in mountainous regions of Vietnam and Laos. The problems of achieving a balance between development and ecological conservation and bridging the gap between policymakers and local communities are considered.

Part Four, 'Indigenous Knowledge and Eco-Technology,' presents articles depicting adaptive and constructive paths to development, especially ecology-based and community-based resource management, that have sustained in people's efforts to seek sound environments in this part of the world. The awareness of disparities between traditional value systems and modern ones leads us to the concept of eco-technology, which suggests an alternative strategy for mitigating modern, often destructive, development processes.

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We would like to express our sincere gratitude to all the contributors of the papers. Wide range of topics of the papers will offer readers various facts, agenda, urgent as well as long-lasting issues Asia faces now for the conservation of ecological environments and area identities. We would also like to express our gratitude to the staffs and students of both institutions who supported the organization of the seminar, and participated to the discussions. We are also grateful to Ms. YONEZAWA Mariko, the chief of editorial board at the Center for Southeast Asian Studies for proof-reading all drafts, and editors who enabled the publication of this book, particularly Mr. SUZUKI Tetsuya, chief editor of Kyoto University Press, and editors of Trans Pacific Press for their pains-taking and excellent editorial work. The publication of this volume is supported by Grant-in-Aid for Publication of Scientific Research Results by the Japan Society for the Promotion of Science.

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Introduction

The world of the 20^{th} century saw another reconstruction and destruction of human society and, at the same time, the one-way destruction of nature. In spite of wars, natural disasters, and environmental pollution, human beings increased the population from 1.6 billion in 1900 to 6 billion in 1999. They lengthened the life span, expanded the permanent habitat and enjoyed the excess mass-consumption of fossil energy and other mass-produced goods. Consequently, the continental glaciers have receded, the forests have shrunk and the deserts have expanded on a global scale. Populations and species of wild life have been decimated and we are now threatened to be buried by garbage or be infected by an unknown pandemic. No doubt we have to re-examine the present situation and change the concept of development which is distorting society towards incredibly materialistic and anthropocentric ends. The concept of development in the 20^{th} century was a mind-set which did not understand other ways of interacting with nature, other than destroying it for human profit. The United Nations Conference on Environment and Development (UNCED), held in Rio de Janeiro in 1992, was based, we believe, on this sort of reflection.

As area study scholars, we have an intense concern about the conservation of individual areas, their ecological and socio-cultural identity *in situ*. At the same time, we watch the global trends that might threaten the diverse and intrinsic identity of individual areas. Actually, these global issues are made visible and perceptible most intensely in the changing ecological environments of individual areas that have adopted the so-called 'modern' life styles. It is important and interesting as well to re-examine whether such changes have already altered the identity of specific individual areas. This is the agenda of this book.

First, a definition of a geographic area is necessary. An area, or *topos*, is a living body that has been created through interactions with nature, man, and institutions. As all living bodies have developed homeostasis in the evolutional process of geological time, the *topos* has achieved its homeostasis evolving on a hominid time scale. As such, the *topos* is a single individual entity having features intrinsic and specific to its location in space and never to be found in other locations. Due respect must be paid to individual areas so as to avoid territorial disputes, which only serve to strengthen the hegemony of the 'big powers', leading to further ecological destruction and global disorder. I will return to ecological homeostasis in the second section, but here I will start with historical accounts of changes that Southeast Asia has experienced in the last five decades.

I War and development

The scale of the changes to the ecological and living environments in Asia have been remarkable. After the Second World War, Asia encountered a large-scale influx of Western ways; more particularly, the modern American life style after the former 19th Century colonizing powers had retreated. The change is probably most striking in Southeast Asia, where rather traditional life styles and communities have existed in harmony with rather intact and diverse natural environments. In the last few decades, outstanding economic growth has been achieved here.

Thailand

When I made my first visit to Thailand in 1963, its population was about 27 million. To add further reference, the population of the major part of Asia, including East Asia, Southeast and South Asia, was 1.6 billion. When I made my last visit to Thailand in 1996, the Thai population was 59 million, and the population of the major part of Asia had increased to 2.77 billion. The population increased in Thailand in these 33 years by 2.2 times which is similar to the increased population growth rate that was observed in the other Southeast Asian countries. However, other third world countries show a little larger population growth rate. This population increase inevitably caused massive changes in the landscape, land use, and furthermore, a larger consumption of the ecological resources as well as fossil energy at a disproportional rate to the population increase.

Northeast Thailand, for example, where I made a soil study of the wet rice fields in 1960s, was full of open and closed dry dipterocarp forests. In many districts they were changing to rice fields, surrounded by simple embankments to hold the rainfall, although they hardly deserved to be called stable wet rice fields since many standing trees were still left in the plots. Some of our colleagues designated this type of rice field as 'rice-producing forests', or 'wooded' rice fields. There was a large tract of lowland dry dipterocarp forest between Buriram and Korat which had just started to be lumbered. The road linking Surin via Buriram to Korat was something like a cart trail, sometimes passing through the dark forest floor and stuck on loose sand. This tract is now completely changed to wet rice fields and cassava fields. Thus, forest canopy coverage in northeast Thailand, which in the early 1960s was about 40 per cent, had rapidly decreased to 15 per cent in 1982, and is at about 12 per cent now. Also, the vast extent of the Tung Kura Ronghai, which is located between Suwannaphum and Surin, was formerly occupied by swamps and flood-prone lowlands which were only sometimes planted with rice. This plain has changed almost completely to wet rice fields. Economic development based on exploiting the ecological environment has created a modern and comfortable lifestyle in one sense, but, at the same time, has caused salinization of soil and water in the northeast plateau, rampant floods on the peninsular coasts, and water and air pollution in the central plain.

In 1963, the country was, as a whole, based on an agricultural economy. More than 85 per cent of the working population were engaged in agriculture. Agricultural products, such as rice, rubber and cassava, were the foremost commodities and occupied the primary share of the export market. Thai cities, except for Bangkok, were all small, neat and quiet and displayed the poor but modest and stable face of local communities, some still showing the traditional style of moated and walled cities like Chiang Mai and Chiang Saen. Some Japanese economists claimed the people were inactive and lazy and discussed the necessity of stimulating a materialistic desire to buy modern tools such as motorized bicycles, washers, TVs, and other so-called modern goods. But, their meddling concerns proved to be useless, as demonstrated by the swift growth of the export industries and, by the early 1980s, textile and other industrial products, produced using joint ventures, predominated the export market (Hara 1994). This has also changed the previously quiet and neat towns into crowded, traffic-jammed and air-polluted modern cities.

This swift change in the national economy was facilitated partly by the Thai government's endeavor to foster import-substituting industries into an export trade, but also by military demands to support the expanding commitment of the US forces in the Vietnam War. By 1963, an all-weather type highway named 'the US-Thailand Friendship Highway' from Bangkok to Korat, had been completed and other roads linking Korat via Udon to Ubon were laterite-paved. The military wharves in Bangkok and Satahip harbors were connected using this road to Udon and Ubon, which, although veiled from the Thai public, functioned as supply roads for core air bases which were used to transport materials to build the air control towers in Laos needed for future air raids into North Vietnam. Pataya grew into the largest beach resort in Southeast Asia, accommodating off-duty GIs who were packed into barracks at US bases in northeast Thailand and on the combat fronts in Vietnam. The US military expenditures spent on Thailand soared with the intensification of the war, amounting to US$256 million in 1968 when air raids into North Vietnam were at a peak (Kitahara 1988). According to this estimate, the foreign capital investment in Thailand in 1968 was US$59 million when Thailand was suffering from import-export deficit of 50 million US dollars. It is easy to understand the importance of US military expenditure on the Thai economy. It fostered road construction technology, auto-repair garages and the related industries, and tourism resorts.

Vietnam

Military procurement for the Vietnam War played an equally important role in promoting the economic development in many areas of Asia, such as in Korea which conscripted as many as 400,000 soldiers for the Vietnam War. It also benefited the Japanese economy, particularly Okinawa, which was used as a key stepping stone for B52s flying from Andersen Air Force Base on Guam Island to Vietnam. The Okinawan economy displayed remarkable growth: 14.4 per cent in 1965, 17.1 per cent in 1966, and 19.4 per cent in 1967 (Furuta 1991). Development advanced hand in hand with the war in Southeast and East Asia. Economic development of this area was vital for the US in winning the Vietnam War as well as the global Cold War. This obsession was manufactured deliberately and influenced the leaders of the 'free' Asian countries. This strategy played an important role in the war mind-sets making the concept of well-balanced development a rather peripheral idea.

Another interesting example produced under the war- and development-oriented mind-set was the so-called 'miracle rice', disseminated with the ringing declaration that hunger and poverty would be terminated in monsoonal Asia. Short-stemmed, erect, and early-maturing rice varieties were first bred in 1965 at the International Rice Research Institute (IRRI), founded by the Rockefeller Foundation just south of Manila. Then US President Lyndon Johnson visited IRRI in October 1966 after he concluded a conference in Manila, with the wise men group from the USA and South Vietnam leaders. He was pictured together with the newly-bred IR8 rice. The dissemination of high-yielding varieties (HYV) of rice was vitally important for the US and South Vietnam government in obtaining support from South Vietnamese farmers who otherwise tended to be anti-US and anti-South Vietnam governments (Kiyono 2001). These so-called IR varieties are only potentially high-yielding if they are heavily dosed with chemical fertilizers and planted in irrigated rice fields. In optimum conditions attainable only in the experimental stations, they yield 8 to 10 tons of rough rice per hectare; that is, three to four times the normal yields that ordinary farmers obtain with traditional local varieties planted in ordinary conditions. According to Kiyono's interview, one Japanese rice breeder says: 'The background that designed IR8 seems to stem from US-fashioned large-scale agriculture. It needs strictly controlled irrigation to achieve the potential high-yield and tends to fail completely if attacked by a dry spell or is unfertilized. The Japanese concept of rice breeding, on the other hand, aims to breed those varieties which can produce a bit higher yield and as importantly adapts to the land qualities under ordinary practices. There is a diametric contrast between the ecological concept of the Asian peasants, on one hand, and the industrial concept of the big American landowners on the other.'

IR varieties were disseminated to the war-stricken and disturbed South Vietnam rural communities, particularly in the Mekong delta, using a hectic method as a result of the on-going war. Gabriel Kolko, in his *Anatomy of a War* (1986), makes a critical analysis on the role of the introduced rice production as being disruptive to the rural Mekong delta communities. This was just the opposite end envisioned by the US. Farmers were obliged to receive the HYV rice as well as a subsidy. The MACV (Military Assistance Command Vietnam) and the South Vietnam government campaigned to increase the planting share of the HYV rice which required extra expense for running pumps, dosing chemical fertilizers and insecticides, and since the subsidy was not enough to cover these costs, the deficit was born by farmers. The HYV rice required double the amount of fertilizer and this caused fertilizer prices in South Vietnam to skyrocket by three times in the period from 1972 to 1974. The price of diesel oil for pumps and agricultural machines also increased tremendously from 1973 to 1974. The disruption of rice production systems that were promoted by MACV and the South Vietnam government increased the dissatisfaction among the Mekong delta farmers and began to threaten the course of war, leading to the unexpectedly swift collapse of the South Vietnam government and the US MACV in 1975.

HYV rice has played a positive role in increasing yield in post-war Vietnam and other Asian countries, particularly in India. The endemic hunger in India seems to be eradicated thanks to the HYV rice. Therefore the introduction of HYV rice was a double-edged sword. However, the framework of the war mind-set produced real ecological devastation in Vietnam; noticeeably, the spraying of herbicides and defoliants to eradicate the prolific vegetation which hid the guerilla forces beneath its canopy. This action indicates precisely that the unilateral belief in the pursuit of efficiency results in ecological disaster. The use of herbicides by US forces was logical *per se*, since vegetation canopies provided shelter for the guerilla forces and were barriers against targeting and terminating the enemy as well as counting bodies. The opposite forces were confronted face to face with the intervening canopy. How the Viet Cong guerilla forces fought the first winning battle in Ap Bak in 1963, by hiding themselves in foxholes covered by the tree lines along the irrigation dikes, is vividly depicted in *A Bright Shinning Lie* by Neil Sheehan (1988). However, the spraying of the defoliants left incurable aftermaths.

The amount of herbicides sprayed was small, at about 280 m^3 in 1963, but it steadily increased and amounted to 19,400 m^3 in 1967. Over a ten-year period from 1962 to 1971, the total amount reached 72,354 m^3 (Westing 1976). The spraying of defoliants destroyed tree lines along canals and rivers, some plantation estates, the vast mangrove and inland forests of Vietnam and the dense primary forests of Laos. Operation Ranch Hand not only damaged the then living vegetation and people, but also left disasters implanted in the genetic chain which were inherited by the following generations. The toxic substance, dioxin, which is an impurity in 2,4-D and 2,4,5-T production, is known as a carcinogen and endocrine disrupter and caused grave damage to the people and ecological environment of Vietnam and adjacent areas.

Although it is beyond our capacity to have a comprehensive understanding of the Vietnam War, we need to understand, at least, the impact of Operation Ranch Hand on the ecological environment and human lives, and to collect information on the advancing research results and on the present situation of the victims and victimized communities. Dioxin contamination is something familiar to the inhabitants of industrialized countries like Japan. The main sources of this contamination in Japan are waste incinerators, the paper and pulp industry, chemical industry, metal refining industry, and emissions from motor vehicles. The task imposed on the Vietnamese in overcoming the aftermath of Operation Ranch Hand is similarly imposed on other nations as well. Five chapters on the aftermath of ecological warfare, which are collected in Part One from Chapters 5 to 9 of this volume, only scratch the surface of this tragic and terrible deed. But they do remind us of the disastrous results of the crazy mind-set that was predominant in the 20th century and do help us renew our resolution to free ourselves from it.

After the Vietnam War ended in 1975, the people of the Indochina peninsula recovered peace, independence and freedom - although it took another dozen years or so for the Cambodian people to enjoy peace and freedom.

Reconstruction of these nations and the ordinary livelihood was initiated most vigorously in the lowlands, since the infrastructure for promoting production was, relatively speaking, most developed there. But in the mountainous areas, which had been kept as autonomous realms of the mountain dwellers, there now appeared new frontiers for immigrants from lowland Vietnam and also from Yunnan Province across the border. Thus, environmental conservation in the mountainous areas of Vietnam-Laos-China border has aroused special concern of a wide spectrum. Part Three focuses on this issue.

The Red River delta was the center of migration in Vietnam. This area's sole industry was the very labor-intensive agriculture and in some districts the population density was over 1100 people per square km even in the 1940s. The mean figure for the entire country was 620 people per square km in 1976 and 830 in 1990. Reducing over-population through emigration has been the major concern for the rulers and for the farmers themselves. According to a study on migration in Vietnam, immigration during the anti-French and anti-American wars moved many to the northern mountains to support the war. These immigrants were organized by the government and amounted to 380,000 in the period from 1960 to 1974. After the unification in 1975, immigration to mountainous areas was further promoted by the government into New Economic Zones, which were established with the aim of integrating economic development and border security in the sparsely populated areas. It is estimated that there were 4.75 million immigrants of this kind across the whole country, mostly originating from the Red River Delta. However, the number of migrants planned by the government was even larger, 6.6 million people. The target area was the northern mountains in the early phase, then, after the Doi Moi policy of the late 1980s, the central highlands, where basalt-derived fertile soils predominate, were included. The Kinh immigrants from the Red River Delta focused on the cultivation of cash crops such as coffee, rubber and peppers, and the ethnic minorities from the northern mountains were engaged in shifting cultivation (Guest 1998).

Beside the organized and spontaneous immigrants, a few million domestic refugees were produced from the 'free-bombing areas' during the wars. Consequently, the former pattern of population distribution, the Kinh people in the lowland and the ethnic minorities in the mountains, was disrupted. As the Kinh people from the lowlands settled in the immigrant sites, the traditional land use of the mountain slopes also changed. Furthermore, the Ho Chi Minh trails that pass through the mountains, while they were the lifeline in winning the war, now function as free access routes for the lowland immigrants and shifting cultivators and are beyond government control. Because the desire for a better life is entrusted to the people's free choice, the government has to facilitate the conservation of the natural environment through policy.

Various policies have been decreed to recover the disturbed environment and the residents' livelihoods, as well as to stabilize agricultural production. According to the statistics (World Bank 1993), forest coverage (including closed and open forests) occupied 14.3 million hectares (43 per cent of the total area) in 1943, but it decreased to 9.3 million hectares (29 per cent) in 1993. Concern has been directed to the barren grasslands, which are estimated to occupy 12 million hectares, particularly in the northern mountains where border-crossing minorities such as Hmong (Myao in China) and Zao (Yao in China) have repeated a shifting cultivation which causes forests to disappear.

One example of these policies is the Decree of the Council of Ministers No. 327, issued in 1981, which reads as follows:

'The plan for the next 10-15 years lays the groundwork to restore denuded or 'barren' hills and mountains, to protect the environment and forests and to exploit the potential of unoccupied land in the hilly regions, denuded beaches and waterfronts in order to increase the production of raw materials and commodities for industries. It will also lay the groundwork to divide the land, settle the population, link social and economic needs, as well as stabilize and raise the material and spiritual standard of living in the new economic zones, in order to stimulate the residents to increase their production efforts and consolidate the national security' (World Bank 1993).

Some important measures were produced from Decree 327, such as, the policy to hand over the land and forest to the residents. Under this policy, each household is allocated a certain area of land or forest to replant, protect and tend, and are given additional arable land to plant short-term and long-term industrial crops. Each household is allowed up to 5000m^2 to farm for its own use. In this framework, an ambitious target has been set to re-green 5 million hectares in 10 years (until 2003). Although accompanied with local adjustments, the balance between the conservation of the natural environment and economic development is going to be implemented along this line.

In the course of implementation some issues became clear. One is the dissatisfaction of the mountain-dwelling ethnic minorities in the northern mountains who lost free access to the land for shifting cultivation in their traditional territory. Most Kinh people who settled in the mountains swiftly and shrewdly switched to cash crop production, while the native ethnic minorities, except for the Thai and Tai, are going to be left behind in their share of these benefits. Various ethnic groups who cooperated during the war despite their different traditions and life styles are becoming increasingly conscious of their differences now that they live side by side. Local officers of the Ministry of Agricultural and Rural Development (MARD) in Son La and Lai Chau provinces, for example, openly acknowledge that there is a difficult gap between government policy and the assured supply of food for shifting cultivators. They say that strictly banning the shifting cultivation and applying the reforestation policy would deprive the shifting cultivators of food. As a result they have made some adjustments, such as regulating shifting cultivation by allocating three plots per household with a three year cultivation cycle for each plot, resulting in a nine year rotation.

In the central highland, the opening of the forest for plantation crops such as coffee and tea has proceeded outside government control. The Kontum-Darlak massifs offer extensive plateaus with fertile soil derived from basalt. Many Kinh immigrants rushed to the area and transformed the forests into small plantation estates, although some are as large as 100 to 200 hectares. The native dwellers, such as the Jarai, Bahnar, K'ho, and others, were pushed aside to the peripheral areas of the massif where the soil is not as fertile as on the plateau and are obliged to work the estates of the Kinh people. Consciousness of this inequality or unfairness seems to persist explicitly on the side of the native dwellers.

Another issue related to the reforestation policy and the security of food for the ethnic minorities is that it requires huge amounts of funding. According to a UNDP publication (1996), major donors include the WFP (World Food Program), SIDA, UNDP, EU, and DANIDA, and the known amount of donor assistance for environmental projects in the period from 1990 to 1995 reached US$466 million. According to the *Hanoi Asia Pulse* of March 1999, the government decided to invest US$428 million to unfinished and new projects for 1999. This heavy burden is going to tempt the government to permit the foreign pulp companies to join in the reforestation projects. Environmental conservation is not only an ecological problem, but it is also one of the effective political devices the West uses to control, not to say to rule, developing countries. It is a difficult task for Vietnam to keep a balance between sustaining independence, achieving economic development, and conserving its natural environment.

Laos

The situation in Laos is quite similar to Vietnam in such issues as land and forest allocation, reforestation projects, accelerated lumbering, and the swift opening of the small-hold plantations on the Boloven Plateau, which is the Laotian counterpart of the Kontum massif. The aftermath of free-bombing and defoliant spraying is also serious along the former Ho Chi Minh Trail. However, forest cover still occupies a larger area, at about 45 per cent of the total area, because of the smaller population density (National Office of Forest Inventory and Planning 1992). This last forest resource in mainland Southeast Asia is going to be encroached on by loggers who export the timber to Vietnam, Thailand, Yunnan and Taiwan. Of particular concern to forest conservation is the control of the forest concession by the army, which may have an entirely different concept on how to exploit the forest resources. Another concern are the many small groups of Vietnamese loggers and traders, as well as the Chinese (Yunnanese or through Yunnan) laborers, peddlers, merchants, restaurants and hotels owners that are looking for precious wood. The Chinese have had an even more substantial effect on land use in the border areas of Vietnam and Laos, where there is an increase in sugarcane fields, the output being brought to sugar mills in Yunnan.

This kind of cross-border trade and population interflow is a long-lived historical event in the inland border area and, as such, it reflects the arrival of peace and is to be welcomed. On the other hand, there are differences among neighbors in many respects with regards to life style, land use, the view of land ownership, as well as ethnic and national identity and value systems. The mountainous border area has had rather mild disturbances. The spread of economic development and population increase in this area has triggered the necessity for exploring a new balance between people and nature.

All of seven chapters collected in Part Three depict the present situation in the mountainous areas of Vietnam and Laos. We studied land use and landscape changes, the official view on land allocation policy and ecological resource management, the shifting cultivators' view and their response to the market economy, traditional non-forest timber products, and other topics. These papers, as a whole, offer a good grass-roots observation of the traditional and changing border communities which are still at a chaotic stage under conflicting demands such as an intruding market economy, the desire for a better life style, conserving the land and water, and building national integrity and security.

Indonesia

Indonesia took a different path in war and development, more benign as compared to Vietnam, Laos and Cambodia, but more turbulent than Thailand. This relates to its ecological and historical background. From the ecological point of view, maritime Southeast Asia, where Indonesia is the major country, has different attributes from continental Southeast Asia. It has a more humid climate that favors the prolific growth of tropical rain forests, rubber trees and palms and, in the case of Indonesia in particular, more mineral deposits such as oil, tin, bauxite, and the very fertile soils of Java. Major economic and cultural development has been staged in Java from ancient times, where the fertile soils and clear spring water on gentle volcanic slopes offer the excellent sites for crops and human life. These rich resources were exploited by Dutch colonialism and, particularly after the mid-19th century, the territory had been molded into an exporting area of estate tree crops, while depending on rice and other grains imported from Continental Southeast Asia. Consequently, the foreign estates had owned huge tracts of land in the colonial time.

The population of Java in 1900 was estimated at about 28.7 million people. The whole of the Dutch East Indies in 1920, including Java, had about 52 million people. In 1960, Java had 63 million people and Indonesia 92.6 million and by 1999, they respectively reached 110 million and 209 million. The population density of Java is 870 people per square km, while the population density of outer islands is quite small. As has often been mentioned, Indonesia is a nation with a dual structure even today; with a different culture in Java and the outer islands; separate system of peasant agriculture and estate agriculture, social distinction between authoritative patrons and humble clients, and Java centralism of administrative power versus dissidents in outer islands, so on.

The efforts to relocate the population from densely populated Java and Bali to the sparsely populated Outer Islands started as early as in the Dutch colonial times. The movement was temporarily interrupted by the Japanese military occupation. In the process of transferring national sovereignty from the Dutch government to Indonesia, which was settled in 1949, the idea of population relocation was rejuvenated again by the Sukarno regime. But it was practiced only on a limited scale until the end of his regime for two reasons; one, was the plans made in the Sukarno regime were too unrealistic, involving the relocation of 31 million people to the outer islands in 15 years from 1947 and then, in a modified plan in 1951, to try to relocate about 48 million people in 35 years from 1953 (Hardjono, J.M. 1977). Such targets were really extraordinary, involving moving about half of the population of Java. The second reason was the Sukarno regime became steadily more of a problem child to the US and the allies because of Sukarno's permissive attitude toward the Communist Party of Indonesia (PKI) and drastic policies such as nationalizing foreign assets and the confrontation with Malaysia. Western donors waited for the appearance of the more realistic, more pro-Western and a more liberal economy-oriented regime, achieved by Suharto and his comrades in 1968. After the termination of PKI members and their sympathizers in 1965, Suharto seized power from the Sukarno regime and drastically changed the direction of Indonesia. When I visited Java in 1969 for the first time, the people told of the still vivid memories of terrible murders that have never been accurately disclosed.

This drastic change was welcomed by the West, and with increased assistance and investment from the US and its allies and also supported by a stable income from the export of petrol, Indonesia stepped toward economic development. The principle that the Suharto regime employed was to aim for a full-set economy of industrial development challenges rather than depending on a comparative advantage. The first step was to enhance the import-substituting production, and soon the program was stepped up to an export-oriented production. This plan was extended to agriculture and was exemplified by the BIMAS project (a package-deal credit plan offered by the government) in 1964-65 that aimed to attain self-sufficiency and furthermore to export rice. This aim was motivated by a critical reconsideration of the import-export structure that had occurred during the Dutch colonial period. To prevent the return of economic deformity of the colonial time, the Sukarno regime replaced the Dutch time agrarian law with a new land law in 1960. A Western style of absolutely exclusive land proprietorship of an individual was denied. Instead, on disposal of the land usufruct (Mizuno 1997), the state assumed power over individual farmers and companies.

The Suharto regime inherited the principle and carried out many projects to achieve state-directed economic independence. Self-sufficiency in rice production was achieved in 1984, with an output of 26 million tons of polished rice. This was one of the remarkable successes of the development policy. Rice production further increased in the 1990s to over 30 million tons, thus enabling the country to export rice.

Indonesia also boasts a vast forest coverage. The FAO calculated the total forest area in 1980 at 158 million hectares. Of the 158 million hectares, 114 million hectares are closed forests. The abundant forest resources also offer a huge amount of export products, such as logs, plywood and processed wood products. According to an estimate, in the period between 1967 and 1980, the volume of tropical hardwoods exported from Indonesia exceeded that of Africa and Latin America combined (Gills 1987). Consequently, the decrease of forests has been remarkable. For 2000, the FAO estimates the total forest as 105 million hectares.

Another major cause of the decrease in forest area is attributed to the population resettlement projects. The population resettlement projects were put into real practice on a larger scale in the successive five-year plans from 1969-70 under the name of *transmigrasi umum* (official transmigration). The target sites were mostly selected for two types of terrains, one in the uplands and the other in the coastal peat swamp, where both of them were opened by clearing of the forests. These projects continued for 27 years in six five-year plans. The assessment of this huge project is of course a difficult task. But, in order to make a start we need to look at the ecological consequences. This would enable us to access the situation more clearly and evaluate the gap between the concept and the results attained in a social context. The first four chapters in Part One try to tackle this topic. Chapters 1 and 2 provide an ecological view and focus on the deplorable failure of the reclamation of resettlement sites on the coastal peat swamps in contrast to successful reclamation by the spontaneous immigrants. Chapter 3 and 4 on the transmigration policy clarify its conceptual framework, the social and political processes and the program's achievements. Chapter 3 tends to give a positive assessment on the program's challenging spirit in opening a new living sphere, while Chapter 4 rules the programs as a failure caused by the unspecified goals of the authoritarian power structure. The Chapter 4 also urges careful attention to the currently emerging euphoria for decentralization and local autonomy.

II Ecological homeostasis

Any living body is separated from the environment by a membrane or skin or bark to maintain its form and keep its internal conditions constant. It achieves this constancy through a self-regulating process called 'homeostasis'. This is essentially the maintenance of a dynamic equilibrium in an open system that is always changing yet remains within a specific range. Major organs of the human being, for example, are regulated by the combined action of the autonomic nervous system and the endocrine system; the former works as an instantaneous on-off switch, and the latter works as a slow-regulating feedback control. Both on-off switches and feedback controls work according to the information preset on the genome in the genetic code. The concept of a homeostatic equilibrium is expanding to other applied fields. One example of this kind is found in 'ecological homeostasis'. This refers to the dynamic equilibrium among different species in a biological community, and it varies from place to place.

This concept has had equivalent forms in various societies throughout history. In ancient Greek, *klima* literally means the angle created between incidental sunrays and the horizon. This angle varies geographically, just as the climate, people and culture are different. This concept motivated Herodotus to tell a different history of Hellas and Barbaros. In ancient China, the concept was expressed by combining the words for wind and soil. The underlying concept is of a geographical unit encompassing environment and culture in a specific area where soil fosters life and emits *chi* (flow of life), which flows into the atmosphere and then the wind distributes it in a certain space. It is implied that a homogenous geographical unit is created. The Chinese concept was imported to ancient Japan and termed *fudo* with the same meaning. Thus, in both ancient China and Japan, geographical monographs relating to the natural geography, history and population were referred to as *fudo-ki* or 'chronicles of *fudo*. In pre-modern Europe, von Herder, a German philosopher of the 18th century, elaborated the Greek view that claimed the climate (the *milieu*) governed all phenomena in one area, such as products, food and drink, life style, labor, clothing, culture, technology, and so on. There are several later versions that insist there is a closer relation between the natural environment and the attributes of the communities. Some of them reached the eccentric conclusion conceived by the Nazis. They presupposed the purity and superiority of a nation and the sacredness of the territory that fostered it. Of course, we do not think this way.

Our premise is, as previously expressed, that an area or *topos* has its own homeostatic identity which has evolved on a hominid time scale and additionally, that each has a regulating system of its own which cannot be arbitrarily transformed. Our premise can be formulated as follows: each area has a *toponome* that represents a preset genetic code. This premise has not been proven in a scientific way, but this does not matter. The living body has existed for an immense period of time, to the point where science cannot create or prove the birth of life. Genome and *toponome*, in our view, are quite similar in their function, differing only in that while the self-regulating range is rather well-defined in the case of the genome, it is less well-defined in the case of the *toponome*. This is because the *topos* is a much more open system and the interactions among the constituents, of which there are at least three, are immense. Even just one constituent, ecological homeostasis, for example, has a huge number of genes and systems involved and complicated interactions among them. This is true of other constituents as well, such as human homeostasis of minds and of institutions.

In spite of the fact that the *topos*' identity is most strongly governed by the ecological homeostasis of the natural environment (there may be dissident views even among us, of course), the conservation of the natural environment has been the most neglected. We find society giving accolades: reverence to wealth has extravagantly dictated to the human homeostasis of minds, to its braveness or savageness, to nobility or hypocrisy and shrewdness or fraudulence. We find some democratic states have welcomed the adulation, slavery and indiscriminate deaths. Tyrants and superpowers are protected by law and institution. On the other hand, the destruction of ecological homeostasis, so as to serve the profits of human beings, has been considered as beneficial under the war-oriented and development-oriented mind-set.

In this situation, the ecological homeostasis of natural environments has been heavily damaged, and the *topos*' identity has lost some of its major attributes, as we will show in Parts One and Three. However, one issue has been lacking in the discussions about *topos*' identity so far; that is, critical discussion about the ecological status of human beings who are the perpetrators, benefactors and victims of environmental destruction. What happens to human and animal health after a series of periods of economic growth based on ecological destruction? With regard to this issue, this book submits a really challenging and innovative idea towards integrating this approach into area study science. By expanding the study network to doctors in clinical and epidemiological medicine, area study science could (I am impressed to mention) deepen the understanding of ecological homeostasis and enlarge the varieties of dissecting tools available in order to see the facts affecting a *topos*. This integration could expand the dimension of space and time on a cosmic scale; from multiplication of virulent bacteria, to community-based geriatric clinics and malaria control; to the study of reproductive anomalies in marine mammals on a global scale; to a clock gene that is several hundred million years old and is fundamentally similar in all life forms on the earth. The chapters collected in Part Two Health are related to this topic. I would like to point to the relevant ones.

Four chapters in Part Two, Chapters 10, 11, 12, and 15 demonstrate two types of infections that have attracted concerns with regard to environmental change as a result of development and war. One type is the pandemic infection by rather ubiquitous pathogens causing cholera and gastroenteritis. In both cases, new virulent strains emerged and became world-wide pandemics in the 1990s. In the case of *Vibrio cholerae*, the pandemic infection lasted almost 10 years from 1990 with the alternating emergence of different dominant strains. This alternating pattern depends, as described by the authors, on the ability of a clone to make genetic rearrangements which are caused by unidentified environmental pressures, for a stronger virulence to survive the immune systems of the host population. Although the authors of Chapter 10 are cautiously reserved on identifying the environmental factors, it is implied that the genetic rearrangements might have been slower were it not for the changes in the environment. In the case of gastroenteritis, the pandemic strain was found coming from the bloody clam of Hat Yai in peninsular Thailand and may have been transferred to other Asian countries and Japan and US by the import-export of seafood. This event reflects the movement of pathogens carried on trading items and demonstrates that any *topos* is vulnerable to lose one of its major protective shields - spatial separation.

The other type of disease is the increased infections by endemic pathogens. One, causing melioidosis, is an endemic disease in Southeast Asia and the other is a new virus named 'Nipah virus' in Malaysia, which causes an encephalitis syndrome in man and respiratory as well as neurological syndromes in pigs. Melioidosis is caused by a bacterium that is found in the subsoil of cleared, cultivated and irrigated rice fields. It multiplies in surface soils in the rainy season when the bacterium comes up with the rising water table. Although the disease is mostly latent in the endemic areas, newcomers to an area are at risk of acquiring a severe clinical disease. This happened to American GIs in the Vietnam War. Nipah virus disease occurred in late 1998 in the Kinta district of Malaysia, and then spread to Negri Sembilan, the center of the largest pig-rearing industry in Southeast Asia. It took a huge toll of 105 human deaths and caused one million pigs to be slaughtered to prevent domestic as well as international spread. The origin of the pathogen was traced back to the fruit bats that inhabited limestone caves nearby. The incursion of pig farms into this district brought the infected bats into closer contact and caused infection of the pigs and the pig farmers. The authors of Chapter 15 paraphrased the lesson as follows: 'The incursion of humans into previously undisturbed remote natural habitats where unknown disease agents exist in harmony with wildlife reservoir hosts could have introduced a new zoonotic infection.'

While studies on epidemic and pandemic infection attract attention to the ability of microbes to mutate and their interactions with the environment, studies on endemic disease, such as malaria control, attract our attention to how the homeostatic balance is dislodged in the infected communities. This is discussed in two chapters., Chapters 13 and 14 on vector-borne diseases in Southeast Asia. In the case of a holoendemic area, such as in the Solomon Islands, the people live with a high parasite density, as indicated by 50 per cent malaria infection among school children. In this situation, the reduction of mosquitos by DDT spraying was the previous countermeasure, but it is not feasible now for fear of environmental hazard. Now, the vectorial capacity is reduced to the mesoendemic level by using bed netting first, and then medicines are used. This countermeasure seems to employ the concept of following the ecological homeostasis; that is, the working interaction among man, mosquito and clinical malaria.

Economic development and health care improvement in the developed countries have steadily increased the population ratio of aged people. Chapter 18 on geriatric medicine focuses on the topic of how to preserve the functional abilities of elderly people. The results obtained from 10 years of observations in a village of Kochi Prefecture, Japan, indicates the importance of a community's intervention in keeping old people active. Community intervention involves activities such as annual health checks, monthly reports by volunteers, patrol visits by community nurses, participation in health lectures, exercise twice a week and other programs. It is encouraging to see the effective improvement of activity reflected in the daily living (ADL) index, even among the most elderly people using these practical interventions. The ADL differed between different locations and is considerable, as revealed by comparative studies carried out in other communities in Japan, Korea and Singapore. What causes the difference in ADL could be directly related to clarifying the *topos*' identity and its ecological homeostasis. This seems to be one of the major tasks of area study science as well as the task of relocating populations back into the sparsely populated areas.

Global contamination by carcinogens and endocrine disrupters is continuing, but few people know that the contamination remains on the earth and not in similar concentrations in all living forms. Chapter 17 offers a clear-cut explanation. Firstly, the organochlorine pollutants emitted from war and economic activities are ultimately 'evaporated into the air, and then carried by long-range atmospheric transport and eventually are concentrated in the water of the open seas, particularly in the polar regions.' Secondly, the physico-chemical properties of the pollutants cause differential condensation: dioxins such as 'PCDDs and PCDFs are less volatile, less water-soluble and of stronger particle affinity, and therefore contaminate terrestrial animals to a greater extent, while coplanar PCBs are more transportable through air and water, and contaminate marine animals more so.' Thirdly, the enzyme activity in decomposing toxic pollutants differs from species to species. There are whales and water birds that have lower detoxifying enzyme activity. Consequently, pinnipeds (seals) and cetaceans (whales), who are at the top of the food chain, are the most seriously affected by organochlorine accumulation. 'Sterility, abortion, stillbirths, and abnormal strandings' in these mammals have been reported since the 1960s. Decreases in testosterone (the male hormone) in porpoises (the dolphins) and other marine mammals have been reported recently. Based on these facts, the author warns that 'organochlorine contamination in the marine ecosystems has reached high potential risk levels.'

If we compare the congenital anomalies that are still continuing in Vietnam, I wonder if these afflictions are confined only to the marine ecosystems and to the marine mammals. Terrestrial ecosystems and human society have also reached critical risk levels, since these congenital anomalies indicate that self-regulating feedback systems have been lost from the genome, and that human control restraining from such atrocities has been lost from the *toponome* of the human homeostasis of minds and institutions.

This chapter on environmental pollution demonstrates an effective approach to analysing the mechanism of ecological homeostasis, which is definitely an important topic in area study science.

The discussions presented above are related to the perception of facts in various *topos*. But, the *topos* is an entity that has been formed in time axis as well. This agenda may require us to display concomitant premises with regard to concepts such as time, location, current change and diversity. In the academic as well as the practical handling of facts, area study science makes it the primary and foremost task to make a location-specific understanding of facts. In this approach, conserving the diversity of the *topos* is most important. One more important premise is related to the perception of time. In my view, the time axis in which the *topos* has been formed should not be perceived as linear. Most probably it is spiral and the direction of spiral-elongation is not supposed to be straight. Accordingly, the clocks in different *topos* tick in a cyclical time with dislocated beginnings and ends in each segment, and each with a different pitch and wavelength.

Consciousness of time and location as environments in which human beings live seem to be different in Asia, Europe and the Middle East. This discussion was once put forward by Watsuji, a Japanese philosopher who reflected on the close relation of *Fudo* (climate) and human culture. He stressed location as a major factor influencing the culture of a society. He did so because he found that European philosophers usually over-valued time and underestimated location (Watsuji 1935). I readily agree with him. From the European perspective, every *topos* keeps time on an absolutely single and linear time axis. Even Levi Strauss, for example, who appreciated the diverse achievements of various wild communities, is not free of this perspective. He writes, 'It is not so much their vegetation which testifies to their identity as minor architectural details, and the suggestion of a way of life which gives one the impression that, instead of covering vast distances, one has moved back imperceptibly in time' (Levi-Strauss 1955, translated by Weightman, J. and D. 1974). The current time of one location is the past of another. All *topos* are arrayed on a single time axis that starts from time immemorial and dashes forward to I wonder...to the last judgment? The linear time axis is as such a convenient tool for displaying facts in books, museums, companies, governments, historical time tables, atlases of the world, geological events, and stock market curves. This is because time seems to be the only independent variable in the universe incapable of dispute.

On the other hand, Asian philosophers, as well as ordinary people, have measured time by life. Each step of sprouting, booting, flowering, fruiting, and withering reveals the ticking of the clock in a unit cycle for a plant. Birth, growing, maturing, ageing, and death are counted in the same way in a unit cycle for a human. Were it not for the tradition of respecting the homology of different living forms, the Asian way of perceiving time would be similar to the West. However, because the animistic tradition has persisted here in Asia (the reason why should be really one of the major research topics for area study science), the different life cycles have been equated and this sensitivity led to the perception of cyclical time with different pitches and wavelengths. This is a biological time concept, while that of the West may be called a physical time concept. In the biological time concept, time is not an abstract and invisible quantity which measures the movement of inanimate objects, but it is an organic and visible scale embodied in the steps and cycles of living forms. Time of immeasurable length is perceived as condensed and crystallized in a life form. And, a *topos* is filled with an innumerable number of lives which make up an exquisite natural system within a subtle homeostasis.

Chapter 19 discusses chronome analysis, ageing and disease, that seems to challenge the unilateral dominance of the physical time concept. The authors of the chapter study the cyclic phenomena of living organisms, particularly the variability of the human heart rate, and find circadian (24 hour cycles), circannual (annual cycles) and circaseptan (weekly cycles), variations that change with growth, maturation and ageing. Of these cyclic components, the authors focus on the circaseptan cycle and find a close correlation with geomagnetic disturbances which occur about every 6.75 days. The discovery that newborns of several species have a weekly cycle led to speculation that primeval organisms on the deep sea bottom would not have responded to a light and darkness cycle but to a geomagnetic cycle. This led the authors to propose the importance of the geomagnetic environment in the make-up of physiological chronomes (clock genes) in all life forms. An interesting idea with regard to these findings is the suggestion that there is a different modulation of the circulating melatonin (a hormone governing bio-rhythm) in the middle latitudes and high latitudes: photic and non-photic effects in the former, and non-photic effects in the latter. This study seems to imply that the chronomes in life forms have formed by taking in the cosmic pattern as well as the location-specific components. My hypothesis that the clocks in *topos* tick in a cyclical time with a different pitch may conform with this concept on the make-up of the bio-chronome. The biological time concept needs to be resurrected to demonstrate how important it is in appreciating and conserving the essential value of each *topos*.

Interestingly, the ecological destruction has rebounded through various movements in the world to close the vast gap between humans and the environment and by relying on the traditional belief in life and nature. For example, innovative ecological movements such as the Greens, Greenpeace, and the Friends of the Earth have various theses, such as deep ecology, social ecology and the rights of nature. More moderate and institutional measures have been pursued by world leaders through conferences, such as the Stockholm Conference on the Human Environment in 1972, the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992, and Rio 10 in Johannesburg in 2002.

Although Agenda 21, transactions from the UNCED, proposed a plausible catch-phrase for sustainable development and resulted in many treaties, the steady degradation of the environment still proceeds. At the Rio Conference someone commented: 'Forced poverty is the real cause of environment destruction. 1.1 billion people in the developed countries have 82 per cent of the world's wealth, and the other 3.4 billion people barely survive with the rest. If this extreme unbalance is not rectified, 'sustainable development' remains just casual dogma.' The unbalanced distribution of wealth has been widened tremendously with the current inflated economy in the US. The US rejected the Treaty on Biological Diversity in Rio, and even while creating 20 per cent of global gas emissions, they stepped out of the 2001 Kyoto Protocol - widely considered to be an ineffective framework for avoiding the 1 to 3.5℃ rise predicted by the end of 21st century (IPCC 2001). Global warming is perceived as a controversial issue. Some opponents deny the fact that warming is occurring and claim that greenhouse gases have no effect. Many on the industry side of the debate, however, claim that the hypothesis is plausible, but forget or neglect that the environmental issues have triggered dissatisfaction among the oppressed majority and continue to pollute the air and water, further exacerbating the gap between the rich and poor.

The same context applies to the relationships among different *topos*. Developed states have claimed manifest destiny and entrusted themselves to manage nature and civilize the periphery of the world. The abuse of nature is seen as progress and the modest life refraining from greed has been rejected as inaction and laziness. Such postures and deeds have caused huge conflicts which affect the various *topos*. The world is made up of innumerable diverse *topos*. To treat all *topos* with a single dose of 'sustainable development' or 'the modern way' displays the arrogance of centralism.

The diversity of *topos* testifies to how local communities have sustained their use of resources by depending on a homeostatic balance in nature. They have elaborated a subtle and effective system of ecological knowledge to coexist with nature and neighboring communities. Although indigenous and traditional ecological knowledge has attracted the attention of the Western world recently, the people of the so-called 'third world' have been talking about this for generations through an oral tradition; for instance in classical works, tales and poems, and in practical works like farming, fostering of forests, livestock rearing, gardening, house building, and in all of the details of the livelihood. In the current context and for the benefit of the IUCN (International Union for Conservation of Nature and Natural Resources) and the Brundtland Commission, I will refer to indigenous knowledge as 'traditional ecological knowledge' (TEK). Several indigenous communities have compiled their TEK and clarified their concept of TEK as well as their reflections on scientific ecological knowledge (SEK).

I introduce here just one of them, taking up Nuu-Chah-Nulth, one of the First Nations on the Vancouver Island of British Columbia, Canada. (Clayoquot Sound Scientific Panel 1995). They state the basic perspective of their TEK in clear phrases, demonstrating the wide extent of essential ideas that are the same in the Asian tradition. First, they declare their firm belief in 'oneness'. 'Nothing is isolated from other aspects of life surrounding it and within it. This concept is the basis for the respect for nature that our people live with, and also contributed to the value system that promotes the need to be of thrift, not to be wasteful, and to be totally conscious of your actual needs in the search for foods.' Therefore, the concept of resource management is paraphrased in this consciousness of interrelatedness. 'Respect is at the very core of our traditions, culture and existence. It is wise to respect nature. Respect the Spiritual. It is inhuman to over-exploit. Never harm or kill for sport. It is degrading to your honor. Nature has that shield or protective barrier that, once broken, will hit back at you.' The legitimacy of private ownership (*hahuulhi*, the system of ownership, control, and resource use) (not proprietorship!) of a territory is derived from the correct practice of using interrelatedness and respecting all life. 'Embedded within the *hahuulhi* initiated from the chief's rights to, and ownership of tribal territories, lie the key to the social and cultural practices, tribal membership and property ownership, economical, environmental and resources controls to promote effective enhancement levels to sustain life for the tribe today and for generations to come.' The major feature of the TEK perspective is thus, holistic, intuitive, qualitative, spiritual, non-linear, based on long-term observations, and passed on intergenerationally by oral tradition. Comparative reflections on the Western perspective and the SEK indicate the indigenous people's sensitivity. As for the holistic view on TEK and SEK, the Nuu-Chah-Nulth state: 'Whereas the western world view may recognize holistic subsystems within the universe, yet may act as though reality is not necessarily made up of related or connected parts.' They, the Nuu-Chah-Nulth, interpret the cause of the difference as follows: 'While TEK holds the oneness principle, SEK, and because of the primacy of repeatable experiments, any single experiment must sever and ignore some natural connections.' And, what follows is 'while the recipient of traditional ecological knowledge is an integral part of the system, the researcher of SEK is deemed to perform best when attempting to behave objectively and as a dispassionate observer of the system.' Difference in the observation time length is noted. 'In Clayoquot Sound (the territory of the Nuu-Chah-Nulth), SEK is based on experiences that have lasted for less than one-tenth of the lifetime of the dominant trees in the forest. The collectively shared experience of the Nuu-Chah-Nulth, on the other hand, reaches far back into history, passed on by centuries of oral tradition.'

Well, I have explored the details of far-flung locations. Coming back to Asia, a few chapters on TEK and eco-technology are collected in Part Four. Although few, they are supplemented by the relevant chapters and discussions in the other Parts. Given the present situation of our network and the current trend on the environment and development in Asia, the editorial committee thought it proper to focus on ecological destruction, health, and development. But, as introduced briefly above, the TEK study is one of the promising topics for clarifying the ecological homeostasis of the *topos*. In the future, I hope we will be able to compile a book on the TEK based on long-term observations *in situ* not only in Asia but also in Africa and America.

Toward the end of his life, the late emeritus Professor Imanishi Kinsi of

Kyoto University embarked on a new field of learning that he called 'nature study'. This naturalist of encyclopedic breadth was a powerful excavator who destroyed fort walls and trenches. He started as an entomologist and biologist, then developed into an ecologist, primatologist and natural philosopher, proposing his own unique antithesis to Darwinian evolutionary theory. He was also well-known as an alpinist and explorer. He criticized the disciplines of the natural sciences claiming they were compartmentalized and distanced the observer from what was observed. They were experts in a single discipline, having a partial rather than a holistic knowledge of nature. In comparison, he viewed artists, the religious and even the majority of ordinary people, as open to the whole range of nature and humanity. Reflecting on this vast gap, he worried that the natural sciences might be creating a drugstore of unrelated categories, rather than a genuinely integrated science. What he blamed was not the fact that the traditional disciplines dug themselves into rocky foxholes, but that they did not dare to move out front. He suggested an analogy with the pilgrims climbing Mt. Fuji. There are several sacred sites on the routes where we can command a really majestic view of the mountain and where we feel united with nature. By avoiding the flat, paved route and choosing instead the rugged pilgrim route up the mountain, we can absorb its multi-faceted perspectives and experience Mt. Fuji as a whole.

In my view, area study has something in common with Imanishi's nature study. The aim of this book is to follow the pilgrim route, viewing Asia from different sites and different angles. This is not just another book filled with discrete facts. Each set of facts represents the creation of a firm track across unbeaten ground, through the rocky outcrops and sandy layers which make up the mountain. By climbing step by step, we will command a fresh and grand view of the ecological homeostasis of contemporary Asia.

FURUKAWA Hisao

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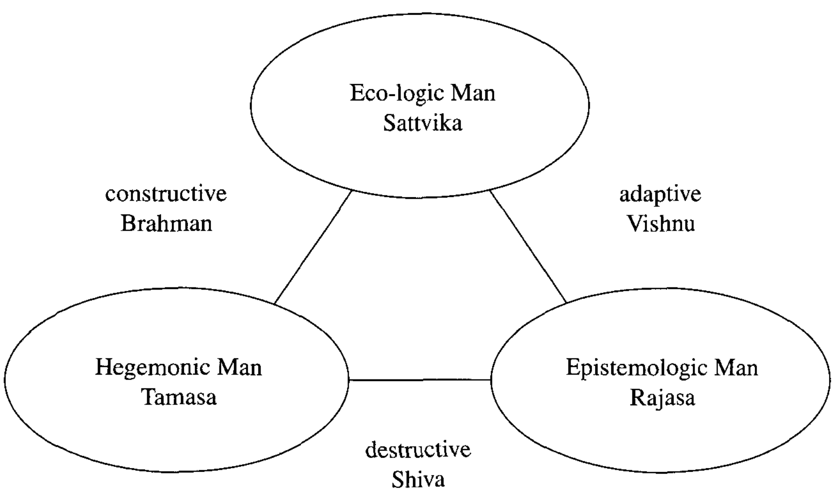
PART 1

Ecological Destruction caused by Modern Technologies

Introduction to Part One

Part One consists of articles that describe actual cases of ecological destruction caused by the application of modern technology. Namely, the large-scale development of peat swamp forests in Indonesia, and the widespread spraying of defoliants during the Vietnam War. These two endeavors have had extensive and long-lasting impacts on the region's natural environment and the health of its human communities. As such, they should serve as stark warnings about the risks of using modern technologies without regard to their potentially negative ecological after-effects. Before introducing the articles, I would like to clarify the conceptual framework used to organize them.

With regard to the way they interact with nature, every human being adopts at least one of three different perspectives, that of eco-logic man, epistemologic man, and hegemonic man (see figure below). Eco-logic man perceives the logic of the ecological environment and behaves in accordance with it. Epistemologic man analyzes the ecology of his environment and utilizes the knowledge gained to transform the environment in order to fulfill his needs. Hegemonic man sets



Types of interactions between man and nature out to conquer the environment, to dominate nature. In my view, these three types can be equated with the three elements of the universe conceived by ancient Hindu philosophers: *sattva*, *rajas* and *tamas*.

The ancient Hindu saints defined these elements as follows. '*Sattva*, being stainless, is light-giving and healing; *rajas* is of the nature of passion, the source of thirst and attachment; *tamas*, born of ignorance, is mortal man's delusion... Knowledge, action, and the doer are of three kinds according to their different elements.... Know that knowledge whereby one sees in all beings immutable entity, a unity in diversity, to be *sattvika*. That knowledge which perceives separately in all beings several entities of diverse kinds, know thou to be *rajasa*. And knowledge which clings to one single thing, as though it were everything, which misses the true essence and is superficial is *tamasa*' (Mahadev Desai 1946. *The Gospel of Selfless Action or the Gita according to Gandhi*, Ahmedabad: Navajivan Publishing House, p.330, 370).

Taking inspiration from this enlightenment, I would like to apply these concepts to the classification of actions. Actions dominated by a combination of either *sattvika* and *rajasa* or *sattvika* and *tamasa* (see the figure below), tend to be either adaptive or constructive. Whereas actions dominated by a combination of *rajasa* and *tamasa* tend to be destructive. In this way, Hinduism's *Trimurti*, the divine triad of Brahman, Vishnu and Shiva, which represents all aspects of the Supreme Being, can also be seen as an expression of the complex nature of man's actions.

Leaving the gods and returning to the secular world, man's actions can be divided into two categories according to their effects on the natural environment, normal actions and extraordinary actions. Normal actions, whether positive or negative, are those that can be absorbed by the natural environment and human society, their effects being transient. Extraordinary actions, on the other hand, are always negative and destructive. Their adverse effects last long enough to appear almost permanent, and they invariably result in upheavals in both the natural environment and human society.

Extraordinary actions, however, can serve a positive purpose by prompting us to examine where exactly our past actions have been at fault. The least we need to know regarding the outcome of extraordinary actions is what exactly happened, what processes led us to take the actions we did, and how we can prevent a repetition of a disaster of that kind. Part One is concerned with this theme and, if Shiva so desires, we will hopefully be able to glimpse the secret of *Trimurti*.

The first four articles deal with the ecological disasters caused by large-scale development of coastal wetlands in Indonesia. They trace the historical processes, features and problems of the transmigration policy, which was at the root of this nationwide development project. Furukawa's article analyzes the causes of the disastrous accretion of vast deltas of pyrite-bearing sediments. It depicts the unfortunate consequences of ecological disturbance and the misery of immigrants, and proposes ways of repairing both the degraded environment and the local communities. He stresses that conventional top-down styles of development do not work in this ecologically sensitive sphere, and that the key to restoration lies in the collective knowledge accumulated by the local people (including immigrants) through decades of observation of innumerable phenomena in the field.

Supiandi's article describes the notorious case of the Mega Rice Project launched in 1996 in the peat swamps of Central Kalimantan. This endeavor, too, resulted in failure and the kind of grave environmental degradation that has repeatedly accompanied similar projects in the past. The vast peat swamp forest, which held immense resources for selective logging, the collection of rattan, swidden agriculture and the hunting of birds and small animals by local communities, was clear-felled. Over-drainage caused by man-made canals resulted in the swift drying and shrinking of the peat, which consequently became tinder for rampant fires. The project's bitter legacies were an unproductive wasteland and conflicts between miserable immigrants and the furious local inhabitants who had been deprived of their land rights.

The next two articles deal with the transmigration policy, which attempted to stimulate economic growth in Indonesia by combining large-scale development with labor resettlement. Sodiono's article, written from a pro-policy viewpoint, reflects on the policy's history, from its origin in the Dutch colonial era to the post-independence transmigration projects. Although Sodiono considers the results of the policy to have been on the whole positive, he also expresses concerns regarding ethnic intolerance and the assimilation of immigrant communities.

Riwanto's article pursues the twists and turns of transmigration policy implementation in successive five-year plans, and investigates the gap between stated aims and actual achievements. Having touched on the ambiguous targets of the policy and discussed the widespread skepticism regarding the official numbers of people permanently resettled, he finally judges the policy "as a national project that failed."

The next five articles deal with the dire consequences of the use of herbicides during the Vietnam War. Nakamura's article vividly and visually depicts the health abnormalities suffered, not only by Vietnamese citizens and soldiers, but also American and Korean soldiers who were exposed to the herbicides used by the US military. The exhibition of his photos in the United States and Korea was one of the driving forces behind the US government's belated apology to, and compensation of, the US Vietnam Veterans. Nakamura makes a heartfelt appeal for the same kind of compensation to be extended to the Vietnamese victims.

Wakimoto's article investigates results of a survey and other forms of research done by Japanese medical doctors in Vietnam and Japan. These doctors found that despite the fact that the dioxine sprayed during the war dissipated rather quickly from the immediate environs of residents, health abnormalities, such as congenital anomalies and birth defects, continued to dramatically increase in these communities. In fact they did not peak until the 1980s, when, in some parts of Southern Vietnam, an incredible 30 per cent of all births were effected. Wakimoto concludes that these results are the long-term after-effects of exposure to extraordinary levels of dioxin pollution during the war. He calls for more intensive research into dioxin toxicity, and for greater collaboration in order to provide medical care for its wartime victims.

The next two articles are concerned with the severe and extensive damage inflicted on the mangroves and wetlands of the Mekong Delta. As the dense canopies and root systems of the mangroves offered ideal cover for the Vietnamese resistance forces, and the Mekong Delta operated as a huge rice granary to support those forces, the US Army sought to destroy the delta's ecosystem by spraying it with herbicides. Phan Nguyen Hong's article attempts to comprehensively assess the destructive impact on the ecosystem in terms of timber loss, soil degradation, enhanced coastal erosion, loss of flora and fauna and so forth. He stresses the importance of mangrove reforestation in reducing coastal erosion, saltwater intrusion, and the discharge of polluted water into the sea. With the killing of the mangroves, these destructive forces were set loose and continue today to constitute a threat to the natural environment and the livelihoods of inhabitants of the coastal zone. The article by Tran Triet *et al* analyses a detailed study that compares the effect of herbicide spraying on the four major types of ecosystem found in the Mekong Delta: mangrove, *Melaleuca* peat swamps, grassland, and cultivated lands. The article warns of a significant decline in the diversity of species and a lack of natural regeneration of the mangroves.

Le Ke Son's summary provides a comprehensive overview of the environmental dioxin contamination levels of southern and northern Vietnam. This overview was made possible by the cooperation of many Vietnamese and foreign researchers over a 25-year period. It is based on the results of analyses of over 4,000 samples, including soil, river mud, foodstuffs, breast milk, human fat tissue and blood. Though the contamination level of soil has decreased over the past two decades to below a critical level, Le Ke Son remains gravely anxious about un-surveyed 'hot spots', the sustained higher dioxin levels in fat tissues and blood of residents of southern Vietnam, and the similarly high incidence of reproductive abnormalities in the south. He stresses that while scientific studies designed to elucidate the effects of dioxin on the environment and on human health continue, simultaneous efforts need to be made to help known victims.

1
The Ecological Destruction of Coastal Peat Wetlands in Insular Southeast Asia

FURUKAWA Hisao

The disastrous effects of large-scale deforestation for lumber production on the natural environment have been reported in various regions of the world. With regard to the impact of deforestation on terrain, we can distinguish two different forms of destruction: (1) transient, reversible destruction and (2) plasmic, irreversible destruction. The former refers to changes that do not affect the nature of the terrain itself, though denudation may cause enhanced soil and wind erosion, desertification, flash flooding, changes in micro-climates and so forth. These changes are transient and relatively slow processes that can be halted or reversed if the affected communities take proper countermeasures. The latter, however, refers to the kind of destruction that causes the soil, the most essential element of any particular terrain, to be transformed into toxicogenic material, or to be lost entirely from the surface of the terrain, together with the forest. These changes, once triggered, are difficult to halt or reverse, and the effects on both flora and fauna, and on local human communities relying on these resources and the environment, are drastic and long-lived.

This chapter describes the causes, effects and ways to remedy plasmic, irreversible destruction of the terrain of the coastal peat wetlands of Indonesia, which were targeted for large-scale exploitation under government-sponsored transmigration projects implemented from the late 1960s. This terrain was originally largely covered by dense primary forests that had been partially opened as early as the 19th century by local people and spontaneous migrants from other islands, such as the Banjarese in a first wave of immigration in the 19th century, and Javanese and Bugis in a second wave that occurred in the early and mid-20th century. The immigrants sought to find new ways of subsisting in these frontier lands, and actually succeeded in establishing an appropriate method of opening the coastal peat and tide-affected wetlands for the production of both essential food and commercial crops. The method established by these spontaneous migrants is to fell the peat swamp forest and dig many small canals in a fishbone arrangement from tidal rivers and creeks so as to drain the acid water of the peat-covered coastal plain during low tides, and to flood the land surface by backed-up river water at high tide. This method is referred to as 'tidal irrigation', although the draining the acid water is actually its more important role.

When the Indonesian government selected tidal coastal peat wetlands as one of the important target areas for its transmigration policy, it imitated this native reclamation method, but in its implementation, used large dredges, bulldozers and other heavy earthmoving equipment, instead of human labor and simple tools such as the axes and small hoes (called *cangkul*) which had been used by the local people in their original endeavors. Consequently, large tracts in the exploited areas were provided with a systematic canal network, and were opened very swiftly for settlement. Wide, deep and all-too-straight primary canals were excavated, with branching secondary and tertiary canals also excavated in a regular and orderly way, and land allotments parceled out in a grid-like pattern. Subsidized houses for the new immigrants, complete with home compounds, were also arrayed along the banks of these canals. The result was settlements of a remarkable geometrical beauty when seen from the air, although the burnt remains of giant trees and large stumps still dot the landscape and, in some cases, dense jungle was left in large tracts of fields allocated to immigrants.

When we come down to ground level and take a look at the real situation in the fields created by these projects, we get a very different picture. In many areas, the soil remained moist for the first seven to ten years, and even though tidal irrigation fell far below the estimates provided by public work officials, immigrants were able to cultivate rice in their allocated fields (usually 2 ha each) thanks largely to rainfall, but only barely enough to fill the stomachs of their families. Moreover, the ground proceeded to dry out rapidly, since the beautiful canal network proved far too effective as a means of drainage. What was really needed to reclaim the peat wetlands was the drainage of surface water that is, excess water absorbed by surface soil no deeper than half a meter. But due to the excessive drainage capabilities of the system, internal drainage was accelerated, as a result of which soft brackish sediments below the surface soil were drained and started to dry out.

After less than a decade at any project area, rice harvests started to decline, while other permanent crops, such as coconut palms, coffee and mangos never bore fruit due to the extremely poor nutrients in peat soil and its further degradation through drainage. Moreover, this process triggered another decisive and fatal response: the release of sulfuric acid from the underlying sediments. The thin peat layer that had covered the reclaimed land to a depth of 1 to 1.5 m disappeared through drying, and subsequent subsidence and decomposition, thus exposing the underlying bluish-gray, fine-textured sediment. This sediment, containing many plant remains such as roots, bark and leaves, and featuring many small dark spots, is pyrite-bearing brackish clay. In particular, it develops under mangrove forests and their adjacent tidal flats. Having dried out, the pyrite-bearing sediments start to produce sulfuric acid, and to release it to the root sphere, canals, rivers and tidal flats. On oxidation, one molecule of pyrite produces two molecules of sulfuric acid, and the pyrite content of these sediments is usually 1 to 2 per cent, but sometimes reaching even 5 per cent of the sediments by weight. It is not hard to imagine the fatal effects of such a tremendous quantity of sulfuric acid on all kinds of plants, small soil fauna, and furthermore to fish in the rivers and mangroves.

This sediment, known as 'acid sulfate soil', or 'sulaquent' to soil experts, is given a more down-to-earth name by the local farmers: *tanah mati*, which literally means 'killing soil'. *Tanah mati* has the effect on crops of not so much stunting their growth, but killing them instantly, although death can be mitigated slightly by generally ineffective countermeasures. Even in such cases, total crop failure is eventually inevitable. Many immigrants abandoned their settlements as a result, and even those who remained do not depend on agriculture for their sustenance.

The majority of coastal peat wetlands reclaimed by government-sponsored projects are now, 20 to 25 years after their denudation, in this phase. The former dense forests, which were made up of giant trees, and inhabited by wildlife such as elephants, bears, hornbills and crocodiles, were denuded, and the land was changed to 'killing soil' in what I refer to as a case of plasmic, irreversible ecological destruction.

Coastal peat wetlands

Since the fate of the reclamation projects and the immigrants in the coastal peat wetlands depends decisively on the nature of sediments, I shall first describe the mode of sediment accretion or land-forming processes.

Land-forming processes

Coastal peat wetlands here refer to the lowland coastal plains, whose hydrology is greatly affected either by daily tidal fluctuations of the sea surface in their lowest reaches, or by seasonal fluctuations in river water level in the transitional zone to mid-stream, and possessing a surface peat layer sometimes exceeding 10 m in depth. Peat-covered deltas are distinctly different from the deltas of

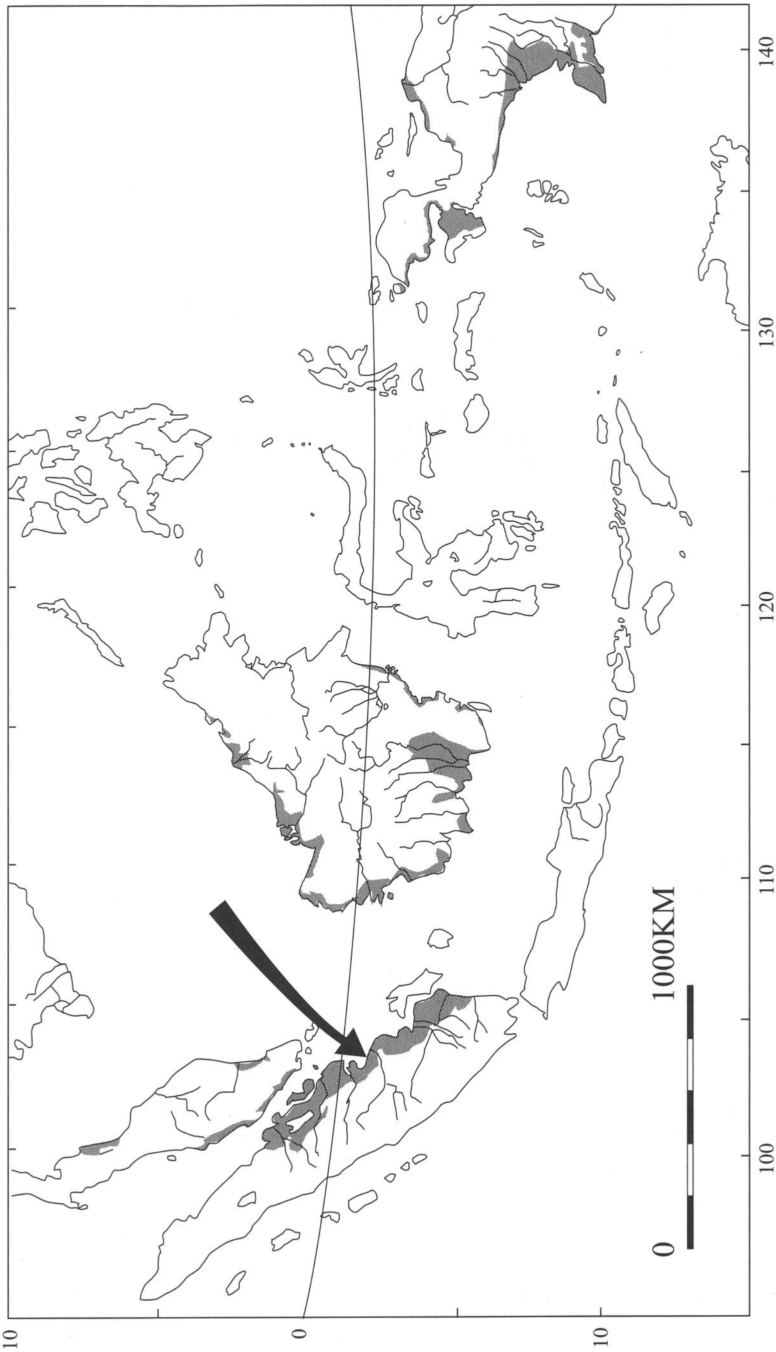


Fig 1.1 Distribution of coastal peat wetlands in insular Southeast Asia (Author's compilation based on FAO-UNESCO Soil Map of the World, 1979), Arrow indicates study site in Fig 1.2.

mainland Southeast Asia. The distribution of coastal peat wetlands in insular Southeast Asia is illustrated in Figure1.1 The peculiar properties of coastal peat wetlands arise from the combined effects of the original topography, the Holocene transgression and regression, and the huge biomass production of tropical rain forests which, in swampy conditions, tend to form peat soils.

There are typically three different kinds of wetlands formed: (1) low deltaic plains which lie closest to the sea, and are strongly affected by tidal action. These are formed through the exposure of pyrite-bearing sediments deposited in very recent tidal flats and lagoons which, ever since their exposure, have been covered by very thin peat; (2) higher deltaic plains at more inland locations, barely affected by tidal action, and formed through the exposure of pyrite-bearing sediments deposited in recent lagoon and tidal flats, which have been covered by thin peat; (3) peat dome plains occupying the most inland or inner areas of the wetlands, formed through the prolonged accretion of peat layers, which reach to a mean depth of 6 to 7 m or deeper, resting on former terraces or semi-recent pyrite-bearing sediments.

For a more detailed description, readers are referred to my earlier work (Furukawa 1994). Here, I provide only a brief account to help in understanding the major land-forming processes.

The most seaward tidal zone (brackish water zone) is occupied by mangrove belts, where saltwater and freshwater mix directly. At high tide, the incoming seawater and the outflowing river water intermix totally from the surface to the bottom. This zone occupies funnel-shaped estuaries and their nearby coastlines. Upstream from the mangrove zone lies a different type of tidal zone, a freshwater tidal zone. At high tide, incoming seawater, because of its higher specific gravity, burrows underneath the outflowing river water in a wedge. Freshwater is pushed upwards as a result, and overflows the river banks, thus enabling the practice of tidal irrigation.

Rivers on the Sunda Shelf are highly tidal, with tidal fluctuation reaching as far as 100 km upstream, causing low-lying terrain to be swampy. Brackish water swamps, such as occluded lagoons, inter-ridge swales and tidal flats, are occupied by mangrove and accreted by pyrite-bearing sediments. Freshwater swamps, such as the saucer-shaped backswamps mentioned by Anderson (1964), are ultimately taken over by a kind of tropical rain forest and covered by peat. Fallen trees, branches and leaves cover the ground, and under swampy conditions, the rate of organic matter addition exceeds the decomposition rate. The excessive addition of organic matter piles up as peat, in this case as woody peat, since the organic matter here is mostly derived from arboreal plants. The deepest peat in our experience is in Jambi and boasts a depth of about 10 m, but others have reported deeper peat in Riau and elsewhere.

The initial phase of deep peat formation is known from our study in Jambi to have started about 6,800 years ago, with peat layers consisting of fern and graminae plants being deposited on compact red and white mottled clay, which without doubt represents the Pleistocene terrace surface. This basal peat is in most cases overlaid by woody peat derived from freshwater swamp forests. This fact demonstrates how one of the terraces which, during the last glacial period, stood high from the lowland of the then dry Sundaland, was converted to swampy ground as the basin became flooded and basin drainage was retarded because of the sea level rise in the Holocene transgression period. The highest sea level was found in our survey to have reached 1.9 m higher than the current level.

In the transgression period, the lower terrain was covered by the sea, and brackish sediments were deposited in the mangrove and the tidal flats of that period. Repeated cycles of rise and fall of the sea surface are suggested by various combinations of stratigraphic structure, such as a peat layer being covered by brackish sediments or the reverse. After the final transgression about 2,000 years ago, the sea level receded, presumably to a level about 0.7 m lower than the previous sea level, and equal to that of the present level. This small change in sea level caused the exposure of vast and level plains of tidal flats, which after their exposure were covered by freshwater swamp forests, producing a thin peat layer overlying the exposed pyrite-bearing sediments. This area is most strongly affected by tidal fluctuation.

To sum up, land-forming processes of coastal peat wetlands of Jambi in East Sumatra are schematically illustrated in Figure 1.2 Almost similar processes have been observed in Brunei as well (Furukawa 1988). It is my hypothesis that coastal peat wetlands of insular Southeast Asia were built up through an essentially similar process.

Miasmic land: shaper of a culture of transience

Highly miasmic, coastal peat wetlands have been utilized by various people, who closely observe ecological conditions for opportunities to exploit particular resources, organize mutually supportive communities, and nurture a culture of transience oriented towards the conservation of the environment. Herein lies the secret of why the reclamation practiced by local inhabitants succeeded, while the later attempts by the government that ignored all these factors failed. It is therefore important to take a look here, however briefly, at the lifestyle and culture of the local inhabitants.

Peat swamp forest

Dense peat swamp forests had covered the land until government-sponsored

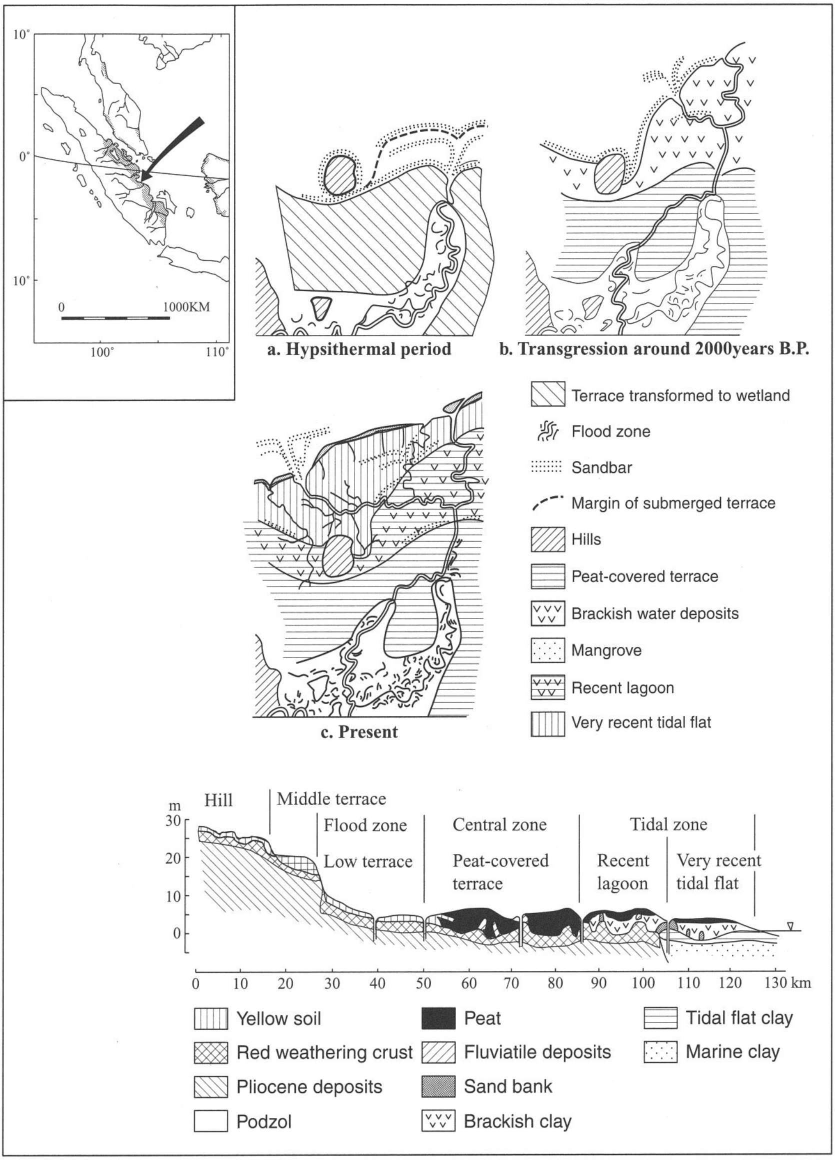


Fig 1.2 Landform and stratigraphy of coastal peat wetlands of Indonesia as modeled for lower reach of the Batang Hari River, Jambi, Sumatra. Landform development (above); Stratigraphy (below)

reclamation projects started to open up the jungles in the 1960s and 1970s. Until these projects, the miasmic environment repelled human intrusion. From my own experience of jungle surveys, the interior of the forest is as I imagine the deep sea bed might be. In the space of about 50 m overhead, several layers of tree canopy overlap, and the little light that reaches the ground is tinged green.

No wind blows in the tightly enclosed forest. Wind blows in the air above the forest, and strong winds at the end of the rainy season sometimes fell tall trees protruding from the forest canopy, but even they do not penetrate the forest. The air is steamy and always supersaturated with moisture. In the mornings, the slight drop in temperature causes a large amount of dew to condense. The whole forest is enveloped in a thick mist, and everything carried by the camper gets soaked.

In these conditions, a profuse growth of moss covers tree trunks. In lighter forest that has been disturbed, stranglers, woody climbers and rattan bind individual trees into a kind of interwoven structure that resists destructive forces.

Sometimes one encounters an isolated clearing, the remains of logging camps, or spaces created by fires or insect damage. Such clearings are slightly drier and do not attract the morning dew. At first they are colonized by herbaceous vegetation, including eulalia, cogon, scirpus, and ferns, and around them pandanuses and rattan are common. Later, *asampaya* (*Salaca conferta*), *palas* (*Licuala* spp.), and other stemless palms spring up. These palms have densely spiny leafstalks and form thickets which are extremely difficult to penetrate. Eventually, however, tree saplings sprout up and begin to grow, and these disturbed areas become covered with young trees.

Biomass is recycled at incredible speed in the forest, fallen trees rotting within a year. Although the harder sapwood maintains the shape of the trunk, the softer heartwood becomes riddled with termite holes and bacteria, reducing it to a red-brown humus. It is not uncommon to find the taproots of saplings penetrating an old fallen tree, young life using the old as a nutrient source, nourishment being recycled directly from one tree to another.

Inside the forest, particularly in the rainy season, the air is thick with mosquitoes. Campers' faces are dimmed by clouds of mosquitoes, and any naked arms and legs soon redden and swell from umpteen mosquito bites. For such reasons, none of the larger fauna dare to come into the swamp forest, although larger insects, birds and monkeys frequent the tree canopy where many kinds of flowers bloom and bear fruit.

Peat swamp forest is really miasmic, but is by no means primeval forest that has never known the axe. It has on the contrary been frequently encroached upon by man. Close inspection of aerial photographs reveals countless lines running through a monotonous texture. On walking through the swamp forest one finds many narrow paths cut for removal of lumber, and there are also many paths trodden by collectors of various forest products.

Traditional resources and lifestyle of local inhabitants

People who collect forest products live in permanent villages located on river banks, river confluences and estuaries, and venture into the forests for short spells to collect forest products. Major forest products include aromatic trees, edible fruits, resin, various kinds of lumber for domestic use, honey and beeswax.

Aromatic trees and resins

Aromatic trees have long been valued for their rarity. Agalloch, known as *gharu* over the whole of Indonesia, is valued as incense. *Gharu* refers mainly to small to medium-sized trees of the genus *Aquilaria*, which are found infrequently in peat swamp forest, while similar essence is said to be contained in *ramin* (*Gonystylus* spp.), which is reasonably abundant in peat swamp forest. Another product is benzoin, known locally as *kemenyan*, and collected as the resin of *Stylax benzoin*, which is still now burned on the occasion of various rituals and ceremonies.

Various resins can be found in the forest. The white latex of the *jelutong* tree (*Dyera* spp.), for example, is commonly collected in the peat swamp forest. Tapping deep into the wood causes a milky sap to seep out which can then be collected. This is done in the dry season, and was once carried out by special collectors from other districts who stayed in temporary stilted huts erected on river banks. Now local indigenous people also collect the sap. Its main use is as a base for chewing gum, for which Singapore is the primary of collection and distribution center of. Large *jelutong* trees, 40 to 50 m in height and more than 1 m in diameter at breast height, are scattered throughout the swamp forest, each invariably sporting the carved initials of a collector.

Damar, a well known resin derived from trees of the genus *Agathis*, is collected either as a mass from a hole cut into the trunk or as a large hardened disc of resin that has been allowed to run down onto the ground. Heated *damar* is used for caulking boats, and also for illumination. Another major use is as an ingredient in paints and varnishes.

Beeswax

Beeswax is used as a mould for manufacturing copper tools through the lost wax method, which is still commonly practiced by local coppersmiths who manufacture small commodities such as a propellers for passenger boats, vases, pins and ornaments.

Nibong and rattan

Two types of tree closely tied to the lifestyles of local residents are *nibong* (*Oncosperma* spp.) and rattan, which are used in large quantities for housing and fish stockades. *Nibong* is a palm which grows to a height of 20 m, but whose trunk never exceeds 15 cm in diameter. It forms pure stands in freshwater swamp forest behind mangrove, which is exactly where the *Melayu* build their aquatic settlements. Cut *nibong* trunks are driven into the soft mud, and halved *nibong* trunks are aligned on top of these to make walkways and floors for raised houses. *Nibong* is also used for the pillars of fishing stockades such as *togok baris*, which are used for catching shrimp by bag-nets in funnel-shaped estuaries, and *togok sarip* which are installed on shallow tidal flats to catch prawn and fish by bag-nets.

Before rubber was developed as a commercial crop, rattan used to be the most important product. Local people had long used it for housing, furniture and baskets; and with Singapore's establishment as a center of trade with the huge markets of Europe, and the setting up of shipping routes by KPM and other companies, demand for rattan has risen sharply. By the start of the twentieth century, 26,000 tons of rattan from the Malay Archipelago, of which peat swamp forests of Sumatra and Borneo produced a major share, were being exported annually through Singapore. At first wild rattan was collected, but the Dutch government later encouraged its cultivation. On the middle reaches of the Batang Hari River in Jambi of Sumatra, cultivation along the river was expanded from around 1906 to 1908, and in the 1920s and 1930s, from 2,000 to 6,000 tons were exported annually.

Local residents of the Barito River in South Kalimantan of Borneo still cultivate rattan in the way established in the Dutch era. Near Buntok, for example, registered owners of rattan gardens possess various sizes of garden in the peat swamp forest. The rattan land is divided into many narrow strips, each 3.5 km long and varying in width from 72 m down to 9 m. The forest is generally a light one of small trees created by the thinning of the tall trees. Ownership rights are established through the clearing of the forest and the subsequent continued use of the land, the customary method in Indonesia's outer islands. Rattan seedlings are prepared from seed in soil boxes floating on the river. Seeds are about the size of maize kernels. About two months after germinating, seedlings are transplanted to a second seedbed, and in one year they grow to about 60 cm. They are then transplanted around the roots of the remaining trees in the thinned forest. At the earlliest rattan is harvested after five years, and more usually after eight. The longest vines attain a length of 300 m. By cutting only the side-stems, a plant can be harvested annually for several decades. The *bungur* tree is particularly suitable as a support for rattan, being strong and having forking branches, and it is often planted for this purpose.

During the Dutch era, almost all rattan was exported to Singapore in its raw state. Today rattan collected along the Barito River is brought to Banjarmasin of South Kalimantan to be manufactured into rattan matting for international trade. The first factory of this industry was opened in 1970 by a resourceful *pribumi* entrepreneur from Amuntai. Through technical collaboration with Japanese buyers, the company introduced various machinery, and by selecting and polishing the raw material, it succeeded in producing a product suitable for exporting to Japan.

Production of rattan matting in 1988 totaled 1.35 million m^2 for the whole of Indonesia, of which this company produced 0.22 million m^2. At the same time, rattan mat factories sprang up across South Kalimantan, and the seventy or so such factories now in operation account for about 80 per cent of Indonesia's total production. This rapid growth has made rattan matting the second most important product of South Kalimantan, after plywood.

Mangrove and nipah

The first mangrove species to colonize the tidal flats of South Sumatra, Jambi and South Kalimantan are *pedada* (*Sonneratia alba*) and *api-api* (*Avicennia alba*), of which *Sonneratia alba* seems to be a real pioneer, extending long roots into tidal flats covered by shallow sea at high tide. These two pioneers put out long spreading roots in all directions, and from these emerge innumerable pneumatophores. About 50 cm in height, with ends like tapered stakes and spongy interiors, these pneumatophores are extremely effective in trapping the mud brought by the ebb and flow of the tide. Branches and driftwood also get caught in this fence of roots. When these two species have built up the tidal flats to some extent, *bakau* (*Rhizophora* spp.) begin to invade. These put down flying buttress roots from high up on their trunks, which branch down into the ground. Their fruits reach over 30 cm in length, and when ripe, they fall and stick into the mud, there growing into new trees around the parent. The result is a scaffolding of roots above the ground, the spaces of which fill with the marine clays brought in by the high tide. As natural land building progresses in this way, *tumu* (*Bruguiera* spp.) and a different species of *pedada* (*Sonneratia caseolaris*) increase on the higher ground.

As the ground becomes even higher and *nibong* palms begin to appear, *nipah* palms can be found forming large colonies on the river banks and side slopes. Their roots are adapted to grip the mud washed by river currents. The roots are gray diaphragm-like discs about 20 cm in diameter overlapping each other on the surface of the mud, and several hundred fine taproots about 10 cm long protrude from the back of each disc to penetrate and cling to the mud. These discs are impressive structures. Packed with hairy fibers, they are extremely light.

The strongly reduced conditions of the mangrove mud together with the plentiful addition of organic matter favor the fixation of sea water sulfates as pyrite minerals, which on drying of the land releases sulfuric acid, and changes the whole tract to 'killing soil'.

Local residents use the mangrove as it is without causing the destructive degradation of the land. The major use of mangroves is to produce charcoal using simple earth kilns. Mangroves also provide suitable poles for fishing stockade stakes, which are needed in large numbers, particularly in the case of *togok sarip* mentioned before and *belat* described below. Since these are invariably installed near mangroves, it is easy for fishing people to procure such materials. Mangroves also play an important role as feeding grounds for sea fish during the high tide. Once the ebb tide begins, fish leave the mangroves. This behavior of sea fish is utilized by fishermen who practice *empang* fishing, otherwise known as *belat*. This fishing method is practiced immediately in front of the mangroves, where a long net is set in a triangular form. The net has long wings of several hundred meters on both sides leading from the mangrove and funneling into a trap. At high tide, when the net is under about 1.5 m of water, fish go shoreward unhindered by the net and enter the mangrove in search of food. At low tide, however, the net projects above the water, and fish moving seaward with the tide are led into the trap.

Leaves of the *nipah* palm are utilized for making *nipah atap*, which is one of the essential materials for thatching roofs and making the walls of traditional local houses and huts in the fields and on beaches. The cut leaves are soaked in brackish water for a while, then dried and plaited into *nipah atap* of about 1 m long and 30 cm wide.

Sago

Because sago palms (*Metroxylon* spp.) favor swampy and submerged lands and also resist brackish conditions, they frequently occupy flooded sites along tidal rivers just behind *nipah* palms. Sago starch, washed from the pith inside the trunk, used to be an important food for local residents throughout the coastal wetlands of Indonesia. Even now, sago starch is an important product along the tidal rivers of Riau, South Kalimantan and, to a lesser degree, in Jambi, South Sumatra, and West Kalimantan. The simplest way of washing sago starch, which is practiced in South Sulawesi and Maluku, is to cut the trunk into halves, hack out the pith with an axe, and knead it by hand with water on a trough of sago leaf sheath. The starch water pours through a sieve made of sago hair into a small vessel, where the white sago is separated from scum and pith fiber by simple decantation.

If sago starch is being produced as a cottage industry, a somewhat improved method is employed. Sago palms are transported as convoys of rafts to a simple stilted hut built on the riverbank. First the trunks are cut into eight pieces, then the pith is grated by a small machine which consists of a small engine turning a drum into which nails have been driven. The grated pith, which looks like white sawdust, is loaded into a basket of coarsely woven pandanus leaves, which is placed on a raised platform above the water. There, water is added and the pith is trodden, causing a milky suspension of starch to be squeezed out through the holes in the basket. This falls through the platform into a boat-shaped vat anchored in the river. The starch is then allowed to settle, and the supernatant liquid discarded. Water is ladled into the settled starch, which is gently but thoroughly stirred by hand. After settling overnight, the suspension separates into two parts, with white starch below and black starch containing many fibers above. The white starch is sold as wet sago, or as dry powder after sun drying.

Selatpanjang of Tebingtinggi Island, and Mandah district near the Indragiri estuary of Riau, East Sumatra, have long been famous for small cottage industries of this kind. One drawback of this method is that it cannot be employed in the rainy season. An overseas Chinese who inherited the factory opened by his grandfather along the Kateman River near Mandah invented a device that may represent a breakthrough in the drying process. He built a 16-meter tower and installed a drying furnace that blows wet sago skywards by creating a powerful wind through a long draft pipe. On the top of the tower, he installed a separator that separates sago from the updraft. The dry sago powder falls down to a collecting vessel placed at the foot of the tower. After several years of trial and error, the owner completed the device, a veritable factory in fact, in 2000, and now produces dry sago powder throughout the year. In the inland swamp behind his factory, he has a sago palm garden of 800 ha, where sago palms of different ages are growing. Sago palms are usually harvested at the age of ten to twelve years, before flowering. Dry sago powder is sold to merchants in Cirebong of West Java, from where it is distributed throughout the country.

Gelam trees

Gelam (*Melaleuca leucadendron*) forest develops as a secondary forest on degraded swampy land. When swamp forest is repeatedly cut and burned for shifting cultivation, or reclaimed for wet rice culture in inappropriate ways and then abandoned due to the toxicity of sulfuric acid, as observed in the government-sponsored reclamation project, *gelam* eventually takes over sole possession. *Gelam* can resist long submersion in the rainy season, when its long white roots extend into the water. Because of the high density of tree stands and abundant roots choking the space between trees, *gelam* forest dams up water and functions as a water reservoir. *Gelam* water reservoirs are sometimes used by local farmers as water sources for flushing paddy fields of their toxic acidity. (I will return to this topic later).

Gelam poles are also important for stabilizing the foundations of concrete buildings and roads in swampy areas where the ground is usually soft mud. A large number of *gelam* poles of 4 m in length are driven into the mud, sometimes in double layers.

Lumber

Before the Second World War, lumber was cut mainly by local residents for the construction of stilted houses and for boat building. The vast swamp forest of the coastal peat wetlands of Sumatra accordingly remained relatively intact, except in some districts opened up by Banjarese and Bugis, and those in South Kalimantan where reclamation was started by the Dutch government in the 1930s. Large demand for tropical timber arose only after the 1950s, when the economic reconstruction of developed countries was accelerated.

When local residents exploited the forest, they of course practiced selective logging, selecting trees for different purposes, such as timber for pillars, wall boards, roof tiles, fine timber for making doors, hardwood timber for boat keels and hulls, and cutting everything with a hand-saw or axe. Lumber was extracted by two method, either by floating logs on small dug canals, or pulling logs on a sled on wooden rails (*kuda lalas*).

In the 1970s, after the start of the government's land reclamation projects, logging flourished throughout the coastal peat wetlands, with a large number of large sawmills and plywood factories run by big companies springing up here and there. These companies acquired HPH (*Hak Pengusahan Hutan*, logging rights), land concessions or purchased them from other HPH owners, and proceeded to clear-cut forests slated for reclamation projects. Big companies installed railways and used fairly big locomotives to carry lumber to river ports. Heavy bulldozers were used for clear-cutting of the forests, and project areas were completely denuded, but the impact of this lumbering was not limited to the project areas themselves. Local residents watched these crude methods and encroached on the remaining forests. In many districts, the number of log traders increased ten times and more, and some of them, imitating the modern but crude technology used by the big companies, built railways into the forest and used small locomotives to extract the lumber. However, they still followed the traditional practice of selective logging.

Since the turmoil of 1998, peat swamp forests remaining in deep peat plains which had been excluded from government reclamation, have started to be exploited. Firstly, big companies have moved into these remaining resource-rich areas, and have again clear-cut the forests for their lumber, and have converted several hundred thousand hectares into acacia, oil palm, coconut and other plantations. Secondly, local communities have again been motivated by this modern but crude concept of logging. During the recent turmoils and inflated economy, many more sawmills sprang up. These small sawmill owners have no heavy machines for felling trees, instead they exploit the plentiful cheap labor offered by immigrants of government reclaimed areas. Since their allocated land yields nothing due to toxic acidity, these immigrants search for jobs outside the reclaimed areas, and they represent a huge pool of potential cheap labor.

This situation gave birth to a new method of lumber extraction, one that utilizes bicycles. Sawn timber cut by chainsaw in the forest is tied tightly to bicycles, which are pushed on two rows of planks to the riverside camp. Laborers ride the bicycles along the plank trails to return to the logging area, making for an incredible sight, since one doesn't expect to see bicycles racing through peat swamp. This method is cheap, easy and speedy. Lumber stocked at riverside camps is transported as convoys of rafts to nearby sawmills. Where roads are available, trucks are used. It is not rare to see trucks with Jakarta license plate numbers being loaded on the roadside with timber extracted by bicycle from the peat swamps of Central Kalimantan.

Another critical feature typifying the turmoil after 1998 is that lumbering without HPH or any kind of permission is tacitly approved. While it is of course doubtful whether HPH has exerted any significant positive influence on forest resource conservation, it did at least provide the basis for orderly interaction between local communities and companies and between man and nature. Now, however, many local loggers openly say that the HPH system is finished and it has been replaced by a cut-and-run system. Others insist that autonomous communities should not require any permission to harvest their crops. Such views represent muted criticism of a new but incomplete system of autonomy, which appears to guarantee the proliferation of the vested interests of local elites rather than the welfare of local inhabitants as a whole.

Whoever the actors may be, they are not concerned about the fate of the coastal peat wetlands, which are doomed to suffer plasmic, irreversible destruction under the present framework of exploitation by modern technology.

Culture of transience

I have already described how the traditional pattern of land use in the coastal peat wetlands has been degraded. The disorder has reached a level of veritable frenzy in the last decade. Before continuing to trace the processes behind this transformation, I would like to submit a brief overview on transitory land use and the culture of transience fostered its use.

Coastal peat wetlands constitute the core of the miasmic lands that are distributed extensively throughout the tropical rain forest area of the outer islands of Indonesia, the latter being known collectively as the *Melayu.* Living in such a unique environment, *Melayu* inhabitants practice a unique form of land use that is clearly illustrated on comparing the *Melayu* world with Java. In Java, with its savannah climate, rich volcanic soil, and spring water on the volcanic slopes, sedentary types of agriculture have been practiced from time immemorial. Wet rice farming was rapidly established on the foundations of existing tuber cropping. Java's land is such that the more one plows the soil, builds bunds and digs canals, burns the stubble and otherwise works the land, the better it becomes and the more rewards it provides. The same is true of Java's natural forests, which have long ago been almost totally cut and replaced by palms and fruit trees. Almost all of the trees and forests of Java, whatever they may be, are artificially planted ones. Such is the nature of Java's soil, which is solid and substantial enough to allow for sedentary settlement.

The reliefs at Borobudur, Candi Jago and elsewhere depict gardens and fields burgeoning with fruits and crops. The surplus wealth they produced enabled the erection of innumerable cultural edifices, such as temples and palaces. Settlements became concentrated along the rivers and coasts and on volcanic slopes and terraces.

The *Melayu* world is different. With its dense cover of tropical rain forest and concomitant rain forest climate, it was not suited even to tuber cropping, and thus it remained a frontier. Opening farmland there mean clearing the giant forest trees. Even after this effort, weeds flourish and within a few years secondary growth of shrubs cover the ground. Maintaining permanent upland or paddy fields requires a vast amount of labor, and the environment is accordingly better suited to swidden agriculture. Land use has therefore tended to be transitory rather than continuous, taking advantage of one phase of the forest transition cycle.

Furthermore, coastal peat wetland consists of peat and acid sulfate soils. If treated in Javanese fashion, the whole of the peat swamp becomes an illusory land, an apparent mirage floating on the Sunda Shelf. Plant remains that should rightly have disappeared are, strangely, still temporarily present. When the land is drained and fired, it burns up completely. When it is tilled it gradually disappears, so tillage is taboo. In Java, soil that is being cultivated does not disappear. Moreover, brackish sediments of the tidal zone, even if they do not disappear when drained and dried under reclamation projects, have a built-in toxicity. Once the fragile balance between oxidation and reduction that was preserved in the wetland begins to tilt towards oxidation, poison is generated at a stroke, and the whole land becomes sodden with sulfuric acid. Behind the land's verdant appearance lurks a demon that may bare its teeth at any time. Because of these conditions, the wetlands have long been preserved as a largely inhospitable wilderness. However they have been exploited as well, albeit in a way that has not caused destruction or the disappearance of the ecosystem itself. Rather, an ingenious, transitory form of land use has been practiced involving the gathering of animals and plants peculiar to the locality.

Exploitation of the forest is impossible with clear cutting. The traditional swiddening involves a mix of tall forest, secondary forest, and arable land, each yielding its own special products. This approach was also adopted by the lumber companies who, as a rule, practice selective logging. The Banjarese and others who have reclaimed land in the tidal zone (to this I will return) have totally cleared certain areas, but at least they have planted coconut, coffee, rubber and similar crops, replacing the inhospitable wild forest with a controlled plantation forest.

Transitory land use also produces wealth, which is generated by sending the products of the wilderness out through far-reaching trade networks. Temples, palaces and other cultural edifices have been built as a result, but because of the continual shifting of the nodes of the trade networks, these monuments have been scattered rather than concentrated in any particular location. At the same time, there was no expansion or accumulation of infrastructures for production, such notions never having arisen in the *Melayu* world.

Melayu land use extends beyond the bounds of the creation of landscape. At the core of the *Melayu* culture is a pattern of behavior based on the concept of movement and transience which has created this form of land use. A major aspect of the culture of transience is the concept of being satisfied with a livelihood that conforms to the capacity of the environment, both in production and disposal, and, as such, the culture of transience contains an important message for the modern world. Its essential strength lies in the fact that production is based on gathering in the forest and the shallow sea, and represents conservative exploitation of the ecological environment.

Through close observation of the environment and its reaction to human intervention, Melayu people learn consciously or unconsciously the laws governing the ecological environment, which are the result of the most intricate interactions among living organisms. In other words, indigenous communities of the Melayu world have acquired one of the most truly 'eco-logical' perspectives on the interactions of the natural environment of any of the world's peoples.

Geographical factors peculiar to the *Melayu* world, particularly its being an archipelago located on east-west sea routes, have caused it to acquire two important attributes. Although *Melayu* has never boasted any large towns, it sometimes seems as if the whole *Melayu* world is one single town, a maritime metropolis spanning the sea. I have known many *Melayu* elders who have moved within this maritime metropolis frequently, showing little hesitation at changing jobs and moving from place to place; for example, the leader who established the settlement of Simburnaik in Jambi's Berbak Delta of east Sumatra was born in the limestone hills of Bone in South Sulawesi as a farmer's son. Accompanying his parents he moved to Johor, then to Tanjung Balai, and then Sungai Trafu opposite Sungai Tungkal in Jambi where his parents acquired a small coconut garden, after which he moved to Pulau Kijan in Riau, where his parents passed away. He worked as a middleman for fish, and sometimes engaged in 'private trading' (smuggling, from the viewpoint of government officials) on Singapore-bound routes, and then moved to Kampung Laut in the Batang Hari estuary. Having accumulated some capital through similar jobs, in 1956 he used it to open up the swamp forest along the Simburnaik Creek. The successful development of farmland allotments made him a big landlord, and in 1989 he started a rice mill. Although this kind of constant changing of locations and jobs is quite common, as someone who has visited these places and is well aware of how remote they are from each other, I find myself nevertheless astonished at the extent to which such distant frontiers are linked through various networks

One more feature of *Melayu* culture is its heterogeneity, its incorporation into the open maritime metropolis of peoples from far and wide. Second-and third-generation Arabs from the Hadramaut coast of Arabia are today found in all areas, and descendants of Chinese immigrants have penetrated as far as small fishing ports. Such diaspora have even created sultanates in various regions and have local power. The founding myth of the Jambi sultanate tells of such a process. This began in the mid-fifteenth century with the marriage between a prince of Constantinople, who drifted ashore at Berhala island in the Jabung Sea, and Queen Purti Pinang Masak, who lived at Cape Jabung. One of their four children, Orang Kayo Hitam, is said to have gained independence from Java and brought the local powers under his control.

The relationship between the local leader and his subordinates is, interestingly, not an oppressive one that concentrates power in the hands of a single totalitarian leader. Rather, it is symbiotic. In this miasmic terrain, populations are small, and arrogant and dictatorial leaders would not be able to attract followers. The symbiotic relationship between leaders and their followers is, moreover, not institutionalized, being rather the kind of relationship that exists between two parties because it brings benefits to both, and in this sense, the two parties are basically equal. I call this '*Melayu*-type symbiosis', a genuine form of democracy that is more substantial than rigid institutional democracy.

It is in fact reasonably common for the pivotal relationship behind production in the everyday arena not to be institutionalized, and this seems to me to be the very essence of a culture of transience. Because it is not fixed, symbiosis begins with a chance encounter and guarantees equality for the parties involved. It is a flexible relationship, and the networks linking people do not capture and confine them, but rather provide them with passageways that facilitate movement and interaction.

Such are my views on the relationships between the ecological environment, traditional life style and nature of culture in the coastal peat wetlands of the *Melayu* world.

Large-scale reclamation of coastal peat wetlands

Reclamation of tidal zones by local inhabitants

The basic concepts of tidal zone land reclamation and its execution were established by local inhabitants. Haji Abu Bakar, the former village head of Kampung Laut in the Batang Hari estuary of Jambi Province, explained this to me by saying that land reclamation was established by the joint efforts of the Banjarese, who designed the reclamation process, of Javanese, who dug canals, and of the Bugis, who provided funds and spread the practice throughout Indonesia.

Background of the Banjarese design

In the tidal zone, the most seaward part of the wetlands, land reclamation depends on the digging of drainage channels inland from tidal creeks. These allow advantage to be taken of the large tidal range to drain toxic water and practice tidal irrigation. Tidally irrigated paddy fields have the merit of easier weed control than the traditional swiddens, and they can be planted every year continuously. This reclamation design is effective not only for rice, but also for upland crops such as coconuts, coffee and rubber.

Though its origin can be traced back at least 2,000 years to south China and North Vietnam, this design was revived for the reclamation of tidal zones of peninsular Malaya in the early 19th century. Large numbers of Chinese migrants settled in Singapore and various Malay states, and they promoted the cultivation of sugarcane in the wetlands of Wellesley, Johor and other provinces in the 1840s, digging ditches specifically for drainage around newly opened land. The European planters who followed the Chinese discovered that the large tidal range facilitated drainage, and the sugarcane could be transported cheaply through the canal network.

This design was then adopted by Banjarese who had fled to the peninsula from Banjarmasin to escape a system of compulsory labor imposed by the Dutch government. At first they moved to Singapore or the Malay Peninsula, and while some settled there, many moved on to Inderagiri Hilir on the east coast of Sumatra. These Banjarese immigrants started to open the swamp forest there in the 1880s.

In Banjarmasin, according to Haji Idak, a Dutch era official in charge of paddy field improvement, the development of the tidal zone was prompted by the construction of the Ulin road linking Banjarmasin with Martapura on Borneo's southeastern plateau. The borrow trench alongside the road functioned exactly like a drainage channel along the edge of the tidal zone, and drainage of the wetlands progressed. The peasants of the upper villages who had worked on the road's construction began to plant rice on the land that had been cleared on both sides of the road. It became known that, drained of the acid water derived from the peat, the wetlands could become good agricultural land.

Almost immediately, the land flanking this road in the tidal zone was planted with rice, coconut palms and rubber. However, belts of deep peat did not drain steadily but remained as wetland, and from this difference, many people realized that the parts of the tidal zone with thin peat could easily be improved by digging drainage canals. Peasants accordingly began opening land at right angles to the ditches alongside the road. Land was divided into plots with frontages of 50 m and stretching back about 250 m. New arrivals extended the existing drainage canals and secured land for development.

It should be noted that on the newly opened lands of the tidal zones, the peasants first planted coconut and rubber. However, when the prices of rubber and copra began to fall in 1928, they immediately cut and burned these trees. At this time, the peat layer was burned along with the trees, resulting in the exposure of the underlying clay. Conversion to tidally irrigated paddy fields then progressed rapidly.

By 1935, peasant-initiated land reclamation had reached the Pulau Petak Delta to the west of Banjarmasin, with the predecessor of the present Jerapat canal being dug in 1928 and paddy fields opened. Prompted by the peasants' activities, the government carried out two major improvement works in 1935. One was the excavation of a trunk drainage canal from southeast of Banjarmasin to the Aluh-aluh River. The other was the widening, dredging and extension of the peasant-dug canal in the Pulau Petak Delta through to the Kapuas River. This reclamation work evolved into the Kolonisasi project that was started in 1938 with the idea of exploiting the tidal zone for reclamation by migrants. I will touch on this briefly later.

Transfer of reclamation design to Sumatra's east coast

Those Banjarese who migrated from Banjarmasin to Sumatra's east coast started to reclaim the tidal zone exactly in the same way as in Banjarmasin. Firstly, the tidal zone of the Inderagiri River became the focus of the reclamation in the late 19th century. Almost all of the suitable land was reclaimed by the early 20th century, and then the focus shifted to the tidal zone of the Tungkal River in Jambi Province in 1910s. I will examine the development of the area, taking Kuala Tungkal as an example, and making use of the account provided by Haji Masuda, a former sub-district head.

Haji Masuda's father accumulated some capital working as a lapidary craftsman in Banjarmasin, and in 1914 migrated to Kuala Tungkal. The area was virtually all forest, with only a fishing settlement built by a few *Melayu*.

Reclamation for cash crops

At first, land could be reclaimed freely, and migrants navigated upstream from the estuary until they found a site with many *tumu* trees (*Bruguiera gymnorrhiza*). The presence of *nibong* palm was also a good indication of suitable terrain. They cut the forest and dug canals of 1 m wide by 1 m deep. Reclamation was carried out by groups of several people, within which sanctions were established to reinforce group cohesion and discourage members from dropping out. Plans were made for the cooperative digging of a canal, called *parit konsi* or *sewa*, running for a distance of 150 *depa* (one *depa* equals 1.8 m) from the river, and land along the proposed canal was distributed by lottery in parcels of about 2 ha, with frontages of 50 *depa* and lengths of 150 *depa*. Canals were arranged parallel and 400 m apart from each other. Within three months of the land distribution being decided, each member of the group had to dig the canal fronting his allotment and if he failed to do so, the canal headman would transfer the land to someone else. Even when the digging was done, the same punishment awaited those who left the forest untouched for more than six months. Anyone who failed to clear his section of canal within one month of notification had to pay an indemnity. If he did not pay, others could harvest his crops.

The main aim of the reclamation was the creation of cash crop gardens, but the newly opened *huma* (reclaimed land deep in the forest) was planted with rice and other cash-crops, coconut palms in this case. Rice could be planted for three or four years until the palms formed a canopy, after which the land became a coconut plantation. In this way, reclamation proceeded gradually inland. At the start of reclamation, the *jelutong* and rattan that could be extracted from the forest was an important source of income, and people went to Singapore every month to sell it.

Rice cultivation

Virtually the same method of rice cultivation was practiced at the time of settlement as is now. Essentially it is a kind of traditional wetland rice cultivation combined with tidal irrigation. Its main features are multiple transplantings, no tillage nor plowing for field preparation, and tidal irrigation. I will describe it briefly.

In December, many first-stage nurseries are built around sedge fields. These are raised on benches to prevent plunder by rats. Germinated rice seed is scattered on a thin layer of mud spread on *nipah atap*, and the whole is covered to keep birds off. The first transplanting is done after ten days. Seedlings are peeled in a mass from the nipa matting, rolled like bedding, and carried to second-stage nurseries in the main fields. Here they are transplanted in clumps a few centimeters across into holes made with a dibble, and left for about one month. When there is little rain, they are transplanted as upland seedlings.

Preparation of the main fields in the sedge plain also begins in December. Major tools used here consist of only two implements; the *parang*, a cleaver with a blade about 60 cm long, and the *tajak*, a scythe that is swung like a golf club. These are used to cut the grass and other vegetation in the fields. The cut vegetation is piled up as round or elongated mounds, which are from time to time hacked with the *parang* and turned upside down to accelerate their decomposition. Once they are completely decomposed, they are spread on the field.

When land preparation is completed, the seedlings from the second-stage nursery are 'stick-transplanted', with a dibble being used to punch holes in the earth, after which a seedling is inserted in each hole. Older roots and the upper parts of stems are cut off from the seedlings. The backwaters of the high tides of late December overflow the river banks and dug canals, flowing onto and flooding the fields. In the most suitable places, flooding reaches a depth of about 20 to 30 cm. At low tide, the river level drops and the water drains from the fields. Few weeds survive this situation and weeding is not done throughout the rice-growing period. In May, the crop is harvested with an ear-cutting knife, threshed by trampling on matting spread in the gardens, and stored in large baskets.

Speculative reclamation by Bugis

The Banjarese design for development of tidal zones spread until the early 1950s throughout the provinces of South Kalimantan, Riau and part of Jambi in East

Sumatra, while South Sumatra was comparatively quiet. However, this calm was shattered in the latter half of the 1950s. From around 1950, there were major disturbances in South Sulawesi when Kahar Muzakkar joined the independence movement he had been sent to quell, and local inhabitants, sandwiched between the rebels and government troops, fled from the fighting in great numbers to Sumatra and Kalimantan. Many of them headed for the tidal zones of South Sumatra, where extensive frontiers still remained, and began development. This movement spread to the Bugis who had come there earlier on *merantau* (seeking a livelihood away from home), sparking a period of large-scale tidal zone reclamation by Bugis.

In the Banjarese design for development, the Bugis found a tried and tested method that proved to be ideal for their purpose of seeking a livelihood. Bugis immigration into the provinces of South Sumatra, then to Riau and Jambi, is now so extensive that they are said to have spread to even the smallest tidal creek.

Unlike the Banjarese, who opened land by digging channels in small groups, Bugis developers had capital and employed Javanese coolies to open the land on a much larger scale. Many Bugis were already living in the *Melayu* sphere, having come on *merantau*; and once word spread that an outstanding leader had begun reclamation and that the basis of a pioneer village had been firmly established, these *merantau* Bugis, who were, so to speak, in Brownian motion, converged on this nucleus. Founders of pioneer villages thus obtained large areas of arable land and recruited tenants to work it, becoming, in effect, farmland entrepreneurs. However, in the kind of pioneer settlement where everyone's fortunes are interdependent, such entrepreneurs cannot hope to win people's hearts simply by acting as landlords, and they tend to become the leaders of the communities they found. Such is the case of Haji Kanna, a pioneering leader of Simburnaik settlement of Lambur Delta in Jambi. He leases his land to tenants from his homeland and other new migrants, and for many he is indeed a landlord. At the same time, however, he leads prayers in an imposing mosque, completed eighteen years after the initial opening of the swamp forest.

Ultimately, most people agree that they owe the orderly growth of the settlement to Haji Kanna. Even after the groundwork was laid, he continued to play a major role. During his term as village head, from 1956 to 1971, he directed the layout of the village roads and the choice of site for the construction of the mosque; obtained funding from the PIR (Peasant Plantation Fund) and the PTP (Public Plantation Corporation) to promote the planting of coconut palms; brought about the early establishment of a clinic; oversaw the organization of the village's administrative system; built the first elementary school at his own initiative; and later secured budgetary support from the provincial administration for the building of five elementary schools and one middle school.

Haji Kanna's account of land reclamation, from the felling of the forest to the digging of the canals, sounds as if he did it all by the sweat of his own brow. While, figuratively speaking, this is true, the actual process of reclamation was considerably different. Many examples point to the fact that the actual work of reclamation in these areas was performed by day-wage coolies, and Haji Kanna hired laborers to reclaim the land. Most of these laborers were Javanese who possessed various technical skills. Javanese laborers are superb diggers, able with a single *cangkul* (hoe) to dig a ditch or build a road as straight as an arrow. Around Bugis settlements there are invariably settlements of Javanese coolies who were engaged in construction work.

Bugis who undertake large-scale reclamation of land do so primarily to create agricultural land to sublet to tenants or sell, rather than to cultivate themselves. This I learned by looking at land registration certificates, and talking with canal headmen in Simburnaik. Without going into details, reclaimed land was divided into allotments and offered for sale. Moreover, most of the registered owners are absentee landlords whose tenants grow rice. In other words, the developers planned from the start to make farmland allotments, and the buyers acquired the land with a view to profiting from tenancy.

Government reclaimed land

Kolonisasi in the Dutch era

Local initiatives for opening new land in Banjarmasin gave the Dutch government the idea of opening the tidal zone for reclamation by migrants. The transmigration policy of moving labor from densely populated Java and Bali to the sparsely populated outer islands was called *kolonisasi*. According to Haji Idak, government-sponsored reclamation in the tidal zone of the Barito River began in 1938. In that year, the first one hundred families of migrants were sent over from Java. At first they rented small holdings of one *bau* (about 0.7 ha) per household in the Gambut district, and learned the unfamiliar skills needed to cultivate the newly created paddy fields. These were upland fields with no bunds or waterways and were littered with felled trees of all sizes. They adopted the Banjarese method of multiple transplanting without tillage, and obtained yields averaging about 2 tons of unhulled grain per *bau*.

In 1938, having selected the Tamban tract south of the Jerapat Canal for settlement by migrants, the government excavated the Tamban Canal. Within the tract they assigned 33,000 ha of land for reclamation by Javanese migrants and, in 1939, migrants were moved to this land. Because of the success of the first year's migrants, in the second year 630 families were dispatched. However, the outbreak of the Second World War put an end to this project after two years.

Paddy fields continued to be created during the Japanese occupation, and the Asahi River was excavated, cutting across the 21 km from the Alalak River to the Barito River. As a result of the paddy field reclamation that was prompted by the construction of the Ulin road, the total area of paddy fields in the Banjarmasin district, which was zero in 1920, reached 48,000 ha in 1948. However, it is not clear how many hectares out of this new reclamation continued to produce crops. As illustrated by the fact that *tanah mati* (killing soil) became widely known through the Banjarese, it is most probable that the release of sulfuric acid had already become noticeable before the 1950s.

Reclamation in transmigration policy

Having seen how the Bugis successfully adopted the Banjarese design to develop the tidal zone on a large scale, the Indonesian government again turned its attention to the tidal zone as a place to receive migrants. Its migration policy continued after the war in the same mold as the pre-war *kolonisasi*, though being renamed *transmigrasi*. In the first five-year plan, which began in 1969, tidal-zone reclamation and migration policy were linked. While the tidal zone had hitherto been a place where spontaneous migrants (called *spontan*) took an active part in a flexible economic sphere set up by merchants, migrants (called *pelita*) now appeared in search of government reclaimed land. The government encouraged them to migrate by offering land, housing, and seed-rice within a rigid framework.

The lands opened by the Banjarese and Bugis spontaneous migrants, described above, have been steadily producing for several decades, but the government reclaimed lands, even after almost thirty years in the case of East Sumatra, and half a century in the case of South Kalimantan, are today still in a borderline situation, and some of them have vanished completely. The cause of the failure, first and foremost, is over-drainage, which has caused the subsequent release of sulfuric acid from the pyrite-bearing sediments, and the mismanagement of hydrological control in the reclaimed land.

Implementation and consequences

According to a government report, the total area of tidal lowland in Indonesia is estimated as 20,100,000 ha, out of which the already reclaimed areas occupy 3,840,000 ha and areas under reclamation occupy 1,000,000 ha as of 1992. By the end of the 20th century, the Mega Rice Project had destroyed another 1,450,000 ha, most of which also fall under the category of tidal lowland. As such, the total area of reclaimed tidal lowland as of 2000 is estimated to come to about 6.3 million ha. Furthermore, deep peat plains in Riau are slated for reclamation for plantation estates at an astounding rate by private companies, the area of a single estate being a hundred thousand hectares or more. As a result, the total reclaimed area may now come to about 7 million ha. Government reclaimed lands occupy about one third of this total, and most of those projects have failed as developments for agricultural production.

Central Kalimantan. The largest and most recent trial, the Mega Rice Project, was virtually abandoned before the completion of the project. In his vivid description of the cause of the failure, Tejoyuwono of the University of Gajah Mada, has pointed out that the Parent Primary Canal (PPC), originally designed to supply fresh water to flush out the acid peat waters functioned poorly: 'It drained the peat water rather than renewing it.' As a result water gates were hastily built at the main intake sites for the PPC, located on the Barito, Kapuas and Kahayan Rivers, to prevent the outflow of peat water. Tejoyuwono also pointed out that the water level of the Main Primary Canal (MPC), which is designed to distribute incoming freshwater, is lower than the height of the land to be irrigated and, furthermore, since 'the water level in the MPC stands at all or most of the time below the average ground water level, effluent seepage is apt to occur and land drainage will prevail', causing peat desiccation (Tejoyuwono Notohadiprawiro 1998). He claims that the fires of 1998, 'were not solely the effect of *el Nino* as is commonly claimed, but were in fact intensified by the overdraining of the wetlands.' Actually, the vast peat dome plain in the project area seems to have dried out intensively, metamorphosing into what was in effect a huge layer of tinder. Supiandi Sabiham discusses this topic in this volume.

South Kalimantan. Since land reclamation in South Kalimantan started earlier, the peat layers had disappeared in most areas, and the local inhabitants had already been aware of the toxic acidity caused by the release of sulfuric acid, which they referred to as 'killing soil'. In this acid-soaked land, eleven transmigration projects covering 39,000 ha were implemented in the 1970s. In the present Pulau Petak Delta, which was the major target area, relatively good crop yields have been obtained only along the Tambang Canal which crosses the delta furthest downstream and boasts the most favorable conditions for tidal irrigation. The area along the western part of the Jerapat Canal, which opens near the convergence of the Barito Murung and the Kapuas Rivers, is also favorable for tidal irrigation.

But, even in these favorable sites, fields require special modifications to avoid damage by toxic acidity, as shown in Figure 1.3. Modifications include the shallow ditch dug into paddy fields to drain acidity before planting, and highly raised mounds for perennial crops made by piling the surface soil together with

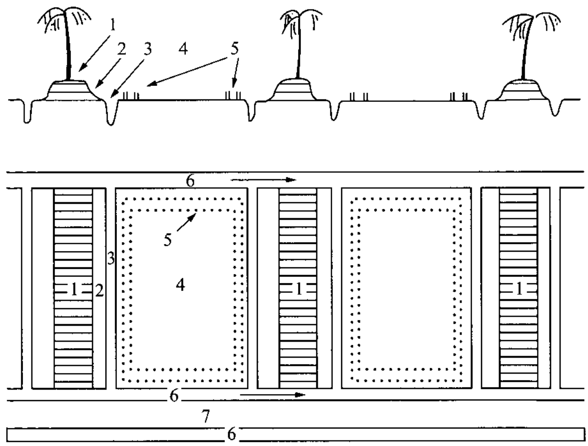


Fig 1.3 Rice frelds with ditches for acidity removal (Purwosari, Tamban Canal, lower reach of Barito River).
1.Large weed bunds, width 2 m, height 50 cm, planted with coconut palms.
2.Second nursery. First nursery is in home garden.
3.Ditch for acidity removal,width 30 cm, depth 50 cm.
4.Rice field surface.
5.Third nursery around perimeter of field.
6.Drainage canal.
7.Road.

plenty of weeds. The roots of perennial crops can grow only within the grass mounds, and those that enter the underlying soil turn black and wither. It is a common practice to replant perennial crops at unusually short intervals, eight years for example in the case of *rambutan*, which bear fruit within two years after planting, reach maximum size in five years and die out in eight years since the roots extend beyond the mounds and are killed by the 'killing soil'.

Other areas of the Pulau Petak Delta are covered by ferns, sedges and grass, and *gelam* shrubs. Many immigrants have left the settlements, returning to Java or migrating to Banjarmasin. Unfortunately, no studies have been conducted on how many immigrants have settled down and how they are making a living. Some immigrants remain and are engaged in farming to supplement other employment. The farming methods they learned from local residents may be described as a variety of shifting cultivation on swampy land. They cut open the *gelam* shrub and plant rice for one or two years, afterwards shifting to another patch of *gelam* shrub.

However there is one remarkable exception, an excellent farming method developed by local inhabitants to overcome toxic acidity (for a detailed account, see Furukawa 1994 and Basuki 1992). This is practiced by a group of spontaneous Banjarese migrants who inhabit Kariyatani village, which is located farther inland from the devastated transmigration site of Barambai. They divided an extensive area of *gelam* forest, which was left intact, into reservoir forest and land for reclamation, and dug a primary canal of about 3 km in length from the reservoir forest. Unlike the government canal, it is small, being only 3 m wide and 1.5 m deep. The reclaimed land was subdivided into plots of suitable size by secondary canals of only 0.5 m in width. When the rainy season begins in November, the weirs of stakes on the main canal and the gates to the secondary canals are left open. Acidity from the fields is washed into the ditches and canals and flows steadily downstream. In late December, the weirs of the primary canal are gradually closed, and the black water flowing from the *gelam* forest is dammed up and diverted into the paddy fields, which begin to fill up with rainwater and irrigation water. Seedlings are transplanted in early March to the paddy fields prepared by the usual methods of weed disposal. Thereafter, the weirs and gates remain closed and the fields remain immersed, but water is continually being replaced. At the end of June, the weirs and gates are opened and the fields are drained. After this, the fields are not irrigated and their produce is harvested in October.

The situation just described applies to a phase of stable rice farming. This gradually changes, however, and eventually gives way to a fallow phase. The peasants are clearly aware that the process passes through several stages, and I named the whole process 'the Kariyatani cycle', which consists of the following four stages:

(1) A period of stable rice production following land reclamation. A thin deposit of 10 to 20 cm of peat that was formed under the *gelam* forest still remains in the reservoir forest and the fields. After about ten years, the peat disappears from the paddy fields, but it remains in the *gelam* forest reservoir.

(2) A transitional period. When the peat of the *gelam* forest is exhausted, the water in the canals turns brown. In the paddy fields, iron colloids separate from the soil, work clothes become stained brown, and large amounts of iron rust accumulate in the drainage ditches. This change is a sign that acidity has started to emerge. A protracted dry season in this period will result in an increase of empty husks.

(3) A period of instability. This period is triggered by the loss of the *gelam* forest reservoir due to land reclamation by migrants from other areas. The reservoir of water necessary for washing away acidity is depleted, and acidity appears in the paddy fields. Water draining from the fields is strongly acidic, around pH 2, and very clear, and the rust in the drainage ditches dissolves. Rice plants wither and empty husks increase greatly. Sedges and *bebesuk* fern dominate, and eventually the field is abandoned.

(4) A fallow period. *Gelam* saplings begin to invade, developing into dense,

even-aged *gelam* forest. After several decades of fallow, a thin layer of peat accumulates under a forest of *gelam* trees. It is then possible to reclaim the land again.

Mr. Anan, a canal headman, assured me that reclaimed land can be cultivated in this way for at least thirty or forty years if the forest serving as a water source remains intact, but with the government's design, the land will obviously not hold up for even a decade. The Kariyatani cycle demonstrates the outstanding powers of observation and knowledge of local inhabitants regarding the nature of coastal peat wetlands.

South Sumatra Here, twenty-six projects covering a total of 373,000 ha were implemented from the late 1960s to 1980s. Major projects included, from east to west, Delta Sugihan Kanan and Kiri, Padang Sugihan, Delta Saleh, Delta Upang, Delta Telang I and II, Pulau Rimau, and the Karang Agung group. Public Works officials boast that about one third or more of the reclaimed land is under intensive farming, but acknowledge that the rest is under non-intensive farming. Here too, there are no reviews of the exact acreage of productive fields, or of the numbers or methods of subsistence of the immigrants who have remained there. The estimate of one third being productive fields might have been correct when there were some rehabilitation projects going on, but it is likely that once the projects were brought to an end, degraded fields that had recovered temporarily, again became unproductive. According to my observations, estimates by Public Works officials seem to be too optimistic and should be lowered by one grade each, meaning that one third are farmed non-intensively and producing somehow, while the rest are lying fallow.

The Delta Upang reclamation project seems to have met with definite success. This project occupies the narrowest segment in the whole Musi-Banyuasin Delta, as a result, most fields receive tidal back-up water. Of the other projects, the most seaward locations, such as the lower reaches of Delta Sugihan Kiri and the central portion of Delta Saleh, seem to produce a relatively good yield, but others, such as the higher terrain of Delta Sugihan Kiri, Saleh, Telang I and II seem quite unstable, and Delta Sugihan Kanan, Pulau Rimau, and the Karang Agung group seem to be almost totally fallow now.

Public Works officials tend to put the blame for poor yields and fallow land on the low motivation of the immigrants, and also on the availability of other jobs such as work in the Bangka Island tin mines or as wage laborers in Palembang, but their reasoning is the reverse of the truth. The real cause of reclaimed land being abandoned is the extremely low or sometimes zero yield of crops due to the toxic acidity. This is of course what kills the motivation of immigrants, and forces them to seek other means of livelihood existence. I can provide several pieces of evidence to prove this, but will present just one example here. In Sugihan Kanan, I once met a group of immigrants who were employing exactly the same method as in Kariyatani. Abandoning the cultivation of paddy fields in their allocated plots, they opened a part of *gelam* forest outside of the project area and created paddy fields which were irrigated by the water coming out of the remaining *gelam* forest. They told me that they learnt this method from the Bugis people. Until a few years ago, they used to go to the Bangka Island mines to earn wages, but they had stopped doing so since their paddy fields rewarded their work with good yields. In answer to my question as to whether they would like to work on the government reclaimed land, they answered with a firm yes. They added, however, that the draining of toxic acidity is a must, but that the size of reclaimed tract may be too big to accomplish this. This amounts to a clear refutation of the claims of officials.

Pulau Rimau is the second largest reclamation project in the Palembang area, consisting of 32,000 ha of field alltoments. From several interviews I conducted here, I estimate that about one fifth to one tenth of the reclaimed land is somehow producing crops, while the rest lies idle and covered in ferns, sedges, grass and *gelam* shrubs because of zero harvests. Many immigrants have left the settlements and, though half still remain, only 10 per cent of them depend on the harvest of the fields, the rest rely on sources of income other than agriculture. Farming is a very insecure occupation due to the strong acidity. Water in the primary canals is strongly acidic, showing a pH of 3, and it is densely turbid with coagulated iron colloids. Water in the connecting canals is even more acidic, around pH 2.8 or so. Sometimes it becomes around pH 2.5, at which point iron colloids dissolve and the water becomes clear.

The immigrants are very eager for the acid water to be drained and replaced by normal river water as soon as possible. This is hardly surprising in view of the fact that quite apart from farming, they have to bathe in this intensely acid water, which is effectively diluted sulfuric acid. They are never free from this acidity which threatens even the small crops of their home gardens. Contrary to their wishes, Public Works authorities installed water gates on the connecting canals in the mid-1990s to keep the ground water level high and prevent the further drying of the soil. This is a total mistake at this stage. They should have installed water gates at the outset before over-drainage took place. The same goes for all reclamation areas. When, for example, swamp areas in the coastal peat wetlands of the states of Selangor, Melaka and Johor in West Malaysia started to be reclaimed, water gates were installed at creek estuaries from the outset. Peat soils in Tanjong Karang have ground water levels properly regulated by field water gates, and continue to be productive as paddy fields and upland fields. Sulfaquent soils in the Melaka coastal plain are well regulated by installing water gates on every tidal creek, and have been successfully converted to paddy fields and fields for other crops. But there is in fact no need to bring up West Malaysia as an example of successful reclamation, since the yields of independent reclamation carried out by the Bugis and other local inhabitants in nearby tidal zones are proof enough of what is possible with the right approach. They have invented a wide variety of mechanisms, such as diked polder gardens, simple water gates and underground ducts that are usually operated by tidal action, and so forth to manage their land, and the whole concept of tidal zone reclamation was of course invented by local inhabitants.

The mistakes committed in the government reclamation processes are plain for all to see, and the belated construction of water gates, an inappropriate measure that also runs contrary to the justifiable desires of the immigrants, has merely exacerbated the situation. Moreover, the water gates are not operated at all, usually being kept closed, representing nothing more than nuisances to the immigrants, who therefore often destroy them.

Jambi The government reclamation of tidal lands in Jambi Province covered 31,000 ha in six projects. The relatively small size is due to the fact that the Bugis had already occupied almost all of the land best suited to tidal irrigation. The government reclamation projects were therefore located inland where the Bugis halted development because of unfavorable conditions such as deeper peat and the unavailability of tidal irrigation. The government tried to overcome the drawbacks of the sites by excavating deep canals that would enable the swift conveyance of back-up water further inland. And, as observed in other project areas, over-drainage took place.

Mr. Sono, who was the cook and foreman for our jungle surveys in 1983 and 1984, lived on canal no.17 of Rantau Rasau as an immigrant from Java. His accounts clarify the circumstances in which immigrants came and what happened to them. He was born in Wonosari, which is situated on the Kidul plateau, one of Java's driest zones. As a child he was adopted by a headman of Kaliboto village in Purworejo, and in 1965 he married his foster father's daughter. He was about twenty-five years old at the time, while his bride was thirteen. Kaliboto village occupies hilly land where rice, foxtail millet, maize and cassava are grown as staples. Long-awned rice, red rice and glutinous foxtail millet are broadcast-seeded in mountain swiddens, and maize is dibbled in between. Around October, work begins on the rain-fed rice terraces. The dry soil is hoed, and harrow is applied as soon as water accumulates, and rice seedlings are transplanted. Such was the environment in which Sono grew up. The Kidul plateau has sparse soil and, like the Kendeng hills, its name is synonymous in Java with poverty. Many people leave there on *merantau*.

In 1974, the last year of the first five-year plan, Sono volunteered to migrate to Sumatra. He took his wife and daughters, aged six and two, with him. Four families left Kaliboto village, joining a further sixteen families at Purworejo and thirty families from Tegal at Semarang. At Semarang port they all boarded a boat, which took them to East Sumatra and up the Batang Hari River to Puding village, gateway to the Rantau Rasau transmigration area. There they were supplied with materials for their livelihood: 15 kilograms of rice per man, 7.5 kilograms per woman, and 6 kilograms per child; one liter of cooking oil, three liters of kerosene; one kilogram each of salted dried fish, sugar, and salt; one packet of tea, two bars of soap, one piece of matting, and five boxes of mosquito coils; one pan, one kettle; two machetes, one hoe, one ax, one weeding trowel, one spade, and one iron bar (*linggis*). These they shouldered and trekked the 10 km to the house provided. The canal and embankment road ran straight through tall forest, dotted with brand new houses on either side. The twenty families from Purworejo were settled on canal no.17, the thirty families from Tegal on canal no.28. On arrival, they were given two tanks for collecting rainwater.

The 2 ha of land provided, consisted of 0.25 ha of garden land around the house and 1.75 ha of paddy fields. When he had applied for transmigration, Sono had been told that the forest had been cleared, but he arrived to find it still standing. He first cleared and burned the 0.25 ha of garden land, collected rice seedlings from the migration office in Puding village, and transplanted his new swidden in the local fashion by dibbling in seedlings. He also planted the seeds and seedlings he had brought from Java: kidney beans, cowpeas, mung beans, peanuts, chilies, cucumbers, watermelons, maize, yams, taros, cassava, banana and others. In the first year, all bore good fruit. He harvested 500 kilograms of unhulled paddy from the 0.25 ha. In the dry season, he cut the rice stubble, burned it and planted maize.

The greatest difficulty of life in the tidal zone is securing water for domestic use in the dry season. Rainfall declines and tanks empty. Water in the secondary canals becomes strongly acidic, and bathing makes the skin tingle and the eyes smart. Sono dug a well in his garden, but it was the same. He and his fellow migrants therefore dug communal wells in sandy ground, where the water is good. The nearest to Sono's house are on canals no.16 and no.27. The sandy ground on canal no.27 is an old beach ridge and is some 1.5 m higher than the surrounding land. When these wells dry up, they have to go to the Batang Hari River to draw water.

Perennial crops such as mango, coconut, coffee and pepper all grew poorly. Although they flowered, none bore fruit even after ten years. The situation is vastly different from that in places with good soil, which can even be found in the government reclaimed areas, for example, Simpang Puding, which borders the river. There, Java-like gardens are planted with coconut and other trees including coffee, cacao, breadfruit, *surikaya,* guava, *jengkol* (*Pithecolobium lobatum*), *petai* (*Parkia speciosa*) and *jambu,* and all are laden with fruit.

On canal no.27, two migrant families returned to Java, seeing no future in the difficult environment of the government reclaimed land. In 1985, Sono bought 0.5 ha of paddy fields from a migrant who returned to Tegal, bringing his holding of paddy fields to 2 ha. Weeding and preparation of this land by *parang* takes him two months working alone; and with the help of his wife and elder daughter, planting takes three months, beginning in October. He transplants only once, from a dibbled nursery, employing a seven-month traditional variety. Harvesting is done with an ear-cutting knife (*ani-ani*) in April and May. His two hectares yield from 2.5 to 3 tons at the first cutting, and in the four weeks this takes, ratoon growth begins to bear an additional yield of about 1 ton, bringing the total yield to between 3.5 and 4 tons. The ears are threshed by trampling, and then winnowed. About 1 ton of unhulled paddy is stored for home consumption and the remainder is sold.

After the rice harvest, the stubble is burned and a thin layer of topsoil is hoed up into low ridges on which cowpeas, mung beans, soy beans, chilies and eggplants are planted, with taros planted around them. Sono claims that subsistence is possible because the soil dries out in the dry-season and he is able to cultivate *polowijo* (off-season upland crops in paddy fields).

When Sono arrived, the soil was soft peat, which would wobble if shaken steadily, and in his paddy fields, he would sink up to his knees. Fifteen years later, only about 20 cm of confetti-like dry peat remains on the surface. Sono has rebuilt his house, which is now surrounded by the greenery of coconut palms, and has transformed the landscape into one far more agreeable and seemingly richer than the treeless expanse of the Bugis paddy fields. This appearance is superficial, however, and in fact his rice yields are far lower than those in the lands settled by Bugis migrants and show no sign of improving. Even after fifteen years, the coconut palms have not borne fruit, their roots creeping along the surface and not going deep.

In May 1989, when I visited Sono at his house, he and his family seemed to be doing all right. During our conversation Sono remarked that turning the soil seemed to improve the rice crop. According to him, after about five years the tree roots had practically disappeared from the soil, but he continued to prepare his paddy fields simply by cutting weeds with a *parang.* However, for the past few years he had noticed that where he had raised ridges for the off-season crops, the soil dried to crumbly granules that gave better seedling growth and better yields of rice. It was conceivable that the soil had been improved by the leaching of acidity from the few centimeters on the ridges reached by the plant roots. But, unfortunately, just beneath the surface soil are several meters of earth that contain huge amounts of poison. I'm afraid that I was unable to agree with Sono's optimistic interpretation of his finding.

In August 2000, I again visited Sono's home, but found no house there. I learned that Sono and his family had left the settlement and gone to an oil palm plantation elsewhere. The landscape in most parts of the Rantau Rasau area had changed. Eleven years before, there were still considerable numbers of paddy fields planted and harvested, and children were running around in the paddy fields and home gardens, playing and laughing. Now they had gone. Most of the paddy fields were covered in tall sedges, ferns and *Melastoma*. Here and there, small plots of *segon* (*Paracianthes falcataria*) and rubber had increased, though their growth seemed stunted.

One neighbor who still remained nearby described the impact of the severe drought of 1997-1998, which finally forced many painstaking Javanese peasants to leave. The drought caused coarse cracks to develop in the soil, and those cracks joined up to form a network of trenches. When the rainy season came, rainwater filled the trenches, infiltrated deep into soil through the cracks, and after prolonged rain, yellow water overflowed from the cracks to the ground surface. This yellow water killed the seedlings that had been dibble-transplanted a few weeks earlier. The man's account was very precise, and clearly explains how the 'killing soil' kills plants.

Other residents had similar stories to tell. The acid drains into field ditches, and then into secondary and primary canals. All of the residents stress that the acidity of the canal water increases in the rainy season. This is understandable in view of the fact that sulfuric acid formed in the soil stays underground in the dry season, but is flushed out to the canals by infiltrating rainwater in the rainy season.

Other reclamation areas, such as Pamusiran and Dendang I and II, show a similar degradation or even worse. In the case of Pamusiran, abandoned fields have increased to almost 100 per cent over the past five years, and only one fifth of the immigrants remain. In the case of Dendang I and II, conditions are a little better, but according to the immigrants' estimates, about half of them have had to rely on exploiting the forest remaining on the deep peat dome plain behind the settlements. The Lambur area used to be highly productive, but now it is declining swiftly after the drought of 1998 and the repeated deepening of secondary and tertiary canals.

Causes of poor crop yields

As illustrated above, the causes of failure of government tidal zone reclamation projects lie first and foremost in the over-drainage of the land, and the subsequent release of sulfuric acid from the drying soil, and mismanagement or total lack of control of water movements in canals.

Over-drainage and sulfuric acid There is much clear evidence to prove that the release of sulfuric acid is the primary cause. In the Dendang I area, there are two small tracts that are ideally suited to produce the best yields every year, even though both of them, about 20 ha each, are located inland and are only rain-fed. The reason became clear by checking the soil, which is derived not from pyrite-bearing sediments, but from outcrops of white clay of the old terrace formation. These small islands presumably stood above the lagoon, and were not covered by sediments of brackish clay during the Holocene transgression period. Thanks to this simple difference in the land-forming process, the immigrants in these tracts produce yields of about 3.5 to 4 tons of rough rice per hectare, a modest yield by common standards, but the best yield in this area extensively covered by sulfaquent, 'killing soil'.

The Lambur area is also extensively covered by sulfaquent soils, but yields have been much higher than in the Dendang area because, due to lower ground height, canal water is easily replaced by back-up water. However, large fields that used to produce 5 to 6 tons of rice have started to decline since the drought of 1997. Yields from coconut palms are also showing an overall decline, but palms in some tracts are not affected. This is because they stand on former sand beach, free from the pyrite-bearing sediments that filled the lower lagoons during the Holocene transgression period.

Figure 1.4 shows the content of sulfur compounds in two representative soil profiles. Pyrite-sulfur is partially dried and has changed into sulfuric acid and jarosite. L 3 indicates the site of a Bugis reclaimed paddy field covered by riverine sediment on the surface. Partly because of this, and partly because of shallow and small canals in Bugis reclaimed land, they have successfully continued farming. However, this soil, as well as another soil derived from recent lagoon sediments, has pyrite-bearing sediments underneath, and is therefore never free from the danger of toxic acidity if intense drought causes it to dry out.

In the initial phase of the drainage process, coarse cracks develop in the unripe (that is, very soft and plastic) clay, as stated earlier. In parallel with this change, innumerable pores develop in the soil as well. This happens as former mangrove roots and grass roots decay, and the cavities change into small stable pipes coated by iron compounds that are separated out by sulfuric acid. Because of the large numbers of these cracks and small pipes, soil porosity increases dramatically and, despite being clay soil, water infiltration is surprisingly high, the coefficient estimated to reach as much as 10^{-3}, almost the same as that of

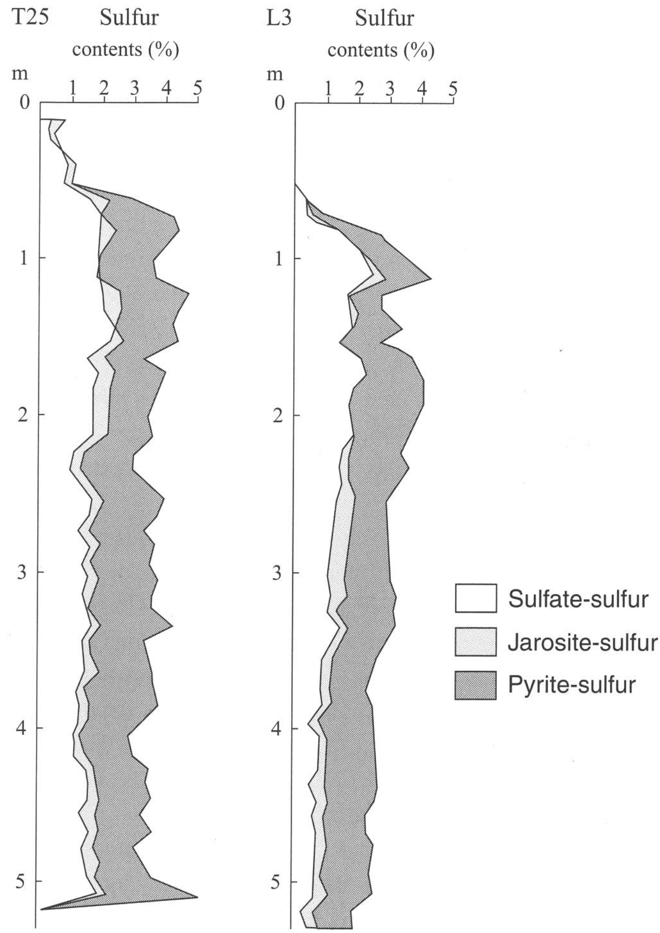


Fig 1.4 Sulfur compounds in tidal zone deposits. The lines at right of each chart represent total sulfur content.

sandy soil. This exacerbates the soil drying process further.

This condition in turn makes wet rice cultivation difficult because it is impossible to inundate the fields with water. Farmers therefore try to use these fields for upland crops, causing the rampant growth of resistant grasses and ferns, which farmers often burn as the easiest means of weeding. This practice changes the surface soil into confetti-like granules which behave just like sand, and further enhances water infiltration. All of these processes make for a vicious cycle spiraling down to complete degradation of the reclaimed land from swamp to acid-soaked desert.

Mismanagement of canal hydrology Most canals in government reclamation projects used to have no water gates. Although belated construction of water gates has been carried out recently, it has only exacerbated the already existing mismanagement of the hydrological situation. Moreover, most water gates are not operated properly or at all, and the canals are in effect open-ended.

Open-ended canals excavated in tidal zones intake water from, and drain water to, two tidal rivers. At high tide, flows of water entering from both ends interfere with each other, so that the propagation speed of back-up water is reduced. At low tide, water drains from both ends, causing the height of the water in the primary canal to recede quickly. The same thing happens in the secondary canals. Under such conditions, water flow in the canal network is not constant (water going backwards and forwards), making for decidedly disadvantageous circumstances for expelling the sulfuric acid from the canals.

In the case of the dead-end canals excavated by local Bugis and Banjarese inhabitants, the expulsion of acid water is achieved relatively quickly. Back-up water is tapped from one inlet which is open to a tidal creek, and the distal end of the canal receives drained surface water from the swamp. In this case, although the drained water also shows to-and-fro motion, it is drained eventually since ultimately there is a large water head difference between ground surface and low tide surface. In other words, drained water flow is confined to one direction, flowing from closed end to open outlet. In the case of open-ended canals, however, the canal does not work in this way. Once toxic water enters the canal, it is subject to the to-and-fro motion of canal water, but with very small head differences at both ends, the expulsion of acid water is impeded. What is needed is the creation of a constant one-way flow in the primary canal, and acceleration of the expulsion of acid water.

Aftermath of failure

Intensified encroachment on forests. The impact of the failure of government tidal zone reclamation projects on the surrounding forests has been severe. Hungry immigrants have encroached on the dense forests in the deep peat dome plain located further inland. Earlier, I touched on some of the innovations conceived in the chaos following the turmoil of 1998, such as the cut-and-run system instead of HPH, and the use of bicycles for the extraction of sawn timber instead of *kuda lalas*.

Estates Most of the immigrants remaining in the settlements acknowledge that they are now effectively residents of housing projects providing cheap laborers for businesses to recruit for the exploitation of the remaining deep peat forests. Exploitation of the forest and swamp land is very thorough. Tens of thousands of hectares are completely denuded and converted into estates of coconut palm, oil palm or acacia plantation. Planting, fertilizer dosing, weeding, harvesting and transporting to the factory all require a large supply of labor, and this demand is in large part met by government immigrants who are obliged to live in wretched conditions. Old people and children stay in government-supplied houses, now dilapidated huts, while active members of the family are employed by estate enterprises and stay in estate-supplied longhouses.

This type of estate is spreading in Riau. The drainage canals of large estates are usually fitted with weirs and water gates at their outlets. These fixtures are aimed, I assume, at excluding encroaching outsiders' boats and preventing thievery, but whatever the motivation may be, they contribute to maintaining the canal water level at a proper depth, and as such to keeping the peat land wet. Well-managed estates, though very few, are thus exploiting the peat land more wisely than the government.

Victims of the bubble economy Some estates make a real contribution to the growth of the Indonesian economy, and a few of them pay serious concern to community development. A top executive of one enterprise told me of his belief that community development is the key to steady and sustainable growth, and that if enterprises single-mindedly pursue only profit, and make no contribution to the welfare of the local community, their estates will be encroached on by local people and suffer theft and vandalizing of growing crops. His firm conviction, also demonstrated by his opposition to acquiring land title through purchase from the local community, seems to me to be well-placed, although this kind of conviction is seldom seen among many other enterprise estates.

Many poor immigrants have become the victims of scams operated by criminal enterprises. In poor villages where allocated fields produce nothing, con men come and offer rosy tales about estate construction, telling the pitiful immigrants that their fields can produce good harvests by planting them with improved varieties of coconut and oil palm and by dosing them with fertilizers, pesticides, herbicides. It is difficult for immigrants to resist such alluring tales, and they ask how they can establish an estate. The con men use their persuasive powers to convince the villagers that they can get bank loans through joining programs such as JPS, KKPA and KUT, funds for which are supplied by CGI and the World Bank. The swindlers tell the immigrants that they can arrange bank loans if the immigrants entrust their land certificates to them. The duped immigrants willingly hand over their land certificates, which are passed on to the bank as collateral. The swindlers take the money from the banks and buy seedlings, fertilizers, herbicides, machines and so forth, but only for demonstration purposes, to create the illusion within the minds of the immigrants that they have become stockholders in what will soon be wonderfully productive estates.

The cheaters, however, have no intention of developing these estates. They redeposit the low-interest loans in other banks, and reap the margin for themselves. They play the immigrants along in this way for two to three years, but in time it becomes evident that even the so-called improved crops cannot grow on 'killing soil'. At an appropriate time, the con men cease their act, withdraw the money and flee. The bank confiscates the land certificates and demands that the swindlers' company pay back the loan. The immigrants lose their land certificates, are embarrassed by the huge debts left, and are obliged to work as landless laborers in other estates.

In the end, settlements in reclaimed tidal zones decline into dilapidated housing projects for cheap laborers, and furthermore produce landless migratory laborers who have little choice but to seek temporary shelter and employment in the longhouses of sawmills or estates which are in turn bent on transforming the jungle for profit in a process which spells the rapid death of the swamp forest ecosystem.

How to rectify the situation

The problem of what to do with the now abandoned Mega Rice Project is a controversial issue. Some people say that it should be allowed to return to nature, while others seek to rehabilitate it on an even larger scale. It is some consolation that this disastrous project did not involve the mobilization of many more immigrants when it was abandoned. Here, I would like to concentrate on what to do with other projects that are still in existence and involve immigrants. Even if left entirely to nature, it would be impossible to restore the original environments in these locations. Restoration would require very strict regulation to prohibit the trespass of local inhabitants and is accordingly not very feasible. On the other hand, simply continuing with the government reclamation concept offers no prospects whatsoever for improving the situation, and so we need to seek other solution that addresses both the technical and the social issues involved.

Technical improvement

Technical improvements would need to be aimed at flushing already released sulfuric acid and reducing its further release. The idea described below evolved through information gleaned through field observations and talks with local inhabitants. Though primarily directed at rice cultivation, it can also be applied to other crops, since if rice cannot be cultivated, no other crops can be cultivated either.

(1) The most serious defect of cut-through canal systems is uncontrolled water

flow. Canal water tends to just move to and fro, and under such conditions, acid water remains within the canal network longer. What is required, particularly in case of primary or feeder canals, is to create a one-way flow of water. This could be accomplished by installing water gates at both ends of the canal, designating one gate as the inlet of fresh river water and the other as the outlet for drainage. At high tide, the inlet gate would be opened fully and the outlet gate closed, so that the canal is filled with freshwater. At low tide, the inlet gate would be closed and the outlet gate opened, so that toxic water is drained. The operation of the gates of secondary canals would vary according to whether they are the dead-end or cut-through type, and also on the stage of flushing. Dead-ended canals should be kept open, particularly at the initial stage of flushing, while cut-through canals should have gates at both ends, and be operated similarly to the primary canal so as to create a one-way water flow.

(2) The toxic water should be neutralized before being drained into the primary canal or river. This is easily accomplished by immersing cane bags containing limestone blocks at outlets from secondary canals.

(3) The surface soil of degraded fields needs to be flushed by fresh water. Many small pumps could be used to lift water from the primary or secondary canals to the fields. The flushing of toxic acidity is indispensable, but it would be required for the surface soil only, not for entire acidified layers.

(4) In order to make flushing effective, it would be important to reduce the infiltration rate of surface soils. Puddling of the surface soils by buffalo trampling or by rotary harrow is needed so as to make soils muddy and ensure the fields are inundated. Buffalo-trampling is ideal because soils and grass get well mixed by the hooves of buffalos.

(5) For the first one to two months of the rainy season, water gate operation should be directed mainly at maintaining drainage and removing toxic water. After surface soils are cleansed of acidity, rice seedlings could be transplanted, and then water gate operation could be gradually shifted to the purpose of keeping paddy fields inundated and maintaining high water levels in canals.

Supporting community development

The authority to control water gates is currently in the hands of Public Works officials, who operate them in a way that serves real requirements very poorly. The right to control water gates needs to be transferred to the local communities.

Public Works officials in charge of the maintenance and operation of the canal networks need to have detailed field information, such as the amount of water discharge of distributaries, water quantity and quality of each segment of canal network and the flooding area in rainy season. Moreover, they need to understand that grave hazards tend to be caused by even a slight deepening of the field canals. Local inhabitants and extension workers, on the other hand, have detailed information on almost all aspects of the rural community, such as soil degradation, crop failure, defects in the canal network and the swiftly changing livelihoods of the community. This is only to be expected since the inhabitants live there, and monitor both the natural and social environment constantly.

The planning and implementation of improvement measures, thus, need to incorporate the knowledge of local inhabitants and to support their spontaneous efforts towards improvement. This opinion may appear to be defying the experts, but that is not my intention. Take the Nokyo (agriculture co-op) and water use associations of Japan, for example. Planning and implementation of almost all activities, such as paddy field improvement, irrigation facilities, rice storage and crop selection, have been based on the experience and knowledge of both experts and local inhabitants. This way of seeking consensus and utilizing all available experience and know-how is the key to achieving sustainable development even in the rural communities of Japan, where an almost infinite volume of information is readily available. This is also true of Javanese rural society, which has an established and elaborate consensus system.

Let us recall the situation in the immigrant communities on newly reclaimed coastal peat wetlands of Indonesia. The physical conditions are changing swiftly, with peat disappearing, swamp changing to dry desert, sulfuric acid being released, new crops introduced on a trial and error basis, and canal gates being built and broken. Social conditions are changing swiftly too, with immigrants flowing both in and out, farmers changing to laborers and large estates causing drastic changes in the labor market. All are in chaotic disorder in a swiftly changing environment, and furthermore, no substantial data is available for reviewing and evaluating the achievements of reclamation projects and the subsequent social build-up in this area.

So-called 'experts' need to develop a correct understanding of who the real experts in agriculture and society really are, since they would be hard-pushed to claim honestly that they possess knowledge relevant to this sphere. It is, of course, the local inhabitants who are the true experts. They live there, constantly observing nature and monitoring the way it reacts to human activities as their textbook. The so-called 'experts' need use the collective knowledge of these local residents. Their role is to make local inhabitants realize their own expertise. Only an effort of this kind will enable short-lived projects to be replaced by sustainable reclamation, community development and conservation of the natural environment.

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2

Ecological Issues of The Mega-Rice Project in Indonesia: A Case Study of Swampland Development in Central Kalimantan

Supiandi Sabiham

Since the 1930s, peoples of several ethnic groups in Indonesia have settled in swampy lands in the coastal regions and increasingly utilized them for agricultural purposes, particularly for paddy field development. Their activities would appear to have had an adverse effect on the swampland environment, as clearly indicated by the degradation of the natural habitats of these lands. In the 1960s, the Indonesian government started the large-scale development of swamplands for agriculture-based transmigration settlements and for the expansion of estate crops as a means of supporting; (i) food self sufficiency in the face of increasing conversion of agricultural lands to nonagricultural uses in Java and Bali; (ii) production of food as a commodity to stabilize the national economy and the constantly increasing demand for rice; (iii) the capability of the national agricultural system to sustain production through diversification; and (iv) the policy to improve balanced regional development, particularly in regions other than Java and Bali, through the transmigration program.

In order to increase food production, in 1995, Presidential Decree No.82 concerning swampland development for food crops in Central Kalimantan was issued. This project, the so-called Mega Rice Project (MRP), covered approximately 1.4 million ha in Central Kalimantan. Various experts and politicians offered their opinions both for and against the MRP ever since its planning and inception in 1996. Many parties predicted that the MRP would adversely impact on the natural and socio-cultural environments of both the project site itself and the surrounding areas. This paper aims to clarify the MRP's impact on fringe areas, including; (i) changes in vegetation cover, (ii) changes in the water regime causing subsidence initiated by drainage, and (iii) changes in physical as well as chemical properties of the soil.

Initial environmental features

Swamplands in Central Kalimantan perform many functions of value to humanity. At the ecosystem level, they moderate the effect of floods, improve water quality and have aesthetic and heritage value. They also contribute to the stability of global levels of carbon dioxide (CO_2) and methane (CH_4). They are, however. very fragile ecosystems which can be very easily destroyed when disturbed for such purposes as agricultural development.

Climate

Central Kalimantan boasts annual rainfall of 1,650 to 2,521 mm. According to Schmidt and Ferguson (1951), the pattern of rainfall in this region is categorized as type A, with 9 to 11 wet months and 0 to 1 dry month. In terms of agroclimate zone according to Oldeman, *et al* (1980), the region falls in the C2 category. The average yearly temperature is 25.1 ℃, the highest being in November (28.1 ℃), and the lowest in December (21.9 ℃). Relative humidity of the region is 81 per cent, the highest being in December (85 per cent) and the lowest in August (76 per cent). Average yearly duration of sunlight is 43 per cent.

Vegetation cover

The Mega-Rice Project area was originally production forest (*hutan produksi*) managed by several lumber concession (HPH) holders, and was then cleared for the MRP, so that the area has undergone two kinds of clearing. Based on a 1992 satellite image map, the vegetation in this project area consisted of primary and secondary forest, shrubs and plantation forest, with the largest area occupied by secondary forest. Shrub areas exist as a result of several activities, such as nomadic agriculture, logging and the burning of the forest.

In the initial stage of planning for the MRP, Institut Pertanian Bogor (1996) suggested that the land be utilized according to the findings of the Environmental Impact Study which, as shown in Table 2.1 and Figure 2.1, advised that forest, including mangroves and peat swamp forest, should be kept as conservation land. However, under the development program adopted by the government, the project area was divided with no clear justification into five development zones, namely zones A, B, C, D and E.

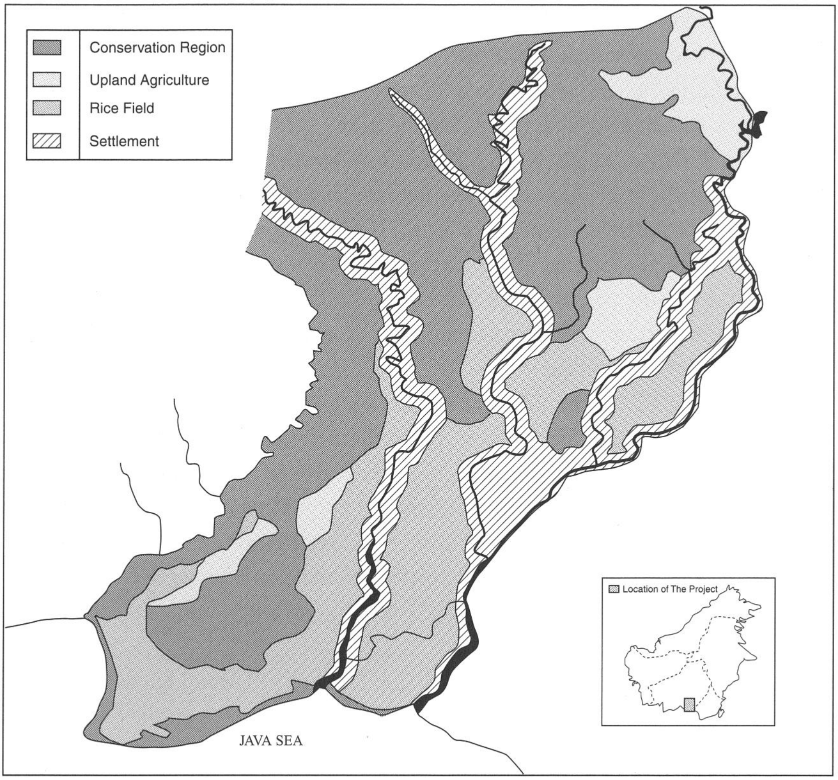


Fig 2.1 Map of proposed land allocation for Mega-Rice Project area [After Institut Pertanian Bogor, 1996]

Table 2.1 Proposed land use of the Mega Rice Project in Central Kalimantan

Land allocation	Item	Area (ha)	
		Item	Total
1. Conservation land			754,952
	a. Mangrove	23,510	
	b. Forest/Fauna	436,690	
	c. Hydrology	223,002	
	d. Quartz	71,800	
2. Rice field			305,121
3. Upland agriculture	Upland rice, cash crop, sugarcane, vegetables, plantations and fruits		95,688
4. Existing agricultural land	Settlements and buffer zones		301,339

Water regime

Water regime is a critical factor for the conservation of swamp forest, and if water content in the soil is decreased, changes in the ecosystem inevitably occur. Large and small rivers, such as the Kapuas, Kapuas Murung, Barito, Mangkatip, Mentangai, Kahayan and Sebangau rivers flow through the MRP. Water surface elevation, the height of flooding above the land and the duration of flooding, was initially greater upstream than downstream for the Kapuas, Barito and Sebangau rivers, exemplifying the role that upstream forest can play in flood retardation by reducing the floodwater surface elevation in the downstream area. The duration of flooding is also shorter downstream than upstream, demonstrating the water storage function of inundated forests.

Such factors had a great influence on the water regime of the project area. The variation of average water surface elevation between rainy and dry seasons varies from 1.8 to 5.0 m. The depth of shallow ground water varies from 0.2 to 0.6 m, while deep ground water has a depth of approximately 40 m or more. The clearing of forest in the MRP has reduced flood retardation functions, causing an increase in downstream water surface elevation and flood duration.

Soils

The MRP area is a unique ecosystem, with a layer of peat and high acidity. Soils in the MRP area are categorized in Table 2.2 and Figure 2.2 on the basis of the thickness of the peat layer. As a result of drainage, the thickness of the soil surface has decreased rapidly. In the dry season, peat is extremely prone to fires, and thus easily degraded in an irreversible way.

Table 2.2 showed that approximately 30 per cent of the total MRP area boasts a peat layer of more than 3 m in thickness, 3.6 per cent in zone A, 5.9 per cent in zone B, 16.4 per cent in zone C, and 3.9 per cent in Zone E. The soil of the MRP area generally has a high acidity level (pH <5) that correlates with high organic acid content and a high level of Al, and has a low level of soil fertility. Decomposition of the organic content of peat produces organic acids that are leached out and carried away by drainage water, affecting soil acidity downstream.

The project area also contains acid sulfate soil which, if oxidized, would produce very high soil acidity (pH <3.5). As such, if these soils are close to the surface, their cultivation poses serious risks, and requires prudent management. The area of acid sulfate soil in the MRP area is shown in Table 2.3. In zone E, acid sulfate soil is rare, but a very large area possessing a sandy layer was found (see Table 2.2). Reclamation of this area would likely accelerate the decomposition of peat, causing the sandy layer underneath to surface.

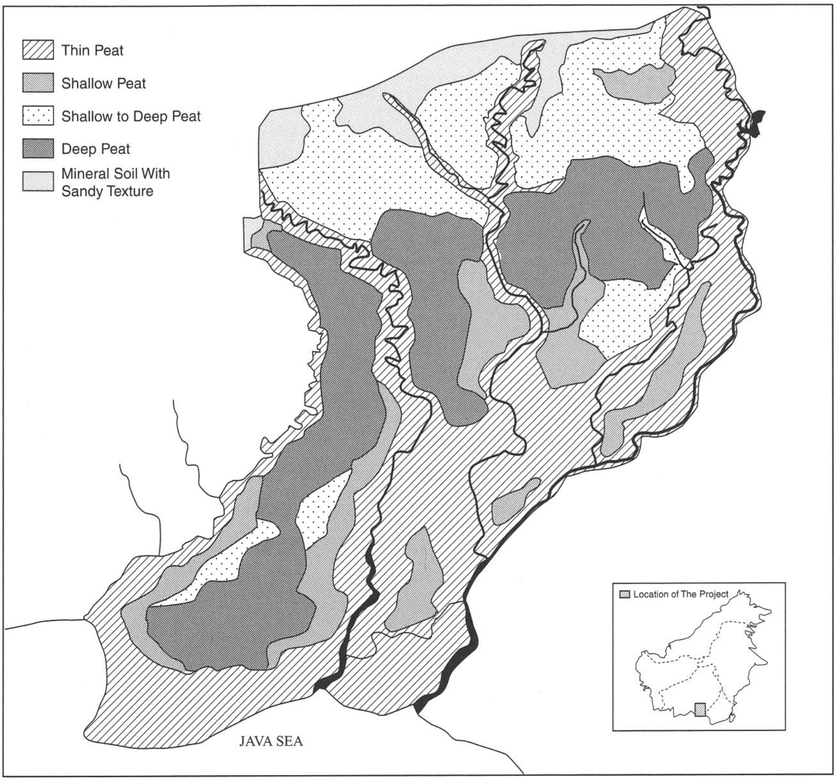


Fig 2.2 Peat disttribution map based on thickness in Mega-Rice Projiect area [After Institut Pertanian Bogor, 1996]

Table 2.2 Area based on the thickness of the peat layer in the MRP area

Development zone	Peat thickness				Sandy[2/]
	<40 cm[1/]	40-130 cm	130-300 cm	>300 cm	
	(ha)				...
A	137,000	52,800	30.000	55,700	-
B	43,495	13,025	13,845	86,015	-
C	137,750	97,200	26,900	238,100	2,200
D	83,705	15,015	-	-	-
E	64,250	21,300	212,700	56,500	69,600
Total	466,200	199,340	283,445	436,315	71,800

Notes: 1/ categorized as mineral soils; 2/ very high content of quartz.

Table 2.3 The area of acid sulfate soils in the MRP area

Depth of acid sulfate soils (cm)	Development zones			
	A	B	C	D
	(ha)			
0 - 50	19,621	1,830	n.a.	47,392
51 - 100	66,273	12,959	n.a.	64,714
101 - 150	76,465	28,498	n.a.	21,110
>150	106,296	113,122	n.a.	5,259

Source: Center for Soil and Agro-climate Research 1998; n.a. = data not available

Environmental impacts of the Mega Rice Project

There are basically two kinds of negative impacts likely to be caused by the development of swampland; namely the negative impact caused by the inherent properties of the swampland ecosystem, and the negative impact caused by the construction of irrigation canals.

Land clearing and its problems

The original aim of the MRP was to develop paddy fields. However, the study carried out by the Institut Pertanian Bogor (1999) found that less than 30 per cent of the land, consisting of 80,200 ha of existing rice fields (Figure 2.3) and 410,800 ha of newly created rice fields, could be used for this purpose. The study allocated a further 95,700 ha for upland rice, cash crops, sugarcane, vegetables and fruits, and designated the rest as conservation areas.

The implementation of the MRP has changed the landscape, with forests being replaced by deforested areas, and man made canals dividing the project area into several parts (Figure 2.4). Changes wrought upon the landscape that fail to serve their intended purposes result in inadequate use of land, and pose a great risk since most of the resources of peat swamp forest are very easily destroyed within a short period of time. NOAA-AVHRR hotspot data indicates that land clearing continues despite the fact that the government has stopped the MRP. Another major cause of the forest degradation is illegal logging, which occurs all over the MRP area, with a strong increase since the economic crisis. Logging and drainage of the peat swamp forest greatly increases the risk of recurrent fires.

An overview of land use changes in the peat swamp forest of Central Kalimantan is presented in Table 2.4. There was a decrease of 16.1 per cent in primary forest from 1991 to 1997. Agricultural land increased by only 17 per cent, while land possessing no vegetation cover increased by 1550 per cent.

Fig 2.3 Paddy fields near the Kahayan River in the south of the Mega-Rice Project area which are influenced by the tidal regime (after Boehm and Siegert 2000)

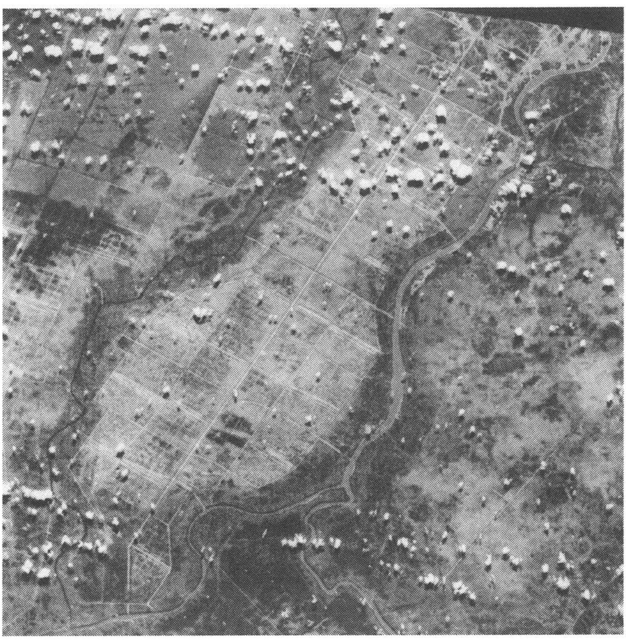


Fig 2.4 Spot image recorded on June 19th 1999, showing regrowth of secondary vegetation in dark grey. The location is dadaphup in block A between the Mengkatip River (left-black) and Barito Rive (right-grey) (after Boehm and Siegent 2000)

Table 2.4 Conversion rate of swamp forest (selected data) in Central Kalimantan (from 1991 to 1997)

Type of vegetation cover	Year		Change	Rate
	1991	1997	ha	%
Primary forest	2,659,921	2,231,239	-428,682	-16.1
Secondary forest	1,038,332	919,749	-118,583	-11.4
Forest plantation	28,590	29,244	654	2.3
Shrub and nonforest regrowth	381,959	354,900	-27,059	-7.1
Agriculture	349,305	408,606	59,301	17.0
Bare	14,878	245,529	230,651	1550.3

Source: Boehm and Siegert 2000

Fig 2.5 The double channel crossing the peat dome in the Kahayan area (after Boehm and Siegert 2000)

Deforestation has caused a decrease in the diversity of species and in the proportion of economically valuable and endangered plants within the plant community. Endangered plants include *Callophyllum soulari, Alseodaphene umbelliflora, Gamma motlyena, Koompassia malaccensis, Gonystylus bancanus, Palaquium sp*., and other rare species. On the other hand, bare land and *alang-alang* (*Imperata cylindrical*) are increasing with land reclamation.

Forest conversion has also disturbed wild fauna, which are, in general, very sensitive to change of habitat. In the Sebangau, Kahayan and Kapuas Rivers, several species that act as indicators of their habitat such as *oranghutan* (*Pongo pygmaeus*), gibbon (*Hylobates agilis*), sunbear (*Helarctos malayamus*) and leopard (*Noefilis nebulosa*) are precipitously decreasing the number in case of the former two and almost extinguished for leopard.

The establishment of canals and their problems

The establishment of canals without paying due regard to the natural hydrology system and the balance of incoming and outgoing water will cause overdrainage (outflow exceeding inflow). In the former MRP area, established canals consisted of (1) a primary canal, 190 km long, consisting of two canals, each 15 m wide at their bottoms, 25 m wide at their upper extremity, 6 m deep, and separated by 100m; (2) a primary canal, 338 km long, 15 m wide at its bottom, 25 m wide at its upper extremity, and 6 m deep; (3) secondary canals, 198 km long, and (4) tertiary canals, 68 km long.

The canals, which were established for irrigating rice fields, failed to serve their purpose due to the lack of water from the upper stream of the Kahayan, Kapuas, and Barito Rivers. The canals were built by cutting through the center of a peat dome, which was a large watershed (Figure 2.5). Moreover, the canals ran towards a lower area downstream, a situation that increased pressure and gravitational forces on the outflow, speeding it up to an extent that could not be compensated by incoming water. Quite apart from this, it is thought that incoming water also adds pressure to outgoing water, making overdrainage inevitable.

The effects of overdrainage are:

(1) Subsidence through the decrease of the peat layer as a result of water loss, including peat water, a vital source of nutrients.

(2) Excessive drying, thus decreasing water retaining features until irreversible drying occurs, creating pseudosand. In the dry season such desiccation causes the land to be prone to fire, which is difficult to handle because it spreads below the ground surface. 10 to 100 cm of peat may be lost to fires, depending on peat thickness and ground water depth. In the rainy season, peat in this condition may induce floods, due to the loss of its water retention capabilities.

Further consequences of subsidence and irreversible drying are:

(1) The steady decrease of peat thickness. The average decrease of peat thickness on agricultural land is reported to be 1.0 to 3.0 cm per year (Limin *et al.* 2000).

(2) Decrease in peat fertility, which is already low due to the loss of active peat water and overall water content.

(3) In forest ecosystems, the drying out of peat inhibits the growth of vegetation, both shrubs and trees.

(4) Changes in the forest ecosystem balance, including climate, biodiversity and

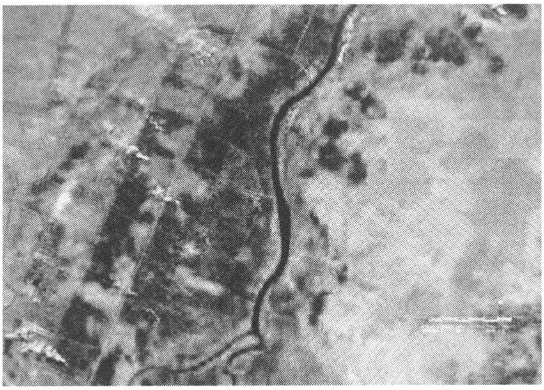
Box

Fires and Smoke Haze Caused by the Mega Rice Project

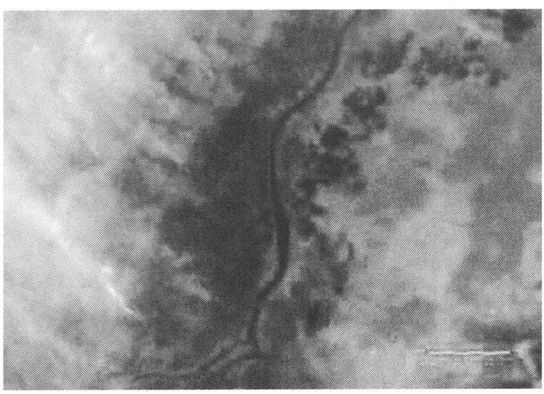
CRISP (Center for Remote Imaging, Sensing and Processing) of the National University of Singapore has displayed the SPOT image sequences of fires that were generated during the land-clearing operation for the Mega Rice Project. The fired area displayed in the SPOT image is located between the Barito River (flowing from north to south in the center of the photograph) and the Mangkatip River to the west, which corresponds to the eastern half of Site A, occupying total of 227,000 ha. The grid lines to the west of the Barito River are the canals. 'The image shown covers about 40 by 30 km.'

First scene: 6 June 1997. 'Land-clearing seems to have started rather recently.'

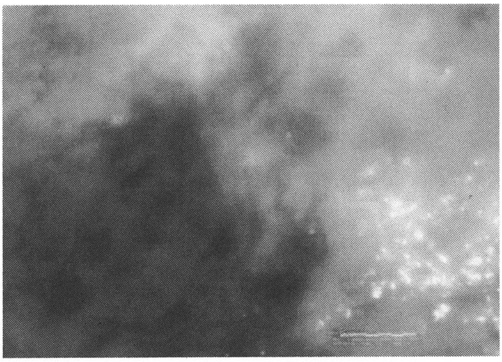
Second scene: 29 July 1997. 'Many smoke plumes rise from burning vegetation,' and large extent of vegetation in the previous image has turned into bare soil or sparse vegetation, which is analyzed as 'the result of burning in the two month period.'



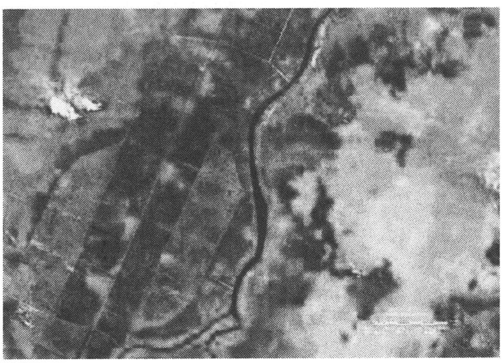
Third scene: 7 August 1997. 'Burning intensifies and the area west of the Barito River is now shrouded in smoke haze.'



Fourth scene: 28 August 1997. 'The whole area is now obscured by dense smoke haze. Through the thick haze, we can see that nearly all the vegetation in the plantation and near the river has been burnt.'



Fifth scene: 8 September 1997. 'The smoke haze has lifted on this day, offering a temporary reprieve and revealing the extent of the damage done. Systematic land-clearing by fire is, however, still in progress.' Two smoke plumes to the west indicate the beginning of land-clearing on the western half of Site A.



Source: SPOT satellite images of forest/plantation fires and smoke haze over Southeast Asia. Fires and smoke haze near Banjarmasin, Kalimantan. Quoted citations are taken from the explanation attached by CRISP.
http://www.crisp.nus.edu.sg/forest_fire/fire/1998/banjarmasin/banjarmasin.html.

(5) Danger of flood in the rainy season and fire in the dry season.

Another important thing to consider is the use of drainage canals for logging transportation - legal or illegal. Satellite images show that canals tend to be constructed through forests. Large, wide canals simplify logging transportation, thus accelerating overlogging and forest degradation.

Swampland development prospect

The management of swampland areas requires serious consideration of the characteristics and suitability for development of the whole ecosystem, with particular attention to the function it already plays as swampland in supporting the surrounding ecosystems. Of the five zones of the MRP, only zone A is suitable for agricultural development, while other zones need to be re-evaluated for their potential in other sectors, such as forestry and reserve forests.

Agricultural value

The soils of swamplands are problem soils, which are not only unsuitable (or only very marginally suitable) for crop cultivation, but are also very fragile ecosystems. An area of 919,000 ha, representing 63.1 per cent of the total area of the MRP, is covered in peat. The use of such peat-covered terrain for agriculture poses several problems, the most serious of which is the high rate of decomposition that occurs within drained peat, and its likeliness to lead to an increased rate of subsidence. About 70 per cent of the annual land subsidence of 2.5 cm in Johor, Malaysia, was caused by peat decomposition (Kyuma *et al.* 1992). Moreover, under anaerobic conditions, peat decomposition produces toxic organic acids, especially phenolic acids which are derived from organic matter with high lignin content. The lignin content of Central Kalimantan's peat is about 80 per cent or more.

Ecological Value

There are many lessons to be learned from the impact of swampland exploitation. Few of the development projects have been completely satisfactory and some have been detrimental. Adverse impacts include increased seawater intrusion, accelerated and uneven subsidence, hydrological disturbances, the development of extreme acidity and hydrophobicity in peat upon drainage, and the production of peat dust particles as a result of desiccation. The fact is that no matter what purpose peat swampland is exploited for, peat should not be disturbed in any way that reduces or destroys its natural functions. Use of the land within peat swamplands requires a zoning plan that accommodates different functions.

Based on the problems induced by land clearing for the MRP, Institut Pertanian Bogor (1996) has recommended 51.8 per cent of land to be allocated as conservation area. Such a conservation area would offer a variety of ecological benefits, such as preservation of biodiversity, replenishment of ground water, trapping of sediments, buffering against seawater intrusion, prevention of coastal erosion, a breeding ground for various water biota including various commercial fish, and a source of non-wooden resources that can be utilized by the local community. Moreover, swampland conservation also maintains water storage functions and hydrological patterns that can prevent excessive drying of swamplands, and concomitant risks of fire.

Conclusion

The MRP project has utilized an extensive amount of swampland and has had a dramatic impact on the ecosystem not only of the local swampland area, but also of areas surrounding the MRP. These changes have resulted in the detrimental development of the land, huge wastage of natural resources, failed community development and adverse impacts on the socio-economic activities of the inhabitants. The MRP accordingly needs to be thoroughly reviewed, and the future utilization of its land based on a serious consideration of the ecological characteristics of the swampland itself.

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3

From Colonization to Transmigration: Changing Policies in Population Resettlement

Sodiono M.P. Tjondronegoro

Population movements between islands of the Indonesian archipelago have been common for at least a few centuries. However, resettlement under government sponsorship, initially known as 'kolonisasi' (colonization) and later renamed 'transmigrasi' (transmigration), involving the moving of people in large contingents, has been practiced only in the 20th century.

The term colonization was already used to denote the movement of small farmers and farm laborers, mainly from Java to Sumatra, to be employed as plantation laborers shortly after *'cultuurstelsel'*, which was a system of forced cultivation of exportable crops, ended in 1870 .

Although plantations were managed by private companies, the colonial administration cooperated by introducing a liberal economic system, consenting to and providing facilities for the recruitment of plantation workers from Java.

These workers were bound by strict rules and treated almost as slaves, with any workers who ran away receiving harsh sentences (*poenale sanctie*). Examples of such treatment are to be found in records concerning Javanese workers employed in plantations in East Sumatra, and ever since known as *Jadel*, a synonym for Javanese in Deli, a well known center of tobacco cultivation. This area was at the time ruled by sultans who were obviously on good terms with the Dutch colonial officials and administrators of foreign plantations.

The idea of recruiting and resettling rural workers that initially occurred towards the end of the 19th century was in fact duplicated when the colonial government started its program of colonization in 1905. A milder and more humane policy was implemented and the migrants were allocated approx 0.75 ha of farmland, which they often had to clear by themselves in dense forest areas.

By and large the migrants were allocated farmland for upland farming and it was only a quarter of a century later that allotments of farmland equipped with irrigation systems improved the entire program of colonization. A well-planned *sawah* (rice field) area that completely changed the landscape was developed in Metro in Central Lampung (Sumatra).

Very few records about these early resettlement projects can be found in Indonesia, and it might be more fruitful to search the official reports of the Dutch controllers and administrators in the Lampung *residentie* in the Royal Archives in The Hague, the capital of the Netherlands.

The earliest academic treatment of the subject was published in the form of a book - now a classic - written by Karl J. Pelzer(1945). His approach was not only scientific, but also comparative, since he compared the Indonesian case with that of the Philippines.

Over a period of nearly one hundred years (1905-2001), migration policies have understandably changed with the requirements and challenges of the age. When promulgated in the early 20th century, the policy sought to aid poor farmers on the island of Java by providing them with the opportunity to improve their fate in Sumatra.

After the Second World War and, more specifically, after the proclamation of the new Republic of Indonesia, the phenomenon of spontaneous migration emerged as population increased.

The doctoral dissertation of Kampto Utomo (now Sayogyo) on *Spontaneous Migration in the Way Sekampung Area of Lampung* has now become a classic academic record of this period. Kampto Utomo saw fit to differentiate between government sponsored transmigration and spontaneous transmigration. The first category also included former armed freedom fighters who were resettled to carry on the struggle, so to speak, by 'turning their guns into hoes' After a thorough analysis, Kampto Utomo concluded that spontaneous migrants were the more successful, and he suggested that a mixed farming pattern would be the most appropriate form for sustainable growth in settlement areas.

The changes in the names of the agencies involved in implementing the transmigration policy over the years also provide an interesting picture of the somewhat capricious search by successive governments for appropriate goals. I think that it would anyway be useful to start by introducing the organizations responsible for overseeing the transmigration policies that have produced the results that we have observed in the field.

Agencies and departments

When population resettlement was started under the name of kolonisasi (1905), the policy fell under the jurisdiction of the Department of Interior. A special commission (H.G. Heyting Report) was entrusted with the study of resettling Javans from the overpopulated Java and Madura to the outer islands.

The first projects involved the migration of 22,940 families within ten years from five locations in Java to six resettlement locations in the Lampung Province. The period 1905-1931 could be described as an experimental period, and 1932-1941, one of more profound and large-scale implementation.

The projects were named 'agricultural colonization' and were directed almost entirely at the demographic objective of population dispersal over a wider expanse that incorporated the outer islands, though migrants were also expected to add to the local labor force.

Pelzer provided an excellent description of the way in which shifting and sedentary agriculture were practiced side by side, but as we see later, shifting agriculture was gradually replaced by the sedentary form. Converting shifting cultivators into sedentary agriculturists can take a very long time, if not several generations.

In the experimental period of 1905-1931, agricultural colonization was limited to upland or rain-fed *sawah*, and it was only after 1932 that colonization was implemented in technically well-irrigated areas, among which the Metro area of Central Lampung (1937), which made use of water from the Way Sekampung River, proved to be the first.

Interestingly, this project was also influenced by the worldwide economic crisis of the 1930s, even educated people in Java were losing their jobs as a result, and seeking new means of making a living by migrating to Way Sekampung (1939). There was a village by the name of Sukohardjo that was inhabited by educated migrants who were at the time known as 'kolonis intelektual' (intellectual colonists).

In the early years of independence (1945-1950), no organized migration or resettlement was carried out, but as soon as the republican government announced new plans for sponsored settlement under the name of *transmigrasi* (transmigration), there was a rush of volunteers, though there was no specific department in charge of transmigration at the time (Kahin 1952).

Certain non-governmental organizations, such as *Biro Rekonstruksi Nasional* (Bureau for National Reconstruction) and *Korps Cadangan Nasional* (National Reserve Corps), also promoted and implemented transmigration, focusing on the families of former armed units and freedom fighters.

In 1947 the government Committee for Economic Strategies gave some consideration to transmigration (Hardjono 1977, p.22), but the program was later placed under the Department of Labor and Social Welfare.

A year later it was transferred to the Department of Development and Youth (1948), and two years later to the Department of Interior (as it was under colonial rule).

It was only after transfer of sovereignty that transmigration came under the Department of Community Development as a Service. Gradually the policy grew in status until it received its own portfolio under the responsibility of the Minister of State for Transmigration Affairs (1957).

Perhaps for the first time the term transmigration was adopted at a ministerial/ departmental level. However, the political winds were pushing the new republic into the direction of guided democracy (4 July 1959). Soekarno, the Republic of Indonesia's first president, decided to introduce this concept because the Peoples Assembly had failed to draft a new constitution after deliberating for more than three years after the first general election (1955).

In the meantime, the regions of Sumatra and Sulawesi were dissatisfied with the political situation, and dissident movements such as the PRRI and RERMESTA emerged in the outer provinces. Several political parties that fiercely opposed Soekarno's decision to install guided democracy (such as *Masyumi*, a Muslim Federation, and the Socialist Party P.S.I.) were banned, leaving only the four largest parties; namely *Partai Nasional Indonesia, Nahdatul Ulama* (Muslim Scholars), Communist Party (P.K.I.) and Murba/Trotskyists.

A Department of Transmigration, Cooperatives and Rural Community Development (known in Indonesian as *Trans Kopemada*) was brought into being by Presidental Decree No. 21 in 1960.

This first step, which sought to merge transmigration with rural cooperatives, reflected a desire to increase social welfare and strengthen economic possibilities through transmigration, but transmigration affairs were later relegated to the status of a service rather than policy, and brought under the jurisdiction of the Department of Cooperatives (Presidential Decree No.99 in 1962).

The capricious nature of these changes in direction was also demonstrated by another change into the Department of Transmigration, Cooperatives and Rural Community Development (Presidential Decree No.232 in 1963), in which four directorates were created to handle transmigration, land clearing, cooperatives and rural community development. A further change occurred with the removal of 'rural community development' (Presidential Decree No. 215 in 1964), creating the Department of Transmigration and Cooperatives. Four directorates were responsible for cooperatives, land clearing, mobilization and settlement, and the consolidation of development in transmigrant communities, respectively.

Shortly after the 1965 - 1966 political upheavals, more fundamental changes took place. Transmigration was transferred to the Department of Home Affairs where it was combined with agrarian affairs to form the Directorate General for Agrarian Affairs and Transmigration (Presidential Decree No. 173 in 1966).

It is interesting to note that transmigration was subordinated to agrarian affairs, while in the same year the Basic Agrarian Law No. 5 in 1960 had been 'put on ice' during the entire period of the New Order regime. Land reform, which was said to be one cause of the political upheavals of September 1965, came to a complete halt, and many landlords whose excess land (that is, beyond a maximum limit) had been redistributed to small farmers and landless laborers, reclaimed it by force, accusing the latter of 'illegal occupation' and land grabbing (*aksi sepihak*).

A further change that reflected New Order government policy incorporated transmigration into the Department of Veterans, which was then renamed the Department of Transmigration, Veterans and Demobilization or TRANSVED (Presidential Decree No. 259 in 1967).

As if all of these maneuvers were not enough, one year later the department mentioned above was again renamed the Department of Transmigration and Cooperatives, which was retained until 1973. Compared with the lifespan of previous departments, this one survived an exceptional six years.

The Department's name subsequently seemed to change every five years. It was combined with others in April 1973 to become the Department of Manpower, Transmigration and Cooperatives, with each of the three sub-departments becoming a Directorate General, and then in the year 1978, when the third Five Year Development Plan started, the Directorate General of Cooperatives was split off to become a department in itself, while Manpower and Transmigration remained united under the same name, with the Indonesian name *Naker Trans*.

The department underwent further name changes in the 1990s, particularly after President Suharto's fall (May 1998), which opened the gate for political reformation. Between 1983 and 1993 the name Department of Transmigration was retained, but in the subsequent year until 1999 it became the Department of Transmigration and Forest Squatters.

The early years of reformation were marked by frequent changes of the Cabinet and presidents of Indonesia, and displayed an even more confusing capriciousness. The Office of the Minister for Transmigration and Population survived only one year (1999-2000), being converted with the inauguration of a new president and Cabinet into an Agency for Population Administration and Population Mobility (2000-2001).

Again with the inauguration of Indonesia's first female president, a new Department of Manpower and Transmigration has been re-established (see Table 3.6).

All of these changes beg the question of whether the newest department will still be able to follow the guiding principles stipulated in Law No. 15 of 1997 on Transmigration Affairs, promulgated under President Suharto's rule.

Box

Transmigrants' life

Men and elephants

Bang! Bang! Bang! The dull and heavy sounds vibrate the leaves of the banana trees planted in foreyard of a nipah house. An old woman continues to beat the ground with a sheath of coconut palm.

'We drive off the elephants like this,' she said. 'They come very close to our houses looking for food.' She pointed to fallen bananas, coconut palms and cassava. 'Sometimes the houses are broken into because they press their itchy skin to house poles and walls to scratch them. It's very awful to hear the sound of snapping trees and to see them puffing around.'

Villagers and immigrants that settled in Jalur 29, Sugihan Kanan of Palembang, look exhausted. The houses are as small as field huts and are inhabited only by old people and children who are obliged to live on a minimal livelihood by producing nipah atap (thatching material). Their eyes are dull, and even the children move slowly without any sign of passion. The village is filled with apathy and a desolate silence. Young men and middle-aged people go away for wages to Bangka, Palembang, and elsewhere.

'How about rice cultivation, you received rice fields, didn't you?' I asked of an old couple. The old man looked at me feebly. Swollen tears filled his eyes. He could speak only after a while with great effort. 'The rice fields are of no use.' He pointed to a vast tall field of sedge.

They came in 1981. In the first six or seven years the ground was wet and could produce about two tons of gabah (unhusked rice) per hectare. After that, the ground dried and the yield decreased. Now nobody cultivates rice because the yield is almost nothing or at most five sacks or about 300 kg per hectare.

Unfortunately, there are also elephants. Formerly tall swamp forests were covering whole tracts of land in this area. They provided good habitat for the elephants. Then the forests were cut and opened for the government transmigration projects. Even now as many as sixty elephants still inhabit the area from Jalur 29 to 27. The elephants have encroached into the immigrants' home gardens where sparse crops are cultivated because the forests that had provided the elephants with food were destroyed. The villagers on one side of the village scare them off with the beating sound. The elephants move to other home gardens on the other side of the village where they are again scared off. They are obliged to roam around the villages of Sugihan Kanan. The government allocated a tract of land in Padang Sugihan that was once opened for the government transmigration project and was abandoned to serve as an elephant sanctuary. The elephants, however, didn't like to move onto a foreign tract but instead still try to live in their former habitat. Both men and elephants are victims of an ill-designed swamp reclamation project.

The transmigration area that is a housing project for wage laborers

Women and children are taking their morning baths in the feeder canal SK16 of Rantau Rasau, Jmbi. In front of the Public Works mess, there is a small market. A wooden bridge in front of the market is busy with people carrying fuel wood, vegetables, planks, bamboo and children on bicycles. Anchored in the feeder canal are some pompongs (motored cargo boats). I wondered what they transport. In the case of settlements opened by spontaneous immigrants, many pompongs carry rice, coconut shells, copra and fish. But here in Rantau Rasau, there are no such products.

I strolled along, talking with people sitting and chatting in front of the market. I asked them, 'What do these pompongs carry - rice, coconut?'. They looked at me, surprised. 'How can they carry a rice harvest when there is no rice crop?' one middle-aged man asked..

'Then, coconut?' 'No, no coconut crop,' many people chorused. 'Then, what do you do? Are you not engaged in agriculture? You came here as farmers, didn't you?'

'Yes, we came here to live by farming, but how can you live as a farmer when it is impossible to grow crops? Less than 20 per cent of us government immigrants can depend on agriculture crops,' the middle-aged man answered.

Many people disagreed, 'No, no, less than ten per cent.' I repeated the first question. 'Then, what do you do? How do you earn a livelihood?' With one voice all answered, 'Earn wages.'

'Then, you are not farmers, are you?' 'We are wage laborers' one youth added with irony,.. 'Rantau Rasau is a housing project with wretched housing for cheap laborers. The pompongs carry commuters to work just like the angkut [city bus] in town'. All agreed with a desperate laugh.

A similar despair permeates most of the government transmigration settlements on the coastal peat wetlands of Sumatra and Kalimantan.

FURUKAWA Hisao

Table 3.1 Cumulative transmigrant totals by areas of origin up to 1968

Year	Area of origin						
	West Java	Central Java	Yogyaka-rta	East Java	Bali	Local	Total
1950	—		—	—	—	—	77[1]
1955	12.032	28.988	12.752	33.251	8.963	10.706	106.692
1960	26.710	78.102	28.079	95.103	16.431	28.443	272.867
1965	40.569	135.510	43.962	121.866	42.208	29.094	413.209
1968	47.326	145.875	46.579	127.860	44.572	29.094[2]	412.212[3]

Notes:
1) Origins unknown
2) No additional transmigrants between 1966-68
3) Local migrants subtracted from 1968 total.

This law substituted Law No. 3 of 1972 on Transmigration.

These successive name changes, more than a dozen in all, leave the impression that transmigration was an inconsistent policy that aimed to redistribute people for purposes that varied according to time and political circumstances.

Despite these efforts, however, the population in Java has remained at about 59 per cent of the total Indonesian population, while the general population census of 1971 indicated an increase in inter-island migration outside Java.

This is no doubt because Java's various public services, facilities and infrastructure are more advanced and modern than other regions, as a result of which people continue to flow into Java for education, health services and even employment opportunities, impeding attempts to reduce its population.

Policy changes

The successive capricious changes in names and institutions responsible for transmigration reported in the previous section suggest that ever since the proclamation of independence, a string of cabinets have struggled to come up with a clear and focused agenda for transmigration. However, the dominant theme over the years has been the redistribution of population from overpopulated Java and Madura and to some extent, Bali and Lombok.

One senses a restless search for a consistent objective/purpose to be realized. Two main elements may be distinguished: one to improve the migrant's social welfare, and another to reap economic benefits in addition to promoting regional development from transmigration. The aim of setting up cooperatives is to empower the migrants economically, and to further sustain regional development in previously uninhabited and rather backward areas of the larger and relatively sparsely populated islands of the vast archipelago.

Provincial governors were happy to support such a policy, since for them transmigration meant opening up and breaking the isolation of remote corners of their provinces. They consequently welcomed transmigration if the projects were aimed at distant locations from the cities, not only because land would be available in greater abundance, but also because such location would require the construction of roads to connect the transmigration area with the capital city and/or larger cities in the province. Agricultural products could then find a market more easily.

This has certainly been a guiding principle for a long time, but the problem is that the more remote the location, the harder it is for transmigrants to market their products, unless infrastructure is adequate, but paradoxically, the purchasing power of migrants in such locations is insufficient to ensure the establishment of adequate public transport networks. It would appear that, for the time being, migrants are content as long as their basic needs are guaranteed and supplied, but they are likely to give voice to increasing demands in the future.

An extensive account of transmigration, particularly of the early 1970s, is provided in the book by Dr. Joan Hardjono (1977), while I have covered the period beyond up to the late 1980s.

If the total number of families resettled is a reflection, albeit partial, of transmigration policy, then the figures covering the period 1950 to 1968 (Hardjono 1977: 14) present an interesting picture.

Table 3.1 shows cumulative totals for successive five-year periods, such that the overall cumulative total up to 1968 is the figure at the bottom of the far-right column. It is assumed that spontaneous migrants, for which figures are unavailable, numbered well over 0.5 million families for the same period.

Duplicate counting of government-sponsored migrants has also occurred as a result of migrants registering more than once in order to acquire additional land in different settlement locations. There are, moreover, no records of sale of land before the required installments have been paid off.

With regard to allocated land area, policy makers came to the conclusion that 0.75 ha is not enough to guarantee a sufficiently prosperous living through farming and, as a result, the size of the standard allotment for the transmigration programs implemented in 1950 was increased to 2 ha. However, this decision was not legalized until 1972, when the law on transmigration (No. 3 1972) was enacted.

The department in charge of transmigration acquired the resettlement area through negotiations with the provincial government. The basic assumption has been that the provincial government enters into negotiations with local *adat* (customary law) notables and council members to obtain their consent. As is well known, the *adat* notables are the ones who decide what the territory should be used for under customary law.

In principle, private property does not exist under customary law, only the right to use and enjoy usufruct.

Clashes between indigenous people and transmigrants due to differences of perception regarding this law seems to have occurred frequently in Sumatra, Kalimantan, Sulawesi and Irian Jaya, where no cadastral registration had ever been carried out.

In actual practice, once a piece of land has been allotted to a transmigrant, the land is owned by the migrant. Due to such conceptual differences, land disputes have occurred frequently after the migrants' arable land begins to bear fruit.

Originally most settlement areas were brush land overgrown with savannah grass (*alang-alang*), certainly not the most fertile land in the region. Once cultivated by diligent migrants, however, it rises in price due to its added value, which in turn spurs indigenous peasants (shifting cultivators), whose perception is still rooted in common rather than individual ownership, to attempt to reclaim the land.

Obviously there are also local people who abuse that concept to reclaim a migrant's arable land. From the Department of Transmigration's point of view, once the provincial government gives its consent to accept transmigration, the status of the land falls automatically under the law, which guarantees legal ownership by the individual migrant. Thus, the sale and purchase of such land also therefore becomes possible, and is in fact often practiced by transmigrants.

The policy of developing transmigration areas in swampy areas did not materialize until the late 1950s or early 1960. One of the early attempts was in Cintamanis, along the Musi River close to the city of Palembang, South Sumatra. In the first five-year development period (1968/69-1973/74), a larger project known as Upang Delta at the estuary of the same Musi River was launched. The province of South Sumatra was probably selected because some 21 per cent of the provincial territory was swampy, and developing the tidal area for Javanese migrants would suit them since they are used to *sawah* rice cultivation.

But while the Upang Delta project was implemented, soil research was also carried out. It appears that water quality, which proved to be too acidic to produce high agricultural yields of rice and soybeans, was causing problems, rather than irrigation system construction or the practice of sawah cultivation in tidal areas.

In many tidal area districts of Kalimantan one would see lush fruit trees such as mango, jack fruit, pineapple and rice fields only along the river beds. The acidity of inland peat soil is clearly a handicap for food crop farmers, and would require a great deal of liming to neutralize it.

A more technical problem in tidal areas seems to be the difficulty of predicting the scale and timing of river floods, information that is critical to the control of drainage as the paddy ripens and no longer needs so much water.

Regulating water supply through sluices and maintaining the irrigation canals is another technical problem. Javanese farmers in well irrigated *sawah* areas in their villages of origin are accustomed to maintaining only tertiary canals, leaving the maintenance and repair of primary and secondary canals to the Directorate General for Irrigation, a service provided within its bureaucratic structure. This system was well organized in Java, but apparently less so in new tidal transmigration areas.

The Upang Delta experiences have shown that only certain long grain varieties of rice can grow well, providing a harvest of 3 to 6 tons per hectare, but allowing only one harvest per year. In the early 1970s there was also a shortage of freshwater, as the river and canal waters were too acidic, and people had to depend on rainwater (Hardjono 1977: 59). Second crops did not grow as well as rice, and farmers had to resort to tree felling to earn additional income.

More lessons were learned on other big islands, such as Kalimantan. Transmigration for rice cultivation was carried out here too, between 1950 and 1960, but on the whole, the projects were not a success.

The first project was started at Takisung in 1953, followed by tidal irrigation projects at Tamban (1957), Marabahan (1959) and Balandean (1961). Tidal irrigation, however, was only nominal. Altogether 10,355 people were settled in these four projects. As in other areas, these transmigration projects were transferred to the provincial government within five years after resettlement. During the first year migrants received some rations of staples such as salt, rice, cooking oil and salted fish.

Barambai, which was established in 1969, initially gained fame because of its good yields, but of late, the area has been declining in prosperity due to poor irrigation system management and poor maintenance of the canals (Ardiyansyah 2001, personal communication).

There is huge potential for larger tidal areas to be developed, as shown in table 3.2, but past experiences have shown that greater investment is obviously needed, not only for the construction and maintenance of irrigation systems, such as dams, canals and sluices, but also for farmers practicing rice cultivation, which requires more fertilizer and lime to neutralize soil acidity.

In 1997 the launch of the largest and most audacious transmigration project ever attempted on swampy land took the place: *Proyek Lahan Gambut* (PLG), or Peat Soil Tidal Area Project, also known as the Mega Rice Project. A territory of 1 million ha in Central Kalimantan between the Kapuas and Barito Rivers was to be reclaimed and converted into a vast irrigated transmigration settlement area.

Despite the sparse population of the area, it was decided to recruit a mix of 40 per cent local migrants from South, East and West Kalimantan and 60 per cent transmigrants from Java, Madura and Bali to settle the PLG area but the question remains as to how many will be willing to develop the PLG project area, as it is so far lying idle. After the ethnic conflicts in the late 1990s, local migrants from a different ethnic group from outside Kalimantan, such as the Madurese, would not take this option.

Assessment

The process of assessing the achievements, successes and failures of the transmigration program serves to remind us of the great diversity of objectives that the program sought to accomplish in the course of almost a century.

The implementation of the program under different departments, as described in the preceding section, resulted in a failure to establish a consistent agenda of objectives. Under the Department of Interior in the colonial era, the emphasis was on resettling poor farmers from densely populated provinces to become plantation/estate workers initially on the island of Sumatra - in other words, it was a demographic solution designed to supply labor where it was needed.

The transmigration program was subsequently directed at the expansion of arable land for rice and second crop cultivation, and still later, to establish cooperatives, strengthen communities and finally to sustain regional development.

In all cases, an intrinsic target has been to empower landless laborers and farmers by improving their living standard.

The first comprehensive assessment by experts interested in resettlement problems appeared in a book edited by Swasono (1985) containing twenty-five contributed articles that described the successes and failures, the hopes and constraints of the program.

Providing a balanced account of the pluses and minuses depends upon one's point of view. The program has certainly been a success in terms of clearing land for the expansion of arable land, and accelerating and stimulating population mobility, as well as supplying labor in previously almost uninhabited areas.

An official report by the former Minister of Manpower and Transmigration, Martono (Swasono 1985), states that based on a survey conducted by the Central Agency of Statistics (BPS), almost 67 per cent of transmigrants had higher earnings than in their original home villages, and 55.7 per cent felt that their housing and living conditions had improved.

However, while they earned the majority of their income from agriculture, almost 33 per cent of migrants confessed that they also had off-farm earnings. It should also be noted that many migrants have been complaining about infertile land allocation, forcing them to open up forest land for survival. This has brought about changes in the local ecology, not always for the better.

There is a general trend towards moving away from agriculture, and second generation migrants prefer to leave the countryside after acquiring better schooling in nearby towns. In recent years, these second generation youth from the oldest transmigration province of Lampung have been moving back to West Java to find employment. Those who have succeeded in obtaining university education might also stay in larger cities on the island of Sumatra, such as Palembang, Medan, Pekanbaru and others.

One factor that seems to impoverish the migrants who were initially allocated 2 ha of land is the fact that they tend to redistribute it in smaller plots to their sons as inheritance. Sometimes land is also sold to cover large expenses. Poor returns on the sweat invested in agriculture also discourage migrants' sons from remaining as farmers like their fathers.

Comparing different patterns of agriculture, it is clear that transmigration to well irrigated fields has been the most successful. Upland transmigration would very much depend on soil fertility, and obviously no provincial administration is going to make the most fertile areas available to the Transmigration Department. Spontaneous migrants who develop good relations with the local population from the very beginning are often better off.

Previous experiences have shown that tidal areas, though seemingly irrigable, are considered to be among the least productive soil types.

The impact of transmigration on previously untouched forest environments is largely indirect. Migrant contingents resettled by the Department of Transmigration are never allocated the best land. More often the land allocated is a secondary forest area at best, or a region overgrown by savannah grass.

The arrival of new settlers does however reduce the area available for shifting cultivation by local people, forcing them to encroach on adjacent virgin forest areas to practice their slash and burn agriculture. They are then occasionally pushed further into the forest by existing forest concessionaries (HPH/HTI) of large estates that have also cleared forest land. Ecological conditions are inevitably changing due to such factors.

Recent events in transmigration areas have made us aware that while settlements have boosted economic opportunities, inter-ethnic tolerance and assimilation are not progressing as fast as hoped for. Subcultural differences seem to require a longer time span to be dissipated through social-economic institutions, inter-marriage and occupational cooperation.

Nevertheless, the fact that from 1969/70 to 1990/91, approximately 1.5

Table 3.2 Swamp area in Indonesia

Island	Swamp Area (x 1000 ha)	Total area (x 1000 ha)	Swamp as % of total
Sumatra	13,211	47,360	28
Irian Jaya	12,780	42,195	30
Kalimantan	12,764	53,964	24
Sulawesi	469	18,204	3

Source: World Bank (1988) Indonesia: the transmigration program in perspective (Washington, D.C. World Bank p.132)

million households, or some 7 million people, were resettled in hundreds of newly opened transmigration areas in the outer islands (see Appendix Table 3.7), represents a very impressive achievement.

Achievements of the last decade

The last decade of the 20th century was marked by the search for a new paradigm in transmigration programs. Since the 1950s the programs had been focused mainly on population redistribution, but particularly from the fifth Five-Year Development Plan (Pelita V, 1990/91-1994/95), the emphasis has been increasingly on providing semi-skilled to skilled workers to needy provinces. In several instances communication between districts with such demands on one side, and districts able to supply such workers on the other, have been established.

Pelita V, as mentioned above, can be seen as the turning point. The figures in Table 3.3 denote the many billions of rupiahs spent by the central government on transmigration throughout the country in this period.

Pelita V was carried out by implementation units of the Department of Transmigration and Settlement of Forest Squatters, and as can be read in Appendix Table 3.6 the department's name was changed in 1999, reflecting a greater focus on population mobility in the new cabinets of the era of reformation.

Particularly after promulgation of Law 22 and 25/1999 on Regional Autonomy, mobility of the labor force became even more important in the context of a more decentralized government.

Since Pelita V the keeping of records of population movements has also improved. In Appendix Table 3.9, figures are presented for twenty provinces on the islands of Sumatra, Kalimantan, Sulawesi, Maluku and Irian Jaya. Those figures show that the present population has declined somewhat, though the reasons why migrants have left the settlement areas are unclear.

Between 1950 and 2001 some 3,054 transmigration units were established, which means that some 2.44 million have been redistributed. Agricultural

Table 3.3 Budget for Pelita V

Year	Routine Budget (Rp)	Development Budget (Rp)
1989/90	30,386,432,790	141,737,362,655
1990/91	32,601,422,210	396,508,968,670
1991/92	46,874,456,067	539,201,379,152
1992/93	52,028,527,252	663,000,156,693
1993/94	68,695,658,961	702,731,881,877

Table 3.4 Productivity in various areas

No.	Commodity	Productivity (ton/ha)		
		Transmigration area (1999)	National (2000)	Outer islands
1	Rice (sawah)	2.2	4.6	4.0
2	Rice (swidden)	1.5	2.3	2.0
3	Corn	1.4	2.7	2.5
4	Peanuts	0.8	1.1	1.1
5	Soybean	0.9	1.2	1.1

Source: Pusdatin (1999) and CBS (2000)

Table 3.5 Monthly expenditure of various households

Migrant households	Rp. 545,000	per month
National average	Rp. 506,280	per month
Non-migrant households in outer island	Rp. 386,052	per month

productivity in transmigration areas, however, is considerably lower than the average national productivity or even the productivity in the outer islands, as Table 3.4 shows.

According to the Research and Development Division of the present Department of Manpower and Transmigration, transmigration to upland areas accounts for roughly 83 per cent of the total, while transmigration to tidal swamp areas accounts for the remaining 17 per cent.

From the point of view of household economics, transmigrants seem to have higher monthly expenditures than other households (see Table 3.5)

Migrants tend to spend much more on the education of their children than on health, after the needs for food and housing are met.

In terms of area development, transmigration areas have given birth to fifteen district and municipality towns and close to ninety subdistrict towns, each of which may cover 100 or more square kilometers, not to mention the 2,500 villages that have also emerged from these settler communities (see Appendix Table 3.10). Such are some of the more tangible and recorded results of almost one hundred years of transmigration.

However, any balanced account of the transmigration program requires due attention also be paid to the project failures and ethnic conflict mentioned in the previous section.

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Appendix

Table 3.6 List of name changes 1947-2002

Year	Indonesian Name	English Translation
1947	Kementerian Perburuhan dan Sosial	Ministry of Labor and Social Affairs
1948	Kementerian Pembangunan dan Pemuda	Ministry of Development and Youth
1948	Kementerian Dalam Negeri	Ministry of Interior
1949	Kementerian Pembangunan Masyarakat	Ministry of Community Development
1950	Jawatan Trnasmigrasi	Transmigration Service Unit
1951-56	Kementerian Sosial, Jawatan Transmigrasi	Same as above under The Ministry of Social Affairs
1957	Kementerian Negara Urusan Transmigrasi	Ministry of State for Transmigration Affairs
1958-62	Kementerian Transmigrasi, Koperasi dan Pembangunan Masyarakat Desa	Ministry of Transmigration, Cooperatives and Rural Community
1962	Kementerian Koperasi	Ministry of Cooperatives
1963-64	Kementerian Transmigrasi, Koperasi dan Pembangunan Masyarakat Desa	Ministry of Transmigration, Cooperatives and Rural Community Development
1966	Department Dalam Negeri	Department of Interior
1967	Departmen Transmigrasi, Veteran dan Demobilisasi	Department of Transmigration, Veterans and Demobilization
1968-73	Department Koperasi dan Pembangunan Masyarakat Desa	Department of Cooperatives and Rural Community Development
1973-78	Departmen Tenaga Kerja, Transmigrasi dan Koperasi	Department of Manpower, Transmigration and Cooperatives
1978-83	Departemen Tenaga Kerja dan Transmigrasi	Department of Manpower and Transmigration
1983-93	Departemen Transmigrasi	Department of Transmigration
1993-99	Departmen Transmigrasi dan Pekukiman Perambah Hutan	Department of Transmigration and Forest Squatters Settlement
1999-00	Kantor Menteri Negara Transmigrasi dan Kependududkan	Office of the Minister of State forTransmigration and Population
2000-01	Badan Administrasi Kependudukan dan Mobilitas Penduduk	Agency for Population Administration and Population Mobility
2001-present	Departmen Tenaga Kerja dan Departmen Tenaga Kerja dan	Department of Manpower and Transmigration

Table 3.7 Numbers of transmigration households 1969/70-1990/91

Pelita & Years	Target	Achievement	%
Pelita I	46,566	46,268	99.4
1969/70	4,489	3,933	87.6
1970/71	3,865	4,338	112.2
1971/72	4,600	4,171	90.7
1972/73	11,200	11,414	101.9
1973/74	22,412	22,412	100.0
Pelita II	82,959	82,595	100.0
1974/75	11,000	11,000	100.0
1975/76	8,100	8,100	100.0
1976/77	13,910	13,910	100.0
1977/78	22,949	22,949	100.0
1978/79	27,000	27,000	100.0
Pelita III			
1979/80	500,000	535,474	107.1
1980/81	50,000	78,861	159.7
1981/82	100,000	100,552	100.6
1982/83	125,000	127,970	102.4
1983/84	150,000	178,732	119.2
Pelita IV	750,000	750,150	100.6
1984/85	125,000	101,888	81.5
1985/86	135,000	166,347	123.2
1986/87	150,000	172,859	115.2
1987/88	165,000	163,947	99.4
1988/89	175,000	145,109	82.9
Pelita V	48,000	73,783	153.7
1989/90	27,000	26,553	98.3
1990/91	60,000	47,250	78.8
Total	2,819,050	2,927,565	101.5

In addition to these government sponsored transmigration programs, the logging and timber industries outside Java and Bali attracted more workers from those islands. The Department of Forestry reported the following numbers of workers, presumed to be mostly males.

Table 3.8 Workers employed in forestry sector.

Pelita	Numbers of workers
Pelita I	69,171
Pelita II	237,762
Pelita III	369,377
Pelita IV	316,868
Pelita V	402,131
Total	1,395,309

Source: Orde Baru dalam Angka (New Order in Figures, p.126
Jakarta, Secretariate General LOLKAR, 1992)

Table 3.9 Transmigration after pelita V up to year 2000

	Province	Realization Households	Persons	Present Households	Persons
1	D.I.Aceh	6,910	28,971	5,096	22,390
2	North Sumatra	3,485	15,304	3,429	15,155
3	West Sumatra	2,240	9,532	2,256	10,098
4	Riau	6,496	25,740	6,847	27,613
5	Jambi	7,094	37,509	7,369	32,329
6	South Sumatra	7,166	30,682	7,230	31,288
7	Bengkulu	-	-	-	-
8	Lampung	3,024	12,723	3,146	13,302
9	West N.T.	2,838	12,792	3,236	13,357
10	East N.T.	2,765	12,447	2,831	13,014
11	West Kalimantan	13,382	54,978	11,775	50,312
12	Central Kalimantan	18,087	71,203	17,649	70,628
13	South Kalimantan	5,070	18,693	5,055	19,950
14	East Kalimantan	8,995	34,139	8,944	33,973
15	North Sulawesi	530	2,063	495	2,077
16	Central Sulawesi	3,965	15,533	4,030	15,723
17	South Sulawesi	5,864	24,814	6,380	26,450
18	S.E.Sulawesi	3,785	14,510	3,798	15,548
19	Maluku	-	-	-	-
20	Irian Jaya	20,092	71,377	18,940	68,861
	Total	121,738	492,510	118,506	482,068

Table 3.10 Development of district and municipal towns

No.	Settlement unit	District / Municipality
1	Janto	Aceh Besar
2	Arga Makmur	Bengkulu Utara (Bengkulu)
3	Metro	Kodya Lampung (Lampung)
4	Metro	Lampung Tengah (Lampung)
5	Menggala	Tulang Bawang (Lampung)
6	Sikadana	Lampung Timur (Lampung)
7	Pleihari	Tanah Laut (South Kalimantan)
8	Marabahan	Barito Kuala (South Kalimantan)
9	Kota Baru	Kota Baru (South Kalimantan)
10	Sendawar	Kutai Timur (East Kalimantan)
11	Raha	Muna (S.E. Sulawesi)
12	Unaha	Kendari (S.E. Sulawesi)
13	Aimas	Sorong (Irian Jaya)
14	Timika	Mamika (Irian Jaya)
15	Desa Tuapejat (UPT Sipara 1, Sipara 2, Sipara 3	Kepulauan Mentawai (West Sumatra)

Source: R. & D. Division, Department of Manpower and Transmigration.
A total of 2,500 new villages, 82 sub-district towns, and 15 District/Municipal towns arose from a total of 3,325 settlement units.

4

A National Project That Failed: A Tale of Population Resettlement Policy in Indonesia

RIWANTO Tirtosudarmo

For researchers in universities or other institutions who have not been directly involved in the process of policy-making during the Repelita periods, studying the complexity of transmigration has been a challenge. The question they face is whether to seek answers through adopting the policy makers' narrow views or through extending the existing terms of reference on the grounds that the solution is most likely to be found within a wider perspective.

Sayogyo 1985, pp.42-43

Sayogyo, a respected professor of rural sociology at the Bogor Institute of Agriculture, was a true academic who was always critical of the development policy adopted by the government. The above quotation, which appears in an edited book to commemorate the eight '*windu*' (years) of population resettlement policy in Indonesia, was a caveat on existing studies on transmigration policy. Sayogyo's views, which he made public in 1985 at the height of Suharto's New Order government, were not surprisingly generally ignored by almost everybody. Yet, not very long afterwards, as the oil price collapsed, the transmigration policy began to experience a paralyzing development. As was the case with other development projects, the decline in state oil revenues, resulted in a significant downscaling of the transmigration program. A well remembered event following the decline in state oil revenues was the statement by the Junior Minister for Transmigration, Martono, on 24 November 1987 to *puso*[1] the houses that had been built in various transmigration destination areas in the outer islands.

The transmigration policy had basically lost its rationale and legitimation since the mid-1980s. From an economic and demographic perspective, the policy to move people away from Java was against the macroeconomic forces that strengthened the expansion of economic opportunities in Java rather than outside Java. The economic shift instigated by the collapse of oil prices has forced the state to adopt a more export-oriented policy, replacing the previous import-substitution strategy. The transmigration program, within the macroeconomic context, therefore became a counter-productive policy within the macroeconomic context, as the overall development trends clearly promoted the creation of employment opportunities in Java rather than in the outer islands. Surprisingly, however, the transmigration policy retains its status as a national priority on the state's policy agenda. The perception among the ruling elite, particularly the military, that the transmigration policy is pivotal to national security, is the only rationale behind continuing the transmigration program in Indonesia.[2]

The state's policy of resettling population from one area to another within the national boundary is not a new phenomenon in the history of mankind. The motivation behind such policies varies, ranging from the simple purpose of saving the population from a natural disaster, to the highly complex purpose of the building of the nation-state. In Indonesia, population resettlement policy - which is known as *transmigrasi* - is perhaps rather unique in the sense that it covers almost all purposes from the simple to the most highly complex goals. Tracing the history of population resettlement policy from the beginning of the twentieth century until today shows that the goals are continuously changing according to the immediate needs of a particular government. The ambiguity and multiplicity of the goals apparently provides the state with a convenient vehicle to be manipulated for various purposes, and this is most likely the underlying reason why successive regimes in Indonesia have continued implementing the policy at all costs. This paper will show that population resettlement policy or *transmigrasi* is a policy of failure. What can we learn from this failed national project?

Population policy and the state's agenda

The United Nations' surveys among developing countries have indicated that the most widely perceived population problems were population distribution and internal migration and, surprisingly, not population growth, as had been widely suggested by most population experts, international organizations and many leaders in Western industrialized countries[3]. The explanation for this contradiction lies within different perceptions of the population problem. The survey results showed clearly that internal migration and population distribution were more frequently perceived as problems requiring intervention than were such issues as fertility or mortality. Unfortunately, the survey did not further investigate why most developing countries considered population distribution and internal migration to be their primary population problems. Myron Weiner (1975, p.66), a political scientist who has written widely on the topic of population, argued that: 'Many governments believe that some of the problems intensified by rapid population growth can be eased by policies directed at the dispersal of populations - partly because they consider population distribution more easily influenced by government policies than fertility, and partly because they may advocate population increases for the country as a whole and view a redistribution policy as a means of reducing some of the costs.'

As with other population-related issues, population distribution policy has become an area that increasingly involves scholars from different disciplines. As a result, the literature on population distribution reflects a variety of interests and different approaches and perspectives. As noted by Richardson (1984, p.263): 'From the point of view of population policy, there are grounds for suggesting that population distribution is the main current and future population issue. There is a substantial degree of argument about what should be done to reduce fertility and mortality, and there have been some notable successes. With respect to population distribution policy, however, there is no consensus and there are no unambiguous successes. The field is riddled with extreme value judgments, ideological stances, and unsubstantiated assertions, many of them myths'.

The view of population policy described by Richardson closely approximates the reality in Indonesia. Compared to family planning policy, which has almost no historical precedent, transmigration policies dealing with sponsored population movement from Java to other islands have been in existence for almost a century. Yet the relative outcomes of the two policies confirm Richardson's judgement. The success story of family planning in Indonesia has been almost without rival among Third World countries. By contrast, transmigration policy is admitted to be a less successful population policy, confronted by formidable problems of implementation[4]. In comparison with other Indonesian development programs, transmigration has been given high priority, receives a significant allocation in the national budget, and is directed towards ambitious and multi-focused goals. As stated by President Suharto in an interview with Hopper (c.1987, p.26), 'Transmigration is one of the absolute necessities if we are to achieve our national goals - a higher living standard for our people, economic growth and national stability'. Yet, a comprehensive analysis of transmigration policy is long overdue. As Babcock(1986, p.160) observed: 'Indeed, so entrenched, even "sacred", a part of national policy and consciousness is transmigration that it has rarely been subject to probing criticism. The media, as well as various research reports, do indeed criticise certain aspects of the programme, and more commonly the failure of particular projects, but they attempt no overall evaluation.'

In Indonesia, development policy has always been influenced by the dynamic relations between the center (Java or Jakarta) and the periphery (the regions or outer islands). This is partly because Indonesia is a fragmented nation of islands, with Java the most populous, and because it is characterized by marked cultural diversity. In addition to their larger numbers, the Javanese have always been the dominant cultural group and the most influential ethnic group; consequently, as noted by Bruner (1974, p.252), 'most other Indonesians see themselves as engaged in a more or less continual struggle to keep from being Javanized'. Since independence in 1945, Indonesia's development has been marked by conflict and consensus between the interests of the regions (non-Javanese peoples) and the center (dominated largely by the Javanese). Transmigration policy has thus been conditioned to a very large extent by the dynamic relations between central and regional governments and between Java and the Outer Islands. Jones (1979: 220) argued that the implementation of the transmigration program had been affected by the state of center-regional relationships within the country: 'The degree to which people in the outer islands will be willing to accept the continued organized influx of rural Javans will no doubt depend largely on the broader political situation, the extent to which the programme is perceived as benefiting Java or Indonesia, and the sensitivity with which the transmigration program is administered'.

Population distribution policies in the Third World

Since the Bucharest Population Conference in 1974, in which population distribution was first considered as a major population problem in the Third World, studies on population distribution policy have flourished. Yet, systematic reviews of this topic have remained few and of an exploratory nature in character (Fuchs and Demko 1981, p.70). Jones and Richter (1981, p.2) noted that, despite the concern and, indeed, obsession of Third World leaders with problems of population distribution, the state of regional development and migration theory is unsatisfactory. There are no clear guidelines even regarding the appropriateness of many widely accepted goals. Part of the problem is the plethora of frameworks of analysis, many of which are primarily descriptive rather than policy-directed. Another limitation of existing studies is the fact that, given the specificity of each country's experience, generalizations or a 'cookbook approach', is of no great help and could be a dangerous undertaking (Whitney

1983; Desbarats 1988). The most substantial limitation of existing studies on population distribution policies, however, is their isolation from Third World political contexts, as correctly identified by Migdal (1977: 242): 'Analyses of policies in the Third World, in particular, have often ignored the political context within which policies are formulated and put into action.'

Although several studies have shown the need to incorporate socio-political factors into the analysis of population distribution policy, few have been conducted on an empirical basis. Among the studies that analyze population distribution policy within country-specific political contexts are studies by Chambers (1969) on settlement schemes in tropical Africa: Farmer (1974) on agricultural colonization in India; Bunker (1979) and Sawyer (1981) on colonization and frontier expansion in Brazil; and Dunham (1982) on land settlement in Sri Lanka. The lack of analyses that place population distribution policy in a Third World political context has resulted in a growing distance between the accumulation of existing knowledge on the subject and reality.

An approach that is able to disentangle the complexities of population distribution policy from its implementation in a specific country context is needed. Population distribution policy is essentially an outcome of a policy-making process that operates within the political realm, especially in the Third World. An analytical attitude towards development issues, which has been described by Goldsworthy (1988, p.507) as 'political mindedness', is perhaps a good starting point for such an endeavour: 'In essence, political-mindedness means a sensitivity to the phenomena of values, interests and power in human affairs... One of the attributes of political-mindedness, then, is a concern to elucidate the relationships between values and policy preferences in terms like these. To grasp these relationships is to be better able to uncover unspoken assumptions and to see through pretensions of value neutrality...(as claimed for example by development technocrats)' (Goldsworthy 1988, p.509).

Many have defined population policy in various ways, but few have agreed on its precise meaning or constituent parts. Recent statements have identified many of the difficulties of defining and identifying policy as it relates to population issues (Jones and Richter 1981; Fuchs 1983; Desbarats 1988). In its most inclusive sense, population policy is a set of actions - stated or unstated, intended or unintended - by a national government or local government, organization or interest group that affects population size, growth rate, composition or distribution. In addition to the recent attention given to population distribution issues, little agreement has emerged so far concerning the specific aims of redistribution policies. Attempts to define goals with operational precision have commonly floundered on value judgements, ideological biases, and unsubstantiated assertions (Desbarats 1988, p.2).

However, three major objectives have been identified as dominating population distribution policies adopted among the Asia Pacific countries (Fuchs 1983): the deceleration or reversal of rural-to-urban migration trends; alteration of rural population distribution, in many cases through colonization or resettlement schemes; and alteration of urban configuration, usually through controls on primary city growth and development of small and intermediate-size cities. Desbarats (1988, p.3) argued that population distribution policies should not be viewed for their own sake, but as a means to achieve broader goals. They cannot be considered in isolation. Fuchs (1983), among others, broadly distinguished two categories of government policies on population distribution: explicit and implicit policies. Explicit policies are those that have explicit intentions to distribute or direct population movements. Such actions are intended and deliberate, whereas implicit population distribution policies are any policies that have an indirect impact on population distribution within the country. Pryor (1976, p.22), on the other hand, viewed population distribution policy somewhat more narrowly as, 'responding to the effects of a population distribution which is viewed as undesirable on some specified or unspecified criteria, or as positively influencing the choice of destination of migrants....'

A broad review of studies on population distribution policies in developing countries shows that most have been based on secondary data. Most studies include detailed descriptions of migration patterns, typologies of population distribution, discussions of the constraints faced because of such policies and, finally, suggestions for improving or overcoming problems caused by, or resulting from, population distribution in developing countries. Usually, options have been provided to Third World planners to enhance their capacity to integrate population distribution and internal migration with national development. Further data needed for this purpose has been identified and future research areas also recommended. Many studies, although comprehensive in their approach, attempt to cover very wide areas; some even cover all developing countries (Findley 1977; UN 1981; Oberai 1983; Fuchs 1983; van der Wijst 1984). Analysis has typically become too general and its applicability is to be questioned, given the uniqueness of each developing country. The recommendations that flow from such analyses have usually been too abstract and difficult to implement. Population distribution policy analysts have failed to adequately understand the policies of developing countries because they have, either intentionally or unintentionally, attempted to apply a 'developed-nations' conceptual framework when analyzing the problems of Third World countries. With such a bias, population distribution policies in developing countries will always be viewed as imperfect or failing to reach their objectives.

Fuchs (1983, p.6) provided a typical example of such views: 'The vagueness of population distribution policy goals within national development plans is often matched by a failure to make explicit the connections between those goals and other aspects of the development plan.' Fuchs further elaborated: 'Vertical linkages "upward" to development goals and "downward" to programs and projects are not clearly specified, nor are the horizontal linkages with economic, welfare, political, or other goals. Population distribution and redistribution objectives sometimes appear to have been prepared in isolation from other parts of the development plan and therefore seem abstract and unintegrated.' This suggests that everything seems to go wrong in the population distribution policies of developing countries. Although from some perspectives the criticisms may be accurate, the analysis does not offer any clues as to why population distribution policy in developing countries has taken this form and what should be done about it. Why do most population distribution policies in developing countries display such characteristics? It is essential to answer this question if we want to devise alternative ways to solve population distribution problems in Third World countries.

The context of policy processes in the Third World

If we consider population distribution policy in Third World countries from the point of view of public policy, we must place it within the context of policy processes in Third World nations. Since the early 1970s, such processes have been recognized as being different from those in the Developed World nations. This recognition arises partly because the process of development or modernization that has flourished and has been adopted by many Third World leaders since the early 1960s has largely failed to achieve its objectives. Modernization theory in general, and political development theory in particular, have been criticized for their ideological and ethnocentric character. Higgot (1988, p.31) wrote: 'Modernization theory came to be characterized as ideologically tainted, methodologically inadequate, and perhaps most important, ineffective as a policy tool.'

Public policy analysts have found that in many cases, even though a policy has been neatly formulated at the national or central level, it cannot be easily implemented (Riggs 1964; Smith 1973a, 1973b and 1985; Caiden and Wildavsky 1974; Grindle 1980; Rondinelli 1983; Higgot 1988). Quick, for example, argued that public policies often do not get implemented at all, and those that do manage to get through the tortuous process of implementation often look very different from what their framers originally intended. He explained that: 'Policy implementation in the Third World bears little resemblance to the classical understanding of implementation as a process of rationally linking broad goals to specific programmatic decisions' (1980, p.40).

On the assumption that policy processes in Third World countries are different from those in developed nations, appropriate methods for evaluating development activities in the Third World must also be different from those that have been developed to evaluate government public policies in developed nations. However, just as the ideas of development or modernization have been largely imported from developed nations, so the approach to policy evaluation also has been based essentially on the experience of developed countries. It assumes, for example, that interest groups and political parties are well-established institutions. In the countries of Asia, Africa, and Latin America, as argued by Grindle (1980, p.15), to a much greater extent than in the political systems of the United States and Western Europe, the process of implementing public policies is a focus of political participation and competition. This arises from the characteristics of the political systems themselves, such as the remoteness and inaccessibility of the policy making process from most individuals, and the extensive competition engendered by widespread need and very scarce resources.

Grindle further explained that: 'Thus, while in the United States and Western Europe much political activity is focused on the input stage of the policy process, in the Third World a large portion of individual and collective demand making, the representation of interests, and the emergence and resolution of conflict occurs at the output stage' (1980, p.15). Hoole also argued that in Third World countries: 'Development activities frequently take place in an unstable and highly political setting. This will result in changing programs and priorities and in problems in implementing and evaluating development activities. Factors such as high turnover of office holders and bureaucrats, domestic conflict and strife, an inflationary economy, uncertain findings for the budget, changes in the international economic order, famines, and unemployment may mean that development planning is not meaningful, that development activities are not implemented as planned, that changes are made as the activity is implemented, or that the activity never occurs' (1978, p.126).

Smith (1985, p.142), reviewing the literature on development policy evaluation in Third World countries, suggested that the type of evaluation that best fits the Third World context would be one that is able to identify problems in the nature of the policy and in the program execution process. That form of evaluation, according to Smith, is implementation analysis. The implementation of policy is the crucial phase of the policy process in most Third World countries. According to Smith: When a Western political system makes a policy, it is assumed that the policy will be implemented and the results will be somewhere near those expected. This is not the case in many non-Western nations for two reasons. First, there tends to be a great deal of symbolic policy making. Governments formulate policies that are never fully implemented or may not be intended for implementation. Just because a developing nation makes a "policy" is not an indication that it is a policy in the Western sense of concept. As Fred Riggs points out, in developing nations it is wise to distinguish between goals (which are not usually implemented) and policies (which the government will try to implement). Secondly, even if a government decides to implement a policy with some degree of vigor, the end results of the policy often are not very satisfactory in terms of the goals of the policy' (1973a, p.246).

Given the concentration of political elements in the implementation process, it is likely that policies and programs will be even more difficult to manage and predict and even more subject to alteration in the Third World than elsewhere. This means that the implementation process may be the major arena in which individuals and groups are able to pursue conflicting interests and compete for access to scarce resources. It may even be the principal nexus of the interaction between the government and the citizenry, between public officials and their constituents. Moreover, the outcome of this competition and interaction can determine both the content and the impact of programs established by government elites, and thus influence the course of a country's development.

In the population policy literature, implementation analysis is basically in accordance with the so-called 'comprehensive country-specific' analysis introduced by Korten (1975). Like other policy analysts with extensive Third World experience, Korten aimed to fill the gaps and deficiencies encountered by most studies in their attempt to understand population policies in developing countries. He argued that to comprehend a population policy within a Third World context required an insight into three crucial elements of the policy process: first, the process through which political support or acquiescence for population policies is developed; second, the dynamic decision making processes through which specific policy choices are made and their programs designed; and third, the contextual aspects of the implementation processes that are central to the success or failure of a given policy.

Hugo (1985, p.6) noted that government policy on population distribution must take full account of the nature of the state in which the policy is to be initiated: 'It is not just the contemporary politico-economic context that should be considered but also the historical context. For example, it should be borne in mind that most of the Third World countries we are dealing with here have been subjected for much of their recent history to fundamentally exploitative colonial systems designed to expedite the extraction of raw materials and control the local population in the most cost efficient way'. Similarly, Weiner argued that migration policies cannot be considered without recognizing the variety of political interest groups that are affected and the politically charged atmosphere within which policy decisions are often made. He also argued that migration policies can best be understood in the context of the political process: 'To consider policy choices only in the context of the quest for more accelerated development, a more satisfactory dispersal of population, or greater equity or any one of a number of desirable objectives is to overlook the hard realities of politics' (Weiner 1975, p.69).

According to Korten (1975, p.146), one of the great values of intensive observation and analysis of policy processes on a country specific basis is the opportunity to work from the policy maker's perspective and to study the policy in context, exploring in all their rich variety the broad range of variables that may influence the policy outcome. Analyzing policy choices and processes in a specific country context can demonstrate the implications of the diverse range of situations in which actions must be undertaken (Korten 1975, p.140). Through the study of actual decisions, it becomes possible to identify the types of choices open to consideration and the wide range of contextual issues to be addressed. These include, among others, relevant political pressures and, relative to the state, the readiness of the politically-relevant public, unique considerations of objectives and strategy, the strength and weaknesses of the local institutional infrastructure, and other specific situational requirements relating to such factors as culture, local politics or religion.

The boom and bust periods: the Third and Fourth plans

In the Third Five-Year Development Plan, the Directorate General of Transmigration became part of the Department of Manpower and Transmigration, while the Directorate General of Cooperatives was transferred to the Department of Trade. Harun Zain, an economist from the University of Indonesia and a former governor of West Sumatra, was appointed Minister of the new department. In addition, a new post of Junior Minister for Transmigration was established, reporting directly to the President but attached to the department. The appointment of Harun Zain, a civilian, as head of the department directly responsible for the transmigration program, can be seen as indicating the interest of the technocrat group in incorporating transmigration into regional economic development. Harun Zain, with his experience as governor in one of the receiving provinces, was expected to play an important role in achieving this goal. However, the appointment of Martono to the position of Junior Minister for Transmigration, a man who was described by Harun Zain as 'a political man' close to the President, was also an indication that the President did not want to hand over policy control completely to the technocrats[5].

The division of responsibility between the Director General, who reported directly to the Minister, and the Junior Minister for Transmigration, who was directly responsible to the President, seemed unclear. Perhaps partly due to this situation, but also as a consequence of the very rapid expansion in the size of the transmigration program since the beginning of the Second Plan, several special decrees were promulgated, particularly Presidential Decree No. 26/1978, in which the organizational responsibilities for the transmigration program were laid down. A series of special bodies-particularly *Bakoptrans (Badan Koordinasi Pelaksanaan Transmigrasi* or Transmigration Implementation Coordinating Body)-were created to coordinate policies, implementation and administration. Although the numerical achievements of the Second Plan were far below target, the Third Plan surprisingly increased the target to 500,000 households (Departemen Penerangan RI 1978, pp.304-337). The reason for increasing the target, apart from the general euphoria occasioned by the second oil boom, was the economist-technocrats' feeling that the implementation of the program would be improved by the increased support being given by many foreign donor agencies.

The second World Bank-assisted transmigration project began in 1979, concentrating on the resettlement of transmigrants in dry-land areas along the new Trans-Sumatra Highway. Technical assistance was also provided to the Junior Minister for Transmigration to aid in coordination of the overall program. Such assistance was important, given that lack of coordination was considered to have been the major problem in the implementation of transmigration under the Second Plan. The focus of the second round of World Bank projects on dry-land and food-crop transmigration schemes, also reflects an important new development. It was a significant departure from the Bank's successful first project on tree-crop transmigration schemes. The change constituted an important development in the evolution of World Bank involvement on transmigration for at least two reasons. First, the World Bank had failed to influence the policy makers in directing transmigration policy into more market-oriented types of population settlements. Second, although the economist-technocrat group had played a larger role in reshaping transmigration policy into the so-called 'integrated regional development' mode, the ambitious targets of the Third Plan mirrored the influence of strong forces that continued to view transmigration as a population policy aimed at relieving population pressures in Java through the development of agricultural settlement in the outer islands.[6]

The beginning of the Third Plan, therefore, indicated an important change in transmigration policies. The change could be interpreted, on the one hand, as a revitalization of the non-economic forces, particularly those represented by the military elite and the government bureaucratic apparatus and, on the other, as an expression of the difficulties and declining roles of the economic views represented, in particular, by the economist-technocrats and the World Bank. The fact that the World Bank also tolerated the more demographic orientation of transmigration policy suggests that the Bank and, in particular its bureaucratic elements, had adopted a rather pragmatic approach. This, aside from its bureaucratic interest in keeping the project going, also reflected the fact that it had become politically impractical for the Bank to withdraw from its extensive involvement in the Indonesian transmigration program. Another factor that also raised the hopes of the government was the success of what it called *Bedol Desa* transmigration. This type of transmigration was carried out in conjunction with the evacuation of an entire population following a government decision to use an area for the construction of a dam or some other large project. The first and apparently the largest resettlement project was the relocation of people from some districts in Wonogiri in Central Java to Sitiung in West Sumatra. The success of the Wonogiri-Sitiung project within the *Bedol Desa* program increased confidence among the transmigration planners that the country was capable of carrying out similar settlement projects in the future. Wonogiri also happened to be the area of the President's childhood home. According to Gondowarsito's study of *Bedol Desa* transmigration (1986, pp.89-90), it was because of this privileged status, that the heavy involvement and cooperation on the part of various government agencies, namely the Departments of Manpower and Transmigration, Public Works, Communication, and Agriculture, were enlisted.

Population distribution and regional development, which had alternately dominated as goals of the First and Second Plans, received equal emphasis in this Third Plan. Given the government's focus on the equal distribution of welfare, under a policy called 'The Eight Paths of Equity' (*Delapan Jalur Pemerataan*), transmigration also became an important vehicle for the achievement of this new goal. The plan also stated that priority would be given to the poorest sending areas, where the problem of landlessness was most acute, and noted that the selection and preparation of receiving areas also needed more careful attention. In the Third Plan, the government anticipated resettling transmigrants not only in dry-land areas, but also on *pasang-surut* (tidal) areas. The increased numbers to be settled led to difficulties in providing sufficient suitable land in the receiving areas. Compared to the First and Second plans, the Third Plan described in great detail the facilities and equipment to be provided to transmigrants, and seems to have been more seriously and professionally prepared than its predecessors. Coordination among the implementing agencies, which was always at the center of the program's problems, was also given more attention.

With the establishment of *Bakoptrans*, the responsibilities of the various departments involved were more clearly defined. For example, the Department of Public Works was responsible for the selection and planning of sites, for land clearing and for construction of infrastructure; the Department of Home Affairs was to conduct land-use planning and deal with the legal status of land; the Department of Agriculture was responsible for planning and implementing agricultural development; and, finally, the Department of Manpower, Cooperatives and Transmigration was in charge of the recruitment, transportation, and resettlement of transmigrants, as well as providing them with five years of economic and social guidance at each site. Under this highly bureaucratic and hierarchical organizational structure, each department was expected to plan its activities and budget in consultation with the Junior Minister. However, the authority, budget and staff of the Junior Minister's office were far too limited for efficient coordination. Furthermore, coordination proved impossible because each department continued to work independently. In addition, since the Junior Minister for Transmigration reported directly to the President, it was inevitable that hidden rivalry arose between the Minister and the Junior Minister[7]. Under the new arrangement, which was implemented in 1978, the Junior Minister was given more authority to control the foreign assistance than the Minister. This authority considerably reduced the power of the Minister to effectively implement the program.

At the end of the Third Plan, 535,474 families were reported to have been moved (Table 4.1), although the target of 500,000 was met only by defining 169,497 spontaneous migrants as transmigrants, with or without government assistance. According to Hardjono (1986, p.29), to say that the Third Plan target was reached gives a slightly exaggerated picture of the extent to which people were moved from Java and Bali at government expense: 'In fact, only 365,977 families were moved by the government transmigration agency as fully supported or general (*umum*) transmigrants'. Furthermore, this figure includes local people who moved into transmigration projects and families that had to be resettled within the same province for some reason. The remaining 169,497 families, representing 32 per cent of the total, were *swakarsa* (literally, "self initiative") transmigrants who moved with limited, or in many cases, no government assistance. Another observer, Babcock (1986, p.182), formerly working as a consultant in the Public Works Department, even described the government's claim that the Third Plan had achieved its target as virtual manipulation to justify the overly ambitious target.

Widespread scepticism has been expressed about the manipulation involved in determining program achievements during the Third Plan. There are quite remarkable statistical inconsistencies among the several sources that have presented the transmigration implementation statistics for the Third Plan. For

Table 4.1 Target and achievement in the Third Plan, 1979-1984 (number of families)

Fiscal Year	Target	Achievement		Percentage
		World Bank	Hardjono	
1979 - 1980	50,000	23,078	49,772	99
		(1,985)	(24,298)	
1980 - 1981	75,000	76,562	108,081	144
		(3,359)	(34,428)	
1981 - 1982	100,000	93,437	123,846	124
		(8,961)	(35,780)	
1982 - 1983	125,000	125,269	167,477	134
		(32,445)	(47,124)	
1983 - 1984	150,000	217,128	86,298	58
		(122,747)	(24,867)	
Total	500,000	535,474	535,474	107
		(169,497)	(169,497)	

Notes :
1.The number in parentheses represents unassisted or partially assisted transmigrants.
2.The percentage figures are calculated from Hardjono's column.
Sources: World Bank (1988, p.11); Hardjono (1986, p.29)

example, the figure reported by the World Bank (1988, p.11) is obviously different from that presented by Hardjono (1986, p.29). Although the total number of resettled migrants is similar, their annual distributions, especially the number of spontaneous migrants, are remarkably dissimilar. While both Hardjono and the World Bank described their sources as the Department of Transmigration, the salient differences in their figures raise serious doubts as to the accuracy of the information. With regard to the distribution of spontaneous transmigrants, although the accuracy of both columns must be suspect, the figures in Hardjono's column seem more logical than those of the World Bank. The distribution of spontaneous transmigrants, who were mostly concentrated in the last budget year in the World Bank data, are unlikely to reflect the actual pattern of movement, which is more likely to have been more evenly distributed throughout the plan period, as in Hardjono's figures. The World Bank concentration of spontaneous transmigrants in the last budget year probably reflects hasty decisions by the Department of Transmigration due to pressure at the end of the plan period to document a public image that program targets had been successfully achieved. The method chosen was apparently through manipulation of statistics on spontaneous transmigrants.[8]

Under Presidential Decree No.45/M/1983, for the first time in the history of the transmigration program, a separate Department of Transmigration was established. Martono was appointed Minister. This ended the previous rivalries

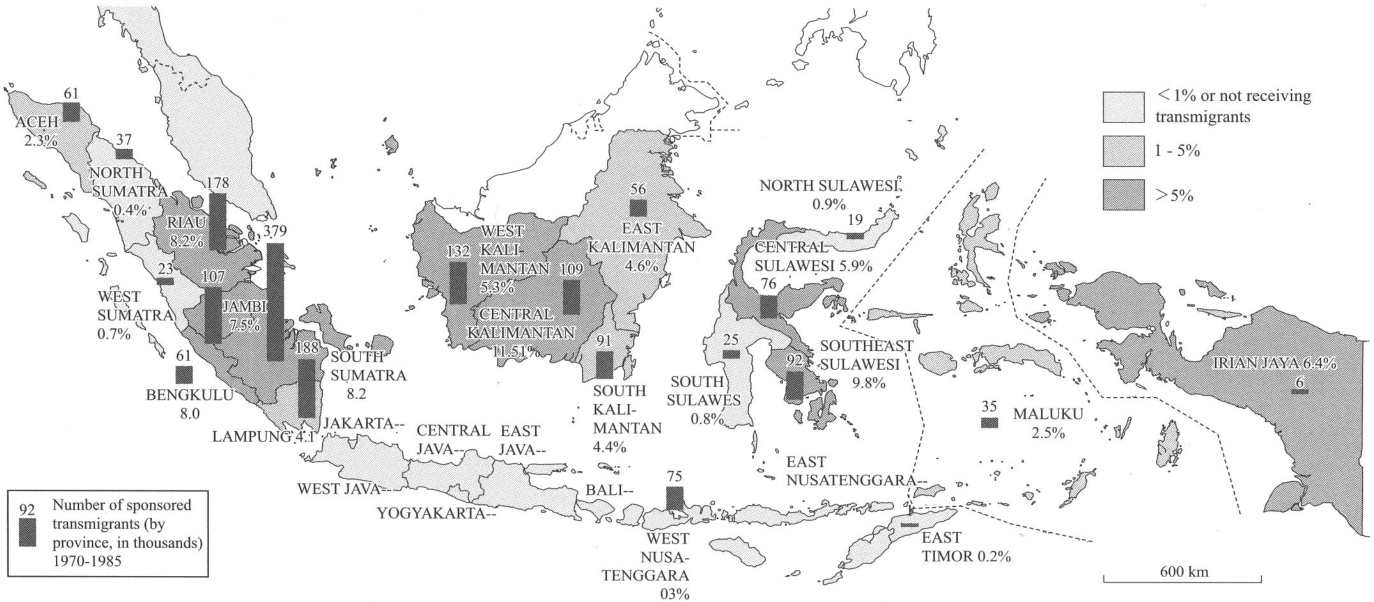

Fig 4.1 Transmigrants 1970-1985 as a proportion of the 1980 provincial population.
(source: Robert Cribb 2000, Fig 2.48)

between the Minister controlling the Directorate General of Transmigration, and the Junior Minister for Transmigration. It was hoped that an independent department would solve the problem of coordination, which had been so serious during the implementation of the Third Plan. The President also established a State Minister for Population and Environment (KLH), who is responsible for the formulation, management and coordination of national population policies. Professor Emil Salim, a Minangkabau and one of the New Order's leading economists, was appointed as minister. An integrated national population policy had been long overdue. Given the number of economists in the central government, including the economist-demographer Professor Widjojo Nitisastro, the lack of integration between population policy and national development policy seemed 'paradoxical', at least to outside observers (Hugo, Hull, Hull and Jones 1987, p.315). The paradox, however, is hardly surprising given the very different perceptions of the 'population factors' held by the President and his military elite and the economist-technocrats. The difficulties that had been experienced by the economist-technocrat group in dealing with the military were confirmed by one of the deputy ministers for Population and Environment.[9]

The political position of the economist-technocrats, as explained by Glassburner (1978, pp.32-33), was almost entirely dependent on their ability to convince the military leadership, and the President in particular, that their expertise was essential. In a similar vein, Rudner (1976, p.255) argued that : 'Having no political base other than military patronage, technocrat ministers and planners were ultimately dependent upon the confidence of the military elite in general, and the President in particular. Whatever their formal functions in economic policy making, the decisions of economist-technocrats became operative only when, and to the extent that they acquired executive support from military leaders and local commanders. In the last analysis, the authority of the economist-technocrats went only so far as their economics proved amenable to the ABRI's own conception of national modernization'. In the Fourth Plan, therefore, it was likely that transmigration would remain largely beyond the influence of the Minister for Population and Environment, Emil Salim, an economist-technocrat, because Transmigration had also become an independent department with a minister who was close to the President.

Following the decision to make Transmigration an independent department, two Directorates of the Department of Public Works were absorbed into the Department of Transmigration. Some sections of the former Directorate of City and Regional Planning (*DITATA*) in the Directorate General *Cipta Karya*, which had been responsible for transmigration site selection and physical planning, became the Directorate of Program Development (*Bina Program*) in the newly formed Directorate General of Settlement Preparation (*PANKIM*). The

Directorate of Land Preparation was moved to that directorate general, from the Directorate General of Highways in the Department of Public Works. The former Directorate General of Transmigration became the Directorate General for Mobilization and Development (*RAHBIN*). The budgets of some agencies, such as health and education, were also incorporated into the Department of Transmigration, while other agencies such as Agrarian Affairs and the directorates in agriculture, retained control over their own funds. Under the new department, the staff and functions of the Inspector General and the Secretary General were expanded in order to improve financial and administrative control.

There is no doubt that the Fourth Plan reflected the increasing role of the transmigration program within the national development policy. The target number to be resettled was increased to 750,000 households. The claimed successful outcomes of the Third Plan had apparently provided a strong argument for the government to increase the target to this level. In the Fourth Plan, foreign financial support to the transmigration program, particularly from the World Bank, also increased dramatically. However, the appointment of Martono as the minister suggested that the technocrats were losing control of the program. Furthermore, instead of demographic and regional development arguments, national defense and security were highlighted as important goals of transmigration (Departmen Penerangan RI 1983, pp.371-372). The important role of transmigration for national defense and security was emphasized by the Chief of Armed Forces, General Benny Moerdani, when he delivered a keynote address at a seminar at the National Defense Institute (*Lemhanas*). According to Moerdani, transmigration policy was the only policy within the economic development framework that had a direct linkage with national security and defense. He argued that it was necessary for the military to be involved in site selection, primarily because transmigration location was strongly linked with the concept of territorial management (Kompas, 8 March 1985).

An obvious attempt by the military to influence the transmigration policy, was shown by the appointment of Major General C. I. Santoso, a former regional commander in Irian Jaya (1978-1982), as the General Secretary of the Department of Transmigration in 1983.[10] In the plan documents, transmigration was discussed in a fairly substantial separate chapter of 58 pages. According to Sjahrir (1987, p.193), an economist from the Center for Policy Studies (CPS), the Fourth Plan showed considerable technical improvement over previous plans, specifically in the utilization of more sophisticated econometrics.[11] However, there were inconsistencies in the numerical targets between sectors and sub-sectors. Sjahrir has argued (1987, p.193), that these inconsistencies may have been due to the strong influence of non-economic considerations in the plan's formulation.

The hopes that had emerged at the beginning of the Fourth Plan, however, were soon confronted with some hard realities. These problems can be broadly categorized as internal and external problems. The internal problems related to departmental management, particularly the problem of the unspent budget that reflected the inefficiency of plan implementation. This problem was exacerbated by the gloomy prospects for world oil prices. These internal problems were first felt, according to the Minister, around the second year of the Fourth Plan. The external problems mostly related to criticisms from abroad, particularly on issues concerning the destruction of tropical forests and unfair treatment of the indigenous populations whose lands were allocated for transmigration. Approaching the end of 1984, the Minister of Transmigration asked Sumitro Djojohadikusumo to act as an adviser to the Minister on matters related to program planning and internal management.[12] Among the key persons working for Sumitro was Harun Zain, the former minister for Manpower and Transmigration. One of the elements of advice requested by the Minister was related to the problem of unspent budgets. A series of meetings and interviews was conducted with several ministers who were directly linked with the transmigration program, such as Public Works, Interior, Population and Environment, Forestry and Food Production, the Governor of West Kalimantan, and several directors general. The report was completed in April 1985 and submitted to the Minister. It was considered 'a reconnaissance phase', and mainly focused on the internal management of the transmigration program (Redecon 1985). The 'technocratic' nature of this report and its avoidance of more controversial issues, such as the influence of the strategic military interests on the policy, can be seen as major limitations to the value of the report as a basis for program improvement.

The external problems of transmigration implementation soared rapidly, especially after the government decided to shift the geographic focus of the transmigration receiving areas to the eastern part of Indonesia, particularly to the border between Irian Jaya and PNG. Such a decision resulted in many technical, as well as social and political problems (Manning and Rumbiak 1987, pp.71-82). Due to such issues as environmental degradation and the displacement of the indigenous population, international criticism began to be heard against the transmigration policy in Indonesia. The World Bank, which for almost fifteen years had supported transmigration policy, also became the target of international criticism. In January 1985 a research team from Gajah Mada University, headed by Professor Mubyarto, was asked by Minister Martono to observe and report on transmigration in Irian Jaya. Their observations were presented at a seminar held at the Center for Rural and Regional Studies, one of the research centers at Gajah Mada University. Among the issues raised during the seminar and subsequently highlighted by the press, was the need to revise and reschedule the transmigration target for Irian Jaya (Kompas, 8 February 1985).

In addition to the potential social and political conflicts, the original transmigration target in Irian Jaya was considered to be economically unrealistic. However, in an apparent response to this criticism, after immediate consultation with the President, Minister Martono strongly emphasized that: 'The transmigration target for Irian Jaya will not be reduced but will even be increased'.[14] Some observers felt that: 'Transmigration has become such a fetish with the President that cabinet members dare not try to persuade him to approve drastic changes to it. The premises and goals are non-negotiable' (Osborne 1985, p.25). However, the program was drastically hit as oil prices collapsed in 1985-86. As a result, the government subsequently reduced the budget for transmigration by 44 per cent in the 1986/87, and a further 65 per cent in the 1987/88 fiscal years (Tempo, 16 January 1988). With the budget cut, the transmigration target seemed likely to be reduced considerably. This drastic reduction was described by Mubyarto, the aforementioned economics professor from Gajah Mada University, as 'the will of God'[15]

The substantial cuts in the government budget for the transmigration program had significantly reduced the government's capacity to continue the program. This was mainly because the cost per transmigrant family in the recent period had become very high. In 1983-84, for example, the cost per transmigrant family was approaching US$6,500, whereas at the beginning of the First Plan (1969-70), the cost per transmigrant family was only US$577 (Arndt 1983, p.66). As extensively reported in the press, many transmigration projects had had to be abandoned since the budget cuts. On 24 November 1987, the Minister for Transmigration announced that 16,000 houses built for transmigration had been built in vain because the government had no money to send people to occupy them (Kompas, 25 November 1987). This setback attracted many comments and criticisms. Some critics suggested that the transmigration program should be overhauled or the department downgraded to its original status as a directorate general.[16] However, rumors surrounding the future of transmigration were dispelled when, in mid-March 1988, the President appointed Major General Soegiarto, a former head of Social and Political Affairs in the Defense Department, as the Minister for Transmigration.[17] This appointment was further evidence that the economist-technocrat group had become less influential in the program, but it was also an indication that transmigration would retain an important role in the national scene for many years to come.

The stalled periods and end of the policy: The Fifth Plan and after

The transmigration policy in the Fifth Plan, indicated a new orientation toward more spontaneous transmigration schemes, as well as toward the promotion of cash crop transmigration settlements. The Fifth Plan set the target of 550,000 families to be achieved within five years, of which only 180,000 families would be fully supported by the government. The remaining 370,000 families were expected to receive assistance through various schemes under the spontaneous transmigration program. The Fifth Plan also aimed at rehabilitating the poor conditions of existing transmigration settlements. Implementation of the Fifth Plan proved to be difficult. Besides the fact that the budget allocated for transmigration was obviously limited, another problem also arose as the public image of transmigration had been severely affected by mismanagement in previous periods. The data on inter-provincial migration revealed by the 1990 population census clearly indicated that many migrants had been moved to urban rather than rural areas (Mantra 1993). It also reflected a remarkable shift from sponsored to voluntary migration in the mid-1980s, as new economic growth centers developed in several urban areas on the outer islands (Tirtosudarmo 1994).[18] During this period, migrants were also attracted by labor opportunities in neighboring countries, particularly Malaysia (Tirtosudarmo 1996). The new Minister, as reported in the press, frankly acknowledged the difficulties faced by his government in recruiting the potential transmigrants. The Minister was also aware that people were less willing to move to transmigration settlements, and preferred to move to other places, particularly to urban areas. At the end of the Fifth Plan, it was obvious that even though the target had already been set at a very low level, its achievement was generally even lower.

In 1993, with the commencement of the Sixth Plan (1993-1998), in a clear move to boost the involvement of the private sector in the transmigration program, the President appointed Siswono Yudohusodo, a successful businessman, to be Minister for Transmigration. Although observers generally regarded transmigration as having lost its rational justification, President Suharto decided to expand the scope of transmigration to include the resettlement of the so-called forest squatters. The department was accordingly renamed the Department of Transmigration and Resettlement of Forest Squatters. The beginning of the Sixth Plan also marked the President's statement about various groups of people who were living below the poverty line. The state's rhetoric on raising the living standard of population groups officially considered as below the poverty line conveniently supported the new task of transmigration (Tirtosudarmo 1993). Forest squatters, including many isolated tribal groups in the outer islands, had been officially recognized as being among those living below the poverty line, and had become a new target of the transmigration policy. In an attempt to attract private and business sectors to invest capital in transmigration areas, an economic and business information center was created in 1994. The main idea of this new transmigration policy was in fact similar to one initiated by the World Bank in 1976 in which transmigration was expected to be integrated into the cash-crop market economy. The major problem with this venture, however, was the lack of legal and business capacities within the Department of Transmigration. The new Minister had indeed pushed the transmigration policy toward a more business and market orientation, but as the existing system in the Ministry of Transmigration became overly bureaucratized, the ministerial effort to attract the private sector into the transmigration program turned out to be unsuccessful.[19]

The prospects of the transmigration policy looked even bleaker as the financial capacity of the state deteriorated under the economic crisis beginning to hit Indonesia in August 1997. In May 1998, Suharto stepped down and was replaced by his Vice President, B.J. Habibie. In an apparently conspicuous move, the President appointed Lt. General A.M. Hendropriyono, one of the politicized military officers, to be Minister of Transmigration. In terms of actual policy, obviously only a small number of transmigrants have been moved during this period. The new Minister seems unmoved by the fact that logistically it was almost impossible to continue the program. In an apparent move to revitalize the transmigration policy, a plan was discussed to develop a system of resettlement which could be a model of national integration, in which transmigrants from different ethnic backgrounds would be recruited and resettled in one place in the hope that they would assimilate and eventually form a newly-blended 'Indonesian community'. However, apparently due to severe financial problems, such a plan was never implemented.[20] The Department of Transmigration was again in a situation of not knowing whether or not the policy would be continued in the near future. During this time, a new elected government was established, and Abdurahman Wahid was elected by parliament to be President.

Under Wahid's presidency, and pressed by the downwardly spiraling economic circumstances, a decision was made to reduce the number of ministries. Judging from actual needs, the Ministry for Transmigration should have been one of the ministries to be relinquished, but surprisingly, it was left intact, although merged with the Ministry of Population Affairs. Two ministries that were abolished were the Ministries of Social Affairs and Information. Being aware that he was elected as President through support from various parties in the parliament, Wahid decided to form a coalition Cabinet. Alhilal Hamdi, a former student activist and now a businessman, representing a newly-established Pluralist Party (*PAN*) was appointed as Minister of Transmigration and

Population.[21] It was very clear that the policy to move people to the outer islands had ceased to exist. The ministry was then caught up in the new task of resettling thousands of migrant families that were forced to leave their villages, many of them returning to their place of origin as a result of violent conflicts that erupted in places such as East Timor, Aceh, Maluku, West Kalimantan and West Papua. Transmigration was evidently entering a new phase in its history in which local people in the former transmigration destination areas explicitly voiced their long suppressed demands to the central government to stop sending transmigrants to their areas. The new movement by the central government to give more autonomy to the regions had obviously become the momentum to end the transmigration policy.

Conclusion: The end of an ideological policy

As a major part of transmigration policy involves the distribution of land, shelter and other facilities, it can be described as a distributive policy. However, the main characteristics of transmigration policy resemble the type of program that has been labelled 'ideological'. According to Quick (1980, p.42), there are three main characteristics of an ideological program. The first characteristic is that the program is expected to realize a multitude of goals at the same time. Suharto, for example, stated bluntly that: 'Transmigration is one of the absolute necessities if we are to achieve our national goals - a higher living standard for our people, economic growth and national stability' (Hooper, c.1987, p.26). The program represents a working model of the new society, and is therefore expected to introduce changes in many aspects of existing social relationships.[22] In addition to being numerous, the goals set for an ideological program are also ambiguous, in that national elites rarely have a clearly worked out view of what is required to move from the existing state of affairs to the new one. A second characteristic is that the program has no hierarchy of goals; that is, no clear statement that goal A is more important than goal B, or at least that goal A should be achieved before embarking on goal B. The ambiguity of goals presents the implementing organization with the clear message that everything must be done at once and that there are no priorities that can be used to orient implementation. A third characteristic of the goal structure of ideological programs is the immeasurability of many of their objectives. The target population is expected to live differently, to act and think differently, and to progress toward many of those goals, but such objectives cannot be measured with any precision. Agencies charged with implementing ideological programs thus have a goal structure that consists of a few measurable goals and many non-measurable ones.

Ideological programs are also affected by the high expectations of the national political elite. Such programs are endowed with a sense of urgency and vital importance, placing the implementing agency under extreme political pressure to produce results. So important is success in these programs that political appointees are selected to head the implementing agency, and resources are made available to this agency that are unavailable to other programs. The organizations charged with implementing ideological programs are also relatively immune from criticism, shrouded as they are by the national priority of their program. These, then, are the basic characteristics that define an ideological program: multiple, ambiguous, and non-measurable goals; high expectations; resource availability; politicized leadership of the implementing organization; and immunity from public criticism.[23] The main characteristics of transmigration policy, suggest that transmigration is an ideological policy. As an ideological policy, transmigration in itself produces formidable counter-productive forces. For example, its immunity to public criticism has created an implementing agency that lacks viable control and feedback. Such counter-productive forces have, in turn, hindered the implementation process. The target groups, which consist of potential transmigrants, and transmigrants and indigenous populations in the receiving areas, are people with only limited bargaining power and alternatives within the existing social, economic and political environment. Their powerless position within the implementation process has allowed the implementing agency to treat them as mere objects rather than subjects.

The various aims of transmigration policy are not only complex and immeasurable, but also often mutually contradictory. Furthermore, within the current framework, the program has been all too easily used to serve various interest groups within the ruling elite, and this has led to an unmanageable program. The setting of an ambitious target number in the Fourth Plan, for instance, reflected the balancing of various interests to obtain a consensus. Such an ambitious target, however, led implementing agencies into immense problems and difficulties. Unspecified goals under the current law have also been easily used to justify elusive motives, such as regional development and national integration, the results of which are very difficult to measure. As an ideological policy, transmigration has enjoyed unparalleled support from the state, as the policy has provided the ruling elites with a convenient tool to be used for different purposes. However, as the state's financial capacity to maintain the policy started to decline after the mid-1980s, the number of people who were actually resettled under the program was considerably reduced. The policy was increasingly modified and has been totally static since the national economy was hit by the monetary crisis that began in August 1997. The collapse of Suharto's New Order government in May 1998 and the various violent conflicts that followed have created a new phenomenon in which return migration has become a trend in the demographic dynamics in Indonesia. Furthermore, the changes in the political landscape have given a new momentum for the people in the outer islands to explicitly state their resentment of the program. The euphoria in welcoming a new decentralization and regional autonomy has significantly put an end to the transmigration policy.[24]

Note

1 The word 'puso' is a Javanese word, commonly used among the farmers in Java when they describe the failure of their harvest or even before the harvest - for example as caused by drought or insects. In the case of transmigration, the Minister used the word 'puso' to describe his unlucky failure to resettle the transmigrants in the transmigration settlement. - this failure resulted in huge numbers (16,000) of unused houses (*Kompas*, 25 November 1987).

2 For assessment of the security dimension of transmigration policy, see Tirtosudarmo (2001).

3 In the 1979 survey, among the 116 developing countries only six reported the overall spatial distribution of their population as entirely acceptable. Of the remaining 110 countries, 42 regarded the spatial distribution of their populations as unacceptable to some extent and 68 found it to be highly unacceptable (United Nations 1980, pp.40-50).

4 President Suharto was honoured in December 1988 by the Population Council as the first national leader to receive its Population Award. In June 1989 he also received a World Population Award from the United Nations for Indonesia's achievement in reducing population growth through the family planning program. By contrast, the failure of the transmigration program reached a climax when Martono, Minister for Transmigration, declared 16,000 houses built for transmigrants to be uninhabited (see *Kompas*, 25 November 1987). Unofficial sources reported that the actual number was about 40,000. This large number of uninhabited houses reflects the failure of the Department of Transmigration to recruit and resettle transmigrants according to their planning schedules.

5 The statement describing Martono as 'a political man' was made by Harun Zain during an interview with the author, January 1988.

6 The central government's obsession with promoting population resettlement based on food crop agricultural systems as practiced in Java, according to Dove (1985, p.32), is essentially a manifestation of the agro-ecological mythology of the Javanese that has developed on Java and strongly influenced the thinking of many policy makers in the central government.

7 A personal communication with a senior member of staff in the Department of Transmigration, December 1987

8 Such statistical manipulation was recognized by the World Bank, which noted in one of its reports(1988, p.134) that: 'Although some spontaneous families were settled in existing areas, no program of partially assisted movement or of support for spontaneous migration was developed in the Third Plan. However, the Third Plan target of 500,000 families was eventually achieved by including 169,500 "spontaneous" families in the total moved. Of these, about 30,000 families were moved with partial assistance and the remaining 140,000 moved without assistance, but were identified in sending or receiving areas. It is important to emphasize that these families were identified to round out official targets, and the data collected from sending provinces is not a good indicator of the number of people who

actually move'.

9 Personal communication with the author, January 1988.

10 According to Anderson (1985, p.140), a long-standing scholar of Indonesian politics, this appointment should be read as General Moerdani's move to take full control of the 'explosive mass-transmigration program in West-Irian'.

11 The Center for Policy Studies is a non-government research institute. Among the senior staff is Professor Sumitro Djojohadikusumo, the 'guru' of the New Order's economist-technocrat group.

12 A source close to Professor Sumitro told the author (January 1988) that the request to employ Sumitro as an adviser on transmigration had come from President Suharto.

13 For example, The Ecologist (No. 2/3, 1986) in collaboration with Survival International and Tapol, published a special issue which strongly criticized the transmigration program in Indonesia.

14 Kompas, 26 February 1985.

15 This description was made by Mubyarto at the 'Conference on Regional Economy in Indonesia' at ANU, Canberra, February 1987, at which the author was one of the participants.

16 See: Tempo, 5 December 1987 ('Interview with Minister for Transmigration, Martono'), also, Far Eastern Economic Review, 29 October 1987 ('Indonesia: Resettlement rethink, the government overhauls its transmigration scheme').

17 Soegiarto, according to Anderson (1985, p.142), was one of the 'stars' among the A.M.N. (Military Academy) Class of 1960.

18 The increasing numbers of voluntary migrants to the outer islands in the last ten years have apparently resulted in the increase of conflict between migrants and local people. In 1995 mass open conflicts broke out between migrants and local people in East Timor, Irian Jaya and Flores, all in eastern Indonesia provinces (Tirtosudarmo 1995). The latest incident occurred in Sanggau-Ledo, West Kalimantan, in the first week of January 1997, between the Madurese migrants and the indigenous Dayak people (*Kompas*, 3 January 1997). Many observers have argued that the economic inequality between migrants and local people are the underlying factors of these ethnic group conflicts (see, Tirtosudarmo 1997).

19 Some observers have even criticized the new attempt as a setback, as it reflects the revival of the old idea of the colonial state's economic strategy.

20 The author, who was among the so-called experts to be consulted during the preparation of the plan, strongly argued that such an idea was wishful thinking.

21 The author was asked by the new Minister to be his expert staff on social and cultural issues.

22 Transmigration programs are also a perfect example of what is described by Bookman (1997) as demographic engineering, which is defined as the state's attempt to reconfigure the ethno-demographic composition of the population for various strategic purposes.

23 The immunity of the transmigration policy from 'independent' evaluation, has been admitted, for instance, by a *Bappenas* official on one occasion where a closed meeting was held between *Bappenas* and the Center for Policy Implementation Studies (CPIS). CPIS is a 'semi-government' consulting agency, attached to the Ministry of Finance, and is assisted by the Harvard Institute for International Development (HIID). A major task of CPIS is to advise the Indonesian government, particularly through the Minister of Finance, on the implementation of various government projects. Its advice was sought after an evaluation of a certain program was conducted by CPIS. In the meeting, the official from *Bappenas* warned the CPIS not to get involved in evaluating two government programs - transmigration and co-operatives - the reason being that these two programs were

considered as 'too political', and the CPIS would face many problems if it attempted to evaluate those two departments. (This information was obtained from a personal communication with a CPIS staff member in January 1988).

24 Writing in 1990 the author noted: 'Viewed from this perspective, the prospect for transmigration policy, at least for the near future, does not seem very bright. Obvious factors, such as only limited areas in the outer islands being suitable for agricultural settlements, will become major constraints for the planners to rebuild a large transmigration program, but, as demonstrated above, several other factors which currently dominate central government thinking will continue to underwrite the broad goals of transmigration policy. In the future, unless a substantial change in the nature of the current military-technocrats coalition occurs in which a more open and democratic decision making process is allowed, transmigration policy is unlikely to move from its current basic assumptions' (Tirtosudarmo 1990). A decade later, in 2000, a significant political change has apparently materialized and transmigration policy has begun to recede into history.

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Appendix

Table 4.1 Five-year Plans I-VI: Transmigrant Families Moved, by Province of Origin

Province	First Plan 1969/70 – 1973/74		Second Plan 1974/75 – 1978/79		Third Plan 1979/80 – 1983/84		Fourth Plan 1984/85 – 1988/89		Fifth Plan 1989/90 – 1993/94		Sixth Plan 1993/94 – 1996/97	
	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
Jakarta	750	2	2,405	4	4,412	1	2,937	1	6,343	3	5,171	2
West Java	4,941	13	7,230	13	60,003	16	37,196	16	36,997	15	23,846	10
Central Java	10,966	29	20,148	37	96,099	26	45,851	20	40,754	16	24,707	11
Yogyakarta	5,260	13	5,150	9	19,998	5	8,950	4	10,352	4	5,761	3
East Java	12,044	31	15,390	28	93,314	25	44,512	19	37,783	15	24,451	11
Java (subtotal)	33,961	88	50,323	91	273,826	73	139,446	60	132,229	53	83,936	37
Bali	5,100	13	3,060	6	14,735	4	4,369	2	6,673	3	4,362	2
W. Nusatenggara	300	1	1,700	3	12,718	3	4,236	2	8,292	3	7,045	3
E. Nusatenggara	–		–		–		3,300	1	3,864	2	3,561	1
Lampung	–		–		–		787		–		–	
APPDT	75		–		22,284	6	43,531	19	95,942	39	53,567	23
Resettlement	–		–		42,414	12	26,896	12	–		76,513	34
Relocation	–		–		–		5,857	3	–		–	
General Transmigrants	39,436	100	55,083	100	365,977	100	228,422	100	247,000	100	228,984	100
Unassisted/Partly -Assisted Transmigrants	–		7,281		169,497		521,728		–			
Totals	39,436		62,364		535,474		750,150		247,000		228,984	

Note: Due to rounding the totals may not add up exactly.

Sources: Presidential Address, 16 August 1985 (Departemen Penerangan RI, 1985:XII/48-50); Presidential Address, 16 August 1989 (Departmen Penerangan RI 1989: XII/692-5); Presidential Address, 16 August 1993 (Departmen Penerangan RI, 1993: XII/18-18); Presidential Address, 16 August 1997 (Departmen Penerangan RI, 1997: XIII/34-37).

Table 4.2 Five-Year Plans I-VI: General Transmigrant Families Moved, by Province of Destination

Province	First Plan 1969/70 – 1973/74		Second Plan 1974/75 – 1978/79		Third Plan 1979/80 – 1983/84		Fourth Plan 1984/85 – 1988/89		Fifth Plan 1989/90 – 1993/94		Sixth Plan 1993/94 – 1996/97	
	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
Aceh	–		800	1	10,771	3	7,084	3	9,312	4	9,507	4
N. Sumatra	200		500	1	8,006	2	3,651	2	4,828	2	6,063	3
W. Sumatra	450	1	3,950	7	7,603	2	9,185	4	6,952	3	5,737	3
Riau	500	1	662	1	37,522	10	27,300	12	39,074	16	26,994	12
Jambi	2,450	6	10,362	19	16,682	5	19,737	9	16,529	7	14,748	6
S. Sumatra	6,254	16	6,598	12	91,340	25	24,446	11	24,832	10	14,965	7
Bengkulu	1,300	3	3,600	7	12,187	3	9,076	4	12,591	5	9,535	4
Lampunng	11,397	29	17,893	8	42,876	12	18,893	9	12,515	5	8,412	4
Sumatra (subtotal)	22,551	56	30,972	56	227,047	62	118,372	54	112,633	52	95,961	43
W. Kalimantan	952	2	2,100	4	15,141	4	19,684	9	24,143	10	24,945	11
C. Kalimantan	1,253	3	700	1	28,221	8	17,907	8	12,880	5	17,117	7
S. Kalimantan	1,490	4	4,300	8	15,374	4	13,922	7	7,744	3	8,985	4
E. Kalimantan	1,775	5	3,311	6	11,878	3	15,179	7	16,525	7	14,054	6
Kalimantan (subtotal)	5,470	14	10,411	19	70,614	19	66,692	30	61,292	25	65,101	28
N. Sulawesi	1,060	3	950	2	4,154	1	2,811	1	1,312	1	1,016	-
C. Sulawesi	3,452	9	5,700	10	15,740	4	10,441	5	13,293	5	11,404	5
S. Sulawesi	4,441	11	3,300	6	3,607	1	5,325	2	10,262	4	6,713	3
S. E. Sulawesi	2,012	5	3,250	6	19,225	5	7,002	3	5,412	2	2,786	1
Sulawesi (subtotal)	10,965	28	13,200	24	42,726	11	25,579	11	30,279	12	21,919	9
Maluku	350	1	200	–	7,635	2	3,270	1	5,789	2	13,450	6
Irian Jaya	100	–	300	–	16,616	5	12,598	6	18,373	7	23,991	10
W. Nusatenggara	–	–	–	–	1,289	–	977	–	2,254	1	2,047	1
E. Nusatenggara	–	–	–	–	–	–	–	–	830	–	1,015	1
East Timor	–	–	–	–	50	–	934	–	1,550	1	4,600	2
Eastern Indonesia Province (subtotal)									28,796	11	46,003	20
Totals	39,436	100	55,083	100	365,977	100	228,422	100	233,000	100	228,984	100

Note: Due to rounding the totals may not add up exactly.

Sources: Presidential Address, 16 August 1985 (Departemen Penerangan RI, 1985: XII/49); Presidential Address, 16 August 1989 (Departemen Penerangan RI, 1989; XII/693); Presidential Address, 16 August 1993 (Departemen Penerangan RI, 1993; XII/17-18); Presidential Address, 16 August 1997 (Departemen Penerangan RI, 1997: XIII/34-37).

5

The Twenty-Five Year Pursuit of Herbicide Damage of the Vietnam War: Tracing the Changes in the Environment and Human Health

NAKAMURA Goro

The jungles of Vietnam are thick and deep, and caused US forces endless torment when they attempted to penetrate them to flush out the enemy. Once the Vietnamese resistance forces slipped back into the forests, they were able to conceal themselves with ease and ambush any American forces pursuing them. Heavy firearms were ineffective against such an invisible foe.

Defoliation schemes involved the systematic dislocation of villagers. *Operation Ranch Hand - the Air Force and Herbicides in Southeast Asia 1961-1971* (Buckingham 1982), a document issued by the Office of Air Force History, describes how the United States implemented the strategy in the Boi Loi area:

'Riot gas was dropped on hamlets in the defoliation target area to add to the occupants' incentive to leave. Some of the bombs dropped by the fighters used time delay fuses, and refugees later reported that they were very effective in inducing fear because they exploded at times when no aircraft were present' (p.111).

The United States ran the defoliation campaign for ten years, from 1961 to 1971. Officially named 'Operation Ranch Hand', American mowers cut down Vietnamese jungles, turning them into wasteland. The total amount of herbicides sprayed over that ten years is estimated to be 24 million gallons (91,000 kl). A Veterans' Administration report gives 22 million gallons (83,600 kl), a rough figure covering only mission sprayings. Other data shows that 1,595 kl of herbicides were sprayed in Laos from 1965 to 1969, and as yet undisclosed data concerning spray missions in Cambodia would add to the overall estimate. A

Photo 5.1 C-123 Providers spraying herbicides on defoliation missions. The planes skimmed 40 m above the jungle at 240 km per hour. (Photo: US Air Force)

reliable source from Germany puts the total at 91,000 kl in total, and this is likely to be the soundest figure (Nakamura 1995).

Twenty-four C-123 Provider planes of the Twelfth Air Command Squadron flew the spray missions day after day. Tan Son Nhut Air base provided a fenced haven for the spray planes at first, but they were later stationed at Bien Hoa Air base. The planes cruised at 240 km per hour at an altitude of 40 m or less, and took no more than four minutes to empty a 1,000-gallon tank full of defoliant.

One C-123 was capable of reducing a strip of land 80 m wide by 16 km long to utter devastation. Winds often served to spread the chemicals even further. A regular sortie consisted of three to six aircraft in formation, and during 1967 to 1969 when activity reached its peak, the spray unit flew eighteen to twenty-seven sorties a day (Buckingham 1982).

Agent Orange, which was used to defoliate the jungle, made up 67 per cent of the herbicides sprayed in the war. The name refers to the color code painted on the drum, not the color of the fluid itself. It was a fifty-fifty mixture of the organo-chlorine herbicides 2,4,5-T (2,4,5-trichlorophenoxyacetic acid) and 2,4-D (2,4-dichlorophenoxyacetic acid). 2,4,5-T contained TCDD (2,3,7,8-tetrachlorodibenzo-para-dioxin), the most toxic substance known, but this was not through any intention on the part of the US military, the dioxin being an inevitable impurity produced in the manufacture of 2,4,5-T. TCDD surpassed other deadly poisons in both lethality and chronic toxicity (that is, in its carcinogenic and teratogenic effect), and 1 ppt (part-per-trillion) poses a threat to human health and the natural environment. Since the 2,4,5-T used in the Vietnam War contained 0.05 to 47 ppm (or fifty thousand to forty-seven million ppt) TCDD, the whole of South Vietnam was in effect poisoned with 168 kg of TCDD (US Air Force estimate, Veterans Administration, USA 1980).

In June 1969, the Saigon newspaper *Tin Sang* (Morning News) began a serialized report on a disproportionate increase in abnormal births in South Vietnam which seemed associated with the defoliation program. No sooner did the report come out than it was censored, but already in the United States an irresistible momentum against Operation Ranch Hand was developing. K. Diane Courtney submitted a study to the National Institute for Health that confirmed that 2,4,5-T caused birth defects and stillbirths among rats (Courtney 1970). A year after the *Tin Sang* report was smothered, Harvard scientist, Mathew S. Meselson and his research team went to Vietnam and warned strongly against Operation Ranch Hand because the dioxin content in Agent Orange was many times the permissible level for domestic herbicides in the United States. Pushed by growing public concern for the safety of Ranch Hand GIs, the Nixon administration at last began to wind the program down, although it was not until 1971 that operations were brought to a complete halt.

The last C-123 sortie for Operation Ranch Hand, which started with a trial spraying on 10 August 1961, flew over cropland in Ninh Thuan on 7 January 1971, and Ranch Hand ended with a helicopter mission on 31 October. The HERBS Tape of the US Air Force recorded a total of 6,542 spraying missions.

Those ten years left the Vietnamese rain forest in tatters, with 40 per cent of mangrove forests and 12 per cent of the interior jungle destroyed, and more than 5 per cent of the cropland devastated. The area defoliated amounted to 3.1million ha (Summary Report 1983).

Unlike the herbicide components 2,4,5-T and 2,4-D, which disintegrate in a few months, dioxin cannot be reduced through natural processes. Dioxin does not dissolve in water but clings to particles of earth and dust. Once settled on the surface of the ground, it mingles with mud and is washed away into rivers and the ocean by rain. The fat-soluble dioxin infiltrates into the human body through food and water and builds up in the fatty tissues where it lingers for years, posing a cancer risk and leading to possible genetic abnormalities. Just as an exposed mother carries a risk of passing toxicity onto her fetus, the capacity of dioxin to damage the human reproductive system could also result in congenital abnormalities in the children of an exposed father (Nakamura 1983).

Operation Ranch Hand has faded into history, but what it sowed is still very much part of the present. GIs have returned to their country only to resume a long, racking battle - this time against a new invisible enemy called 'dioxin' lurking inside their bodies. And what about Vietnam and its people? They have had to endure the destruction and pollution caused by ten years of spraying and its aftermath.

The situation in Vietnam

All over Indochina, including Vietnam, 14 million tons of artillery shells and bombs were dropped during the Vietnam War, and an official of Quang Tri province said that Vietnam's soil still hides two million unexploded bombs. Moreover, it is difficult to accurately count the number of victims of Operation Ranch Hand; some people put the number at one million, while others say three million. I have made at least 29 visits over the past 31 years, including during the Vietnam War, to the villages and jungles targeted by Operation Ranch Hand. I always spent time with local people while there, ate the same food and slept in the villages. I have been covering the issue of Agent Orange during the 26 years that have elapsed since the war ended.

Photo 5.2 The mangrove forest in Cape Ca Mau, southern most area of South Vietnam, has been destroyed by the defoliation operation. A Vietnamese boy (his name is Nguyen Van Hung) is standing in the forest (1976).

Cape Ca Mau

On the 6 May 1976, a year after the Vietnam War, I entered the heavily sprayed area with my friend and guide. In the rain our canoe cleaved through waterways in the mangrove forest. The forest of Ca Mau Peninsula was one of the strongholds of the liberation forces (referred to by the Gis as Viet Cong), and the site of fierce battles against the US and Saigon forces.

When the rain cleared, I encountered a dead world that was not a jungle at all, but a boundless stretch of carcasses of ruined trees. This eerie, desolate landscape was the scar the defoliation missions had created. When I asked to be put ashore, the Vietnamese boatman interjected: ' No way. We can't go ashore here, it's just too dangerous. The whole area's filled with *chat doc hoa hoc* (toxic chemicals), you know?' Leaving him behind, I landed on the riverbank and threaded my way down through dead mangroves - a once thickly canopied forest until the late sixties when the US dispersed Agent Orange over the area. I came across a naked boy. I approached him and struck up a conversation. 'My parents are fisherman,' he said, his bare feet in the mud. 'We live nearby. We were in a refugee camp during the war...'

In early 1982, I returned to the Ca Mau forest. It had been six years since my previous visit. The destroyed forest was now turning into desert. 'We cannot just

Photo 5.3 At our meeting after a lapse of nineteen years, Nguyen van Hung stands with his mother (behind) and sister on the spot where I took Photo 5.2. A worsening paralysis akin to cerebral palsy or Parkinson's disease has left him almost speechless. The site is now used as a prawn farm. (Vien An village, Cape Ca Mau, 1995).

rely on natural recovery. It's just too uncertain,' H. Q. Hung of the Ca Mau forestry office told me. 'Planting mangrove seeds boosts the chances of recovery considerably. We've so far completed 24,000 ha of sowing.' Vietnam's mangrove planting program was, in the end, expected to cover 160,000 ha of destroyed land (Nakamura 1983).

In February 1995, almost twenty years since the end of the war, I again visited Ca Mau. I had been thinking about the boy I met there nineteen years ago: had he survived such severe circumstances? He must by now be a grown man. In a village near the point of the promontory, an elder guided me to the house where the boy and his family lived. A young man came out of a room - Nguyen Van Hung, the boy I had been looking for. He recognized me, but he was unable to speak. The jerky, involuntary movements he made reminded me of cerebral palsy.

In January 2001, I received news from Vietnam that he was bedridden, and his condition had taken a turn for the worse. It would be difficult to prove an association between Agent Orange and the symptoms he suffered. It would be absurd, nevertheless, to assert that his health condition was wholly uninfluenced by the dioxin-soaked environment in which he was raised.

Investigations

M. Matsuda and T. Wakimoto, of the Department of Environment Conservation, Ehime University, Japan, have conducted successive field studies in Vietnam. According to their report 'PCDDs/DFs Pollution in Vietnam Soils' (1994), the dioxin 2,3,7,8-TCDD originating from herbicides was found in one fifth of the soil samples collected from 111 sites all over the country.

In Thay Ninh, one of the targeted areas for the defoliation missions, the mean value of the dioxin concentration in the soil was 14 ppt. In the untargeted Ho Chi Minh City, on the other hand, the contamination level was as high as 59.2 ppt. This suggests, the result of the random spread of dioxin in the Vietnamese environment. It has become difficult now to detect dioxin in the natural environment in Vietnam, even under close investigation. Dioxin trapped in the soil can sometimes be found, but the dioxin levels in crops, fish, prawns and meat in Vietnam (except areas formerly occupied by US air bases) are the same as or lower than these in other industrialized countries.

Inside the human body, however, the problem remains. Since the war, only human beings have been accumulating dioxin in the body from food and water. Wild animals, fish and domestic animals no doubt also concentrated dioxin through biological accumulation when the contamination was severe, but the dioxin in their bodies has already been lost through succeeding generations or constant metabolism; many of those animals would have died naturally, and others were eaten long ago. Only humans have survived since the herbicide spraying operations. Once dioxin enters the human body, it accumulates in fat cells and is rarely expelled.

In November 1993, the Vietnamese '10/80 Committee for Investigation of Consequences of the Chemicals used during the Vietnam War' released the results of an epidemiological study (Le Cao Dai *et al.* 1993). According to the study, the people of Son Be province in South Vietnam, known as 'one of the strongholds of the liberation force' and heavily sprayed with herbicides as a result, displayed 2,3,7,8-TCDD in blood samples and the levels were found to range between 3.4 and 32 ppt. This study, covering six years from 1987, examined 913 people living in 16 areas in the South who had lived through the war and were 40 years old and over. Residents of Hanoi, where no defoliation operations were conducted, were chosen as a control group. The TCDD levels in blood samples of Hanoi residents were 2.4 ppt or less, which means that the concentration of TCDD in Son Be samples was more than thirteen times higher than that of Hanoi samples. A 10/80 Committee study conducted in 1985 showed that some people in South Vietnam were contaminated with dioxin levels as high as 100 ppt. Comparing these two studies, body dioxin levels seem to be gradually decreasing. Nevertheless, the contamination level in Vietnamese people remains extraordinarily high.

Pollution of former-US air base Bien Hoa

Apart from people exposed to herbicides in targeted areas, people living in Bien Hoa, which was the site of one of the biggest Agent Orange stockpiles in the late 1960s and served as the air base for the defoliation mission aircraft, were found to have blood TCDD levels of up to 271 ppt, 135 times greater than residents of Hanoi. TCDD contamination as high as 600,000 ppt was also found in some nearby soil samples (Schecter, A., Le Cao Dai, Matsuda, M. *et al.* 2001).

The main base for defoliation mission aircraft was moved from Tan Son Nhut air base to Bien Hoa, and then later to Da Nang. Each air base has big storage tanks and drums filled with herbicide, and some of them were destroyed in battle. In the late 1960s, more than 28,000 liters of herbicide solution spilled out from the storage tanks of Bien Hoa air base.

The next generation also affected by Agent Orange

'It was at dawn, I think.' Hong Thi Phuong recalled the day of her baptism by Agent Orange in the war. 'When American airplanes came, my father pulled my hand and we ran into a ditch. We could escape from the bombing, but we could do nothing to protect ourselves from something like mist falling from the planes. My father wetted a cloth and covered my nose and mouth. It sure had a smell,

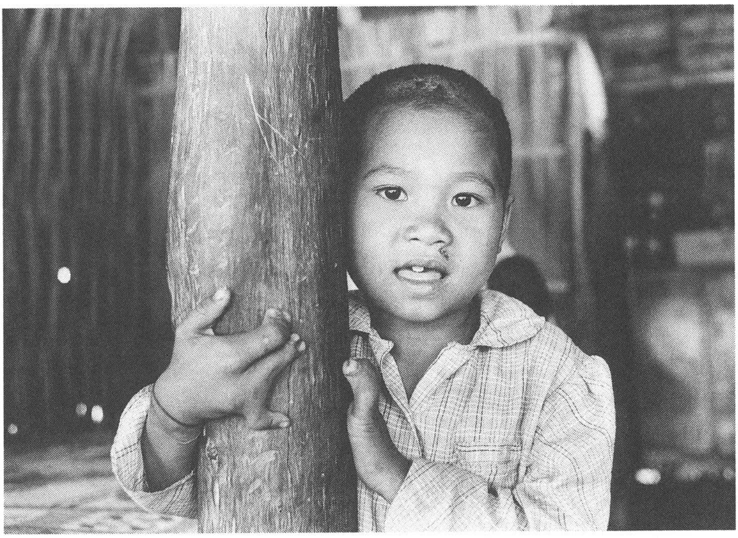

Photo 5.4 Nguyen Thi Hong (8 years old) suffered from severe malformation of the fingers. Eczema was also affecting her shaven head. Her mother was exposed to herbicides in Cambodia. (Xa Mat, Tay Ninh 1981).

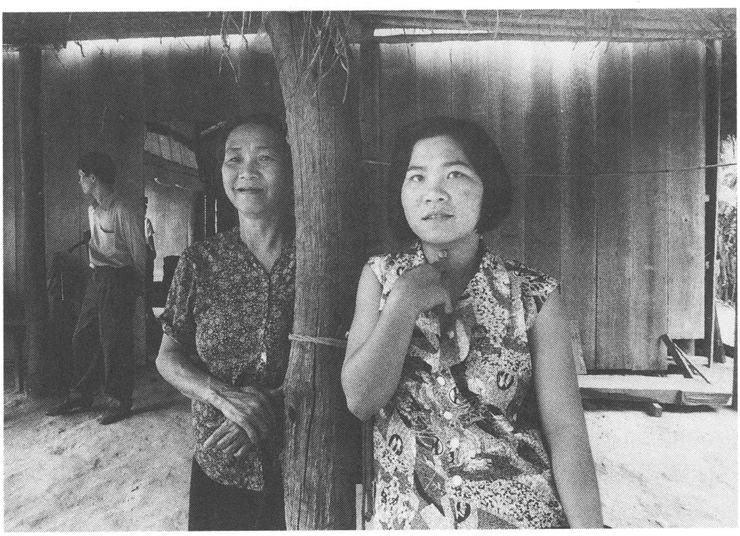

Photo 5.5 Hong in 1995. The genial twenty-two-year-old girl still has the same knotted fingers that orthopedic operation today can restore. 'I'm not able to afford an operation,' she said. She earns her meager income from selling cashew nuts at the market (Xa Mat).

but now, I'm unsure what kind of smell it had. I was only ten years old or so at that time.' At the end of 1981, I met her at Loc Hung village in Thay Ninh province. She became a young mother at the age of 24. She held two girls in her arms - one was three years old and the other was four. Both girls had harelips. 'I had a miscarriage before these two girls. The baby after these two had a harelip too, and died soon.' Her village is close to the Boi Loi forest where the liberation forces had their base. She told me that the village was repeatedly exposed to the defoliation missions. 'Many women have suffered miscarriages since then,' she said (Nakamura 1983).

That dioxin causes birth defects has been confirmed through animal experiments conducted by Dow Chemical and others. As expected, it has happened with human beings as well. Many Vietnamese mothers have unwittingly played the role of proving the reliability of the lab experiments with their own bodies. Dioxin-induced malformations and congenital disabilities manifest themselves in various ways, from visible malformation, such as cleft lip, cleft palate, conjoined twins, deformed limbs, and anencephaly (no formation of the brain), to internal organ malformation or problems such as heart and reproductive organ anomalies.

Conjoined twins

When I first met the twin babies in Hanoi's Viet-Duc Hospital in late 1981, I

Photo 5.6 Ten-month-old conjoined twins Viet and Duc at Viet-Duc Hospital in Hanoi. They were born in defoliated Sa Thay, the central plateau of southern Vietnam, on 25 February, 1981 (Hanoi, December 1981).

sensed these little ones, born conjoined at the belly, would not live very long. For ten-month-old infants, they were quite expressive and moved their limbs with exuberance. But the heavy symphysis in the hips left them only one leg each, both sticking out from one side of the body. Presumably they shared some internal organs, too. Everyone, the doctors included, feared they would not survive such dire conjoining; they had heard incessant reports from various parts of Vietnam of newborn babies with similar problems, most of whom had died within a month. 'Look,' said Dr. Lien, pinching Duc's ear, 'Viet doesn't feel pain, while Duc does. Obviously they have independent nervous systems, even though their bodies are bonded. But I think separation would be difficult.'

Viet and Duc were born in Sa Thay, Kon Tum province on 25 February 1981. Situated in the central plateau of southern Vietnam, Sa Thay had experienced Ranch Hand attacks. After a long strenuous labor, both mother and midwife supposedly fainted at the sight of the newborn twins. The neighbors took the babies to a local clinic, the clinic to a bigger hospital, and finally, in May 1981, they were brought to Viet-Duc Hospital (Nakamura 1995).

Without the fetus-deforming effects of the dioxin in Agent Orange, the prenatal symphysis of the twins would be inconceivable. No chromosome aberration was found; nor did the problem seem genetic. A report had already come out that in South Vietnam the birthrate of malformed infants of this rare kind had shot up since the war, a dozen times higher. The commonly used name 'Siamese twins' certainly confused some of the ignorant, who actually believed that such deformities were indigenous to Indochina. The term came into currency simply because a nineteenth-century British doctor found in Siam, now Thailand, the belly-bonded twins Chang and Eng (1811-74). A WHO survey showed no conspicuous difference in the incidence of such babies in any part of the world. But the really significant fact to emerge from the survey was that there had been in Vietnam growing numbers of cases of deformities and birth defects, miscarriages and stillbirths since Operation Ranch Hand.

The first crisis struck the two in the summer of 1986. Viet contracted an unidentified fever and fell into a critical condition. On 11 June I flew to Ho Chi Minh City with a group of doctors from the Red Cross Hospital in Japan, from whom the Vietnamese hospital had requested emergency medical support.

Viet survived but his physical instability continued. Brain damage from the encephalitis had left him in a stupor. Recurring pneumonia harried him. The doctors finally decided on the risky bid to separate the twins. The operation was performed on 4 October 1988, at Tu Du Hospital, by chief surgeon Dr. Trang Dong A. and a group of forty Vietnamese doctors. Remarkably, Dr. Trang and many others on the team were former South Vietnamese army surgeons who had been well trained in Texas, USA. Without any post-surgical infection, Viet and

Photo 5.7 Specimens of infants that were stillborn. Their mothers were living in the sprayed area (Tu Du Hospital, HCM city, 1982).

Duc made a relatively smooth recovery.

In February of 2001, both of them marked their 21st birthday in good health.

In Vietnam, the children who were born during and soon after the defoliation operation are now grown up, and they have become parents to a whole new generation. As such, the country is faced with a new problem; namely the fate of the babies of this new generation, since the contamination is passed from mother to child.

During the war, in 1970, American researcher Dr. Mathew S. Meselson of Harvard University and his colleagues visited the sprayed area to examine the dioxin level in the breast milk of Vietnamese women. Their study showed that the breast milk was highly contaminated with dioxin, the average level of which was of 484.9 ppt, with a maximum of 1,450 ppt. (Baughman and Meselson, cited in Le Cao Dai 2000). The result of a later study conducted between 1987 and 1988 by the Vietnamese Committee to investigate the aftermath of Agent Orange, showed that dioxin in breast milk in contaminated areas was 131 ppt, and an even more recent study in 1993 showed a gradual decrease in the breast milk contamination of 10 to 20 ppt on average (Le Cao Dai 2000).

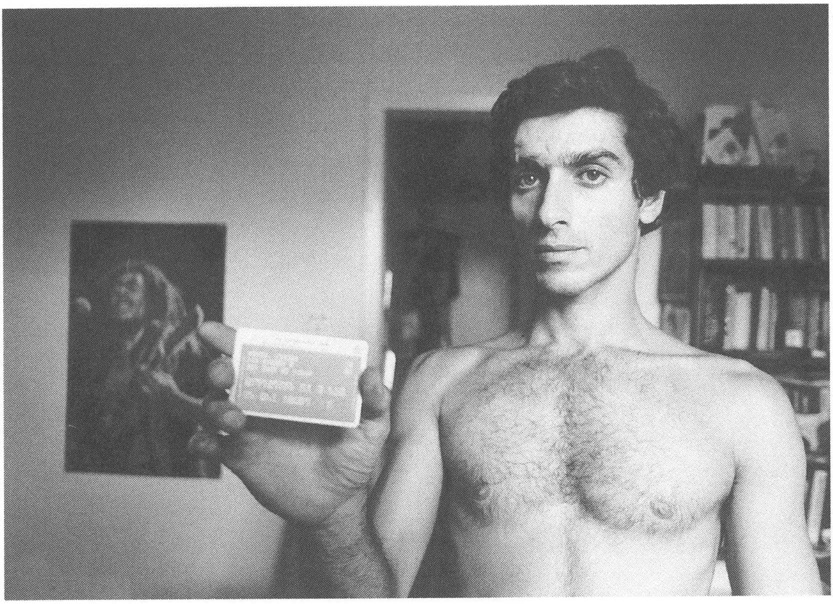

Photo 5.8 A former paratrooper, Thomas Vuono, who has suffered with dermatitis, showing the Agent Orange patient card issued by Veteran's Hospital. His wife left him (New York 1982).

In the US, Korea, and Japan

US Vietnam veterans and Agent Orange

In the United States, strange illnesses began spreading among some Vietnam veterans in the 1970s, including cancers, dermatitis, paralysis, sexual dysfunction, neurosis and the like. In 1978, Vietnam veterans began to file 'Agent Orange law suits'. However, under US law, former servicemen cannot sue the government for damages resulting from their missions. Therefore, veterans decided to sue the chemical companies, such as Dow Chemical, Monsanto, Hercules, Occident, Diamond Shamrock, Uniroyal and Thompson Heywards, which knew the risks of toxic herbicides and continued supplying them to the US forces. In May 1984, just before the trial in the federal court began, the companies changed their opinion that they bore no responsibility for the damage caused by Agent Orange on the veterans, and they offered a US$180 million settlement. This was a trivial amount if divided among the veterans concerned; a mere US$3,200 each even in the case of death or development of a fatal cancer (Schuck 1986).

The number of veterans who have developed or will develop symptoms is estimated to be 10 per cent of the men and women who served in the Vietnam

War, or approximately 300,000 people. As of 1995, 70,000 veterans have become aware of their symptoms and have been receiving medical treatment. As of 1993, only 486 people have received compensation, even though 39,419 veterans had filed applications for benefits.

In 1999, the Institute of Medicine (IOM) of the National Academy of Science (NAS) submitted a new evaluation of the health risk due to exposure to Agent Orange (*Veterans and Agent Orange - Update 1998*, National Academy Press). This investigation was called for by the US Congress to review the scientific evidence on the possible health effects of exposure to Agent Orange and other herbicides (Agent Orange Act of 1991 - Public Law 102-4, enacted on 6 February 1991). Its findings are shown as follows:

1) Sufficient evidence of an association between exposure to herbicides and the following health outcomes:
   soft tissue sarcoma
   non-Hodgkin's lymphoma
   Hodgkin's disease
   chloracne
   porphyria cutanea tarda (in genetically susceptible individuals).

2) Limited or suggestive evidence of an association between exposure to herbicides and the following outcomes:
   respiratory cancers (lung/bronchus, larynx, trachea)
   prostate cancer
   multiple myeloma
   acute and subacute transient peripheral neuropathy
   porphyria cutanea tarda
   type 2 diabetes
   spina bifida in the children of veterans
   acute myelogenous leukemia (AML) in the children of veterans.

3) Inadequate or insufficient evidence to determine whether an association exists between exposure to herbicides and the following health outcomes:
   hepatobiliary cancers
   nasal/nasopharyngeal cancer
   bone cancer
   breast cancer
   female reproductive cancers (cervical, uterine, ovarian)
   urinary bladder cancer
   renal cancer
   testicular cancer

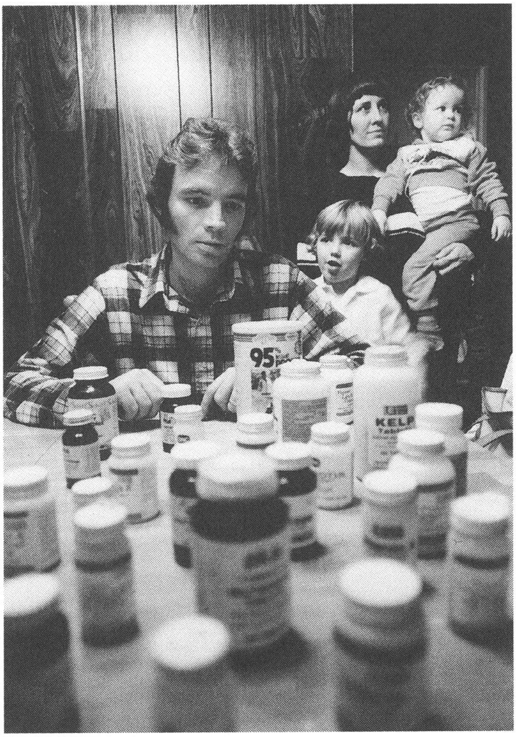

Photo 5.9 James Lutz, a former crew member of a reconnaissance plane O-1 Bird-Dog, and his family. Since he came back from the war, he has taken 20 types of medication every day due to dermatitis and hypersensitivity to heat (1982).

leukemia
spontaneous abortion
birth defects (other than spina bifida)
neonatal/infant death and stillbirths
low birth weight
childhood cancer in offspring
abnormal sperm parameters and infertility
motor/coordination dysfunction
chronic peripheral nervous system disorders
metabolic and digestive disorders
immune system disorders
circulatory disorders
respiratory disorders

Table 5.1 The health status of Korean veterans and their siblings

Total number of veterans who had medical examination			. 75,950
Cases examined as disease of after effect			4,415 (6.2%)
(Type of disease above)			
Non- Hodgkin's lymphoma	129	Chloracne	128
Soft- tissue sarcoma	20	Hodgkin's disease	15
Peripheral neuropathy	3,203	Lung cancer	504
Porphyria cutanea tarda	1	Larynx cancer	143
Trachea cancer.	2	Multiple myeloma	28
Prostate cancer	38	Buerger's disease	204
Second generation			31
Spina bifida	3	Deformity of lower leg	1
Peripheral neuropathy	27		
Quasi-defoliant-related case			41,554 (58.0%)
Dermatitis	4,662	Mental illness	5,812
Internal organs	31,080		
Unrelated cases			25,635 (35.8%)
Under examination			4,315

(Source: Korean Veterans Administration, 31 July 2001.)

Photo 5.10 A Korean realtor hangs out 'Agent Orange Liaison Office for Veterans Served in Viet Nam' sign by hankle letter on the door of his office. He and his friend were Vietnam veterans, and suffering from cancers by Agent Orange (at Anyan, Korea, 1993).

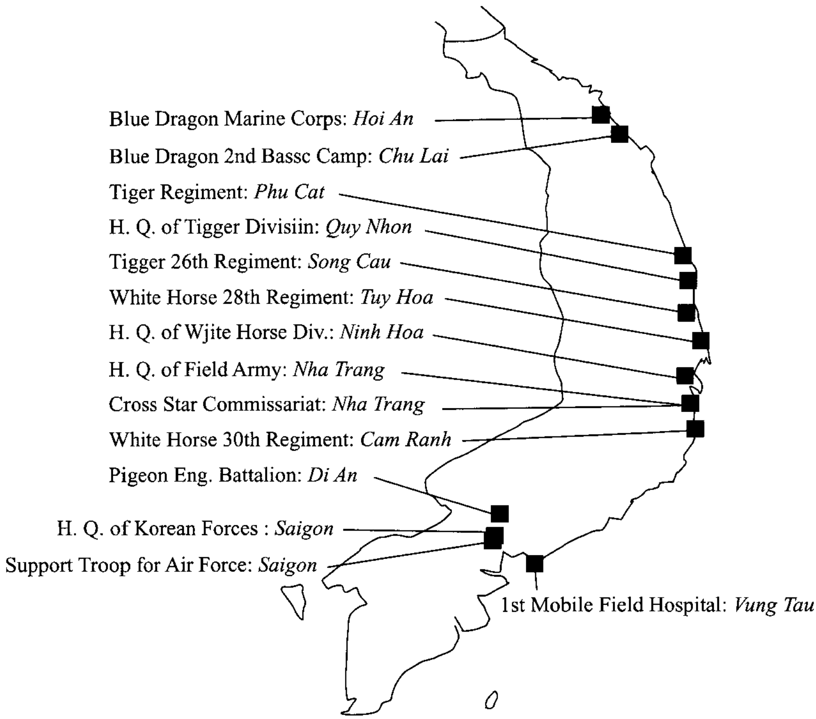

Fig 5.1 The placement of korean force in the Vietnam War

AL-type primary amyloidosis.

4) Limited or suggestive evidence of no association between exposure to herbicides and the following health outcomes:
   gastrointestinal tumors
   brain tumors.

I would like to pay attention to spina bifida and acute myelogenous leukemia (classified as 'suggestive evidence of no association') among the children of veterans, since the inclusion of these two diseases signifies that the exposure of their fathers to herbicides affected the next generation, even though men have no uterus. If chemical substances such as TCDD can alter genes and trigger cancers and birth defects, this is a matter that could threaten the very survival of the species as a whole, rather than just certain individuals.

Photo 5.11 Kang Ju-gwan (47 years old) was a medic in Tiger Division, Korean Army. He is suffering from severe dermatitis. His wife and daughter left him, and now he lives all alone. He started calligraphy to forget the suffering. His calligraphy has improved to the level of a master (his work at his back). However, his health has yet not recovered (at Shimpo, Korea, 1993).

The tragedy of mercenaries from Korea

313,000 South Korean soldiers served in Vietnam, obeying the demand of the US government during the war. Consequently, many Korean soldiers were also exposed to Agent Orange, but it was not until 1992 that coverage of this issue by the South Korean news media was permitted, because the military regimes of Chun Doo-whan and Roh Tae-woo were in power for about twenty years after Park Chung-hui (Pak Keun-ho 1993). As news coverage of this issue developed, South Korean Vietnam War veterans began to report their health problems caused by herbicides. In 1993, the Agent Orange Victims Relief Act became Korean law and, based on this Act, the process of official recognition of the victims has been ongoing.

The number of veterans who have been recognized as patients suffering from Agent Orange is inferred in the Table 5.1.

Both military presidents Chun Doo-whan and Roh Tae-woo were leaders of South Korean forces dispatched to Vietnam, and after the Vietnam War, they were promoted as a result of their combat career in Vietnam. It was in 1964 that

President Park Chung-hee made the decision to send forces to Vietnam, a medical division of 140 personnel being dispatched in September 1964. Year after year, new decisions to send more personnel were made. The South Korean government dispatched the Tiger (*Maeng Ho*) Division, which was the principal division based in Seoul; the White Horse (*Baeng Ma*) Division, the largest division in the army; the Blue Dragon (*Cheong Nyong*) Brigade from the marines; the Cross Star (*Sip Jaseong*) Commissariat; the Silver Horse (*Eun Ma*) from the air force; the White Seagull from the navy; and the Pigeon (*Pidulgi*) engineering battalion. In order to avoid isolation from the international community, the United States requested other countries to actively participate in the war, but only nations in which US military bases were located responded; Australia sending 45,000 soldiers, New Zealand 2,500, Thailand, 38,000, the Philippines, 6,000, and South Korea 312,853 soldiers. The numbers of South Korean soldiers were clearly very significant.

The Park administration at that time needed a large sum of US dollars in order to stabilize political power and rehabilitate the domestic economy. When it decided to participate in the war, it also concluded the Korea-Japan Treaty, and received five billion dollars in governmental aid and loans from Japan, and a three billion dollar non-governmental loan.

Between 1965 and 1972, the United States paid approximately 10 billion dollars to the Korean armed forces for their participation. When a Korean went to Vietnam, even a private was paid up to $45 a month, and if he was a colonel, he could be paid $200 a month by the US. Of these salaries, 90 per cent were sent directly to their homeland or to their homes as electric appliances purchased at the PX. Korea's participation in the Vietnam War was driven by 'mercenary' motives, as was indicated in the record of the Symington Committee of the US Senate in July 1970. Korea lost 5,051 soldiers, including 4,687 deaths in action. A minimum of $1,400 was paid as compensation for a death in action. Over 16,000 Korean soldiers were wounded. In exchange for its soldiers' lives, South Korea gained US dollars and the benefits of munitions, these serving as a springboard for later economic growth (Pak Keun-ho 1993).

After the end of the military regime, the new Korean government promptly prepared the draft of the Agent Orange Victims Relief Act, and on 10 May 1993, the Kim Yeong-sam administration implemented the Act. Soldiers who were Agent Orange victims realized that they could not rely on existing veterans' groups and, in June 1992, the Agent Orange Korean Veterans Association was established with 1,200 members. In June 1994, the Veterans Association filed a case against American chemical companies in the US California District Court, but the case was dismissed.

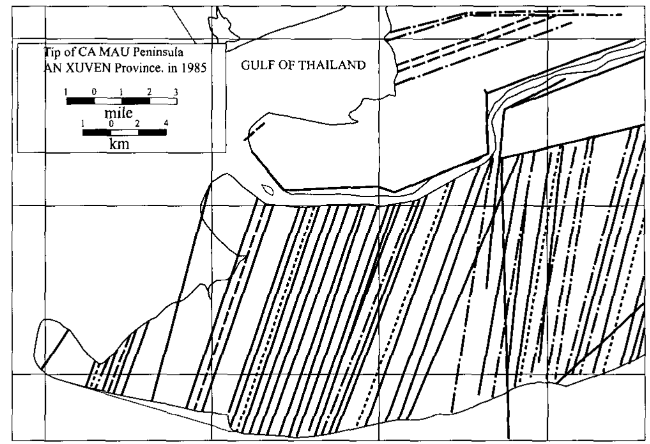

Fig 5.2 Enlarged defoliation chart of Mau Peninsula (SOURCE. NAS, "The Effects of Herbicides in South Vietnam, 1965-701").
Right: This diagram is simplified for clear reproduction. Each line traces a spraying flight and the kind of sprayed herbicides; full lines show 'Agent Orange'; chain lines show 'Agent White'; broken lines show that Both 'Agent Orange' and 'Agent White' were sprayed.
Left: Map, made according to 1972 satellite photographs, shows in white the defoliated area. (SOURCE: from NAS,"The Effects of Herbicides in South Vietnam, 1965-70")

Dioxin accumulation in Japanese people

'Vietnam's situation is certainly serious. But I believe that dioxin contamination will also become a really big problem in industrialized countries like Japan,' Dr. Nguyen Thi Ngoc Phoung said to me repeatedly in the 1980s.

As she forecasted, dioxin contamination has indeed become a serious problem in industrial countries. The main sources of this contamination are waste incinerators, the paper and pulp industry, chemical industry, metal refining industry, and emissions from motor vehicles. Needless to say, organo-chlorine pesticides have also played a part in the contamination.

Studies have confirmed that dioxin is the most lethal of all of the toxic chemical compounds known to humans. It also works as an endocrine disrupter in the human body. In addition to abnormal births and cancers, dioxin induces a variety of illnesses at even very low levels of contamination. Dioxin's characteristics, such as the mechanism of toxicity, chemical behavior, and causal relationship with diseases, have now been verified. Dioxin has come to confront us as a life-threatening problem on our own doorsteps, rather than being limited to some far away locations in Vietnam.

Dioxin is produced by burning chlorine-containing plastics, such as products made of poly-vinyl-chloride, wood treated with insecticides, wastes containing PCBs, medical waste and such like. Under the prevailing Japanese waste treatment system of incinerating any 'combustible waste', 1,841 municipal incinerators burn 95,000 metric tons of waste every day, not to mention several thousand incinerators for industrial waste that also burn huge amounts of waste every day. In Japan, dioxin is produced in and discharged from incinerators daily, and its amount is estimated to be 13.2 to 48.4 pounds (6 to 22 kg) a year. If the practice is continued, it will, in 8 to 30 years, match the total amount of dioxin - approximately 396 pounds (180kg) - sprayed all over South Vietnam.

Being invisible, dioxin clouds discharged from incinerators can travel anywhere and everywhere. Dioxin-containing fly ash from incinerators is buried in landfills, and dioxin falling to the surface of the ground is washed into rivers by rain. Dioxin drains into lakes and the sea, to be taken in by fish and shellfish in affected areas. Due to this sustained low-level contamination, dioxin is accumulating in our bodies. Japan, Germany and the United States are now among the most contaminated countries after Vietnam.

To what extent is the general population of Japan contaminated with dioxin? According to Nagayama Junya, at Kyushu University Medical Junior College, a Japanese adult takes in 834 picograms (pg) of dioxin a day (1 pico = 1/trillion). Most of this intake is from food, but 19.8 pg also comes from the air, and 0.036 pg from water. In one gram of human fat tissue, which is prone to dioxin accumulation, dioxin is found at a high level, ranging from 41.9 to 54.6 pg (Nagayama, J. 1994). Hirakawa Hakusen and his colleagues at Fukuoka Institute of Health and Environmental Sciences examined dioxin levels in the fat tissue of 36 Japanese who died in traffic accidents. According to this report of December 1994, there is an upward trend along with age in dioxin accumulation in fat tissues: 35 pg of dioxin at 19 years of age, 37.9 pg at 20 years, 48.2 pg at 40 years, 61.4 pg at 60 years, and 78.1 pg at 70 years. Although dioxin is excreted from the body little by little, dioxin accumulation in fat tissues increases because the amount of dioxin intake exceeds the amount excreted. In this study, the average amount of dioxin in fat tissues was 58.4 pg. This is serious contamination compared with the 30 to 45 pg average for industrialized countries, and approaches the level of 65 pg for South Vietnam, where the defoliation missions were carried out. Meanwhile, in some places in North Vietnam and China which are not industrialized nor sprayed with herbicides, the amount of dioxin in human fat tissue is as low as 12 to 13 pg (and around 2 pg in blood).

Dioxin contamination is not limited only to fat tissues, but also affects other organs and tissues such as liver and blood. Besides, a more serious problem is that fat-rich breast milk is more contaminated with concentrated dioxin than the mother's body itself. What will happen to breast-fed children?

Contaminated breast milk

According to A. Schecter, Professor of Environmental Sciences, University of Texas School of Public Health, Dallas, dioxin contamination levels in breast milk were 35 ppt in samples from mothers living in Da Nang, one of the sprayed areas in Vietnam, followed by 27 ppt in Germany and Japan, 26 ppt in Canada, and 20 ppt in the US. The dioxin levels of these samples are higher than the level of 18 ppt found in samples from Saigon. South Vietnam once stood out for its high contamination with dioxin, but the contamination level has been decreasing for 30 years since the end of Operation Ranch Hand, except around some former US air bases. Accordingly, in terms of the dioxin contamination level in breast milk, 'industrialized' countries are overtaking Vietnam. As expected, elsewhere in non-industrial areas in Indochina, the dioxin level in breast milk is found to be as low as 8.5 ppt in Hanoi, North Vietnam, and 3 ppt in Thailand and Cambodia.

In September 1994, the US EPA presented a report that reassessed the effects of dioxin on human health, and brought up what was an important perspective at the time. The report confirmed that dioxin was a toxic substance that could cause various types of diseases and disorders, even if present in much smaller quantities than those required to produce cancers. Before this report came out, the association between dioxin and cancer production was the criterion used to consider standards covering dioxin contamination regulation. However, while of course cancer is very serious, the report revealed that much lower amounts than those required to produce cancer will significantly affect resistance and maintenance of the metabolic functions of human beings, giving rise, for example, to immune system disorders, reproductive dysfunction, development delays, hormonal dysfunction and so forth (suggesting its effects as an endocrine disrupter). Dioxin produces cancers and, what is worse still, it defeats a person's immune system. This would result promoting the production of cancers. Besides, it seems quite likely that humanity could be on the road to extermination by dioxin, since people are made vulnerable to infectious diseases and dysfunctional in sexual development (EPA 1994). In other words, the EPA report suggests that the regulation of dioxin concentration must be done in a much more rigorous fashion. In fact, it has been reported that the amount of sperm in men has diminished by half over the last five decades. Examining the sperm of 15,000 men in Denmark, N. Schakkebaek and his colleagues at the University of Copenhagen found that both the density of sperm and the volume of semen were half as great as those in the same research conducted in 1940. This study showed that 'persons with reproductive dysfunction' are increasing. The authors assume that noxious substances, like PCB, in the environment are the cause of this finding (Giwercman, Keiding and Skakkebaek 1992).

The tolerable level of dioxin for daily intake (TDI) in Japan, 4 pg per 1 kg body-weight per day, was adopted in 1999. However, in their food intake, especially fish, almost all Japanese people reach this limit every day.

The Japanese people have suffered numerous tragedies caused by environmental pollution and the adverse effects of medication and contaminated drugs. As those tragedies have proven, environmental protection and drug safety issues in Japan tend not to be addressed unless effects on the human body become apparent. Measures against carcinogens with delayed toxicity, such as dioxins, need to be taken as soon as the risk is foreseen. For toxic chemical substances, the principle of 'Guilty until proven innocent' must be applied. Failure to regulate contamination on the grounds that 'dioxin's effects on human health have not yet been established beyond doubt' should be punished as criminal neglect.

Prospects

Vietnamese and American officials met on 2 July 2001, in Hanoi to talk about how to conduct joint research on the after-effects of Agent Orange on human health and the natural environment. The first official talks between the two governments were held in Singapore in November 2000, just after US President Clinton's first visit to Hanoi.

More than thirty years have passed since the end of Operation Ranch Hand. One could argue that it is now too late to investigate the real effects of the US defoliation operation. However, we should welcome this development as a first step in cooperation between both sides to reveal the facts relating to the operation and its aftermath. This kind of collaboration on the Agent Orange issue is, I think, of vital significance, and I hope it will bear fruit, since dioxin contamination is a problem faced not only by Vietnam, but also increasingly by Japan and other countries.

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6
The Fate of 2,3,7,8-TCDD Herbicides and Defoliants Used During the Vietnam War

WAKIMOTO Tadaaki

Chemical warfare lasted from 1962 to 1971 in the Second Indochina War, which was fought between armed guerilla forces of the North Vietnam Army and South Vietnam residents against well-equipped US forces and the South Vietnam Army. The US force's Operation Ranch Hand aimed to destroy the jungles of the mangroves and dense forests of the Iron Triangle and other strategic areas since these jungles provided protective cover for the guerilla forces. The herbicides used were 2,4-D (dichlorophenoxyacetic acid), 2,4,5-T (trichlorophenoxyacetic acid), and mixtures of cacodylates. In the operation, these herbicides were called Agent Orange, White, Blue, Purple, Pink, and Green according to the color code on the containers. Table 6.1 shows the active ingredients, amounts used and the 2,3,7,8-TCDD (tetrachlorodibenzo-p-dioxin) concentration in each agent. The concentration of 2,3,7,8-TCDD was much higher in the herbicides used before 1965 than later, when it was lowered to 1/30. We estimated the total amount of sprayed 2,3,7,8-TCDD was about 130 kg, as shown in Table 6.1. This estimate may be an underestimate, as compared to the 170 kg estimated by the US, and

Table 6.1 Ingredients of Herbicides used in Vietnam War and Estimated Concentration and Amount of Sprayed 2,3,7,8-TCDD (Watanuki & Kawamura, 1984)

Agent	Ingredients	Used Amount gallon	Period	2,3,7,8-TCDD
Orange	2,4-D, 2,4,5-T	10,646,000	1965-70	1.98 ppm
White	2,4-D, Picloram	5,633,000	1965-71	–
Blue	Cacodylic Acid	1,150,000	1962-72	–
Purple	2,4-D, 2,4,5-T	145,000	1962-65	32.8
Pink	2,4,5-T	123,000	1962-65	65.6
Green	2,4,5-T	8,000	1962-65	65.6
Total			1962-71	131 kg

far less than the Vietnamese claim of 500 kg which does not seem to be based on firm evidence. Nevertheless, there is no doubt that a large amount of 2,3,7,8-TCDD was sprayed onto the forests of Vietnam.

Close to the end of the war, a large increase in reproductive abnormalities were observed and, by 1988, thirteen years after the end of the war, the incidence of reproductive abnormalities was estimated to have reached 30 per cent of the total births in some localities in southern Vietnam. At this point, the medical staff from Vietnam approached Japanese medical institutions to research and suggest a remedy. The first team of ten Japanese medical personnel visited Vietnam and made a survey. The survey strongly indicated that the abnormal occurrence of the reproductive abnormalities was probably associated with dioxins still remaining in the environment. A chemical study of the environment was initiated by Professor Tatsukawa of the Laboratory of Environmental Chemistry at Ehime University, and he and his colleagues, including the author, made an eco-chemical survey to detect dioxins in the Vietnamese environment from 1989 to 1993.

I would like to offer a summary of this research and discuss the destructive influence of dioxins on human health in Vietnam.

Analysis of dioxins in soils

Distribution of soil samples

Soil samples were collected from 111 places in eight localities, as shown in Figure 6.1. The sampling density was not even, and varied depending on the reported intensity of the spraying missions. For example, the 54 places surveyed in Tay Ninh were the most heavily sprayed. 2,3,7,8-TCDD was detected in 14 out of 54 places in Tay Ninh, in 3 out of 6 places in Hue and Phu Loc, in 1 out of 11 in Song Be, in 2 out of 9 in Ho Chi Minh City. It was not detected in Doc Bin Kieu, Ca Mau and Tam Nong which were all heavily sprayed, nor was it detected in Hanoi.

It was presupposed that the major constituent of the remaining dioxin should be 2,3,7,8-TCDD and that the concentration should reach more than 25 ppt if the estimate of the sprayed amount was correct. However, we only found concentration less than 25 ppt in more than half of the soil samples, and concluded that either the spraying of the herbicides did not take place at all, or that the dioxins were washed away. 2,3,7,8-TCDD is known to be stable in natural conditions and rarely decomposes or dissipates in the soil. Therefore, if they remain in the soils, they should be detected. It should be noted that the proportion of 2,3,7,8-TCDD was higher than the other dioxin isomers where dioxin was detected in the soils. This was a clear contrast to what we know about the proportion of dioxin isomers derived from the atmosphere and incinerator ash data collected in Japan. This fact made us assume that the presence of 2,3,7,8-TCDD in Vietnamese soils was the result of accretion from sources other than incinerators.

Considerations on the measured value of dioxins

The detection of contaminated soil with dioxins was far less than expected. We found that the proportion of 2,3,7,8-TCDD among other isomers was the highest in dioxin-detected soils. However, as the results shown in Table 6.2 illustrate, some dioxin isomers may be those derived from sources other than herbicides, and we may conclude that incinerator-derived dioxins are contaminating the atmosphere over Vietnam through hemispheric circulation.

Our survey was confined to those places which were designated by the Vietnam government and we had no free choice of where to take the samples. The Vietnamese government apparently expected us to obtain the measurements from intact soils. Soil samples collected from a fenced zone of a former US base camp showed a very high concentration of 2,3,7,8-TCDD in the ppm order, indicating the site was a handling site for the herbicides. Detailed surveys were not permitted and, as we learned later, the Vietnamese government started the survey of the former US base camps.

Sampling location of Vietnam soils.

Tay Nink (54)	Hanoi (5)
Tam Nong (4)	hue, Phu Loc (6)
Doc Bin Kieu (6)	Song Be (11)
Ca Mau (16)	Ho Chi Minh (9)

(Number of sample)

The detection rate of 2,3,7,8-TCDD in analyzed sample.

Tay Ninh 14/54	Hanoi 0/5
Tam Nong 0/4	hue, Phu Loc 3/6
Doc Bin Kieu 0/6	Song Be 1/11
Ca Mau 0/16	Ho Chi Minh 2/9

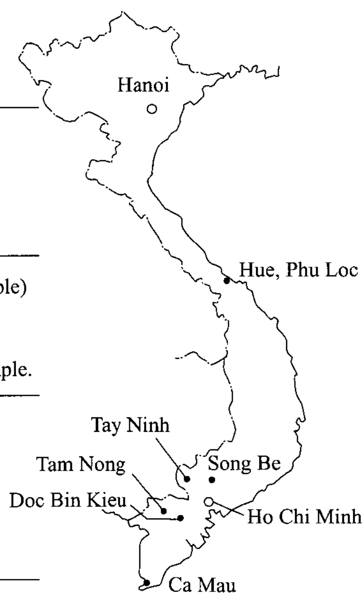

Fig 6.1 Soil-sampling location and detection rate of 2,3,7,8-TCDD

Table 6.2 Concentrations (pg/g dry weight) of PCDDs/DFs in soils from Vietnam

	Hanoi (5)	Hue Phu Loc (6)	Ho Chi Minh (9)	Tay Ninh (54)	Song Be (11)	Tam Nong (4)	Doc Binh Kieu (6)	Ca Mau (16)
2,3,7,8-		4.37-16.8(4)	2.98,59.2(2)	1.2-38.5(14)	6.0(1)			
1,3,6,8-				0.3-49.6(13)	0.6(1)			
1,3,7,9-			10.6(1)	0.5-18.9(10)				
ΣTeCDD	–	4.37-16.8(4)	2.98-59.2(3)	0.5-92.4(18)	0.6-6.0(2)	–	–	–
ΣPeCDD	–	–	4.74-9.96(2)	6.1-40.3(10)	1.0(1)	–	–	–
ΣHxCDD		–	36.2-98.4(6)	14-416(12)	4.7,9.5(2)	–	10-18(6)	33-85(11)
ΣHpCDD	40.4(1)	11.1-105(3)	67.9-402(8)	3.5-2900(40)	2.7-185(10)	–	26-53(6)	43-154(15)
OCDD	66.3-578(5)	72.8-1318(6)	317-1865(9)	17-16000(49)	11-880(11)	69(1)	180-380(6)	210-900(16)
ΣPCDD	66.3-619(5)	77.2-1428(6)	469-2268(9)	11-16970(49)	13.7-1065(11)	69(1)	227-451(6)	253-1139(16)
ΣTeCDF	–	–	9.21-43.7(5)	1.6-509(19)	4.9(1)	–	–	–
ΣPeCDF	–	–	–	29,165(2)	–	–	–	–
ΣHxCDF	–	–	37.1(1)	11.4-662(6)	–	–	–	–
ΣHpCDF	–	–	71.7(1)	14-830(5)	–	–	–	–
OCDF	NA	NA	NA	3.6-560(5)	–	–	–	–
Σ PCDF			9.21-152(5)	1.6-2190(24)	4.9(1)			

— : less than the detection limit
NA: Not Analyzed
Number in parenthess shows detected sample

Concentration of dioxin isomers in vietnamese environments

Figure 6.2 shows the total concentration of dioxin isomers as converted into TEQ (toxic equivalents) for the surveyed locations (Matsuda *et al.* 1993). Soils around Ho Chi Minh City showed the highest values in Vietnam, at an average of around 10 ppt. The soils of Song Be, where residents testified to intensive spraying, did not show such high concentrations. Japanese soils, in comparison, unexpectedly showed two to three times higher values.

Comparing the whole of Vietnam, soil samples from southern Vietnam south of Hue and Phu Loc, showed significantly higher contamination which shows that South Vietnam had the most intense spraying of herbicide.

Figure 6.3 compares the isomer composition of dioxins between the source of herbicides and insecticides and those detected in soils (Matsuda *et al.* 1993). Herbicide 2,4,5-T contains 2,3,7,8-TCDD at a peculiarly high concentration, while 2,4-D contains higher concentrations of 1,3,6,8- and 1,3,7,9-TCDD. Similarly, CNP (chlornitrofen) and PCP (pentachlorophenol) also show a contrasting composition of their major constituents: CNP has isomers of 4,5,6-chlorinates while PCP has 8,7,6-chlorinates. The isomer composition can be used as a fingerprint to identify the source of the contaminants. Based on this fingerprint, we determined that dioxins in the Vietnamese soils were derived not only from herbicide

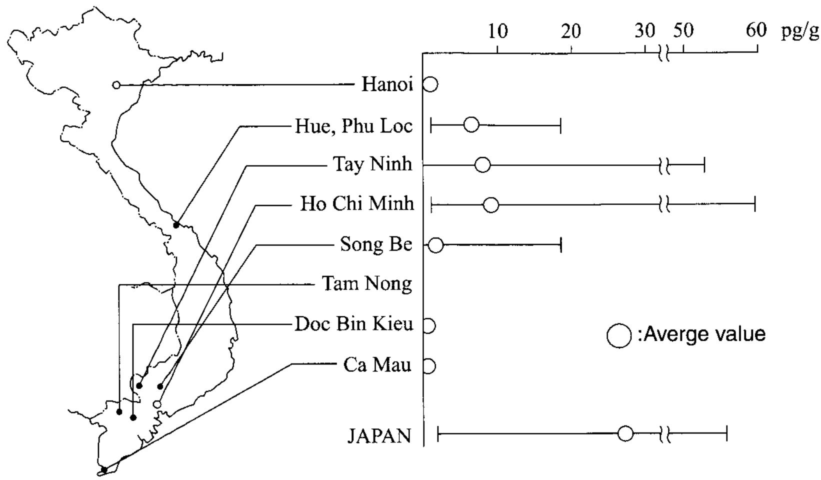

Fig 6.2 Comparison of TEQ in soils between Vietnam and Japan.

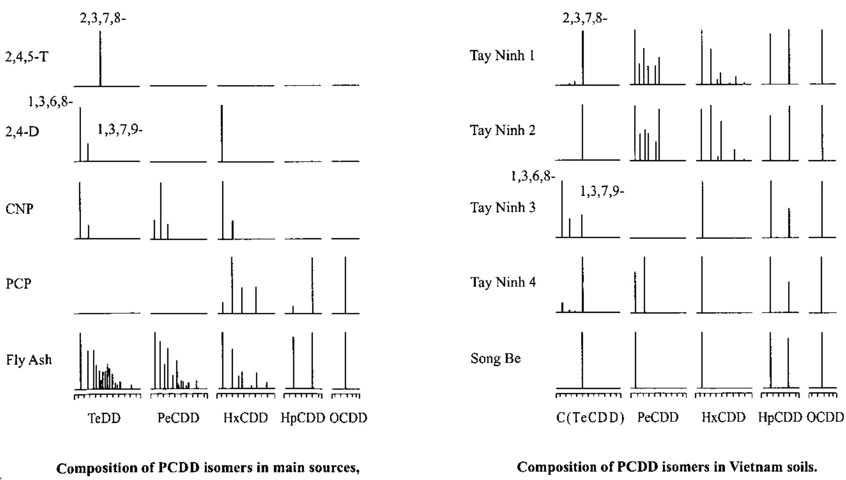

Fig 6.3 Composition of PCDD isomors in sources and soils

defoliants, but also from other sources, including close similarity to those from incinerator ash and fly ash. This indicates that the present dioxin pollution in Vietnam is a complex pollution not necessarily derived solely from herbicide and defoliants. A similar finding was observed when furan dioxins were taken as indicators and illustrates the same conclusion. Thus, we have concluded that Vietnamese soils at present are not heavily polluted by dioxins. Figure 6.4 shows

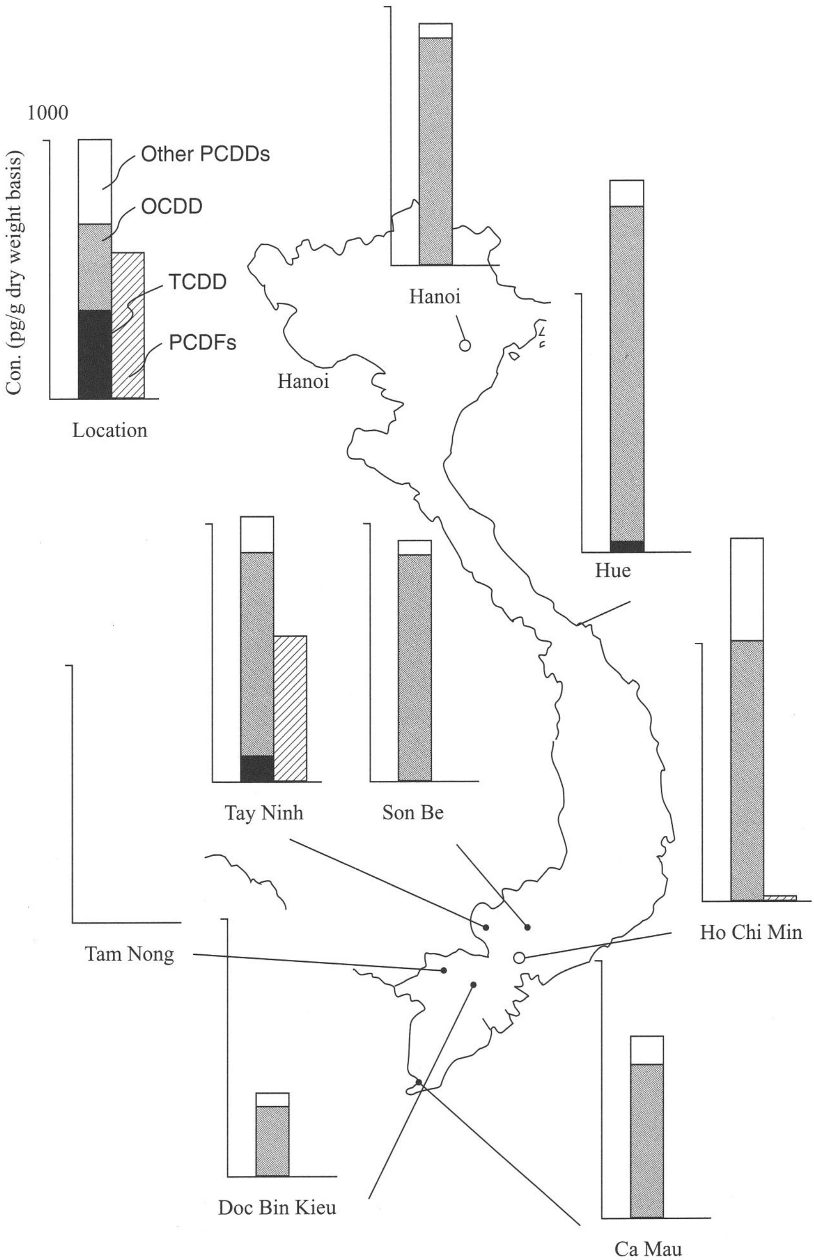

Fig 6.4 Levels of PCDDs and PCDFs in soil from Vietnam

the level and composition of dioxin isomers recovered from Vietnamese soils, which show almost identical concentrations as compared to Japanese soils.

Dioxins in Vietnamese fat tissues and breast milk

Although we have confirmed that dioxin soil pollution in Vietnam was not very high, this fact may not be relevant because there are abnormally high occurrences of reproductive abnormalities. Therefore, the next assumption to be considered was to determine if dioxins accumulated in the bodies of the human population. Accordingly, we collected 19 fat tissue samples and 16 samples of breast milk in Tay Ninh, where wide forest tracts were repeatedly sprayed with herbicides and defoliants. Table 6.3 shows the result of dioxin analysis of these samples.

The donors ranged in age from thirteen to forty-three for the fat tissue samples, and seventeen to thirty-seven for breast milk, all being native residents. 2,3,7,8-TCDD in fat tissue samples showed a concentration range from 1.3 to 18 pg/g, which is not an especially high accumulation. The composition of dioxin

Table 6.3 Levels (pg/g, fat basis) of PCDDs/DFs in human adipose tissue and breast milk from the south of Vietnam (Tay Ninh), 1991

	Adipose tissue		Breast milk	
Age	13~44	mean	17~37	mean
(n=)	19		16	
2378-TeCDD	1.3 – 18	4.3	<0.8 – 9.1	2.7
12378-PeCDD	<1.1 – 17	5.2	<0.5 – 9.7	4.1
123478-HxCDD	0.9 – 140	18	0.8 – 16	4.6
123678-HxCDD	< 1 – 57	11	<0.8 – 32	12
123789-HxCDD	< 1 – 53	8.2	<0.8 – 11	3.8
1234678-HpCDD	1 – 280	66	11 – 120	39
OCDD	20 – 500	180	120 – 220	190
2378-TeCDF	0.8 – 11	3.7	0.1 – 27	6.1
12378-PeCDF	2.0 – 121	5.1	1.8 – 13	5.4
23478-PeCDF	3.1 – 14	4.8	<0.5 – 46	7.4
123478-HxCDF	<0.8 – 44	8.0	<0.8 – 10	4.7
123678-HxCDF	<1.2 – 49	9.4	<0.8 – 12	4.6
123789-HxCDF	<0.8 – 21	4.4	<0.8 – 41	2.5
234678-HxCDF	< 1 – 50	8.9	<0.8 – 40	5.3
1234678-HpCDF	<1.6 – 420	46	<1 – 63	14
1234789-HpCDF	<0.2 – 28	3.9	<0.4 – 13	0.9
OCDF	<0.6 – 50	8.7	<0.9 – 5.2	2.8
PCDDs	76 – 680	290	15 – 300	77
PCDFs	18 – 710	100	3.2 – 152	50
TEQ	4.1 – 75	18	2.1 – 42	12

Table 6.4 Levels (ng/g, fat basis) of organochlorine compounds in human adipose tissue and breast tissue and breast milk from the south of Vietnam (Tay Ninh), 1991

	Adipose tissue		Breast milk	
Age	13~44	mean	17~37	mean
n	19		16	
p,p'-DDE	470 – 8200	3200	420 – 7600	3400
p,p'-DDT	100 – 2400	1700	13 – 3100	1400
p,p'-DDD	9.1 – 48	140	14 – 240	50
o,p'-DDE	<0.1 – 6.2	4.1	1 – 9.8	4.9
o,p'-DDT	5.6 – 630	180	26 – 340	130
o,p'-DDD	<0.1 – 34	3.4	<0.1 – 1	0.2
α-HCH	1.3 – 31	6.8	<0.1 – 0.5	0.3
β-HCH	1.1 – 400	42	17 – 330	140
γ-HCH	2.9 – 88	14	1.2 – 142	21
δ-HCH	<0.1 – 6	1.5	<0.1 – 14	12
PCBs	80 – 1200	310	90 – 630	300

isomers is similar with that of Japanese, showing the preferential presence of 2,3,7,8-TCDD. 2,3,7,8-TCSDD in Vietnamese breast milk ranged from 0.8 to 9.1 pg/g, which is not a high accumulation either. Accordingly, we concluded that the present abnormally high occurrences of reproductive abnormalities in Vietnam may not be due to the presently polluted environment, but may be due to past exposure to herbicides and defoliants used during the war from 1962 to 1972, which may have caused damage to reproductive systems and caused long-lasting after-effects such as molar pregnancy, fetal death, stillbirth, abortion and birth defects.

Table 6.4 shows the analytical results of the synthetic chemicals accumulated in fat tissues of the Vietnamese. An abnormally high accumulation of p,p'-DDE (dichloroethane derivative of DDT) and p,p'-DDT (dichlorodiphenyltrichloroethane) was found. The latter is the metabolic product of DDT and the former will dominate if DDT is stopped. The high accumulation of p,p'-DDT indicates the pollution by DDT is ongoing and sustained. This pollution may be associated with the present spraying of DDT for the prevention of malaria, as indicated by the high DDT concentration in the air of Ho Chi Minh City. The concentrations of HCHs (benzene hexachloride) in fat tissues are low, suggesting they are not the major chemicals applied to agricultural fields. Contamination with PCBs (polychlorinated biphenyl) seems to be low as well. This may be attributed to less use of PCB in Vietnam because it is not an industrialized country.

After-effects of dioxin pollution in Vietnam

High incidence of congenital anomalies

Through field surveys and laboratory analyses, we have confirmed that there is a higher incidence of reproductive abnormalities in the sprayed regions, even though the present environment is not particularly polluted with dioxins. The abnormalities are represented by birth defects such as hydrocephalic, anencephalic, deformities of the spinal column, conjoined twins, and also by abortion, premature birth, fetal death, bronchocele and others. A group of Japanese doctors made an epidemiological survey of three villages in South Vietnam and concluded that the high incidence of congenital anomalies in Vietnam seems to be strongly associated with the spraying of herbicides and defoliants and is still sustaining a high incidence of anomalies even one and half decades after the end of war. A part of the epidemiological survey was done independently by Tu Du Hospital of Ho Chi Minh City. The epidemiological survey made by the Japanese medical doctors used an intensive survey method in three villages of South Vietnam and may be the first one ever made in Vietnam (Yamamoto *et al.* 1993; Harada *et al.* 1993). The group chief, Dr. Harada Masazumi of the Department of Medicine at Kumamoto University, was relatively certain that the high incidence of the anomalies was strongly associated with dioxin after-effects, although he was reservedly cautious. Their survey report vividly conveys the great concern which swelled irreversibly in their fact-finding processes.

I attended the survey at one of the three villages, Doc Binh Kieu village in Dong Thap Province, in February 1989. I offer the survey report below.

The population of Doc Bin Kieu village is about 7,000. 292 people (172 female) from the village were examined, including all generations from babies to old people. The medical examination included touch and blood and urine checks. The incidence of congenital anomaly during the last three decades, as reported by the villagers, really shocked us. Among these people there were 92 multiparous women to whom 182 babies were born alive over the 30 years. The congenital anomaly was zero until 1970; this increased to 4 out of 61 births (6.6 %) in the period from 1971-75; to 13 out of 83 births (15.7 %) from 1976-80; to 18 out of 92 births (19.6 %) from 1981-85; and to the surprising rate of 15 out of 48 births (31.3 %) from 1986-88. This figure, 31.3 per cent, means that one baby out of three births was destined to have a congenital anomaly-a really incredible figure. The normal incidence is a few tenths per cent at the highest. Therefore, 31.3 per cent is alarming. Slowly and steadily during the period from 1970 to 1988, dioxins seem to have developed toxic and critical after-effects on the reproductive systems of these villagers. These figures were corroborated by the Vietnamese doctors whom we found to have a high credibility. Their medical knowledge and technology was high level, and their clinical judgment was demonstrated daily.

As the survey continued in Vietnam, many facts like those reported here were revealed. Even though there are no dioxins found in the environment of Vietnam now, I suspect that dioxin may still remain in the reproductive systems of the Vietnamese people. This hypothesis, however, has not been proved.

Hydatidiform mole and choriocarcinoma

Major conditions revealed by the Japanese doctors were the high incidence of hydatidiform mole and choriocarcinoma. Professor Takeuchi of the Department of Medicine of Teikyo University states in his report: 'Abnormal occurrences of hydatidiform mole in Vietnam is outstanding and it is to be noted that it transforms to choriocarcinoma with a high probability. In view of the fact that many patients suffering from choriocarcinoma lose their lives in spite of treatments taken by the medical staff, I am convinced of the urgent need for the cooperation of medical care and remedy'.

Hydatidiform mole is an anomaly which takes place on the villus during the embryonic process of a fertilezed ovum and is caused by the abnormal multiplication of the villus epicyte which ultimately transforms into a cyst-like block. The incidence is relatively high in Southeast Asia as well as in Japan and the occurrence in Japan is two to three per 1,000 births. The uterus after the pregnancy usually recovers rather smoothly, but ten per cent result in a secondary tumor where one to two per cent malignatize into choriocarcinoma.

Professor Takeuchi reports the data accumulated in Tu Du Obstetrical and Gynacological Hospital of Ho Chi Minh City. According to the data, hydatidiform mole cases show an incidence of 500 to 700 (35-50/1,000 births) per year, and the choriocarcinoma incidence was at 100 to 150 (5-10/1,000 births) per year. This data shows that ten to twenty per cent of the hydatidiform mole conditions transform into choriocarcinoma. Compared to data collected in Japan, the incidence of hydatidiform mole in the Vietnamese is twenty times higher, and ten times higher for choriocarcinoma. These figures are really abnormal.

Abortion, stillbirth and rate of birth defects

In this last section, I introduce the report made by 'the medical doctors group visiting Vietnam' headed by Dr. Harada of Department of Medicine at Kumamoto University.

The report is based on data that we obtained at the Tu Du Hospital in Ho Chi Minh City, which is the largest obstetrical hospital in South Vietnam. It has 750 beds and is staffed with 90 doctors and 400 nurses. It handles the parturition of

13,000 to 17,000 pregnant women, and performs 5,000 operations per year.

Abortion and stillbirth

The US Operation Ranch Hand began in 1961. The abortion rate immediately after was about 0.45-1.2 per cent, and then it showed a steady increase to 14.76 per cent in 1967, 13.91 per cent in 1971, and 20.26 per cent in 1976. The rate slightly decreased after 1979, yet remained around 10 per cent.

Stillbirth was 0.12-0.58 per cent before 1961, but it increased to 0.86 per cent in 1976, and to 1.62 per cent in 1977, and maintained this steady increase.

Birth defects

This hospital accommodated the famous Viet Duc twins, conjoined twins with one body and two heads. Similar twins account for four to five cases per year. Anencephalic and hydrocephalic births account for 21 to 26 (1.37-1.81 %) and five to 14 cases (0.3-0.83 %) per year, respectively. Other birth defects are also observed, such as twisted limbs and hands, loss of the ocular globe, cleft palate and cleft lip and others. All of these births were 2.32 % in 1952, then increased to 5.91 per cent in 1965, 4.19 per cent in 1967, and 10 per cent in 1979, and afterward increased gradually.

Concluding remarks

The results of our survey in the field and the laboratory led us to consider that the dioxins sprayed during Operation Ranch Hand disappeared rather swiftly from the immediate environs of the residents, whereas health abnormalities such as congenital anomaly and birth defects increased in large numbers and reached a peak in the 1980s, and still remain at high levels. We conclude these findings to be the after-effect of exposure to extraordinary levels of dioxin pollution. The exposure to dioxin mist at high concentrations caused anomalies in human tissues, and these anomalies have been sustained for a long period of time, over thirty years.

Many people dispute this research, by asking 'Who died because of the dioxin?' To this question we have responded by showing the high rate of birth defects, which mean high mortality for babies even if they were born alive. Moreover many women were killed by choriocarcinoma and related diseases. We have enough evidence, though indirect, to show dioxin is 'guilty'. What makes the situation obscure is that twenty years have elapsed between the cause and the result. Though death is long drawn out due to dioxin, it is still homicide. To prevent the further spreading of dioxin pollution, we need to understand the nature of dioxin toxicity through intensive surveys, and we need to collaborate to provide medical care for the victims.

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7

The Severe Impact of Herbicides on Mangroves in the Vietnam War and the Ecological Effects of Reforestation

PHAN Nguyen Hong

Mangroves form a rich and diversified ecosystem, which is, however, very fragile and prone to destruction due to natural and human impacts. Coastal dwellers in the Mekong Delta have, since ancient times, had a close relationship with the mangroves, which have not only been a source of food for them generation after generation, but also provide many other products, such as timber, charcoal, firewood and medicine. Mangrove forests also offer food, habitats and reproductive grounds for many terrestrial animals (including bird sanctuaries) and other valuable marine species, and are a convenient nursery for shrimp, crabs and fish. The mangrove forest plays a major role in creating the ecosystem, in trapping sediments and dispersing the energy of storms, tidal bores and winds.

During the wars against the French and American armies, mangroves in the south provided strong resistance bases for the Vietnamese people. Consequently, the American army used bombs, cannons, herbicides and defoliants in high concentrations to destroy these forests and the resistance bases they hid.

Such actions have caused huge damage to natural resources and the environment. When the forests were destroyed, animals died or had to move to other places, depriving local people of their daily livelihood. The loss of the mangroves meant not only the loss of a dense green wall protecting resistance bases, but also an increase in fallow land, and the erosion of river banks and the coast.

The impact of chemical warfare on the resources and environment of mangrove areas

Use of herbicides and defoliants to destroy the mangrove areas

Mangrove forests, with their dense root systems, made it difficult for big patrol ships or boats to pass by, and so were very useful as shelters for anti-American troops. During the Vietnam War, mangroves in the south were used to receive and store weapons brought from the north, and were therefore heavily targeted for destruction by the American army.

The United States used herbicides and defoliants (hereafter referred to as herbicides) to kill and defoliate mangrove vegetation. The main chemical agents used in this area were color coded as 'Orange', 'White' and 'Blue'. Agents Orange (1.124:1 mixture of 2,4,5-T and 2,4-D) and White (3.882:1 mixture of 2,4-D and picloram) were mixtures of compounds that interfered with the metabolism of the plants, thereby killing them, and were particularly damaging to dicotyledonous plants. Agent Blue (2.663:1 mixture of sodium dimethyl arsenate and dimethyl arsenic) was a desiccating compound that prevented plants from retaining any moisture, and was more effective against monocotyledonous plants (NAS 1974).

According to Ross (1975), mangroves were sprayed with Agent Purple (similar to Agent Orange) along Highway 15 from Bien Hoa to Phuoc Tuy in January and again in March 1962. Some areas along the coast of the Mekong Delta were sprayed in 1964 and 1965. Two areas heavily sprayed with herbicides from 1966 to 1970 were Rung Sat and the tip of Ca Mau Peninsula. The tapes of the herbicide data file (HERBS) for the years 1965 to 1970 show that a total of 299 missions were flown into the Rung Sat area with 927,116 gallons dispersed. From 1966 to 1970 the tip of Ca Mau Peninsula received 669,548 gallons of herbicides (Table 7.1) through 55 missions (Ross 1975). The number of defoliation missions over the mangroves rapidly increased from 1966 to 1969. In 1966, the mangroves in all of the provinces along the coast of the Mekong Delta were sprayed (Hong and San 1993).

Effects on human populations

Studies by Vietnamese and foreign scientists have provided information about the effects of dioxin contained in Agent Orange on the human population in mangrove areas. Such effects include mutagenic effects, obstetrical accidents and birth defects (Cau 1983). Increased levels of dioxin from Agent Orange have been found in many people in southern Vietnam, in wildlife such as snakes and turtles and in sediments from the bottom of rivers. Researchers believe that the increase in certain cancers and adverse reproductive outcomes, such as

Table 7.1 Quantities of herbicides sprayed by the American army on main mangrove areas (unit: gallon)

Province	Principal herbicide				Total
	Orange	White	Blue	Others	
Bac Lieu	98,818	21,098	5,675	55	125,646
Ben Tre	186,869	53,333		2,966	243,168
Ca Mau	448,396	197,621	22,138	1,385	669,548
Can Gio (Ho Chi Minh City, Dong Nai)	542,052	273,208	78,357	33389+ 110	927,116
Soc Trang	43,374	10,002	1,280	2,558	57,914
Tra Vinh	164,038	16,163	6,000	2,825	189,026

Source: Cl. Smith and Don Watkins (1981) (The VN Mapbook), a self-help guide to herbicide exposure, Winter Soldier Archive, Berkely, California US Army and Joint Service Environmental Support Group (Service Herbs Tape) P.Ross (1975).

congenital malformations, may be related to Agent Orange and dioxin.

Schecter (1991) noted that 'Vietnam is the only nation currently known to have large populations with both higher and lower levels of dioxins in [human body] tissues' as well as in human milk. The lower levels of dioxins in samples from northern Vietnam allows researchers to use them as a control group for conducting comparative studies into dioxin levels amongst populations in southern Vietnam where Agent Orange was sprayed. It has been found by Schecter and other researchers, that individuals exposed to dioxins have elevated levels of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) or 2,3,7,8-tetrabromodibenzo-p-dioxin (TBDD) for up to thirty-four years after exposure. Between 1961 and 1975, 10 per cent of the land area of southern Vietnam is believed to have been contaminated with about 170 kg of 2,3,7,8 TCDD.

The differences in dioxin levels found in people from northern to southern Vietnam indicate that 2,3,7,8 TCDD is environmentally persistent in southern Vietnam. Recent studies indicate a greater causal link between Agent Orange exposure and an increase in certain cancers caused by phenoxyherbicide exposure (Schecter 1991). Since fairly high levels of TCDD persist among the southern Vietnamese, there appears to be reason for concern that cancers and genetic malformations may continue to increase in the future. As Schecter *et al.* (1989) note, 'Vietnamese and Vietnam veteran populations may ultimately show an excess of cancers; the end of the usual latency period after exposure to chemical carcinogens is approaching'.

Areas of mangroves sprayed with herbicides during the war

It is estimated that before the Second Indochina War (1955-1975), mangrove forests in Vietnam covered an area of 480,580 ha (Moquillon 1950), 290,000 ha of which were found in the south (NAS 1974).

According to reports of the Committee on Impacts of Herbicides in Vietnam of the US National Academy of Science (NAS 1974), 104,939 ha or 36 per cent of mangrove forest in the south were sprayed by herbicides and defoliants.

After the liberation of southern Vietnam, the area of mangroves sprayed with herbicides in some typical districts has been calculated by Vietnamese scientists by using Landsat MSS 1973 photos and aerial photos, and comparing field survey data with archive documents. The results are as follows:

Rung Sat

Rung Sat was the name of a resistance base in a mangrove area in the south, which used to belong to the three provinces of Gia Dinh, Bien Hoa and Phuoc Tuy. In 1978, the government of Vietnam decided to transfer most of the land of Rung Sat (71,360 ha) to Ho Chi Minh City and establish Can Gio district. The remaining area belongs to Dong Nai Province. Rung Sat was the mangrove area that was sprayed earliest with herbicides (in 1962).

Based on the aerial photos of the World Wide Survey (WWS) of 1958 and aerial photos of 1972, the Committee on Impacts of Herbicides in Vietnam (NAS 1974), referred to above, prepared the following table to compare the percentages of land and vegetation sprayed and land and vegetation not sprayed with herbicides (Table 7.2).

The above data shows that of the total mangrove area of 53,913.6 ha in Rung Sat, 35,575.5 ha were sprayed with herbicides.

Cape Ca Mau

Cape Ca Mau was sprayed with herbicides later (1966-1970) but on a larger

Table 7.2 Comparison of percentages and areas of various types of land and vegetation in Rung Sat from 1958 (before herbicide spraying) to 1972 (after herbicide spraying)

Type of land	Area in 1958		Area sprayed		Area not sprayed	
	per cent	Area* (ha)	per cent	Area* (ha)	per cent	Area* (ha)
Mangroves	51.2	53,913.6	33.5	35,575.5	17.7	18,638.1
Previous cultivated land	6.3	6,633.9	2.6	2,737.8	3.7	3,896.1
Bush land and grass land	4.9	5,159.7	3.9	4,106.7	1.0	1,053.0
Cultivated land	7.9	8,318.7	0.8	842.4	7.1	7,476.3
Land without vegetation	5.4	5,686.2	3.3	3,474.9	2.1	2,211.3
Land planted with other trees	1.6	1,684.8	0.1	105.3	1.5	1,579.5
Water surface	22.7	23,903.1	13.1	13,794.3	9.6	10,108.8
Total	100.0	105,300.0	57.3	60,336.9	42.7	44,936.1

Note: * The areas above were calculated from percentages of the total area of Rung Sat (105,300 ha NAS, 1974) shown in the table.

Table 7.3 Areas of mangroves in Ca Mau before and after the spraying of herbicides

Year	Total area of mangrove land (ha)	per cent	Bare land before herbicide spraying (ha)	per cent	Area sprayed with herbicides (ha)	per cent	Area of remaining forests (ha)	per cent
1943	149,982	100						
1965	149,982	95.7*	6,449	4.3*	0		143,533*	
1973	149,982	100	6,449	4.3*	73,942	49.3*	69,591	46.4*

Note: * The percentage of area supplied by N.M.Cuong (1996).

Table 7.4 Area of mangroves sprayed with herbicides in main provinces of the Mekong Delta

Current name	Previous name	Area (ha)	Current name	Previous name	Area (ha)
Ben Tre	Kien Hoa	24,396	Tien Giang	Go Cong	804
Tra Vinh	Vinh Binh	17,664	Bac Lieu		1,120
Soc Trang	Ba Xuyen	1,921	Kien Giang	Kien Giang	5,549

scale. According to NAS (1974) and P. Ross (1975), 52 per cent of the mangrove area in Ca Mau was sprayed with herbicides. Based on UTM picture maps (1965) and Landsat MSS 1973 photos, Nguyen Manh Cuong (1996) calculated the percentage of remaining forests and forests destroyed by herbicides (Table 7.3).

Moquillon (1950) classified old forests in Ca Mau into eight sections with a total area of 149,982 ha, which were strictly controlled. I have used this total area as the standard area to calculate the area sprayed and the area of remaining forests (Table 7.3).

The data in Table 7.3 shows that the area of mangroves sprayed with herbicides in Ca Mau was 73,942 ha, accounting for 49.3 per cent of the total area.

Coastal areas of the Mekong Delta

According to the statistics of the Forest Inventory and Planning Institute (FIPI 1980) and the data of provincial forestry agencies, the areas sprayed with herbicides in coastal areas of the Mekong Delta are shown in Table 7.4.

Assessment of the quantities of timber lost during the war

The literature of foreign authors on the chemical warfare in southern Vietnam does not contain data on the loss of timber and other resources in mangrove areas.

Based on the survey data and calculation by FIPI (1984) of mangrove forests in the south, we calculated the quantity of timber and firewood lost immediately after the forests were killed.

Rhizophora apiculata and *Bruguiera parviflora* are two main wood species that have high economic value. However, other genera such as *Avicennia, Sonneratia* and *Lumnitzera* are of lower economic value. As a result, mangrove trees are divided into two groups: the *Rhizophora* group and other species group.

Rung Sat

According to V. V. Cuong, 1964, *Rhizophora apiculata* occupied 50 per cent of the total mangrove area in Rung Sat. Thus, the area of *Rhizophora* sprayed was 17,787 ha. Calculation by FIPI (1984) shows that the timber reserve of Rung Sat is 111.3 m^3/ha. The quantity of *Rhizophora* timber destroyed by herbicides was therefore:

113.3 $m^3 \times$ 17,787 ha = 1,979,693 m^3

The remaining 17,787 ha (50 per cent) consisted of lower value timber such as *Avicennia alba, A. officinalis, Xylocarpus granatum, Lumnitzera racemosa, Ceriops decandra, and C. tagal* and had lower reserves because most of the forests here are secondary forests. According to FIPI (1984), the reserves of these forests are 50 m^3/ha. The quantity of timber lost is thus:

50 $m^3 \times$ 17,787 ha = 889,350 m^3

Cape Ca Mau

Cape Ca Mau has the largest mangrove area and also the biggest mangrove trees, of which the highly valued *Rhizophora apiculata* and *Bruguiera parviflora* account for a large proportion. According to research results of FIPI in 1984, each hectare of mature *Rhizophora apiculata* with 305 trees of the average height of 26 m produces 349.88 m^3 of wood, which consists of 257.72 m^3 of logs, 37.21 m^3 of big poles and 3.22 m^3 of small poles and the remainder being used as firewood. Middle-aged Rhizophora forests (with 673 trees/ha and the average height of 22 m) have a productivity of 278.16 m^3 of wood. The mean productivity calculated from the average productivity of these two types of forests is shown in Table 7.5.

The immediate loss of wood in Ca Mau was more severe than in any other place. The quantity of wood lost on 73,942 ha sprayed was 19,979,867 m^3 (Table 7.5).

According to the data of B.Christensen (1978), the wood increment of *Rhizophora apiculata* forest in the south of Thailand is 20 ton/ha/year. Therefore, the additional losses of mangroves in Cape Ca Mau after the spraying of herbicides were very high. However, we cannot provide an accurate extrapolation, since growth rates in different areas are not the same and some

Table 7.5 Wood productivity of average forests in Ca Mau and damage of wood caused by herbicides (based on productivity data of FIPI, 1984)

Mean mature forest	Area (ha)	Product					
		Logs (m^3)	Big poles (m^3)	Small poles (m^3)	Total of timber (m^3)	Firewood (m^3)	Total (m^3)
Productivity	1	232.51	34.56	3.14	314.2	44.0	628.41
Quantity destroyed by herbicides	73,942	17,192,254	2,555,435	232,178	19,979,867	3,253,448	

forests have reached an age that is suitable for exploitation.

Coastal areas of the Mekong Delta

Before the war, coastal provinces of the Mekong Delta were poor, and without inland forests, the main source of fuel was wood from mangroves. Mangrove forests were heavily exploited due to lack of control, and in these areas the percentage of *Rhizophora apiculata* was low. The local forests comprised mainly other species such as *Avicennia alba, A.officinalis, Lumnitzera littorea, L.racemosa, Sonneratia alba, S.caseolaris, Bruguiera sexangula, Ceriops tagal and C.decandra* with reserves of approximately 60 m^3/ha (FIPI 1984). Our calculation of the total area sprayed with herbicides is 50,334 ha. Thus the quantity of wood destroyed was:

$60 \text{ m}^3 \times 50{,}334 \text{ ha} = 3{,}020{,}040 \text{ m}^3$

Assessment of changes in mangroves after the war

Impacts of herbicides on soil properties and consequent degradation

During the period of chemical warfare, many mangrove forests were killed. Formerly, most of these areas had been covered with naturally regenerated forests or replanted forests. Forest soil was changed due to the loss of vegetation, high temperature and the lack of rainwater in the dry season. The remaining areas have either been barren since chemical spraying, or were left fallow after local people used them for cultivation of agricultural crops for a certain period of time. If there is no investment to improve the soil, they cannot be used due to the formation of acid sulfate soil.

From analysed data of soil samples in natural forests not sprayed with herbicides, in regenerated forests and in fallow land after herbicide spraying (Hong 1983; Tuan and Hong 1990), the following remarks can be made on chemical properties.

(1) The pH KCl

This, in regenerated forest, is neutral, the same as in original forests. In fallow land or land which was left fallow after herbicide spraying, pH became lower (from 5.6 to 4.6), due to the fact that after the loss of forests, the soil does not receive sufficient fresh water in the dry season. In addition, the strong impact of light and high temperature speeds up the formation of pyrite (FeS_2), changing the soil into acid sulfate soil, and making it impossible for trees to grow.

(2) Exchange cations and soil solution

Avicennia alba and *Rhizophora apiculata* forests regenerated on land sprayed with herbicides; both have two cations of Fe^{3+} and Al^{3+}, though the quantity is small. In barren land caused by herbicides and land left fallow after a period of cultivation, the quantities of Fe^{3+} and Al^{3+} are fairly high.

The quantity of Ca^{2+} in original *Avicennia* and *Rhizophora* forest land is higher than that in regenerated forests. On the contrary, the quantity of Mg^{2+} in original forests is much lower than that of regenerated forests and fallow lands because the two latter types of land contain a huge quantity of dead leaves from trees that were killed.

Total content of dissolved salts and SO_4^{2-} and Cl in both natural forests and regenerated forests are lower than those in fallow lands because where there is no forest, evaporation is high, and salts in the soil increase in quantity and move gradually to the surface.

Mangrove forests in Cape Ca Mau were formed mainly from alluvia and detritus from the sea (alluvia of the Mekong Delta brought in mainly by the sea). As a result, the principal physical component is clay and the soil is rich in sulfur. At present, the formation of acid sulfate soil is continuing in fallow lands, which are not submerged by tidal waters, and if no improvements are carried out, these lands cannot be used.

Impact of chemical warfare on fauna resources

As mentioned above, mangroves form a diversified ecosystem, which is not only of economic value, but also contributes a great deal to the breeding of various fauna species and the protection of the environment.

After these forests were destroyed by herbicides, as in Can Gio (Ho Chi Minh City) and the Mekong Delta, terrestrial animals lost their habitat and feeding grounds and had to leave. Reptiles and mammals used to be abundant in both Rung Sat and Ca Mau. Some fishermen were even eaten by crocodiles when they went fishing on canals in Nam Can (Ca Mau), but after mangroves were destroyed by herbicides, species such as crocodiles and tigers became extinct. Monkeys, monitor lizards and birds, which used to be found in huge numbers in mangroves, also decreased gradually after the war (Hong 1997).

It was found that immediately after the defoliant spraying, fish, crustaceans, molluscs and other aquatic resources increased as mangrove leaves fell and decomposed, creating abundant food in the water. However, after three years, they decreased rapidly in number because no mangroves remained (Hong and Tri 1986; Hong and San 1993).

Impact of the loss of mangroves on coastal erosion

Erosion in Can Gio district after chemical warfare

Can Gio is influenced by an irregular semi-diurnal tidal regime with quite high amplitude. In the months with the highest amplitude (July, August and September), the amplitude in the south of the district is 3.6 to 4.1 m and in the north, 2.8 to 3.3 m (Thanh 1988).

In the past, the mangrove vegetation of *Avicennia alba*, *Sonneratia alba*, *Rhizophora apiculata* and nipa palm, with a dense system of roots above ground, reduced the impact of waves, as a result of which river banks were not eroded much. Every year, pioneer species gradually invaded rivers and created good coverage for the soil surface. After the loss of these forests, the soil was no longer protected, especially in the dry season with high tides and the strong northeast monsoon. Consequently, erosion has become more and more serious (Hong and San 1993). Analysis of aerial photos shows that the water surface area has increased. The percentage of the water surface was 22.70 per cent of the total area in 1958 (NAS 1974), but had increased to 30.56 per cent in 1978 (Department of Statistics, Ho Chi Minh City 1979).

Coastal erosion at Ca Mau Peninsula

The coast of Ca Mau Province connects the East Sea (South China Sea) and the Thailand Gulf. Under the influence of the tidal regime and the local current, the coast of Minh Hai is subject to both erosion and accumulation (a stretch of over 100 km from Ghenh Hao to Xom Mui suffering from serious erosion), the main reason being that the northeast monsoon causes big waves in the dry season, which coincides with the period of highest tides from the East Sea. The speed of erosion over the last thirty years has been twice as high as before that period, due largely to the fact that coastal protective forests have been destroyed by the war and other human activity. When motorboats go to and fro on the rivers and canals, they give rise to waves, which make the river banks crumble. Where forests were sprayed with herbicides, the erosion speed is twice or three times as much as that of forested areas.

Coastal erosion in the Mekong Delta

Like Cape Ca Mau, the coastal area of the Mekong Delta is affected by the semi-diurnal tidal regime of the East Sea with high tidal amplitude. Observations of tidal levels from 1985 to 1994 show that the highest and lowest tidal amplitudes at Vam Kinh Station (next to the coast) are 4.2 m and 3.88 m respectively, and 3.56m and 3.26m at My Tho Station (42 km from the coast) (SubFIPI 1995). This area is under the influence of three wave directions that coincide with prevailing northeast, east and southeast winds. The average wave height is 1.5 to 0.5 m, decreasing from the sea towards the coast. The current flows of branches of the Mekong River are all large.

The combination of the three factors above (tide, sea waves and current) is the main cause of coastal and river bank erosion in many places. When mangroves existed, the pace of erosion was low, but after these forests were killed, erosion occurred much more rapidly (SubFIPI 1995).

The total length of eroded coast and river banks in areas with mangroves in the Mekong Delta is 51 km out of a total of 200 km of coastline.

Restoration of mangroves affected by chemical warfare

Extent of reforested mangroves

Though American forces sprayed herbicides and defoliants and bombed at night, local people and the resistance forces in Cape Ca Mau voluntarily replanted mangroves to protect the resistance base. From 1965 to 1973, 10,315 ha were rehabilitated (Table 7.6) (Minh Hai Forestry Service 1981).

After the war, between 1975 and 1980, 46,210 ha of mangrove forests were replanted on the lands affected by herbicides in some southern provinces (Table 7.7).

However, due to bad management and the policy on the expansion of agricultural areas, a number of mangrove forests were destroyed for rice, corn and soybean production. Some years later, the land here became degraded and was abandoned. The conversion of mangrove forests, including rehabilitated and protected forests, to shrimp ponds between 1985 and 1994 led to a serious decline in mangrove area.

In Ho Chi Minh, the rehabilitation of mangroves was carried out later than

Table 7.6 The area of rehabilitated mangroves on the land sprayed with herbicides in Cape Ca Mau

Year	Area (ha)	Year	Area (ha)
1965	133	1970	1,426
1966	314	1971	422
1967	389	1972	2,785
1968	582	1973	800
1969	3,464		
		Total	10,315

Table 7.7 The area of rehabilitated mangrove on the land sprayed with wartime herbicides in some provinces of southern Vietnam

Province	Period	Extent (ha)	Sources
Ben Tre	1975-78	10,470	Ben Tre Forestry Service, 1981
Tra Vinh	1976-77	3,990	Tra Vinh Agricultural and Rural Development Service, 1996
Soc Trang	1976-77	1,750	Soc Trang Agricultural and Rural Development Service, 1996
Minh Hai (Ca Mau + Bac Lieu)	1975-78	25,900	Minh Hai Forestry Service, 1981
Dong Nai	1978-80	4,100	Dong Nai Forestry Service, 1981
Total		46,210	

other provinces. From 1978 to 1999, the replanted area was 21,427 ha (Tuan 2001). These forests have so far been well protected.

Cost of mangrove reforestation

Except for the 10,315 ha of mangroves voluntarily planted by local people from Cape Ca Mau during the war to protect resistance bases (from 1965 to 1969) (Minh Hai Forestry Service 1981), all other mangroves (*Rhizophora apiculata*) were replanted on land sprayed by herbicides after liberation, (1975) with funding from local and central budgets.

The cost for the planting of mangroves in different localities is not the same, being dependent on seed source, planting density, planting site, mortality rate of planted mangroves that then require gap filling, and soil type.

In Cape Ca Mau, propagules (seed source) of *Rhizophora apiculata* were collected from remaining stretches of mangroves, and were therefore cheaper. In other provinces, such as Ben Tre, Tra Vinh, Soc Trang and especially Dong Nai and Ho Chi Minh City, propagules were purchased from Ca Mau and transported by boats, and therefore cost more.

According to the Department of Science, Technology and Environment in the province of Ca Mau (2001), the average cost for planting and caring for 1 ha of *Rhizophora apiculata* was VNDong three million (US$200).

The total cost for replanting mangroves in Minh Hai (including Ca Mau and Bac Lieu) was US$200x25,900 ha=US$5,180,000. The Department of Agriculture and Rural Development of Ho Chi Minh City gives more details about this (Tuan 2001). Payments for planting, caring and protecting 1 ha of Rhizophora apiculata (at the spacing of 1m x 1m) in the first three years was VNDong 3,401,102 (US$242.9), so the total cost for planting mangroves in Rung Sat (Can Gio and Dong Nai) was: US$242.9 × 25,527 ha = US$6,200,500

Table 7.8 Cost for planting one hectare of Rhizophora apiculata in Ho Chi Minh City (Fixed Price in 1994 in VNDong)

Investment items	Unit	Volume	Unit price	Total
Propagule collection fee	kg/ha	300	700	210,000
Diesel for boating	l/ha	11	3500	38,500
Gasoline for boating	l/ha	0.33	9,000	2,970
Water supply	m^3/ha	3.73	20,000	74,600
Planting fee	workday	56.5	20,576	1,162,572
Preparation of site	workday	43	20,576	884,789
Designing	workday	45	40,000	40,000
Care and gap filling: year 1	workday	30	20,576	925,942
Care and gap filling: year 2	workday	19	20,576	617,295
Care and gap filling: year 3			20,576	390,953
Total				3,401,102

Note: US$1 = VNDong14,000
Source: L.D. Tuan 2001

Data for other provinces is not available. However, the cost of planting one hectare of *R.apiculata* in the Mekong River Delta is a little higher than that in the province of Ca Mau (and can be estimated at VNDong3,150,000 /ha = US$210).

The cost of planting mangroves on land sprayed with herbicides in some provinces of the Mekong River Delta, such as Ben Tre, Tra Vinh and Soc Trang is accordingly:

US$210 × 16,210 ha = US$3,404,100

The total cost for replanting mangroves in areas sprayed with herbicides is US$14,784,600.

Such money would otherwise have been used for infrastructure construction and improvement of local life in coastal areas after the war if the mangroves had not been lost.

Effects of mangrove reforestation: a case study in Can Gio District, Ho Chi Minh City

Can Gio mangrove forests have been successfully restored and conserved, and these efforts have been highly recompensed by the results achieved. On 21st January 2000, Can Gio was designated for inclusion in the World Network of Biosphere Reserves by the President of UNESCO Paris.

Flora

Compared to the flora investigated by Cuong (1964) before wartime herbicide spraying, the natural mangrove flora now is fairly similar, but individual numbers and distribution are not the same. There are 72 flora species reported, 30 of which are true mangroves and 42 associate mangrove species. Besides the mangrove flora, 95 species belonging to 42 families of inland plants dispersed by humans and animals have been found. These species form diverse communities on different biotopes (Hong *et.al.* 1996).

Vegetation

Today, the mangroves in Can Gio are more diverse in community structure than before the wars. An explanation for this is that in the Can Gio mangroves, replanted species mixed with naturally regenerated ones have been rehabilitated. Some are found naturally regenerating on abandoned shrimp ponds. The main communities are as follows (Hong 2000B):

Communities in areas of high salt concentrations

(1) Pioneer communities of *Sonneratia alba/ Avicennia alba* can be found on the coastal and estuarine newly accreted lands daily flooded by tides. The salinity here is high.

(2) Pioneer populations of *A. alba* are present on newly formed mud flats along rivers and creeks.

(3) *Rhizophora apiculata* and *Avicennia alba* communities are seen between replanted *R. apiculata* and populations of *A. alba* naturally regenerating on deep muddy soil.

(4) *R. apiculata* and *A.officinalis* communities are distributed on firm mud flats flooded by normal high tides. These two species are found naturally regenerating in groups with scattered *Ceriops decandra* and *A. alba.*

(5) Communities of *R. apiculata, Lumnitzera racemosa* and *Ceriops decandra* are found on firm mud flats flooded by spring tides. Only *R. apiculata* was planted between 1981 and 1985 and later on chopped down, leaving behind bare areas and naturally regenerated shrubs.

(6) Communities of planted *R.mucronata* and regenerated *Phoenix paludosa* and *Lumnitzera racemosa* grow on firm mud flats flooded by spring tides. Phoenix was burnt to spare land for *Rhizophora* planting. After that, the species vigorously regenerated from stumps in the rainy season.

(7) Communities of *Ceriops tagal and C. decandra* can be seen on sandy mud flats flooded by spring tides. The dominant species *C. tagal. R. apiculata* and *L. racemosa* are sparsely distributed.

(8) Communities of *Phoenix paludosa* and *Acrostichum aureum* are found on firm sandy clay flats only flooded by spring tides. Associate species are *L.racemosa, Excoecaria agallocha* and *Pluchea indica.*

(9) Populations of *Excoecaria agallocha* form on the firm sandy or loam flats.

(10) *Avicennia marina* populations regenerate on the high land of sandy clay or on the substrate of abandoned salt pans.
(11) Communities of *Sesuvium portulacastrum*, and *Paspalum vaginatum* are found on waste lands of firm sandy clay or former salt pans and shrimp ponds.

Brackish water communities
In general, brackish water communities at present are not very much different from those found prior to the wars. Some main communities are:
(1) Pioneer mixed communities of *Sonneratia caseolaris and Avicennia alba*
(2) Pure *Nypa fruticans* populations
(3) *Nypa fruticans, Acanthus ilicifolius and Cryptocoryne ciliata* communities
(4) *Sonneratia caseolaris and Nypa fruticans* communities
(5) *Annona glabra and Flagellaria indica* communities on land rarely flooded by tides.

Benthos
Mangrove rehabilitation has changed the soil's properties thanks to the sediments formed by litter fall with the help of large quantities of fine and fibrous root matter. The mud has the highest concentrations of organic carbon and nitrogen (Alongi and Sasekumar 1992). This has directly influenced the distribution of benthos. On the other hand, benthos play an important role in the decomposition of litter fall.

Through our preliminary surveys, 118 species of invertebrate macro-benthos have been listed. Polychaeta have 32 species of 18 families; Mollusca comprise Gastropoda class, with 15 species belonging to 8 families and Bivalve class with 17 species of 7 families. In the Crustacea class, 28 species belonging to 7 families of Macrura and 25 species in 4 families of Brachyura have been found (Mien *et al.* 1992; Hong *et al.* 1996; Nhuong 2000).

Fish
Fish use mangrove waters as nursery grounds, permanent habitats or breeding grounds (Aksornkoae 1993). 127 species belonging to 38 families have been found, the majority of them being true estuarine species and the remainder being eurythermal and euryhaline fish. Most species live in shallow waters and often enter estuaries for feeding (Mien *et al.* 1992; Hong *et al.* 1996; Lai 1997).

Amphibians
Since the local people carried out reforestation and excavated shrimp ponds in mangrove areas, the development of amphibian and reptile populations have

been facilitated. These fauna dig holes in the embankments of the ponds and come out to feed at night. Preliminary surveys show that there are nine species belonging to the four amphibian families. Tree frogs (*Racophorus leucomystax*) are commonly found, their loud croaks often able to be heard in the forests (Hong *et. al.* 1996; Dat 1997).

Reptiles

Of the 30 species of 14 families found in Can Gio, 8 species belong to the family Colubridae and 3 to Cheloniidae, the remainder being found only in large rivers and on the sea shore. The King cobra (*Ophiophagus hannah*) is distributed throughout the natural and replanted forests, while *Naja naja* is widely distributed in village gardens. A number of aquatic snakes, such as *Achrochordus javanicus, Lapenius hardwickii* and marine turtles such as *Chelonia mydas* and *Leidochelys olivacea* are caught on the sea shore in fishing nets (Dat 1997; Tri *et al.* 2000).

Birds

From 1975 to 1980, birds were very rare in the Can Gio mangrove areas, especially on the high land only flooded at high tide, as birds' dung was rarely seen on the ground or near tree bases.

Since the 1980s, more and more birds have come back to the area. Besides waterfowl, many flocks of migratory birds from the north such as *Charadrius alexandrinus, Pluvialis squatarola, Pluvialis fulva* and especially *Tringa glareola, T. erythropus* and *Himantopus himantopus* have been seen.

About 130 species of 44 families are known to occur in Can Gio. Of these, 49 species are waterfowl, including 22 migratory species. The rest are common in the delta and are seen in different habitats (Hong *et. al.* 1996; Dat 1997).

Birds play an important role in the ecosystem, contributing actively to the enrichment of the source of food in mangrove areas and making the soil fertile.

Mammals

Nineteen mammal species belonging to 13 families, including five species of chiropterans, have been recorded (Dat 1997). Among the terrestrial mammals, after mangrove restoration, the most numerous species is the macaque (*Macaca facicularis*). Since 1992 macaques have multiplied very rapidly, particularly in the forestry park. Groups of wild boar (*Sus scrofa*) are fairly abundant in the *P. paludosa* patches.

Sometimes local people see fishing cats (*Felis viverrina*) in the natural *Avicennia* forests. This species is well adapted to the tidal areas and feeds on fish, birds, bandicoot, oysters and other small animals (Hussain *et al.* 1994).

In the Mekong coastal area, many animal species have become endangered or threatened species as a result of mangrove habitat degradation, while the number of these species in Can Gio has increased (Table 7.9).

Supporting the development of coastal fishery and aquaculture

Rehabilitated mangroves in Can Gio are of significance to fisheries. Nutrients from mangrove detritus nourish plankton including crustaceans and fish larvae, which form the first link in coastal food chains including many species of commercial fish. Many large fish use mangroves as both a nursery area for juveniles and a feeding area for adults (Harty 1997).

Can Gio mangroves are also important to other marine fauna including shrimps, crabs and oysters. The lives of local inhabitants have been improved thanks to these resources.

Recently blood ark-shell and clam farming on the new sandy mud flats along the river and creek banks has become the principal income of many local dwellers.

Table 7.9 List of rare animals in Can Gio
(According to Red Data Book of Vietnam, 1992)

No.	Scientific name	Status	No.	Scientific name	St.	No.	Scientific name	St.
	Fish		11	*Ophiophagus hannals*	E	19	*Porjana paykullii*	R
1	*Elops saurus*	R	12	*Chelonia mydas*	E	20	*Tringa guttifer*	R
2	*Megalops cyprinoides*	R	13	*Erethmochelis imbricata*	E	21	*Sterna dougallii*	E
3	*Albula vulpes*	R	14	*Lepidochilus olivacea*	V	22	*Sterna sumatrana*	E
4	*Chanos chanos*	T	15	*Crocodylus porosus**	E		**Mammals**	
5	*Nematolosa nasus*	E		**Birds**		23	*Lutva lutva*	T
	Reptiles		16	*Pelecanus philippensis*	R	24	*Aonyx cinerea*	T
6	*Gekko gecko*	T	17	*Mycteria leucocephala*	R	25	*Felis viverrina*	R
7	*Varanus salvator*	V	18	*Mycteria cinerea*	V	26	*Felis bengalensis*	R
8	*Python molorus*	V						
9	*P. reticulates*	V						
10	*Bugaris fasciculatus*	T						

Note: E: Endangered, V: Vulnerable, R: Rare, T: Threatened
* In Can Gio Forest Park, thirty crocodiles have been reared in the mangrove area.

Table 7.10 Statistics of tourists in Can Gio Forest Park

Year	Number of tourists (person)	
	Domestic	Foreign
1996	3,644	no data
1997	26,999	221
1998	37,956	359
1999	42,004	232
2000	140,000	365
2001(Jan. - Jun.)	116,300	100

Ecotourism

From 1998 to 2001, eco-tourism in Can Gio has developed rapidly (Table 7.10). Recently, the troupes of macaques and captive-bred crocodiles, together with other wild mammals in the forest park, have attracted many tourists, especially children. The development of eco-tourism has been contributing to the socio-economic improvement of the local community. However some environmentally unaware tourists have thrown rubbish into the mangrove forest rivers, causing pollution. A large number of tourists will likely create a big demand for fresh marine products, giving rise to the risk that these valuable resources will be illegally overexploited in the Can Gio mangroves and adjacent areas.

To conserve the Mangrove Biosphere Reserve, the Ho Chi Minh City authority has decided to develop ecotourism only in the Can Gio Forest Park, an area of 2,214 ha, under Sai Gon Tourist Corporation's management. The forest park's staff are chiefly responsible for protecting and developing this forest so that it has the most typical features of a mangrove ecosystem, serving scientific research, sightseeing, study and ecotourism. Moreover, since this used to be the revolutionary base of Rung Sat's (mangrove forest) militia and people during the two resistance wars, it is of much value in educating future generations about history. Thanks to appropriate management, the harvesting of sea produce, which is often practiced too close to estuarine areas and mud flats, has been effectively prevented. The study of management and development of forest animal populations has also been carried out so as to implement rehabilitation programs for protecting animals, and at the same time to contribute to ecotourism activities in Can Gio Forest Park.

Enhancing environmental conditions

The rehabilitation of mangrove forests in Can Gio has resulted in certain changes in the environment and ecological processes. The organic debris produced by mangrove vegetation, together with the shelter provided by mangroves, improves local environmental conditions and promotes food chains, and spawning and nursery grounds for many vertebrates and fish.

Previously, the coastal area and river banks of Can Gio suffered from extensive erosion when the northeast monsoonal winds blew. As rehabilitation progressed, mud flats have been formed along the river banks and are subject to erosion by waves and tidal action. At the beginning of November 1997, an unusual storm hit the coastal zone of southern Vietnam and caused serious damage to many coastal provinces. Yet, the mangrove belt in Can Gio helped a lot in mitigating the loss resulting from the storm (Hong 2000b).

The rehabilitation of mangrove forests has brought about certain changes in the physical and chemical properties of soil in the area. The substrata has been gradually transformed into loam and the pH value subsequently increased, indicating a reduction in soil acidity.

Due to the development of mangrove pioneer species such as *Avicennia alba* and *Sonneratia ovata* and planted nipa palm, the erosion of river banks have been reduced; accretions have developed rapidly, creating large tidal sandy mud flats for benthos habitats and blood ark-shell and clam farming.

Mangrove rehabilitation, combined with water regulation of Tri An and Dau Tieng reservoirs, has contributed to reducing salt intrusion in the agricultural production areas of Can Gio and neighboring districts both in the rainy and dry seasons (Hong 2000a).

Rehabilitated mangroves also act as filtering systems, trapping sediments and preventing solid waste from Ho Chi Minh City discharging into the sea. In this way, mangroves assist in maintaining water quality by providing a natural safeguard against excessive water turbidity and nutrient enrichment which in turn leads to lowered production of phytoplankton (Harty 1997).

The large stretches of rehabilitated mangroves are important for cleaning the waters of the estuary and filtering air pollution. People of Ho Chi Minh City regard Can Gio mangroves as the kidneys and lungs of the city. Can Gio's mangroves have also been recognized as a Mangrove Biosphere Reserve in the UNESCO/MAB world network, a great honor and source of pride to the people of Ho Chi Minh City.

Conclusion

1) Approximately 150,000 ha of mature mangrove forests in the southern regions of Vietnam were destroyed. American wartime herbicide use on mangrove areas had a severe impact on natural resources and the

environment.

2) A large quantity of timber was lost, and biological resources were reduced; erosion along the river banks and coast was accelerated; fallow land became acid sulphate soil. The mangrove landscape was devastated.
3) A large amount of money (estimated at US$15 million) has been spent on mangrove restoration.
4) The rehabilitation of mangroves has ensured soil and water conservation, increase in biodiversity, the development of ecotourism and the raising of local living standards.
5) It is hoped that domestic agencies and international organizations will cooperate closely in the planning and implementation of further in-depth studies on the consequences of chemical warfare on mangrove forests.

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8

Wartime Herbicides in the Mekong Delta and their Implications for Post-War Wetland Conservation

TRAN Triet, J.A. Barzen, L.E., CONG Kiet, and D. Moore

Approach to the problem

During a period from 1961 to 1971, large quantities of herbicides were sprayed over South Vietnam by the army of the United States of America. In 1972-1974, the US National Academy of Science conducted an independent study to assess the level of damage caused by military-use herbicides in South Vietnam (Lang 1974). That study remains the most thorough study on the impacts of herbicides used during the Vietnam War. There are several other studies that address the issue (for example, Westing 1976, 1984; Cau *et al.* 1994; Hatfield Consultants 1998). There has not, however, been any attempt to assess the extent of herbicides used in the Mekong Delta region during the Vietnam War. The purposes of this investigation are to assess the magnitude of herbicides used for military purposes on the Mekong Delta, and evaluate the levels of herbicidal attack on different wetland environments existing in the Mekong Delta. For this study, the geographical area of the Mekong Delta is defined as the territory of Vietnam located south of the East Vam Co River.

The study area

The five-million hectare delta region of the Mekong River is an immense wetland system, supporting a wide diversity of wetland vegetation and wildlife, many species of which are threatened or endangered (Duc 1989; Dugan 1993; Buckton *et al.* 1999). However the delta is not only home to myriad plant and animal species, but also nourishes more than fifteen million Vietnamese people, making it one of the most populous rural areas of the world. In terms of its ecological significance, the Mekong Delta has been listed as one of the world's most important wetland systems (Dugan 1993).

Of the five million hectare land area of the Mekong Delta, 3.9 million ha are in Vietnam, the rest in Cambodia. Located in a region of monsoonal climate, the Mekong Delta has two distinct seasons: the dry season (December to April) and the rainy season (May to November). Mean annual precipitation ranges from 2,400 mm/year in the western part of the Delta, to 1,300 mm/year in the central and 1,600 mm/year in the eastern part (NEDECO 1993). Except for some small areas of limestone outcrops and low granitic mountains in the southwest, the Mekong Delta is a low, flat plain with an average elevation of 0.8-1 m above the mean sea level. There are three vast depressions: the Plain of Reeds, the Ha Tien Plain and the Ca Mau Peninsula.

Vegetation of the Mekong Delta wetlands exhibits a tremendous variation in floristic composition and structure: from the mangroves of coastal areas to inland freshwater marshes; from woody swamp forests to grasslands; from the aquatic vegetation of permanently inundated wetlands to the vegetation of seasonally flooded wetlands of various water depths and duration; from communities that are adapted to highly acidic soils to those adapted to nutritionally poor, sandy soils (Ngan *et al.* 1989; Ho *et al.* 1992; Kiet 1994). In general, the following main vegetation types can be distinguished: mangrove, swamp forests dominated by *Melaleuca cajuputi*, seasonally inundated grassland, and vegetation in permanent water bodies such as canals, streams and ponds (Triet 1999).

Within the developmental history of Vietnam, the Mekong Delta is a relatively newly developed region. Migration of settlers to the Delta first took place in earnest in the 17th and 18th centuries (Li 1998). At first, the economy was mainly subsistence; the market economy emerged by the mid-19th century when the area was a French colony (Brocheux 1995). The presence of a wet season, during which a large part of the Mekong Delta is inundated, hinders road construction, making waterways the most important means of transportation. Canal construction became a prerequisite for economic development in the Mekong Delta (NEDECO 1991; Brocheux 1995).

Herbicide use during the Vietnam War

An estimated 55 million kg of active herbicides ingredients were sprayed on South Vietnam by the US military during the period 1961 to 1971 (Westing 1984). The immediate damages caused by such a huge quantity of warfare chemicals on the native vegetation were insufficiently assessed (Lang 1974), and the long-term effects on the environment and on human life are inadequately documented (Hatfield Consultants 1998). The US military's herbicide spraying operation, codenamed 'Operation Ranch Hand', was carried out in an effort to

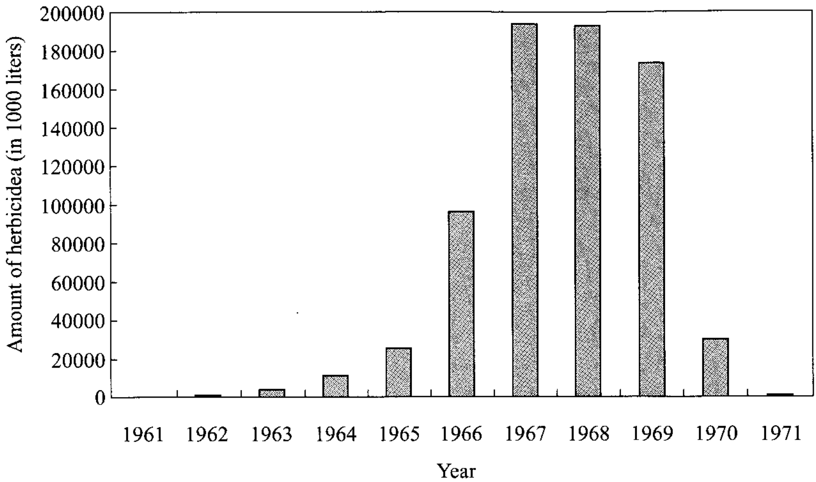

Fig 8.1 Amount of herbicides sprayed over South Vietnam (1961-1971)

deny concealment and, to a lesser extent, destroy the food supply of the resistance forces (Lang 1974; Buckingham 1982).

Operation Ranch Hand started on a small scale in 1961, reached its peak from 1967-1969, and was phased out during 1971 (Figure 8.1). It has been estimated that 83.7 per cent of the herbicides were sprayed on forests, 14.1 per cent on crops, and 2.2 per cent on miscellaneous woody vegetation (Westing 1976). The mangroves and inland forest were the two main targets of herbicidal attacks on forested lands (Lang 1974).

The three main types of herbicide used, Agent Blue, Agent Orange, and Agent White (see Table 8.1) comprised respectively 61.3 per cent, 27.4 per cent, and 11.3 per cent of the total volume of herbicides used in South Vietnam (Westing 1984). In addition, Agent Green, Agent Pink, and Agent Purple, all containing 2,4,5-T, were used experimentally, but not after 1965 (Hatfield Consultants 1998). Agent Orange and Agent White contain plant hormone-mimicking compounds that interfere with the normal metabolism of treated plants, whereas Agent Blue consists of a desiccating compound that prevents plants from retaining moisture (Westing 1976).

2,3,7,8-TCDD (tetrachlorodibenzo-para-dioxin), often referred to as dioxin, a byproduct arising in the manufacture of 2,4,5-T (Lang 1974) has been found to be teratogenic (fetus-deforming) and adversely affected the viability of laboratory animals (Nelson 1969; Courtney *et al.* 1970).

The sources of data for herbicide spray missions were made available to the public by the US Department of Defense in two separate databases: the HERBS

Table 8.1 Types and amounts of herbicides used for military purposes during the Vietnam War. Herbicide volume is given in cubic meters (1 m^3=1000 liters).

Type	Active chemical components [(a)]	Amounts used in the period 1961-1971 [(b)]	Amounts used in the period 1965-1971 [(c)]
Agent Blue	A 2.663:1 (by weight) mixture of Na dimethyl arsenate (Na cacodylate) and dimethyl arsenic acid (cacodylic acid)	8,182	4,240
Agent Orange	A 1.124:1 (by weight) mixture of 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) and 2,4 - dichlorophenoxyacetic acid (2,4-D)	44,338	42,472
Agent White	A 3.882:1 (by weight) mixture of 2,4 - dichlorophenoxyacetic acid (2,4-D) and 4-amino-3,5,6-trichloropicolinic acid (picloram)	19,835	19,835

(a), (b) source: Westing 1984

(c) source: Lang et al. 1974, amounts were converted from US gallons to liters (1 US gallon =3.7854 liter).

tape and the SERVICES HERBS tape (Black 1993). The HERBS tape listed a total of 6,542 missions conducted from August 1965 to February 1971 by fixed-wing aircraft (Lang 1974). The SERVICES HERBS tape provided similar information, with an addition of 2,389 missions performed mostly by helicopters and ground platforms such as boats or vehicles (Black 1993). Data from the HERBS tape represent approximately 92 per cent of the total amount of herbicides used, including 96 per cent of Agent Orange, 100 per cent of Agent White, and 52 per cent of Agent Blue (Westing 1976). Despite certain errors, the HERBS tape is considered to be a comprehensive and reliable inventory of herbicide sprayed for military purposes during the Vietnam war (Lang *et al.* 1974).

Materials and methods

Data from the HERBS tape, as provided by Smith and Watkins (1981), were used as the source of information about herbicide spray missions. Herbicide data were first entered into a spreadsheet database. An electronic map of the Mekong

Delta was prepared by scanning the Delta's topographic map (scale 1:250,000), which is an UTM (Universal Transverse Mercator) projection (Vietnam Mapping Agency 1980). Waypoints of each spray mission were connected by a solid line and displayed on the topographic map of the Delta to produce a map of herbicide spray missions.

Of particular interest are the estimates of the amounts of herbicides sprayed on mangroves, peat swamp forests, and inundated grasslands of the Mekong Delta. A simplified map of major wetland types of the Mekong Delta - with only four types: mangrove, *Melaleuca* peat swamp, grasslands and cultivated lands - was prepared by consulting the vegetation map of the Mekong Delta (Ngan *et al.* 1989) and the wetland map of the Mekong Delta (Nhan 1997). The map of the wetland environment was overlaid on the map of herbicide spray missions in order to obtain estimates of herbicide amounts applied on each type of wetland environment. Finally, a layer that shows the boundaries of nature conservation areas in the Mekong Delta (Vietnam National Environment Agency 2001) was overlaid on the herbicide map.

Results

Herbicide spraying missions over the Mekong Delta are presented in Figure 8.2. The total amount of herbicides sprayed on the Mekong Delta was 10.815 million liters, including 7.272 million liters of Agent Orange (67.2 per cent of the total amount), 3.228 million liters of Agent White (29.8 per cent), and 0.315 million liters of Agent Blue (3.0 per cent) (Table 8.2, Figure 8.3). The amount of herbicides used in the Mekong Delta constituted 16.3 per cent of the total amount of herbicides used in South Vietnam during the comparable period of 1965 to 1971. The mangroves received 6.369 million liters of herbicides (58.9 per cent of the total herbicides used in the Mekong Delta); *Melaleuca* peat swamp, grasslands and cultivated lands received 0.942 million liters (8.7 per cent), 1.695 million liters (15.7 per cent) and 1.809 million liters (16.7 per cent) respectively (Figure 8.4).

Mangroves of the Mekong Delta were heavily hit by herbicidal attacks, since spray missions covered almost all areas of the mangroves (Figure 8.2). Most areas of *Melaleuca* peat swamp in U Minh Ha (Lower U Minh) were covered by spray missions. U Minh Thuong (Upper U Minh) peat swamp, however, seemed to be intact, and very few spray missions were carried out in the grasslands of the Ha Tien Plain. The majority of herbicidal attacks on the Plain of Reeds took place in areas along the East and West Vam Co rivers, and the area in between the two rivers (Figure 8.2). These areas were covered mainly by woody riparian

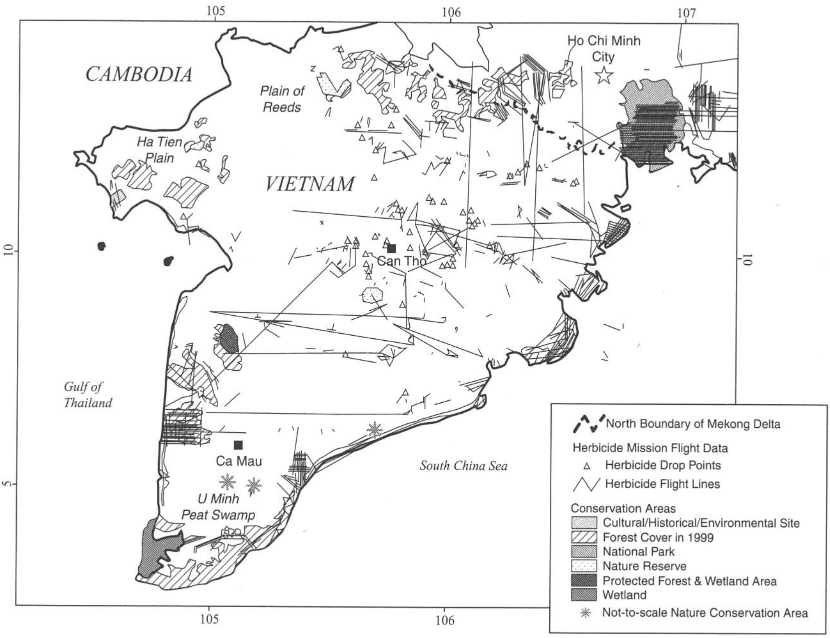

Fig 8.2 Map of herbicide spray missions over the Mekong Delta during the Vietnam War (1965-1971) and current conservation areas.

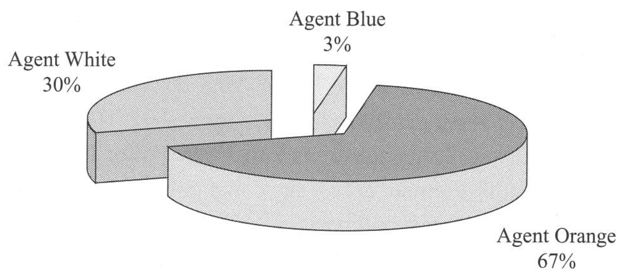

Fig 8.3 Proportions of Agent Blue, Agent White and Agent Orange sprayed over the Mekong Delta (1965-1971)

vegetation or by *Melaleuca* woodlands and *Melaleuca* scrubs (Ngan *et al.* 1989). Spray missions were scattered in cultivated lands. A closer look at the distribution of spray missions on the cultivated lands reveals that most of the missions were carried out along canals, which presumably functioned as lines of communication and transportation routes in wartime.

When the locations of current nature conservation areas were overlaid on the herbicide map, it became clear that some major protected areas of the Mekong Delta, such as Tram Chim National Park (Dong Thap Province), U Minh

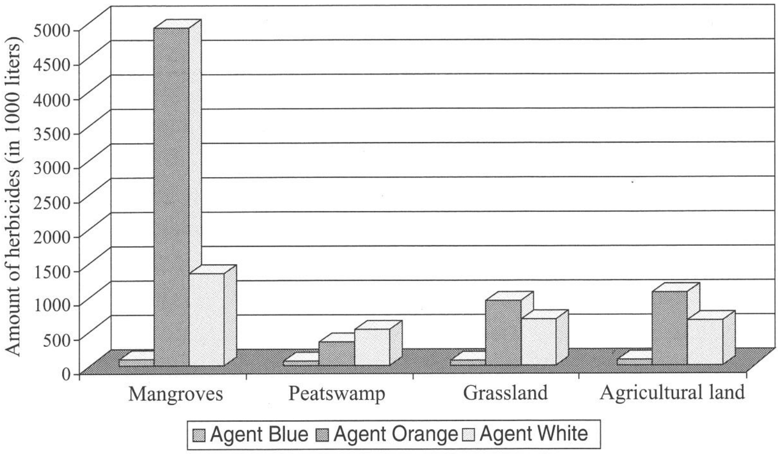

Fig 8.4 Types and amounts of herbicidcs sprayed on different wetland ecosystems of the Mekong Delta (1965-1971).

Thuong Nature Reserve (Kien Giang Province) and Nui Cam Nature Reserve (An Giang Province), were not affected by wartime herbicides. Conservation areas which were severely affected are those located in the mangrove zone, such as Dat Mui Nature Reserve (Ca Mau Province), Thanh Phu Nature Reserve (Ben Tre Province), and to a lesser extent the *Melaleuca* peat swamp forests of Vo Doi Nature Reserve (Ca Mau Province) and freshwater wetlands of Lang Sen Nature Reserve (Long An Province).

Discussion

In the Mekong Delta, the US military actively worked to eliminate tree cover capable of hiding combatants. The easiest way to accomplish this in wetlands of the Delta was to drain these wet areas and then burn them, but where drainage was not possible, vegetation was killed with herbicides. From the map, the ecosystems where herbicides were most heavily used were situated in the estuarine regions along the coast. Since these coastal wetlands are influenced by tides, it is difficult to drain them fully and burning is ineffective. Herbicides were considered the next best option, especially to remove trees. In contrast, vegetation in areas such as the Plain of Reeds or the Ha Tien Plain was not sprayed. Forests native to these areas were removed by draining wetland areas and burning off the vegetation during the dry season.

Herbicides were also used intensively along canals in more populated areas of the Delta. People tended to build homes on the dredge spoils of canals, as these dikes are often the highest points of land (4-6 m ASL is the average elevation in the Delta). Tree lines and other thick foliage often grew on the dredge spoils, creating conditions where boat traffic in the canals could be easily ambushed. Fire here was ineffective as well, and removal of this vegetation required the use of herbicides.

The source of herbicide data for this analysis is from the HERBS tape (Smith and Watkins 1981), which slightly underestimates the actual amount of herbicides used (Westing 1976). The boundary of the Mekong Delta defined by this analysis includes the area south of the East Vam Co River. The estimated 10.81 million liters of herbicides used in the Mekong Delta is higher than the 6.36 million liters estimated by Westing (1976) for the Military Region IV, one of the four military regions of South Vietnam. The Military Region IV encompasses the area of the Mekong Delta except for Long An Province, which was heavily sprayed during the war.

The initial map of spray missions showed that some mission records were apparently in error. Some plotted lines represented missions longer than 100 km, or represented missions being carried out over the ocean. These errors were believed to stem from mistakes in the identification of UTM quadrants (Lang 1974). There were 509 missions for which the coordinates of only one waypoint were provided. Displayed on the map as points, these 'one-point' missions recorded in the HERBS tape were considered to be errors in the recording of coordinates (Lang 1974). Similar types of errors in mission coordinates in the HERBS tape were also reported by Lang (1974, pp 3-5).

Among the four defined wetland environments, mangroves and *Melaleuca* peat swamp correspond closely to the actual mangrove and peat swamp areas of the Mekong Delta, whereas the grasslands and cultivated lands categories are somewhat arbitrary. The grasslands category includes most of the seasonally inundated grasslands of the Plain of Reeds and the Ha Tien Plain. This category, however, also contains cultivated lands and stands of *Melaleuca* woodland. The cultivated lands category consists mostly of paddy fields, upland crops, fruit gardens and some areas of *Melaleuca* woodland.

Woody mangroves are particularly sensitive to herbicides (Lang 1974). A single herbicidal attack was enough to essentially destroy the entire plant community of a targeted mangrove area (Ross 1974; Sylva and Michel 1974). Species of the genus *Rhizophora* (Rhizophoraceae), including many commercially valuable woody mangroves, are especially sensitive; the genus *Avicenia* (Verbenaceae) is somewhat more tolerant to herbicidal attacks (Snedaker 1984). The disruption of vegetative cover following herbicidal attacks badly affected the highly diverse mangrove fauna, both aquatic and avifauna, which depend upon the vegetative cover for food and shelter (Westing 1976). In denuded mangrove areas, soil erosion was accelerated (Weatherspoon and Krusinger 1974), and soil fertility deteriorated (Snedaker 1984).

Regeneration of the vegetative cover in many herbicide-affected mangrove areas was dominated by 'weed' species such as the fern *Acrostichum aureum* (Pteridoideae), the palm *Phoenix paludosa* (Palmae), and the fast growing pioneer tree *Excoecaria agallocha* (Euphorbiaceae) (Lang 1974; Snedaker 1984). Hong (1984), in a detailed study of the natural regeneration of mangroves in Ca Mau Tip (the southernmost part of the Mekong Delta), reported five plant communities occurring in areas that had been sprayed: *Phoenix paludosa, Avicennia alba, Rhizophora apiculata, Ceriops decandra and Excoecaria agallocha.* These dominant plant communities indicated a significant change in mangrove species composition as compared to the pre-disturbance one (Hong 1984). Fast growing species such as *Acrostichum aureum*, *Phoenix paludosa* and *Excoecaria agallocha* often formed extensive dense stands, preventing the colonization of other woody plants. Hong (1984) also reported the decrease of mangrove forests dominated by *Bruguiera parviflora* and *Bruguiera gymnorrhiza* in Ca Mau fifteen years after the war. Tung (2000) reported a decline in the abundance of *Rhizophora mucronata* in Can Gio mangrove forest, south of Ho Chi Minh City - an area that was most heavily affected by herbicide spraying. Natural regeneration, therefore, may not be successful in re-establishing the pre-disturbance species composition of mangrove forests (Hiep 1984; Hong 1984; Snedaker 1984).

Post-war mangrove reforestation in the Mekong Delta was characterized by the selective planting of tree species having high commercial value, especially for timber production. *Rhizophora apiculata* is the species that was most often chosen for mangrove reforestation in the Mekong Delta. Experiments have been carried out to determine suitable methods for replanting other tree species, such as *Thespesia populnea, Sonneratia caseolaris, Xylocarpus granatum, and Xylocarpus mekongensis* (Nam and Thao 2000; Buu and Phuong 2000).

In the study by the US Academy of Science (Lang 1974), impacts of herbicides on *Melaleuca* peat swamp of the Mekong Delta were not assessed due to security reasons. The effects of herbicidal attacks on *Melaleuca* peat swamp are still the least known among the impacts suffered by forested ecosystems sprayed with wartime herbicides. The assessment of herbicidal impacts on species diversity is hindered by the lack of good documentation of pre-disturbance species composition of mixed peat swamp forests of the Mekong Delta. Ngan and Hien (1987) noted the disappearance of two rare epiphytic orchids (*Dendrobium crumenatum* and *Oberonia* sp.) that were recorded for peat swamp forest of U Minh Ha (Lower U Minh) in pre-war times. However, no evidence of the direct causal relationship between herbicide spraying and the decrease of species diversity was established.

The impacts of herbicides on cultivated lands were difficult to assess (Lang 1974). Even though only a small number of spray missions were officially classified as crop destruction (only four crop destruction missions were designated for the Mekong Delta), many defoliating missions actually targeted cultivated lands. For all of South Vietnam, Lang (1974) estimated that officially classified crop destruction missions accounted for about 16 per cent of the permanently cultivated land area that was sprayed with herbicides.

The persistence of herbicides in the environment should be considered when assessing the impacts of their military use. Westing (1984) reported that levels were of 'environmental insignificance', a measure of herbicide persistence determined by the lack of obvious effect of major herbicidal ingredients used in the Vietnam War on all but the most highly sensitive of planted test species. For 2,4-D, the level of environmental insignificance is reached within a month; for 2,4,5-T, within five months or so; for picloram, within eighteen months; and for cacodylic acid, after about a week. Dioxin, a contaminant of the 2,4,5-T in Agent Orange, is significantly more persistent than Agent Orange itself, and is reported to have an environmental half-life of 3.5 years (Westing 1984).

During 1994-1998, Hatfield Consultants, a Canadian environmental consulting firm, conducted a comprehensive study on dioxin contamination in A Luoi Valley, an area located in central Vietnam that was heavily sprayed with herbicides during the war (Hatfield Consultants 1998). The study found that more than thirty years after the war, some areas in A Luoi Valley are still contaminated by dioxin to such a level that they would be declared 'contaminated sites' according to most Western standards. Residues of dioxin were found in former US airbases, in farmers' fields, in fishpond sediments, in cultured fish, in ducks, and in human blood. The study also found evidence of the accumulation of dioxin in the food chain, leading to significant human exposure and intake.

In conclusion, the environmental impacts of herbicides use during the Vietnam War in the Mekong Delta were severe. The impacts were, however, different for different wetland environments. Among the four major wetland environments of the Mekong Delta, mangroves were most heavily affected by wartime herbicides. Natural regeneration in mangrove areas affected by herbicides failed to re-establish the pre-disturbance species composition and forest structure. Post-war reforestation concentrated mostly on species of high commercial values, such as *Rhizophora apiculata*. The assessment of changes in peat swamp forests was hindered by the lack of information about the pre-disturbance forest constitution. More efforts should be made: first, to systematically document the status of rare and minor species in mangrove and peat swamp forests of the Mekong Delta that were affected by wartime herbicides; and then to reintroduce those that have been under-represented. These tasks are seriously hampered by the fact that the remaining mangroves and peat swamp forests of the Mekong Delta are being converted to agricultural and aquacultural lands at a very fast pace.

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9
Agent Orange in the Vietnam War: Consequences and Measures for Overcoming it

LE Ke Son

During the Second Indochina War, in addition to conventional weapons, the American military forces also used several toxic chemicals to spray large areas of the southern regions of Vietnam, as well as parts of Laos and Cambodia.

The chemical warfare lasted a full decade, from 1961 to 1971. Although many kinds of chemical substances were used, today, almost thirty years after the end of the use of chemicals, it is the use of herbicides and defoliants that continues to capture public attention. Most noteworthy among these is Agent Orange and its contaminant, dioxin, a chemical that is extremely toxic to the environment and to human health.

A large number of findings have been collected on dioxin's effects on human bodies and natural environments. The task has been born primarily by Vietnamese people, and also collaborated by many foreign researchers. I would like to offer a brief overview on the topic.

The Toxicity of Dioxin

As described in the preceding four chapters, dioxin became a focus of attention because it is the most toxic of all the chemicals human beings have synthesized thus far. The quantity necessary to kill 50 per cent of the laboratory animals (LD50) in a given experiment is measured in micrograms (a millionth of a gram per kilogram of body weight). Small quantities at nanogram (a billionth of a gram) levels per kilogram of weight are sufficient to cause birth complications (miscarriages, premature births and monstrous deformities). Long-term exposure to small amounts causes cancer in laboratory animals.

On the assumption of dioxin's half-life to be 3 to 3.5 years, Westing (1984) calculated the long-term effects of chemical warfare in Vietnam as follows, 'Given an estimated 170 kg of dioxin dropped on Vietnam, then by 1990 there should be still one kilogram in the environment.' However, more recent researches, as exemplified by Chapter 5 and 6 of this volume, seem to indicate that the half-life of dioxin is not 3 or 3.5 years, but much longer. Herbicides persist for a few days to a few weeks, while dioxin remains in the environment for several decades. Today, nearly thirty years after the end of the war, after all the herbicides have disintegrated, it is suspected that dioxin remains in nature and/or in the bodies of human beings (though supposed to be mostly diminished compared to the time of primary spraying). It is precisely this stability of dioxin, particularly of 2,3,7,8-TCDD, that makes it useful for researching the effects of Agent Orange. Dioxin can be called 'the fingerprint' or 'the evidence' left from the use of Agent Orange during the war. Dioxin persists even longer in the mud of rivers and lakes, and soil and mud could rightly be called the storehouses of dioxin.

To test for dioxin in nature (and more generally, for all PCDD/F and PCB chemicals), it is possible to measure air, water, soil, river mud, and the output of the drain-pipes from factories. But it is soil and mud that contain the highest concentrations of dioxin, as a result of which they are often used to measure dioxin pollution in the environment. From the soil and mud, dioxin enters shrimp and fish, especially the fish that live in the deepest levels of lakes and rivers, or in the mud, such as catfish, eels, and mollusks (clams, snails and mussels). Dioxin concentrates in the fat of such fauna, and Canadian scientists have shown that heavy concentrations of dioxin are found in crabs, especially in the fat inside the crabshell (Hatfield Consultants 1998).

It is important to note, however, that many researches in various countries have shown that adverse effects of dioxin in the soil on plant growth is mitigated rather swiftly. Such crops as rice, corn, potatoes, cassava and fruit trees, even when planted in soils containing dioxin, appear not to absorb dioxin in critical amounts after a few years. It is also important to note that while dioxin is not to be found in grains, cereals, fruits and vegetables, soil particles polluted with dioxin tend to cling to the plant, grass or farm products, and if farm products are not washed, then dioxin will enter the body of the animals and the people who eat these farm products and animals.

The Effects of Chemical Warfare on Nature and the Environment

In the southern regions of Vietnam (from the 17th Parallel to Cape Ca Mau) before the war, the land was covered by 5,800,000 ha of evergreen forests, 500,000 ha mangrove forests, 100,000 ha of rubber trees and 3,000,000 ha of farmland. Forests made up 60 per cent of the total area, agricultural lands 17 per cent, and rubber plantations 0.6 per cent.

According to Forestry Inventory and Planning (FIPI) statistics, the total area of forests sprayed was 3,104,000 ha, or 17.8 per cent of the total forested area. Inland forests made up 95 per cent of the forests sprayed, and mangrove forests 5 per cent.

The destruction of several million hectares of forests caused a loss of ecological equilibrium. There was great loss of wood, wild life and of forest products. The loss of the seed source for forest trees created difficulties for reforestation. The function of forest protecting and enriching the soil nutrients was lost. The loss of the capacity to retain surface water not only caused flash-flooding in the rainy season and drought in the dry season, but also damaged agricultural production. Flash-floods caused erosion, washed away rich topsoil, and left the soil poor, exhausted and lateritized, creating further difficulties for reforestation.

While certain valuable animals were destroyed, at the same time certain pests flourished. For example, there was a great increase in crop-destroying mice, which might account for the incidence of plague on some of the battlefields in the central highlands. Mosquitos flourished as well, greatly increasing the danger of malaria and hemorrhagic fever.

Analysing the amount of dioxin remaining in the environment and the human body is important for studying the consequences of chemical warfare in general and the consequences of the use of Agent Orange in particular, for several reasons.

First, dioxin persists over time, while herbicides disintegrate quickly after they enter the environment. Thus, if contamination from other industrial sources is excluded, the presence of dioxin in the environment and the human body constitutes objective evidence of exposure to Agent Orange during the war.

Dioxin analysis also helps determine those regions still contaminated by dioxin, contributing to a basis for clean-up and protective measures for people and other organisms in the region. Moreover, such analysis is an objective indicator that can be used to evaluate the effectiveness of environmental detoxification and preventive treatment.

Worldwide there are roughly a dozen laboratories recognized as meeting international standards for valid dioxin analysis, a very sophisticated form of analysis that requires modern equipment. The cost of analysis for each sample is from US$1000 to US$3000, so that extensive analyses are not easy. In the past years, through international cooperation, we have obtained analytical data on roughly 4000 samples of all kinds including soil, river mud, food and human tissues.

The following laboratories have participated in testing samples from Vietnam for dioxin: the Center for GC/MS Analysis at the University of Nebraska, USA; Laboratory of Environmental Toxicology, Amsterdam University, Holland; the Center for Chemistry, Helsinki University, Finland; Department of Chemistry, Munster, Federal Republic of Germany; the Center for Chemical Analysis of Food, Ottawa, Canada; Ehime University, Japan; ERGO, Hamburg, Federal Republic of Germany.

Results of dioxin analysis of soil and river mud

Since 1980, many samples of soil and river mud from different regions have been analysed, and major results were presented in First and Second International Conference in Hanoi .

Results by Schecter *et al* (1989) and Matusda *et al* (1994) have indicated that out of 121 soil samples and eight samples of river mud taken from nine regions and three different rivers in the south of Vietnam, there were twenty-five samples that still showed dioxin as of 1990, but most of these at levels that were not exceptionally high (30-40 ppt; the highest level was 59 ppt) to warrant clean-up (based on international standards of 1 ppb, or 1000 ppt). In the mud of some large rivers, such as the Dong Nai River, which crosses the town of Tan Uyen, dioxin is no longer found. But in the mud sample of a branch of the Sai Gon River, there is still a great concentration (210 ppt).

However, it is important to note that certain limited areas are still highly contaminated by dioxin: former airfields, wharves, storage areas and the places where Agent Orange was loaded into planes before spraying missions. These are the 'hot spots' that may still be heavily contaminated by dioxin. We have not yet been able to do much research in these hot spots.

The phenomenon of the relatively rapid disappearance of dioxin from the environment may be explained by certain special conditions of weather and geography in the south, and by the tropical climate. The south experiences months of blistering sun followed by a rainy season with torrential rains and sudden floods, compounded by the geography and the topography of the south, which generally slopes from the Truong Son Mountains to the Eastern Sea. In addition to that, in the coastal area, a tidal range of up to 7 m with effects up to 60-70 km inland, may contribute to the rapid dispersal of dioxin out to sea.

Results of dioxin analysis of foodstuffs

During the war (in 1973), a group of Harvard scientists took samples of fish and shrimp from the Sai Gon and Dong Nai Rivers and from the seashore at Can Gio. The analytical result, as cited by Dai, L.C. (2000: 101), are shown in Table 9.1.

The table shows that in 1973, when the chemical war had just ended, there was a high concentration of dioxin in fresh and salt water products in Vietnam, ranging from 18 ppt to 814 ppt, with an average of 297 ppt. From 1986 to 1990, nearly 100 samples of all kinds of foodstuffs were analysed.

The comparison between the two periods is made visible in Figure 9.1. It is clear that in 1973 when the chemical war had just ended, the foodstuffs in the south were heavily contaminated with dioxin. The quantity of dioxin ingested

Table 9.1 Results of dioxin analysis in the food supplies of Vietnam (1973) (cited from Dai, L.C. 2000)

Sampling place	Kind of sample	Dioxin analysis result (ppt-wet weight)
Dong Nai River	snake	540
(north of Bien Hoa)	catfish	814
	catfish	522
Sai Gon River	catfish	70
(north of Sai Gon)	shrimp (river)	42
Can Gio seacoast	frog	79
	shrimp (ocean)	18

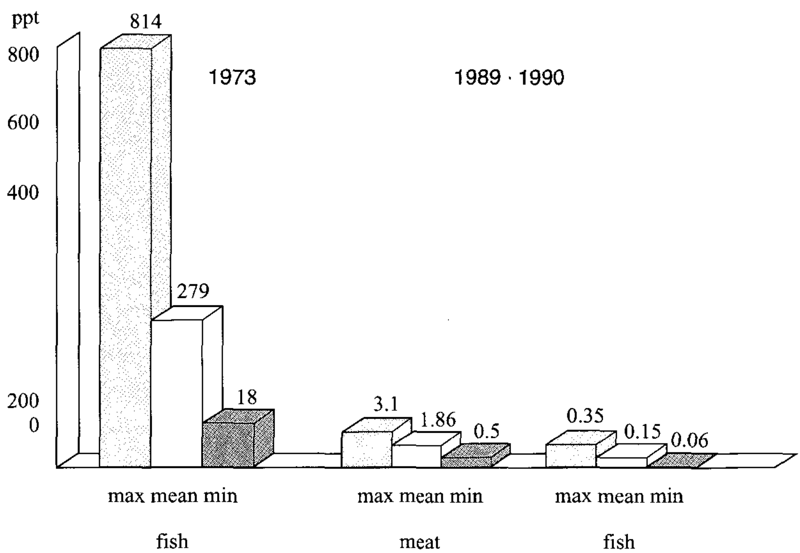

Fig 9.1 TCDD levels in food from Vietnam

Table 9.2 Dioxin daily intake

WHO guideline	Vietnam (1973)	Vietnam (1986-1990)
500pg/person/day	19,990-117,830 pg/person/day	51.9-14.15 pg/person/day
	from 40 to 235 times WHO guideline	1/10-1/30 times WHO guideline

(pg per person per day)

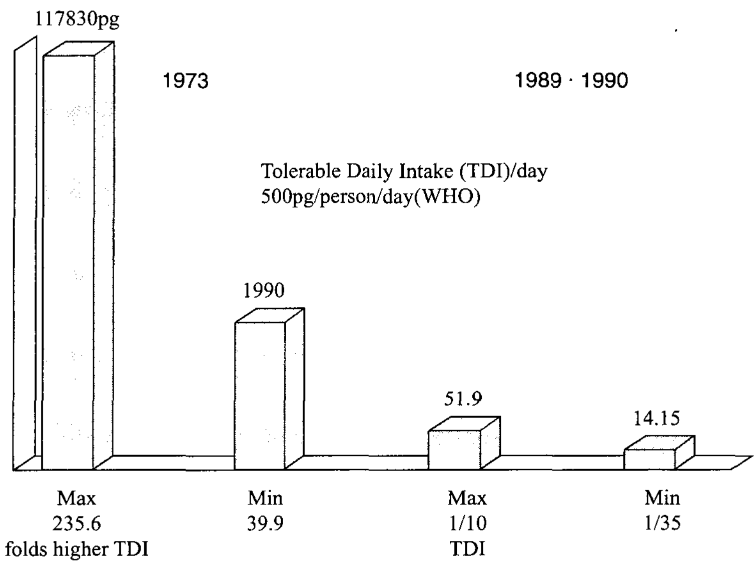

Fig 9.2 Daily intake of dioxin from foodstuffs

daily was from 40 to 235 times the warning level set by the World Health Organization (see Table 9.2). However, according to studies done in 1986 and repeatedly later, the quantity of dioxin has greatly decreased and is now at normal levels. The daily intake as shown in Table 9.2 (according to a study by the Nutritional Institute of the Ministry of Health) has decreased to between 1/10 and 1/35 of the critical level set by the WHO (see Figure 9.2). Yet, several data indicate that the concentration of dioxin in the foodstuffs of the north and the south differs considerably, and that it is still much less in the north where spraying was not done.

Dioxin levels in human tissue

Not until 1984 did we have adequate conditions to conduct systematic tests for dioxins in human tissue (fat, blood and breast milk) taken from people living in sprayed areas and non-sprayed areas. The first study was performed in 1984 and 1985, when seventeen pooled samples of human fat tissue were taken surgically, from thirty-five donors in hospitals of northern Vietnam and 114 donors from southern Vietnam. Only 12 per cent of the samples taken in northern Vietnam, which were not affected by chemicals, tested positive for dioxins with average concentration of 1.7 ppt., while as many as 83.3 per cent of the samples taken in southern Vietnam, where chemical spraying operations took place, showed positive for dioxins. The average concentration was as high as 17 ppt (Dai, L.C. 2000: 114-5). Researches by Schecter, A. et al (1992), Phiet, P.H. et al (1994), and Matsuda, M. et al (1994) have contributed to these findings.

Thus, the dioxin level in fat tissue of people living in sprayed areas in southern Vietnam is higher than that of people living in non-sprayed areas. Dioxin levels in sprayed areas of southern Vietnam were ten times higher than those in northern Vietnam and two or three times higher than in industrialized countries.

During the Second Indochina War, many young northerners including soldiers, volunteers and administrative officials participated in the war in the south

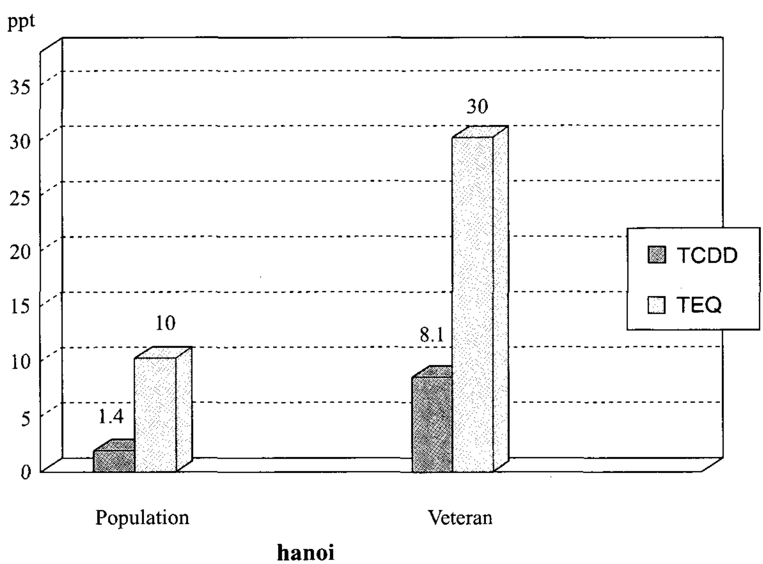

Fig 9.3 Dioxin levels in fat tissue in northern general population and northern Vietnam veteran

and were also exposed to herbicides. Tests for dioxins in fat tissue and blood were conducted among ex-soldiers in an attempt to study the long lasting effects of the chemicals. Results of these tests, shown in Figure 9.3, indicate that the dioxin burden of ex-soldiers who were in the southern battlefields is much higher than that of people who lived permanently in the north.

Dioxin level in breast milk and blood

Breast milk taken from nursing mothers living in sprayed areas (Tan Uyen in Song Be Province and Can Gio District of Sai Gon in southern Vietnam) was tested for dioxins for the first time in 1970 by scientists from Harvard

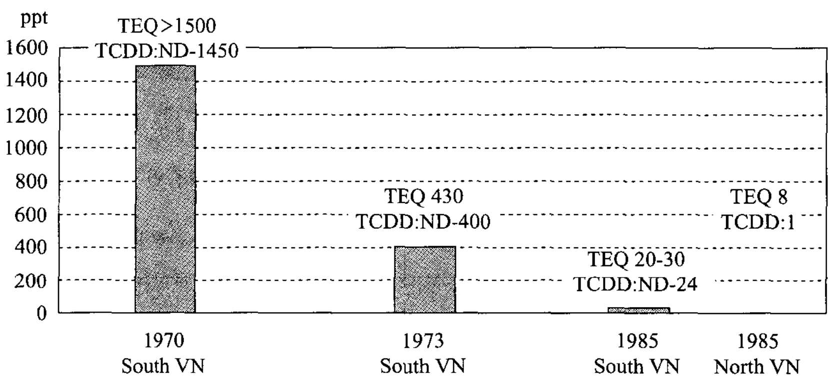

Fig 9.4 TCDD-equivalents in milk, Vietnam (1972-85), ppt

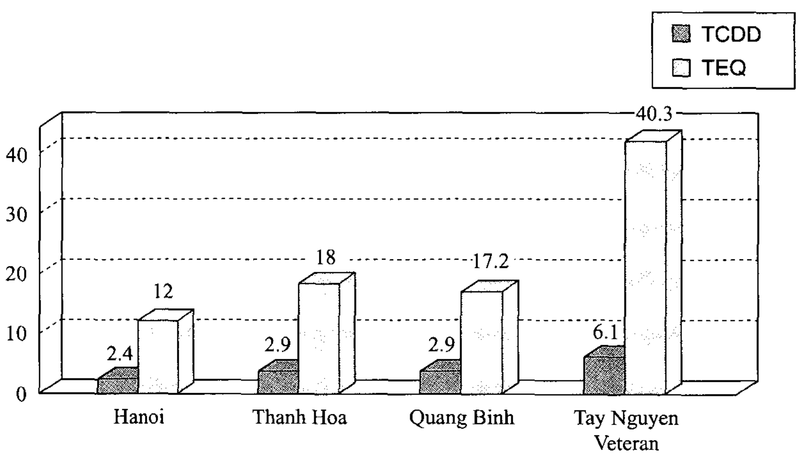

Fig 9.5 Dioxin levels in pooled blood samples of north Vietnam compared to veterans

University. Three years later, in 1973, the same group returned to the same places to repeat their sampling .

In the 1970 study, dioxin levels in breast milk were very high, averaging 484 ppt with some samples reaching 1,450 ppt, the highest level recorded in the world. The 1973 research found that although dioxin levels in breast milk of nursing mothers had decreased, they averaged 131 ppt and ranged from zero to 400 ppt.

Similar research was conducted in 1986, showing that dioxin levels decreased remarkably compared to 1973, ranging between 7 and 20 ppt. However, breast milk from southern Vietnam still showed three to six times higher dioxin levels than samples taken in northern Vietnam (average 1.8-2ppt) (Schecter, A. et al 1989; Schecter, A. et al 1995). These results are summarized in Figure 9.4.

The dioxin levels in the blood were worked out by Dr. Schecter (New York City University) with us to study the presence of dioxin in different regions in the southern Vietnam in comparison with the north (Schecter, A. et al 1992). For the analysis, we used pooled blood taken from three regions in the north (Hanoi, Thanh Hoa and Quang Binh), as well as one sample from northern veterans. The result is illustrated in Figure 9.5, which shows a remarkably high contamination level of northern veteran's blood.

In conclusion, tests for dioxins conducted since 1986 indicate that the level of dioxins in the environment and in human tissues decreased over time. Dioxin levels in commonly used food returned to normal. Levels of dioxin in once contaminated soil are not as high. However, we still have to pay attention to soil around former air bases, former military bases and former chemical warehouses.

People who were exposed to Agent Orange, that is, people who lived in sprayed areas and northerners who served in the south during the war, still have higher level of dioxins than those who have always lived in non-sprayed areas in northern provinces of Vietnam. Most critical is the level of dioxins in breast milk of nursing mothers because the high level of dioxins in breast milk indicates the spread of contamination from mothers to children.

The 'hot spots' remaining after the spraying operation

Since 1989-92, based on the testing of pooled blood samples taken from several people living in different locations, we are able to map out the dioxin level in several places of southern and northern Vietnam. We found that the places with high dioxin levels correlated to former air bases set up by the USA during the war.

The study published recently by the Hatfield group of Canada (1998) showed that, in a former American air base at Aso, Aluoi valley, Thua Thien, Hue Province, an elevated level of dioxin existed in the soil (897 ppt), contaminating a nearby fish pond to the extent that fish fat showed a level of 51 ppt, and poisoning nearby inhabitants (31 ppt).

A study conducted in 1993 at Bien Hoa air base (a huge former American air base) reveals a surprisingly high level of dioxin in the soil (Matsuda *et al.* 1994) varying from 10,000 to 1,140,000 ppt, levels that are from 10 to 1,140 times higher than the critical level (1,000 ppt), considered toxic for humans. The blood tests of people living close to the air base (Schecter, et al 1992) also showed high levels of dioxin, from 20 to 30 and even up to 130 times higher than the normal level in northern Vietnam.

These studies suggest the persistence of 'hot spot' areas highly contaminated with dioxin inside the chemical warehouses connected to several American air bases. These 'hot spots' persist to the present time, and their presence represents a threat to surrounding inhabitants.

Effect on Human Heath

Many studies done recently by world scientists documented several harmful effects of dioxin on human health. WHO recognize that dioxin is a human carcinogen. The US NAS, in its publication, *Veterans and Agent Orange: Update 1998*, recognizes ten different diseases linked to Agent Orange exposure. Other studies recently recognized an increased rate of birth defects in the offspring of former Vietnam veterans exposed to Agent Orange. Another study by IOM recognizes the link of Agent Orange exposure and diabetes.

In Vietnam, despite the many difficulties in scientific research, we have also identified several illnesses believed to be linked to Agent Orange exposure. People living in sprayed areas of southern Vietnam, and former veterans of North Vietnam who fought in the south of Vietnam during wartime, showed various symptoms as follows:

Increased rate of several kinds of cancer (besides the cancer recognized by NAS).

Increased rate of liver cancer and pharyngeal cancer.

Immune deficiencies leading to an increased development of infectious diseases.

Metabolic disturbances and diabetes.

Nervous system problems.

Several pregnancy problems such as miscarriages, still birth, premature birth, low birth weight, hydatidiform mole and choriocarcinoma, genetic problems leading to congenital malformation, and several malformations in the same family over several generations.

To Overcome the Aftermaths of Agent Orange

We have to tackle three major problems simultaneously.

(1) Clean up of 'hot spots': We can use the guideline proposed by EPA (1000 ppt) or the stricter guidelines of the Canadian government (350 ppt) as the limit for soil that requires decontamination. These 'hot spots' continue to pose a serious threat to surrounding inhabitants.

(2) International collaboration on scientific research: the effect of Agent Orange and dioxin is still a new and controversial issue. Quite apart from Agent Orange, dioxin is also of concern to industrialized countries. Many scientists consider Vietnam as the biggest laboratory in the world for studying the effect of dioxin on human health. Joint international research on the effect of dioxin in Vietnam will not only benefit Vietnam, but also the US, Australia, New Zealand, South Korea and other countries involved in the war in Vietnam, in fact, all industrialized countries. We could set up research institutes to study dioxins in Vietnam similar to the institute set up in Japan after World War II to study the effects of exposure to radiation.

(3) The chemical war ended more than thirty years ago, and victims of Agent Orange can wait no longer for scientists to establish further scientific proof of the effects of the chemicals. Scientific research must be accompanied by offering help to the victims. This is justified not only because worldwide scientific studies recognize the harmful effects of dioxin exposure, but also on humanitarian grounds.

The legacy of Agent Orange is not only a scientific issue, but also a matter of conscience. We call on international organizations, and the US Government in particular, to take up this responsibility and help the Vietnamese people solve the severe aftermath of the chemical war. With joint efforts we hope that in the coming years we shall be able to resolve the various consequences of Agent Orange, close the door on the tragedy of the chemical war, and cultivate mutual trust and understanding between scientists and people of all countries.

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PART 2

Health

Introduction to Part Two

For Part Two we invited papers dealing with Asian health, environment, and human interactions. The chapters report problems, issues, or study methods used to address these subjects. The most important health problem in Asia is infectious disease. The natural environment serves as the reservoir for various infectious agents and they are transmitted to humans by various modes. Nair *et al.* give an overview of cholera, the classical water-borne infection, and its spread from Asia to other parts of the world. Nishibuchi reports an infection by a seafood-borne pathogen, *Vibrio parahaemolyticus*, in and around Asia. Puthucheary reviews an infection caused by a soil-borne pathogen, *Burkholderia pseudomallei*. This infection is well known in Southeast Asia but not in other parts of the world. Ogiwara and Gomi emphasize that malaria and dengue, diseases transmitted by mosquitoes, are particularly important vector-borne diseases in Southeast Asia. Ishii *et al.* report their experience on malaria control in two study sites in Asia. Narasiman and Jamalddin report a fascinating story about the discovery of a new viral pathogen, harbored by a fruit bat, during their efforts to control an unforeseen outbreak of an encephalitis in pigs and humans in Malaysia. Not only biological agents, but also chemical substances in the natural environment can cause diseases in humans and other animals. Ando and Ishida describe minerals in drinking water that are serious problems in Asia. Tanabe shows that man-made substances released into the natural environment are becoming significant health problems in Asia and other parts of the world. The development of medical and health care helps humans to live longer. Aging is becoming an important issue in Asia. Matsubayashi and Okumiya discuss improved ways of taking care of the elderly based on their study results in Japan and two other Asian countries. Otsuka *et al.* introduce an interesting concept, 'chronomes', and hypothesize an environment-human link from the results of their studies on aging and health in Asia and other countries. Finally, Tanimura and Mizota introduce a new geographic method applicable to studies on and services for health at the regional as well as on a global scale.

Nair *et al.* report detailed contemporary information about cholera epidemics.

Cholera is a well-known infectious disease. The pathogen, *Vibrio cholerae*, is a bacterium that the aquatic environments of the Bengal area, infects humans, and then contaminates the environments again causing further infection. This vicious circle leads to pandemics (global epidemics) of the disease. Although the study of cholera has a long history, a wealth of new information has been gained in the last twelve years. The spread of cholera to Latin America in the early 1990s attracted much attention. Recently, in Africa, cholera has become a serious problem in refugee camps. A new type of cholera pathogen named 'O139 Bengal' emerged in 1992 and caused many deaths in the Bengal area and then spread to surrounding countries and other parts of the world. However, the new type of cholera pathogen was soon replaced by the classical cholera pathogen called 'serotype O1'. Later the new pathogen returned. The authors review biological, molecular epidemiological and environmental data and speculate on why, recently, there is frequent change occurring in the cholera epidemiology.

Nishibuchi also reports about an epidemic disease caused by an aquatic environmental pathogen. The pathogen, *Vibrio parahaemolyticus*, is a bacterium belonging to the same group (genus *Vibrio*) as the cholera pathogen. This pathogen is a marine bacterium that contaminates seafood. People previously believed that infection by this bacterium was acquired through consumption of contaminated local seafood. However, Nishibuchi and his collaborators demonstrated that a new clone of *V. parahaemolyticus* emerged in around 1996 and spread infection most likely from Asian environments to other parts of the world. Enough epidemiological evidence is presented to support the fact that this is the first reported pandemic of a *V. parahaemolyticus* infection.

Puthucheary describes 'melioidosis', a disease caused by a soil-borne pathogenic bacterium, *Burkholderia pseudomallei*. Most reports of the infection caused by this pathogen are from continental Southeast Asia (Thailand, Vietnam, Malaysia, Cambodia, and Laos) and tropical Australia. The author shows how the natural environmental conditions of this area may be suitable for the distribution of this pathogen and further emphasizes that there is a homeostatic balance in nature between man, this pathogen, and the environment. The author concludes that the disturbance of this balance by human activities (logging, road building and vegetation) will trigger infections by the pathogen and its subsequent spread.

Ogiwara and Gomi review the diseases in Southeast Asia and then focus on vector-borne diseases. They point out that malaria and dengue fever are particularly important in Asia and discuss ecological issues associated with these infections.

Ishii *et al.* report the results of a malaria control trial carried out in Indonesia and the Solomon Islands. They conclude from their study that malaria could be controlled using chemotherapy with two drugs and vector-control bed netting.

Narasiman and Jamalddin report their recent experience with a new disease in pigs and humans in Malaysia and Singapore (1998-1999). It was the outbreak of an infection due to a previously unreported virus. Using epidemiology, they found that a bat originally harbored the virus and hypothesized that disturbance of the bat's ecosystem by human development activities probably triggered transfer of the virus from the bat to pigs and then to humans.

Ando and Ishida show that the development of irrigation systems in dry areas of Asia result in the exposure of humans to drinking water containing natural minerals that are at toxic concentrations. The introduction of ground water pumping systems for rice cultivation in Bangladesh leads people to use ground water for drinking. The government encouraged this because ground water is free from pathogenic microorganisms. However, people now suffer from the toxic effects of arsenate contaminated ground water. The use of large amounts of river water from the Aral Sea for cotton and rice farms has caused a concentration of salts and a deterioration in the drinking and cooking water quality in the Kazakhstan area.

Tanabe reviews the contamination of the natural environment by man-made toxic substances belonging to organochlorine compounds. These are called endocrine disrupters and include DDTs and other substances used as insecticides for agriculture and malaria control and PCBs mainly used for industrial purposes. The author shows distribution of these substances in the Asian environment (coastal water and shellfish). These substances are also spread globally by evaporation and persist in the environment because they are chemically stable. Their accumulation in animals causes serious toxic effects. Marine mammals and birds are especially sensitive, but humans are not an exception and succumb to their effects. The author emphasizes that pollution from these substances will be an important issue in developing countries.

Matsubayashi and Okumiya's paper deals with aging, one of the growing issues in Asia. They carried out their study in Kahoku, a small town in Japan. They demonstrate that the elders who are living independent lives are healthier than those receiving institutional care. Comparison of this result with those obtained in three other towns in Japan, Singapore and Korea by the authors' group indicated that regional differences occur. The elders' tendency to live an independent life may be influenced by ecological differences such as their natural environments, historical backgrounds, lifestyles, habits, religions and the health promotion policies practiced in their area.

Otsuka *et al.* focus on the heart rate as indices of health and aging. They examined the heart rate variability in individuals of various age groups in Asian countries, the US and Norway. Their idea is based on evidence that life responds to various bands of the electromagnetic spectrum and that we sense these energies generated in the Universe. From the results of a global study, the authors put forward the hypothesis that the physiological chronomes have counterparts in our environment and that our genetic make-up towards time may have evolved in adaptation to and integration with our cosmos.

Tanimura and Mizota review applications of how the geographic information system (GIS) is used for international health. GIS is used in epidemiological studies, health service research and ecological studies. GIS applied to malaria studies in India, Africa and other places, are good examples of the usefulness of this system. However, they conclude that this new technique is still underutilized in the health field. This is partly due to the fact that the GIS technique is still a new and immature technique and that international health workers are not well-enough trained to use this computer-based technique. The authors encourage the readers to familiarize themselves with this method. The principle of the GIS application to an epidemiological study is nicely demonstrated using John Snow's 18th century cholera study: the classic historical example of epidemiology.

10

Molecular Epidemiology of Vibrio cholerae: *Masquerade of a Deceptive Pathogen*

G. Balakrish Nair, Shah M. Faruque, Pallavi Garg,
T. Ramamurthy and Takeda Yoshifumi

Cholera is a notifiable disease and international health regulations require a case by case reporting. From the declining trends in the 1980s, the global cholera scenario has received a reversal, with a huge increase in the global incidence of cholera in the 1990s principally due to two important but unrelated events. This includes the re-emergence of cholera in 1991 in the Americas after 100 years. The story of the re-emergence of cholera in the Americas is the story of its unpredictability. The seventh pandemic strain of cholera, the O1 El Tor strain, entered Latin America in January 1991 in the form of explosive outbreaks in

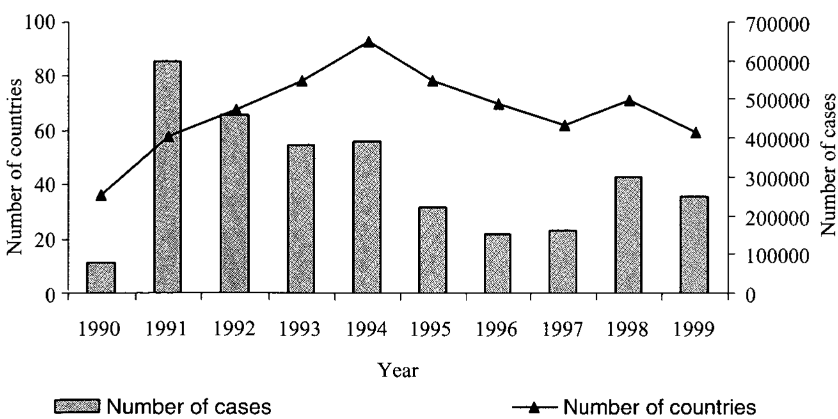


Fig 10.1 Countries reporting cholera and cases reported by year from 1990 to 1999. The figure has been adapted from the reference 13 (World Health Organization. 2000. Cholera, 1999.Weekly Epidemiol. Rec. 75: 249-256).

Peru. From there it spread rapidly to other South American countries at the rate of approximately one country per month (Tauxe *et al.* 1992). What baffles epidemiologists is, why did this occur in 1991? Conditions in some of these countries were conducive for cholera all along. The other event, in India, was the genesis of a new serogroup associated with epidemic cholera we named '*V. cholerae* O139 Bengal' (Shimada *et al.* 1993;), an unprecedented event which occurred for the first time in the recorded history of cholera (Albert *et. al.* 1993, Ramamurthy *et. al.* 1993). Both of these events had an immense impact on the global incidence of cholera. The number of cases and the number of countries reporting cholera to the World Health Organization showed an abrupt increase (Figure 10.1). The 1991 spike in the number of cases (of around 600,000) is attributed to the re-emergence of cholera in the American continent after a lapse of 100 years (WHO 1995). In fact, in 1994, 94 countries reported cholera to WHO, which is a record of sorts, so far.

Cholera-the disease

Cholera, the scourge of humanity, is an ancient disease that still ranks high in the etiology of diarrheal diseases. The term 'cholera' is derived from the Greek words 'chole' (bile) and 'rein' (to flow). In Hebrew, cholera means 'bad disease'. All of these different derivations suggest that cholera may have been known to ancient civilizations in the Mediterranean, in the subcontinent and in the Middle East. The causative organism, *V. cholerae*, was first described by Pacini in 1854 (Howard-Jones 1972) and isolated in pure culture from an Egyptian stool sample by Robert Koch thirty years later (Koch 1884). Cholera infection results from ingestion of toxigenic *V.cholerae*, usually through contaminated water or food. The incubation period of cholera can range from several hours to five days and is dependent in part on the inoculum size (Levine *et. al.* 1981). Onset of illness may be sudden, with profuse, watery diarrhea or there can be premonitory symptoms such as anorexia, abdominal discomfort and simple diarrhea. Mucous in the stool imparts the characteristic rice-water appearance. Cholera may lead rapidly to tachycardia, hypotension and vascular collapse due to dehydration (Pierce and Mondal 1974, Morris 1985; Morris 1994;). Peripheral pulses may be absent and blood pressure may not be recordable. Skin turgor is poor, giving the skin a doughy consistency, the eyes are sunken, and the hands and feet become wrinkled. All of these result from the activity of cholera enterotoxin, which triggers adenylate cyclase and, subsequently, intracellular levels of cAMP is increased. cAMP activates a cAMP-dependent protein kinase, leading to protein phosphorylation, alteration of ion transport, and ultimately to diarrhea.

Box 1

The cholera setting

Vibrio cholerae has an aquatic niche in which it has a seasonal cycle dependent on the life cycles of other aquatic fauna, particularly the copepods. This was first documented by pioneering studies by Professor Rita Colwell (inset) in the 1970s. Although this was not met with immediate acceptance, especially by clinicians, we today know that the environment has a profound role on the occurrence of cholera epidemics. It is a tribute to the perseverance of Dr. Colwell that we have these insights. This picture shows a mother carrying her child, stricken with cholera, to the Matlab Hospital (ICDDRB) in Bangladesh.

Cholera as a re-emerging disease

On a global basis, from 1997 to 1998, an increase from less than 140,000 to more than 290,000 cases was reported (WHO 1999). The year 1999 saw a slight reduction in the total number of cholera cases globally with the overall case-fatality rate (CFR) remaining constant. The Americas reported the greatest decrease in case numbers, whereas the total number of reported cases increased in Asia. The number of cases notified by Africa still exceeds by far the number of cases reported from other continents (WHO 2000). In 1999, global incidence was about 254,000 and Africa alone accounted for about 81 per cent of the total global number of cases. The same year CFR in Africa reached 4.2 per cent, constituting more than 95 per cent of the world's total deaths from cholera (WHO 2000). In 2000, multiple outbreaks of cholera were reported in populations inhabiting various islands in Oceania. As the pandemic is ongoing, the number of countries affected continues to increase. The problem of cholera is, therefore, a very real one and the disease is certainly here with us.

The number of cases and countries reporting cholera to the WHO represent only the tip of the iceberg. In part owing to surveillance difficulties, but also for fear of economic and social consequences, the morbidity and mortality caused by *V. cholerae* are likely to be grossly under-reported (WHO 2000). Take for example, the yearly cholera map published by the WHO showing the global incidence of cholera. A country like Bangladesh is shown as not having cholera because it does not report cholera due to fear of economic and logistical penalties. But actual surveillance estimates at least 40,000 to 2 million cholera cases annually in this country of about 100 million people (Sack 1995). Therefore, there is gross under-reporting of cholera in certain countries, including India, wherein the magnitude of the problem is much greater than is actually published.

Currently recognized serogroups

The major surface antigen employed in characterization of *V.cholerae* is the O antigen. A flagellar (H) antigen is also present, but the value of this antigen for species identification is limited due to the presence of common H epitopes among all *Vibrio* species (Shinoda *et. al.* 1976; Simonson *et. al.* 1988). The O

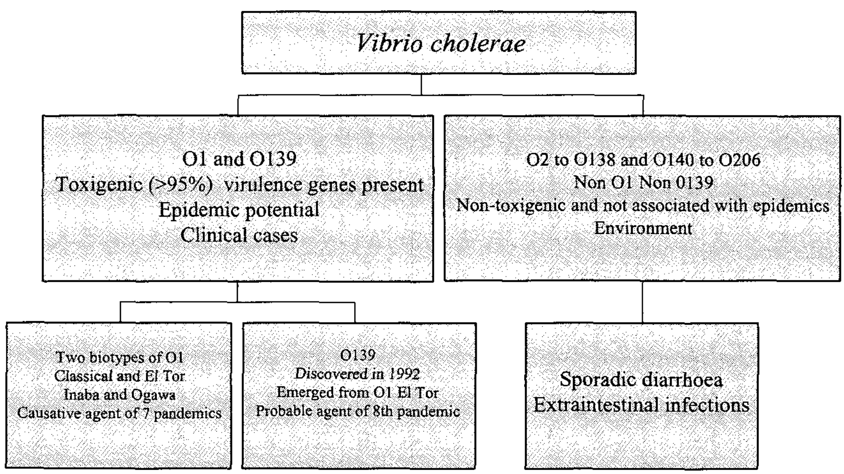


Fig 10.2 Current classification of *V. cholerae*

antigen has been implicated in various processes in the pathogenesis of cholera. It represents a protective antigen. It is heat-stable and is not destroyed by treatment with 50 per cent methanol and 1N-HCl at 37 °C for 24 hrs. It is composed of a homopolymer containing the amino acid sugar D-perosamine (4-amino-4,6-dideoxy-D-mannose), in which the amino groups are acylated by 3-deoxy-L-glycero-tetronic acid (Redmond 1975; Kenne *et. al.* 1982). The somatic O antigen, the outermost part of the lipopolysaccharide layer of *V.cholerae* (and other Gram-negative bacteria) has been used to classify the strains into 206 serogroups, starting from O1 to O206 (Yamai *et al.* 1997).

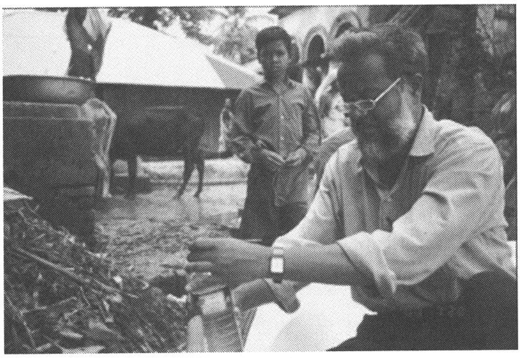
V. cholerae O1

V. cholerae of the O1 serogroup has long been associated with epidemic and pandemic cholera. *V. cholerae* O1 strains have historically been divided into two biotypes, classical and El Tor (Figure 10.2). This is decided on the basis of six biochemical tests but the recent approach is a multiplex PCR with El Tor and classical specific primers giving different sized amplicons (Keasler 1993). Each biotype can be further subdivided into two major serotypes, 'Ogawa' and 'Inaba'. Ogawa strains produce the A and B antigens and a small amount of C, while Inaba strains produce only the A and C antigens (Sakazaki 1992). A third serotype, 'Hikojima', contains all three antigens, but is rare and unstable (Kelley *et al.* 1991). *V. cholerae* O1 strains of the same biotype and serotype can be differentiated by bacteriophage typing. The recent typing scheme could separate 1000 *V. cholerae* strains into 146 phage types by using ten typing phages (Chattopadhyay *et al.* 1993). Restriction fragment length polymorphism analysis using *ctxB* (99 per cent conserved) gene probe (Olsvik *et al.* 1993) can divide toxigenic O1 serogroup into three genotypes. Genotype 1 was found in the classical biotype and El Tor strains from the US Gulf Coast. Genotype 2 was found in El Tor strains from Australia and genotype 3 was found in the seventh pandemic strains and the recent Latin American outbreak. The multilocus enzyme electrophoresis (MEE) technique can distinguish classical and El Tor strains (Momen and Salles 1985; Wachsmuth 1994). MEE has grouped the toxigenic El Tor biotype strains of *V. cholerae* O1 into four major clonal groups or electrophoretic types (ET) representing broad geographical areas which include the Australian clone (ET1), the Gulf Coast clone (ET2), the seventh pandemic clone (ET3) and the Latin American clone (ET4) (Salles and Momen 1991; Chen *et al.* 1991; Wachsmuth *et al.* 1993; Wachsmuth *et al.* 1994). Among these four global types, the Australian strains are closely related to the US Gulf Coast strains and are more distantly related to the current seventh pandemic clone (Salles and Momen 1991). RFLPs of genes encoding rRNA have also been employed to study divergence among *V. cholerae* isolates

Box 2

Ecological study of cholera

At the ICDDR,B in Bangladesh; sampling of the environment is performed at regular intervals to understand the ecology of *Vibrio cholerae*.



(Kobalvi *et al.* 1990; Wachsmuth *et al.* 1993). Popovic and colleagues (Popovic *et al.* 1993) have proposed a standardized ribotyping scheme for *V. cholerae* O1 strains. The rRNA RFLPs were grouped into seven different ribotypes among classical strains and 20 ribotypes and subtypes among El Tor strains.

V. cholerae O139

The simple distinction between *V. cholerae* O1 and *V. cholerae* non-O1 was rendered obsolete in early 1993 when the first reports of a new epidemic of severe cholera-like disease emerged from eastern India and Bangladesh (Albert *et al.* 1993; Ramamurthy *et al.* 1993). The organism responsible for this outbreak did not belong to the O serogroups previously described for *V. cholerae* but to a new serogroup, which was given the designation 'O139' and a synonym 'Bengal' in recognition of the origin of this strain (Shimada *et al.* 1993). In the initial period of the epidemic, the adult population was largely infected with O139 cholera, suggesting that O139 is a new serogroup and prior exposure to O1 had not afforded cross-immunity to O139 cholera (Cholera working group 1993; Nair *et al.* 1994; Takeda *et al.* 1994).

Molecular studies, directed at understanding the genesis of this novel serogroup and its relationship with El Tor biotype *V. cholerae* O1, indicate that the O139 serogroup is likely to have originated from the El Tor biotype (Hall *et al.* 1994; Calia *et al.* 1994; Bik *et al.* 1995; Mooi and Bik 1997). The O139 serogroup probably evolved by horizontal gene transfer between a non-O1 and an O1 strain and the acquired gene has altered the antigenic property of the recipient O1 strain. The O139 strains do not produce O1 LPS, as it lacks some of the genetic material needed for production of the O1 antigen (Manning *et al.* 1994). The important virulence factors, specifically cholera enterotoxin and toxin co-regulated pilus of *V. cholerae* O139 strains, are indistinguishable from typical *V. cholerae* O1 biotype El Tor strains (Ramamurthy *et al.* 1993; Johnson *et al.* 1994).

V. cholerae non-O1 non-O139

All strains that are identified as *V. cholerae* on the basis of biochemical tests, but which do not agglutinate with O1 or O139 antisera are collectively referred to as 'non-O1 non-O139'. Other formerly used names for this group are 'non-cholera vibrios' (NCVs) or non-agglutinating vibrios (NAGs). The current classification includes 206 different 'O' serogroups of *V. cholerae* (Yamai 1997). Non-O1 non-O139 *V. cholerae*, therefore, includes all serogroups of *V. cholerae* except the O1 and O139. They had never been involved in cholera epidemics, but have been found associated with limited outbreaks of diarrheal diseases (Aldova *et al.* 1968; Dakin *et al.* 1974). Sporadic cases of outbreak caused by *V. cholerae* non-O1 non-O139 have been reported, with symptoms varying from mild to severe cholera-like diarrhea, sometimes with vomiting, fever and bloody stools (Blake *et al.* 1980; Morris 1990). Some *V. cholerae* non-O1 non-O139 cause septicemia, suggesting that they might have an invasive character (Sanyal 1992). Non-O1 non-O139 strains, apart from human feces, have been isolated from a variety of extra-intestinal infections, including wounds, ear, sputum, urine and cerebrospinal fluid (Blake *et al.* 1980; Morris 1990). They are regularly found in estuarine environments and infections due to these strains being commonly of environmental origin (Morris, 1990). A great majority of the non-O1 non-O139 strains do not produce cholera toxin, but some non-O1 non-O139 strains isolated from patients, like those from the Sudan outbreaks, have been found to produce cholera toxin identical to that produced by *V. cholerae* O1 (Zinnaka *et al.* 1972).

Molecular epidemiology of *V. cholerae* in India

Over the past decade, the National Institute of Cholera and Enteric Diseases have worked to understand the reasons for this unpredictability of cholera using a predominantly molecular approach. A variety of molecular typing techniques

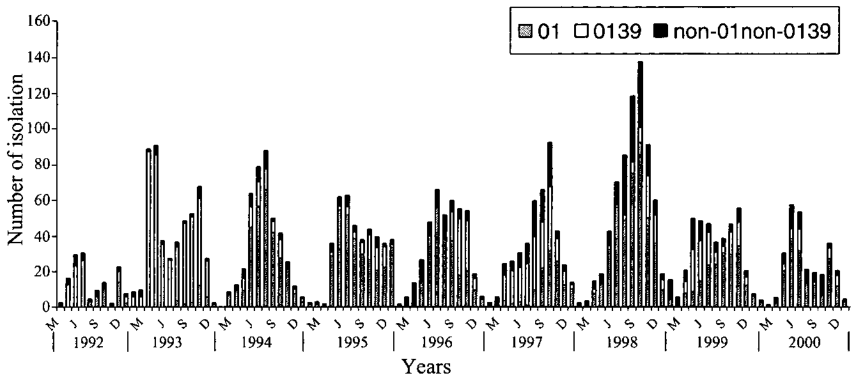


Fig 10.3 Isolation profile of *V. cholerae* strains isolated from patients admitted to the I. D. Hospital Calcutta, India from 1992 to 2000

can now efficiently distinguish between different clones of *V. cholerae* and this approach has provided unique insights into the problem of cholera.

The entry of Vibrio cholerae O139

The number of cholera cases admitted to the Infectious Diseases Hospital (IDH) in Calcutta during the O139 epidemic that occurred from February to July 1993, showed a four-fold increase from the usual incidence of cholera during that time of the year (Nair *et al.* 1994). It must be emphasized that this was an event that happened in 1993 and not in the Victorian age. At Calcutta, where the facilities and infrastructure to handle cholera are adequate, O139 cases overwhelmed the IDH, the largest in South Asia, in two days. At its peak, IDH was admitting a cholera patient approximately every four minutes. This shows how a new variant of an old organism can completely overwhelm existing public health infrastructure and also shows what we should be prepared to handle in such a contingency. Serogrouping and the ability of producing cholera toxin by strains which did not agglutinate with the O1 polyvalent antiserum were the first clues to the emergence of a new serogroup. None of the four epidemic strains of *V. cholerae* isolated from Madras, India and one from Bangladesh, agglutinated with polyvalent O1 antiserum or with monoclonal antibodies against factors A, B and C of *V. cholerae* O1 or with antisera prepared against the 138 existing non-O1 serogroups, at that time (Shimada *et al.* 1993). Likewise, antisera prepared against the five epidemic strains did not agglutinate the O1 serogroup, but agglutinated each other, indicating the strains were clonal and different from the O1 serogroup and from any of the existing non-O1 serogroups.

One of our first studies was directed at understanding how similar the cholera toxin (CT) produced by O139 was to that produced by O1 (Sanyal 1992).

Comparison of the deduced amino acid sequences of the A and B subunits of CT revealed exactly the same sequence as that of the El Tor A and B subunits of CT. The amino acid sequence of the O139 and El Tor CT B subunit varied from CT produced by classical strains of *V. cholerae* at position 38 and 68 of the CT B subunit (Zinnaka 1972). At this point, we were riding the crest of a discovery and we had a fleeting feeling that we had understood the mechanics of the epidemiology of cholera. In fact, we had pompously ended one of our manuscripts published in the *Journal of Infectious Diseases* with the words 'undoubtedly the beginning of the eighth pandemic of cholera' (Nair *et al.* 1994).

Reappearence of V. cholerae O1

Therefore, in July 1993, while the O139 epidemic was waning in Calcutta, we were surprised to again isolate *V. cholerae* O1. These sporadic isolations of O1 started increasing over the months and by February 1994, the O1 serogroup was firmly entrenched and again became the dominant serogroup causing cholera in Calcutta (Figure 10.3). For us, this was a reminder of the prodigious ability of *V. cholerae* to reinvent itself and speedily adapt to new conditions, and above all, to act in a unpredictable fashion.

However, when we analyzed our epidemiology data at great length, we found that the introduction of *V. cholerae* O139 in 1992 and the concurrent disappearance of *V. cholerae* O1 biotype El Tor provided a unique opportunity in that it punctuated the otherwise continuous incidence of *V. cholerae* O1, an event, which probably had never occurred before. This enabled us to identify two groups of *V. cholerae* O1: one that prevailed before the genesis of O139 and the other that reappeared after the epidemic of O139 in Calcutta. We referred to them as the 'before' and 'after' O1 strains (Mukhopadhyay et al. 1996).

Our first target was to examine these 'before' and 'after' strains using the panoply of biochemical, physiological and antibiotic susceptibility tests, including the use of biotype specific classical group IV and El Tor group V phages. We had expected differences in some traits between the 'before' and 'after' O1 strains, but apart from changes in the antibiogram there were no discernible differences. Both 'before' and 'after' strains were susceptible to group V El Tor phage, indicating that both the 'before' and 'after strains belonged to the El Tor biotype. Resistance to commonly used antibiotics showed interesting variations. The 'after' strains for instance, were resistant to co-trimoxazole, nalidixic acid and chloramphenicol, as compared to the 'before' strains. When compared to the O139 strains, it became clear that the O1 and O139 strains being isolated at that time had identical antibiograms, with the exception of nalidixic acid with 91.3 per cent of the O1 strains being resistant to this drug, while the O139 strains were sensitive to nalidixic acid. There were, therefore, minor differences in the 'before' and 'after' strains, but not sufficient to describe it as a new clone. What intrigued us was that if this was the same clone of O1 as that prevailed earlier, then why did it disappear and then reappear? The disappearance could be explained as competition between the O1 and the O139 serogroups. O139 prevailed due to the lack of specific immunity against this new serogroup in cholera endemic populations. For the same reason, O139 serogroup also had a competitive edge over the O1 serogroup in the replacement dynamics, but how and why did the O1 serogroup reappear given the fact that clinical infection with *V. cholerae* O1 is known to give rise to a high level of strong enduring protection against reinfection and this protection reportedly persists for three years (Levine *et al.* 1981)?

Using the same set of 'before' and 'after' O1 strains and a set of O139 strains being isolated at that time, we performed macro-restriction DNA analysis using pulsed field gel electrophoresis (Yamasaki *et al.* 1997). Genomic DNA of the strains was digested to completion using *Not*I. The cleavage patterns generated by *Not*I clearly differentiated the 'before' and 'after' strains of O1 and these patterns were different from the O139 strains being isolated during the same time frame. This was the first inkling that the strains of O1, which appeared after the O139 outbreak, were clearly a new clone. We further compared the *Not*I restriction pattern of the 'before' and 'after' O1 strains with patterns generated by four standard strains of *V. cholerae* O1; namely ET1, which represents the Australian clone; ET2,which represents the US Gulf Coast clone; ET3, which represents the seventh pandemic clone; and ET4, which represents the Latin American pandemic clone (Wachsmuth *et al.* 1994). The PFGE pattern of the 'before' strains of O1 matched with the pattern shown by ET4 or the Latin American pandemic clone, while the PFGE pattern of the after O1 strain did not match the PFGE pattern exhibited by any of the representative ET types, thus attesting to its novelty (Yamasaki *et al.* 1997).

The next issue that was addressed was to ascertain the presence of O139 genetic material in the new clone of O1. Hybridization data using a 1 kb O139-specific DNA indicated that there was no O139 specific genetic material in the new O1 clone or, for that matter, in any of the O1 strains examined (Yamasaki *et al.* 1997). We also used an O1 specific probe to examine if the fragment which hybridized with the O1 probe was same or different in the 'before' and 'after' strains. The results again showed that the fragment which hybridized with the 'before' and 'after' strains were different. The PFGE studies therefore enabled us to identify rearrangement in the O1 strains, which would have otherwise gone unnoticed. A question we began asking ourselves was whether the genetic re-assortment in the 'after' O1 strains was accompanied by, hitherto, undiscovered discreet changes in the structural configuration of the organism.

Based on the results of PFGE, we intensified our molecular studies to see how different the 'before' and 'after' O1 strains were. To accomplish this we used ribotyping: a technique that was successfully used to type O1 strains isolated over the past sixty years from different parts of the world (Kobalvi et al. 1990; Popovic *et al.* 1993). For ribotyping, the restriction enzyme *Bgl*I was chosen, because this enzyme has been shown to produce good discriminatory patterns for *V. cholerae* and because this would allow us to make comparisons with the standardized ribotyping scheme for *V. cholerae* developed by the Centers for Disease Control in the US (Popovic *et al.* 1993). The results of the ribotyping were interesting; three different ribotypes which we designated as RI, RII and RIII were obtained (Sharma *et al.* 1997). The ribotype RI was displayed by the 'before' strains and it matched ribotype 6a of the standardized ribotyping scheme for *V. cholerae* (Popovic *et al.* 1993). The ribotypes RII and RIII of this study were found in the 'after' strains and did not match any of the profile in the standardized scheme (Popovic *et al.* 1993) suggesting the evolution of two new ribotypes among the El Tor biotype of *V. cholerae*. Further analysis of the ribotyping data revealed that although RI was occasionally observed among strains isolated after June 1993, RIII was not isolated before November 1992, confirming the uniqueness of this ribotype.

Resurgence of V. cholerae O139

Epidemiologically, the new clone of *V. cholerae* O1 had by now prevailed in Calcutta and became the dominant serogroup, and the isolation of O139 had become rare. By analyzing strains received from different parts of the country, we were able to establish that the new clone had spread into several of the cholera endemic areas in India and neighboring countries. Among cholera workers, it was felt that the appearance of the O139 serogroup was a one-time event and the organism was slowly becoming extinct.

To prove that this was not the case. A huge resurgence of *V. cholerae* O139 was witnessed in September 1996 in Calcutta (Mitra *et al.* 1996). Phenotypically, the re-emerged *V. cholerae* O139 was different from those that appeared in late 1992 in that the current O139 strains were sensitive to co-trimoxazole (Mukhopadhyay 1998). At this stage, we again embarked on testing our hypothesis that the re-emerged O139 strains were different from those that prevailed earlier. This was accomplished using ribotyping and RFLP of the CTX prophage. We were, however, surprised to observe that despite differences in antibiogram, the 1992 O139 and 1996 O139 strains had identical ribotype. Restriction fragment length polymorphism of CTX prophage indicated that there is a continuous change in the structure and organization of CTX prophage along with emergence of a new type of CTX prophage. The 1992-93 strains showed two CTX prophages connected by an RS1 element, while the 1996 strains showed three CTX prophages arranged in tandem. Most of the 1998 O139 strains from Calcutta exhibited only one CTX prophage, while those isolated from other parts of India were identical to the 1996-97 strains or showed two CTX prophages arranged in tandem (Sharma *et al.* 1997b; Kimsey *et al.* 1998). In 1996, O139 strains exhibited two types of CTX prophages, with the first of the three prophages being an El Tor-type CTX prophage and the second and third CTX prophages being a new type of CTX prophage, with difference primarily lying in *rstR* gene, which codes for the repressor proteins of CTX prophage. In 1998, we observed that two new clones of O139 had evolved probably from the 1996-97 strains with two epicenters; namely Calcutta and Alleppey, South India. Calcutta strains showed only the El Tor-type CTX prophage and not the unique O139 CTX prophage of the 1996 strains, while the reverse was the case with the Alleppey strains. Therefore, at this point, there are two different clones of O139 circulating at two different locations with different CTX prophages; indicating that re-assortment in the genome is taking place in the O139 strains. This molecular epidemiology study revealed clonal diversity among the O139 strains and the emergence of new epidemic clones, as evidenced by the change in the structure, organization and location of the CTX prophages over a period of seven years.

Spread of the new clone of V. cholerae O1 from Calcutta to Guinea-Bissau (West Africa)

Extended molecular studies showed that the new clone of *V. cholerae* O1 had spread into other cholera endemic areas in India and also into the West African country of Guinea-Bissau, where it was responsible for an epidemic of cholera during 1996. The *Bgl*I cleavage pattern of a representative strain isolated after the O139 epidemic in Calcutta matches the pattern of a representative *V. cholerae* O1 El Tor strain recovered from a cholera outbreak in Guinea-Bissau, whereas, the 1987 isolate from the same region did not match (Sharma *et al.* 1998). The results of the PFGE typing further supported the results obtained by ribotyping since identical PFGE typing patterns were shown by strains CO840 from Calcutta and 9868 from Guinea-Bissau. Thus, the use of two different typing methods strongly indicated that the two geographically distant strains belong to the same clone. Chronologically, the clone existed in Calcutta during 1995 and may subsequently have been introduced into Guinea-Bissau in 1996.

PFGE patterns of V. cholerae O1 Ogawa and reappeared Inaba (1998-99) strains from India

With the advent of the O139 serogroup in 1992, the Inaba serotype of *V. cholerae* O1 was displaced in Calcutta and other parts of India by the O139 serogroup. From 1990 onwards, the isolation of Inaba serotypes became rare. In December 1998, we received a representative set of *V. cholerae* O1 strains form Delhi, of which two strains were identified as Inaba serotype. In November 1999, seven *V. cholerae* O1 strains sent from Sewagram were also identified as Inaba serotype. Analysis of PFGE patterns showed that the Inaba strains isolated recently had a profile different from Inaba strains isolated in 1989. The recent Inaba strains differed form Calcutta isolates of Ogawa during 1995 by the presence of more than one band in the 145.5 kb region (Garg *et al.* 2000). Interestingly, O1 Ogawa strains isolated during 1998 had a PFGE profile identical to that of the recently isolated Inaba strains, indicating that the Inaba strains that had recently emerged were similar to the prevailing O1 Ogawa strains. The above finding was further confirmed by RFLP and ribotyping.

Genetic analysis of V. cholerae non-O1, non-O139 from acute diarrhea cases

The non-O1, non-O139 serogroups of *V. cholerae* comprise a heterogeneous group of organisms whose clinical association with humans is inadequately understood. Clinically, the non-O1, non-O139 serogroups of *V. cholerae* continue to be of less importance since these strains are associated with illness only in a low percentage of patients hospitalized due to acute secretory diarrhea. Based on hospital surveillance conducted at Calcutta, it has become increasingly evident that the non-O1, non-O139 serogroups are involved in the emergence of newer variants of *V. cholerae*, a fact supported by the genesis of *V. cholerae* O139, which is believed to have evolved as a result of horizontal gene transfer. However, there was an inexplicable upsurge in the incidence of non-O1, non-O139 serogroups of *V. cholerae* among hospitalized patients admitted to the IDH, Calcutta for the first time in February to March 1996. The PFGE profiles of the non-O1, non-O139 serogroups of *V. cholerae* showed a variety of patterns, which correlated well with the profiles obtained by ribotyping and serogrouping. All O144 strains had identical patterns. Likewise, strains belonging to O11 and OUT (untypable serogroup) also displayed nearly identical patterns. For the first time, we used the nomenclature of enteropathogenic *Vibrio cholerae* (EPVC) to designate such strains (Sharma *et al.* 1998b) and their virulence mechanisms are being investigated.

Box 3

Cholera cot

To a patient with cholera, the " 'cholera cot' is perhaps the best invention. The cholera cot is a plastic or wooden cot with a hole in the center. This picture shows the inside of the extended part of the cholera hospital (ICDDR, B) in Dhaka during a cholera outbreak.

Molecular eepidemiology of cholera in Bangladesh

In Bangladesh, epidemic outbreaks of cholera usually occur twice during a year, with the highest number of cases just after the monsoon during September to December, and a somewhat smaller peak of cholera cases during the spring between March and May (Siddique *et al.* 1992). Until 1970, more than 90 per cent of cholera in Bangladesh was caused by the classical Inaba serotype and by 1972, 85 per cent of all cases were due to classical Ogawa (Khan *et al.* 1986). The El Tor biotype of *V. cholerae* O1 appeared in Bangladesh in the middle of 1973 and almost completely replaced the classical biotype. However, in 1982, the classical biotype re-emerged as a predominant epidemic strain in Bangladesh and coexisted with the El Tor vibrios until 1992, when a new epidemic strain of *V. cholerae* emerged and caused outbreaks in India and Bangladesh (Ramamurthy *et al.* 1993). The bacterium responsible for the outbreaks in Bangladesh and India resembled *V. cholerae* O1 in cultural and biochemical characteristics, but did not agglutinate with *V. cholerae* O1 antisera. The new epidemic strain of *V. cholerae* was later serogrouped as O139 and given the synonym name 'Bengal' (Shimada *et al.* 1993). In the beginning, the new strain totally displaced the existing *V. cholerae* O1 strains, including both classical and El Tor biotypes which co-existed only in Bangladesh. However, during 1994 and until the middle of 1995, in most northern and central areas of Bangladesh, including the capital city Dhaka, the O139 vibrios were replaced by a new clone of *V. cholerae* O1 of the El Tor biotype, whereas in the southern coastal regions the O139 vibrios continued to exist. During the second half of 1995 and in 1996, nearly four years after the initial detection of O139 vibrios, cases due to both *V. cholerae* O1 and O139 were detected in various regions of Bangladesh. Recent surveillance revealed the coexistence of *V. cholerae* O1 and O139 in Dhaka as well as in some rural districts of the northern, central and southern regions of the country affected by outbreaks of cholera between June and December of 1996 (Faruque *et al.* 1997). Cholera surveillance in Bangladesh has shown that until 1992, *V. cholerae* O1 belonging to both of the biotypes caused regular epidemics and, since then, both *V. cholerae* O1 and O139 continue to be a significant cause of infection and morbidity, although the frequency of infection varies from year to year in different regions of the country.

As noted above, recent developments in DNA analysis techniques have introduced several new typing methods and has enabled the study of the epidemiology of *V. cholerae* on a larger perspective (Wachsmuth *et al.* 1994; Faruque *et al.* 1995, 1997, 1997b, 2000, 2000b). These techniques include the analysis of restriction fragment length polymorphisms (RFLPs) in different genes. The use of gene probes to study RFLPs in the *ctxAB* genes and their flanking DNA sequences as well as in conserved rRNA genes has been particularly useful. Molecular analysis of epidemic isolates of *V. cholerae* between 1961 and 1996 in Bangladesh revealed clonal diversity among strains isolated during different epidemics (Faruque *et al.* 1995, 1997b, 2000). These studies demonstrated the transient appearance and disappearance of more than six ribotypes among classical vibrios, at least five ribotypes of El Tor vibrios and three different ribotypes of *V. cholerae* O139. More recently, genetic analysis of *V. cholerae* O139 strains isolated in Bangladesh and India since the first appearance of the serogroup in 1992 has revealed the presence of at least six different ribotypes within this serogroup (Faruque *et al.* 2000, 2000b). Different ribotypes often showed different CTX genotypes resulting from differences in copy number of the CTX element and variations in the location of the CTX element in the chromosome (Faruque *et al.* 1995, 1997b). These studies indicated that there had been a continual emergence of new clones of toxigenic *V. cholerae* which replaced existing clones, possibly through natural selection involving unidentified environmental factors and the immunity of the host population.

Influence of genetic variations in the epidemiology of cholera

For the past few years, we have been attempting to understand the molecular variation in successive isolates of *V. cholerae* O1 and O139 and to discern if these genetic variations dictate the emergence of new clones of *V. cholerae.* A pertinent question at this point would be whether the genetic re-assortment in the O1 and O139 strains is accompanied by hitherto undiscovered discreet phenotypic changes in the organism. An important area that needs to be addressed is whether pre-existing immunity against one clone of either O1 or O139 can provide protection against another emerging clone. From an epidemiological viewpoint, it certainly appears that genetic rearrangement fosters some advantage to the emerging clone.

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11

Infection by a New Clone of Vibrio parahaemolyticus*: an Infectious Disease that Emerged in Asia and Spread to a World Wide Pandemic*

NISHIBUCHI Mitsuaki

Vibrio parahaemolyticus is a marine bacterium that contaminates seafood and causes enteric infection in humans. Professor T. Fujino discovered this bacterium as a cause of human gastroenteritis when he investigated a food poisoning case associated with the consumption of semi-dried and salted juvenile sardines in Japan in 1950. Since then, many food poisoning cases occurring in summer in Japan have been attributed to an infection by *V. parahaemolyticus*. *V. parahaemolyticus*-associated gastroenteritis cases and isolation of this bacterium from marine and estuarine environments in tropical and temperate countries have also been reported. Studies on the pathogenic mechanism of *V. parahaemolyticus* revealed that not all strains in the marine environment are pathogenic. Clinical strains were found to produce clear beta-type hemolysis on a special blood agar medium, Wagatsuma agar. This phenomenon was discovered by the workers of the public health lab in Kanagawa Prefecture, Japan, and it was named the 'Kanagawa phenomenon' (KP). Almost all clinical strains showed KP-positive (KP+) phenotype, whereas only 1 to 2 per cent of environmental strains were KP+ (Sakazaki *et al.* 1968, Miyamoto *et al.* 1969). The KP+ was subsequently found to be due to the production of a thermostable direct hemolysin (TDH) (Takeda 1983). TDH is encoded on the *tdh* gene. KP+ strains usually carry two *tdh* genes, and most KP-negative strains lack the *tdh* gene (Nishibuchi *et al.* 1985, Nishibuchi and Kaper 1990). The enterotoxicity of TDH was demonstrated using a clinical strain and its isogenic *tdh*-defective mutant strain where both *tdh* genes were inactivated by allelic exchange methods (Nishibuchi *et al.* 1992). The *trh* gene that is 68 to 69 per cent homologous to the *tdh* gene and encodes a TDH-related hemolysin was first discovered in a group of *tdh*-negative strains isolated from the patients with diarrhea (Honda *et al.* 1987; Nishibuchi *et al.* 1989). Subsequently, molecular epidemiological studies revealed that most clinical strains possess the *tdh* gene, the *trh* gene, or both genes (Kishishita *et al.* 1992; Shirai *et al.* 1990). The *tdh* gene or the *trh* gene is rarely detected in environmental strains (Nishibuchi *et al.* 1985; Kishishita *et al.* 1992, Shirai *et al.* 1990). Therefore, strains carrying the *tdh* gene, the *trh* gene, or both genes are considered virulent strains. The distribution of such virulent strains is very low (less than a few per cent) in the *V. parahaemolyticus* population from the environment. Harvested seafood, if contaminated with a virulent strain, supports propagation of the strain and may serve as the source of cross-contamination of other foods. Bacterial cells, when grown to a high concentration, can establish infection if the food is improperly cooked and ingested.

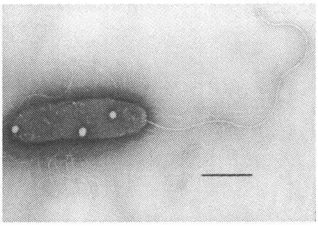
The concept of the pandemic in the history of *V. parahaemolyticus*

The tools to study epidemiology of *V. parahhaemolyticus* infection had been limited until molecular genetic tools became available recently. The KP of the isolated strain was examined in early epidemiological investigations. It is being replaced by the examination for the *tdh* and *trh* genes. The serotypes of O (heat-stable somatic) and K (heat-labile envelope) antigens can vary among the strains and there is a correlation between the O antigen and the K antigen. The serotypes of O and K antigens and their relationship approved in 1996 are listed in Table 11.1 According to this O:K serotyping, *V. parahaemolyticus* strains can be differentiated into more than 70 serovars. The O:K serovar of *V. parahaemolyticus* is thus very useful for epidemiological investigation. *V. parahaemolyticus* infection is usually sporadic, and the causative strain varies from case to case, as evidenced by different O:K serovars in different cases. There have been outbreaks of *V. parahaemolyticus* infection (infection of a large number of individuals who ate the same food), and the O:K serovar of the causative strain also varied from outbreak to outbreak. An exceptional case was the reports on the prevalence of an O:K serovar in several outbreaks; O4:K12 strains were isolated from outbreaks on the western coasts of the United States and Mexico in the 1980s (Abbott *et al.* 1989; Nolan *et al.* 1984).

It has been only recently shown that many sporadic cases and outbreaks of *V. parahaemolyticus* infection occurring in various parts of the world were attributed to the strains sharing not only the toxin gene (*tdh* and *trh*) profile and the O:K serovar, but also other genetic features. Therefore, we judged that the causative strains were clonal and considered that the infections were due to the

Box

Vibrio parahaemolyticus



(Electron micrograph of the *V. parahaemolyticus* cell prepared by Michiko Arita)

Discovery

- ◆ Prof. T. Fujino discovered as a cause of the "SHIRASU" food poisoning case in Japan in 1950.

Ecology

- ◆ A bacterium prevalent in the marine and estuarine environment.

Epidemiology

- ◆ If seafood contaminated with a virulent strain is improperly cooked and consumed, infection is established.
- ◆ Infection has been reported from temperate and tropical countries in the world.

Major virulence genes

- ◆ *tdh* gene: thermostable direct hemolysin (TDH) gene
- ◆ *trh* gene: TDH-related hemolysin gene (*tdh* and *trh* genes are 68% homologous).

Virulent strains

- ◆ Carry the *tdh* gene, the *trh* gene, or both genes
- ◆ Less than a few per cent in the environmental population

(Fresh market in Hat Yai, Thailand [left] and Nha Trang, Veitnam [right] where local fresh seafood is sold).

Table 11.1 Correlation of the serotypes of O and K antigens (Ishibashi *et al.* 1996)

O antigen serotype	K antigen serotype
1	1, 5, 20, 25, 26, 32, 38, 41, 56, 58, 60, 64, 69
2	3, 28
3	4, 5, 6, 7, 25, 29, 30, 31, 33, 37, 43, 45, 48, 54, 56, 57, 58, 59, 72, 75
4	4, 8, 9, 10, 11, 12, 13, 34, 42, 49, 53, 55, 63, 67, 73
5	15, 17, 30, 47, 60, 61, 68
6	18, 46
7	19
8	20, 21, 22, 23, 39, 41, 70, 74
9	23, 44
10	24, 71
11	19, 36, 40, 46, 50, 51, 61
12	19, 52, 61, 66
13	65

spread of a single clone. This type of worldwide epidemic is called 'pandemic'. This pandemic was first recorded in the history of *V. parahaemolyticus*. The discovery was made possible by a combination of two approaches: use of DNA fingerprinting methods and multinational collaboration. The details of the discovery and current situation of the pandemic are reviewed in this paper.

O3:K6 strains isolated from the patients in India and international travelers hinted that a pandemic was occurring

There was a sudden increase in the number of *V. parahaemolyticus* infection in Calcutta, India in February 1996. A collaborative study with Dr. G. B. Nair's group of the National Institute of Cholera and Enteric Diseases in Calcutta was initiated to find the reason. Characterization of strains isolated from the patients revealed that the increase was due to infection by strains belonging to O3:K6 serovar that emerged in February 1996 in Calcutta (Figure 11.1) (Okuda *et al.* 1997). The O3:K6 strains isolated after February 1996 were judged to belong to a unique clone as characterized by unique genetic features (the toxin gene type [tdh^{+}, trh^{-}], the DNA fingerprint generated by an arbitrarily primed polymerase chain reaction [AP-PCR]. This new clone was also detected among the strains isolated from international travelers with diarrhea who came from Indonesia, Thailand, and Singapore to Osaka Airport and Kansai Airport in Japan after 1995 (Okuda *et al.* 1997). The finding suggested that an international spread or the pandemic of infection by the new O3:K6 clone was occurring.

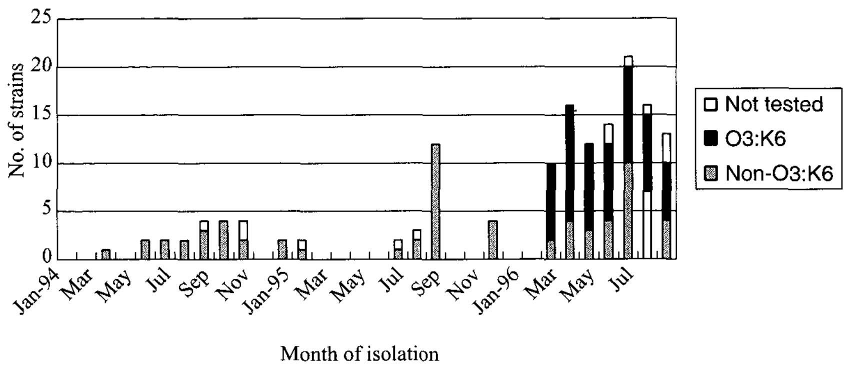


Fig 11.1 Serovars of *V. parahaemolyticus* strains isolated from the patients with Diarrhea in Calcutta, India (Okuda et al. 1997)

A multinational collaborative study confirmed the pandemic spread of O3:K6 strains

We therefore carried out a multinational collaborative study to examine the possibility of the pandemic spread of the new O3:K6 clone. We examined *V. parahaemolyticus* strains isolated from the patients with diarrhea at the International Centre for Diarrheal Diseases, Bangladesh (ICDDR, B) between 1977 and 1998. Of 277 clinical strains examined, only eight strains isolated in the 1980-1981 period and 22 strains isolated in the 1996-1998 period belonged to O3:K6 serovar. Although all strains showed the tdh^+ and trh^- toxin gene profile, only those isolated in the 1996-1998 period exhibited the same AP-PCR profile as that of the O3:K6 strains that emerged in Calcutta in February 1996 (Matsumoto *et al.* 2000). The result indicated that these O3:K6 strains were absent in the 1977-1995 period and emerged in 1996 in the Bangladesh-India area.

Infections by O3:K6 strains were prevalent in many countries after 1997. Investigators in and around these countries collaborated and examined O3:K6 strains isolated in seven Asian countries and the United States (Table 11.2). This study included Laos, where *V. parahaemolyticus* infection had not been reported before. The examined strains showed the same genetic properties as those shared by the recent Indian and Bangladeshi strains (tdh^+, trh^- , a unique AP-PCR profile [Figure 11.2]) (Matsumoto *et al.* 2000). We wished to further confirm the clonality of the examined strains by looking at the genetic property other than the toxin genes and the AP-PCR profile. Our research group demonstrated in earlier studies that the *toxRS* genes are the genes of choice for the phylogenetic study of the bacteria belonging to the family *Vibrionaceae*. These

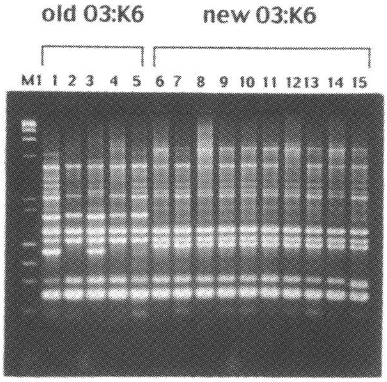


Fig 11.2 AP-PCR profiles of O3:K6 strains. lanes 1-5: strains isolated between 1980 and 1992 (old O3:K6). Lanes 6-15: strains isolated between 1995 and 1998. M1: molecular size markers

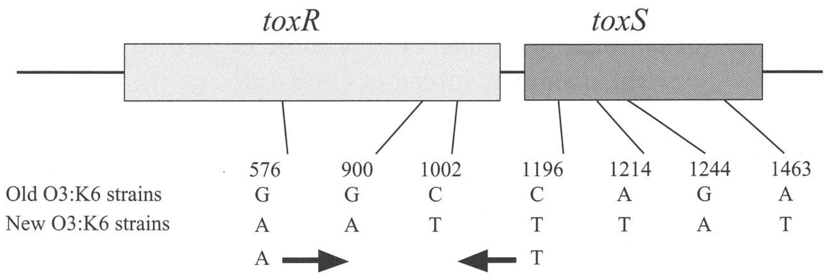


Fig 11.3 Principle of the GS-PCR Method. Difference in the nucleotide bases between the toxRS genes of old and new O3:K6 strains are shown. The GS-PCR primers are targeted to the A base at position 576 and the T base at position 1196 of the new O3:K6 strains. The arrows indicate the directions of amplification of the nucleotide sequence from the new O3:K6-specific primers

genes were originally discovered in *Vibrio cholerae* as a regulatory gene stimulating expression of the cholera toxin gene. However, it is now understood that the genes are conserved in the family *Vibrionaceae* and interspecies homology values of the *toxRS* genes are relatively low (50 to 60 per cent). We therefore utilized the *toxRS* sequence to establish polymerase chain reaction (PCR) methods for identification of *Vibrio* species (Kim *et al.* 1999; Vuddhakul *et al.* 2000; Okuda *et al.* 2001). We postulated that the variation in the *toxRS* sequence is useful even for grouping the strains within the species. When we examined the *toxRS* sequence of representative O3:K6 strains, we found the difference in the nucleotide sequence between the strains isolated before and after 1995 were at seven base positions (Figure 11.3). We then developed a simple PCR method targeting two of the seven bases unique to the strains

Table 11.2 Characteristics of the O3:K6 strains isolated from diarrhea patients between 1980 and 1998

Location/source of isolation	Year of isolation	Gene:			GS-PCR results	No. of strains
		tdh	*trh1*	*trh2*		
Bangladesh	1980-1981	+	–	–	–	8
Int. travelers	1982-1993	–	+	–	–	8
Int. travelers	1983	+	–	–	–	1
Int. travelers	1985-1992	–	–	+	–	4
Int. travelers	1995-1996	+	–	–	+	5
Bangladesh	1996-1998	+	–	–	+	22
India	1996-1998	+	–	–	+	26
Taiwan	1997	+	–	–	+	9
Laos	1997	+	–	–	+	36
Japan	1997-1998	+	–	–	+	35
Thailand	1998	+	–	–	+	20
Korea	1998	+	–	–	+	2
United States	1998	+	–	–	+	21

isolated after 1995 (called 'new O3:K6 clone') to identify the new clone, and we named this PCR method 'GS-PCR' for group-specific PCR. All of the O3:K6 strains isolated from international travelers and the patients in seven Asian countries and the United States between 1995 and 1998 gave positive results in this GS-PCR assay (Table 11.2), which confirmed clonality of these strains (Matsumoto *et al.* 2000). Accordingly, we concluded that the prevalence of infections observed in many countries after 1996 was due to the pandemic spread of the new O3:K6 clone. Subsequently, our collaborators also confirmed the clonality of these strains using other genetic fingerprinting methods: ribotyping and pulsed field gel electrophoresis analyses (Bag *et al.* 1999; Wong *et al.* 2000).

Emergence of variants in the pandemic clone

When we examined the strains belonging to the serovars other than O3:K6 by the GS-PCR method, all O4:K68 strains and some strains of O1:K untypeable (KUT) serovar yielded positive results. All of these strains were isolated in India and Bangladesh and from international travelers after 1997 and showed the toxin gene profile and the AP-PCR profile that were identical to that of the O3:K6 pandemic clone (Matsumoto *et al.* 2000). Our collaborators also showed that the O4:K68 and O1:KUT strains are genetically indistinguishable or very similar to the O3:K6 pandemic clone by using other genetic fingerprinting methods including ribotyping, pulsed field gel electrophoresis analyses, and restriction analyses of a lysogenic filamentous phage genome (Chowdhury *et al.* 2000a; Chowdhury *et al.* 2000b; Chang *et al.* 2000). The genetic relatedness of these strains indicates that they are a part of the pandemic clone. The spreading pattern and chronology of emergence suggest that the pandemic clone of O4:K68 and O1:KUT serovars are serovariants that diverged from the O3:K6 pandemic clone. A recent survey at ICDDR, B in Bangladesh indicated that O1:K25 serovar belonging to the pandemic clone has emerged (Bhuiyan *et al.* 2002).

Prevalence of infection by the pandemic clone in Thailand and Vietnam: possible areas where the pandemic clone emerged

We wondered where in the environment the pandemic clone originally emerged. Among the international travelers coming to Japan, those originating in Thailand, followed by Vietnam, were infected with *V. parahaemolyticus* very frequently (Table 11.3). Our collaborators thus investigated the situation of *V. parahaemolyticus* infection in these countries.

Dr. Sineenart Kalnauwakul's group at the Faculty of Medicine, Prince of Songkla University, Thailand examined specimens obtained from patients with diarrhea in Hat Yai City, Songkla Province, Thailand in 1999 (Laohapretthisan *et al.* 2003). *V. parahaemolyticus* was isolated from 317 of 11,474 diarrhea specimens collected in two hospitals in the one-year survey (Table 11.4). The strains having the genetic characteristics of pandemic clone (GS-PCR+, *tdh*$^+$ and *trh*$^-$ toxin gene profile, a unique AP-PCR profile) accounted for 242 (76.3 per cent) of the 317 strains. Most strains of the pandemic clone belonged to O3:K6 (80 per cent), O4:K68 (8.4 per cent), and O1:KUT (1.8 per cent) serovars. Furthermore, the strains belonging to O1:K25, O1:K41, O4:K12, and O3:weak K6 serovars were also found among the pandemic serovars. Other workers proposed that the nucleotide sequence of the open reading frame 8 (ORF 8) in the genome of a lysogenic filamentous phage is a good marker for the pandemic

Table 11.3 The number of *V. parahaemolyticus*-infected international travelers who arrived in Japan in the year 2000

Origin of travel	No. of patients	Origin of travel	No. of patients
Thailand	108	Taiwan	2
Vietnam	41	Korea	2
Philippines	32	Cambodia	2
China	17	Australia	2
Singapore	14	Macao	2
Malaysia	11	Nepal	1
Hong Kong	11	Bangladesh	1
Indonesia	9	England	1
India	2	Others	2

Table 11.4 Number of *V. parahaemolyticus* strains isolated from diarrhea specimens in two hospitals of Songkla Province, Thailand in 1999

O:K serovar	GS-PCR$^+$, *tdh*$^+$, *trh*$^-$	GS-PCR$^-$, *tdh*$^+$, *trh*$^-$	*tdh*$^+$, *trh*$^+$	*tdh*$^-$, *trh*$^+$	*tdh*$^-$, *trh*$^-$
O3:K6	192	0	0	0	0
O4:K68	21	6	0	0	0
O1:KUT	4	0	2	1	1
O1:K25	22	1	0	0	0
O1:K41	1	0	1	0	0
O4:K12	1	1	0	0	0
O3:K$^-$	1	0	0	0	0
Others	0	33	5	3	22
Total: 317	242	40	8	4	23

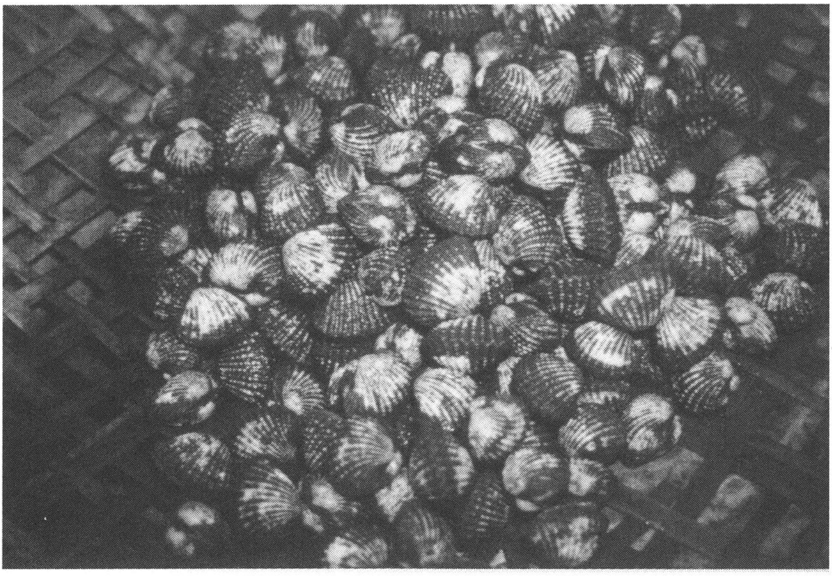


Fig 11.4 Bloody clam (*Anadara granosa*): a shellfish popular in Thailand and neighboring countries

clone (Nasu *et al.* 2000). All pandemic strains detected in this Thai study also possessed the ORF 8 sequence. The result confirmed the prevalence of infection by the pandemic clone and the divergence of the pandemic clone in this area.

People in Hat Yai City enjoy local fresh seafood that is harvested from Songkla Lake and Andaman Sea. Dr. Varaporn Vuddhakul's group at the Faculty of Science, Prince of Songkla University examined the hypothesis that the fresh local seafood marketed in Hat Yai City is the source of the prevalent infection by the pandemic clone in this city. It is not easy to selectively isolate scarcely distributed virulent strains of *V. parahaemolyticus* from an environmental sample that is loaded with non-virulent strains of *V. parahaemolyticus* and other marine bacteria. However, the use of a special selective method, based on the immunoaffinity for the K6 antigen, allowed the workers to isolate an O3:K6 pandemic strain from fresh bloody clam between December 1998 and January 1999 (Figure 11.4) (Vuddhakul *et al.* 2000). This shellfish is relatively cheap, and local people usually eat it without sufficient heating by tradition. The result supports the hypothesis that the pandemic clone is prevalent in the environment around Hat Yai City and that the pandemic clone in this environment probably serves as the source of infection among local people and international travelers through the consumption of fresh seafood in this area.

For the study in Vietnam, we collaborated with the researchers at the Nha Trang Pastuer Institute in Nha Trang, the National Institute of Hygene and Epidemiology in Hanoi, and the International Vaccine Institute in Korea. We surveyed the incidence of *V. parahaemolyticus* infection in Khan Hoa Province (population 345,669) in the period between January 1997 and April 1999. People with diarrhea were encouraged to visit one of forty health care centers in this area. A total of 531 strains of *V. parahaemolyticus* were isolated from the patients with diarrhea. Interestingly, statistical analysis of the patients and healthy individuals revealed that socio-economic factors had more influence on the chance of *V. parahaemolyticus* infection than did the hygienic condition; those who were in higher social status and rich enough to afford seafood were infected more frequently (Tuyet *et al.* 2002). Based on the GS-PCR result, about 50 per cent of the isolated strains were pandemic strains and the pandemic strains belonged to eleven different serovars. Transition of major pandemic serovars, O3:K6 to O4:K68 followed by O1:K25, was clearly observed. Like the study in southern Thailand, the results indicate that the infection by the pandemic clone is prevalent in Khan Hoa Province and suggests that the infection is mediated through the consumption of local seafood. In addition, the emergence and transition of serovariants of the pandemic clone observed in this study area reflected the worldwide tendency, suggesting a possibility that this area could be one of the reservoirs of the pandemic clone.

Conclusions

The O:K serotyping, a conventional method to study the epidemiology of *V. parahaemolyticus*, is and has been the tool employed in the initial analysis of the prevalence of *V. parahaemolyticus* infection. This method was useful in obtaining the clues indicating that the pandemic infection was occurring, but not enough to confirm it. The AP-PCR method, a DNA fingerprinting method, is a very effective tool to confirm the pandemic. The newly-developed GS-PCR method is a useful tool in confirming the pandemic strains, and it also allows the discovery of serovariants of the pandemic clone. Other DNA finger-printing methods including ribotyping, pulsed field gel electrophoresis, and restriction analyses of a filamentous phage genome also corroborated in confirming the pandemic. These molecular genetic methods will be indispensable tools in the future epidemiological study of *V. parahaemolyticus*.

Research collaboration across international borders was also a key to the success in the study of the pandemic. It started as collaboration between the author's lab and Dr. Nair's lab in India. The study was soon expanded to cover a wide geographical area including Bangladesh, Thailand, Laos, Taiwan, Korea, Japan, the United States and, finally, Vietnam in a timely fashion. These investigations were possible because open-minded researchers agreed to collaborate.

The study also included analysis of the strains isolated from international travelers and those isolated from the environment. The results of all of these investigations allowed us to propose a working hypothesis that a new pandemic clone emerged in the Asian environment and then spread to the world. This hypothesis needs to be supported by more evidence, particularly the demonstration of the pandemic strains of various serovars in local environmental samples and imported/exported seafood. Those who are interested in biology of pathogenic bacteria will try to understand why the pandemic clone is so powerful and easily spread across the international borders. These are the subjects we have to study in the near future.

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12

Burkholderia pseudomallei and the Environment

Savithri D. PUTHUCHEARY

Soil, one of earth's most precious resources, is also an important habitat for microorganisms that cause human disease. Melioidosis is caused by *Burkholderia pseudomallei*, a gram-negative, anaerobic, motile bacillus found in the soil as a saprophyte. It was first described by Whitmore and Krishnaswami in 1912, causing 38 fatal cases of pneumonia amongst the destitute and morphine addicts in Rangoon, Burma (Whitmore and Krishnaswami 1912).

The bacterium was originally known as *Bacillus whitmori*, and subsequently as *Bacillus pseudomallei*. The bacterium was reclassified as *Pseudomonas pseudomallei* based on its growth, motility and metabolic characteristics (Redfearn *et al.* 1996, ; Stainer *et al.* 1996). In 1992, Yabuuchi and co-workers reclassified seven species of *Pseudomonas* belonging to homology group II to a new genus, *Burkholderia* (Yabuuchi et al.. 1992). The reclassification was based on the 16S RNA sequences, DNA-DNA homology values, cellular lipid and fatty acid composition and phenotypic characteristics: that now describes Whitmore's bacillus as *Burkholderia pseudomallei.*

The analysis of soil and clinical isolates of *B. pseudomallei* by Wuthiekanun and colleagues revealed two biotypes of the organism which were almost identical in terms of phenotypes and biochemical profiles, except for a difference in their ability to assimilate L-arabinose (Wuthiekanun *et al.* 1996). The arabinose non-assimilators (Ara-) are virulent and can be isolated from both clinical specimens and the environment, whereas the arabinose assimilators (Ara+) are usually avirulent and mainly found in the environment. Further work by Brett *et al* on a comprehensive 16S and 23S phylogenetic analysis supported the existence of a new *Burkholderia* species named '*Burkholderia thailandensis*' (Brett *et al.* 1998). Both strains are structurally and immunologically similar. However, the two strains differed on the basis of the 16S and 23S DNA nucleotide sequences, biochemical profiles and virulence traits.

Geographical distribution of melioidosis

Melioidosis is widespread in Southeast Asia, but the disease remains greatly under-diagnosed. Although the main endemic areas are located between 20°N and 20°S of the equator, recent reports demonstrate that the natural habitat of the organism may be more widespread. Almost all countries in the world have reported patients with active cases of melioidosis either acquired locally or while abroad (Leelarasamee and Bovornkitti 1989).

Large numbers of cases have been reported from Thailand, Vietnam, Malaysia, tropical Australia, Cambodia and Laos. There is also evidence that the disease is endemic in the Philippines, China, Taiwan, the Indian subcontinent, Indonesia, Central and South America. Sporadic cases have been reported from Hong Kong, Hawaii, Fiji, Haiti, Puerto Rico, Japan, France, the Middle East and Africa (Dance 1991). But over the past 15 fifteen years, Thailand has consistently reported more cases of melioidosis than any other country in the world.

Natural habitat of *B. pseudomallei*

Melioidosis is a disease of tropical and subtropical climates and *B. pseudomallei* is found in the soil in these regions. Some of the earliest environmental surveys were conducted by American workers in Malaysia (Strauss *et al.* 1969). The highest isolation rate was found in wet rice fields and other cleared and cultivated areas (Photo 12.1). In the more urban environment of Singapore, the isolation rate was greatest from sports fields (Thin *et al.* 1971). In Thailand the highest isolation rates were also from cultivated areas such as rice field and rubber plantations (Nachiangmai *et al.* 1985). Newly-planted oil palm areas, monsoon drains, marshes, gardens and playgrounds were also found to be positive for *B. pseudomallei* in endemic areas.

In Australia, isolation from the soil has been reported most frequently in paddocks grazed by animals which had contracted melioidosis, or from the water supplied to livestock (Thomas *et al.* 1979 ; Thomas *et al.*. 1981). These workers also found that the most probable number of organisms two months after collection were 100 per g in dry brown soil and 430,000 per g in very moist light clay. Smith *et al.* found that the mean *B. pseudomallei* count in soil in northeast Thailand, where melioidosis is common, was two-fold higher than the mean count in central Thailand where the disease is rare (Smith *et al.* 1995). It is thus

Photo 12.1 Rice field - natural habitat of *B. pseudomallei* (Top) and disruption of the natural habitat (Bottom)

apparent that the sites most likely to yield the organism in Southeast Asia are cleared, cultivated and irrigated agricultural sites.

Soil type and depth

It is generally accepted that cultures of soil surface samples rarely yield *B. pseudomallei* and studies conducted in Thailand have confirmed this. In a study of a single rice farm in northeastern Thailand, the isolation rates of the organism from surface soil were extremely low, none being isolated during the dry season, and only one isolate was obtained during the wet season.

During the wet season, isolation rates increased with the increasing depth of sampling, where the soil was sandy loam down to a depth of 120 cm. During the dry season, the isolation rates were uniform from 30- 90 cm and were only recovered from cultivated and watered areas. *B. pseudomallei* was found in over two-thirds of the rice fields in northeastern Thailand (Wuthiekanum *et al.* 1995).

In northern Australia, *B. pseudomallei* was isolated from samples collected from the clay layer at a depth of 25- 30 cm. No isolates were obtained from the sand layer and only one from the brown sandy loam layer. The clay layer evidently has a marked influence on the ecology of the organism (Thomas *et al.* 1979).

In Malaysia, the organism has been isolated from soil at 8-12 cm and 16-20 cm below the surface. There is also a wide distribution of *B. pseudomallei* in the surface soil and water (Strauss 1969). Soil moisture was an important criteria in the isolation of the organism.

Melioidosis is described as a disease of tropical and subtropical climates, but factors other than climate must also be important in determining the distribution of *B. pseudomallei*, since it is present in varying numbers in regions with largely similar climates. Some of these factors are:

Temperature

The temperature of the soil is an important determinant for the survival of *B. pseudomallei* in the environment; the optimal growth temperature being 18-42 ℃. The optimum growth temperature *in vitro* is 37-42℃ and most workers have found the organism unable to grow at temperatures below 12℃. The conditions in wet rice fields, which have been reported to attain a temperature of 40-43℃ would thus appear to be ideal for the growth of the organism. Furthermore, soil-temperature studies of a cleared area and an adjacent forested area showed temperature ranges of 26-31℃ for the cleared areas and 22-25℃ for the forested areas (Strauss *et al.*. 1969). While forested areas may well have the moisture needed for growth, soil temperatures appear to be well below those needed for optimum growth, which might account for the greater yield of *B. pseudomallei* from cleared areas.

Box

Melioidosis: the disease brought to the public eye through the Vietnam War

The term 'melioidosis' was coined in 1925 by Stanton and Fletcher and is derived from the Greek words 'melis', meaning,a distemper of asses, and 'eidos', resemblance. This was because the disease clinically and pathophysiologically resembled glanders, a chronic and debilitating disease of equines due to *Pseudomonas mallei.* The disease is often fulminating and fatal and is endemic in tropical Southeast Asia, the Caribbean and northern Australia. Melioidosis became known to the world when American soldiers contracted this disease during the Vietnam War. The range of symptoms varies from benign and localized abscess, to severe community-acquired pneumonia to acute fulminating septicemia with multiple abscesses, often leading to death. Melioidosis is a disease that strikes slowly, is difficult to diagnose, is potentially fatal and remains an emerging infectious disease with serious implications as an international environmental and public health problem.

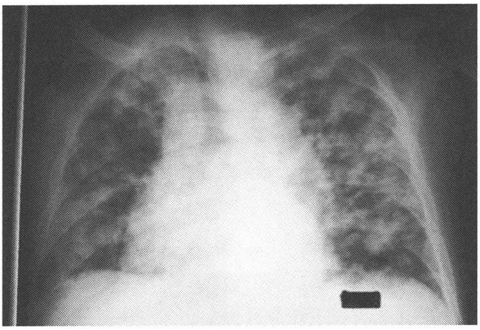

Photo 12.2 Chest X-ray film of the patient with pneumonia.

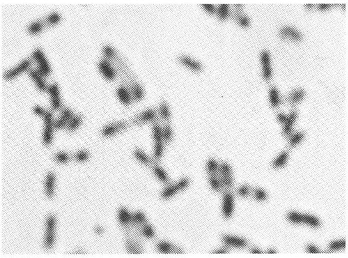

Photo 12.3 Micrograph of *Burkholderia pseudomallei* stained by the Gram method.

Survival of the organism in the environment also depends on the temperature; the optimum for survival *in vitro* appears to be between 24 and 32℃ (Tong *et al.*. 1996). This would appear to favor the persistence of the organism in warm climates.

The organism has been shown to survive for up to 36 months in soil (Thomas and Forbes-Faukner 1981) or distilled water (Withiekanum *et al.* 1995) under laboratory conditions at tropical room temperature. But some strains appear able to survive for long periods, greater than 190 days at 5 ℃ under laboratory conditions (Yabuuchi *et al.* 1993). Although cases of melioidosis have been reported mainly from tropical countries, survival of *B. pseudomallei* for several years in soil was reported during the French outbreak in the mid-1970s (Mollaret 1988).

Rainfall

The incidence of melioidosis in humans and in veterinary practice has a seasonal periodicity in endemic areas, peaking during the months of heaviest rainfall and after flooding. Suputtamongkol *et al.* in Thailand demonstrated the marked seasonal occurrence of melioidosis with 75 per cent of cases presenting during the rainy season, and a strong correlation was shown between the quarterly incidence of melioidosis and the average rainfall during the same period (Currie *et al.* 1993). In addition, dramatic increases in incidence have frequently coincided with heavy monsoon rains in Australia (Merianos *et al.* 1993). In Malaysia, although the percentage of water and soil specimens positive for *B. pseudomallei* was higher during increased rainfall (Strauss *et al.* 1969) (Figure

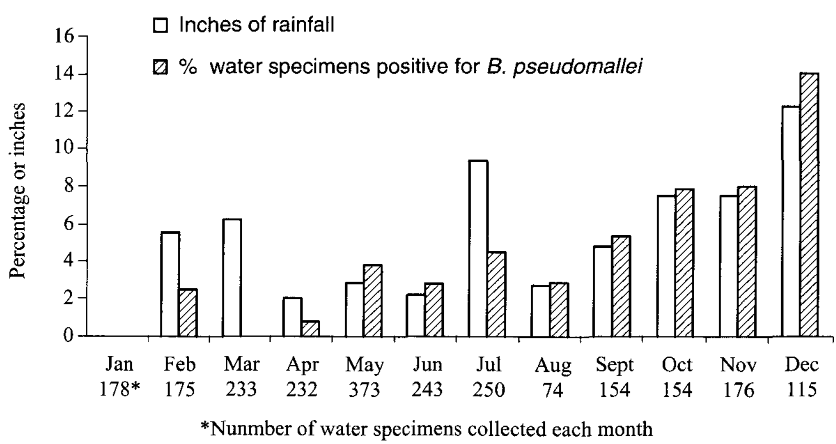

Fig 12.1 *B. pseudomallei* from water in Malaysia (ref. 16).

12.1), there appeared to be only a slight increase in the number of cases during this the period i.e. May-June and October-December from 1976-1978 (unpublished data).

The ease with which *B. pseudomallei* can be isolated from the environment is markedly influenced by reasonably high temperatures, increased humidity and consistent rainfall allowing for the accumulation of stagnant pools and muddy water courses, thus increasing the rates of isolation (Nachiangmai *et al.* 1985). Bacteria and water are thought to be electro-statistically attracted to clay particles which then retain some of the moisture that would normally descend into the water table (Thomas and Forbes-Faukner 1979). During the rainy season the water table rises to the surface, carrying with it bacteria which then multiply in the favorable conditions. It is possible that in this way the organism is adapted to survive in areas experiencing a long, dry season (Strauss *et al.* 1969). But during the wet season there is also increased exposure to the organism during planting and plowing of the rice paddies in endemic areas.

pH

It has been reported that *B. pseudomallei*, when compared with other pseudomonads, is better equipped for survival at relatively acidic pH, as found in the soil of northeast Thailand where the pH of the rice paddy is 4.4- 7.7 (Kanai and Kondo 1994). This organism has been isolated from soil and water of widely varied pH, ranging from 2.8 to 7.4, by Strauss *et al* (1969). Under laboratory conditions it was found to survive best between pH 5.0 and 8.0, although it was able to survive for long periods at pH 4.0 (Tong *et al.*. 1996). The optimum growth *in vitro* was recorded to be at pH 6.8.

Soil and surface waters are highly complex ecosystems in which a vast range of physical, chemical and biological factors interact.

Chemical factors

The chemical composition of soil is highly variable and the potential for soil chemistry to influence the suitability of a particular soil as a reservoir for *B. pseudomallei* is correspondingly vast (Dance 2000). Two factors that might favor the growth and survival of the organism in agricultural land are the use of weed killers and fertilizers. It was reported that the herbicide glyphosate could be used by *B. pseudomallei* as a sole source of phosphorous.

Kanai and Kondo (1994) reported that a serial chemical reaction takes place in the rice paddy by nitrifying and denitrifying bacteria to bring the environment into a more anaerobic condition. *B. pseudomallei* is capable of carrying out anaerobic metabolism and obtains energy by the reduction of nitrates. Thus, the use of nitrate fertilizers might contribute to its proliferation in agricultural land.

Biological factors

The genus *Burkholderia*, like many gram negative saprophytic pseudomonads, multiply in the rhizosphere, which is defined as the region of soil modified as a result of the uptake and deposition of substances by a growing plant root. Although a specific plant host for *B. pseudomallei* has not yet been described, it is plausible that the plant species may play a possible role in the rice paddy field (Pitt 2000).

It is possible that the presence of other bacteria, fungi or protozoa may facilitate or inhibit the growth of *B. pseudomallei* in a particular environment. Inglis *et al.* (2000) demonstrated an interaction *in vivo* between *B. pseudomallei* and the free-living *Acanthamoebae*; : coiling phagocytosis, the survival of *B. pseudomallei* in amebic vacuoles, and eventual bacterial escape from vacuoles into amebic cytoplasm and then into the surrounding medium. A similar interaction *in vivo* may possibly affect the environmental survival of the organism and subsequent human exposure. Incorporation of bacteria in amebic cysts has also been shown to confer resistance to adverse environmental conditions, such as exposure to biocidal agents.

Other factors that might aid in the environmental persistence of the organism are its biofilm mode of growth and its probable existence as a viable but non-culturable state in soil and water.

While these observations are of interest, they do little to narrow down the specific attributes which might enable the organism to persist in some tropical regions better than others, such as hyper endemic foci or "hot spots" that are known to exist in northeastern Thailand and East Malaysia. This may be due to one or more of the following reasons:

1) An unusually susceptible population (e.g.that is, an especially high prevalence of predisposing diseases such as diabetes mellitus, or some other genetic susceptibility);
2) Specific practices (e.g.such as, farming techniques) which expose the population to particular risk of infection.;
3) A localised proliferation of unusually virulent or infective strains of *B. pseudomallei.*
4) A particularly high concentration of *B. pseudomallei* in the soil and waters presumably related to some climatic or geological or ecological features.

Dissemination

Although *B. pseudomallei* is a soil saprophyte, it is important to realize that infected humans and animals might play a role in the transmission of the organism to new environments. The organism is found in the pus, sputum, urine and feces of infected persons, which can contaminate their surrounding environment. Soil, water and plants transported from endemic areas may also carry with them the microorganism with them. Similarly, animals such as livestock as well pets can inadvertently transport *B. pseudomallei* to new environments.

Mode of acquisition

Very little is known about the mode of acquisition of infection, but it seems logical to assume that melioidosis is acquired mainly by contact with contaminated soil and water through penetrating wounds, or existing skin abrasions, ulcers, burns, or by inhalation of dust particles, by aspiration of contaminated water during near-drowning episodes, iatrogenic inoculation and by laboratory accidents. Human-to-human transmission is very rare (Dance 2000).

Thus, exposure to contaminated environments, occurring through occupational or recreational activities, is the most common method of acquisition of *B. pseudomallei.*

Persons at risk

In endemic areas, acquisition is through outdoor activities, occupational exposure being high on the list. In Thailand, farmers make up the largest group of infected individuals. In Malaysia, a variety of personnel such as farmers, forest rangers, construction site employees, lorry, van or bulldozer drivers, carpenters, gardeners as well as others have been reported (Puthucheary *et al.* 1996). These are usually older aged patients who also have diabetes mellitus. Children and adolescents usually get infected via trauma while playing outdoors (Figure 12.2).

Travelers from non-endemic to endemic areas are also at risk, especially with regard to eco-tourism. This is also true of military personnel and other tourists.

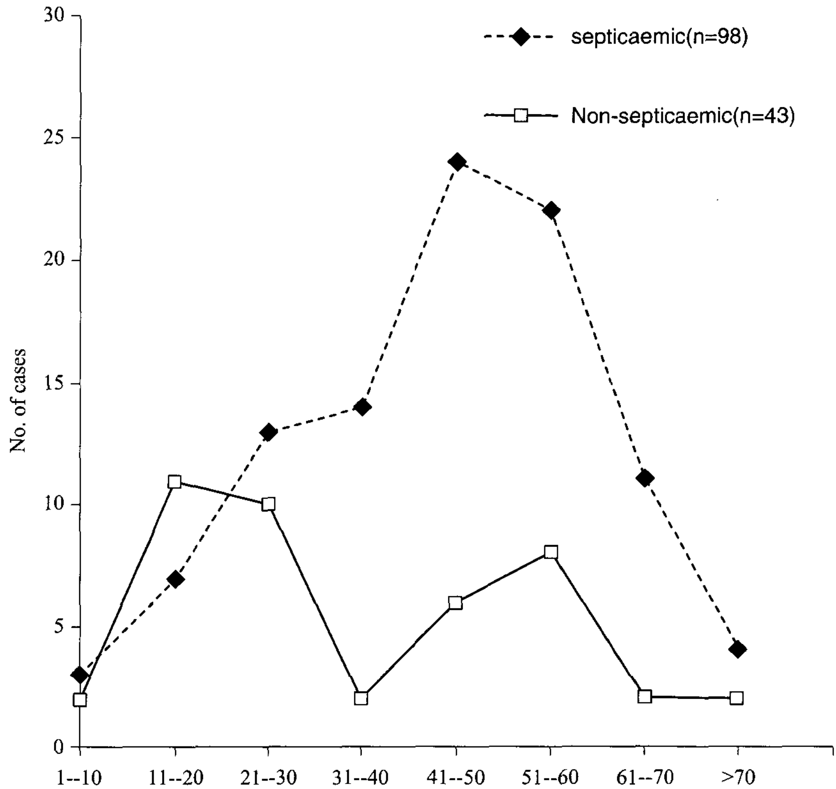

Fig 12.2 Age range (years).

Possible outcome

When humans and animals acquire *B. pseudomallei* from the environment, a number of outcomes are possible. These include:

1) no effect.
2) asymptomatic seroconversion; that is, no clinical signs of infection but specific antibodies to *B. pseudomallei* are detectable.;
3) clinically apparent infection. The host-pathogen interaction will determine the seriousness of the illness.

It must be emphasized that although the first two categories may be the desired outcome after acquisition of the organism, the ability of this organism for dormancy and latency make it possible for the "infected" person to present many years later with clinical melioidosis. In a similar manner, after clinical recovery from the acute illness, the patient may also present with recurrent infections in the future.

Conclusion

B. pseudomallei is a soil saprophyte and the tenacity of the organism to survive in a hostile environment should not be underestimated. There is a homeostatic balance in nature between man, the organism and the environment. Any large disturbance of this equilibrium by activities such as logging, clearing of large tracts of vegetation for the construction of dams and other buildings or other occurrence will upset this equilibrium and result in disastrous consequences for man, animals as well as the environment.

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13
Clinical Ecology of Vector-borne Diseases in Southeast Asia

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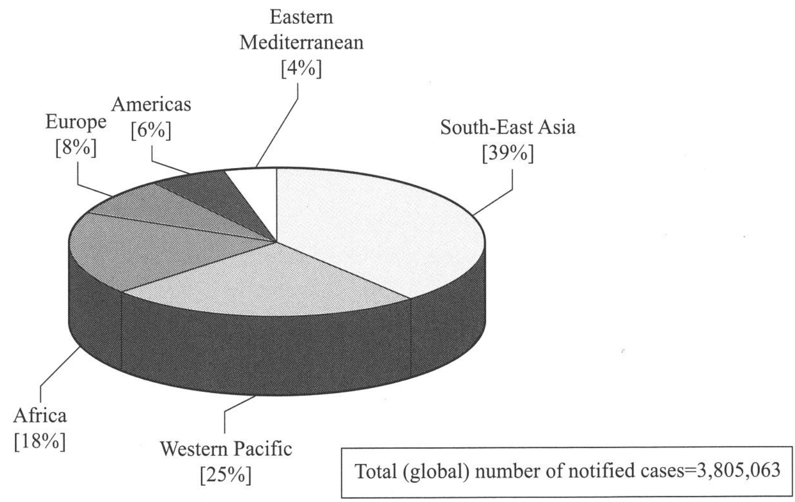
Communicable diseases figure prominently in the spectrum of illnesses in the Southeast Asia Region (SEAR), resulting in nearly seven million deaths every year. Diseases like tuberculosis (TB) and malaria still dominate, with the added concerns of drug resistance. The SEAR, with 25 per cent of the world's population, carries a disproportionate proportion of tuberculosis 39 per cent. This disease kills more adults than any other infectious disease. TB accounts for 750,000 deaths a year among people in their reproductive years, compounding the loss to their families, to their communities, and their countries. The emergence of HIV/AIDS in the mid-1980s is of great concern in the context of infectious disease, especially TB, because of the higher susceptibility of the HIV infected individuals to TB. Areas of SEAR where HIV infection is high have already begun to report higher rates of TB (Figure 13.1).

The SEAR has long accounted for a substantial proportion of total leprosy cases in the world. Presently, Bangladesh, India, Indonesia and Myanmar report approximately 76 per cent of global cases. The introduction of multi-drug therapy MDT in the early 1980s, led to a dramatic decline in the number of leprosy cases. With the introduction of MDT, the number of registered leprosy cases from the SEAR declined from around 3.5 million in 1985 to less than one million in 1998 (Figure 13.2).

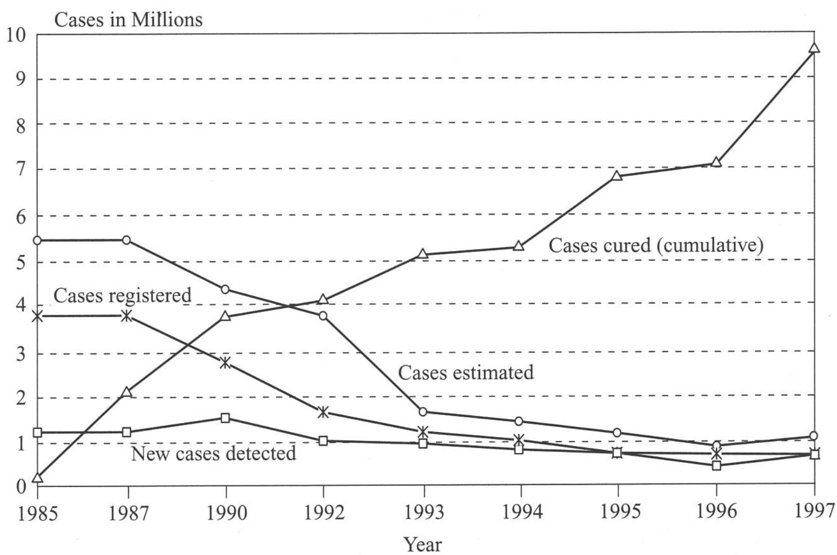
The incidence of HIV/AIDS, as of January 2000, was over 135,000 cases. More than five million people in the SEAR are estimated to be infected with HIV, an alarming 15 per cent of the world's total cases. India, Thailand and Myanmar report the majority of persons with HIV/AIDS in the SEAR (Figure 13.3).

Since 1988, when the World Health Organization adopted the resolution calling for the global eradication of poliomyelitis, significant progress was made for the SEAR. From over 25,000 polio cases in 1988, the number dropped to less



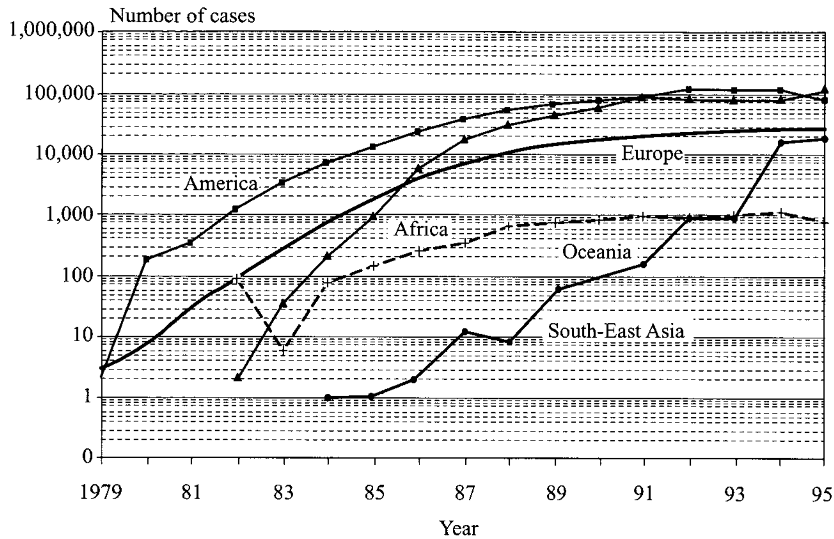
Source: WHO Geneva, TB Control Programme, 1997

Fig 13.1 Reported tuberculosis case by WHO region, 1996



Source: WHO/SEARO, Leprosy Unit

Fig 13.2 Trends in leprosy cases in SEAR



Source: WHO/SEARO, STD/AIDS and Tuberculosis Unit

Fig 13.3 Trends in AIDS cases by region

than 2000 in 1998.

Due to uncontrolled urbanization and industrialization, and wanton deforestation in most countries in the SEAR, much of the degradation is visible in the large cities, with their congested roads, choked sewers and polluted air. Polluted air is one of the main causes of increased acute respiratory infection (ARI) for the SEAR. Drinking water is now available to more people in the rural and urban areas in the SEAR (49.1 per cent and 96 per cent, respectively). Its safety is not assured. Drinking water remains scarce and sometimes contaminated. This is important, considering that the substantial proportion of water-borne and food-borne diseases are cholera, amebic and bacillary dysentery, typhoid fever, and hepatitis A and E. Hepatitis B is highly endemic. Rabies has also been reported from the SEAR (WHO, SEARO 2000).

This chapter focuses on ecological aspects of vector-borne diseases of the SEAR, especially malaria and dengue fever.

Human activities have directly affected environmental ecology (Knudsen and Sloff 1992). Changes in environmental ecology have a great impact on the public health issues of the SEAR. Recently, there has been an increased concern about the rising rate of vector-borne diseases (Knudsen and Sloff 1992). Many countries in this region have had rapid urbanization. The population density in urban areas of the SEAR is, on average, 47.4 per cent. Deteriorating conditions are the result of population growth, poor levels of hygiene, increasing poverty, and the continuous movement of the population from the countryside to the urban areas.

The World Health Organization estimated the population growth in urban areas in the world. In the year 2000, an estimated 39 per cent of the population in developing countries lived in urban areas and, by the year 2025, this figure will increase to 56 per cent. On the other hand, in developed countries, 74 per cent of the population live in urban areas and, by the year 2025, it is expected to increase to 79 per cent (United Nations 1986; Department of International Economic and Social Affairs 1988; United Nations 1991; Knudsen and Sloff 1992; Gubler and Meltzer 1999; Vaughn and Green 2000). High population density is one of the characteristics of SEAR. Population density for the SEAR is 211 people per square kilometer, while population density of the entire world is 43 people per square kilometer. This reflects the fact that twenty five per cent of world's population lives in the SEAR, while its land proportion is only five per cent of the entire world.

This rapid population expansion in urban areas of developing countries has brought about inevitable problems. These include inadequate housing, absence of a safe and reliable water supply poor sewage and drainage systems, and insufficient solid waste management practices. These rapid environmental changes have caused a great impact on the incidence of the major vector-borne diseases in Southeast Asia (Figure 13.4).

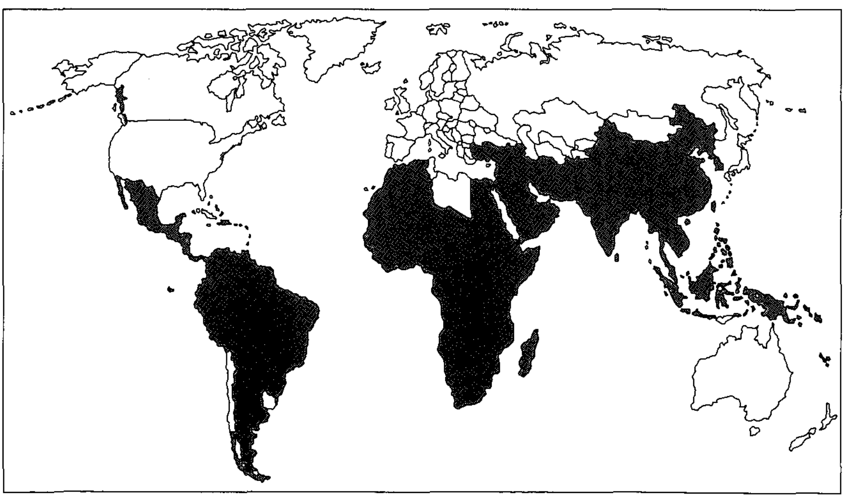
Fig 13.4 View of Antananarivo Madagascar

Vector-borne diseases in Southeast Asia

Vector-borne diseases are present in all countries or areas, except for malaria in Brunei Darussalam and Singapore, where normally only imported cases occur. In the SEAR, Japanese encephalitis, dengue and dengue hemorrhagic fever are endemic in both urban and rural areas. Mite-borne typhus has been reported in deforested areas in most countries of the SEAR. The major vector-borne diseases in the SEAR include malaria, dengue fever, filariasis and schistosomiasis. These vector-borne diseases are an important cause of morbidity and mortality throughout this area.

Malaria

Malaria is one of the most widespread and serious tropical diseases in the world (Figure 13.5). Forty per cent or more of the world's population, or more than 2000 million people, are at risk of contracting malaria in 103 countries. Malaria eradication programs were launched in the mid-1960s and led to a remarkable reduction in cases. Yet by the early 1970s, there were clear signs that malaria had returned. In 1976, the SEAR reported over seven million cases. Several reasons for this resurgence are considered: financial constraints reducing treatment; the development of mosquito resistance to DDT; and degraded



Countrics with Malaria Risk   Countrics with No Malaria Risk

Fig 13.5 Malaria endemic countries

environments. By the 1980s, the incidence of *P. falciparum* malaria increased, and mortality from malaria is on the rise in many countries.

Strategies for malaria control have been revised several times. In 1992, the global strategy for malaria control by WHO was to prevent mortality and reduce morbidity as well as reduce social and economic loss. In 1998, the WHO, Unicef, the UNDP and the World Bank adopted the Roll Back Malaria initiative.

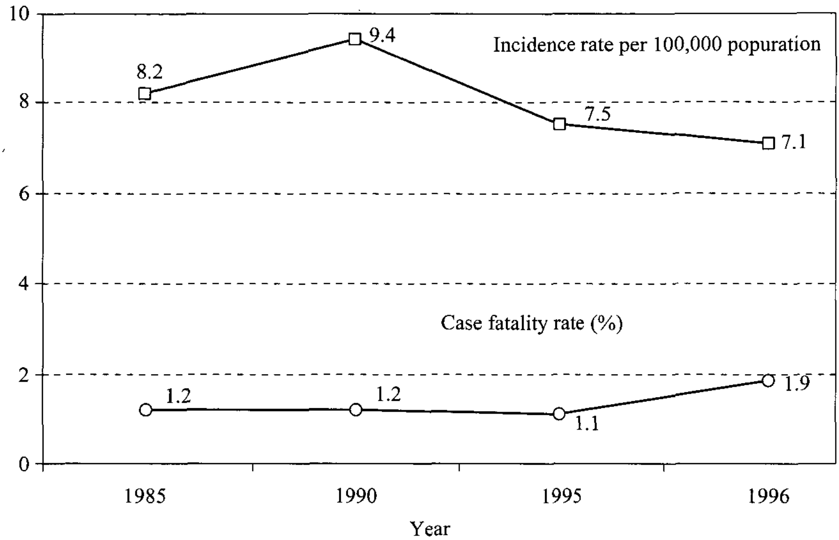
It is estimated that there are 110 million clinical cases of malaria every year with around 280 million people infected. Africa has the highest number of cases. Outside the African continent, 95 per cent of the 5.2 million cases reported to the WHO in 1989 came from 25 countries, with India accounting for 39 per cent. Brazil was at 11 per cent and the remaining top six countries in descending order were, Afghanistan, China, Myanmar, Sri Lanka, Thailand and Vietnam accounting for a total 25 per cent of the world is cases. Among the top six countries, four countries are in the SEAR. Malaria is increasing in all areas where people strive for economic development and in those areas where war, lawlessness, and refugee migrations are commonplaces. Figure 13.5 shows the malaria endemic countries of the world in the year 2000 according to the statistics of the CDC.

Dengue and dengue hemorrhagic fever

Dengue is considered to be the most important arbovirus disease affecting humans. In its fatal form, it is known as dengue hemorrhagic fever (DHF). It was previously restricted to Southeast Asia and the Pacific. Dengue fever was first reported in the SEAR in an epidemic in Thailand in the 1950s. It later spread to other countries and today is endemic in Bangladesh, India, Indonesia, Maldives, Myanmar, Sri Lanka, and Thailand. The reported cases of dengue fever to the World Health Organization has increased noticeably since 1980 (Figure 13.6). The reported cases increased from less than one million between 1950 and 1980 to nearly four million between 1981 and 1998 (Gubler 1997). A vaccine for dengue fever was developed in Thailand and now vaccination trials are currently being conducted.

Vector-borne disease and ecology

This section describes methods to overcome the vector-borne diseases through environmental interventions and using some case examples.



Source: WHO/SEARO, Division of Integrated Control of

Fig 13.6 Trends in dengue/dengue haemorrhagic fever

Changing human habitats and behaviors

Housing and vector-borne disease (malaria)

A case example to demonstrate the relationship between housing and vector-borne disease occurred in Kataragma, Sri Lanka. People living in poor housing (incomplete walls and roofs made of palm thatch and mud) had a higher malaria incidence rate of 21.2 per cent compared to 10.5 per cent of the people living in houses with complete brick, plaster walls and tile roofs. The poorer homes also experienced a higher mean mosquito density during the wet and dry seasons.

Zooprophylaxis for diversion of mosquito vectors of Japanese encephalitis (JE)

It is recommended that pig pens be situated away from homes and rice fields to help reduce Japanese encephalitis virus transmission by *C. tritaeniorrhynchus*, the major JE vector in Japan and China.

Community sanitation for suppression of dengue vectors (dengue fever)

In 1978, in urban Suva, Fiji, an environmental sanitation program for the control of *A. aegypti* and *C. quinquefasciatus* successfully used a combination of community cleanup of larval foci (containers) by hired labor, distribution of pamphlets, monthly inspections for mosquito production sites and an ultra-low volume spray of malathion.

Environment modification

Water supply and vector-borne disease (schistosomiasis)
The provision of piped communal and individual water supplies to houses reduced the transmission of *S. mansoni* in the Riche Fond Valley in St. Lucia between 1970 and 1975.

Community participation in malaria
The Sarvodaya Malaria Control Research Project in Sri Lanka conducted several experiments in community-based malaria vector control from 1984 to 1986. The project had success in reducing the density of anophelines in test villages using an environment management (EM) approach with community participation.

Vector control by using the environment management approach

This section explains the environment management approach as an efficacious tool for vector control (Arata 1994).

What is environment management for vector control?
There are three major approaches to vector control using EM: one) environment modification, creating permanent or long-term changes in a vector's habitat; two) environment manipulation using temporary or repetitive measures to manipulate the natural factors that limit vector reproduction and survival; three) reducing human contact with infective vectors by zooprophylaxis and modification of human habitats.

Current uses of EM in vector control
Human economic activities, particularly rural development (construction of roads, dams and reservoirs) and urbanization, often physically disrupt vector habitats, reduce the abundance of natural enemies and reduce the stability and diversity of the ecosystem. This disruption often creates new or expanded habitats readily utilized by vectors. People displaced from the rural economy often become immigrants to the cities and may carry the infection to the city from the rural area where vector-borne tropical diseases are more prevalent. The infected vectors themselves may be transported into towns and cities in the vehicles or in the belongings of displaced people and migrant laborers.

Why EM is desired and needed?

Currently there is a renewed interest in EM among vector control specialists, partly in response to a series of problems faced by many vector control programs. These problems include the increased costs of insecticide production, marketing and distribution as well as stricter toxicological testing and vector resistance to certain insecticides. Vector control problems are being viewed more often as an unforeseen consequence rather than a symptom of changes in the ecosystems made by humans. Solutions are also being sought not solely through traditional eradication programs, but also through the use of EM, where a deeper understanding of vector ecology can be integrated into the various control strategies.

Conclusion

There has been a long conflict between economic development and the prevention of diseases of environmental origin, especially in developing countries. The problem in developing countries is that people tend to be in favor of strong economic development rather than environmental disease management. The construction of the Aswan-High Dam in Egypt is a good example of this conflict. The construction of the Aswan-High Dam caused an increase in the prevalence of shistosomiasis. What was supposed to be an economic benefit with increased access to electricity and flood prevention, resulted in higher disease. Rapid urbanization without due preparation of the infrastructure (roads, waste management and water supply) is one of the main causes of the increase in communicable disease.

The environment influences not only communicable diseases, but also non-communicable diseases. For example, in Cairo, there is an increase in respiratory illness due to air pollution. Also, it is reported by USAID that a high concentration of zinc near one factory in Cairo has caused a decline in the IQ of primary school children in that area. For vector control, we believe that we should not only focus on killing the vector, but also focus on managing the environment - making vector management very efficient and cost effective. A global and integrated project of vector control programs should be developed, taking into consideration future social and economic factors. To do this successfully, health through community participation will be vital in changing human behavior.

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14
Malaria Control Studies in Indonesia and Solomon Islands

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Malaria, together with tuberculosis, is the most important single agent disease, not only in Asia, but also around the world. More than 40 per cent of the world population live in malarious areas and are facing the risk of malaria infection everyday. It is estimated that every year about 0.3 to 0.5 billion people are infected with malaria and, 1.5 to 2.7 million people, mostly children, die of malaria. The numbers of malaria cases in Southeast Asian and western Pacific regions are summarized in Tables 14.1 and 14.2.

The World Health Organization (WHO), after terminating their Malaria Eradication Program, started the Malaria Control Program and advised every country to utilize the Primary Health Care (PHC) system to cope with malaria problems using early diagnosis and treatment. This measure was suggested by a declaration at the Alma Ata in 1978. Facing problems such as the environmental hazards of DDT, the resistance of malaria parasites to chloroquine and financial problems, the WHO was forced to resort to a rather passive strategy.

Diagnosis and treatment of fever cases are not enough to block transmission in the villages and efforts of passive case detection will have to continue endlessly forever.

In many countries in Asia, malaria is a high priority public health problem. Despite this two countries have success stories. In recent years, Vietnam has succeeded in reducing mortality, mostly in adults, by introducing a new own national product of anti-malarial drug, Artemether. And the Solomon Islands reduced the prevalence of malaria by distributing bed nets using the support of WHO and other donated funds. However, in many other countries people are

Table 14.1 Malaria profile of countries of SEAR (Southeast Asia region) 1998

Country	Malaria Cases		Malaria Deaths	
	Reported	Estimated	Reported	Estimated
Bangladesh	60,023	453,486*	528	2,000
Bhutan	7,693	13,500	17	30
India	2,146,935	15,000,000*	658	19,500
Indonesia	160,282	3,232,762*	45	700
Maldives		No indeginous transmission		
Myanmar	100,419	2,450,000*	3,182	5,000*
Nepal	8,895	20,737*	7	15
Sri Lanka	211,691	225,000	115	125
Thailand	131,055	125,583*	688	880*
SEAR 98	2,826,993	21,521,068	5,240	28,250
SEAR 97	3,327,555	21,150,580	5,222	28,185
SEAR 96	3,706,694	25,924,348	8,053	30,816

WHO

Table 14.2 1998-2000 Malaria cases and deaths in WPR (Western Pacific Region, WHO)

Country	1998		1999		2000	
	C	D	C	D	C	D
Cambodia	66,140	621	58,478	891		
China	27,090	24	26,797	67	18,620	39
Republic of Korea	3,932	0	3,621	0	4,142	1
Lao PDR	41,623	485	29,367	339	40,006	350
Malaysia	13,491	27	11,106	21	12,705	35
Papua New Guinea	20,900	651	18,564	567	81,192	617
Phillippines	50,709	262*	37,061	755	11,452	190
Solomon Islands	72,808	33	63,131	24	67,884	38
Vanuatu	6,181	0	5,152	0	6,416	-
Viet Nam	72,091	183	75,534	190	74,329	148
Total	374,965	2,024	328,811	2,854	316,746	1,418

*1998 figure is based on 1996 data.

Some of the 1999 data has been submitted unofficially, and may be subject to revision.

still suffering from malaria due to widespread outbreaks, a high transmission rate, and the resistance of the disease to multiple drugs.

There are large problematic malarious regions in Asia, such as West Asia, the Indochina Peninsula and the southwest Pacific islands. On the Indochina Peninsula, the most serious problem is multiple drug resistant malaria parasites. Many programs are in place to fight malaria including the Mekong Malaria Project and the Border Malaria Project.

From 1978 to 1989 we worked on malaria in North Sumatra, Indonesia and most recently in the Solomon Islands. In North Sumatra people suffer from mesoendemic seasonal malaria, which is transmitted by *Anopheles sundaicus*. In the Solomon Islands, similar to Africa, people suffer from holoendemic malaria, which is transmitted by *Anopheles farauti.* In the holoendemic area, sooner or later almost everyone gets infected.

Our study in North Sumatra was done as a community health project supported by the Japan International Cooperation Agency (JICA). In conjunction with an Indonesian national development project, the Asahan Project, the program began in 1978 and lasted for eleven years.. The Asahan Project built a hydroelectric power station near Lake Toba and an aluminum smelter factory in the coastal area of the Asahan Regency.

The study in the Solomon Islands began in 1993, first with a research grant from the Japanese Ministry of Education, followed by a grant from the Japanese Ministry of Health.

To control malaria, based on a series of epidemiological studies, we developed new methods of diagnosis and treatment strategy. We attempted to block malaria transmission by attacking malaria's sexual stage: gametocytes.

Study area and methods

North Sumatra, Indonesia

The Asahan Regency was the project area. The initial epidemiological study revealed that malaria was a problem mostly in the coastal area. We identified a spleen rate of under 50 per cent showing that the malaria there was intermediate or mesoendemic. We used repeated visits to community villages and schools to perform chemotherapeutic control with mass examination and treatments by experts and local staff. The Provincial Medan Laboratory offered rooms for laboratory works and performed the microscopic examination of blood smears.

We introduced a new G6PD deficiency detection method incorporating the formazan formation on an agar plate (Fujii *et al.* 1984).

Solomon Islands

Three community villages-Talaula (village A), Bambara (village B) and Kolona (village C) on Guadalcanal Island were selected as the project study area. The population of these villages is around 200, and people live on subsistence agriculture and some fishing. Bambara faces the sea. They are about 50 to 60 km from the capital city of Honiara. The villages are separated by about 2 km.

In Talaura (A), people testing postive were treated with chloroquine and primaquine. In Bambara village (B) we used chloroquine alone. And in Kolona (C) we used chloroquine, primaquine and bed net distribution.

Box

Spleen rate

The enlargement of the spleen has long been known as an indicator for the fever disease, malaria. Children aged two to nine are the target group for examination for an enlarged spleen in order to obtain epidemiological indicators of malaria endemicity (Photo 14.1). If spleen rate is higher than 75 per cent, as in such places as Africa and the Solomon Islands, the area is called holoendemic: meaning malaria is highly endemic and all people are infected with malaria sooner or later.

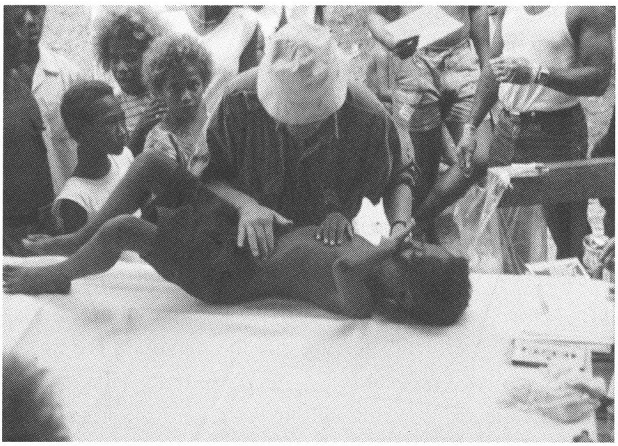


Photo 14.1 Touch examination (Palpation) to determine the spleen rate.

A mobile team consisting of researchers, local staff and a driver visited with equipment and medicine once or twice a year. We tried to introduce an ultrasonographic machine to detect splenomegaly, acridine orange fluorescent staining, DNA diagnosis (including micro-titer plate hybridization), and immunochromatographic methods (ICT/Pf/Pv and others) to detect the malaria infection (Ohmae et al. 1991; Kawamoto 1991; Wataya et al. 1991, 1993; Uchida et al. 1995).

The agar plate method of Fujii as improved by Hirono *et al.* (1998) was used to detect G6PD deficiency as a single-step screening method (SSS or tube method). The tube method made it possible to detect G6PD deficiency within 20 to 40 minutes in the village on the day of the examination (Iwai *et al.* 2001; Tantular et al. 1999).

Box

G6PD deficiency

This is a most common hereditary enzyme deficiency in the red blood cell, which makes chemotheraphy of malaria difficult. About 400 million of the world population has this deficiency and very often the deficiency rate is high in malarious areas. The real reason is not known, but there is a report that the deficient subject does not suffer as much from severe malaria. One problem we have with this deficiency is that primaquine and some other drugs may cause hemolysis when given. This drug prevents relapse of vivax malaria and kills gametocyte to block the transmission of, especially, falciparum malaria. Detection of G6PD(glucose-6-phosphate dehydrogenase) deficiency has long been done using a spectrophotometric method but a new simple method, was invented and is available in Japan (Photo 14.2).

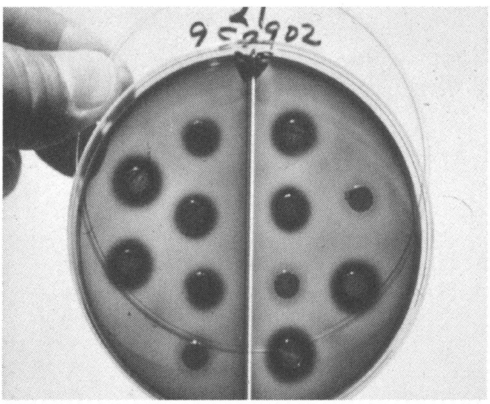


Photo 14.2 The agar method of Dr. Fujii, used to examine G6PD (glucose-6-phosphate dehydrogenase) deficiency. A black color reaction indicates normal and a non-black small reaction, G6PD deficiency.

We used primaquine in addition to chloroquine for the purpose of transmission blocking. We did not give primaquine to G6PD deficient subjects to avoid the possible adverse effect of hemolysis caused by primaquine administration.

With these new methods, we conducted the malaria control visits as a selective primary health care activity using a mobile unit in these remote rural

Box

Parasite rate

The percentage of infected people in a target population is the most important indicator of malaria endemicity. Malaria is principally a disease of children and the parasite rate in children is higher than in elderly people. The real parasite rate in a population is calculated after adjusting the rate from that of children using an age constitution profile in the population calculation (Photo 14.3).

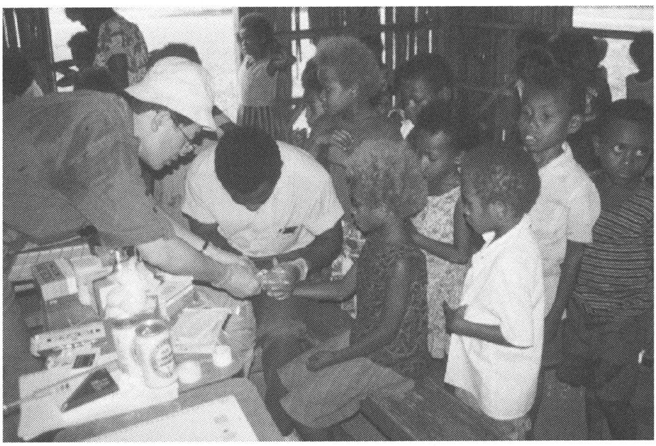


Photo 14.3 Blood examination for the determination of the parasite rate in school children in the Solomon Islands.

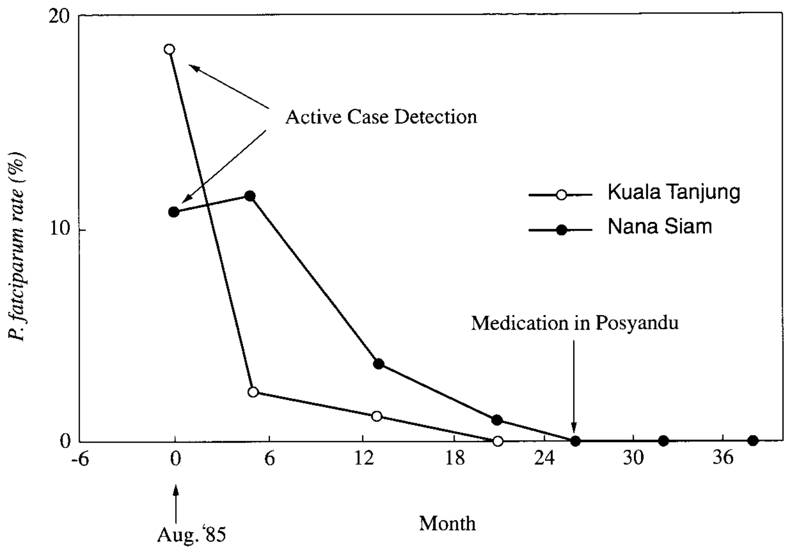
villages.

Further, we introduced a mathematical model of malaria epidemiology and tried computer simulation to analyze and predict the outcome of our operational trials (Ishikawa *et al.* 1996; Ishikawa *et al.* 2000).

Results

North Sumatra, Indonesia

Mesoendemic malaria, mainly *Plasmodium falciparum* and *P. vivax*, was found in coastal villages (Kanbara and Panjaitan 1983, Doi 1990). Spleen rate was



The changes of *P. falciparum* rate under drug treatment

Fig 14.1 Decrease in parasite rate (*P. falciparum*) in two rural villages in North Sumatra, Indonesia under selective chemotherapeutic malaria control (Doi et al. 1988 Cited by Ishii, 1991).

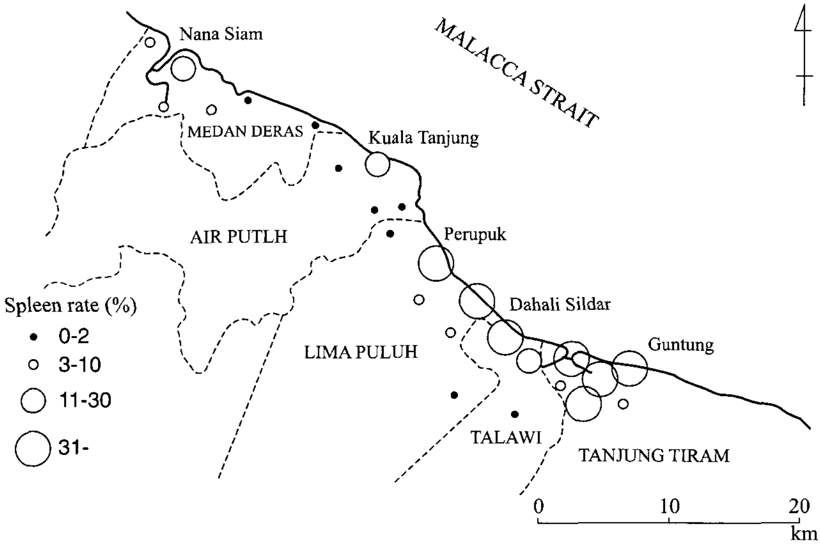
examined by palpation and found to be between 30 and 50 per cent. The malaria was not evenly distributed but interestingly it was rather patchy.

Experts found that gametocyte carriers were mostly in the age group of less than twenty years. The most important finding was a gametocyte density higher than 100/mm^3 blood in the age group under fifteen years (Itokawa *et al.* 1989). Fujii's agar plate method revealed around 5 per cent of G6PD deficiency in the area (Matsuoka *et al.* 1986).

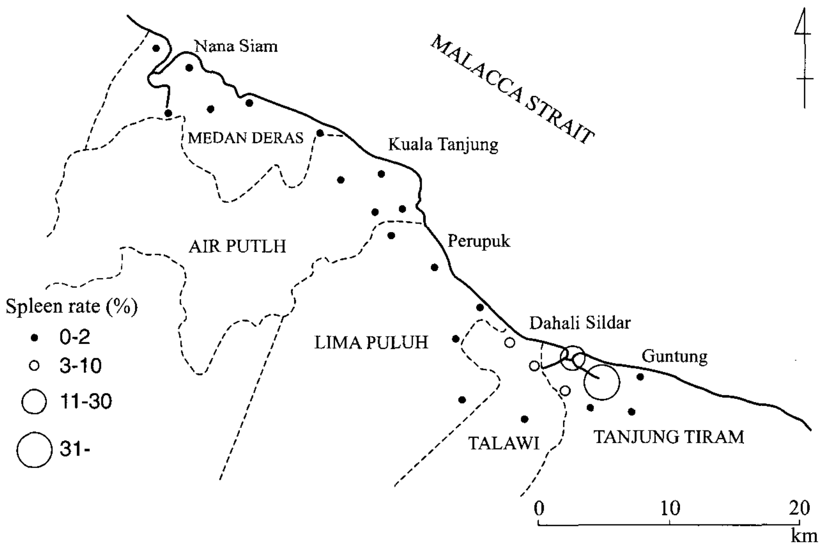
After using this selective age group chemotherapeutic malaria control method with not only chloroquine but also primaquine, the parasite rate and spleen rate decreased to nearly zero (Doi *et al.* 1989; Ishi 1991; Kaneko *et al.* 1989; Matsuoka *et al.* 1987) (Figures 14.1 and 14.2).

Solomon Islands

The detailed results of this study were reported in Ishii *et al.* (1998). Only the essential points are summarized below. In three villages, parasite rates were very high,. More than 50 per cent of school children showed positive results for malaria infection. Even after adjusting for the demographic profile, the parasite rate was estimated at higher than 20 per cent.



Coastal malarious area in 1985/86



Coastal malarious area after chemotherapeutic control in 1988

Fig 14.2 Malaria in coastal villages in Asahan regency, North Sumatra, Indonesia. Upper figure shows patchy distribution of malaria expressed in spleen rates. Lower figure shows decrease of spleen rates after chemotherapeutic control. Tanjun Tirum was untreated as a comparison area. (Doi et al. 1988 Cited by Ishii, 1991).

Box

Vectorial capacity (C)

This is a transmission probability index and is used to express the efficiency of the vector mosquito to transmit malaria. The formula is: c=ma2pn/-logeP where m is the relative density of female Anophelines; a, the probability that the mosquito will take a human blood meal during a particular day; and pn, the proportion of vectors surviving the parasite's incubation period. If C is higher than 10, there will be holoendemic malaria like that occurring in Africa and the Solomon Islands. The vectorial capacity of the vector Anopheline mosquito in the area decides the level of endemicity of malaria occurring. However, the actual provision of the capacity is difficult in the field, where entomological inoculation rate is now used more often.

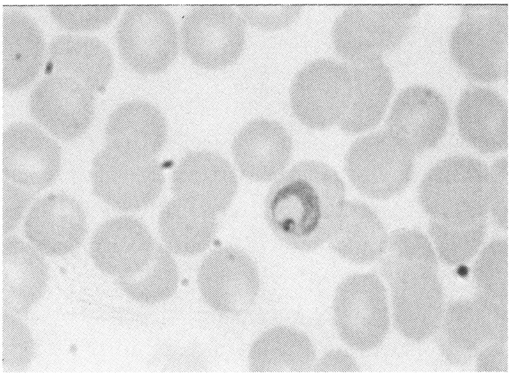


Photo 14.4 The malaria parasite (*Plasmodium vivalx*) detected in a blood smear sample in the Solomon Islands.

Fujii's method, and later Hirono's method, of single step screening (SSS or tube method) for the detection of G6PD deficiency was used, and around 10 per cent deficiency rate was found (Ishii *et al.* 1994). We did not give primaquine to G6PD deficient subjects.

In the later years of the study, we introduced an immuno-chromatographic method (ICT/Pf/Pv) to detect the malaria infection.

In spite of the repetition of our treatment operation, it was not easy to reduce the parasite rates, largely because of frequent reinfection due to the high

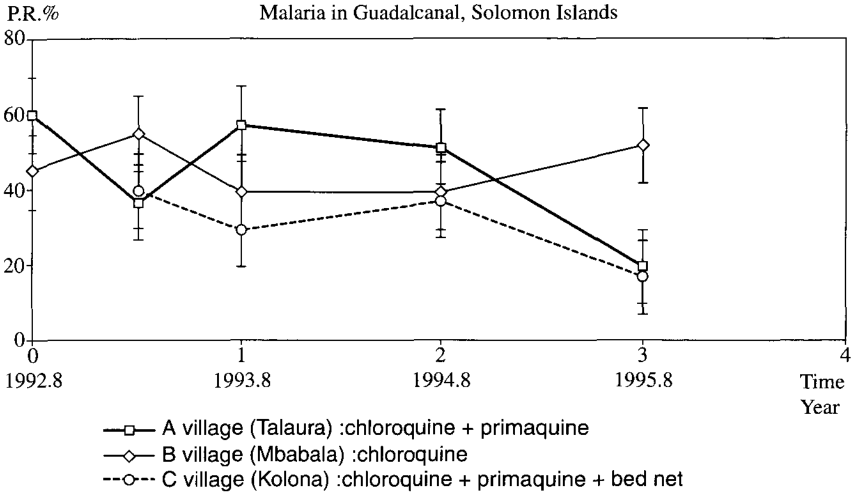


Fig 14.3 Sequential changes of malaria parasite rates in three villages in Guadalcanal, Solomon Islands after a series of control visits. Difference in parasite rates between B compared to A and C villages was statistically significant. B village was Given only chloroquine and A, C villages received primaquine treatment

transmission of malaria in the Solomon Islands. However, after the fifth visit, two and half years later, we found a statistically significant reduction of the parasite rate in villages A and C as compared to village B. This means the use of primaquine did reduce parasite rates more effectively than using chloroquine alone (Ishii *et al.* 2000) (Figure 14.3).

The people of the village were very cooperative as the control activity was easy to understand. This was particularly the case after we introduced the safer ICV/Pf/Pv and the test tube method of G6PD detection.

We found that reducing the vectorial capacity of the mosquito was very important. This was shown by the use of mathematical models. For the purpose of the reduction of vectorial capacity, bed net distribution is now promoted by donor agencies.

Another important point we proved, from the computer simulation of a stochastic mathematical model by Dr.Nakazawa *et al.*, is that even if we had an 80 per cent effective malaria control measure, it is necessary to attain a higher coverage of the population, preferably greater than 85 per cent. If we could attain 85 per cent coverage, we would be able to control malaria within a year (Nakazawa *et al.* 1998) (Figures 14.4 and 14.5).

We are now proposing a new method of malaria control; that is, to conduct selective age group chemotherapeutic control based on computer simulations of malaria epidemiology (Ishii *et al.* 1998; Ishii 1998; Ishii *et al.* 1999; Ishii *et al.* 2000).

Discussion

Recently, the malaria control strategy has been largely based on the WHO policy. The Primary Health Care (PHC) approach is recommended, and every country is requested to reduce mortality and morbidity of malaria in children and pregnant women. Early diagnosis and treatment is essential to prevent mortality and morbidity. Vietnam and the Solomon Islands have succeeded in complying with this. This was a most important first step for malaria control, but we must make further efforts to attain this level of control in all countries.

However, as we encountered in the Solomon Islands, malaria infection exists in the villages in the asymptomatic-carrier state. More than half of the children in schools carry the malaria parasite in their blood and some of them suffer from

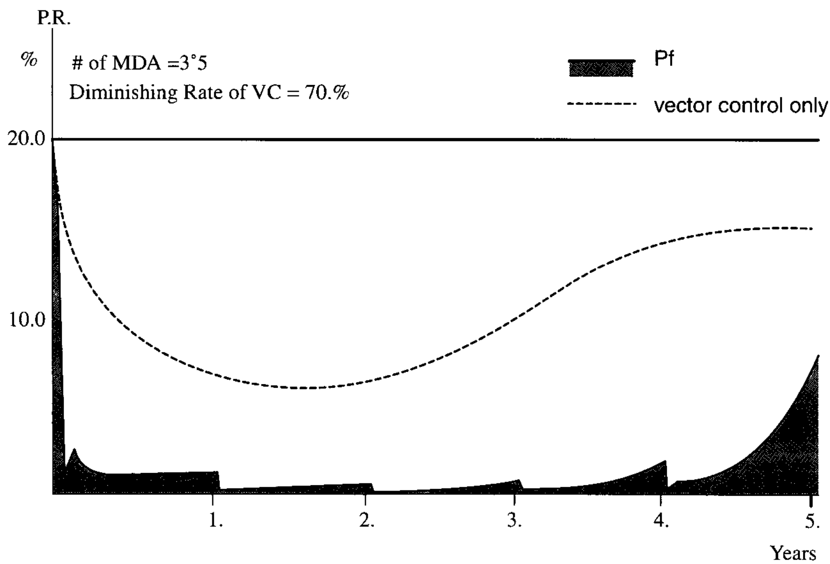


Fig 14.4 An example of computer simulation of malaria epidemiology in the Solomon Islands (Ishikawa Model). Adjusted parasite rate was around 20%. Dotted line shows predicted curve of parasite rate after 70% reduction of the vectorial capacity of mosquite by only vector control: fairly effective but later rebound occur probably due to loss of immunity. Thatched area shows predicted amount of malaria by chemotherapeutic malaria control with chloroquine and primaquine after reduction of vectorial capacity down to 30% by vector control such as bed net use.

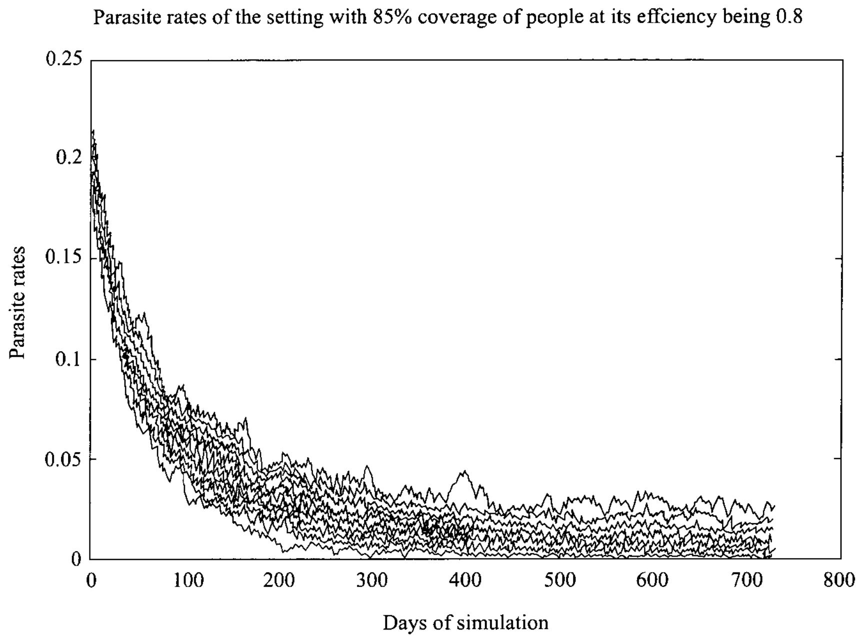


Fig 14.5 An example of computer simulation of stochastic malaria model (Nakazawa model). Parasite rate will reach to zero within one year if we could have an 80% effective control measure and attain 85% coverage of the population.

fever and require treatment. Cases of mortality and morbidity are just the tip of the iceberg. Unless we eradicate the large malaria reservoirs in the villages, diagnosis and treatment will have to continue indefinitely.

In North Sumatra, we have succeeded in reducing the parasite and spleen rates using chloroquine and primaquine in chemotherapeutic trials within the selected age group.

In the Solomon Islands, we failed to do so because of frequent reinfection in a holoendemic state of intense transmission.

Our analysis, based on the mathematical epidemiology model, revealed that the vectorial capacty of the vector mosquito is of paramount importance. Vectorial capacity determines the level of malaria transmission. The reason why Africans suffer from holoendemic malaria is because they have *Anopheles gambiae*, which has a high vectorial capacity of greater than ten. This is also true in the Solomon Islands, where they have *A. farauti*. Our estimation of its vectorial capacity was 13.8.

In North Sumatra we reduced the prevalence of malaria after our treatment trials. The reason for this was that they have *A.sundaicus*, which has a low

Box

ICT/Pf/Pv

To detect the malaria parasite in the blood, a smear stained with Giemsa dye solution is examined by microscope (Photo 14.4). This has been practiced for over a century. Recently, immuno-chromatographic detection of malaria was invented to replace the microscope. ICT/Pf/Pv is a kit product originally from Australia. It is simple to use, with blood collected by finger prick and a quick result can be read by anyone without special knowledge or training (Photo 14.5). The problem is that it costs a lot.

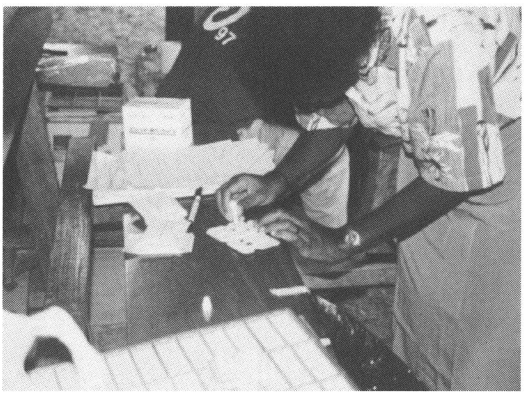


Photo 14.5 Examination of a blood sample using an immuno-chromatographic test kit.

vectorial capacity of around 5. Therefore, we must reduce the vectorial capacity first if we are to effect malaria control in holoendemic malaria areas.

Once the vectorial capacity is reduced by vector control measures such as bed net distribution, it will be possible to control malaria using our method of chemo-therapeutic control with not only chloroquine, but also with gametocytocidal primaquine.

Now that we have new methods of malaria detection with ICT/Pf/Pv and the tube method for detecting G6PD deficiency, we should be able to control malaria in the villages. A mobile unit works efficiently in selective primary health care activity. As Walsh and Warren proposed, selective PHC activity can involve not only malaria control, but other community health activities, such as tuberculosis control (Walsh and Warren 1979). In Vietnam they have already started to use mobile units for providing community health.

One thing we should keep in mind is that coverage of higher than 85 per cent of the population is necessary to make this method effective.

Acknowledgements

We wish to thank the Japanese Ministry of Education and Ministry of Health for their financial support.

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15

Effects of Intensification of the Traditional Farming System on the Environment and Bio-safety of the Human Population: Nipah Virus Outbreak in Malaysia

Narasiman MUNIANDY and Jamaluddin Abdul AZIZ

Over the past three decades, the animal industry in Malaysia has seen an intensification in the farming systems, especially in the poultry and pig sector. The swine industry in peninsular Malaysia has been one of the most successful industries, having obtained self-sufficiency status since 1960. In 1998, the total production was 3.88 million head, with an output of 233,888 metric tons of pork and an estimated ex-farm value of RM 1.34 billion (Department of Veterinary Services [DVS] Statistics 1988). Thus, pig production has been a lucrative endeavor over the last thirty years and has attracted foreign markets since 1981. The intensification and expansion of traditional pig farming has been on-going, with a certain degree of modernization in the feeding and production systems. However, the environmental impact assessment of the ecosystem and the biosecurity measures adopted, left much to be desired. Further, the traditional farming system did not adequately incorporate good modern animal husbandry practices. Pollution control and proper waste management practices were minimal.

In peninsular Malaysia, swine fever, Aujezky's disease, Japanese encephalitis (JE) and porcine reproductive respiratory syndrome are among the major pig diseases. However, between late 1998 and early 1999, a new pig disease, characterized by a pronounced respiratory and neurological syndrome, sometimes accompanied by the sudden death of sows and boars, was noticed spreading among some pig farms in the Kinta district in the state of Perak (Aziz *et al.* 1999; Nordin *et al.* 2000). Since the morbidity and mortality rates were not high and the clinical signs were not markedly different from those of other diseases of pigs, the new syndrome was not identified initially. However, an increasing number of pig farm workers suffered severe febrile encephalitis due to this mysterious disease. At first, JE was suspected, but all measures instituted to stringently control the outbreak failed. A new virus belonging to the Paramyxoviridae family was isolated from a human case and was confirmed to be the agent responsible for the disease in both humans and pigs (Anon 1999; Chuah *et al.* 1999). Between October 1998 and May 1999 there were in excess of 265 viral encephalitis cases among pig farm workers, with 105 human deaths recorded in Malaysia.

This chapter provides information on the outbreak, diagnosis, control and eradication of the disease and regional preparedness for future challenges to the swine industry and bio-safety of the human population.

Nipah virus disease in humans - recognition and spread of the new disease

In September 1988, in the villages of Ampang, Ulu Piah and Tambun in the state of Perak, a cluster of viral encephalitis cases appeared in farm workers closely associated with pigs during farrowing, treatment, feeding and cleaning of pens. These cases were characterized by a mild flu-like illness with associated headaches of varying severity, fever, body aches and a variety of neurological symptoms. Other symptoms included vomiting, drowsiness, disorientation and altered speech which, in some individuals progressed into flaccid paralysis of the upper limbs, and in others, into coma. Reports of a similar illness in farm workers from the surrounding farms indicated that the disease had spread either by the movement of infected pigs through the normal practice of boar-sharing, sale of gilts and weaners, or movement between farms of infected peridomestic animals such as dogs and cats. The severity of illness and development of more distinct clinical syndromes progressed as more pig farm workers started falling ill with the typical symptoms. The disease in the pig farm workers was provisionally diagnosed as JE, based on the clinical signs in human victims working in close association with pigs. A total of twenty-seven cases were reported with fifteen deaths in the state of Perak.

In December 1998, the outbreak spread southward to Sikamat in Negeri Sembilan involving seven cases with five deaths (Chuah *et al.* 1999). The outbreak then spread to the Bukit Pelandok area in the same state from mid-December 1998. Cases of viral encephalitis peaked in March 1999 and involved 224 pig farm workers, resulting in 80 deaths. In March, eleven abattoir workers in Singapore handling possibly infected imported pigs from Malaysia developed Nipah-associated encephalitis or pneumonia that resulted in one fatality (Chew *et al.* 2000). The last cluster of disease appeared in Sungai Buloh, Selangor, in

Table 15.1 Summary of viral encephalitis cases and deaths by locality (from 29th Oct 1998 31st July 1999) (Ministry of Health, Malaysia)

Location	No. of cases	No. of deaths
Kinta, Perak	27	15
Sikamat, Negri Sembilan	7	5
Bukit Pelandok, Negri Sembilan	224	81
Sungai Buloh, Selangor	7	4
Total	265	105

May 1999 and involved seven cases with four deaths. Thus, during the period from September 1998 to May 1999, 265 cases of viral encephalitis, with a total of 105 human deaths, were reported to the Ministry of Health, Malaysia (Table 15.1) (Taha 1999).

In March 1999, a new virus, belonging to the paramyxoviridae family, was discovered and named 'Nipah' after a village called 'Sungei Nipah' where the virus was first isolated from a human case (Chuah *et al.* 2000). From the exposure history derived from some specific cases, it appeared that the incubation period for Nipah virus (NiV) infection was around ten to fifteen days.

Nipah virus disease in animals

Close monitoring of pigs revealed that the clinical patterns of the disease during natural infection varied with the age of the pigs. Porkers were noted to present primarily with a respiratory syndrome, while in the sows a neurological syndrome predominated. The disease appeared to be highly contagious, with concurrently affected animals distributed randomly over a farm rather than in clusters. The incubation period in pigs was estimated to be seven to fourteen days (Nordin and Ong 2000). Weaners and porkers presented respiratory signs ranging from increased or forced respiration to a harsh loud non-productive cough (loud barking cough) or open mouth breathing and haemoptysis. Mortality in the latter was low at less than one per cent to five per cent; however, infection rate approached 100 per cent.

Dogs living around the infected farms were also shown to be infected with the virus as diagnosed by immuno-histochemistry (Daniels *et al.* 2000) and suffered fulminating disease during the outbreak. However, serological studies of dogs in and around infected areas showed no evidence of transmission of the infection from dog to dog. Serological screening on more than 3000 horses in the country did not detect any positive reactions; except three reactions were detected in the polo club adjacent to infected pig farms in Ampang, Perak. Animals such as cats, horses and goats were infected only if exposed to infected pigs, and there was no evidence of transmission among these animals. Serological investigations of other animals on pig farms, including goats, birds, small mammals, reptiles, rats and other rodents showed no evidence of the spread of 'NiV' infection among these species. (Asiah *et al.* 2001; Daniels *et al.* 2000).

Epidemiological trace-back studies and spread of the disease among pigs

An epidemiological trace-back study of the NiV outbreak conducted by scientists from the Centers for Disease Control (CDC, Atlanta, USA) and the Australian Animal Health Laboratories (AAHL, Geelong, Australia) with the collaboration of local veterinarians, revealed that a patient from a pig farm suffered encephalitis in January 1997 (Bunning *et al.* 2000). Pig farms in this district were interspersed among orchards with a wide variety of fruit crops. There were also a few limestone caves near the farms that formed roosting grounds for fruit bats. The pig farms normally had fruit trees around the pig pens and seasonal activity of fruit bats was reported. Pig barns are comprised mainly of concrete pens at a meter in height under a gable roof that does not have walls. Hence, in this area there would appear to be considerable opportunity for the bats and the pig populations to be within potentially close contact. Although the exact method of the transfer of virus infection remains speculative, this contact could have occurred by the entry of infected bats or some body excretions into the pens of pigs. Farmers interviewed admitted that several farms in the larger infected area bought breeding stock from farms in the Kinta district. In many cases, a transaction involving the movement of pigs from an infected farm to a new farm that immediately preceded the occurrence of a new human encephalitis case.

It was established that the mode of transmission of virus between pig farms within and between the states of peninsular Malaysia was the emergency sale ('fire sale') of sick pigs and especially the movement of pigs from the infected farms in the state of Perak to Bukit Pelandok, Negri Sembilan (Figure 15.1). It must be pointed out that the pig farms in the Kinta district were isolated from one another by at least 1/2 to 1 km, whereas those in Bukit Pelandok, the largest pig growing area in Southeast Asia, were heavily concentrated with neighboring farms within a distance of less than 100 m. Further, the latter farms adopted virtually no bio-security measures. Thus, the disease was observed to spread rapidly among pigs on infected farms and also spread due to the close proximity of one farm to another. The mode of transmission between pigs within a farm was possibly through direct contact of the infected pigs' excretory and secretary

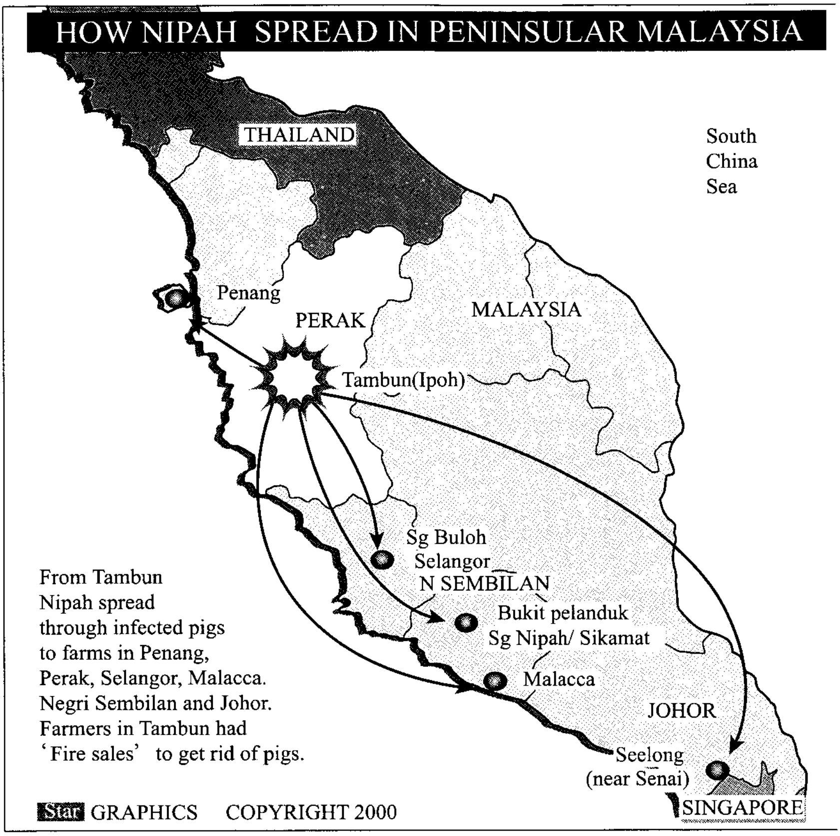

Fig 15.1 Spread of nipah virus disease in Peninsular Malaysia and Singapore

fluids such as urine, saliva, and or pharyngeal and bronchial secretions. This was especially so in pigs that were kept in close confinement. Transmission studies in pigs at AAHL in Australia established that pigs could be infected by either the oral route or by parenteral inoculation and have demonstrated the excretion of the virus via oral-nasal routes (Middleton *et al.* 2000). It was also observed that the infection spread quickly to the exposed pigs and neutralizing antibodies were detected on day fourteen (Daniels et al. 1999). Virus shedding from asymptomatic pigs was also demonstrated.

Laboratory diagnosis of Nipah virus infection

Nipah virus is a BSL4 (biosecurity containment level 4) agent, virus isolation is the least safe method for demonstration of the disease agent and the procedure entails great risk for laboratory staff. The serious zoonotic nature of NiV makes the development of and adherence to safe working procedures a prerequisite to any investigation or research. An indirect enzyme-linked immunosorbent assay (ELISA), using gamma-irradiated NiV-infected cell lysate, was used as the antigen for screening purposes that involved approximately 30,000 to 40,000 samples for the first National Swine Surveillance (NSS) program in 1999 (Muniandy *et al.* 1999). Positives detected with the screening ELISA were confirmed with a serum neutralization test (SNT) performed in a BSL4 laboratory at AAHL, Geelong, Australia. In order to reduce false-positives detected by the screening ELISA, a modified ELISA was developed at AHHL and implemented at VRI (Muniandy *et al.* 2001). The latter method ensured the elimination of false-positive reactors due to non-specific reactors not supported by SNT, as any doubtful or positive serum was always tested by SNT for confirmation. When serological tests revealed evidence of infection in a farm, further investigations on the farm animals were carried out. After post-mortem examinations, formalin fixed tissues were subjected to immunohistochemistry to demonstrate Nipah viral antigens using the immunoperoxidase detection system.

The reverse transcriptase polymerase chain reaction (RT-PCR), or nested PCR, was used as another supportive tool to detect viral nucleic acid from the buffy coat fraction of the blood of live infected animals. Primers based on the N gene of NiV were used in primary and nested PCR. Sequencing and restriction enzyme analysis of the amplified fragments were used to differentiate between HeV and NiV (Maizan *et al.*, 2000).

Control and eradication

Phase I: Control and eradication program (March-April 1999)

When the etiology of the disease was confirmed as NiV, a National Task Force was formed and an outbreak of virus encephalitis emergency was declared on 20th March 1999. The Task Force developed a policy for the eradication of the disease by mass culling of diseased and exposed pigs. Eradication 'by stamping out' was applied to pigs and dogs on the farms where there were human cases or when pigs were dying with clinical signs of the disease and in farms within a 10 km radius of the affected farms. The army, police, volunteers from non-governmental organizations (NGOs), the Department of Veterinary Services (DVS) and other government agencies were involved in the culling operation. Culling was accomplished by shooting the pigs and burying them in deep pits near the pens. Public management and risk communication issues were seen as

Box

Invasion of humans into previously undisturbed natural habitats moved a new disease from animals to humans

New land uses such as deforestation, development projects, or the clearing of caves for highways may have disturbed the natural habitats of fruit bats (the left photograph). The fruit bat came in to contact with farming activities. Nipah virus, a previously unknown virus and naturally harbored by the fruit bat, was excreted from the urine of the bats. The urine contaminated pig farm areas and infected the pigs (the right photograph). The pig farmers and the surrounding people then became ill with a lethal encephalitis.

The fruit bat (*Ptreropus hypomelanus*), a suspected natural reservoir of Nipah virus

Neurological signs in sows infected with Nipah virus

important aspects of controlling the outbreak of this zoonotic disease.

The culling of pigs in the affected areas successfully controlled the human epidemic in the states of Negeri Sembilan, Perak and Selangor. All interstate movement of pigs was also banned during the culling period. During this phase 1 control program an estimated 901,228 pigs from 896 farms were destroyed. Partial compensation in the form of hardship assistance was given to affected farmers.

Phase II: National Swine Surveillance Programs

National Swine Surveillance and Control Program (May-July 1999)

After the removal of farms in the outbreak areas of Bukit Pelandok, Sungei Buloh and Kinta, a surveillance program, called the 'National Swine Surveillance

Program' I (NSSP I) was developed to detect NiV infection in the remaining pig farms in peninsular Malaysia. The program was instituted because epidemiological investigation indicated that the emergency sale of diseased pigs occurred in Ipoh, Perak, during the peak of the outbreak, which dispersed pigs across the country (Ong *et al.* 2000). An ELISA, called 'screening ELISA' was used to test at least fifteen blood samples, collected twice at an interval of four weeks, from each farm in the country (Muniandy *et al.* 1999). A total of 36,125 blood samples collected from 879 farms and 8 abattoirs were tested. Farms with at least three positive sera during the first or second testing were depopulated. As a result, a total of 50 farms that involved 172,750 pigs in the states of Penang, Perak, Selangor, Malacca and Johore were depopulated.

Abattoir surveillance (May 1999 onwards)

5587 samples collected from pigs slaughtered at the pig abattoirs managed by the DVS during the phase II surveillance and control program were also subjected to ELISA. In the on-going NiV screening program of the abattoir samples from October 1999 to February 2000, the percentage of positives detected for this period decreased sharply to 0.8 per cent (91 out of 10,982). Those samples that tested positive by the screening-ELISA were later confirmed negative by the SNT.

Phase III: National Swine Surveillance Program II (NSSP II) and modified ELISA (April-December 2000)

A second National Swine Surveillance Program II (NSSP II) was carried out from April 2000 to further screen for residuals of infection in all of the 946 pig farms in peninsular Malaysia, Sabah and Sarawak. Pig sera were first tested by the screening ELISA. Sera that reacted positive in the screening ELISA were retested by a modified ELISA. Any doubtful or positive sera were always tested by SNT at the AAHL for confirmation.

From a total of 45,874 sera screened by the indirect ELISA, only thirty sera from two farms in Perak reacted positive by the modified ELISA and were subsequently confirmed positive by SNT. Pigs from these two farms were considered to have residual antibody titers, possibly due to past infections, and were culled in order to avoid any possibility of spread of infection (Muniandy *et al.* 2001). There have been no new cases of NiV disease diagnosed in people or in pigs since the surveillance program was completed. Abattoir surveillance was continued in 2001 and 2002 and all negative results seem to indicate the absence of any form of persisting active infection of the NiV in the pig farms in Malaysia.

Natural reservoir hosts: bats

Paramyxoviruses have emerged from several wildlife species and have caused unusual disease outbreaks over the last two decades. Since 1994, four new bat-derived paramyxoviruses have been isolated and characterized: Hendra (Murray *et al.* 1995) and Menangle viruses (Philbey *et al.* 1998) from Australia, and Nipah (Chuah *et al.* 1999) and Tioman viruses (Chuah *et al.* 2001) from Malaysia. Both Nipah and Hendra virus (HeV) appear to be viruses of fruit bats, commonly known as 'flying foxes', members of the genus *Pteropus*. Antibodies to HeV were found in approximately 50 per cent of four Australian *Pteropus* species (Young *et al.* 1996) and the HeV appears to have been present in the Australian flying fox population for at least twenty years. A targeted wildlife surveillance program in Malaysia showed that neutralizing antibodies to NiV were present in one species of insectivorous bat (*Scotophilus kuhlii*) and four species of frugiverous bats: *Pteropus hypomelanus* (island flying bat), *P. vampyrus* (Malayan flying fox), *Eonycteris spelaea* (cave bat) *and Cynopterus brachyotis* (lesser dog-faced fruit bat) (Johara *et al.* 2001). NiV has been isolated from the urine of *P. hypomelanus*, a fruit bat from the island of Tioman, some 400 km away from the putative source of the outbreak (Chuah *et al.* 2001) This finding strengthens the contention that flying foxes are a probable natural host of NiV. Although the transmission of HeV and NiV from *Pteropid* bats to animals or humans is very rare, the overlap in habitats of the flying foxes with those of humans and their farm animals in some newly-encroached jungle area surrounding limestone caves similar to those in the Kinta district are of concern.

Changes in ecology due to new land-use and human demographics and behavior, increased travel and commerce, advances in technology and industry, microbial adaptation and the breakdown in public health have been identified as some of the factors contributing to disease emergence. The incursion of humans into previously undisturbed remote natural habitats through activities such as deforestation for various development projects, clearing of caves for highways, and the encroachment of humans (including their domestic animals) into wildlife areas where unknown disease agents exist in harmony with wildlife reservoir hosts, could have introduced a new zoonotic infection into the domestic animal population. It has also been speculated that the heavy haze caused by large-scale open burning of forests in Indonesia in 1996 and 1997 might have displaced the bats from their natural habitats. Upon contact with new and naive species, the agent might have 'jumped' species barriers, thereby spilling over into livestock and humans. High population densities and stocking densities of animals may have facilitated the rapid spread of the pathogens throughout the livestock populations. Infections may be passed directly to humans from the natural reservoir, or may be transmitted to humans via an intermediate, amplifying host (Field *et al.* 2001). Thus, it was hypothesized that the human NiV outbreak in Malaysia probably had as a necessary condition of the 'jump' of NiV from a wildlife reservoir in fruit bats, a need to establish itself in farmed pigs. The human outbreak depended on the propagation and amplification of the virus among large populations of susceptible pigs that were reared under intensive farming conditions, the movement of infected pigs from farm to farm and then, interstate and internationally, and the close contact of people with infected pigs (Daniels *et al.* 2000).

Planning for future regional preparedness

The importance and impact of the NiV outbreak as a newly-emerging viral disease in the Asian-Oceanian region cannot be understated. Although the disease has been eradicated from pigs in Malaysia, its natural history suggests that there is an on-going need for preparedness for the potential of further outbreaks of the Nipah disease in the region. Now that there is an awareness in the region that an acute zoonotic disease, causing heavy losses to both human and animal populations, may arise anytime and anywhere, countries in the Asian and Oceania regions should develop their own preparedness program. This issue has been adequately addressed by Daniels *et al.* (2000).

These were some of the salient issues considered during the recent 'Regional Seminar on Nipah Virus Infection', jointly organized by the Office Internationale des Epizooties (OIE) and DVS at Kuala Lumpur in April 2000 (Daniels *et al.* 2001):

(1) Laboratory preparedness issues, including bio-safety, epidemiology, scientific skills, quality assurance, and technology transfer;
(2) NiV disease diagnosis issues, which includes the diagnosis of the disease on the farm and in the laboratory as well as the control of infection in pigs by serological surveillance programs;
(3) Pig industry related issues, where finance is the core issue in relation to affordable safe food for the society, and the adoption of a code of good management practice which is to the advantage of producers.

In order to prevent any further NiV epidemics, herd health monitoring and maintenance of farm bio-security are expected of the industry. Herd health monitoring requires farmers to know the health status of their animals backed by record keeping, the correct interpretation of records and appropriate responses to agreed key performance indicators.

Future challenges for the swine industry in Malaysia

The outbreak of NiV encephalitis had a devastating impact on the pig industry in Malaysia. Not only is the loss of human lives still being felt by the associated families, but the livelihood of some 620 families has been seriously affected. The control and eradication program has reduced the standing pig population from 2.4 million to 1.2 million. The annual export market to Singapore and Hong Kong at US$ 120 million has been lost. The total loss has been estimated to be US$ 500 million. Some of the challenges facing the pig industry in future are described below.

Declaration of Nipah virus infection-free status

The NiV infection in Malaysia was eradicated by 'stamping out' of the infected and exposed pigs. National swine surveillance programs implemented in 1999 and 2000 ensured the elimination of residual infected pigs in the country. Thus, eradication of NiV has been considered complete since May 1999. Malaysia has undertaken the eradication procedure in accordance with International Animal Health Code for the declaration of infection-free status, and the Malaysian Ministry of Agriculture is now awaiting the status report from OIE Paris.

Pig farming areas and restocking

Policy and new conditions for restocking previously infected farms in all states have yet to be announced. New guidelines proposed by the DVS to restructure the industry in line with the Pig Farming Areas (PFA) and good animal husbandry concepts are to be implemented in each state. The identification and allocation of lands for PFAs as a long-term sustainable strategy should be implemented without much resistance from all parties concerned.

Modern production system

The need for reform in improved and modern production systems is urgent. The traditional farrow-to-finish system, with its inherent disease problems, must be phased out and replaced with modern methods. The old traditional concept of sharing boars or moving sows from farm to farm must be a practice of the past. Despite the initial increase in capital outlay for infrastructure, bio-safety and cost of production, the resulting long-term benefits to the sustainability of the industry must be emphasised.

Environmental management and pollution control

Modern livestock farming, particularly of the intensive industries type, result in the over production of waste which, if not properly managed, can have serious negative effects on the environment. Proper control of the waste-water and modern methods of waste management ought to be implemented to reduce malodor, fly and mosquito populations and damage to the environment. An environmental code of practice for piggeries ought to be drawn up and enforced. Containment, collection, treatment, storage and subsequent utilization of effluents from feedlot pens and intensified farming systems should be adopted as an environmentally friendly farming practice. In addition to lagooning, other systems such as anaerobic digestion, activated sludge processing, composting, using the deep litter system and modular waste treatment practices must be adopted.

Biosecurity on farms

The prevention and control of infectious disease on the modern intensive farm depends on surveillance for disease and biosecurity. In Malaysia, NiV was transmitted from farm to farm by the sale and purchase of infected pigs. The epidemic would not have occurred if farmers had a strict policy of keeping their farms self-contained. The introduction of animals of unknown health status carries the risk of introducing disease. Proper biosecurity measures ought to be adopted. Protection against exposure to infection, prevention of infection by isolation of sick animals, proper disposal of dead animals and reducing the effects of disease are some of the biosecurity measures.

The problem of a wildlife reservoir for the Nipah virus

The management of the risk of reinfection of pigs from wildlife (such as fruit bats) is an important consideration in Malaysia and other countries in the region. As the fruit bats have been strongly implicated as the natural reservoir of this virus (and other similar viruses), the probability of the recurrence of an infection, although remote, cannot be excluded. Hence, pig farms should not be located in areas to which bats are attracted, such as orchard districts. Fruit trees should not be grown in and around pig farms.

Trade and movement of pigs across nations

The movement of infected pigs from Malaysia to Singapore resulted in the development of the disease across an international boundary. The consumption of pork has not resulted in the spread of NiV infections, whereas the handling of live or freshly-killed infected pigs has resulted in the human disease. For the international movement of companion and performance animals a number of countries require serological testing of horses, dogs and cats prior to their importation. OIE guidelines would be useful for the management of the trade in live farm animals.

Conclusion

The 1999 NiV disease outbreak was a tragedy for the Malaysian pig industry. Malaysians were unfortunate and unprepared to handle the problem. The trauma, both emotional and financial, experienced by the Malaysians should not happen to residents of other countries and should serve as a lesson, especially for those countries in the Southeast Asian region. The emergence of this new deadly virus has taught us a lesson about the need for preparedness and an early warning system for any emerging infectious disease in future. Such an outbreak should not be allowed to occur, but if and when it does, efficient diagnostic, control and eradication measures must be implemented immediately. The importance of efficient and effective diagnostic capabilities and facilities in the veterinary and medical laboratories for countries in the region must be emphasized. There is an urgent need for inter-departmental, inter-agency, national, regional and international collaboration in dealing with such a deadly disease, especially in the areas of identification, control, surveillance and eradication. It will be crucial in avoiding a future catastrophe in the region. Intensification efforts in any farming system must be planned with respect to their effects on environment, the flora and fauna, bio-security and sanitation, and the bio-safety of human populations.

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16
Water Quality Problems Affecting Livelihood in Bangladesh and Kazakhstan: A Natural Environment as a Local Area

ANDO Kazuo and ISHIDA Norio

Of all of the Asian environmental health problems, the deterioration of drinking water has significantly affected the livelihood of rural people and has become a very serious issue (JCE 1997). We see the following impacts of improper water use in Bangladesh and Kazakhstan:

1) Environmental health problems in terms of the affected population and area have become widespread.
2) Industrial factories are not releasing arsenic into ground water, but it is dissolved naturally from soil into water under the ground. In spite of several research projects, the exact causes have not been ascertained because there may be multiple causes.
3) Ecological disease is commonly observed in people living at the periphery of the Aral Sea. The doctors of Kazakhstan give the name 'Ecological disease' to several diseases, including chronic pyelitis and anemia. Ecological disease is an ecology-related health problem. The causes of ecological disease are believed to be natural factors in the local environment rather than the chemicals released by human activities (Hashizume 2001).

The arsenic problem in Bangladesh and ecological disease in Kazakhstan may have been created in the natural environment through changes due to human activity. In an effort to increase agricultural production by large scale of irrigation with ground and surface water and improve the quality of drinking water by hand tube well, a harmful chemical was disturbed and released into the water source. Governments introduced programs to address these problems with conventional methods of searching the mechanism of the causes and preparing the solution, but because of complicated socio-economic matter, it was difficult for villagers to understand the relation between cause and effect and take the measure for solution given by the government. Unless rural people are involved directly to plan the program in the solutions and to implement it with their initiatives the problems cannot be permanently eradicated.

In this chapter, we first give a general account of the change in the ecological environment that occurred as a result of human activities in rural Bangladesh and in the periphery of the Aral Sea in Kazakhstan. Second, we address the results of our field studies on water usage and quality in Bangladesh and Kazakhstan. Finally, we discuss and recommend a framework or concept of how to approach the environmental health problem in relation to the 'area study'.

Land and climate suitable to modern irrigating agriculture

Bangladesh is located along the Bay of Bengal at the southern front of the Himalaya Mountains. The climate is tropical monsoon, having distinct rainy and dry seasons. Kazakhstan is located in Central Asia on the northwest side of the Tien Shan Mountains. The climate of most of the country is desert or semi-arid, having distinct dry and ice-covered seasons.

The annual rainfall of Bangladesh is 1500-3000 mm, concentrated during the rainy season from May to October. As Bangladesh lies at the confluence of many large rivers, four times the annual rainfall flows into the country during the rainy season. Accordingly, one third of agricultural fields every year are flooded with 50 to 300 cm of water, but this inundation recedes and the soil reappears from November to April. Winter daily temperatures from December to February are 13-15 ℃ at minimum and 20-25 ℃ at the maximum. The dry season, from November to April, is a good season for crop cultivation. The major constraint for rice cultivation during the dry season is water. Therefore, it was thought that irrigation could change the dry plains of Bangladesh into good rice fields during the dry season by pumping water from wells.

However, in Kazakhstan the annual rainfall of the country (except the mountain region) is around 150-400 mm (Hirata *et al.* 1999). The periphery of the Aral Sea is, however, a severe desert area. The annual rainfall is only 100-200 mm. The daily average temperature in Almaty is below the freezing point from November to March and reaches -20 ℃ in January. The temperature becomes appropriate for crop cultivation from May to October (above 10 ℃). The temperature of the summer season, from June to September, has been considered by agricultural scientists to be good enough to cultivate rice. The maximum daily temperature can reach above 30 ℃ The desert plain around the Aral Sea are cropfields that would be especially suitable for cotton cultivation if irrigation is made available.

The ecological environments of Bangladesh and Kazakhstan are very different, but there are common features between these two regions. They each have a vast plain and a dry climate. The plain land and dry climate are environments that can be most easily changed by modern mechanical technologies for facilitating irrigation (if the water is available). Bangladesh has plenty of ground water, which is rechargeable in the rainy season and stocked deep under ground. The two big rivers, namely the Amudarya and the Syrdarya, which flow into the Aral Sea from the snowmelted on the mountains, provide plenty of surface water in Kazakhstan.

The arsenic-tainted ground water problem in Bangladesh

More than 90 per cent of the total population presently depends on ground water for drinking (DPHE and UNICEF 1997). According to our observation in rural Bangladesh, most people use a tube-well especially a hand tube well, (HTW, Photo 16.1). The water lifted by the tube well from the shallow ground layer is polluted by arsenic in the areas shown in Figure 16.1. We can find the arsenic

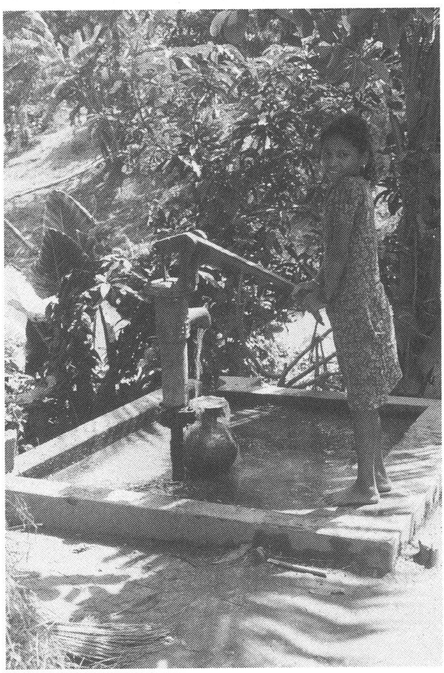

Photo 16.1 Hand tube well

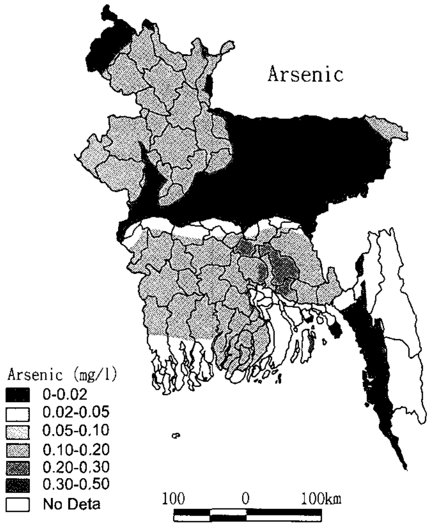

Fig 16.1 Map of arsenic polluted area (EGIS II,1998)

problem in almost all of the regions of Bangladesh. The government of Bangladesh prohibits the drinking of water containing arsenic at more than 0.05 mg/L. The WHO's standard is 0.01 mg/L. Four million people are exposed to arsenic by drinking water at a level of >0.05 mg/L. However, at the WHO's minimum standard of >0.01 mg/L, the exposed population becomes 46-57 million. As the total population of Bangladesh was 125.5 million in 1999, it is estimated that half of the national population is drinking arsenic polluted water. The polluted areas classified as having more than 0.02-005 mg/L arsenic in figure have deltaic and alluvial soils (EGIS II 1998). The areas of the most severe contamination are in the lower Meghna flood plains. The spatial variability of arsenic concentration is related to geology and the sediment source (EGIS II 1998).

The clinical symptoms of arsenic poisoning are usually arsenic lesions including skin cancers. However, at the national level, there are no available statistics for the number of patients who have symptoms of arsenic poisoning. In the West Bengal state of India, where arsenic was found earlier than in Bangladesh, the number of patients is estimated at 0.22 million persons from 1.5 million persons exposed at the 0.01 mg/L level. In Bangladesh, 820 patients were recorded in 18 districts in 1996 (AAN 1997). The number of patients in Bangladesh is estimated at 8.8 million or 40 times that of West Bengal. In Samta Village, in the Jessore district, 291 patients in 152 families were recognized out of 3,533 persons in 682 families in 1998 (Tani 2000). About 8 per cent of the

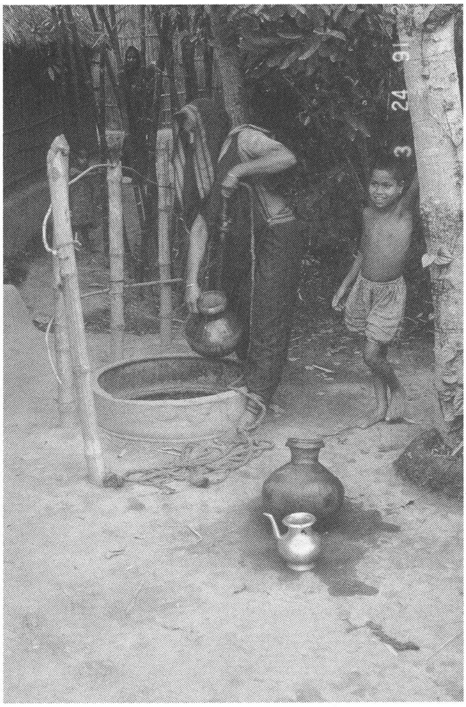

Photo 16.2 Dug well

Photo 16.3 Sanitary latrine

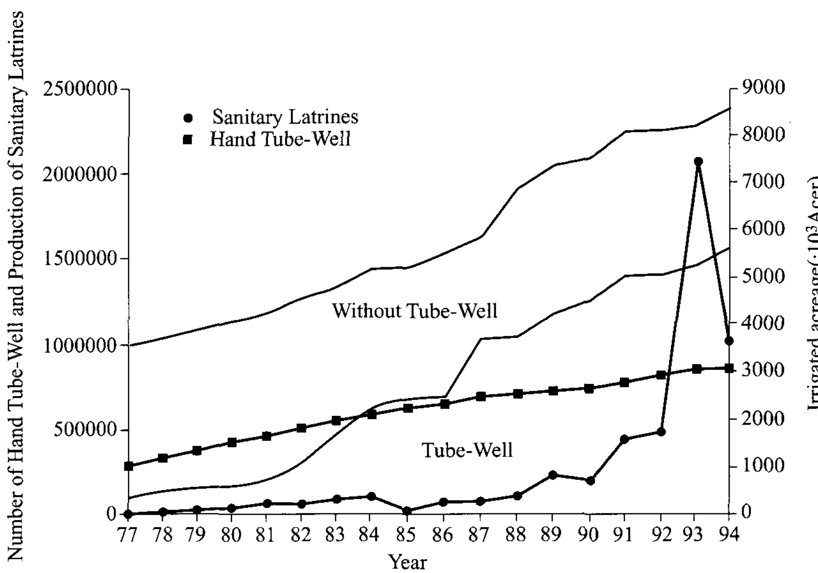

Fig 16.2 Change of irrigation acreage, number of hand tube well and production of sanitary latrines. Note: 1. Year is cropping year. 2. "Without Tube-Well" is mainly irrigation from the surface-water of river, pond and canals.

total population in the village of Samta were arsenic poisoned patients.

Professor Chakraborty states: 'The excessive ground water used by tube wells to irrigate rice during the dry season has decreased the ground water and changed the oxidation-reduction potential in the earth to release arsenic (AAN 1997)'.

This hypothetical statement is generally believed because the emergence of the arsenic poisoned patients coincided with the rapid increase of irrigated acreage with tube wells in the 1980s (Figure 16.2). The equipment used for the irrigation of rice has gradually changed from *don* (traditional manual lift) to electric or diesel shallow tube wells (STWs). There are many STWs being used in the villages during the dry season, especially in the villages located on the flood plains.

The government of Bangladesh launched a campaign to increase the number of HTWs to mitigate bacterial diseases, including severe diarrhea, dysentery and typhoid. It is thought that polluted drinking water is the source of these diseases. This program has been continuously encouraged since the 1970s. The number of HTWs was only 260,000 in 1976, but 2,600,000 in 1996. The water resources in rural Bangladesh have rapidly changed from ponds, rivers, tanks and *Kups*, or open dug wells (Photo 16.2), to HTWs. The HTW is a safer water source away from severe inundation or flood. The introduction of the sanitary latrine (Photo 16.3) was instituted for the same reason as the HTW. The sanitary latrine can prevent diffusion of excrement into the environment. HTWs and sanitary latrines are considered appropriate technology to provide a hygienic life to rural people. Rural people have also accepted these technologies thanks to the extension program of the government and NGOs. The time serial statistical data on the HTW and sanitary latrine show this to be true and the numbers of HTWs and sanitary latrines are increasing, as are the number of tube wells for irrigation (Figure 16.2).

Ecological disease and its background in the periphery of the Aral Sea

Grabish (1999) summarized ecological disease as follows: 'The environmental disaster in the periphery of the Aral Sea has caused serious health problems for the people of Karakalpakstan in Uzbekistan, especially women and children, as a result of wind-blown salt from the dried seabed and agricultural pollutants. A recent case study of the region, 'Women Respond to a Shrinking Aral Sea', details the devastation in human terms:

-Maternal mortality rates are three to four times higher than the national average.

-99 per cent of women and children suffer from anemia.

-90 per cent of women have complications during pregnancy and delivery.

-The frequency of birth defects is five times higher in Karakalpakstan than in most of Europe.

-A 1995 UNDP report states that the average infant mortality rate in Karakalpakstan was 4.48 per cent, the highest in Uzbekistan, which has an overall average infant mortality rate of 3 per cent.

-Nearly 6.5 per cent of children below the age of fourteen suffer from skin diseases.

-Children are prone to water-borne diseases, notably diarrhea, and to acute respiratory illness.

-Viral hepatitis has increased from 62.4 to 94.8 per cent in the past nineteen years.

-Cancer incidence has increased from 0.163 to 0.183 per cent from 1985 to 1992.

-Skin disease is twice the national level, affecting 9.83 per cent of the general population.

The world's fourth largest freshwater lake in 1960, the Aral Sea has already shrunk to half of its former size. This is the result of unsustainable cotton cultivation that began less than forty years ago. Although the sea itself can no longer be saved, its toxic salt plains have paradoxically given rise to a new spirit to clean the region (Grabish 1999). As Figure 16.3 shows, the inflows of two rivers, the Amudarya and Syrdarya have decreased from 1970 to 1990. Conversely, the irrigated area (mainly for cotton) has increased gradually along with the reduction of the Aral Sea.

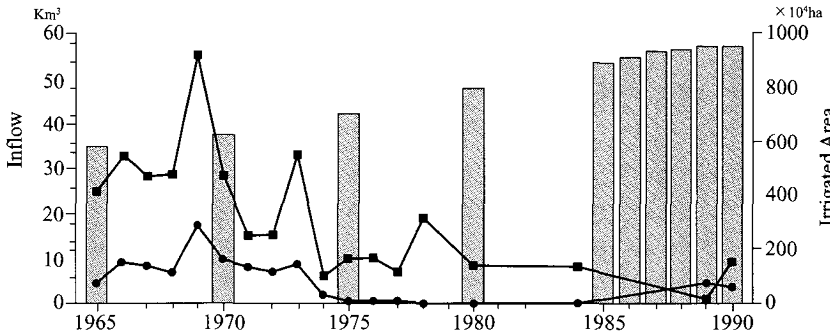

Fig 16.3 Inflow into the Aral Sea from two major rivers and irrigated acreage in Central Asia (Kazakhstan, Uzbekistan, Turkmenistan, Tajikistan and Kyrgyz).
Note: ■ Inflow of Amudarya ● Inflow of Syrddarya
Source:http://src-home.slav.hokudai.ac.jp/sympo/97/summer/islamov. html;JRAK(1993).

Results from field work in Samuta Village, Jessore district, Bangladesh

We investigated the water resources and usage for drinking and cooking with a historical perspective. A questionnaire, observations and interviews were performed with the cooperation of field assistants. The survey was carried out in July and August 1998 (Takahashi and Ando 2001). The study site was located in a region of Bangladesh which is severely arsenic polluted. All of the households of West Para (a community smaller than a village), consisting of 132 households and 591 persons (male: 296, female: 295) were surveyed. The total population of the village was about 3,000 persons.

According to the questionnaire, given to all of the households of West Para, *Kups/Idras* (open dug wells) and ponds were the general water resources used during the British period. However, during the Pakistan period, the HTW was used by 40 per cent of households and after 1972 (Independence), rose to 90 per cent. Nearly 100 per cent of households have consumed drinking water from a jar (*Matir Korushi*) since the British period. Most villagers are still using *Matir*

Table 16.1 House hold number by different materials of jar used for keeping water in West Para of Samta Village

Period	British	Pakistan	1972-86	1986-97
Matir	38	61	118	113
Kasar	0	0	0	0
Steel	0	0	0	1
Aluminium	0	0	3	4
Bell-metal	0	0	2	0
Matir+Bell	0	0	0	1
Juge	0	0	1	2
Leads	0	0	3	5
total	38	61	127	126

Note: Figure is number of the household which has answered in 132 household.
Matir: Soil, Kasar: Copper, Bell-metal: Brass
Juge: This is the equipment of a pitcher usually made of lead or brass.

Table 16.2 Household number by different materials of glass used for drinking water in West Para of Samta Village

Period	British	Pakistan	1972-1986	1986-1997
Matir	1	1	0	0
Kasar	35	54	12	4
Steel	0	2	88	93
Aluminium	1	4	20	25
Leads	1	0	5	3
total	38	61	125	125

Note: Figure is number of the household which has answered in 132 households.

Korushi. Few households are using aluminum or lead jars at present (table 16.1). The cooper glass (Kasar) was used for drinking water during the British and Pakistan period. 70 per cent households and 20 per cent households have used the steel glass and the aluminum glass since 1972 (Table 16.2).

At present, 42 per cent of households use only HTWs, 42 per cent only ponds, 15 per cent HTWs and ponds, and one per cent use a combination of HTWs, ponds and *Kups* for cooking water. For bathing water, 90 per cent use ponds, seven per cent use ponds and HTWs, two per cent only HTWs and one per cent use *Doba* or pools. The figures show that pond water is widely acceptable for bathing and about half of the households consider it better than water from the HTWs.

Sixty-six households, or 50 per cent of total households, have their own HTW. The rest of the households are using the HTWs of their neighbors. An HTW is

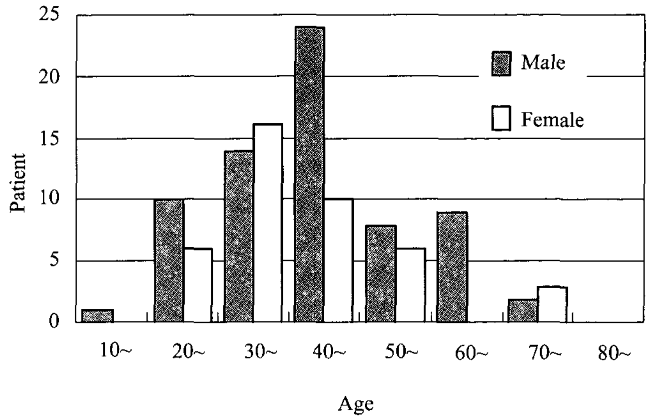

Fig 16.4 The number of patient as per sex and age

usually set in the corner of the yard of a homestead or behind the house. The pipes of 80 per cent of HTWs are 100 - 120 feet deep. 53 per cent of households have at least one patient among them. There is at least one patient among 59 per cent of the total HTW using households. 47 per cent of households without HTWs have a patient. The differences in incidence among patients indicates that something must be different between households using HTWs and households without HTWs.

80 per cent of patients report symptoms appearing within the last four to ten years. Before knowing about arsenic poisoning, twenty-four households drank the water after boiling and 108 households (82 %) drank water without boiling. Usually, the water was carried from an HTW and was kept in a soil jar *Matir Korushi*. After learning about arsenic poisoning, most households keep the HTW water in a jar for several hours to one night before drinking. The water from deep tube well is also a preferred use for drinking. There is a general opinion that the way water is consumed among patients and non-patients is not so different. However, the arsenic patients said that their main drinking water was fresh water from HTWs. Four patients used only water kept in a jar for drinking.

Among the 109 patients, 68 patients are male and 41 patients are female (Figure 16.4). The greatest number of patients are males between 30 and 40 years old. In the age group from 40 to 60 years, half of the males are patients. Among the females, the largest number is in the over 40 years age group. The villagers commented that males usually work in the fields and after their return from the fields, they are eager to drink the fresh and cool HTW water. That is why the males are more affected than the females. 67 patients (61%) require clinic treatment of NGO and the government of Bangladesh use vitamins.

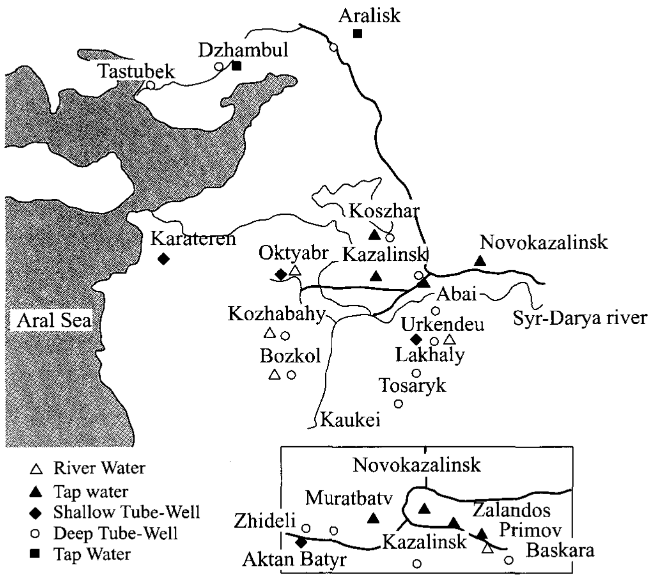

Fig 16.5 Water sources of Aralisk Area

Results from field work in the Aralisk area in Kazakhstan, 1999

We collected water samples from five water sources: river, agricultural canal, shallow tube well, deep tube well and tap water. The locations of sampling are indicated in Figure 16.5. As shown in Table 16.3, the water sources vary among the villages due to the availability of water. We have conducted a detailed analysis of the positive and negative ions in these water samples at the laboratory at Kyoto University.

In the Alalisk area, the Syrdarya River is the important source of drinking water. Figure 16.6 shows the fluctuation of runoff and mineralization at the upper stream (Chandra), middle stream (Kyzyl-orda) and lower stream (Kazalinsk). The pattern of the runoff is almost the same at all three places. The maximum runoff occurs in April due to snow melting in the mountains. Since irrigation began, the runoff has decreased. The runoff of the Syrdarya River gets smaller and smaller from the upper to the lower stream. The runoff at Kazalinsk is one-third of Chandra. Conversely, the mineralization is higher in the lower than in the upper stream. This indicates that the water quality of the Syrdarya River becomes worse in the lower stream than in the upper stream. This suggests that the decrease of the runoff has caused the deterioration of water quality of the

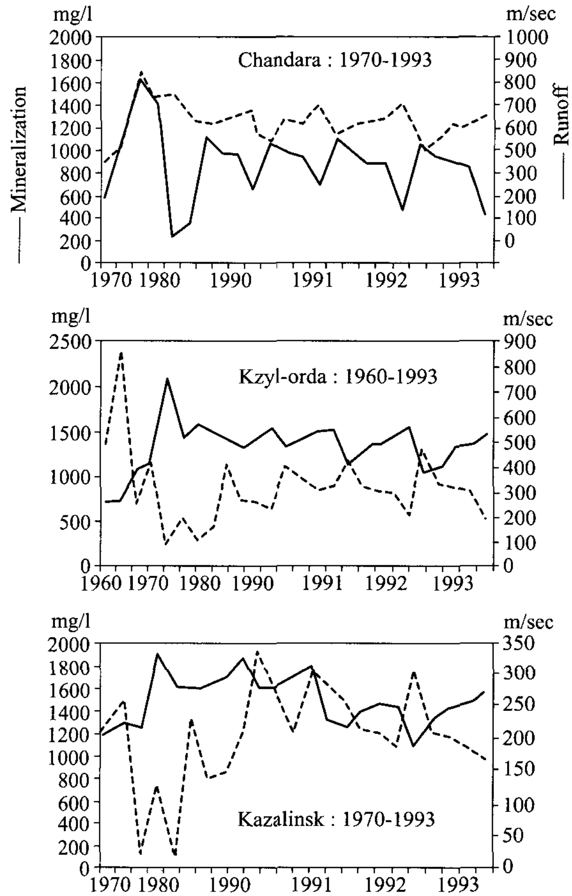

Fig 16.6 Runoff and mineralization at three points of Syrdarya. (Source: Kazakhstan Agricultural Academy)

Syrdarya River.

Figure 16.7 shows the water quality in the different types of water sources in the villages of the lower stream of the Syrdarya River. The problem is that the content of salts in the Syrdarya varies seasonally and the drainage water from the irrigated crop fields flows into the river. Nevertheless, the content of salts is low enough that the water of the Syrdarya is suitable for drinking. The water quality of shallow tube wells varies greatly from place to place. We believe that the shallow tube well has the same water quality as the drainage water from the fields. The salts in the soil may be carried into the river. Shallow tube wells, therefore, must be investigated one by one.

Table 16.3 Sources of Drinking Water in Aralisk

Name of village/town	SW	DTW	STW	TW	Remarks
Tastubek			○		Most of all the villagers use STW.
Dzhambul			○	○	Ninty percen of population use TW.
Aralisk				○	
Koszhar	○				
Karateren			○		
Novokazalinsk		○			
Kazalinsk	○				
Oktyabr	○		○		
Zhideli		○	○		
Murathaey	○				
Aktan Batyr	○	○			DTW is mainly used.
Baskara	○	○			
Primov	○	○			
Zalandos	○				
Ahal		○			
Kozhabahy	○	○			Some DTW has facility of desalinization.
Bozkal	○	○			
kaukei		○			
Tasaryk		○			
Lakhaly		○			
Urkendeu		○	○		STW is own by individual person. Most of all family only use DTW.

Note: SW: surface water, DTW: deep tube well, STW: shallow tube well, TW: tap water.

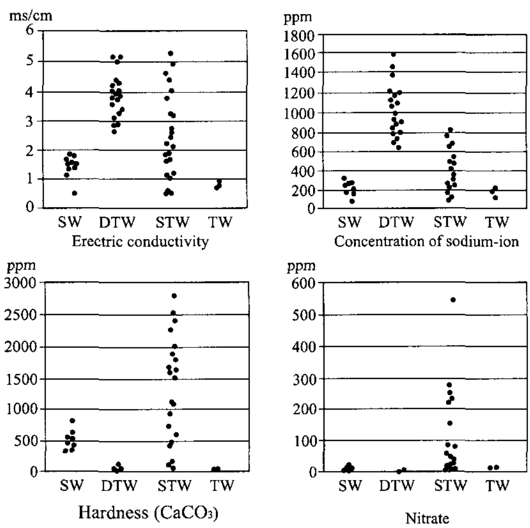

Fig 16.7 Water qualities as per varieties of water-sources
Note. SW, Surface Water, DTW, Deep Tube-well; STW, Shallow Tube-Well; TW, Tap-Well,.

The water from the deep tube wells are not potable due to a high concentration of salts: the sodium ion ranges from 600 to 1,600 ppm. However, if salts could be removed from the water, the deep tube well could become a suitable water source.

The water quality of the tap water system is adequate, but it is too expensive to establish and maintain.

The result of our study reveals that all of the water sources are not equally appropriate for drinking water. If treatment would be applied to the river water, local people could get good water from the river. Unfortunately, in the Aralisk area, the local government still believes in the judgement of the 1970s that the quality of the river water is poor and that the river water is not appropriate for drinking. However, since the 1970s, no water tests have been conducted and, furthermore, local people do not get any scientific information about the water quality of their water sources.

Conclusions and remarks

The environmental health problem of the arsenic problem in Bangladesh and the 'ecological disease' problem in Kazakhstan are created by a change in the environment itself, and they are both chronic problems caused by many factors. However, as we discussed, there is consensus that the introduction of the modern agricultural production systems, especially large-scale irrigation with ground water or inflow river water during the dry seasons, has largely interrupted the rhythm of the natural environment in Bangladesh and Kazakhstan. It is extremely difficult to find the causes of arsenic poisoning and 'ecological disease', but local people are eager to take any action to prevent them. This has caused a re-evaluation of their life styles and production systems.

The result of field work in the village of Samta suggests that even a small change in the method of collecting and storing drinking water probably decreases the arsenic content. This connection was identified by the villagers themselves, but overlooked by outside researchers. Consequently, conventional research frameworks should be abandoned and alternative approaches, in which villagers participate in discussing and finding a solution, should be employed. Our fieldwork at the periphery of the Aral Sea, in which we seek to understand how local people use water resources in their environment, is a new departure in 'area study' research. We hope to demonstrate that this new partnership between researchers, experts and local people can provide an alternative approach to environmental health problems. This approach involves considering the area we study to be both the natural environment and the human environment, the casual relationship between them, and the consequent effects on health.

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17

Contamination and Toxic Effects of Persistent Organic Pollutants in Wildlife and Humans in Asia

TANABE Shinsuke

Many endocrine disrupters have been found in a range of environmental media and biota and their toxic impacts on wildlife and humans are of concern (Colborn *et al.* 1996). Among these endocrine disrupters, the most hazardous ones for wild animals are those that have severe toxicity, high accumulation potential in the body and are persistent in the environment. As representative chemicals having such properties, organochlorine compounds like DDTs, HCHs (hexachlorocyclohexanes), CHLs (chlordane compounds) and PCBs (polychlorinated biphenyls) have attracted great attention due to their potential to degrade the environment and to pose ecological risk. The organochlorine insecticides, such as DDTs, HCHs and CHLs, have been used as insecticides for agriculture and public health purposes like malaria eradication. PCBs are mainly used for industrial purposes, such as dielectric fluids in transformers and capacitors. Substantial production and usage of these organochlorines started after the Second World War. However, due to the concern regarding their toxic impact on humans and wildlife, many developed nations prohibited their production and usage in the 1970s and 1980s. However, some developing countries are still using these organochlorines. These compounds are chemically stable and, therefore, quite persistent in the environment. Additionally, they have a strong bioaccumulative nature and are highly toxic in the bodies of wildlife and humans. These organochlorines are known to affect endocrine function as well.

This chapter reviews contamination and the toxic effects of persistent endocrine disrupters in marine wildlife, particularly higher trophic animals, such as marine mammals and birds, with an emphasis on the extent of knowledge gained so far from collaborative studies with Asian environmental scientists.

Global contamination

In our first comprehensive global monitoring survey , we have shown the global contamination by organochlorine endocrine disrupters. Due to mass production and the worldwide use of organochlorines, these chemicals have dispersed all over the globe. In this context, we found that the pollution sources of PCBs are in developed nations, whereas the sources of organochlorine insecticides are present in developing countries. Apart from emission sources, the ultimate end accumulations (sink) of these pollutants are found to be in the marine environment, particularly at the polar regions.

According to our previous studies of water pollution, considerable contamination by organochlorine insecticides such as HCHs and DDTs were found in developing countries in the Asian tropics (Iwata *et al.* 1994). The Asia Pacific phase of the Mussel Watch Project also revealed a similar pollution pattern showing DDT contamination (Figure 17.1) (Tanabe *et al.* 2000; Monirith *et al.* 2003). Contrary to organochlorine insecticides, PCBs concentrations in mussels were apparently higher in developed nations than in developing countries (Figure 17.2). Using resident and migratory birds as bioindicators for monitoring organochlorine contamination, high concentrations of organochlorine insecticides and PCBs were found in birds collected at stopover or wintering areas of tropical

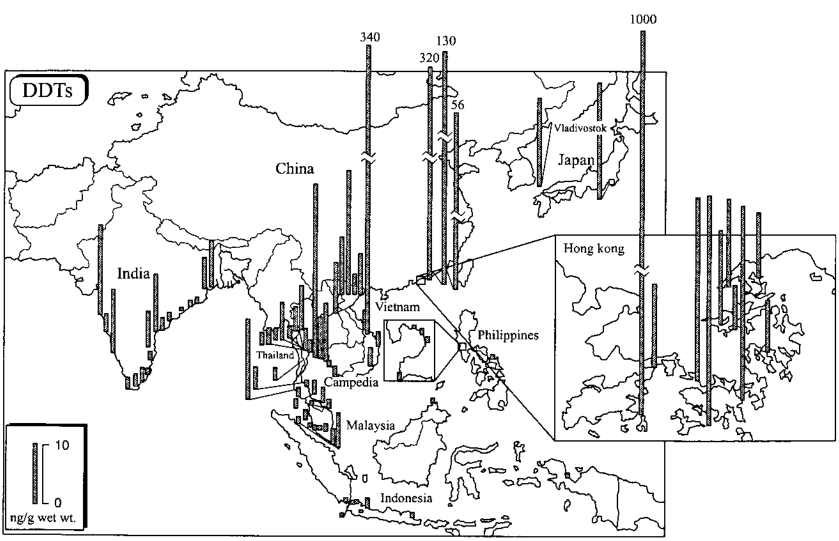

Fig 17.1 Distribution of DDTs (p,p'-DDT+p,p'-DDD+p,p'-DDE) concentrations in mussels collected from Asian coastal waters.

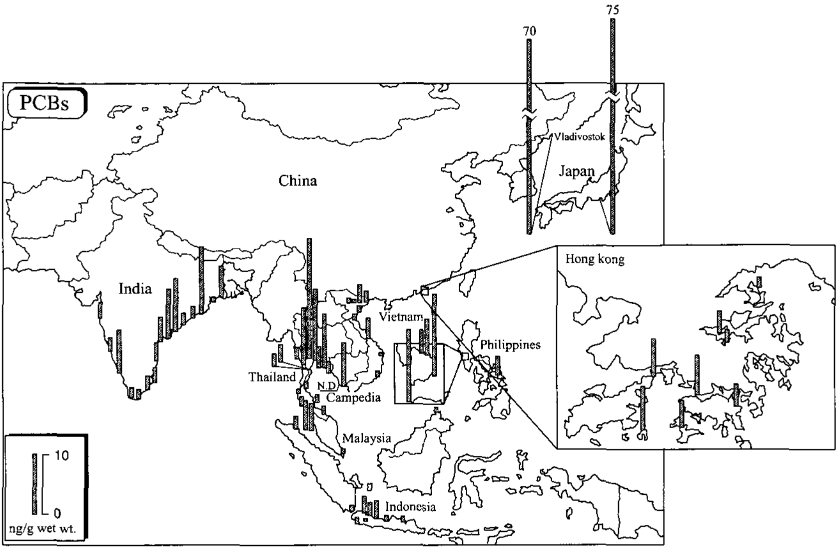

Fig 17.2 Distribution of PCBs concentrations in mussels collected from Asian coastal waters.

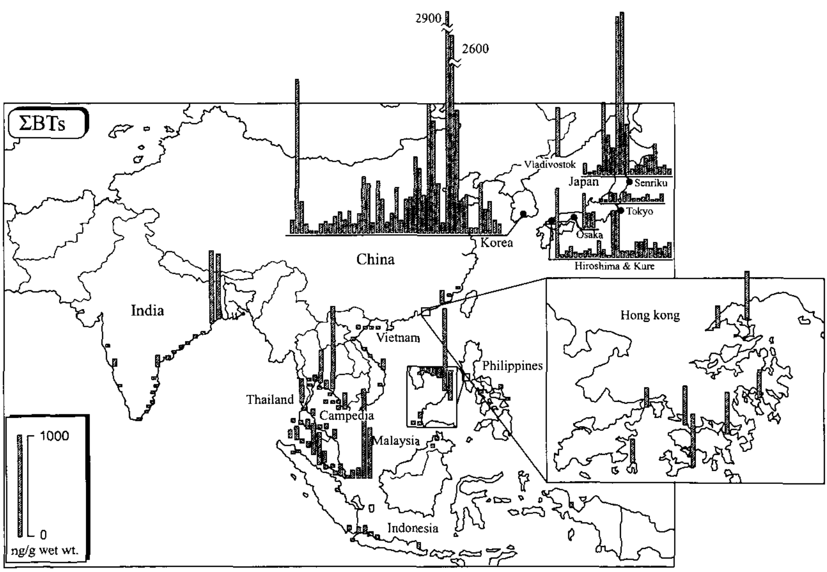

Fig 17.3 Distribution of butyltins (SBTs=Tributyltin+Dibutyltin+Monobutyltin) concentrations in mussels collected from Asian coastal waters.

Asian developing countries and in Russia and Japan (Tanabe *et al.* 1998; Kunisue *et al.* 2002; Minh *et al.* 2002). In addition to organochlorines, the Asia Pacific Mussel Watch Project also revealed the contamination of butyltin compounds in Asian coastal waters (Sudaryanto *et al.* 2000, 2002; Hong *et al.* 2001), where high concentrations of butyltins were found not only in developed nations such as Japan and Korea, but also in some cities of developing countries (Figure 17.3). These observations clearly indicate that the major pollution source of these endocrine disrupters may be found not only in developed nations, but also in some tropical developing countries. This suggests the invasive pollution of endocrine disrupters, even in developing countries.

In this context, it should be remembered that high temperature and heavy rainfall are rather common in the tropics, where most of the developing countries are located. Such climatic features can favor extensive evaporation of organochlorines which would lead to them spreading globally. In our earlier studies, the distribution of organochlorine insecticides and PCBs in the open ocean atmosphere and surface seawater showed widespread contamination, even in the Arctic and the Antarctic oceans (Iwata *et al.* 1993). Among these organochlorines, HCH residues in surface seawater were higher in temperate and colder regions than in low latitude regions. The pattern found in the open sea was apparently different from a pattern found in coastal waters that were more contaminated in the tropical areas. This is probably due to the long-range atmospheric transport of HCHs from tropical coastal waters to the northern open seas.

Summarizing all of these results, the organochlorines used in developing and developed nations are more or less evaporated into the air, and then carried by the long-range atmospheric winds and eventually deposited in the water phase of the open seas, particularly in polar regions. This global transport and the fate of organochlorines are indicative and may be a representative model for other endocrine disrupters of similar physico-chemical properties. Most likely the pollution source of endocrine disrupters and their final sink may be different. In any case, the toxic impacts of endocrine disrupters may affect not only the local ecosystems of the emission sources, but also unexpected areas, such as the Arctic and the Antarctic regions. The environmental impacts of endocrine disrupters should be examined on a global basis, as has been done for issues like the ozone depletion by freons and global warming by carbon dioxide.

Ubiquitous contamination in the ecosystem

Another finding was the ubiquitous distribution, both spatially and temporally, of organochlorines in marine mammals and their characteristic bioaccumulation as shown by their specific physiological functions.

When comparing the number of chemicals detected in marine mammals in the 1960s to that in the 1990s, only five organochlorines and mercury were detected in 81 marine mammals in the 1960s. However, by the 1990s, 265 organic pollutants and 50 elements were detected in more than 5000 marine mammals from all over the world (O'Shea and Tanabe 2003). This summary apparently indicates an anthropogenic influence and the use of tremendous numbers and amounts of chemicals during the past three decades. These chemicals have been released into the environment, spread over the world's oceans and seas, and have accumulated in marine mammals through the food chain. Endocrine disrupters other than organochlorines and heavy metals may follow the same pattern.

Reflecting this rapid chemical industrialization, the cetaceans, including dolphins and whales from the northern Pacific Ocean and Asian waters, had a concentration of toxic organochlorines in their bodies (Prudente et al. 1997), supporting ubiquitous and widespread contamination by organochlorines on a

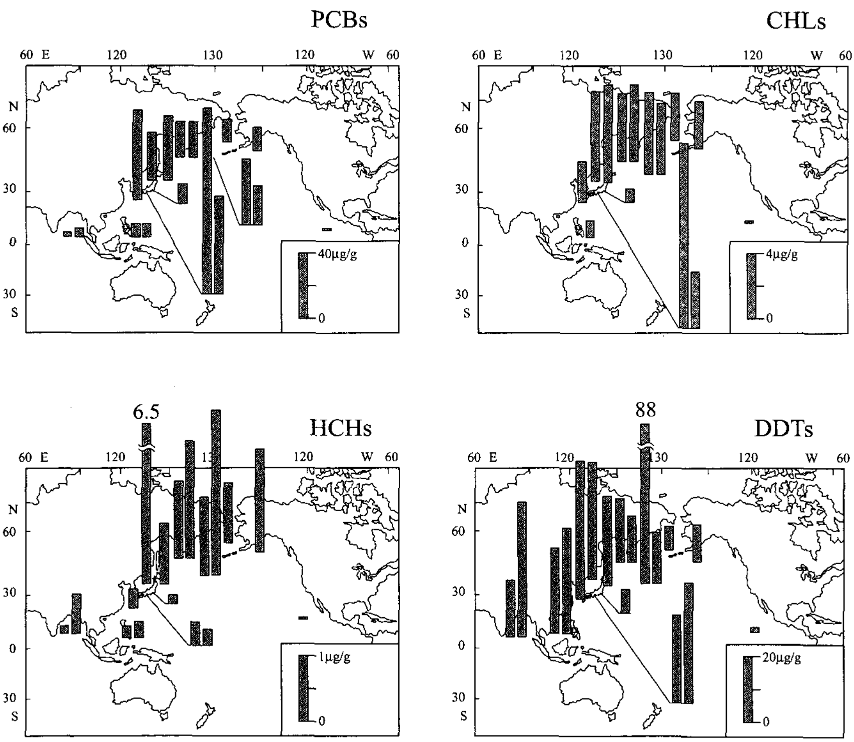

Fig 17.4 Distribution of PCBs, HCHs, CHLs and DDTs concentrations (wet wt basis) in Cetaceans from various locations of the North Pacific, Indian Ocean and nearby seas.

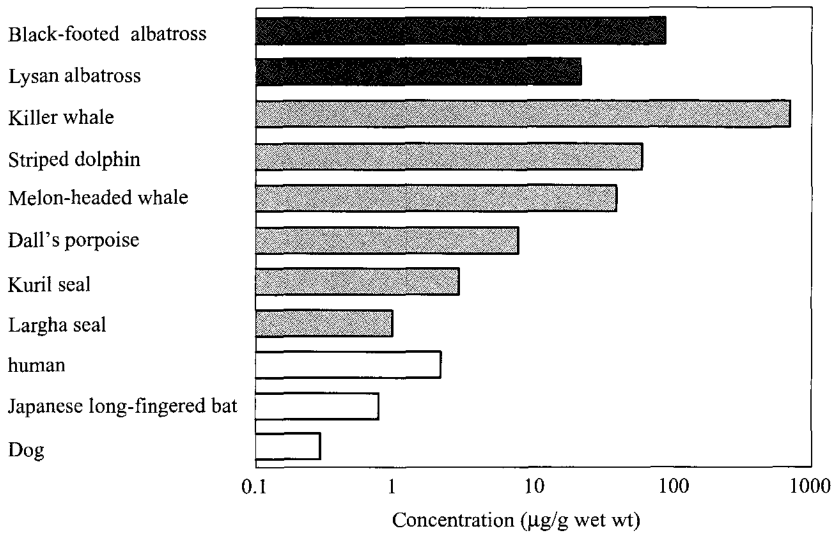

Fig 17.5 PCBs concentrations in mammals and birds collected from Japan and nearby seas.

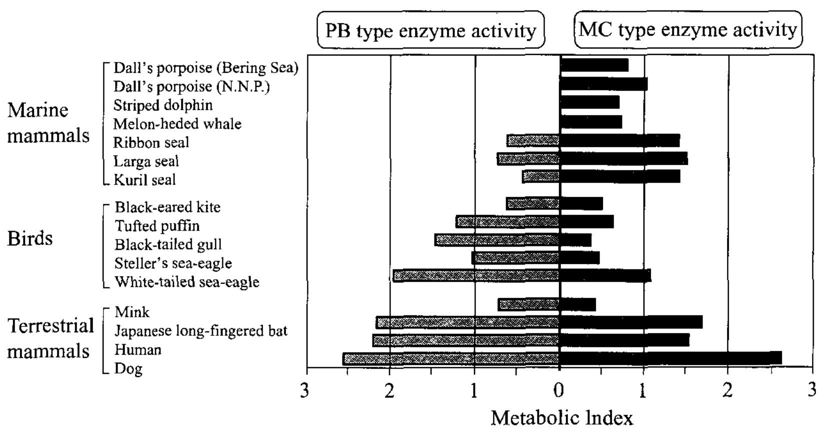

Fig 17.6 Estimated metabolic capacity of PB- and MC-type enzymes in marine and terrestrial higher animals.

global scale (Figure 17.4). Interestingly, the HCH concentrations found in dolphins and whales were higher in species from the high latitude areas than in the low latitude areas. On the other hand, DDT levels were higher in species from southern locations than in northern locations. The patterns of organochlorine distribution found in dolphins and whales are quite similar to those found in seawater. This consistency strongly suggests that the water pollution is the start-

Box

Toxic Man-made Substances Threaten Wildlife

Persistent organic pollutants (POPs) such as PCBs, dioxins, DDT are highly concentrated in the bodies of marine mammals and seabirds. They cause serious toxic effects such as immunosupression and endocrine disruption. Abnormal diseases and mass mortalities have increased in these animals in the last decades that were possibly caused by the toxic effects of these man-made substances.

ing point of bioaccumulation in marine ecosystems.

In addition to ubiquitous contamination, specific and unique accumulation of organochlorines was found in marine mammals. Monitoring studies of PCB contamination in some mammals from the terrestrial, coastal and open ocean environment in and around Japan showed much higher concentrations of PCBs in the cetaceans from open seas than in coastal and terrestrial animals (Tanabe *et al.* 1994a). This is despite the fact that cetaceans inhabit oceans far from areas of industrial and human activities (Figure 17.5). High concentrations of PCBs were also found in some albatross species from open ocean areas, far from human activities (Guruge *et al.* 2001).

Further studies made clear that the specific and high accumulation of PCBs found in dolphins and whales are due to their specific degradation capacities. As shown in Figure 17.6, we have elucidated very low enzyme activities in cetaceans as compared with terrestrial mammals (Tanabe *et al.* 1994a). Therefore, cetaceans have a low capacity to decompose toxic contaminants and retain them in their bodies. These observations suggest that some animals may have specific physiological functions that are apparently different from humans. This may lead to animals with high accumulations and a high sensitivity to pollutants, and it may result in a high risk from such exposure to endocrine disrupters.

Occurrence of toxic effects

In general, many of the abnormalities suspected to be elicited by exposure to these toxic environmental contaminants have been largely found and specifically reported in marine mammals. Additionally, physiological dysfunction from exposure to toxic contaminants has also been suspected in marine mammals, based on the examination of biomarkers such as CYP enzymes and hormones.

Since the 1960s, sterility, abortion, stillbirths and other abnormalities have been observed in pinnipeds and cetaceans from the coastal areas of some developed nations (Delong *et al.* 1973; Helle *et al.* 1976a, 1976b; Reijnders 1986; Beland *et al.* 1993). As reported by Simmons (1991), Colborn and Smolen (1996), various diseases, mass mortalities and abnormal strandings have been increasing in marine mammals all over the world. Interestingly, most of these abnormalities have taken place during the latter half of the century, particularly during the 1980s and the 1990s. The causative factors are still unclear, but many researchers believe that toxic contaminants may play an important role.

Studies using varopis biomarkers have also suggested that organochlorines can pose toxic effects to marine mammals. As seen in Figure 17.7, northern fur seals, collected from the Pacific coast of northern Japan, showed a positive correlation between PCB residues and EROD/PROD enzyme activities (Tanabe *et al.* 1994a). A study of the exposure to organochlorines and its toxic effects in adult male dall's porpoises from the northern Pacific showed a reduction of testosterone levels in the blood with increasing residue levels of DDE in the blubber. This suggests the anti-androgen effect of DDE or the breakdown of steroids by organochlorine or its metabolites-induced enzyme activity (Tanabe *et al.* 1994a). The effects of organochlorines on steroids, thyroid hormones and CYP enzymes have also been shown in other species of marine mammals (Brouwer *et al.* 1989; Reinders 1990, Boon *et al.* 1992). These results imply that enzyme induction and endocrine disruption by some organochlorines may have taken place in natural ecosystems, at least in marine mammal species. Considering these observations, it can be said that the present status of

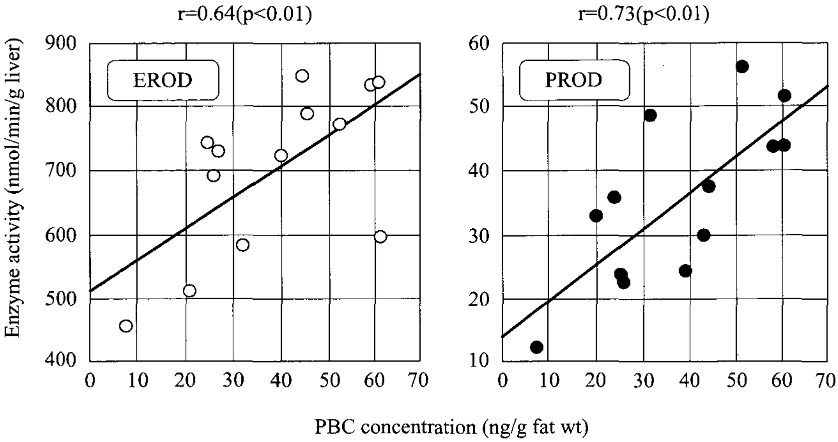

Fig 17.7 Relationship between enzyme activities in the liver microsome and PCB concentrations in the blood of northem fur seal from North Pacific

contamination by organochlorines in the marine ecosystem has already reached potential risk levels, and is likely to cause the induction of P-450 enzymes and to disturb endocrine functions in higher trophic species like the marine mammals.

Future trends of contamination

It is essential to understand the future trends of contamination in order to evaluate forthcoming risks posed by persistent endocrine disrupters. Hence, we have examined the historical trends of organochlorine residue levels in archived fat tissues of the mammary glands of northern fur seals collected from the northern Pacific (Tanabe *et al.* 1994b). PCB and DDT residue levels were found to be at maximum early in the 1970s. DDT levels declined continuously through the 1980s and the 1990s, and those levels at the end of the 1990s reached about one thirtieth of the maximum values found in the early 1970s. Nevertheless, PCB levels in the 1980s and the 1990s showed a steady-state condition with about half of the maximum value found in the 1970s. HCH and chlordane residue levels were constant and no apparent decline has been noticed since 1971. A study to elucidate temporal trends of organochlorine residues was conducted using archived blubber samples in Antarctic minke whales collected from the Southern Ocean from 1984 to 1999 (Aono *et al.* 1997). As described in Figure 17.8, concentrations of organochlorine insecticides and PCBs did not decline during these periods.

From the above results, it should be noted that recent contamination by

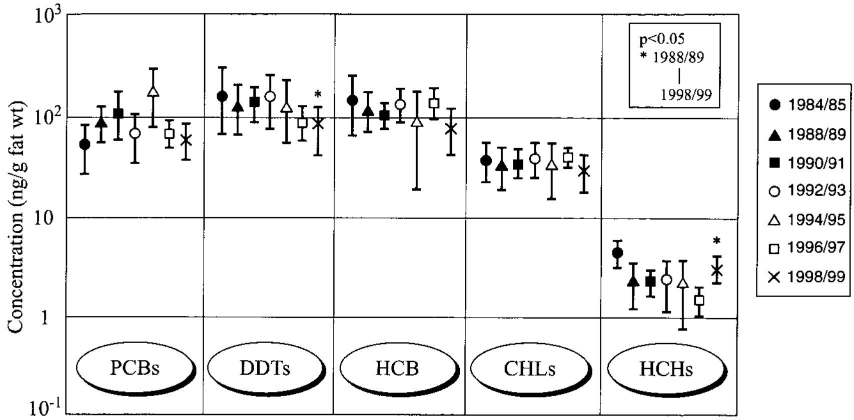

Fig 17.8 Temporal trends of organochlorine residue levels in Antarctic minke whale.

organochlorines in marine mammals has decreased from the severely polluted status in the 1970s, but their declining trends have been very slow in recent years. Particularly PCBs, which are one of the prominent contaminants of concern, showed a slow temporal decrease of residue levels in the marine ecosystems. If the present levels of PCBs continue for a long time, it is probable that their toxic effects on marine mammals will increase. Considering all of these facts, it can be concluded that marine mammals are one of the most vulnerable targets of the long-term toxicity of hazardous man-made chemicals.

Contamination of dioxins and related compounds

Dioxins and related compounds, such as polychlorinated-*p*-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs) and coplanar PCBs are a growing concern due to their toxic effects in marine mammals and birds. According to a comprehensive national survey by the Japanese Ministry of Environment (1999), dioxins and related compounds were widely detected in Japanese wildlife, with fish-eating animals, like kites and cetaceans, containing very high concentrations. Interestingly, terrestrial animals are more contaminated with PCDDs and PCDFs than coplanar PCBs. However, fish-eating animals such as kites and marine mammals are highly polluted by coplanar PCBs rather than PCDDs and PCDFs. This is due to the difference in the physico-chemical properties of PCDDs/PCDFs and coplanar PCBs. PCDDs and PCDFs are relatively less volatile, less water soluble, and have a stronger particle affinity than coplanar PCBs. Therefore, PCDDs and PCDFs are less transportable from

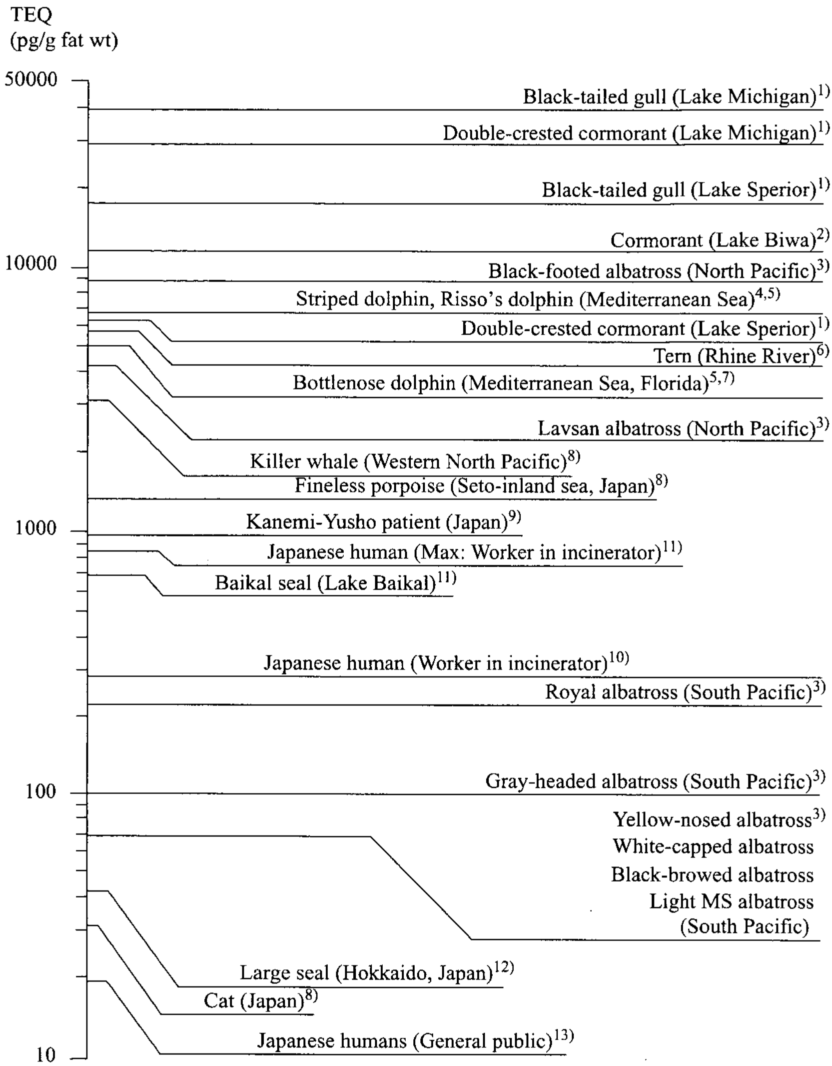

Fig 17.9 Comparison of TEQ (Toxicity Eqivalents) values of dioxins and relaed compounds in humans and wildlife.
1) Yamashita *et al.* (1993); 2) Guruge and Tanabe (1997); 3) Guruge *et al.* (2001); 4) Kannan *et al.* (1993); 5) Corsolini *et al.* (1995); 6) Bosveld *et al.* (1995); 7)Watanabe *et al.* (2000);8) Kannan *et al.* (1989); 9) Tanabe *et al.* (1989); 10) Ministry of Health, Labour and Welfare (2000); 11) Nakata *et al.* (1997); 12) Nakata *et al.* (1998); 13) Ministry of Enivironment (1999).

the terrestrial to the marine environment through air and water. Conversely, coplanar PCBs are much more transportable through air and water. Reflecting these properties, coplanar PCBs are largely retained in marine animals, whereas PCDDs and PCDFs are principally accumulated in terrestrial animals.

When summarizing some of the representative data reported so far, we can infer that the residue levels of dioxins and related compounds in terrestrial and coastal animals are much higher in wildlife than in humans. Some fish-eating mammals and birds retained great concentrations of dioxins and related compounds (several thousand ppt in TEQ) in their bodies, implying a higher risk from exposure of wildlife to dioxins and related compounds (Figure 17.9). Strict regulations on the emission of dioxins and related compounds have been requested to protect animal as well as human health.

Perspective of dioxin pollution

In order to reduce and phase out persistent organic pollutants (POPs), an intergovernmental treaty will be ratified in 2004 (UNEP 2000). The global pollution of many POPs is expected to decrease in the future. However, developing countries may continue to be a potential source of some POPs, particularly dioxins and related compounds.

In the urban regions of developing countries, large-scale dumping of municipal wastes is common. A variety of wastes, including plastics, metals, papers, woods and raw materials are dumped in large open land areas. The major problem in such open dump sites is the burning of wastes at low temperatures generating methane gas. Low temperature burning of wastes usually forms dioxins and related compounds. Our research group has recently conducted surveys of dioxin pollution in some Asian developing countries. High concentrations of PCDDs, PCDFs and coplanar PCBs were found in soil samples from dumping sites in some developing countries (Table 17.1). TEQ concentrations detected in some soil samples exceeded the environmental quality standard set forth by the Japanese government (1000 TEQ pg/g on a dry weight basis). This suggests the potential for adverse effects on the health of humans and wildlife in developing countries.

In any case, it is believed that dioxin problems are a major issue in developed nations. No contamination problems in developing countries, other than some incidents such as the herbicide Agent Orange in Vietnam and Yusho disease in Taiwan, are known. However, as pointed out here, the dumping sites of municipal wastes in developing countries can be a significant source of dioxin related compounds. This source may lead to widespread environmental and marine

Table 17.1 Concentration (pg TEQs/g dry wt basis) of PCDDs, PCDFs and coplanar PCBs in soil samples from dumping sites of municipal waster in some Asian developing countries.

Countries	*n*	PCDDs	PCDFs	Coplanar PCBs	Total TEQs
India	13	5.6-140	4.3-94	2.4-10	13-210
		(27)	(23)	(5.2)	(55)
Cambodia	6	46-1500	70-1100	na[b]	110-1700
		(410)	(440)	17-34	(860)
Philippines	3	170-290	240-350	(26)	440-660
		(230)	(300)		(560)

Data was indicated as range and mean (in parethesis) concentrations.
[a] TEQs were caluculated using WHO-TEFs for human and mammals (Van den Berg *et al.* 1998).
[b] Not analyzed.

pollution. In view of marine pollution by dioxins and related compounds further studies are needed in the developing regions of Asia.

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18
Ageing, Diseases and Ecology

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The ultimate objective of clinical medicine is to cure diseases and save human life. However, this fundamental philosophy of clinical medicine is not necessarily true for the elderly people who may have chronic organ damage and who are nearing the end of life. What is the ultimate objective of geriatric medicine? What is the most important principal for geriatric medicine? To address these important issue we considered new paradigms for medical philosophy in relation to the aged.

The rising age of the population

The elderly population in Japan is growing at the fastest rate in the world. In 1960, 5.7 percent of the Japanese population was aged 65 years or older, whereas in 2003, this per centage had increased to 18.0 per cent; the projected per centage for the year 2025 is 27.4 per cent (Statistics and Information, Minister's Secretariat, Ministry of Health and Welfare 1997). In response to the increasing population of the elderly, there has been an intense debate on how to provide efficient and effective health care to older persons. In 1980, Fries warned that the practical focus on health improvement over the next decades must be on chronic instead of acute disease, morbidity not mortality, quality of life rather than its duration, and on postponement rather than cure (Fries 1980). Although comprehensive geriatric assessment with long-term management has been reported to be effective for improving survival and function in the elderly (Epstein 1987, Applegate 1990, Stuck 1993), only a few trials of comprehensive geriatric assessment beyond medical diagnosis and treatment have been performed in the hospital setting in Japan. While each Japanese local self-governing body has expended a great deal of individual effort, both in public finance and personnel to care for the frail elderly, the benefits of these strategies and their effects remains undetermined.

Kahoku Longitudinal Aging Study (KLAS)

To address this important issue, since 1991 we have annually conducted a community-based comprehensive geriatric assessment and appropriate interventions in the rural town of Kahoku, Kochi Prefecture, Japan. Twenty-nine per cent of Kahoku's population in 1991 was 65 years or older. This project was called 'Kahoku Longitudinal Aging Study '-(KLAS). Data was collected using geriatric physicians, care providers and the town office administrators. The question addressed in this chapter is whether community-based comprehensive geriatric assessment and appropriate interventions are useful in preserving the functional abilities of elderly people living in a community. We investigated this relationship for ten-years with serial data from community-based samples from these rural elderly Japanese.

Subjects and method

The subjects

A geriatric survey of residents aged 65 years or older living in Kahoku was conducted in 1991, and has been continued annually since (Matsubayashi *et al* 1996). Kahoku is a rural town in Kochi Prefecture located in the southwestern

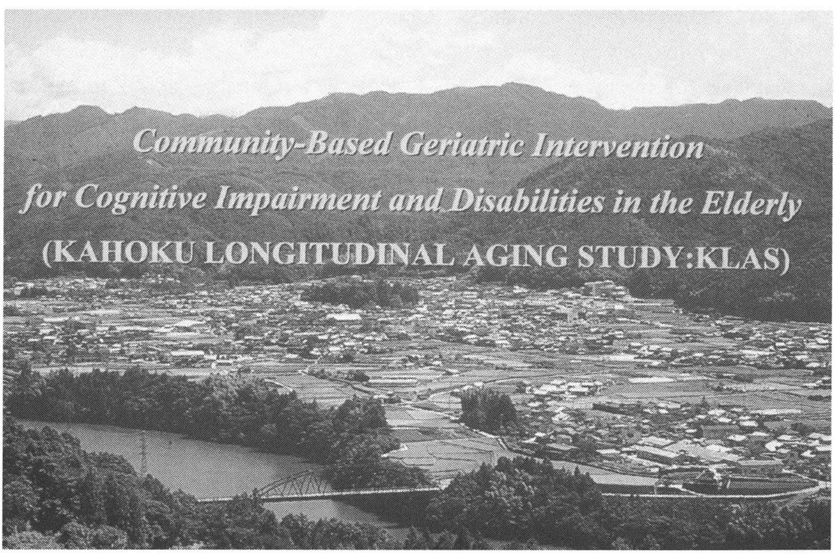

Fig 18.1 A panorama of Kahoku town

Box

Keywards

ADL: Activities of Daily Living

For the basic ADL assessment, we calculated the scores for seven items (walking, ascending and descending stairs, feeding, dressing, using the toilet, bathing and grooming) using a rating scale of from 0 (completely dependent) to 3 (completely independent) into a basic ADL score (0-21). For advanced ADL, we employed the Tokyo Metropolitan Gerontology Institute index (TMGI index) rating scale of from 0 to 13. This scale includes instrumental ADL (0-5), intellectual activity (0-4), and social role (0-4).

QOL: Quality of Life

Seven indicators of QOL (sense of subjective health, mood in recent days, relationship with family, relationship with friends, financial satisfaction, life satisfaction and subjective happiness) were rated on a 100 mm visual analogue scale (worst QOL on the left end of the scale, best on the right). We asked participants to mark on the scale the level of their QOLs for each indicator. We measured the distance in mm from the left end to the marked position to determine each QOL score.

part of Japan (Figure. 18.1). Its population in 1991 was 6,085, of whom 29.35 per cent were aged 65 years or older. Approximately seven to eight per cent of residents aged 65 years or older and registered in the town were long-term institutionalized. The number of subjects who are institutionalized long-term every year has remained unchanged over the past ten years. All the elderly residents aged 65 or older living in Kahoku, except patients who had been institutionalized long term, were sent a letter together with a questionnaire inviting them to participate in the survey. This was followed up a few days later by a visit from trained interviewers who confirmed the answers and collected the questionnaires. If a person was unable to give informed consent owing to disability, the principal caregivers or relatives were asked for consent. About 3 per cent of those approached refused to participate. This refusal rate was similar every year during the ten years. The annual numbers of subjects who completed data in this survey in 1991 to 2001 were, respectively, 1488, 1590, 1639, 1680, 1724, 1775, 1778, 1805, 1853, 1865, and 1841. These numbers represent 95 per cent-97 per cent of Kahoku residents aged 65 or older living in the town.

Measures of health

Each subject was asked about demographic characteristics, education, sensory functions such as eyesight and hearing, current health problems, psycho-social environment and social support, use of medical care, and a list of diseases with which the subject might have been diagnosed. Each subject was also asked in detail about his or her capacities for seven items of activities of daily living (ADL). They were walking, ascending and descending stairs, feeding, dressing, toileting, bathing and grooming. We also asked how much help was needed and rated them using a score from 3 to 0, where a score of 3 equaled complete independence, 2=needed some help, 1=needed much help, and 0 was completely dependent (Ozawa 1992). These seven scores were added to give a rating ranging from 0 to 21, with a low score indicating disability. We defined as subjects 'independent' in activities of daily living in subjects with combined scores of 21.

Community-based geriatric interventions

Community-based geriatric interventions in the Kahoku Study consisted of seven kinds of trials.

(1) Geriatric examination of the elderly aged 75 years or older

The subjects aged 75 years or older were annually invited to participate in the health screening such as blood pressure measurements, electrocardiography, screening of blood chemistry, medical examination by geriatric physicians and in the assessment of cognitive and neurobehavioral functions by psychometric specialists. Based on the findings of the examination, each subject was given medical guidance.

(2) A monthly report as to the health condition of the elderly subjects

Several volunteers in every district reported every month on the health condition and activities of daily living for the elderly subjects with whom each volunteer was in charge.

(3) Patrol visits by community nurses

Based on the report from each district volunteer, five contracted community nurses visited the residences of the elderly subjects to check their state of health. They called on each elderly subject an average of three times a year. When community nurses judged that it was not good to take care of the elderly at home, the patient was offered (after consultation with the physician in charge), the chance to go to rehabilitation or enter the hospital and do short-term rehabilitation.

(4) House calls and temporary nursing at home
A request for house calls or temporary nursing at home for the frail elderly subjects was used as much as possible as opposed to insitutionalizing them. Moreover, four contracted staff members visited residences of elderly persons living alone to regularly help them with the domestic doctors if they wished.

(5) Health lecture meetings
We gave twelve lecture meetings every year instructing the elderly in disease prevention and health promotion. The number of participants at each lecture was approximately 200.

(6) Exercise programs for the elderly
A supervised 60-minute exercise session twice a week for twenty-four consecutive weeks for the elderly over 75 years old was attended by 22 participants in 1992. This was found to be effective in the improvement of neurobehavioral functions in the elderly (Okumiya 1996). Based on the evidence of the positive effect of exercise in this preliminary study, exercise programs have continued and more than 150 participants participated in 1996.

(7) Daytime-care services for the frail elderly
Daytime-care services for the frail and predementic elderly, including programs for mild physiotherapy, occupational therapy and group play therapy, were conducted in 1995 with 40 participants.

In a follow-up survey of independence and mortality, we investigated the per centage of people who were aged 65 or older that were independent in activities of daily living from 1991 to 2001. We also investigated the risk factors of subsequent overall death and dependency in ADL during ten years. We identified the death of a subject based on death certificates registered in the town.

Independence rates were compared using the Chi-Square test. Cumulative survival curve for the independent and dependent was obtained using the Kaplan-Meier method. Relative risk for death within ten years adjusted by age and sex was calculated using the Cox proportional hazards model and logistic regression models.

Results

Tables 18.1 and 18.2 show the relative risks and 95 per vent confidence intervals for subsequent death within ten yeras in monovariate analysis using logistic regression models in subjects from the 1991 cohort (N=1488). Table 18.3 shows the relative risks analyzed by a multivariate analysis using independent variables from the monovariate analysis.

Tables 18.4 and 18.5 show the relative risks and 95 per cent confidence intervals for the subsequent ten-year dependent group in the ADL by monovariate analysis using logistic regression models in subjects of the 1991 cohort (N=1488). Table 18.6 shows the relative risks for subsequent ten-year dependence in ADL analyzed by a multivariate analysis using independent variables in monovariate analysis.

Figure 18.2 shows the trend in per centage of people aged 65 or older who were independent in ADL from 1991 to 2001. Notably, the proportion of the independent elderly aged 65 years or older annually increased from 1992 to 1997, and slightly decreased from 1998 to 2000 which may have been due to the introduction of national long-term care insurance. This trend has stopped and has again increased in 2001.

Figure 18.3 shows the yearly trends in the average medical expenses for an elderly subject per year in Kahoku and in mean of all of Kochi Prefecture, as well as the trend in the ADL-independence rate of the elderly people living in Kahoku from 1990 to 2001. The proportion of the independent elderly aged 65 years or older in Kahoku increased. Although average medical expenses per year for an elderly subject were annually increasing, both in Kahoku and in the whole

Table 18.1 Monovariate analysis of relative risk for subsequent death within ten years (1)

Factors	RR	95% CI	P
Age	1.154	1.132-1.176	<0.0001
Gender (female)	0.637	0.507-0.799	<0.0001
ADL			
Independent basic ADL in 1991	4.216	3.297-5.392	<0.0001
Impaired information related function in 91	3.48	2.748-4.408	<0.0001
Incontinence	5.744	3.425-9.631	<0.0001
Falls	2.002	1.487-2.697	<0.0001
Medical			
Hx of stroke	—	—	NS
Hx of heart disease	—	—	NS
Hx of cancer	3.419	1.034-11.306	0.0439
Hx of osteoarthropathy	—	—	NS
Hypertension	—	—	NS
Depression (GDS≧5)	1.674	1.326-2.114	<0.0001

Table 18.2 Monovariate analysis of relative risk for subsequent death within ten years (2)

Factors	RR	95% CI	P
Social factors			
Financially poor	2.576	1.863-3.564	<0.0001
Spouse being well	0.637	0.505-0.803	0.0001
Solitude	—	—	NS
Satisfactory Family life	—	—	NS
Life Style			
Acive group activity	0.481	0.326-0.710	0.0002
Everyday working	0.411	0.324-0.521	<0.001
Drinking	0.654	0.507-0.844	0.0011
Smoking	0.758	0.578-0.993	0.044
Walking everyday	0.54	0.416-0.702	<0.0001
Joining exercise class	0.105	0.033-0.337	<0.0001

Table 18.3 Multivariate analysis of relative risk for subsequent death within ten years

Factors	RR	95% CI	P
Age	1.152	1.113-1.192	<0.0001
Gender (female)	0.572	0.334-0.978	0.0412
Independent basic ADL in 1991	1.924	1.201-3.082	0.0065
Drinking	0.575	0.353-0.938	0.0266

Table 18.4 Monovariate analysis of relative risk for subsequent dependence in ADL within ten years (1)

Factors	RR	95% CI	P
Age	1.139	1.108-1.170	<0.0001
Gender (female)	1.991	1.501-2.639	<0.0001
ADL			
Impaired information related	2.297	2.197-3.898	<0.0001
function in 91		—	
Incontinence	—		NS
Falls	3.313	2.160-5.081	<0.0001
Medical			
Hx of stroke	5.646	1.516-21.020	0.0099
Hx of heart disease	—	—	NS
Hx of cancer	—	—	NS
Hx of osteoarthropathy	2.69	1.626-4.449	0.0001
Hypertension	1.51	1.146-1.988	0.0033
Depression (GDS≧5)	1.589	1.211-2.085	0.0008

Table 18.5 Monovariate analysis of relative risk for subsequent dependence in ADL within ten years (2)

Factors	RR	95% CI	P
Social Factors			
Financially poor	2.667	1.669-4.261	<0.0001
Spouse being well	0.672	0.505-0.894	0.0064
Solitude	–	–	NS
Satisfactory family life	–	–	NS
Life style			
Acive group activity	0.624	0.425-0.916	0.016
Everyday working	0.491	0.361-0.667	<0.0001
Drinking	0.492	0.365-0.664	<0.0001
No smoking	1.711	1.192-1.192	0.0036
Walking everyday	0.589	0.417-0.831	0.0026
Joining exercise class	0.545	0.306-0.972	0.0397

Table 18.6 Multivariate analysis of relative risk for subsequent dependence in ADL within ten years

Factors	RR	95% CI	P
Age	1.163	1.120-1.207	<0.0001
Gender (female)	1.741	1.026-2.954	0.04
Impaired information related function in 91	1.95	1.293-2.941	0.0015
Falls	1.855	0.982-3.504	0.0569
Hx of stroke	4.901	1.024-23.453	0.0466
Depression (GDS≧5)	1.411	0.951-2.029	0.0868
Drinking	0.601	0.375-0.962	0.0339
Joining exercise class	0.519	0.260-1.034	0.0622

Kochi Prefecture from 1990 to 1998, the increased rate during eight years in Kahoku (¥783,24 in 1990 and ¥922,800 in 1996; 18 per cent increase) was lower than the increase in the average for the whole of Kochi Prefecture (¥755,976 in 1990 and ¥966, 084 in 1998; 28 per cent increase). Medical expenses in both Kahoku and Kochi Prefecture decreased in 2000 due to the introduction of national long-term-care insurance.

Discussion

Specific organ disease-oriented medicine in the elderly in the highly-developed Japanese hospitals is of little value in realizing the idea that 'health in the elderly is best measured in terms of function' (World Health Organization Regional Office for Europe 1959). There are many care hospitals filled primarily with chronically ill, bedridden-, and largely neglected elderly patients who were transferred from highly-developed hospitals. These elderly patients have not received proper

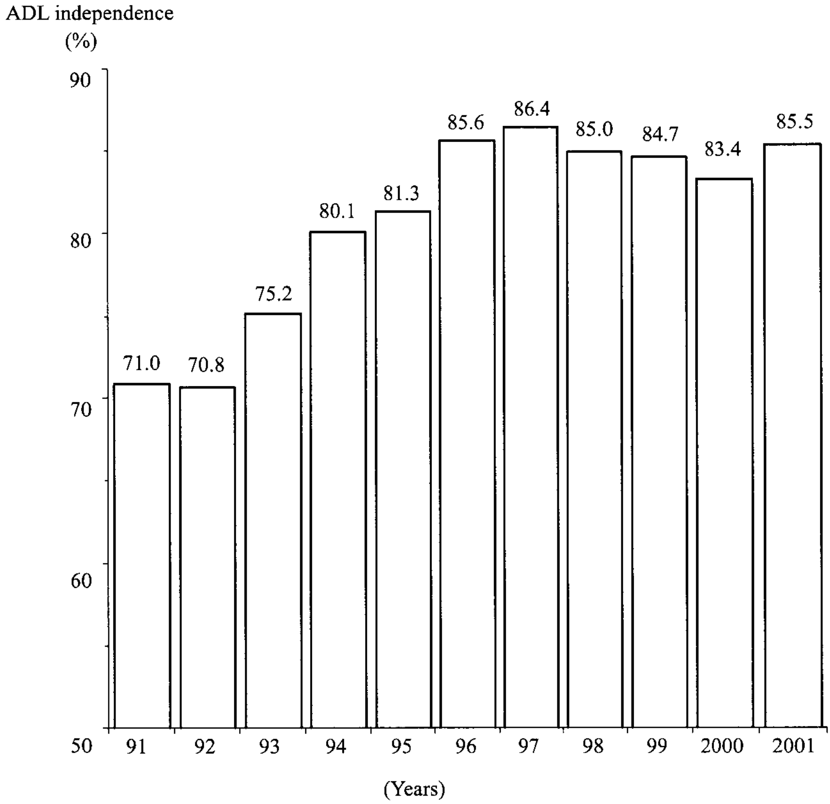

Fig 18.2 Annual trend in ADL independent rate in elderly subject in Kahoku from 1991 to 2001

rehabilitation and were thought to be in need of lifelong institutionalization in Japan. In contrast to the development of high-level medical technology, a great number of geriatricians in Japan have made a belated start in appreciating the concept of geriatric assessment postulated by British geriatrician Marjory Warren. During the late 1930s, Dr Warren advocated that all elderly patients receive a comprehensive assessment and an attempt at rehabilitation before being admitted to a long-term care hospital or nursing home (Matthews 1984). The concept of geriatric assessment, at long last, has begun to be recognized by Japanese geriatric practitioners. Geriatric assessment attempts are done to match the needs of older persons with the health care services they receive (Williams 1986). It can be defined as a multidimensional, often interdisciplinary, diagnostic process intended to determine a frail elderly person's medical, psycho-social, and functional capabilities and problems. The objective is to develop an overall

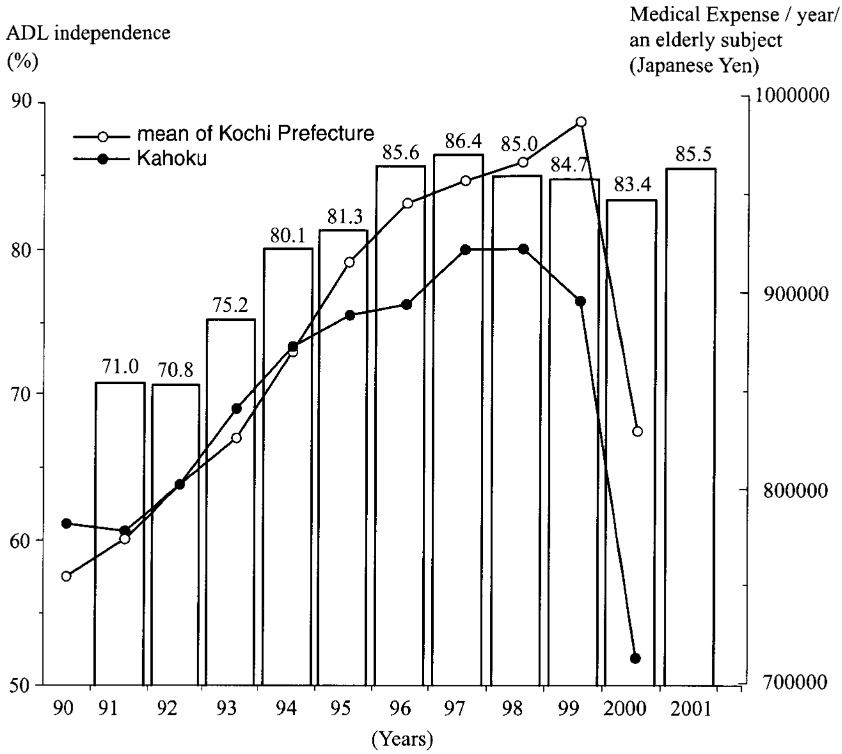

Fig 18.3 Yearly trends in an average medical expense for one elderly subject by 1 year in Kahoku (Closed Circles) and in whole prefecture (Open Circle) as well as trend in ADL-independent rate (bars) of the elderly people living in Kahoku from 1990 to 2001

plan for treatment and long-term follow-up. (Rubenstein 1989). In the Kahoku Study, we, the geriatric clinicians, have started community-based geriatric assessments and interventions in cooperation with town administrators, community nurses, volunteers and home doctors in this district.

In this chapter, we reported a ten year improvement in the self-care and independence of the elderly population living in the community. Although the proportion of the elderly population aged 65 or older increased from 29 per cent to 36 per cent during ten years in Kahoku, our data revealed that the prevalent rate of independent elderly subjects also increased from 71 per cent to 86 per cent. Of particular note in our study is that the improvement in independence was more conspicuous in the extremely old age group than in the middle or younger older group. These results indicate that the frailty of the older subjects, at least in part, may be more reversible by interventions such as rehabilitation or exercise programs, than that of the younger elderly subjects. Most of the physical disabilities of the younger old subjects might be due to irreversible diseases such as stroke or osteoarthropathy, whereas the disabilities of older old subjects might include reversible ones due to aging itself or a daily immobile life style. Active geriatric interventions should be urgently applied to the latter kinds of disabilities for the preservation of the functional capacities of older subjects.

Recent studies, based on community-based samples of the elderly, have shown that dependency in activities of daily living are significant predictors for mortality in several countries (Warren and Keight 1982; Branch 1984; Manton 1988, Tsuji 1994, Grand 1990, Ho 1991, Koyano. 1989 Matsubayashi. 1999). Both of our seven-year prospective comparative results of cumulative survival rates between independent and dependent subjects in activities of daily living are consistent with previous studies, confirming that impairment of activities of daily living is a predictor of subsequent mortality (Matsubayashi 1999). The risk ratio of dependency was by itself a significant predictor for subsequent death after adjustment for the effects of age and sex.

In 1980, Fries presented a view of the future in which the survival curve and also the morbidity curve would be made more rectangular (Fries 1980). He argued that the number of very old people would stop increasing, morbidity would be compressed into shorter periods before death, and the need for medical resources would be reduced. However, criticisms and controversies exist as to whether Fries' hypothesis is relevant to issues of immediate concern. Schneider (1983) argues that the number of very old people is increasing rapidly, the average period of diminished vigor will probably increase, chronic diseases will probably occupy a larger proportion of our life span, and that the need for medical care in later life are likely to increase substantially (Grundy 1984) Although we agree with Schneider's opinion, due to the fact that in Japan the elderly population and the need for medical care are rapidly increasing, our data indicates that the disability-free curve in Kahoku and not the morbidity curve itself, appears to be more rectangular as Fries has suggested. Though we do not accept all of Fries' conclusions, the average age of irreversible disability, at least in activities of daily living, can be increased by changes in life style and appropriate geriatric interventions. Whether 'compression of disability' is achievable or not is a separate issue.

Because we lacked a cohort case-control in our study design, whether the improvement in the independence of elderly people in Kahoku was a natural trend or the effect of community-based geriatric interventions remains unproven. However, our serial cross-sectional data suggests that the proportion of subjects with disability, at least in non-institutionalized elderly people in Kahoku, is not parallel with an increase in the proportion of the elderly population. And data of ten-year trends in medical expenses and in ADL suggests that the improvement in ADL independence in the elderly may suppress the increasing rate of medical expenses for the elderly. We think that community-based strategies for the promotion of health the elderly, at least of the community-dwelling elderly, may curb the increase in medical expenses for the elderly population. In conclusion, the increasingly rectangular shape in the disability-free curve in our study indicates that a higher per centage of elderly in the population does not coincide with a higher proportion of disability in the elderly.

Conclusion

Our study also suggests that comprehensive geriatric assessments and intervention in the community may have great potential for preserving the independence of the elderly, confirming what previous studies have suggested (Rubenstein 1992).

ADL independence of elderly people and ecology

To add to the longitudinal geriatric intervention study in Kahoku, in cross-sectional studies we surveyed the elderly living in three other towns in Japan (741 eligible older subjects in Yogo in Shiga, 2689 eligible subjects in Sonobe in Kyoto and 741 eligible subjects in Urausu in Hokkaido). Furthermore, we also investigated older subjects living in two areas abroad; 117 volunteers in Choa Chukang, Singapore and 1034 volunteers in Hongchang, Korea. Figure 18.4 shows the comparison between the independence rate in ADL in the older subjects living in six different Asian areas including four rural towns in Japan. The study populations consisted of all of the eligible population aged 65 years or more in four towns in Japan and Korea, and elderly volunteers aged 65 years or more in Singapore. Although the mean age of the study population is younger in Korea and older in Singapore than the population in Japan, the independence rates were different among the six areas, indicating that ADL independence in community-dwelling elderly subjects may be influenced by ecological differences such as natural environments, historical backgrounds, life style, habits, religion and health promotion policies. With a longer life span and a decreasing birth rate, demographic ageing is now an established trend not only in developed countries but also in developing countries, such as in Southeast Asia. Therefore, the issue of efficient health care for the elderly is going to be a more urgent issue in the Southeast Asian countries.

To achieve appropriate policies to detect the ecology-related risk factors for

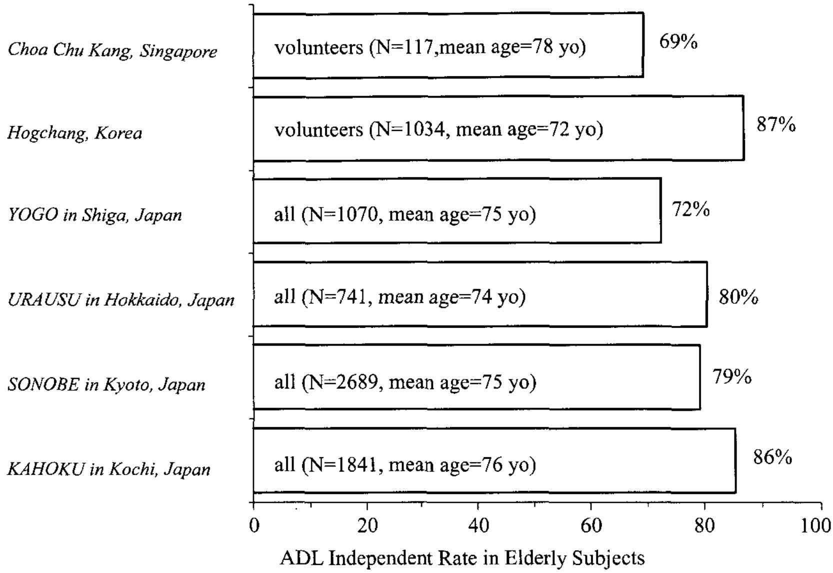

Fig 18.4 ADL independent rate in elderly subjects in six different areas in Asia. All: All eligible elderly subjects aged 65 years or older in each area.

frailty in the elderly and to prevent disabilities in the elderly population, as well as to provide the useful care services, we need to further investigate each comprehensive area from the the standpoint of health and diseases.

In the future, appropriate and individual comprehensive geriatric assessments and intervention in Southeast Asian communities, as well as in Japan, will need to be conducted based on the achievements of ecological medicine and area studies.

Acknowledgements

We thank all of the members who worked on the Kahoku Study and all of the residents, especially the elderly residents, living in Kahoku. We also thank all of the subjects examined in Singapore, Korea and Japan. Without the participation of all these people, the insights we made would not be possible.

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19
Chronomes, Aging and Disease

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Circadian, circannual, circaseptan (about 7-days) and other variations in the incidence of adverse vascular events, such as acute myocardial infarctions, strokes and sudden cardiac deaths (as recorded by their time of onset), have been noted in many studies and may carry important pathophysiological implications (Cornelissen *et al.* 1999; Cornelissen *et al.* 1994; Cornelissen *et al.* 1993; Cornelissen G 1999; Cornelissen and Halberg URL http://revilla.mac.cie.uva.es /chrono, Cornelissen *et al.* 2001; Halberg *et al.* 1997; Halberg 1969, Otsuka 1998; Reinberg and Smolensky 1983; Smolensky *et al.* 1972; Touitou and Haus 1992). Most studies showed an increased onset in the morning, with a peak incidence between 06:00 and 12:00, although a secondary peak in the late evening has also been observed. These results have been aligned with the concomitant rapid increase in blood pressure (BP), heart rate (HR), cardiac output, platelet aggregation and the corresponding decrease in cardiac vagal activity and fibrinolytic function (Cornelissen *et al.* 1997; Halberg *et al.* 1998; Halberg *et al.* 1996; Halberg *et al.* 1999; Halberg et al. 2002; Katinas *et al.* 1999; Little and Halberg 1991; Otsuka *et al.* 1997; Otsuka *et al.* 1997; Otsuka *et al.* 1996; Otsuka *et al.* 1999; Otsuka K 1997). These patterns are synchronized by socio-ecologic factors such as human life styles, economic conditions, the climate in its broadest sense and also includes storms in space (Baevsky *et al.* 1998; Baevsky *et al.* 1997; Breus *et al.* 1995; Bubenik *et al.* 2000; Ghione *et al.* 1998; Gmitrov *et al.* 1999; Halberg *et al.* 2000; Halberg *et al.* 2000; Halberg *et al.* 1995; Halberg *et al.* 1990; Halberg F 2000; Hanson *et al.* 1984; Lipa *et al.* 1976; Malin and Srivastava 1979; Mikulecky 1994; Ossenkopp *et al.* 1983;

Rajaram and Mitra 1981; Stoupel *et al.* 1983; Stoupel *et al.* 1995; Villoresi *et al.* 1994; Villoresi *et al.* 1994; Vladimirskii *et al.* 1995). Therefore, more attention must be paid to broader ecological issues (Matsubayashi *et al.* 1999; Matsubayashi *et al.* 1997; Matsubayashi *et al.* 1996; Mikulecky M. 1994; Okumiya *et al.* 1999) including the geomagnetic latitude.

Previous archival studies have reported morbidity or mortality patterns in the occurrence of cardiovascular events, but few records have been kept on weekly, monthly, yearly or even longer-term physiological (that is, infradian) variations. Among the latter, variations along the scale of a week in electrocardiogram (ECG: one of the indices in monitoring the heart and diagnosing heart disease) physiology and pathology are also prominent. We postulate that the physiological chronomes, such as that of the heart rate variability (HRV), have counterparts in our environment and that our genetic make-up over time may have evolved from our adaptation to and integration with our cosmos, We should examine how these phenomena in the cosmos including helio magnetics and geomagnetics, can affect physiological chronomes (from 'chronos': time, 'nomos': rule and chromosome; 'chronome' then complements the related term 'genome', derived from gene and chromosome) particularly for the HRV. Therefore, in this study we compare the infradian patterns of heightened susceptibility to vascular disease as they relate to time. We compare different countries, notably in Asia, for correlation with geographical differences in life style, climate and economics.

Chronobiology, chronocardiology and chronoecology

'Chronobiology' was proposed by Franz Halberg in 1950. He showed a diurnal variation in eosinophil levels in mice (Halberg and Visscher 1950) and used the term 'circadian' for the first time in 1959 (Halberg 1969). The concept of chronobiology (Aschoff 1965; Aschoff 1974; Horz 1990; Pittendrigh 1993) was known all over the world when the paper titled 'Chronobiology' was published in the Annual Review of Physiology (Halberg 1969). In recent years, the science of chronobiology has shown relevance in the sciences of brain and heart research. At present, most organisms, from cyanobacteria to mammals, are known to use circadian clocks to coordinate their metabolism with the natural 24-hour light/dark cycle. When the human clock gene was found and mapped to chromosome 17p12-13.1 in 1997 (Tei *et al.* 1997), it was surprising that the clock gene is closely similar in all life forms on Earth. In plants, several molecular components have been described for the circadian system, including the blue light photoreceptor cryptochrome and the red light photoreceptor phytochrome. Cryptochrome also functions in mammalian circadian clocks

Box

Glossary

aa: geomagnetic activity level at an invariant magnetic latitude of about 50; one of the indices showing geomagnetic activity
ANOVA: analyses of variance
ap: a geomagnetic field disturbance index
BP: blood pressure
Bz: vertical component of interplanetary magnetic field
CAD: coronary artery disease
DCM: dilated cardiomyopathy
ECG: electrocardiogram (one of the indices monitoring heart and checking out heart disease)
F: total field; a component showing the intensity of geomagnetic activity
H: a horizontal component
HF: high frequency
HR: heart rate
HRV: heart rate variability
ICEHRV: International Chronome Ecologic study of HRV
Kp: a geomagnetic disturbance index
LF: low frequency
pNN50: per cent of difference between adjacent normal cycle intervals
r-MSSD: root mean square of successive differences
RR50: total count of difference between adjacent normal cycle intervals
SD: standard deviation
SDNN: standard deviation of all normal intervals
TF: total frequency
ULF: ultra low frequency
VLF: very low frequency
Z: a vertical component

(Casmore *et al.* 1999). These observations suggest that early organisms on Earth developed and adapted to the surrounding cycles of the cosmos.

Physiological temporal organization is much more extensive than circadian systems (Halberg *et al.* 2000; Otsuka *et al.* 1998). Long-term physiological quasi-ambulatory monitoring of blood pressure and heart rate among other variables, such as those of the ECG, part of the neuroendocrinologic armamentarium, has already yielded information on circaseptan (about 7-day) and circadecennian (about 10-year) cycles which are found in bacteria and other forms of life, including humans. In mammals, these rhythms occur in mitoses and RNA and DNA synthesis during regeneration. Hormones like melatonin are secreted time-dependently along several system scales. The nervous system displays rhythms, chaos and trends called 'chronomes'. Environmental and organismic interactions are also cyclic along with a host of frequencies. These resolvable time structures, chronomes, have other counterparts around us also consisting of rhythms, trends and chaos and we are now recognizing them more and more.

There is the much broader concept of the time structure, chronomes, in larger and larger systems along longer and longer time frames within us, and still longer time structures around us. For any component in the biological spectra, one looks for, and we often find, the natural (as well as anthropogenic) physical environmental counterparts (Halberg *et al.* 2000). If coherences are found, for example, by looking across the spectra, there are external and internal interactions to account for possible chronome maps. This was found for a built-in free-running about-weekly, but not exactly 7-day (circaseptan) component in the spectra of human urinary 17-ketosteroid excretion (17-KS) (Halberg *et al.* 1965). A similar, but again not exactly 7-day natural 6.75-day counterpart was shown for the geomagnetic disturbance index, Kp (Halberg *et al.* 2001).

In the biological week, free-running as opposed to the social one, we found a weak near-match of 6.75 days in over a half a century's data on the Kp which has been confirmed by physicists and extended by them to data covering over a century of data on the aa (geomagnetic activity level at an invariant magnetic latitude of about 50; one of the indices showing geomagnetic activity). The weekly biological component's origin may be the result of an integrative evolution of a consensus *partium in tempore*. Its genesis was perhaps away from the daily alternation of light and darkness where requirements internal to an organism prevailed; perhaps at the bottom of a sea. This may be a weak weekly geomagnetic component nearest to these internal needs, such as for growth and repair using processes that took several days. It also seems possible that the prominent weekly component in newborns of several species may recapitulate, as a living fossil, the scenario of billions of years ago, when natural physical environmental factors exhibited a much more prominent environmental week than can be found today. These two possibilities are not mutually exclusive; complementarily characterized as an internal integrative and an external adaptive evolution.

A recent finding on an 8-hour periodicity in circulating endothelin, and also in the population density of endotheliocytes, is one of the most noteworthy observations in recent years (Herold *et al.* 1998, Katinas *et al.* 2001, Portela *et al.* 1995, Simpson *et al.* 1990). This is very interesting when considering the hypothesis that 8-hour periodicity is a key between the linear and non-linear system of life, as proposed by Li and Yorke in 1975 (Li and Yorke 1975); and when we argue on an idea that such mechanisms may well reside in endotheliocytes, since the circulation of cortisol can show no 8-hour component.

Subjects and methods

Focus is placed on circadian, circaseptan and circannual changes in the HRV as a function of aging in clinical health. Alterations of different time and frequency measures of the HRV in the presence of coronary artery disease (CAD) and chronic congestive heart failure, secondary to dilated cardiomyopathy (DCM), are assessed. For this purpose, subjects in the following seven groups were investigated: Tokyo Group, India Group (Moradabad), Ukraine Group, China Group I (Shandong), China Group II (Chengdu), Minneapolis Group (Minnesota, USA) and Norway Group (Alta, subarctic area). Circadian rhythmicity was studied in 285 healthy male subjects, one month to 92 years of age in Tokyo. The investigation also included 66 patients with CAD and ten DCM patients, 30 to 89 years of age. Infradian changes and latitude effects were assessed within the scope of the International Chronome Ecologic study of HRV (ICEHRV), which consists of monitoring the ECG for at least seven days in different seasons and in different geographic locations. Results on 242 such profiles are reported. Four elderly subjects (two women and two men aged from 70 to 83 years) repeated the around-the-clock 7-day ECG profile in each of the four seasons.

A 24-hour ECG was obtained from each of the 285 healthy males, from the 66 CAD males, and from the 10 DCM patients in Tokyo using an ambulatory two-channel Holter recorder (SM-28, Fukuda-Denshi, Tokyo) and an analyzing system (SCM-280-3, Fukuda-Denshi, Tokyo) that included an interval counter for R-R intervals and a built-in A/D converter. The interval resolution was 8 msec.

For the time domain measurements we calculated SDNN, pNN50, SDANNs (1, 5, 30 and 60 min), SDmeans (1, 5, 30 and 60 min), r-MSSD, RR50(+), RR50(-), total RR50 and pNN50. The mean cycle length of the normal-normal RR (NN) intervals for 24 hours and standard deviation (SD) of NN intervals for

24 hours were calculated as 24-hour NN and SDNN, respectively. SDANNs (1, 5, 30 and 60 min) were calculated as the SD at 1, 5, 30 and 60-minute mean NN intervals over the entire 24-hour ECG recordings, respectively. Similarly, SDmeans (1, 5, 30 and 60 min) were calculated as the mean of the SD at 1, 5, 30 and 60-minute NN intervals over 24 hours, respectively. In our investigation of pregnant women, the triangular index (TI) and TINN were also evaluated.

Next, the difference between adjacent NN intervals was computed. The root mean square of successive differences (r-MSSD) is calculated as the square root of the mean of the sum of the squares of differences between adjacent NN intervals over the entire 24-hour record. RR50 was assessed as follows: successive NN intervals were subtracted from each other and compared in 50 msec intervals. If the difference was larger or smaller than 50 msec, the positive or negative count was incremented by one, with the totals over 24 hours being represented by RR50(+) and RR50(-) respectively. RR50 and pNN50 represent the total count, and the percentage of the differences between adjacent NN intervals that are greater than 50 msec are computed over the entire 24-hour ECG recording.

Frequency domain measurements were obtained using a MemCalc/CHIRAM (Suwa Trust Co., Ltd., Tokyo Japan). The time series of NN intervals covering 5-minutes were processed consecutively and the spectral power in different frequency regions was computed in the 'very low frequency' ('VLF', 0.003-0.04 Hz), 'low frequency' ('LF', 0.04-0.15 Hz) and 'high frequency' ('HF', 0.15-0.40 Hz) ranges. The VLF/TF, LF/TF and HF/TF power ratios were also calculated where 'TF' stands for 'total spectral power' (of the 3-hour spectrum).

As an approximation of the cosine function, including circadian and circaseptan variations, the data series of the different HRV measures were computed at 5-minute intervals and analyzed by the cosinor method of Halberg (Bingham *et al.* 1982), which, in this case, involved the least squares fit of consecutive 150 cosine curves between the period of 168-hour and 1.0. The amplitude (A) provides an objective measure of the extent of change within a day or a week, and in this investigation, the 'circaseptan A / circadian A' ratio was considered as an index of circaseptan periodicity.

One-way and two-way analyses of variance (ANOVA) and linear regressions examined changes as a function of age. Group, day and seasonal comparisons and latitude effects were carried out by one-way ANOVA. Results were considered to be statistically significant when $p<0.05$.

Circadian periodicity of HRV

The HRV end points were very circadian periodic where the spectral power centered around 3.6 sec and HF peaks during the night and the ~10.5sec/~3.6sec

LF/HF power ratio peaks during the day. The best fit period was 24 hours, which was observed in 292 profiles (81.3 per cent) out of the 359 using around-the-clock 7-day ECG monitoring. An 8-hour period was second most frequently observed in 14 profiles (3.9 per cent), and the third was a 12-hour period in 13 profiles (3.6 per cent).

Circaseptan periodicity of HRV

Statistically significant 7-day (circaseptan) periodicity was observed in 254 profiles (70.8 per cent) out of the 359 in the around-the-clock 7-day ECG monitoring. In middle aged subjects from 38 to 49 years of age, SDNN was minimal on Mondays with a secondary trough on Fridays; while in elderly subjects aged from 70 to 83 years, the SDNN was the lowest on Fridays.

Circannual periodicity of HRV

Table 19.1 shows seasonal variation of HRV in the four elderly subjects. Both the LF and HF components show the lowest value in the winter ($p=0.0164$ and $p=0.0264$, respectively). The r-MSSD also shows a trend of being less in the winter ($p=0.0762$). The circannual component of β (slope of the 1/f fluctuations of RR-interval) is demonstrated with a statistical significance ($p<0.01$) and the slope was the most negative in the summer when an 83-year old man experienced a minor stroke.

Age trends in HRV

Figure 19.1 indicates how SDNN and pNN50 change as a function of age in 255 clinically healthy males ranging in age from seven to 92 years. SDNN, SDANNs and SDmeans decrease linearly with age ($p<0.001$) and NN50, pNN50 and r-MSSD decrease exponentially with age ($p<0.001$).

Table 19.1 Seasonal variation of heart rate variability indices

	Spring		Summer		Autumn		Winter		ANOVA	
	average	S.D.	average	S.D.	average	S.D.	average	S.D.	F-value	p-value
PR	833.53	39.51	849.93	4.86	890.38	72.57	838.23	40.75	2.32	N.S.
β (slope of 1/f)	-1.407	0.198	-1.419	0.181	-1.319	0.131	-1.378	0.209	4.39	0.0366
TF	3710.32	533.42	3887.17	603.51	4625.11	559.34	4011.40	837.94	1.24	N.S.
ULF	2762.36	339.27	2929.05	499.10	3240.88	513.96	2978.86	512.11	0.55	N.S.
VLF	714.45	295.77	718.34	229.87	955.18	50.03	793.70	343.25	2.36	N.S.
LF	151.81	31.11	152.98	59.34	263.80	53.22	144.54	44.31	5.91	0.0164
HF	58.89	29.97	57.68	20.95	100.21	52.16	54.53	20.61	4.98	0.0264
LF/HF ratio	3.70	2.32	3.59	1.85	3.58	1.53	3.60	1.89	0.06	N.S.
SDNNIDX	34.17	4.89	34.16	3.89	39.87	2.97	35.37	5.51	2.01	N.S.
MSSD	19.20	4.13	18.57	2.67	22.63	5.24	18.03	1.93	3.21	0.0762
pNN50	2.09	1.47	1.49	0.67	3.87	3.36	1.15	0.38	2.33	N.S.

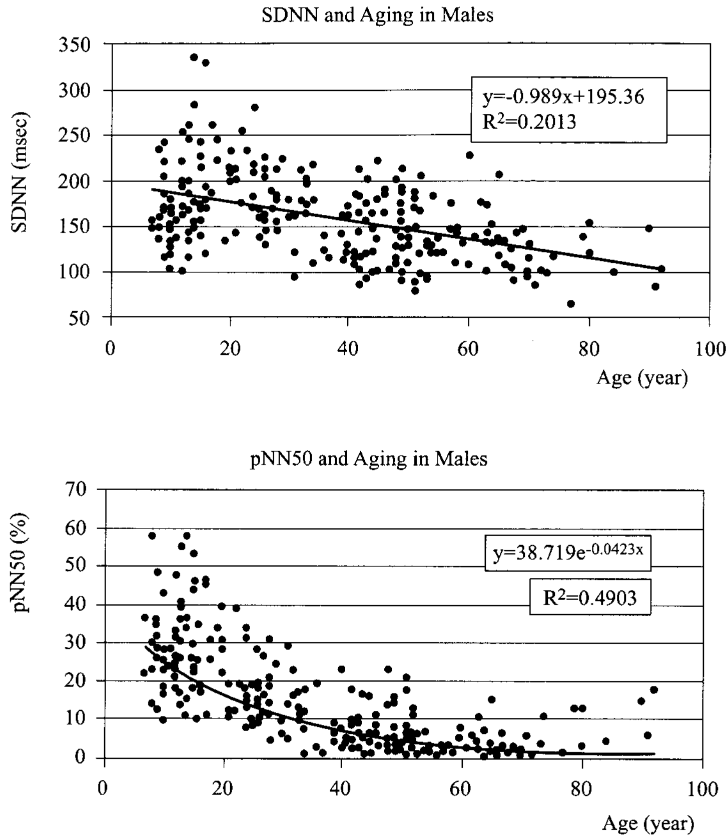

Fig 19.1 Top: Linear decrease of SDNN with age in male subjects. Bottom: exponential decrease of pNN50 with age in male subjects.

Chronome alterations of HRV in the presence of disease

Circadian changes in the HRV were assessed in 66 male patients with CAD aged from 30 to 88 years and compared with the corresponding circadian characteristics of 141 clinically healthy men at least 30 years of age. The CAD patients were found to differ from the clinically healthy men of similar age in terms of SDNN, SDANNs, total spectral power (over a 10-minute span; TF), spectral power around 10.5 sec (LF) and ~10.5sec/~3.6sec (LF/HF) spectral power ratio. These parameters were statistically significantly smaller in CAD patients as compared to their healthy peers (Table 19.2).

The decrease in the HRV was most prominently seen in the ten patients with congestive heart failure, secondary to the DCM patients. Their results are as follows: 24-hour averaged NN, 672.4 msec; SDNN, 64.8 msec; r-MSSD, 47.3

Table 19.2 Comparision 24-hour and points of HR variability inpatients with coronary artery disease (CAD) versus clinically haelthy men*

Varieble	CAD	(n=66)	Healthy	(n=141)		
	Mean	SE	Mean	SE	F-value	P-value
averNN	835.5	15.4	831.3	9.0	1.415	0.024
SDNN	113.1	4.1	141.3	3.1	12.720	<0.001
rMSSD	43.7	3.9	39.1	1.9	1.333	0.250
RR50	4073.9	484.4	6226.6	474.1	0.671	0.423
RR50 +	2031.3	248.1	3220.8	251.3	0.825	0.375
RR50 −	2041.0	243.5	3005.8	224.9	0.511	0.483
pNN50	4.20	0.53	6.24	0.49	0.653	0.429
SDANN1	106.1	3.9	135.5	3.3	14.861	<0.001
SDANN5	99.9	3.6	130.4	3.2	17.026	<0.001
SDANN30	91.0	3.5	122.2	3.2	16.949	<0.001
SDANN60	86.8	3.5	117.5	3.2	15.674	<0.001
SDmean1	35.8	2.1	41.6	1.0	0.818	0.377
SDmean5	47.0	2.6	55.0	1.3	1.545	0.210
SDmean30	61.6	3.0	70.4	1.5	2.483	0.117
SDmean60	68.2	3.1	77.6	1.6	2.962	0.087
LF	364.3	42.0	696.2	44.1	4.045	0.046
HF	233.2	27.8	348.8	29.0	2.306	0.130
TF	2437.1	203.2	3736.1	166.1	5.185	0.024
L/F	2.146	0.188	3.221	0.139	6.428	0.012

*In same age group-one-way ANOVA with age as the covariant

msec; RR50, 6742.8; pNN50, 5.74 pecent; SDANN (5-min), 48.0 msec; SDmean (5-min), 36.8 msec; spectral power around 10.5 sec (LF), 215.2; spectral power around 3.6 sec (HF), 355.9; total spectral power (TF), 1339.7; and ~10.5sec/~3.6sec (LF/HF) power ratio, 0.72. Averaged NN, SDNN, SDANN (5-min), TF, LF and LF/HF were statistically significantly smaller for the DCM patients than for the coronary artery disease (CAD) patients. Six of the ten DCM patients died within several weeks of the ECG monitoring.

Latitude effects on the HRV

For detecting the latitude effect on the HRV, three representative areas were selected as follows: area A, Alta, Norway, latitude 70 degrees North; area B, Jinan, Shandong, China, latitude 37 degrees North; and area C, Chengdu, Sichuan, China, latitude 30 degrees North. Because of the high latitude, the sun was not visible above the horizon in Alta, Norway for 52 days in winter (from 26th Nov to 17th Jan) and did not set for 72 days in the summer (from 17th May to 27th July), as shown in Figure 19.2. During the remaining 241 days (8 months), there was an alternation between light and darkness (day-night). Circadian characteristics of physiological functions undergo circannual changes in humans. An effect of daily sunshine duration (from sunrise to sunset) on

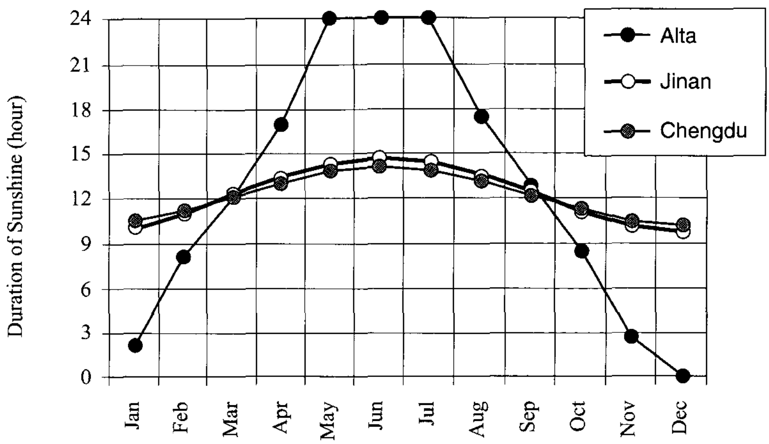

Fig 19.2 Seasonal variation of the duration of sunshine (time from sunrise to sunset).

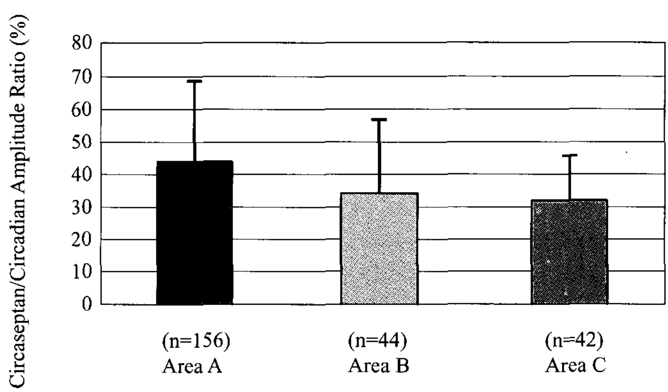

Fig 19.3 The circaseptan amplitude / circadian amplitude ratio was larger with an increase in latitude. (Area A; Alta, Norway, Latitude 70 Degrees N, Area B; Jinan, Shandong, China, Latitude 37 Degrees N, Area C; Chengdu, Sichuan, China, Latitude 30 Degrees N)

circadian characteristics of frequency-domain measures of the HRV was investigated.

The best fitting period of the HRV indices in these A, B and C areas was 24-hours in 78.8 per cent, 89.1 per cent and 82.6 per cent, respectively, with no significant difference among them. But the circaseptan/circadian ratio of the amplitude was larger with an increase in the latitude, as shown in Figure 19. 3 (p=0.002).

Chronomics

This study shows that in clinical health the HRV is characterized by a broad time structure, including not only a prominent circadian variation, but also statistically significant circaseptan and circannual components in addition to changes in these trends with aging. Alterations in the HRV chronome are observed in the presence of disease. Previously, we have reported that a circadian periodicity is demonstrated in both genders and in different age groups (<10 years, 10-20 years, 20-30 years, 30-40 years, 40-50 years, 50-60 years, 60-70 years and >70 years) except for the oldest age group. Herein, we confirm the previous study which showed the presence of a circadian rhythm in the component of the HRV. The HF component may reflect the parasympathetic activity with a peak during the night. A strong circadian component is also shown for LF/HF spectral power ratio which is for an end point of the HRV considered to be an indicator of sympatho-vagal interaction with a peak during the day.

A circaseptan component is also demonstrated for all of the HRV indices including SDNN and was observed both in the middle-aged and in the elderly subjects. SDNN is known to be a good predictor of long-term survival both in patients with myocardial infaction and in a cohort of elderly subjects. Previous studies showed an increased incidence of myocardial infarction on Mondays, with a secondary peak on Thursdays and Fridays. The circaseptan pattern seen in SDNN for the middle-aged subjects suggests that a decrease in HRV on Mondays with a secondary trough on Fridays may be at least one of the reasons why the circaseptan variation was observed for the incidence of the cardiovascular events. On the other hand, the result obtained in the group of elderly subjects shows a small dip in SDNN only on Fridays. This observation may result from the difference in life style between the two groups. Noteworthy is the following description by Cornelissen *et al.*, who meta-analyzed 47 studies and found that 16 studies showed a peak occurrence of myocardial infarctions on Mondays-Tuesdays and that in 9 studies, the peak occurred on Thursdays-Fridays. They concluded that an important aspect of circaseptan variability is the relative prominence of the circasemiseptan (3.5-day) component.

A circannual variation in the LF and HF components was also observed for four elderly subjects who live in Shandon Province, China, where the environmental temperature is hot in summer (up to 40 degrees C) and cold in winter (as low as -15 degrees C). Physiological interpretations of the LF component are still to be clarified. The LF fluctuations reflect combined sympathetic and parasympathetic activity. The LF peak is strikingly reduced by atropine. An increase in its power has been observed as a consequence of sympathetic activation. Thus, an increase in LF is accepted by many authors as a marker of sympathetic activation and vice versa. DeBoer *et al.* suggested that the

LF peak was caused by the rather slow baroreflex response at 2 to 3 seconds in the beat-to-beat changes in arterial pressure. Thus, this seasonal decrease in LF in the winter may suggest an episodic increase in arterial pressure related to an alteration in the environmental temperature. It is noteworthy that there is a circannual component of β (slope of the 1/f fluctuations of RR-interval) which has been noted as one of the most important predictors of cardiovascular adverse outcomes. The ' β (beta)' was the most negative in the summer when an 83-year old man experienced a minor stroke. Nicolau *et al.* investigated seasonal differences in cardiac mortality and reported a peak in July with a broader peak during the cold season. Previously, Smolensky *et al.*, Reinberg *et al.* and Halberg *et al.* also reported a circannual pattern of incidence of cardiovascular events.

The prevalence of cardiovascular disease increases markedly with advancing age. An age-related rise in efferent sympathetic nervous activity has been postulated as one of the underlying factors. We have already reported that the HRV end points, except for the LF/HF spectral power ratio, decreases with age in both genders and that the slower decline with age in females as compared to males of the r-MSSD, NN50, pNN50 and HF indices, may reflect the cardiac vagal activity. This is also in keeping with epidemiologic outcome data.

Previous studies have demonstrated that the HRV in patients with CAD is lower than in healthy subjects and that a reduced amount of parasympathetic activity may be a useful predictor of post-infarction mortality. We also observed a reduced HRV in CAD patients in terms of SDNN, SDANNs and TF. Kleiger *et al.* and Rich *et al.* have also reported that reduced SDNN and SDANN predicts mortality in patients surviving an acute myocardial infarction (MI). Bigger *et al.* (1993) also obtained 24-hour ECG records from MI patients and reported that the risk of subsequent mortality was strongly correlated with low HRV measures, particularly a depressed spectral power around the VLF range. These results are interesting since they show that the major difference lies not in the short-term, but rather in the long-term variability of R-R intervals, suggesting the clinical significance of a long duration decrease in parasympathetic activity.

We examined patients with chronic congestive heart failure secondary to DCM and also revealed a severely reduced HRV in terms of SDNN, SDANN and TF. It is noteworthy that six of the patients with DCM died within a few weeks after the monitoring session. This result is in keeping with a report by Fauchier *et al.* showing the prognostic value of SDNN in idiopathic DCM. Excessive reductions of global indices of HRV such as SDNN, SDANN and TF (including the VLF and ULF components) have been denoted 'chronome alterations (CAs) of HRV', of CAHRVs. CAHRVs should be new clinical entities in predicting long-term survival not only in patients with CAD or DCM, but also in eldery subjects.

We show here that a relation exists between the HRV and latitude, and this means that there is an effect of sunshine duration on the chronome mechanism that affects the HRV measurements. This may also show a close association between human beings and environmental factors who have adapted to the surrounding cycles in the cosmos.

Chronoastrobiology

Long-term physiological ambulatory monitoring has already yielded information on the effect of geomagnetic disturbances upon human cardiovascular variability. Wolf's relative sunspot numbers, long known to undergo ~10.5- (circadecennian) and ~21-year (circavigintunennian) cycles, named after Schwabe and Hale respectively, have near-matching numerical biological counterparts. About half-yearly, about-weekly and, in certain solar cycle stages, about half-weekly features of anthropogenically geomagnetic indices, such as the Kp or aa, also have biological near-matches. Rhythms with various frequencies coexist with chaotic changes and trends in temporal structures that are the chronomes' variables in and around us. Rhythmic elements of biological chronomes with a common genetic origin (in the sense of a classical homology) may also have a common environmental cycle responsible for their genetic coding in the first place. We postulate a broad physico-biological homology, as compared to the classical homology implying a common genetic origin. We extend this to our evolution in time as done conventionally with respect to a spatial morphology which leads to several rules of procedure. A physical near-match to our environment may be built-in to the biological rhythm; or a biological circa-match may have eventually corresponded to each physical environmental rhythm; or a third possibility, a biological rhythm with a missing natural environmental near-match, impossible to definitively prove, may be posed by an internal evolution.

Many investigators have studied the possible health hazards of natural solar variability-driven temporal variations in the Earth's magnetic field. These variations exhibit complex spectra and mainly cover the periodicities in the range of minutes to hours in the frequency band from 0.001-10 Hz. Associations of these geomagnetic variations are interplanetary (if not galactic) in origin, with the human cardiovascular variables involving the endocrines (Ossenkopp *et al.* 1983; Stoupel *et al.* 1983), blood pressure (Stoupel *et al.* 1995), heart rate (Baevsky *et al.* 1998; Ghione *et al.* 1998) and the heart rate variability (HRV)

(Gmitrov *et al.* 1999).

Contradictory results have been reported for geomagnetic activity and the incidence of various human diseases (Lipa *et al.* 1976; Malin and Srivastava 1979; Rajaram and Mitra 1981). Putative associations between geomagnetic storms and myocardial infarction or stroke are of particular interest and constitute active areas of current research (Baevsky *et al.* 1997; Breus *et al.* 1995; Halberg *et al.* 2000). In Minnesota, mortality from myocardial infarction has increased by 5 per cent during times of maximal solar activity (Cornelissen *et al.* 1999) when geomagnetic disturbances occur more frequently. Susceptible individuals may then be at an increased cardiovascular disease risk. Although there is mounting evidence for such associations, they are far from being fully understood and have remained controversial (Ghione *et al.* 1998; Lipa *et al.* 1976).

HRV is known as a powerful predictor of vascular disease risk in apparently healthy people, as evidenced in an elderly cohort (Vladimirskii *et al.* 1995) as well as in patients suffering from coronary artery disease, valvular heart disease, and congestive heart failure (La Rovere *et al.* 1998). Herein, we examine the start of a planetary study on any influence of geomagnetic disturbances that are most pronounced in the aurora oval. The aurora may show correlation to the HRV.

Observation of geomagnetic activity

Since the geomagnetic field is a vector field, at least three components are necessary to represent the field. The components describing the direction of the field are declination (D) and inclination (I). D is the angle between magnetic north and true north and I is the angle between the horizontal plane and the total field vector. Components describing the field intensity are the total field (F: a component showing the intensity of geomagnetic activity), horizontal component (H) and vertical component (Z). In this investigation, a geomagnetic record with the following variables was obtained at 1-minute intervals from the Auroral Observatory at the University of Tromso, Tromso, Norway (latitude 69 degrees 39 minutes north, longitude 18 degrees 56 minutes east): F; total intensity (nT), declination (D); angle between geographic and magnetic north (degrees), inclination (I); angle between horizontal plane and magnetic direction (degrees), H; horizontal intensity (nT), and Z; vertical intensity (nT).

Nearly-continuous, 7-day beat-to-beat ECG records were obtained between 10 December 1998 and 2 November 2000 on clinically healthy men (15) and women (4) from Finnmark University College in Alta, Norway. Their age ranged from 21 to 59 years. Alta is located at 69 degrees 56 minutes north latitude, and 23 degrees 22 minutes east longitude at an altitude of 3 m above sea level. Mean atmospheric pressure in Alta was 1007.7 hPa. The yearly mean outside temperature was 2.3 degrees C and the lowest recorded temperature was -30.8 degrees C with temperatures below 0 degree C for almost half of the year. Because of the high latitude, the sun was not visible above the horizon for 52 days in the winter (from 26 November to 17 January) and did not set for 72 days in the summer (from 17 May to 27 July). During the remaining 241 days (8 months) there was an alternation between light and darkness (day-night).

Graded response of the HRV associated with an alteration of geomagnetic activity

Geomagnetic activity was gauged by the ap index of geomagnetic disturbance. This index is based on local K indices determined in different geographic locations. Each local K index is based on the measured amplitude of variation of the local geomagnetic field over consecutive 3-hour intervals. Corrections for local effects are applied to yield world ap indices. Measures of the HRV assessed over separate 24-hour spans were compared among days of low, middle and high geomagnetic activity, defined as days with ap values <7, 7-20, and 20-45 respectively.

For assessing the graded effect of geomagnetic disturbances on HRV, five clinically healthy students were selected among Finnmark University College (5 men, 21 to 31 years of age). HRV end points were compared among the 3 classes of ap values (low, middle and high).

Table 19.3 summarizes the graded response of the HRV end points to geomagnetic activity. SDNN and length of the Lorenz plot both show a statistically significant decrease on magnetically disturbed days as compared to quiet days ($p<0.01$). A decrease in frequency-domain measures the HRV on days with $7<ap<20$ and $20<ap<45$ versus days where the $ap<7$ is validated with statistical significance for the TF power (by 18.1 per cent and 1.6 per cent respectively; $p<0.001$). The decrease in spectral power was found primarily in the ultra-low frequency (ULF) (by 18.1 per cent and 27.5 per cent, respectively; $p<0.01$) and in the very low-frequency (VLF) (by 12.9 per cent and 28.6 per cent; $p<0.02$) regions of the spectrum. The decrease in spectral power around 10.5 seconds (low frequency (LF)) and around 3.6 seconds (high frequency (HF)) was of a much lesser extent and was not statistically significant. The extent of the HRV response may be further amplified by the fact that the subjects lived in a subarctic area where geomagnetic disturbances tend to be stronger and can affect biological systems more directly, notably the cardiovascular system.

The results indicate that HRV decreases in a graded fashion as a function of the level of increasing geomagnetic disturbance. A more prominent relationship

Table 19.3 Heart rate variability parameters on days of low, middle and high geomagnetic activity in healthy subjects (n=5).

	Low		Middle		High		ANOVA
	Mean	SD	Mean	SD	Mean	SD	p-value
ap	5.35	1.37	12.20	4.95	28.65	8.16	<0.001
HR	63.18	6.89	63.89	7.07	67.73	5.43	N.S.
SDNN	107.2	22.6	97.9	20.4	89.0	13.6	<0.01
r-MSSD	72.6	29.0	63.3	18.8	55.4	11.2	N.S.
pNN50	36.86	12.67	33.01	9.36	27.52	5.75	N.S.
Length (L)	498.6	111.1	457.2	98.4	419.7	76.0	<0.01
Width (W)	197.9	97.6	164.7	63.1	147.5	48.2	N.S.
L/W ratio	3.11	0.92	3.31	0.70	3.41	0.35	N.S.
TF	19871.0	9433.1	16300.6	8548.1	13595.0	6750.4	<0.001
ULF	9619.2	4764.9	7874.5	5507.1	6969.5	5184.1	<0.01
VLF	6302.5	2869.7	5489.8	2288.1	4497.4	1597.4	<0.02
LF	2080.0	998.5	1874.6	693.8	1576.8	430.2	N.S.
HF	1307.3	1350.7	950.2	790.5	692.2	304.8	N.S.
LF/HF	3.59	1.61	4.07	1.63	3.95	1.26	N.S.

Average HR = 24-hour average of heart rate (bpm); HF; high frequency spectral component ($msec^2$); Length 90% = 90% length of Lorenz plot (msec); L/W ratio = Length 90% to Width 90% ratio; LF = low frequency spectral component ($msec^2$); pNN 50 = percent of difference between adjacent normal cycle intervals >50 msec computed over the entire 24-hour ECG recordings (%); r-MSSD = root mean square successive difference (msec); SDNN = mean of the SDs of all NN intervals for all 5-min segments of a 24-hour ECG recording (msec); TF = total frequency spectral component ($msec^2$); ULF = ultra-low-frequency spectral component ($msec^2$); VLF = very-low-frequency spectral component ($msec^2$); Width 90% = 90% width of Lorenz plot (msec).

is observed for the HRV measurements that reflect long-term HR fluctuations (TF, ULF and VLF) than for the HRV measures associated with short-term HR fluctuations, such as LF and HF, usually related to the cardiovascular parasympathetic activity. As an impaired HRV has been shown to serve as a predictor of mortality among patients with a variety of other vascular diseases, the results here may point to some underlying physiological mechanism responsible for the response to changes in magnetic activity other than the parasympathetic nervous system.

Electromagnetic field exposure effects on biological and clinical phenomena have been previously reported. It is known that electromagnetic fields act not only at the cellular level, but also through the central nervous system, predominantly the hypothalamus. But such induced biological responses are usually associated with field intensities in the range of 10^{-6} to 10^{-4} tesla. Physiological responses in association with geomagnetic storms, however, involve much weaker fields of only 10^{-7} to 10^{-6} tesla. The graded response of the HRV end points to geomagnetic disturbances observed herein suggests that a receptor-associated mechanism may be responsible for picking up the geomagnetic information.

Birds are able to use the geomagnetic fields as a compass to find direction. In the search for sensory mechanisms of magnetoreception, research focused on direct magnetic responses to magnetic stimuli. Aquatic bacteria, Aquaspirillum, exhibit magnetotactic behavior. Each bacterium contains a chain of about twenty single-domain magnetite particles. This discovery elicited a search for magnetoreceptors in a variety of animal species. Phillips and his colleagues proposed a new hypothesis that an animal's photoreceptor can pick up geomagnetic information, and a light-dependent magnetoreception mechanism was reported in newts. The search for human magnetoreceptors and/or for a mechanism of human magnetoreception may be rekindled by the results presented here.

Alternating light-darkness-influenced human electrocardiographic magnetoreception in association with geomagnetic pulsations

Frequency-domain measures of the HRV were compared for each person in 24-hour spans of high geomagnetic disturbance versus quiet conditions. As a result, a 7.5 per cent increase in the 24-hour average of HR ($p=0.00020$) and a decrease in the HRV were documented on days of high geomagnetic disturbance. The decrease in HRV was validated statistically for the TF end point (18.6 per cent decrease, $p=0.00009$). The decrease in spectral power was found primarily in the VLF component (21.9 per cent decrease, $p<0.000001$) in conjunction with the ULF and LF components (15.5 per cent decrease, $p=0.00865$ and 14.2 per cent decrease, $p=0.00187$ respectively). It is noteworthy that most of the decrease in HRV, except for the VLF component, was observed only in the season in which sunshine alternated with darkness (DL), as shown in Table 19.4; a finding suggesting a mechanism influenced by the alternation of light and darkness.

Altered HR variability on geomagnetically disturbed days and the following two days in sub-Arctic

Geomagnetic activity may influence biological processes, including the incidence of various human diseases. There is evidence that heart rate variability may serve not only as an index of autonomic coordination of the circulation, but also as a powerful predictor of risk in apparently healthy subjects. Halberg *et al.* (Cornelissen *et al.* 1994) has shown that mortality from myocardial infarction is increased on the day following a southward turn of the Bz (vertical component of interplanetary magnetic field), which has been associated with auroral geomagnetic storms. Thus, we focused on how long the effect of geomagnetic disturbance on the HRV continues by assessing HRV of healthy men living in a sub-Arctic area on four consecutive days before and after high geomagnetic

Table 19.4 Geomaagnetic disturbance-associated decrease in Variability during the alternation of darkness (D) and light (L), i, e, DL versus continuous darkness (DD) or light (LL)

Endpoint	Continuous light	Control		Geomagnetic Disturbance		t-value	p-value
		Mean	SD	Mean	SD		
Heart Rate	D/L	61.42	5.14	66.05	7.32	-3.5721	0.01601
	D/D or L/L	61.06	6.11	66.38	7.67	-5.6800	0.00236
NN interval	D/L	983.0	88.6	917.8	105.83	4.6307	0.00568
	D/D or L/L	1010.9	101.0	935.3	99.57	6.0950	0.00172
β (slope of l/f)	D/L	-1.03	0.12	-1.08	0.15	0.9356	N.S.
	D/D or L/L	-0.94	0.10	-0.98	0.17	0.8011	N.S.
"TF"	D/L	16851.0	7550.3	13610.1	7928.5	7.8010	0.00056
	D/D or L/L	16426.0	3080.7	13391.5	4962.8	2.0461	N.S.
"ULF"	D/L	9233.2	4037.0	7708.1	5017.7	2.6359	0.04621
	D/D or L/L	8413.7	2882.8	7362.6	3775.7	1.0318	N.S.
"VLF "	D/L	5664.1	2923.0	4245.0	2453.3	6.8679	0.00100
	D/D or L/L	5409.9	1294.0	4185.5	1458.1	4.7584	0.00507
"LF"	D/L	1410.0	624.9	1272.1	692.2	4.1032	0.00933
	D/D or L/L	1492.9	504.9	1275.0	324.2	1.4299	N.S.
"HF"	D/L	511.0	497.1	355.8	290.0	1.4011	N.S.
	D/D or L/L	1045.1	1248.3	574.1	263.1	1.1216	N.S.
"LF/HF"	D/L	5.390	4.489	6.087	5.780	-1.0361	N.S.
	D/D or L/L	2.973	1.386	3.490	1.567	-2.4620	N.S.
"ULF/TF"	D/L	0.5578	0.0606	0.5585	0.0876	-0.0278	N.S.
	D/D or L/L	0.5070	0.1000	0.5291	0.1061	-0.8503	N.S.
"VLF/TF"	D/L	0.3266	0.0529	0.3132	0.0636	0.8387	N.S.
	D/D or L/L	0.3297	0.0537	0.3061	0.0468	1.0825	N.S.
"LF/TF"	D/L	0.0881	0.0306	0.1040	0.0520	-1.7132	N.S.
	D/D or L/L	0.0959	0.0334	0.1110	0.0452	-1.8897	N.S.
"HF/IF"	D/L	0.0259	0.0181	0.0225	0.0086	0.6418	N.S.
	D/D or L/L	0.0649	0.0598	0.0510	0.0299	1.0665	N.S.

D/L(n=6), D/D or L/L(n=6)

activity (ap > 30). The effect of geomagnetic disturbance on HRV is examined on the basis of 7-day records by Holter ECG, obtained longitudinally on eight clinically healthy subjects (7 men and 1 woman, aged from 21 to 59 years), in Alta, Norway (70 degrees N). Frequency and time-domain measure pleats of HRV, including the slope of 1/f fluctuations of NN intervals (β (beta)$_{3h}$, 0.0001-0.01 Hz), were analyzed for each subject on four consecutive 24-hour spans.

Associations between geomagnetic storms and HRV were observed for the two days following the geomagnetically disturbed day. One illustrative example is given in Figure 19.4, which shows the concomitant five-day record of the one-minute geomagnetic H-component and the five-minute β (beta) index (the slope of 1/f fluctuations) of HRV. The lasting effect of geomagnetic storms on the power-law scaling of the power spectra was further checked for the case of β

β (beta)$_{3h}$ by ANOVA using Bonferroni's correction. Results indicate that β (beta)$_{3h}$ became statistically significantly steeper not only on the day of the storm, but also on the two days following a geomagnetic storm ($p<0.0001$), Figure 19.5, suggests that geomagnetic disturbances have a lasting influence on the fractal scaling of the HRV.

First, the results confirmed our previous observations that the HRV decreases on geomagnetically disturbed days as compared with quiet days. Next, we found a decrease in the HRV on a geomagnetically stormy day not only in measures reflecting long-term HR fluctuations (TF, W, SDNNIDX (30-min), SDNNIDX (5-min), VLF and VLF/TF) and short-term HR fluctuations (r-MSSD, pNN50 and HF), but also in fractal scaling of HRV as assessed by the power-law behavior of NN-interval variability. Most importantly, we showed that some measures of the HRV remained altered for another day or two following a geomagnetic storm, notably the long-term fluctuation of HR gauged by SDNNIDX (30-min) and the power-law scaling of the power spectra (β (beta), slope of 1/f fluctuations of NN). The L/W ratio of the Lorenz plot also remained altered on the day after a geomagnetic storm, although its clinical implication has not been clarified. Time and frequency-domain measures of HRV over the entire 24-hour span have been known to be strongly correlated with each other. These strong correlations exist for both mathematical and physiological reasons.

Bigger *et al.* (1993) have reported that the VLF component of the HRV has a strong and significant independent association (relative risk of 4.4) with all-cause mortality to assess the risk rate after myocardial infarction -after adjustment for other risk predictors and compared to other measures of HRV. Halberg *et al.* (Breus *et al.* 1995, Cornelissen *et al.* 1994) have shown that there is a statistically significant increase in myocardial infarction ($p=0.027$) on the day following a southward turn of the Bz (which has been associated with auroras and magnetic storms) by analyzing 6,304,025 calls for ambulances in Moscow. Thus, prolonged suppression of SDNNIDX (30-min) and L/W among various HRV indices presented in this investigation are associated with geomagnetic disturbances and may account, in part, for the observation that myocardial infarctions occur frequently not on the day of a geomagnetic storm, but on the next day. Any delay between the occurrence of a southward Bz turn and the peak disturbance in a local or global geomagnetic index also deserves consideration. Any such delay notwithstanding, the similarity in spectral coherence of the incidence of myocardial infarctions and the Bz or the geomagnetic disturbance index Kp is noteworthy.

Herein, we focused on how long high variations in the Earth's magnetic field affected human HRV measures. We found that the slope of 1/f fluctuations of NN (power-law scaling of the power spectra, β (beta)) on the day of a

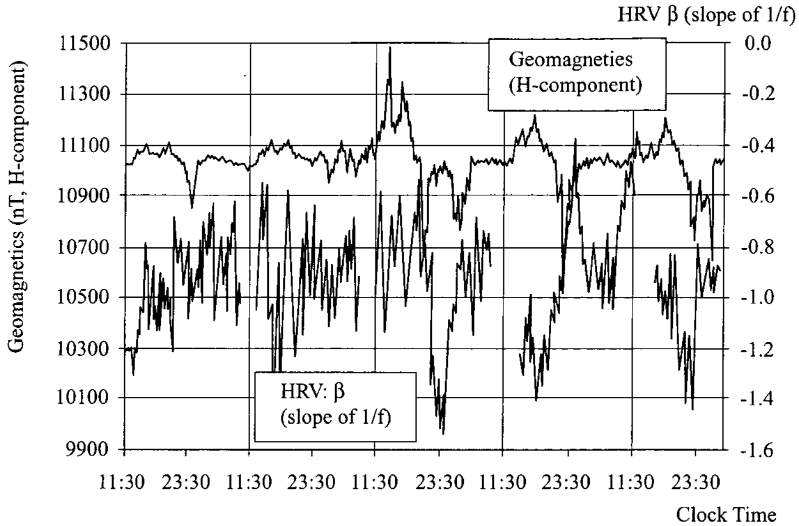

Fig 19.4 Concomitant 5-day record of the 1-minute geomagnetic H-component and 5-minute beta index. Beta index (beta 3h) becomes steeper not only the day of the storm but also on the first 2 days following a geomagnetic storm.

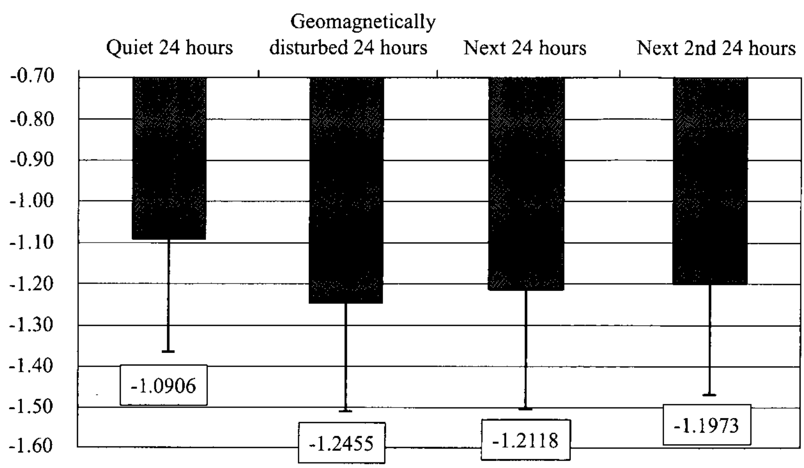

Fig 19.5 Effect of geomagnetic disturbance on the fractal scaling of the HRV.

geomagnetic storm was much steeper (-1.1838 , $p<0.005$ by paired t-test) than on a geomagnetically quiet day (-1.0738). In 1982, Kobayashi and Musha reported the frequency dependence of the power spectrum of RR-interval fluctuations in a normal young man (Kobayashi and Musha 1982). They computed the power spectrum of a 10-hour recording of RR intervals made in a laboratory setting and plotted the resulting power and frequency on a log-log graph. Over a frequency range of 0.0001 to 0.02 Hz, they found that the plot was described by a straight line with a slope equal to -1, indicating that the power decreased approximately as the reciprocal of frequency, 1/f. On the basis of their observation, we also computed the slope over the two-decade band of 0.0001 to 0.01 Hz, which is a fundamentally different RR-interval power spectral measure than the standard band power components ULF, VLF, LF, or HF. In contrast to the latter, the slope reflects not the magnitude, but rather the distribution of power in this two-decade region. These frequency-domain features have implications in the time domain. Relatively rapid RR-interval oscillations with periods from 100 to 1000 seconds will equal the variance of much slower oscillations with periods from 1000 to 10000 seconds. This feature is called 'scale invariance' or 'self-similarity'. In healthy young and middle-aged subjects, the slope of the log (power) on log (frequency) regression line is very close to -1. Cardiac transplantation (denervation) and myocardial infarction shift the entire regression line down and it has been shown that its slope is much steeper (around -2) for patients with heart transplants (denervated) than for healthy subjects (around -1). The results presented here show that β $(\text{beta})_{24h}$ was -1.0738 (SD; 0.1155) during geomagnetically quiet conditions and that it was much steeper (average; -1.1838, SD; 0.1106) during a geomagnetic storm. Several authors (Bigger *et al.* 1996; Makikallio *et al.* 2001) proposed that this slope is a better predictor of all-cause mortality than the traditional power spectral bands. Thus, the concomitant longitudinal monitoring of geomagnetic activity and clinical data, especially such fractal scaling of the HRV, may provide useful information for designing countermeasures for the prevention of adverse vascular events among patients at high cardiovascular disease risk.

Quo vadis chronoastrobiology

The effects of geomagnetics have been observed and we found a decrease in HRV on geomagnetically disturbed days as compared with quiet days. As compared the HRV measured among days of low, middle and high geomagnetic activity, a graded response has been demonstrated. The extent of the HRV decrease depended on the degree of geomagnetic activity. This suggests the existence of human magnetoreceptors, but the putative mechanisms of magnetoreception have not been clarified.

This effect was more apparent in the presence of daily dark-light alternation than in continuous conditions (L/L or D/D). The decrease in HRV indices was statistically significant only in the darkness-light alternation as shown. Phillips *et al.* proposed a light-dependent magnetoreception mechanism and established a link between magnetic field sensitivity and the visual system in eastern red-spotted newts. The results observed in this study suggest the operation of a light-darkness alternation-influenced magnetoreception mechanism in humans.

In addition, we found another alteration of the HRV in association with increased geomagnetic activity, that is the power-law scaling of the power spectra (1/f fluctuation) became significantly steeper (β (beta) from -1.091 to -1.246, $p<0.0001$). Noteworthy is the fact that the alteration of β (beta) as well as of the SDNNIDX (30-min) continued for another two days following the peak geomagnetic activity ($p<0.0001$). These alterations of HRV, especially of the β (beta), could account for an increase in mortality from myocardial infarction not only on the day of, but also on days after a geomagnetic storm.

In recent years, the analysis of time- and frequency-domain measures of HRV from 24-hour ambulatory ECG recordings have provided prognostic information on patients after an acute myocardial infarction, did fractal analysis methods for the general population and for patients with impaired left ventricular function (Huikuri *et al.* 2000). Abnormal HRV predicts both non-sudden fatal and nonfatal cardiac events as well as non-cardiac causes of death. A number of new methods for nonlinear system theory (chaos theory and fractals) have been developed to quantify the complex HR dynamics and to complement the conventional measurement of the HRV. Increasing evidence shows that scaling properties of the HRV analyzed by methods using nonlinear system theory may provide more powerful information on the risk for life-threatening arrhythmic events than do traditional measures in different types of pathophysiological settings. Thus, our results suggest that prospective studies not only in sub-Arctic areas, but also at other latitudes may be needed to confirm possible health hazards of natural solar variability-driven temporal variations of the Earth's magnetic field, especially focusing on fractal measurements of the HRV.

General discussion and conclusion

This investigation shows that in clinical health the HRV is characterized by a broad time structure that includes the prominent circadians and also circuseptan and circannual changes in addition to undergoing trends with growth, maturation and aging. Alterations in this HRV chronome are observed in the presence of disease and at times of increasing magnetic activity. We postulate that the physiological chronomes, such as that of HRV, have counterparts in our environment and that our genetic make-up in time may have evolved to adapt to and integrate with our cosmos. Future work should focus on how phenomena in the cosmos, including helio- and geomagnetics, can affect physiological chronomes, and that of the HRV in particular.

As to a biochemical basis, it seems pertinent that at the middle latitudes we may find by day a circannual and by night a circasemiannual modulation of circulating melatonin in humans as photic and non-photic signatures. At high latitudes the non-photic effect predominates as a circasemiannual signature around the clock. The possible or rather probable circannual stage-dependence of geomagnetic effects upon the 'grids' of the heart is in keeping with the possibility that melatonin from the pineal gland, a putative window for both light and magnetics, and/or from the gastrointestinal tract, may be a link in interacting photo-magnetoreception. The study presented here shows the need for a chronome approach that accounts for a broad time horizon although our system time is just a week.

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20
Application of Geographic Information Systems in International Health

TANIMURA Susumu and MIZOTA Tsutomu

International health is defined as the 'comprehensive and applied study of health problems in developing countries with reference to environmental, social and cultural factors' (Yamamoto 1999). The discipline is very broad, including or overlapping with epidemiology, public health, health services and health planning.

The Geographic Information Systems (GIS) is a highly efficient and functional database system that can deal with all kinds of data if the data has a field of 'location' in its records. Because it has excellent performance and the functionality, the system has been applied in various areas, including marketing, client management, land evaluation, physical distribution of resources, land utilization, appropriate location of businesses or services, environment assessment, traffic control, river basin control, disaster prevention planning and landscape evaluation.

Now that related technologies have been developed and deepened, it is regarded as a science: 'Geographic Information Science' (Openshaw 1991).

GIS can now be used to solve health problems including international health issues. An early meeting of health and GIS professionals was convened in 1990 by the World Health Organization (WHO). It suggested implementing a health and environment GIS (De Lepper *et al.* 1995). In 1993, a joint program of the WHO and the United Nations Children's Fund (UNICEF) began using GIS for support management and monitoring of the Guinea Worm Eradication Program (Albert 2000). Since 1995, the work has been expanded to other disease control programs and other public health programs in general. GIS is now widely utilized in world health.

GIS has a variety of uses in health and can be categorized as shown in Table 20.1. As the table shows, there is some difficulty in describing GIS while avoiding confusion among each type of user, because the uses are wide ranging and different.

Table 20.1 Type of user and health GIS (HGIS)

Type of user	User demand	Type of GIS	Typical health GIS
HGIS Specialist	Analysis/Development	Large and Flexible	Commercial GIS for General Use (ARC/INFO, ArcView, MapInfo)
			Specific Analytical Application (GAM, SaTScan, Crimestat, Dismap Win)
General Researcher Using HGIS	Analysis/Specific Use	Compact and Manageable	Customized GIS (EpiMap2000, WHO HealthMapper)
			WebGIS (Gather, Health Map of Japan)
Management/ Decision Maker	Evaluation/Easy to Use	Small and Beautiful	
Target Group/Non-Specialist	Information Well Accessible	Small and Beautiful	

Source: Nakaya, T. Geomedical approaches based on geographical information science: GIS and spatial analysis for health researchers. The proceedings of AISA GIS 2001, Tokyo, 2001.

In this short review, the authors summarize the technologies and analyze issues related to GIS, show some selected applications, and discuss the future of health related GIS.

GIS and related technologies

GIS

The Geographic Information Systems (GIS) does not separately deal with map data and their attribute data sets, but unifies them as spatial information. It imports a tremendous amount of spatial data from various data sources, and establishes a database system designed to enable a most effective method to capture, store, edit and analyze geographically referenced data. This supports decision making. The core concept for GIS is shown in Figure 20.1 to illustrate reality in layered maps. Each data set in a layer shows items like vegetation, roads, water, terrain or buildings that can be collected from different data sources and overlaid as shown in the figure. This makes it easier to grasp a total geographical condition.

Acquisition of geographic information

The kind of data that is required depends on what type of application is being conducted. If available and appropriate, we can purchase or download a digital

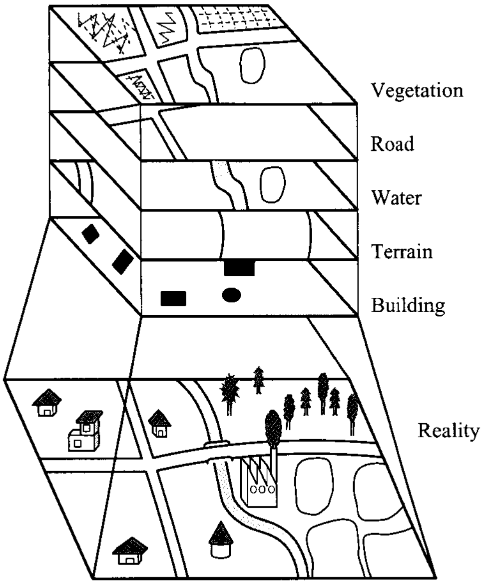

Fig 20.1 Concept of GIS

map, satellite imagery, an aerial photo and statistics as attribute data. If only a paper map is available, we can manually convert it to a digital map with a digitizer. When neither a paper nor digital map exists, we have to collect geometric and attribute data using a receiver, such as the global positioning system (see later section on GPS). If a good geocoding system is available, we can address the data matching the map to the attribute data.

Remote sensing (RS)

RS is the analysis and interpretation of the earth's landscape and resources using aerial photography or satellite imagery. The Normalized Differential Vegetation Index (NDVI) is calculated from the imagery. This collects important environmental factors, especially for the ecological study of vector habitats (as in the mosquito for malaria). Since the RS satellites change position regularly over the earth, it is often easy to obtain a time series of images to observe changes over time. It is also very useful for the study of natural disasters because of its ability to see the situation in a wider geographic perspective.

Global positioning system (GPS)

In order to map disease events, latitude and longitude of the events' points are required. The global positioning system (GPS) can measure this anywhere on the earth where a GPS receiver can find the signals from the GPS satellites. The principles of GPS are simple: each satellite has a very accurate atomic clock inside and transmits accurate time through radio waves; the receiver receives different times from different satellites because the distances between the receiver and satellites are different; a position is calculated with simultaneous equations containing three variables: longitude, latitude and time. Hence, it is obvious that at least three satellites are needed to calculate a location. Error in the positioning process happens when very slight inaccuracies of satellite clocks, orbit errors, delays from the ionosphere and troposphere, receiver noise, and multipath signals occur. To avoid some errors, adjustment is sometimes required with reference to the station, whose position is accurately known (Hurn 1993).

Spatial data analysis

Spatial analysis

Spatial analysis is required to answer a question that cannot be solved without spatial information. A number of methods were developed in the field of geographic information science: geometric measurements (distance, circumference, equilibrium, area and volume), proximal analysis, buffering, overlay, network analysis and Voronoi diagram. It is impossible to analyze this data manually, so the computer-assisted system is essential for these methods. In combination with statistics, spatial data analysis has advanced.

Detection of disease cluster

Detection of disease clustering strongly helps probing the cause of epidemics and in the detection of unknown diseases. One good example is the John Snow cholera study, which showed a contaminated pump as the cause of a cholera outbreak after observing an aggregation of deaths on a map (see the boxed article). In this case, the aggregation was apparent, but often we need a subtle distinction of disease clustering. For this solution, several statistical methods have been developed: a permutation test (Lloyd and Roberts 1973); the Bayesian approach (Leukaemia Research Fund 1990); clustering (Tango 1995); and a point pattern analysis (Gaterll and Loytoen 1998). Since it is incomplete to probe etiology only with geographical examination, time-space clustering of disease is required. Mantel has developed this method for the clustering of cancer (Mantel 1970).

Spatial interpolation

Point data sets are unsuitable to evaluate a tendency in the value of all data points or to estimate the intensity or probability of disease infection at any point in the study area. Spatial interpolation is a solution to this problem. The Kriging method is one of the most popular approaches and is based on statistical theory (Bailey and Gatrell 1995).

Analysis of correlation

Analysis of relationships between diseases and geographical factors is one of the important approaches in unveilling the etiology of diseases. Correlation coefficients and regression models are often used to determine if an observed value at a certain point is influenced by values in a surrounding area. It is also necessary to adjust for spatial autocorrelation to avoid a misleading conclusion. Therefore, multiple regression analysis is combined with the spatial error model to detect spatial autocorrelation. Another approach to detect these relationships is a geographically weighted regression (Fotheringham *et al.* 1996, 1997). This estimates geographical variation of regression coefficients at each point in a study area, whereas the conventional regression model gives us only one regression coefficient for the total area.

Case studies of GIS application

Spatial epidemiology

Epidemiology is used to clarify the etiology of diseases and estimate disease risk to health. Extreme stringency is required to avoid misjudging and excluding false determinants surrounding diseases. In this context, data quality and other confounding factors are cumbersome problems in spatial examination (Elliott *et al.* 2000). Since GIS processes massive amounts of information easily, it provides an effortless platform to conduct spatial analysis. For example, a cluster of malignant pleural mesothelioma cases occurred in Turkey and was subsequently linked to the exposure to naturally occurring erionite fibers (Baris 1987).

Health service research

Health service researchers can benefit from GIS by solving complex planning and management problems (Antenucci *et al.* 1991). Application of GIS in health service research is used in three areas: the allocation of medical human resources; the allocation of hospitals and other health care facilities; and in monitoring, surveillance and emergency planning.

A spatial decision support system (SDSS) was demonstrated in 1996, helping decision making in locating potential medical practice locations to best utilize both professional and personal criteria (Jankowski and Ewart 1996). Using

Box

Demonstration of spatial analysis using GIS —Dr. John Snow's cholera study data

Fig 20. 1 Dr. John Snow

In 1854, a deadly cholera epidemic terrified the people of London. Dr. John Snow (1813-1858), a historic giant in epidemiology, halted a cholera outbreak using a disease-mapping approach. Surprisingly, he did this 29 years before *Vibrio cholerae*, the causal bacteria of cholera was found in 1883.

Dr. Snow mapped the locations of deaths and showed there was a relatively concentrated spot around a water pump. Sealing the pump confirmed his hypothesis. The epidemic was successfully stopped, proving that the source of the cholera had come from the water pump.

Today, GIS technology can be used to solve this kind of problem. A demonstration is shown here of how Dr. Snow would have used GIS technology to halt the cholera epidemic.

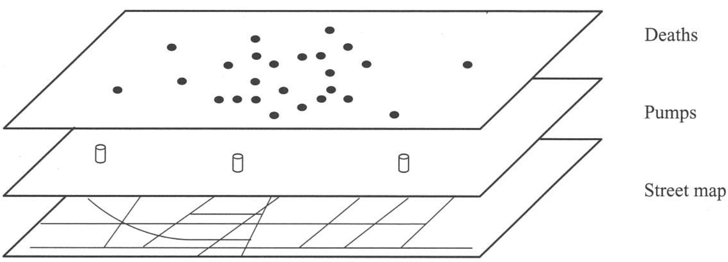

Fig 20.2 Data set and layers

The example data set for this study contains a London street map, the locations of deaths, and the locations of the water pumps. For this example the data is abbreviated to three layers in the GIS context so as to be easily understandable (Figure 20.2). With GIS software, Dr. Snow could have overlaid these three layers or many more (see Figure 20.3).

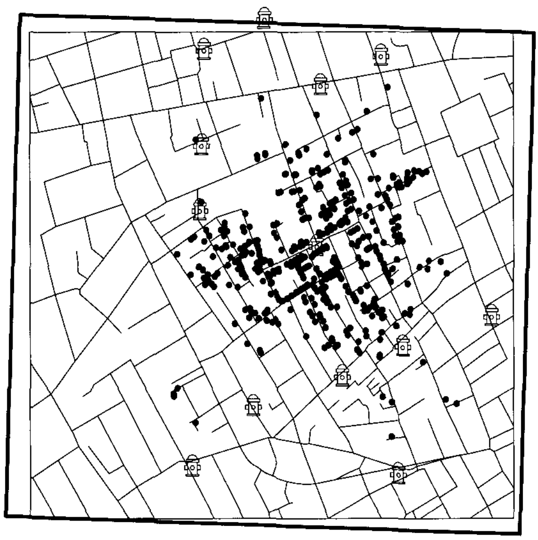

Fig 20.3 An overlaid map with three layers

The above map looks like Dr. Snow's original map, on which he based his hypothesis. This map shows that the cluster is not obvious but conjecturable.

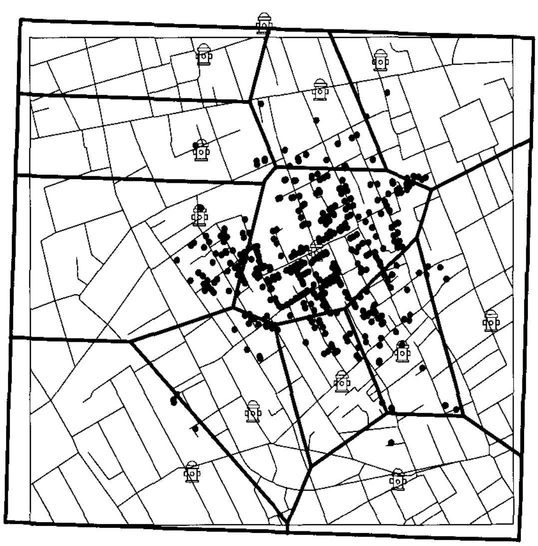

Fig 20.4 Voronoi diagram

This map would have been divided into areas according to a rule that the closest pump to all points inside an area is the same one. In other words, lines are drawn on the midpoint between every pair of pumps. This technique is called a "Voronoi diagram" (see Figure 20.4).

Fig 20.5 Number of deaths in each area

If Dr. Snow had counted the number of deaths inside each area, he would have obviously noticed the area with the highest number. The area with highest number of deaths implies that the pump in this area is most likely closest to the source of the epidemic (see Figure 20.5).

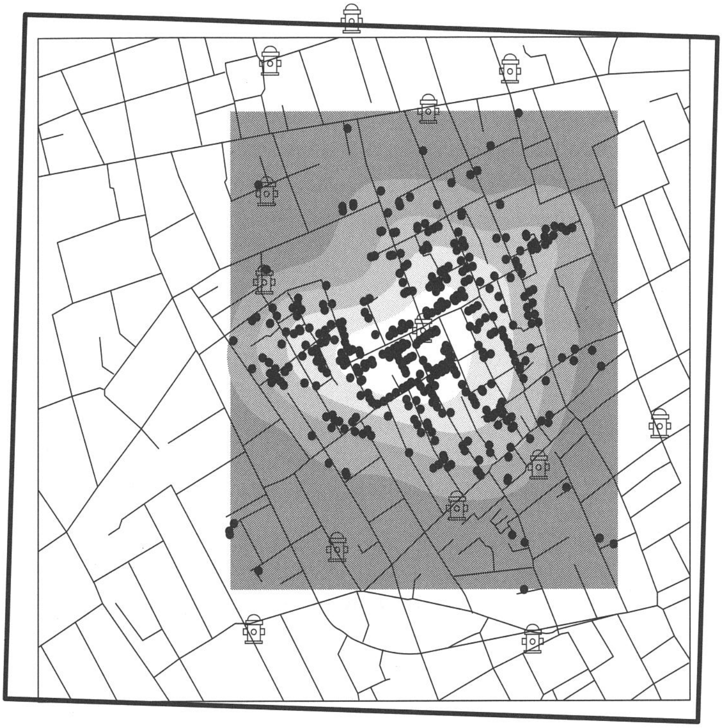

Fig 20.6 Density conversion

Dr. Snow could have improved the visual appearance of the results using another technique of spatial analysis called '"density conversion"', which transforms the point data to surface data. From this analysis it would have been obvious that the white center is the most suspicious (see Figure 20.6).

Using the above GIS techniques, Dr. Snow would have been more confident in pointing out the location of the contaminated pump. Today's health specialists computerize many layers of digital data positioned on a spatial map to integrate a probable disease foci.

This demonstration, the application of GIS technology to Dr. Snow's cholera study, was originally presented in the studies by Dr. NAKAYA Tomoki (Nakaya, 2001; 2004).

physician licensure data, Albert et al. examined the location characteristics and distribution pattern of physicians with GIS (Albert and Gesler 1996).

Distance to health care facilities is an important criteria examined in health service research. This had been done using the abilities of GIS in measuring straight-line distances (Kohli *et al.* 1995; Love and Lindquist 1995), relative travel time, (Furbee and Spencer 1993) and road or network distance (Walsh *et al.* 1997). Evaluation of a hospital service area gives us dependable evidence to site new hospitals when GIS and area marketing methodology are applied.

Vector control

Some infectious diseases transmit through vectors such as mosquitos, ticks, flies, mice and foxes. GIS related technologies, especially RS and spatial analyses, are strong tools for ecological analyses of the vectors. Geographic variation of natural environmental factors like vegetation, soil, water, temperature and rainfall can help determine vector habitat. Taking advantage of RS imagery and spatial interpolation, we can predict the vector habitat even in an area that is impossible to physically visit.

The earliest application of GIS in health was to establish a geographical information database to support the Guinea Worm Eradication Program. Such a database is a straightforward starting point in GIS for vector control (Elliott *et al.* 2000).

The use of GIS in malaria study was one of the earliest applications in the field of international health and has been conducted in several countries: Israel (Kitron *et al.* 1994), Ethiopia (Ribeiro *et al.* 1996), India (Sharma and Srivastava 1997), Mozambique (Thompson *et al.* 1997), Kenya (ESRI 2000) and others. The Center of Disease Control and Prevention (CDC) in the USA uses GPS located cases to collect data helping malaria research in Kenya. The use of bed netting in neighborhoods was examined with the spatial statistical approach (ESRI 2000).

Discussion

The main uses of GIS as applied to international health are epidemiological studies, health service research, and ecological correlation studies. In this decade, the number of published papers using the keyword 'GIS', is increasing year by year. In combination with spatial analysis and spatial statistical analysis, GIS is not limited to a data visualization tool as is common in other fields. Instead it can be used as a probing tool focusing on research questions in health.

GIS is a powerful tool, but not a panacea because it has several limitations.

Some limitations are derived from the fact that GIS is still an immature information processing system. Immaturity leads to two disadvantages. First, even if a researcher struggles to maximize its abilities and functions, its immaturity keeps them from doing so. The other disadvantage is that a certain level of knowledge and skill for using computers are required to take full advantage of GIS. Since most researchers in the field of international health are not educated in information technology, they have big obstacles to overcome before they can start to learn and apply GIS to their work. At present, only a few researchers have the computer skills necessary to take advantage of GIS in the fields of international health. This may be one of the explanations as to why GIS is under-utilized.

The simplest solution to these disadvantages is that international health researchers do not remain just users, but develop the system to suit their particular needs. They should not just use set computer programs, but develop them for themselves. Further, education and training in information technology and GIS should increase to take maximum advantage of the functions of GIS. Professionals in GIS and information technology are required to develop the computer programs for use by the researchers. Since GIS is spreading to various fields other than health, it is better for health researchers to wait until the system grows. In the meantime, the health researcher should learn to use this computer-based system. Thus, *information technology and geographic information* technology should be integrated into the education system as one of the basic skills of research for students majoring in international health. With experience in information processing used in GIS, such as image processing and spread sheets, students should significantly enhance their interest and confidence in using computers.

Conclusion

The theory, methodology and technology of GIS have great potential in their application to the field of health. A combination of GIS, associate technologies, and spatial analyses have become very strong tools for spatial epidemiology, health service research and vector control. The more health researchers are trained to use GIS and associated computer systems, the more familiar these systems will become and the more they will be used to achieve research-based objectives.

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PART 3

Eco-resource Management in the Development Process

Introduction to Part Three

This section considers the development processes going on in the mountainous regions of mainland Southeast Asia, including northern Vietnam and the northern part of Laos. Compared to the lowlands, mountain ecosystems are much more vulnerable and unstable due to steep slopes, non-alluvial soils and the erosion of soil and nutrients. People's livelihoods directly rely on the ecosystem in *situ* using slash-and-burn swidden farming, while they also utilize various kinds of forest products to make their living. Because the mountains are very fragile, eco-resources management is, therefore, a most critical issue for the people in this region, more so than in other parts of Southeast Asia. Recent development trends, including both economic and environmental aspects, have required intensive land use, and increasingly risk overloading the capacity of the ecosystem. The following seven chapters describe development policies, the spread of the market economy, changes in land use and farming practices and the dynamics of the village economy. We discuss the diversity and complexity of the region and the implications these have in forming policy for rural mountain communities.

Rambo discusses the contemporary upland development policies being applied in the northern mountain region of Vietnam. This development policy covers almost all aspects of the people's livelihood, including natural resource management, infrastructure development, poverty elimination, income generation and education, and how these policies have significantly contributed to a remarkable upgrading of people's livelihood in the region - particularly after the economic reforms in the late 1980s called '*doi moi*'. He points out, however, that the lack of a comprehensive development strategy has caused contradictions among the various policy objectives. The administrative capacity of the local governments is far below that required for effective policy implementation. The bureaucratic shortcomings in the implementing agencies constrain the achievement of the development targets. He concludes that a better understanding of the complexity and diversity of the natural and social conditions of the region is essential for the effective design and implementation of appropriate development policies.

Sikor and Dao Minh Truong focus on a Black Thai commune in Son La

Province, Vietnam, carefully analyzing the changes in land use, modes of farming and the land management policy during the last five decades. They provide us with a clear-cut view of the dynamics of a mountain village, dividing observed changes into three phases. The first phase was from the 1960s to the mid-70s, in which the government started intervening in the village community in terms of agricultural collectivization and providing advanced agricultural technology and supplies such as chemical fertilizer. Then, until the beginning of the 1990s, the collapse of collectivized farming caused a rapid expansion of fields and the reduction of forest land. Finally, during the last decade, *doi moi* has had substantial impact as the villagers shifted from the expansion of agricultural land to the intensification of agricultural production. The authors' major concern in this paper was to study the interdependency between local institutions and national policy.

Tran Duc Vien highlights changes in farming in a Tay village in Hoa Binh Province, Vietnam, after *doi moi*; the 'third period' in Sikor and Dao Minh Truong's classification. Farming in this village is characterized by a composite of the swidden system with permanent wet rice fields in the valley bottoms and shifting swidden fields on the hill slopes. Although this system has been maintained since the beginning of settlement, during the past decade farming has shifted drastically from a subsistence-oriented economy to the market-oriented economy. Commercial crops such as corn, canna and ginger were widely introduced and their cropping has fluctuated according to market prices. Traditional varieties of wet rice were replaced by high-yielding and hybrid varieties and approximately half of the rice produced is now sold at market. These findings clearly show the villagers' quick and practical adaptation to the spread of the market economy. He also points out that the changes of the last decade were not limited to farming, but also cover the entire livelihood system and locally available natural resources.

Yanagisawa describes more dynamic changes occurring during the last decade at Moc Chau, Son La province, Vietnam. In this area, the shifting cultivation of upland rice for subsistence purposes was totally replaced by the permanent cropping of commercial as well as new subsistence crops, such as maize, canna and fruits. Hybrid varieties of maize and the application of chemical fertilizers are popularly employed. Different ethnic groups, including the H'mong, Muong, Thai and the Kinh show differences in terms of the timing of the introduction of commercially-oriented farming and their adaptation to the market economy. Sooner or later they all experienced a similar change in intensification and commercialization of their farming. This area has been receiving Kinh and Muong immigrants, mostly from the Red River Delta, since the 1950s. The author suggests that the close relationship between this mountainous area and the lowland communities is the core reason that provides the basic condition that enabled these people to quickly transform their land use and farming practices.

Using the viewpoint of a Laotian policy maker, Pravongvienkham critically analyzes past policies and development approaches as well as the current vision, approach and organizational setting for future upland resource management in Laos. He shows that past policies concentrated on the eradication of shifting cultivation, promoting a move away from upland rice to paddy rice cultivation. Although land allocation and land use zoning were implemented and irrigation facilities were expanded in order to achieve these goals, this approach showed few gains in rural welfare or in slowing forest degradation. The major reason for this lack of impact was that these interventions did not take into account the diversity and complexity of the uplands and the upland livelihood systems. The government has, therefore, identified decentralized land management and reorganizing research, extension and training systems as the key for national strategies to eradicate poverty in the upland areas. This is an area-based livelihood systems approach, which is the core approach under their newly-formulated development strategy. It will be a real challenge for eco-resource management in the development process.

Kono *et al.* present analysis from a Kamu village in Oudomxay Province, Laos, exploring the impact of the implementation of land allocation policy and the intrusion of market economy into a shifting cultivation-based economy in the 1990s. They found a quick response by the villagers to these new situations. Before 1990, village land was communally managed, but now an individual interest in land holding is emerging. Rice production of both upland shifting and lowland paddy has increased beyond the rate of population growth, and rice has become the major source of cash income due to its stable selling price. They even started producing non-glutinous rice for sale, even though their staple food is glutinous rice. Other economic activities, including the collection of non-timber forest products are also common. The growth of the village economy was achieved based solely on the intensive use of local resources, such as land and labor, where there was little input of new technology or agricultural information supplied to the village. The authors remark that there is a risk that this response may create economic disparity among households, a new problem for the shifting cultivators' community. Development processes must pay attention to social sustainability in addition to environmental stability.

Takeda discusses recent changes in the production of benzoin, a non-timber forest product, in relation to the land allocation policy. Based on a field survey at a village in Louang Prabang Province, Laos, the author argues that benzoin is a commercial balsamic resin extracted from *Styrax tonkinensis* and was historically an important item for commerce in Southeast Asia and northern Laos in particular. The fruit seeds of *S. tonkinensis* on the forest floor are stimulated to germinate by the heat of the slash-and-burn method used in shifting cultivation. The seedlings grow densely among the upland rice in the first year, and later as pioneer trees on fallow land because *S. tonkinensis* is a light-loving and fast-growing species. Harvest of benzoin starts when the trees are seven years old and continues for two to three years. Then, the villagers use the land for shifting cultivation again. Recently implemented land allocation policy limits the fallow period to four years, which is too short to maintain this traditional agro-forestry system. This chapter highlights the complexity of an indigenous land use system and the necessity of an area-based livelihood system approach to natural resources management.

21

Development Policies and Development Trends in Vietnam's Northern Mountain Region

A. Terry RAMBO

The hills and mountains of the Northern Mountain Region (NMR) cover most of the surface area of northern Vietnam and are home to more than fifteen million people. Their contribution to GNP is much less than their share of land area or population because they remain economically underdeveloped in comparison to the lowlands. The per centage of households living under the poverty line is the highest of any region in the country.

Since the initiation in the late 1980s of the economic reform process known in Vietnamese as *doi moi*, the Vietnamese state, guided by the Communist Party, has greatly intensified its development efforts in the northern mountains. Development is being pursued to achieve multiple objectives. These include integrating remote, subsistence-oriented communities into the market economy; modernizing agricultural technology and encouraging the production of cash crops; construction of transportation and communications infrastructure; provision of health and education services; eradication of hunger and reduction of poverty; and strengthening national integration and defending Vietnam's territorial integrity. Supported by massive inflows of foreign development assistance funds, the Vietnamese state has committed hundred of millions of dollars to achieving these policy goals.

In order to more clearly understand the nature of changes that are occurring in the NMR as a consequence of this development effort, I will briefly review the historical background of development in the NMR, describe some of the key areas of policy concern, and examine some of the implications of ways in which these policies are being implemented. In these discussions I will draw heavily on information collected from an extensive SIDA-funded research project on development trends in Vietnam's northern mountain region (Le Trong Cuc and

Rambo 2001).

Historical background

The lowlands are the core area of the Vietnamese state. Two-thirds of the population, and all of the main urban centers, are located in the lowlands. But three-quarters of Vietnam's territory is mountainous, with some twenty-five million of its citizens inhabiting upland areas (Jamieson, Le Trong Cuc, and Rambo 1998). The uplands are where most of Vietnam's ethnic minorities reside. Of the 54 officially recognized ethnic groups, only four live primarily in the lowlands (the Kinh, the Khmer, the Hoa or Sino-Vietnamese, and the Cham). All of the other groups, and a large number of Kinh as well, live in the mountainous areas. Thirty-one ethnic groups are found in the NMR alone. The Thai and Tay have more than one million members each, the H'Mong, Muong, and Dao have several hundred thousand members, while some of the smaller minority groups, such as the Pu Peo and La Hu, number only in the hundreds (Dang Nghiem Van 1998).

The minority ethnic groups in the NMR are characterized by great linguistic and cultural diversity. They speak languages belonging to several different families, including Tai, Mon Khmer, Viet-Muong, H'Mong-Dao and Tibeto-Burman. Groups growing irrigated wet rice in the valleys and intermontane basins, such as the Thai and the Muong, were rank-stratified hierarchical societies organized as 'feudal' principalities, with several localities owing allegiance to a single hereditary leader. The military power of such proto-states was miniscule compared to that of the Vietnamese kingdom, however, and all were tributaries of the Vietnamese kings. The minority groups dwelling on the mountain slopes and practicing shifting cultivation (Kho Mu, Dao, H'Mong) were relatively simple and small-scale societies organized according to principles of kinship and co-residence. Vietnamese ethnologists describe these societies as representatives of the 'primitive pre-class' stage of society in the Marxist evolutionary sequence. The village was, in most cases, the maximal unit of socio-political organization. Some of these groups, such as the Kho Mu, who dwelled on the lower slopes near the valleys and basins, were in a subordinate tributary relationship to the Thai chiefdoms in the valleys, while others, such as the H'Mong, who dwelled in the high mountains, were largely autonomous.

With the exception of the valley dwelling Thai, Muong, Tay and Nung, who practice irrigated wet rice agriculture often combined with swiddening, a system referred to as 'composite swiddening' (Rambo 1998), most of the minorities (until recently) were wholly dependent on shifting cultivation. Technology was almost exclusively based on human muscle power, productivity was low and unstable, and periods of hunger recurrent. Economic specialization was little developed, production of commodities on a small scale, and trade weakly developed, although all of the mountain minorities had to purchase some essential commodities, especially salt, from the lowlands.

Environmental diseases, notably malaria, were prevalent and life expectancies very low. Settlements were small and widely dispersed and population densities often below 25 persons per square kilometer. Decades of warfare and banditry during the colonial conquest further decimated populations, leaving large areas virtually uninhabited. The French eventually 'pacified' most of the mountains, but did little to improve the lives of the mountain minorities (Rambo 1997). Indeed, colonial taxes and demands for corvée labor increased their hardships and led to worsened impoverishment.

Until the end of the colonial era, except for paying taxes and performing corvée for the French rulers, the ethnic minority populations of the NMR were relatively isolated from the lowlands, although certainly not uninfluenced by their political and economic relations with them.[1] During the revolution and the long Resistance War against the French colonialists, however, relations between the Kinh (lowland Vietnamese) and the minorities were greatly intensified. The resistance bases of the Viet Minh were mainly located in the forests and mountains, and the revolutionary leadership (including President Ho Chi Minh and General Vo Nguyen Giap) lived for long periods in close contact with ethnic minorities. In the process, the leadership developed a deep sympathy for their difficult situation accompanied by a strong desire to reduce the poverty and improve the living conditions of the minorities by changing their ways of life to more closely resemble that of the Kinh majority (Jamieson 1991).

Following the victory against the French at Dien Bien Phu in 1954, 'developing the uplands simultaneously with the lowlands' became one of the key policies of the Democratic Republic of (North) Vietnam. Strengthening of national unity was perhaps the most important objective. Members of all minorities, even those who had only recently immigrated into Vietnam, were recognized as full citizens of the multiethnic Vietnamese nation. Over the half century since the winning of independence, the Vietnam state has expended a considerable share of its limited financial and human resources on attempts to develop the uplands and improve the living conditions of the minorities, although the results of this investment have not been fully commensurate with its magnitude. In the past several years, efforts to develop the uplands have been greatly intensified and the amounts expended vastly increased. The pace of change is accelerating and the impacts of development efforts increasingly felt in even the most remote communities.

Contemporary upland development policies

Contemporary Vietnam is very much a 'development state', in which a primary role of the governing apparatus is seen as mobilizing and guiding local people in efforts to develop the nation into a wholesome, wealthy, egalitarian and civilized society. Under the leading slogan of 'industrialization and modernization,' the Communist Party and the state are actively seeking to transform the countryside by eradicating hunger and reducing poverty; encouraging the adoption of science and technology to increase productivity while protecting the natural environment; promoting education and eliminating illiteracy; improving health and reducing the rate of population increase; stamping out social evils; and protecting and developing an advanced culture deeply imbued with national ethnic characteristics. It is seen as the right and the duty of every citizen, including members of minority groups in the most remote mountain hamlets, to fully participate in this great national project of renovation and progressive development. Space does not allow a detailed review of the multitude of policies aimed at the uplands, so I will focus on only some of the most important:

- land allocation
- agricultural and forestry development and environmental protection
- exploitation of mineral and water resources
- hunger eradication and poverty reduction
- construction of roads and infrastructure
- development of the market economy
- education and eradication of illiteracy
- national integration and defense of the territorial integrity of the state

Land allocation

Historically, assuring farmers access to land has been one of the major concerns of the Vietnamese state. As part of the *doi moi* reforms, the NMR experienced its third major land reform of the 20th century. The first reform redistributed land from landlords to landless farmers; the second involved transferal of land from peasant households to the cooperatives; and the present reform is reallocating land from the cooperatives to be managed by the households and other social units.[2] The results of allocating land to households have generally been positive. In particular, the productivity of agriculture has improved at an impressive rate. Grain yields in the paddy fields are far higher than they were during the cooperative period and large areas of formerly barren hills have been successfully re-greened (Le Trong Cuc *et al.* 1996).

After 1986, virtually all wet rice land was quickly allocated to households, but allocation of hill lands has been much slower and is still not completed. The process of allocating hill lands to households has not been a smooth one. In one community studied by the author, the cadre from the district land office made many mistakes when preparing the land map; that is, the rights to plots actually being managed by one household were assigned to a different household and the 'red books' issued to the households were incorrect. After more than three years, the errors have still not been corrected. This has created a complex maze of overlapping rights that cause many difficulties for the farmers, including generating conflicts between households having competing claims.

Allocation of hill land has also suffered from other serious problems. Much of the land involved has been classified as 'land not yet in use' (*dat chua dung*). In reality, as Hoang Xuan Ty (1998, pp.97 - 98) has observed, this is a major mistake, because there is no land in the mountains that is not being used by someone for some purpose or other. Much of the land officially classified as 'unused' is fallowed swidden fields where farmers are allowing the forest to regenerate before clearing and burning their plots again. Large areas are also used for free-range grazing of livestock and collection of bamboo and other non-timber forest products. Allocation of lands formerly treated as an open access community resource to individual households' control threatens to severely reduce the resource base of the poorest households.

Another problem in the land allocation process is that a 'one size fits all' model has been applied nationally, without regard to local customary land management practices. In many upland communities, hill lands were managed as a communal resource. Individual households were permitted to clear swiddens there, but the use rights returned to the community as soon as the swidden was put into fallow, allowing the plot to be used by another household in the future. In practice, some communities have found ways to ignore the formal allocation of rights to households and maintain communal management, but this is an unsatisfactory expedient in the long-term.

In the five communities included in the SIDA study (Le Trong Cuc and Rambo 2001), allocation of land has been done in a highly equitable manner. The Gini coefficients for the total area of household landholdings on a per capita basis varied from 0.34 to 0.49. This is a higher level of equality than exists in contemporary China, where the Gini coefficient is 0.54 (McKinley and Griffin 1998). The high level of equitability in the distribution of land is matched by a correspondingly high equitability in the distribution of income among rural households, with Gini coefficients for income ranging from 0.26 to 0.38 in our communities. Given that maintenance of equality is one of the four central goals of Vietnam's development effort, this is an impressive achievement.

The maintenance of high levels of social and economic equality among households in the NMR is threatened, however, by the policy to promote the formation of large commercial farms (*trang trai*). Under the *trang trai* system, a single operator (either a wealthy individual or a group of such people) is allocated long-term use rights to 'unused' hill land. The state has given a very high priority to stimulating formation of *trang trai* in the NMR because these commercial farms are believed to be an effective way of promoting rapid agricultural development. By 1998, there were 9,863 commercial farms in the northwestern region, 15,491 farms in the northeastern region, and 13,392 farms in the central northern region; a total of almost 39,000 units in the northern mountains and midlands (Nguyen Duc Thinh 2001, pp.106, Table 6). At present, commercial farms are heavily concentrated in areas that have good roads and other infrastructure (especially the midlands), but they can be expected to spread more widely as highway construction and rural electrification reach more remote parts of the NMR.

The scale of these farms varies: most (76 per cent) are under 5 ha, but 19 per cent are 5 to 10 ha, 2 per cent 10 to 30 ha, and 0.1 per cent are larger than 30 ha (Nguyen Duc Thinh 2001:111, Table 8). One farm of 304 ha and another of 80 ha are reported from Yen Binh District in Yen Bai Province (Nguyen Duc Thinh 2001, p.112). Interestingly, no data on the total area of land allocated to commercial farms, or the share that this represents of total land area, have been published, but these figures must be very large.

The policy of promoting commercial farms is based on the belief that large, heavily capitalized units will adopt highly productive cash cropping using modern technology. It is true that although *trang trai* constitute only approximately one per cent of all farms in Vietnam, they produce 40 to 60 per cent of most cash crops (Nguyen Duc Thinh 2001, p.42). This does not support the assumption that such farms have higher productivity per unit of land, labor or capital than peasant plots, but only shows that they are oriented toward production for the market, whereas peasant farming is primarily aimed at meeting the subsistence needs of the farm household. Dao The Tuan (personal communication, 1998) has found in Son La Province that peasant plots actually display higher land and labor productivity than commercial farms.

The government believes that commercial farms will generate employment opportunities for under-employed small farmers and landless people. Commercial farms of less than 5 ha do not generally employ wage laborers, but units having between 5 to 10 ha offer irregular employment to two or three workers. Farms larger than 10 ha employ three to five workers, but only one or two of these work on a continuous basis. One very large *trang trai*, in Yen Bai, that covers more than 300 ha provides continuous employment for approximately 100 workers. Such workers receive a monthly wage of

VND350,000 to 500,000 (approximately US$23 to 33) (Nguyen Duc Thinh 2001, p.120). No figures seem to have been published for total employment generated by commercial farms so it is impossible to verify if they actually generate significant employment opportunities.

It is the underlying assumption that unused land is in abundant supply in the uplands that is the most questionable aspect of the policy to promote the establishment of commercial farms. It is true that population densities are much lower in the NMR than in the Red River Delta, but that does not mean that there is any surplus land. In fact, because of the very low agricultural productivity of mountain lands, population pressure on land is actually much higher in the NMR than in the Red River Delta.[3] Although this low productivity is in part the consequence of 'lack of knowledge,' 'backward technology,' and 'lack of investment,' (which are the standard explanations that one hears among development planners in Hanoi), the productive capacity of most of the uplands is intrinsically limited by the poor quality of soils and scarcity of water, so that productivity per hectare will always be far lower in the mountains than the plains.

It may well be, as Charles Bailey has observed (personal communication, 2000), that the *trang trai* are a contemporary analog of the enclosures that so radically transformed the agrarian system of England at the beginning of the industrial era. Rights to use hill land are being transferred from a very large number of small peasants into the hands of a small elite group. The beneficiaries of this process are not necessarily the most progressive farmers; instead they may be mainly individuals who are positioned to be able to manipulate the system of land allocation to their own advantage.[4]

Agricultural and forestry development and environmental protection

Vietnam has recognized that allocating land to farmers is not sufficient in itself to ensure rapid rural development. It is also necessary to improve agriculture and forestry so as to expand production in a sustainable fashion. Efforts to this end have focused on the introduction of modern technology, elimination of shifting cultivation, establishment of national parks and protected forest reserves and reforestation of barren areas.

Introduction of modern agricultural technology

Vietnamese development planners have great faith in the ability of modern technology to transform traditional upland agriculture. Strong efforts have been made to introduce high-yielding crop varieties, promote the use of fertilizer and pesticides, and stimulate the planting of industrial crops in designated zones. Considerable success has been achieved. The amount of grain produced per capita has vastly increased, alleviating, although not totally solving, the problem of food security in the NMR. High yielding rice varieties have been widely accepted and are now sown in most irrigated paddies in the NMR. Chemical fertilizer and pesticides, which are provided to farmers in the uplands at highly subsidized prices, are also now widely used in wet-rice cultivation, but much more rarely on dry-land fields. The area planted with tea, coffee and fruit has greatly expanded.

New technology has primarily been applied in the valleys and lower-lying slopes having good soils and reliable supplies of water. Little of the new technology is suitable for conditions on steep slopes at higher elevations. Thus, H'Mong farmers in Ha Giang say that the HYV corn seed supplied by the government gives much higher yields than the traditional varieties on the small patches of good soil in the valleys, but gives a lower and less stable yield on the sloping fields. Virtually no effort has gone into improving the dry rice varieties planted in the swiddens and they still provide most of the grain for highland farmers.

The planting of industrial crops has enjoyed considerable success. The growing of fruit and tea now brings considerable cash income to many rural households. However, poor roads and consequent high transportation costs, the relatively small size of the internal market, and the absence of processing facilities are all serious constraints on the expansion of the area of industrial crops in the NMR. In years with unusually good fruit harvests, the market soon becomes glutted and prices fall to disastrously low levels. Fortunately, the planting of coffee has only recently been promoted in the NMR and the farmers there have been spared the consequences of the collapse of world coffee prices that has devastated upland farmers in the central highlands ('Vietnam coffee dream crumbles due to low price,' *Daily Yomiuri*, 9 December 2001).

Elimination of shifting cultivation

Since the early 1960s, the Vietnamese state has sought to eliminate shifting cultivation and to resettle minority populations in fixed communities. According to the conventional wisdom, traditional swidden agriculture is a primitive type of farming that employs backward and inefficient technology. It is characterized as having low productivity, using land wastefully and causing widespread deforestation. Because of its supposed inefficiency and lack of sustainability, the minorities that practice it are believed to be forced to lead a nomadic life characterized by deep poverty and frequent hunger.[5] Based on this (mis)understanding of the nature of swidden agriculture, suppression of shifting cultivation and its replacement with permanent forms of agriculture has been a key policy for decades. Vast sums and great efforts have been invested in largely unsuccessful programs for sedentarization and fixed cultivation. In the late

1950s, H'Mong and Dao from the high mountains were moved to valley land, where they were assigned wet rice fields as part of the *ha son* ('down from the mountains') program. Subsequently, a nationwide program called 'fixed fields, fixed settlements' (*dinh canh, dinh cu*) was established and continues to operate today. According to official statistics, 167,000 households in 630 villages in the northern mountains have been more or less successfully settled and now practice fixed cultivation (Phan Huu Dat 2001, p.74). In reality, however, many communities that have been officially classified as practicing fixed cultivation in fact continue to engage in swiddening. In some communities in Hoa Binh Province studied by the author, for example, the people, realizing that shifting cultivation was unacceptable, began referring to their swiddens as 'mixed gardens' (*vuon tap*) when reporting to district officials. The latter duly reported that shifting cultivation had almost totally been eliminated in their district, although one could sit in the People's Committee offices and see swiddens on the hills surrounding the district capital.

The persistence of shifting cultivation is often explained in terms of the supposed 'backwardness' and lack of knowledge of minority farmers. In my experience, however, upland farmers generally recognize that swiddening is no longer a productive system and would like to find alternatives. The main constraint on change is not the attitudes of the farmers, but the lack of viable alternative agricultural systems for sloping lands. The area suitable for wet rice cultivation is limited and most of it has already been developed. Tree-based cropping systems can be productive and sustainable, but expansion of areas under perennials is constrained by lack of capital, the long delay between the time the trees are planted and the time when farmers earn any income from them, and restricted and unstable markets for many tree crops. Agro-forestry systems are also generally not able to meet the need for grain for home consumption. Many mountain areas are well-suited to rearing livestock, and the sale of livestock has become a major source of cash income for many upland households. However, restriction of shifting cultivation and reforestation of fallowed swiddens is reducing the area of pasture. Unless and until better alternatives can be developed, shifting cultivation will continue in the NMR on a large scale.

Forest protection and reforestation

For many years the authorities have expressed concern over the rapid reduction of forest cover in the uplands. In large parts of the NMR no natural forest has survived the ruthless overexploitation of the immediate post-war years. In response, the authorities have banned all logging of natural forests and initiated major reforestation programs. The 327 Program, under which farmers received annual cash subsidies to re-green barren hills and protect existing forest, had a major positive impact in many areas. The 327 Program has now been superceded by the even more ambitious Five Million Hectare Program.

The results of these efforts have been mixed; illegal logging continues in remaining areas of natural forest, even inside national parks and nature reserves, and the area of mature natural forest continues to decline. But reforestation efforts have enjoyed considerable success in parts of the midlands and many formerly barren hills are now covered with trees (Le Trong Cuc *et al.*,1996). Nationally, according to a recent estimate by the Forest Inventory and Planning Institute, forests now cover 33 per cent of Vietnam's land area, compared to 28 per cent just five years ago (but 43 per cent in 1943) (AP news service, 8 January 2001).

Exploitation of mineral and water resources

The NMR is seen as holding a vast store of natural resources that must be exploited to support national economic development. The NMR contains at least thirty kinds of minerals (coal, manganese, apatite) and has 270 mines (Khong Dien 1996, p.35). Mining makes a large contribution to national income, but the local environmental consequences are often severe. Unregulated and illegal mining for gems and gold has badly disturbed many watercourses in Tuyen Quang and other provinces and caused severe downstream siltation and water pollution.

The NMR has a large share of the nation's hydropower potential. The Da River alone has a potential capacity of 50 billion Kw/h, which is 19 per cent of the total national hydropower generating potential (Khong Dien 1996, p.19). The Hoa Binh Dam provides much of the electrical power used in the north and also helps to protect the Hanoi and the Red River Delta from flooding. Most of the undoubted benefits of this project have flowed to the lowlands, however, while the social, economic and environmental costs have mostly been borne locally. A large number of Muong households, who formerly lived in the valley flooded by the reservoir, lost their wet rice fields and had to relocate onto steep slopes in the watershed surrounding the dam, making a precarious living by practicing swidden farming. The proposed Ta Bu Dam, in Son La Province, will flood an even larger area and force the relocation of about 100,000 households, mainly Thai. The social and environmental impacts of this project are so adverse that none of the international development assistance agencies are willing to support it, but the Vietnamese government is still attempting to carry on using internal funds.

Perhaps the greatest shortcoming of the efforts to exploit the natural resources of the uplands is the absence of mechanisms to ensure that a fair share of the benefits stay in the affected localities. Thus, it was almost a decade after the completion of the Hoa Binh Dam before electrical power lines were constructed serving the villages in the Da River watershed. Revenues from the dam belong to the state and do not directly flow into the provincial budget. Most mines are operated by state enterprises under ministerial control and again contribute little or nothing to local budgets. Most of their workers are brought in from the lowlands.

Development of the market economy

Development of a market economy in the mountains, especially the replacement of subsistence-orientation with cash-orientation, is a major policy goal. To achieve this end, considerable resources have been devoted to the construction of markets and the expansion of the network of outlets of state retailers selling consumer goods (*kinh doanh hang hoa*). Despite the competitive advantages enjoyed by the state-subsidized commercial sector, the number of private merchants and service providers has also greatly increased. The variety and volume of goods available in the mountains has expanded dramatically.

The poor state of transportation infrastructure is perhaps the greatest impediment to economic activity in the NMR. Because of the terrain, the costs of road construction and maintenance are very high. Given the low traffic volume on most routes, it is unlikely that the economic returns of road construction are sufficient to even cover maintenance costs, let alone the repayment of initial capital costs of construction. Consequently, the road network is very thin and unevenly distributed. Vast areas in the higher mountains are inaccessible by motor vehicles, and horses and backpacking remain the main means of transporting goods to and from market centers. Even where there are roads, transportation costs are extremely high.

Demand, rather than supply, is another major constraint on the further expansion of the market economy in the uplands. Cash incomes in remote villages are extremely low. In our study of five communities we found that the average annual per capita cash income in Khe Nong, a Dan Lai hamlet in the deep forest in Nghe An, was only VND116,000 (less than US$8), and in Thai Phin Tung, a H'Mong village in the high mountains in Ha Giang was VND320,000 (US$21) (Le Trong Cuc and Rambo 2001). Consequently, purchasing power is limited. People have many unfilled needs, which may be increasing due to greater exposure to television, and the search for new sources of cash has become quite intense. This is one force driving the intensification of the exploitation of non-timber forest products that have a high market value. Excessive collection has led to a rapid decline in populations of many valuable wild species in many areas (Donovan 1998; 1999).

Elimination of hunger and reduction of poverty

Poverty and hunger are widespread in the NMR. The northern uplands contain just 18 per cent of Vietnam's total population, but have 28 per cent of its poor people (Joint Report 1999, p.17, Table 1.5). Even worse, while in 1996 18 per cent of rural households in the whole country were below the food poverty line, 23 per cent of households in the northern mountains were classified as 'hungry' (General Statistical Office 1999, p.70:Table 1.27). Ethnic minorities, who mostly live in the mountains, are particularly vulnerable to poverty. Minorities constitute only 14 per cent of Vietnam's national population, but in 1998, accounted for 29 per cent of the poor (Joint Report 1999, p.vii).

Poverty is not evenly spread among the communities of the NMR. The SIDA study revealed a great deal of variation from site to site. In Khe Nong, the poorest community in our study, the average combined per capita cash and in-kind income of households is only VND332,000 per year, or about US$22! In Lang Thao, which is the most well-off community, the average annual per capita income is VND2.9 million (US$193). The incidence of households living in poverty also varied among the communities: all households in Khe Nong, 93 per cent of households in Thai Phin Tung, 43 per cent in Tat, 22 per cent in Ngoc Tan, and 15 per cent in Lang Thao have combined per capita cash and in-kind incomes that place them below the food poverty line.

Because these are largely subsistence-oriented economies, income may not be the best measure of poverty. The incidence of hunger may be a more reliable measure. In the most well-off community in our survey (Lang Thao), ten per cent of the households report that they suffer from hunger at least some months of the year. In Khe Nong, the poorest community in our sample, only one household out of twenty has enough to eat in every month of the year. In the H'Mong community of Thai Phin Tung, 55 per cent of households suffer from hunger for at least some months each year.

Faced with these grim realities, the Vietnamese government has launched a massive program to reduce poverty in the NMR. Notable progress has been achieved in a very short time. National sample surveys show that in recent years the incidence of poverty in Vietnam has fallen everywhere, including in the mountains. Nationally, the per centage of poor people declined from 58 per cent in 1993 to 37 per cent in 1998 (Joint Report 1999, p.iii, Figure 1). In the same period, the incidence of people living in poverty in the northern uplands declined from 79 per cent to 59 per cent (Joint Report 1999, p.15, Figure 1.4).[6] This is a remarkable achievement by any standard.[7]

The main institutional vehicles for reducing poverty are the 133 Program for the eradication of hunger and the reduction of poverty and the 135 Program for socio-economic development. The 135 program targets the 1,715 poorest communes in the country, a large share of them located in the NMR, for special development assistance. The 135 Program provides funds to the People's Committees of every commune to use for locally initiated development efforts, such as building roads and constructing irrigation systems. The communities benefit both through the long-term improvement of infrastructure and immediate gains in income obtained through employment as laborers on these public works projects. In 1999 alone, the government committed some VNDseven thousand billion (almost US$500 million) to the 133 Program nationwide, with a large share of these funds going to the NMR (Nguyen Thi Hang 2000, p.198).

In addition to such major programs, the government also provides direct assistance to households in poor communities by exempting them from the payment of school fees and normal charges for medical services at village clinics. Using the mechanism of the 'policy goods' program, it also subsidizes the transportation costs of essential commodities (kerosene, fertilizer, school notebooks) so that they can be sold at the same price in remote mountain communities as in the lowlands.

Perhaps most importantly, the state is involved in making massive transfer payments to the uplands. The weakly developed economies of the NMR do not generate sufficient revenues to support even minimal state administrative services. Thus, the costs of these services are heavily subsidized by the central government budget. In the case of Bac Can, one of the poorest provinces in Vietnam, some 90 per cent of the provincial budget is provided by Hanoi, while 80 per cent of the province of Cao Bang's budget is funded by the central government *Viet Nam News* 23 July 2001, p.1).

The economies of many households in the NMR have become heavily dependent on government transfer payments. These payments include salaries paid to the cadre of the local government, the Communist Party and mass organizations, pensions paid to retired cadre and soldiers, and monetary assistance given to households by development projects. In our study of five communities in the NMR, we found that transfer payments contributed from 1.2 per cent of total household income in the poorest community (Khe Nong, province of Nghe An), to 19.7 per cent in the most well-off community (Lang Thao, Phu Tho Province). One must raise the question of what will happen to local economies in the NMR if the state should prove unable to sustain the current high level of transfer payments and subsidies.

Education and eradication of illiteracy

Even at the height of the Resistance War against the French, the Viet Minh attempted to raise the very low educational level in the uplands. Soldiers, cadre and students were mobilized to teach literacy classes in even the most remote settlements. After the regaining of national independence in 1954, teams of linguists were assigned to developing alphabets for minority languages. Basic textbooks were published in Thai, H'Mong and other widely used minority languages. Great efforts were made to establish schools and train teachers. Literacy rates among the minorities dramatically increased, although never achieving the almost universal level of the lowlands. These gains, which represent one of the proudest achievements of the socialist system, have been threatened by the post reform shifting of educational costs from the cooperatives to individual households. Poor households lack the financial resources to pay school fees and cannot afford to lose the labor services of even young children so that even those enrolled in school are often absent helping their parents work in the fields. Many parents, lacking the resources to provide schooling for all of their children, favor boys over girls. Consequently, literacy rates have declined in many communities (Khong Dien 1996, p.243).

The physical state of schools in many poor and remote communities is shocking. Teachers are often poorly trained, badly paid and often absent from their classrooms while they carry on sideline activities to supplement their inadequate salaries. The situation of young Kinh women sent to teach in remote schools is particularly difficult. Not only must they live under difficult conditions, but their chances of finding suitable husbands are very low. For reasons that remain unclear, teaching in minority languages was largely abandoned after 1975 and has only been revived in recent years. Not surprisingly, children from groups such as the H'Mong, where few people speak the national language fluently, experience great difficulty in learning. For example, only 22 per cent of males and five per cent of females are literate in Thai Phin Tung, (Le Trong Cuc and Rambo 2001).

As a consequence of these limitations, only a small per centage of minority children complete secondary schooling and only a tiny minority go on to tertiary levels. Thus, there is a persisting shortage of minority candidates to fill technical positions in the government services. Most extension workers, teachers and doctors in the uplands are still, of necessity, recruited from among the Kinh.

National integration and defense of the territorial integrity of the state

Strengthening national integration and defending the territorial integrity of the nation are given a very high priority by the state. Vietnam is an explicitly multiethnic nation with 54 officially recognized ethnic groups. Native-born members of all ethnic groups are automatically granted full citizenship, with all of its rights and duties. At the same time, the constitution grants members of all ethnic groups the rights to use their native languages and protect and develop the 'positive' aspects of their own cultures. All citizens also have an obligation to learn the national language, Vietnamese, which is the native language of the Kinh majority, and the language in which all governmental affairs are conducted.

Although there are no current serious threats of invasion, memories of the 1979 Chinese incursions are still vivid and attention to border security is correspondingly high. A special paramilitary border force maintains a strong presence in all frontier districts and works in close cooperation with the local population in patrolling sensitive areas. The border force also engages in an extensive program of civic action, helping minorities to improve agricultural production, providing medical care, and teaching literacy classes. Militia units (*dan quan*) have been set up in border area settlements and receive training from the regular army. Service in the militias is also a source of some income for many minority youth.

The border force is also involved in development of the National Defense Economic Zones (NDEZs) in border areas that were abandoned by inhabitants fleeing the Chinese attacks. These border areas have not been reoccupied because of uncleared minefields and unexploded munitions. Twelve NDEZs, that can accommodate 70,000 households, have been approved (VNA web site, 29 June 2001).

Enlisting in the national army is also one of the few channels of upward mobility open to ethnic minority youth in remote areas. During their army service they become fluent in the national language, learn to read and write, and often are selected to become Communist Party members and then sent to special schools for political training. After demobilization, such men frequently assume leading positions in the administrative apparatus in their local communities.

Enhancing national integration and the maintenance of internal security are constant preoccupations of the central authorities. The Communist Party places great emphasis on the strengthening of unity among the nation's different ethnic groups. Perhaps the most often repeated national slogan is *'doan ket, doan ket, dai doan ket'* (unity, unity, great unity). The metaphor of the Vietnamese nation as a single 'great family' is frequently invoked. Displays of the majority group's ethnic chauvinism are officially discouraged. Many senior government officials in mountain provinces and districts are members of ethnic minorities and the share of minority representatives in the National Assembly is actually greater than their share of the national population would justify.

As in any multiethnic polity, however, there are unavoidable tensions between the desire to strengthen national integration and the recognition of the rights of minority cultures. The mass media, although overtly treating minority cultures sympathetically, sometimes display a certain condescension in discussions of their cultural traits and beliefs when they are presented as 'backward' and 'superstitious' (Ambler and Salemink 1997). In particular, the continuing attribution of massive deforestation to shifting cultivation by the minorities, despite well documented evidence that shifting cultivation is not the major current cause of deforestation, and frequently repeated statements that the mountain minorities have low levels of knowledge (when what is meant is that they have low levels of formal education), reinforce negative stereotypes of the minority cultures among the majority population. Unfortunately, many minorities themselves have internalized these negative stereotypes. The SIDA study found that 78 per cent of H'Mong respondents, 65 per cent of Dan Lai, 29 per cent of Da Bac Tay, and seven per cent of Cao Lan, but no Kinh respondents perceived their own cultural group as being 'backward.' Sixty per cent of H'Mong, 55 per cent of Dan Lai, 33 per cent of Tay, 22 per cent of Cao Lan, but only 5 per cent of Kinh, saw their own groups as 'ignorant.' (Le Trong Cuc and Rambo 2001).

Such widespread feelings of low self-esteem and perceived cultural inferiority may have a number of serious consequences. Earlier efforts to suppress traditional minority religious beliefs and practices that were perceived as 'backward superstitions' have, in some cases, decimated traditional religious leadership and created a spiritual vacuum (Tran Huu Son 1996). This vacuum is now being filled in a variety of ways, some of which (with varying degrees of justification) are perceived by some in authority as threats to stability and national security. Thus, the recent rapid spread of Protestantism and unsanctioned new religions among the minorities has caused deep official concern.

Some difficulties encountered in implementing development policies in the NMR

Policies are formulated in Hanoi for implementation in the countryside. What happens there does not always match the intention of those who formulated the policies. Many factors influence how policies are actually implemented, including contradictions among various policy objectives; the limited administrative capacity of upland local governments; and bureaucratic shortcomings in implementing agencies.

Contradictions among policy objectives

Policy-driven efforts to develop the NMR impact on the people of the uplands through a vast array of government programs and projects which affect virtually every aspect of their lives. It is impossible to compile an even partially comprehensive list of these state initiatives, but the following are some illustrative examples of major programs that currently exert influence on villagers in the NMR:

- the iodized salt campaign
- the family planning program
- the program to subsidize prices for essential commodities in the mountains; items such as (salt, kerosene and school notebooks for example.)
- reforestation programs, including the 327 Program and the Five Million Hectare Program.
- the program to allocate forest lands and 'barren hills' to households, commercial farms and social units
- the creation of national parks and nature reserves
- the campaign to suppress the planting of opium poppies
- the literacy campaign
- the program to eradicate hunger and reduce poverty in the 1,715 poorest communes
- special rural credit programs from the Bank of the Poor and the Bank of Agriculture
- prohibition of logging in natural forests
- the program for sedentarization and fixed cultivation of minorities engaged in shifting cultivation (*dinh canh, dinh cu*)
- construction of centralized village centers (*cum xa*)
- the creation of district and provincial boarding schools for ethnic minority students
- the campaign to promote 'grassroots democracy'
- The program to develop 'cultural villages'
- projects to supply clean water to rural households
- the extension of the national electric grid to rural areas in uplands
- expansion of highways and roads in mountain areas
- hydropower projects such as the Hoa Binh Reservoir and the proposed Ta Bu Dam
- rural development projects funded by ODA (SIDA, World Bank, EU, GTZ) and international NGOs.

This list is far from complete, but it gives a sense of the multiple fronts on which development of the NMR is expected to simultaneously advance. Because there is no comprehensive development strategy for the NMR, however, there are numerous contradictions among different specific policies and programs which sometimes undercuts the effectiveness of the overall push for development. For example, the construction of the Ta Bu Dam will flood much of the best agricultural land in the northwestern mountains and force the relocation of more than 100,000 people, mostly members of the Thai minority. The experience of the relocation from the Hoa Binh Dam suggests that many of the affected households are likely to become impoverished shifting cultivators on forested hill slopes around the reservoir. Thus, achieving one national development objective (increasing the supply of hydropower) may undermine efforts to eliminate shifting cultivation, protect forestlands and reduce poverty. Similarly, experience has shown that the construction of highways into remote areas, although absolutely essential to expansion of the market economy and reduction of poverty levels, is almost invariably accompanied by increased illegal logging and over-exploitation of non-timber forest products and the consequent degradation of remaining natural forests.

Limited administrative capacity of local governments

The multitude of development policies, initiatives and projects places a heavy strain on the very limited administrative capacity of provincial, district and village governments in the NMR. In the SIDA study (Le Trong Cuc and Rambo 2001), we assessed the impact of some development programs in our five case study communities (Table 21.1).

It is evident that all of the communities in our sample, even the poorest and most isolated ones (Khe Nong and Thai Phin Tung), have felt the impact of at least some government development programs, although not every community has been equally affected by every program.

All of the normal activities of governmental structures at provincial, district and local levels, such as the running of schools and clinics, registration of births and deaths, collection of taxes and the maintenance of law and order have been

Table 21.1 Impact of development policies, programs and projects on communities

Policy, program or project	Khe Nong, Nghe An	Thai Phin Tung, Ha Giang	Tat, Hoa Binh	Ngoc Tan, Phu Tho	Lang Thao, Phu Tho
Family planning	1	2	3	3	3
Reforestation	0	1	2	2	2
Allocation of hill lands	0	3	4	4	4
Creation of parks and nature reserves	4	0	0	0	0
Rural credit	0	3	1	4	4
Prohibition of logging	4	0	4	0	0
Sedentarization and fixed cultivation	4	0	1	0	0
Clean water	0	4	2	0	0
Electrification	0	0	1	4	4
ODA funded community development	0	0	0	3	3

Note: '0' indicates that the program does not exist or has had no impact in the community; '1' indicates that it exists but has had little impact; '2' that it has a moderately strong impact; '3' that it has a strong impact; and '4' that it has a very strong impact.

omitted from Table 21.1. Without questioning the desirability of quickly achieving all policy goals and implementing all of these development programs, one can ask whether communities in the NMR have sufficient administrative capabilities to be able to simultaneously deal with so many different initiatives.

Bureaucratic shortcomings in implementing agencies

Promulgations of appropriate policies and the allocation of large volumes of funds to implement them is not in itself sufficient to ensure that programs are effectively implemented. Much depends on the functioning of the agencies charged with the implementation of the development policies. Many factors operate to constrain their effectiveness, including poor planning, bureaucratic inertia, the incompetence of local level officials and corruption. The latter factor is widely believed to be endemic in upland development projects. For example, as part of the large-scale effort to eradicate hunger and reduce poverty, the state underwrites the cost of providing free medicine, educational materials and essential commodities (iodized salt, kerosene, seed and fertilizers) at subsidized prices to people in the uplands. Trinh Cong Khanh, deputy head of the Committee for Ethnic Minorities and Mountainous Areas (CEMMA) has stated that ' ...some people are trying to make a profit by selling the free and subsidized goods we distribute to the communes at higher prices' *Viet Nam News*, 12 July 2001, p.6). Mr. Khanh said that CEMMA has set up new regulations to make provincial leaders directly responsible to the prime minister for the execution of the program and 'will also make local authorities operate more transparently [so that] the public will be able to see for themselves how the projects are going.' Even central agencies are not immune to problems of corruption and incompetence. An article published in the newspaper, *Thanh Nien* (Young People), on 6 February 2001 stated that thirteen party members in CEMMA, including the chairman and four vice chairmen, had been disciplined: 'It is reported that under their management, many serious corruption and embezzlement cases were found in socio-economic projects in mountainous areas which are seen as the main obstacle hindering the development of the country's poverty reduction program.'

Reliable information on the true magnitude of corruption is, by the nature of this problem, unavailable. Knowledgeable Vietnamese and foreign observers claim that some 30 per cent of all funds are lost at the ministerial level, with more funds diverted at every lower administrative level until what actually reaches the people in the uplands is very much less than was initially allocated. According to an article in *Thanh Nien*, on 5 January 2001, 63 to 70 per cent of funds to help ethnic minority farmers in the provinces of Son La, Lai Chau and Thanh Hoa had been misappropriated by local officials.

State and party leaders have frequently expressed their deep concerns about bureaucratic shortcomings and have taken measures to try to bring them under better control. The Communist Party has launched a major drive aimed at identifying corrupt cadre. The newspaper, *Phap Luat* (Law) reported on 14 February 2001, that 69,000 party members have been found guilty of corruption and other crimes over the past five years. According to an AFP report (13 February 2001), a high-level government task force to investigate complaints of official corruption was established in September 2000, but only conducted investigations in seventeen provinces and recommended punishment for eight officials.

Conclusions

The development situation in the NMR has changed dramatically in the years since *doi moi* was implemented. Agricultural production and market activity have both greatly increased and the number of households living in poverty have been greatly reduced. Major steps have been taken to improve transportation and protect forests and other natural resources. Thus, development policies have achieved many of their initial objectives. Given the immense problems facing the NMR and the equally immense difficulties of implementing development projects there, progress has been far more rapid than seemed possible even a few years ago. The Vietnamese can take very legitimate pride in what they have accomplished in barely a decade.[8]

Many problems have been encountered in the implementation of development programs, however. These problems must be resolved if development is to continue at an equally rapid rate in the future. Although vast additional resources will be required to achieve basic objectives, particularly the continued rapid reduction in poverty levels, simply throwing more money at these problems will not solve them. Indeed, it may cause new problems unless some of the fundamental issues of upland development discussed in this chapter are addressed. As Neil Jamieson, Le Trong Cuc, and I have argued elsewhere (Jamieson, Le Trong Cuc and Rambo 1997), it is the weakness of the knowledge base that most seriously constrains the effective design and implementation of appropriate development policies for the NMR. Thus, while the goals of existing development policies are almost wholly laudable ones, the actual mechanisms and means for implementing them are too often based on faulty premises about the nature of social and ecological conditions in the NMR. As a consequence, correct policies may sometimes produce perverse outcomes.

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Note

1 There were, of course, considerable differences from place to place in the extent to which upland communities were involved in relationships with the lowlands. The Tay and Nung communities in the northeastern region (Viet Bac) historically had a much closer relationship with the traditional Vietnamese state than the minority communities in the northwestern region (Khong Dien 1996).

2 Although media attention has focused almost exclusively on allocating land use rights to farm households, in fact as much as five-sixths of hill lands have been allocated to 'social units' (presumably state farms and forest enterprises, but not village communities).

3 A recent analysis by Stephen Leisz (Le Trong Cuc and Rambo 2001) found that, when actual current land productivity is taken into account, population pressure is actually more severe in many communities in the NMR than it is in the Red River Delta. Nguyen Xa, the most densely populated village in the Delta supports 1,497 people per km^2, but because of double and triple cropping, and very high productivity, has a land production density of 9.5 people/ha. Thai Phin Tung, a White H'Mong village in Ha Giang Province has a population density of 101 persons/km^2 but, because of the very limited area of arable land, and its extremely low productivity, has a land production density of 18 persons/ha or almost double the density of Nguyen Xa. Other communities in the NMR also display very high densities in terms of land productivity. Khe Nong, a Dan Lai settlement in the Pu Mat forest in Nghe An Province, has an absolute population density of only 8 persons/km^2 but a land production density of 14.7 persons/ha and Ban Tat, a Da Bac Tay hamlet in Hoa Binh Province has an absolute density of 59 but a land production density of 12.5 persons/ha (Le Trong Cuc and Rambo 2001, p.108, Figure 4-5).

4 That this is the case is suggested by official statistics showing that 30-50 per cent of *trang trai* owners are party members, 75-80 per cent are peasants, 10-15 per cent are retired cadre or demobilized soldiers, 3-5 per cent are active cadre, and 1-3 per cent are 'others' (Nguyen Duc Thinh 2001, p.168). That the various categories do not equal 100 per cent should not surprise anyone used to working with official statistics in Vietnam. It is likely that individuals can belong simultaneously to several categories (for example be a demobilized soldier of peasant origin who is a party member and works as a village cadre). Thus, 70 per cent of commercial farms may be in the hands of individuals having some sort of privileged relationship to the administrative structure.

5 The realities of shifting cultivation are more complex than the conventional view allows for. Under conditions of low population density and abundant land it could be a highly productive and sustainable system that did not cause widespread deforestation, as Bui Minh Dao (2000) has shown in his admirable description of traditional swiddening in the central highlands. In the NMR, however, soils are poorer, population densities much higher, and some minority groups, notably some H'Mong populations, engaged in pioneering shifting cultivation that converted vast areas of forest to grassland over the past century. At present, however, almost no pioneering shifting cultivation is occurring in the NMR, reflecting the fact that virtually no suitable forest is left. Previously sustainable systems of rotational swiddening are suffering a serious decline in productivity, however, and finding sustainable alternatives has become an urgent necessity.

6 According to another source (Nguyen Thi Hang 2000, p.197), the share of households living below the poverty line in the NMR fell from 27 per cent in 1996 to just under 17 per cent in 1999. It is unclear why there is such a large discrepancy between these two sources although one refers to per centage of the population and the other to per centage of households. In any case, both figures indicate that poverty levels are being reduced very rapidly.

7 Despite these gains in absolute income levels in the mountains, the relative gap between the NMR and better-endowed parts of the country is growing rather than narrowing. Thus, in 1993 the gap in living standards between Vietnam's best-off region (the southeast region, which contains Ho Chi Minh City) and the northern mountain region was 1.9 times. In 1998 it was 2.6 times (Joint Report 1999, p.ix). If the country's economy continues to grow this gap will almost certainly widen.

8 Development of mountainous areas has proven to be a difficult problem everywhere in the world. In the United States, despite vast expenditures by the federally-funded War on Poverty, Appalachia remains the poorest region in the nation with higher poverty rates, lower educational levels and worse health conditions than any other part of America.

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22

Changes in Land Use in Black Thai Villages in Response to Changes in the National Land Management Policies

Thomas SIKOR and DAO MINH TRUONG

Black Thai villages have experienced radical changes in national land management policy over the past five decades. In the 1960s and 1970s, the Vietnamese government mandated the villages to work the land in agricultural collectives, subjected exchange to administrative controls and put forests under state administration. Decollectivization shifted control over agricultural production and exchange back to households in the 1980s and early 1990s. This chapter examines the effects of changing agricultural policy on land use in ten Black Thai villages of northern Vietnam. Have the radical changes in policy, we ask, effected similarly drastic transformations in land use practice?

This chapter is intended to contribute to a growing set of studies on land use changes in the mountains of mainland Southeast Asia (Fox *et al.* 1995; Cropper *et al.*. 1999; Long *et al.* 1999; Xu *et al.* 1999; Fox *et al.*. 2000; Trebuil *et al.* 2000). Focusing on one commune in northern Vietnam we examine changes in forests, vegetation cover and land under cultivation over the past fifty years. Our analysis of remote imagery and statistical data highlights the dynamic nature of land use. As forests and agricultural fields expand and contract over time, short-term trends are significantly different from long-term trends.

We also seek to enhance understanding of the socio-economic forces shaping land use in the mountains of mainland Southeast Asia. In particular, we examine the effects of collectivization and decollectivization on land use. Implying comprehensive and radical changes in agricultural institutions, one may hypothesize that collectivization and decollectivization led to significant changes in land use. Our findings suggest linkages between policy and land use changes, but they also point out that the interactions between policy and practice go both ways. In addition, we find that other factors, mainly technological change and marketization, also exert significant influence on land use.

The chapter begins with an introduction on the Black Thai in northern Vietnam. After a summary of the study method, we present results on changes in agricultural policy and its local implementation, on the one hand, and land use changes in the ten Black Thai villages, on the other. We then proceed to examine the effects of agricultural policy on land use. We conclude by discussing the linkages between agricultural policy and land use in the post-collective countries of Southeast Asia, as well as more broadly.[1]

The setting

Black Thai people moved into the mountains of what is today northwestern Vietnam in the first centuries AD (Wyatt 1982). They began to live in the valleys, which provided good conditions for wet rice agriculture. The lower mountain ranges adjacent to the valleys offered ample opportunities for upland cultivation. Black Thai villages remained fairly autonomous over the centuries. The rugged topography and lack of infrastructure protected them against outside influences. The situation did not change much after 1888, when the Black Thai villages became a 'formal part of the French overseas territory' Tonkin.

Most of the Black Thai villages became part of the Democratic Republic of Vietnam in 1954. Today, there are approximately 400,000 Black Thai living in

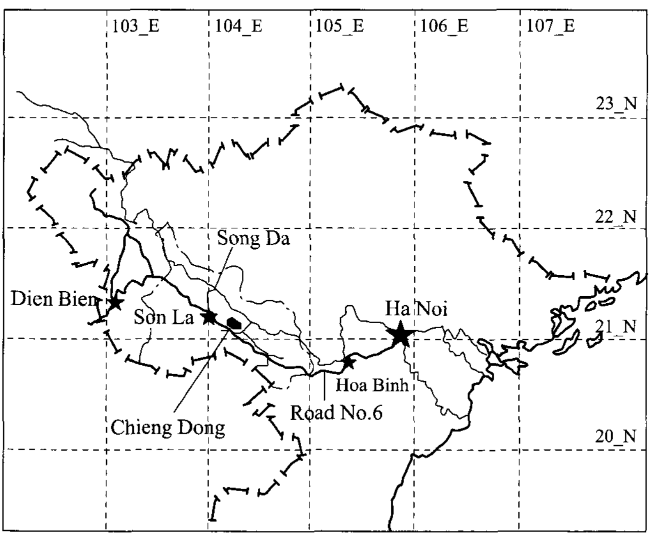

Fig 22.1 Chieng Dong in Northern Vietnam

northwestern Vietnam. Virtually all Black Thai continue to be engaged in agriculture (Nguyen and van der Pool 1993). Crop cultivation and animal husbandry have remained the major sources of livelihood. Very few have left their villages to study or take up employment in local towns or the lowlands.

Chieng Dong commune, our study site, currently includes ten Black Thai villages (Figure 22.1). The villages are fairly representative. They are located around the valley of a small river that flows into the Da River, one of the major rivers in northern Vietnam. Villagers work paddy fields in the valley and upland fields far up the surrounding slopes. The villages' population have grown steadily at around 2.6 per cent over the past five decades; from under 2,000 in 1950 to more than 6,000 in 1997. The villages have never experienced migration in any significant numbers. The villages enjoy only one advantage over other Black Thai villages: road improvements have put them within seven hours distance from the lowlands.

Methodology

The research uses data from three primary sources: remote imagery, government statistics and socio-economic field research. We acquired SPOT satellite imagery for 1989, 1993 and 1996 and aerial photographs for 1952 and 1968. The images and photos were of sufficiently small scale to detect larger patches of forest and fields, but not small fields and terraces. The aerial photos and satellite images were manually interpreted and classified into six land cover categories: closed-canopy forest, open-canopy forest, scrub land, upland fields, wet rice fields, and residential land. The results of the classification were transferred to a 1:25,000 base map using recognizable topographic features (streams, roads, mountain ridges, etc.). The land cover maps were digitized and entered into a Geographic Information System (GIS) database. The accuracy of the final land cover classifications were not checked in the field, but judging from the authors' knowledge of vegetation types and land cover patterns (gained during many walks of the terrain), they appear accurate.

We also collected government statistics on agricultural production to complement the remotely-sensed data. Statistical data on population and agricultural production had been collected for Chieng Dong by the local authorities since 1958. The quality of the statistics varied. Data on areas under wet rice and paddy output from wet rice cultivation were considered reliable until 1989, when the role of cooperatives was drastically reduced. Data on upland areas under cultivation were not available. Output data were available for upland crops and of sufficient quality to indicate trends over time.

Data on land use practices, the implementation of state policy and other potential factors influencing land use stem from in-depth research in three villages of Chieng Dong. Research included semi-structured interviews with a randomly-chosen set of 65 households, probing informants for contemporary land use practices, household economy and plot histories. Direct observation helped to examine labor allocation and land tenure. Key informant interviews with village elders, village leaders, merchants and local government officials facilitated better understanding of historical changes in the institutions regulating agricultural production, markets and state policy, as did the review of policy texts and reports published in the provincial newspaper since 1962.

Results

Changes in agricultural policy and local implementation

The central government decided to expand the collectivization drive into the mountains in April 1959 (Ban 1994), and the newly-established local authorities rapidly implemented the campaign. By 1961, almost all households in the valleys of the northwest, including Chieng Dong, had joined agricultural producer cooperatives. Control over agricultural production and the distribution of output shifted toward collectives. All adult villagers were required to work around 200 to 250 days per year in collective rice production, cassava cultivation and buffalo husbandry. Corn and cassava cultivation as well as pig and poultry raising remained with individual households.

Collectivization came in combination with an ambitious program for mountain development (Chu 1962; Ban 1994). Local authorities constructed irrigation projects, distributed new seed varieties and chemical fertilizer, and provided technical advice to promote the intensification of wet rice production. They promoted cassava as an upland crop that met local needs for food and animal feed, and at the same time provided watershed protection. The local authorities also demarcated large upland areas as 'forestry land', or land for forestry, and put the district Forest Protection Units in charge of managing the land. The villages had to seek official approval for the location and area of upland fields annually.

Collective agriculture remained an unstable project in Chieng Dong, as in many other Black Thai villages. Collective control over production eroded after 1975, when the war ceased to be a major motivational source for collective production. It became increasingly difficult for cooperative leaders to motivate members to perform collective work. Members preferred working fields and raising animals outside the collective, as the connection between effort and reward was much more direct. Their labor contributions to the collective declined significantly, as did the share of land worked in common.

Decree 100, promulgated in January 1981, responded to the widespread erosion of collective control through a partial devolution of management authority to households (Fforde 1989; Kerkvliet 1995). The decree legalized the 'end-product contract', a particular form of the many contractual arrangements applied by northern cooperatives in 1980. The end-product contract implied that cooperative leaders concluded annual contracts with members about the management of collective fields. The members were to assume all basic production tasks and be allowed to keep output in excess of a predetermined quota.

Implementation of the 'end-product contract' in the cooperatives of Chieng Dong halted the erosion of collective control. The cooperative leaderships concluded contracts with households in which they were requested to work specific wet rice fields and a certain area of upland rice fields. Households received labor points for each plot worked. The labor points were added up and expected to satisfy the households' labor quotas. Households were also required to meet output quotas for each plot. If they harvested more than the quota, they were allowed to keep the surplus. If production fell short of the quota, they had to make up the deficit from production outside the collective. After harvest, the total product was divided among households according to their labor contributions.

The success of cooperative reform was short-lived, however. Households rapidly gained full control over labor allocation after a few years. The collectives gave up control over land preparation. They also reduced the collective labor quotas significantly, giving households much more time for production outside the collective. Authority over water buffaloes also shifted to households, because the cooperatives sold most of the collective herd and because households increasingly raised their own buffaloes. Similarly, collective control over output weakened. Much of crop production in the uplands was outside the collective distribution system. Only paddy output from wet rice cultivation remained under significant collective control.

Resolution 10, passed by the Communist Party in April 1988, practically called for full-fledged decollectivization. Problems with the 'end-product contract' had become widespread all over the country, not just in Chieng Dong (Bien 1987). The cooperatives of Chieng Dong formally implemented Resolution 10 at the end of 1988. Its implementation had little impact on the institutions of agricultural production, however. Households had already gained extensive control over production in the 1980s. In addition, the villages did not implement a key element of Resolution 10: they did not allocate the collective wet rice fields to households under the long-term lease arrangements mandated by the new policy.

Instead, they continued to reallocate collective wet rice fields among households every few years.

Lowland traders began to pass through Chieng Dong in larger numbers in 1989, when central policy mandated the lifting of barriers on inter-provincial trade. The private traders brought consumer goods, which had been notoriously scarce in previous years. Numerous small stores sprung up along the road offering an increasing quantity and variety of goods. The traders also purchased cassava and corn to meet the rapidly growing demand from feed mills in the lowlands. They provided a virtually unlimited outlet at relatively stable prices. Market expansion also provided villagers with access to new seed varieties for rice and corn with yields that exceeded those of previous varieties by far. Chemical fertilizer became available in growing amounts and at decreasing prices.

The nationwide program of land allocation reached Chieng Dong in 1994. The National Assembly had passed a new Land Law in 1993, which mandated the state to allocate land to households under long-term lease arrangements. It designated land allocation as the vehicle through which the state measured land, registered it, and issued land use right certificates. Control over land had moved to the core of the new policy toward agriculture and rural areas. Despite its importance at the national level, the new Land Law had virtually no effect on land tenure relations in Chieng Dong (Sikor 2001). The villages openly protested the long-term allocation of collective wet rice fields, motivating the local state authorities to exclude collective wet rice land from allocation in 1994. They continued to expand upland fields far up the slopes, ignoring formally demarcated forestry land. They also maintained the practice of neighbors flexibly adjusting boundaries between upland fields from year to year, though those boundaries had been fixed on paper.

In sum, state policy toward rural areas and people has changed radically over the past five decades. Black Thai villages formed agricultural producer cooperatives and later dissolved them in response to state policy. Yet, as radical as the changes looked in policy texts, they turned out much more moderate in practice. People actively reacted to policy changes and adapted them to their own conditions and interests. In addition, some policy changes followed upon changes in practice. Decollectivization policy was in large part a reaction to changes in local practices that predated national-level reforms.

Changes in land use

Analysis of aerial photographs and satellite images demonstrates that land use in Chieng Dong did not follow a uniform trend over the last five decades (Table 22.1,Figure 22.2). Forest cover was higher in 1952 than in 1968 and 1989, yet it

Table 22.1 Land use in Chieng Dong, 1952-1997

(Unit: ha)

	Closed canopy	Open canopy	Scrub land	Upland fields
1952	534	2,438	3,601	133
1968	568	1,258	4,511	317
1989	517	224	4,571	553
1993	544	687	4,548	800
1997	551	885	3,988	1,115

Source: Interpretation of aerial photographs (1952, 1968) and SPOT imagery (1989, 1993, 1997).

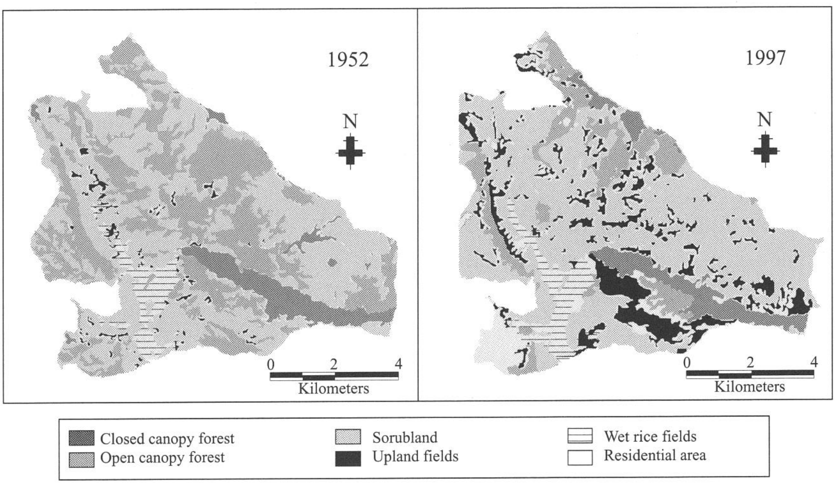

Fig 22.2 Land use in 1952 and 1997

also exceeded the 1989 level in 1993 and 1997. The differences in forest cover were due to fluctuations in open-canopy forest, as the area of closed-canopy forest remained fairly constant. The area of scrub land was the same in 1968, 1989 and 1993, but lower in 1952 and 1997. The only constant trend was the increase in area under cultivation: the later the year, the larger the area under cultivation.

The statistical data attest to the dynamic nature of land use in Chieng Dong. Wet rice outputs demonstrated strong growth over the whole period (Figure 22.3). The highest growth rates appeared between 1966 and 1975 and again after 1988. Upland rice output followed a different trajectory, declining sharply over the whole period. Upland rice output typically increased when wet rice output declined, and vice versa. In particular, upland rice output boomed in the 1980s.

Cassava output was insignificant in the 1960s, but experienced strong growth in the second half of the 1970s and remained high in the 1980s. Cassava gave way to corn in the 1990s, when corn output skyrocketed (Figure 22.4).

The number of water buffaloes and cattle followed different trends from the 1960s to the 1990s (Figure 22.5). The number of water buffaloes dropped in the 1970s and never regained 1960s levels. In contrast, farmers only began to raise cattle in significant numbers in the 1970s. Cattle husbandry boomed in the 1980s, reached its peak in 1988, and stabilized at a high level thereafter.

Remote imagery and statistical data suggest three periods of land use in Chieng Dong. First, agricultural production shifted from extensive upland cultivation to valley-based wet rice fields in the 1960s and the first half of the 1970s. Agricultural production had been very extensive in the 1950s, as upland rice fields, in both cultivation and fallow stages, and grazing by the high number of water buffaloes covered large parts of the uplands. As a consequence, scrub land and open-canopy forest were the predominant types of land cover in 1952 (Table 22.1). Forests grew back in the 1960s, though this is not yet captured in the 1968 image. The area under upland rice cultivation shrank significantly, as wet rice production improved and cassava offered a new source of food.

The second period began in the second half of the 1970s and lasted until the late 1980s. Agricultural fields and cattle husbandry rapidly expanded up the slopes, while wet rice cultivation stagnated. There were only three years, 1981 to 1983, in which wet rice and upland cultivation increased at the same time. Output growth was driven by area expansion, as yields remained stable. The landscape attested to agricultural expansion by the end of the decade. The land under cultivation had almost doubled. Scrub land covered about three quarters of the land. Forests had receded to limestone formations and other areas that were unsuitable for cultivation.

Lastly, agricultural intensification set in around 1990. Intensive uses of land, in particular wet rice and corn cultivation, grew strongly, while extensive uses in the form of upland rice and cassava farming declined. The growth in wet rice production stemmed from yield improvements and the expansion of sown areas. Villagers opened up new terraces, enlarging the sown area by around forty per cent within a few years. In contrast, upland rice cultivation fell precipitously after 1991. Agricultural intensification allowed forests to regenerate, though agricultural fields continued to grow (Table 22.1). Forests grew back because villagers increasingly grew corn on permanent fields, abandoning field rotation and thus reducing the demand for land. Therefore, the 1997 landscape was shaped by the dominant agricultural use, but it also included significant patches of open and closed-canopy forest (Figure 22.2).

In summation land use has been very dynamic over the past five decades.

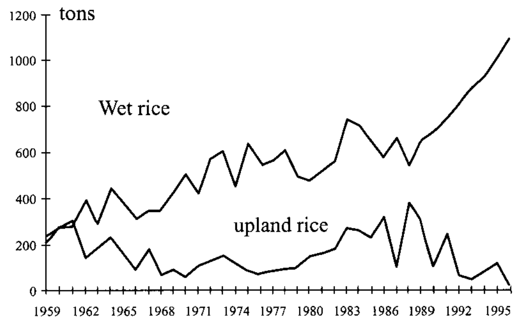

Fig 22.3 Rice output 1959-1996

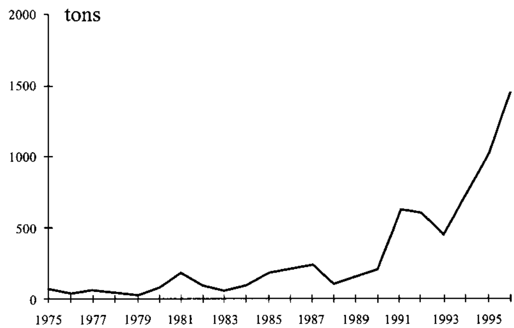

Fig 22.4 Corn output 1975-1996

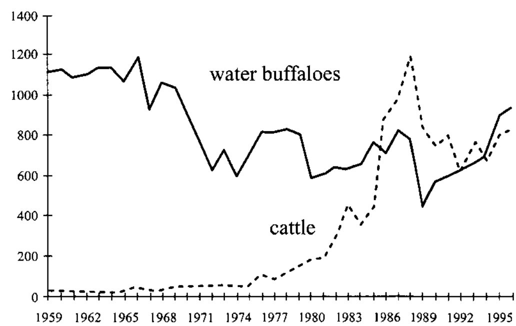

Fig 22.5 Water buffaloes and cattle 1959-1996

Radically different trends in land use followed each other. Villagers intensified production in the 1960s and early 1970s, they drastically expanded the land under cultivation in the late 1970s and 1980s, and shifted to more intensive uses again in the 1990s. The forests of Chieng Dong reflected the changing trends in land use. Forests grew back in the 1960s and early 1970s, then disappeared rapidly in the late 1970s and 1980s, but grew back again in the 1990s. Despite the dynamic nature of overall land use, the area of dense forest has remained fairly constant. Another continuity has been the dominance of scrub land in the landscape. Scrub land has always covered a larger share of the land than forests and agricultural fields taken together.

Discussion

Our results indicate that agricultural policy and land use have undergone radical changes over the last five decades and that the major changes roughly coincided. Can we conclude that collectivization and decollectivization policies caused the changes in land use? This conclusion would be premature. Associations between changes in policy and land use do not necessarily imply that policy changes transformed land use. The direction of causation may be the reverse, as policy reforms may respond to land use changes. Or, changes in land use may be due to other factors, such as markets, technology, population or climate. Analysis of the relationship between state policy and land use requires further discussion, which is the purpose of this section.

How did collectivization affect land use in Chieng Dong? The lack of hard data, for example on weather and taxation, prohibits conclusive explanations. Our findings let us infer, however, that collectivization contributed to intensification. Collective organization of production facilitated the cooperation required for investments in water control and new fields as well as for changes in paddy management practices. Besides collectivization, direct state intervention appeared to have a strong influence on land use, as it modified the returns to labor in crop production. The demarcation of large upland areas as forest land generated disincentives for upland rice farming, as villagers were confined to small areas and risked fines if they expanded beyond them. At the same time, state support of new seed varieties, chemical fertilizer and technical extension increased labor productivity in wet rice.

How has decollectivization influenced land use? Here we need to differentiate between national reforms and the local-level erosion of collective control. Our material suggests that the erosion of collective control over production drove the expansion of land under cultivation in the late 1970s and 1980s. The loss of collective control didn't so much 'pull' household production into the uplands, as the end of collective control opened up new opportunities there. The local trajectory of decollectivization also 'pushed' villagers into the uplands, as the collectives maintained control over wet rice cultivation. Upland rice fields yielded twice the returns to household labor than wet rice cultivation (six kg versus three kg paddy per labor day). In response households moved their labor out of collective wet rice production and into individual production activities, mainly upland rice, corn, cassava and cattle.

Local-level decollectivization was the major factor underlying the expansion of cultivation in the second half of the 1970s and 1980s. National policy reforms followed upon the changes in practice. The effects of Decree 100 were very short-lived. Wet rice cultivation grew for three years, but declined thereafter. Just like national reforms, other factors did not appear to influence land use much. Markets for agricultural products, inputs and consumer foods remained tightly controlled by the state. Villagers sold only small amounts of agricultural products and bought only the most essential consumer goods (such as, salt, lamp oil). Farming technology remained constant, as did the local climate.

What factors explain the shift toward agricultural intensification around 1990? National decollectivization policy around 1990 had virtually no effect on land use in Chieng Dong. Resolution 10 did not cause any changes in land use because the shift toward household-based production in Chieng Dong anticipated the policy reform. Land allocation did not influence land use because it did not modify village land tenure institutions, as one of us concludes in a different paper (Sikor 2001). Agricultural intensification in the 1990s was driven by market expansion and newly-available technologies. New seed varieties and increasingly available chemical fertilizer at decreasing prices facilitated significant yield increases in wet rice cultivation. In connection with the rapidly declining fertility of upland soils, changing markets and technology elevated the returns to labor in wet rice above those in upland rice (five kg versus three kg paddy per labor day). An increasingly secure food supply, improved seed, the development of a stable outlet and an increasingly favorable relative product price also motivated villagers to cultivate more corn.

One frequently cited factor has been suspiciously absent from our discussion: population growth. As noted at the beginning, Chieng Dong's population has grown rapidly over the past five decades. Population growth has clearly influenced land use in the long-term, as it has increased the local requirements for food and animal feed. The villagers of Chieng Dong worked a much larger area of wet rice and upland fields in 1997 than in 1952. Forests have receded to upper slopes and limestone rocks. Landscape transformations over the long-term have thus reflected the effects of population growth. Yet our findings call attention to other factors that have modified the effects of population growth on land use, in particular state policy, markets and available technology. It is the latter factors that account for the highly dynamic nature of land use in Chieng Dong.

Conclusion

Our account of a highly dynamic landscape in Chieng Dong matches the literature on land use change in the mountains of mainland Southeast Asia (Fox *et al.* 1995; Long *et al.*. 1999; Xu *et al.* 1999; Trebuil *et al.* 2000). Agricultural land expands and contracts over time. Forests shrink and regenerate, facilitated by favorable climatic conditions. The dynamic nature of land use implies that short-term changes may differ from long-term changes in land use. Long-term trends can be hidden by short-term changes, just as one cannot assume that short-term changes follow long-term trends.

We surmise that collectivization and decollectivization have shaped mountain landscapes in Vietnam and China. Though this is largely speculative, we hypothesize that collectivization provided means and opportunities for agricultural intensification. In comparison, Fox *et al.* (1995) observe in three small watersheds in Thailand that land use became more extensive during the same period. Yet collectivization only led to agricultural intensification if it was accompanied by investment in wet rice cultivation. In the absence of such investment, it drove an expansion of upland fields through its emphasis on grain production (Xu *et al.* 1999).

We further speculate that decollectivization caused an initial boom in production, driven by the expansion of agriculture up the slopes - a reaction also observed by Xu *et al.* (1999) in China. Subsistence needs initially remained at the core of production and growth. Thereafter, in the face of rapidly declining soil fertilities, expansion was followed by more intensive forms of agricultural production. Ecological decline, new markets and technological opportunities, and the lack of off-farm employment opportunities accelerated the intensification process, including a larger role for market crops (Donovan *et al.* 1997; Long *et al.* 1999). Thus, decollectivization accelerated the transition toward more intensive agricultural practices in comparison with other parts of mountainous Southeast Asia, such as Thailand (Fox *et al.* 2000).

Our findings support the increasing attention paid to the influence of macro policy on land use (Sunderlin *et al.* 2000; Mertens *et al.* 2000). At the same time, we suggest that the relationship between national policy and local land use is complicated by three factors. First, changes in local institutions may predate national policy reforms. Policy reforms may be a response to, not a cause of, changes in local practice. Second, changes in land use may be due to other socio-economic factors. Changes in state policy often come together with changes in other factors, such as technology and markets. Third, the implementation of national policy and resulting local institutions may differ between places (Agrawal 1995). Local authorities and people may enjoy significant leeway in interpreting national policy.

This last complication, local mediation of national policy, may assume particular relevance in mountain regions. Mountains are typically characterized by physical remoteness and geographical conditions that are different from other regions. Mountain people have often been integrated into nation-states more recently, enjoy more extensive autonomy than their compatriots in the lowlands, and differ in their social relations. In addition, local government interests in the mountains frequently differ from those in other regions. If the mountains, their people, and government interests are different, we may expect a relatively high degree of local mediation. Thus, national policy may affect land use in the mountains, yet its effects may be mediated in ways particular to mountain conditions.

Acknowledgements
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Note

1 A more detailed presentation of our results can be found in Sikor and Dao (2000), which is available at www.mekonginfo.org.

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23

Changes in the Composite Swiddening System in Tat Hamlet in Vietnam's Northern Mountains in Response to Integration into the Market System

TRAN Duc Vien

In 1992, when we began our research at Ban Tat, it was still a very remote and isolated settlement. The narrow road that connected it to the district town was passable only by jeeps or heavy-duty trucks. Only two or three vehicles passed through the settlement each week. People had to walk half a day to reach the nearest market at Cao Son town, about 12 km away from the hamlet. Most household production was for subsistence purposes and trade in commodities was limited to a few essential items and production tools. Like 'a closed autonomous economy,' the Tay produced almost all of the things needed in their daily lives and had extremely limited involvement in the larger market system. At that time, almost no manufactured consumer goods were to be seen. There was only one very poorly stocked shop selling salt, matches and kerosene; and prices of these things were quite high. People used kerosene lamps for light within their houses and used bamboo torches when walking outside in the dark. Sale of cassava and bamboo was the main source of cash income.

Today, barely nine years later, the hamlet has become much less isolated. The economy of the whole of Ban Tat has been transformed into a heavily market-oriented one. Seven well-stocked shops offering a wide range of goods have been established, and local people have reoriented their production activities to generate the cash needed to meet new consumption patterns. Several factors have contributed to this transformation. Among these were the improvement of the road and a great increase in motor vehicle traffic. Government policies have also had a major impact. The allocation of long-term land use rights to individual households, for example, was a major stimulus for change.

A daily bus service today links Ban Tat to the outside world. A private motorcycle-for-hire service easily and quickly takes people to the market at Cao Son. Local people have become deeply involved in the market economy. They have developed much greater dependence on manufactured consumer goods in their daily existence. For example, battery-powered flashlights have almost entirely replaced bamboo torches. Virtually all houses now have electric lights powered by micro-hydropower generators. Many houses have transistor radios and some have television sets. Young people have largely abandoned wearing traditional dress in favor of blue jeans and T-shirts, attempting to follow styles seen on the national television programs. More significantly, being more closely connected to the larger world and consequently more aware of the real demands of the market, households in the hamlet now devote much of their effort to the production of goods for sale in accordance with market demands. Agricultural patterns have changed accordingly.

Definition of the composite swiddening system

The defining characteristic of composite swiddening as practiced in Ban Tat is that households simultaneously manage permanent wet rice fields in the valley bottoms and shifting swidden fields on the hill slopes and also exploit the wild resources of the forest (Rambo 1998). Similar composite systems are found among the Muong of northern Vietnam, the Shan of Burma and northern Thailand, the Hani of Xishuangbanna Prefecture in southwestern China and the Ifugao of the Cordillera in the Philippines.

For a long time, the Tay of Ban Tat have been 'composite swiddeners'. As Rambo (1998) has observed, the distinctive characteristic of this system is that swiddening comprises an integral component of the total system. It is not a gradually vanishing survival of an earlier, more primitive, pure swiddening adaptation that is in the process of being replaced by more advanced irrigated farming. Nor is swiddening present as a recent response to rapid population growth that has exceeding the carrying capacity of the wet rice fields and forced people to expand their farming onto the forested slopes. Instead, composite swiddeners such as the Tay have practiced both wet rice farming and swidden agriculture as an integrated system of subsistence for a very long time; certainly for generations and probably for centuries. In Ban Tat, it is said that people employed both systems when they first began to settle the valley at least one hundred years ago. At that time, the entire area was covered by primary forest and there was ample land on which to make paddy fields in the valley bottoms. Even in the mid-1950s, with only seven households in the hamlet, the area of paddy fields was much smaller than it is now, and good forest land was abundant and free for the taking. Thus, it would have been possible, indeed it would have been very easy, for households to have cultivated only paddy fields or only swiddens. But they chose to do both. Now, of course, their situation has changed.

The Tay cultivate several different types of monoculture swiddens: rice, cassava, corn, canna and ginger. Rice swiddens are the most valued, and that is probably why they are located on the most fertile land available. Other swiddens with less fertile soil are planted with cassava, corn, canna or ginger. Most households cultivate several swidden plots at the same time. Some households have as many as eight different swidden plots under cultivation at the same time, each planted with a different crop.

As shown by many recent changes in response to the market economy, the composite swiddening system is quite dynamic. When we began our study in 1992, only rice (especially glutinous rice) and cassava swiddens were cultivated. As access to larger markets has improved recently and people have learned more about market demand, canna and corn have become important swidden crops and the area devoted to their cultivation has rapidly expanded. Ginger production has also fluctuated due to its unstable price in the market and the problem of protecting this crop from thieves.

In response to its integration into the market system, composite swiddening has evolved to produce more cash crops (such as ginger, canna, corn) in the swidden fields. Collection of bamboo and bamboo shoots from the fallowed swidden fields has also become a major source of cash income. Unfortunately, illegal logging has become another major source of cash.

However, there are many difficulties involved in swidden agriculture. State law prohibits villagers from clearing new areas for rice fields and most of the forest land has been allocated to households for protection. Thus, the swidden fields have been used continuously for many years and the fallow period has shrunk dramatically, causing the quality of soil to become poorer and poorer. As in the paddies, rice swidden fields also suffer crop destruction from stem borers, leaf rollers, stinkbugs and rats.

At present, due to the system of land allocation, the area available to make swidden fields is very limited. Permission cannot be obtained to clear forest to make more swidden fields. Consequently, local people now cultivate swiddens with shorter fallow periods. Lands are exhausted much more rapidly than before. Ideally, land would be left in fallow for eight to twenty years during a swidden cycle. But now many households cut, burn and plant their swidden fields after only three or four years of fallow. This has a direct negative influence upon environmental security and soil quality.

To meet their food needs and to get the cash they need to buy consumer goods, villagers have to intensify their wet rice or paddy cultivation, as well as grow more cash crops in their swidden fields and tree gardens.

Physical characteristics of the Tat hamlet (Ban Tat)

Located in the mountain and valley realm of the northern mountain region (NMR), Ban Tat's total surface area is 737 ha. Cultivated land comprises only around 71 ha, or ten per cent of the total land area. The rest of the area of the hamlet, 693 ha, or 94 per cent of the total area, is covered by natural vegetation. Most of this land consists of hill slopes and mountains, with some extremely steep and inaccessible peaks. Less than 20 per cent of the hamlet's land surface has a slope of less than 25 degrees, and only a few hectares of land are flat enough for the construction of bunded wet rice fields. Ban Tat has a population of 432 persons divided into 91 households (Census 1998). In late 1998, the mean population density of Ban Tat was 58.6 persons per square kilometer.

Apart from the small areas of extremely steep and inaccessible peaks covered with primary forests, and hill tops and ridge lines covered with mature secondary forest with a slight degree of canopy differentiation, most slopes are now covered with swiddens or fallowed plots covered with grasses, herbs and scattered patches of bamboo and small trees (Rambo and Vien 2001).

Ethnic identity of the Tay of Ban Tat

The Tay are one ethnic minority group out of the fifty-four officially recognized ethnic groups in Vietnam. With a population of some 1,190,000 people (Census 1999), they are considered to be the largest of Vietnam's ethnic minority groups. Most of the Tay live in the central and northeastern parts of the NMR and are divided into several branches based on the specific characteristics of each group in different places.

The Tay in Ban Tat are culturally and linguistically quite distinct from the main body of the Tay. They belong to a smaller, geographically isolated, Da Bac Tay population of approximately 17,000 individuals found only in the province of Hoa Binh, and primarily in Da Bac District. Some ethnologists classify them as a distinct Thai group.

The actual origins of the Tay community of Ban Tat are obscure, but it is said that the hamlet was settled a little over a hundred years ago, when a small group of people belonging to a clan coming from Son La (another province in the NMR of Vietnam) joined with other people already living in the area to form

Ban Tat. Although they have long practiced rotational swiddening, these people are not by any stretch of the imagination nomadic. They have lived at the same site and farmed the same territory for a full century.

Changes in the composite swiddening system of Ban Tat

Ban Tat's economy is primarily based on animal husbandry, the collection of forest products and farming, including swidden agriculture. Some households supplement their incomes from other sources, such as work as government cadre, occasional employment as wage laborers, shop-keeping and handicraft production. In the past, the households were largely self-sufficient in terms of basic needs, but in recent years, owing to closer connection to the outside world, they have become increasingly dependent on the market for the supply of many material needs, even rice. Because of this increasing inter-connectedness, the structure of farms themselves, as well as cropping patterns, are changing in some ways.

Wet rice fields

Ban Tat has a total of 7.6 ha of wet rice or paddy area, which amounts to around 169 m2 per capita on average (1998 village statistics; Cuc and Rambo, 2000). Almost all of this paddy area is comprised of terraced fields. About 6 ha (or 78.9 per cent) of the paddy area is relatively low lying, and is capable of producing two crops (spring and summer crops) per year. The rest of the paddy land (1.6 ha or 21.1 per cent) is higher and only one crop (summer crop) per year can be grown there. The crop calendar for spring rice is from 20 March to 10 June, and for the summer crop, is from 20 July to 30 October.

Wet rice cultivation activities of the hamlet have changed remarkably in recent years, especially with regard to pesticide use and the selection of rice varieties. In the beginning of the 1990s, pests and diseases, such as stinkbugs, stem borers, and leaf rollers, caused considerable difficulties for wet rice production. The productivity of crops was not ensured. Rats and other mammalian herbivores (*dui*) also destroyed and ate the rice before it could be harvested. There was only one piece of pesticide-spraying equipment in the hamlet and the use of pesticides was still not very common. Now, with relatively easy access to bigger markets and more distant places where pesticides and rat poison are abundantly sold, Tat villagers use these and other chemicals more frequently to protect their fields from losses due to harmful pests, rats and diseases.

At the beginning of the 1990s, local people cultivated only traditional rice varieties (glutinous and non-glutinous) in their paddies. In the view of local people, these varieties are of good quality, but they produce very low yields. Among the six traditional varieties of glutinous rice and seven traditional varieties of non-glutinous rice cultivated, the average yield is only 1,112 kg/ha/crop if planted in paddies. The productivity of the spring crop is usually higher than that of the summer crop. Surveys conducted in 1998 showed that most households had shifted to using new high-yielding rice varieties such as *CR203*, *Tap giao 5*, C70 and *Chiem den* to cultivate in their paddies. Information on yields of some rice varieties in Ban Tat is shown in Table 23.1.

Early in the 1990s, villagers used only manure from water buffaloes and pigs to fertilize their paddy fields. They did not even know about chemical fertilizer. In recent years they have started using chemical fertilizers. The 1998 survey investigated the use of chemical fertilizers such as urea, phosphorous, and potassium in Ban Tat. The data showed that, on average, the Tat villagers used 6.88 kg urea/1,000 m^2; 31.68 kg phosphorous/1,000 m^2; and 3.2 kg potassium/1,000 m^2 (derived from Table 3-11, Cuc and Rambo 2000).

Recently, although the total area of paddy land of the hamlet has increased slightly, the amount of paddy land per person has actually been decreasing. Villagers have utilized the foothills and the lands along a stream to make new terraces. This expansion of paddy fields was not done solely to meet the food needs of a growing population, but also to produce a surplus to sell in the market as people became increasingly aware of marketing possibilities. Both their need and their desire for a wider range of consumer goods has increased, stimulating them to strive for high cash incomes by intensifying agricultural production in the paddies.

Swidden cultivation

Swidden cultivation is the main type of agricultural production in Ban Tat. According to village statistics, the total area for swidden agriculture in the hamlet was 47.25 ha, but the actual swidden area is much bigger, because local people use the term 'dry rice' instead of `swidden` when they have to report to the village leader. One hamlet leader said that he estimated the area under swidden cultivation was at least about 63 ha. This figure matches data that we

Table 23.1 Yields of some paddy rice varieties in Ban Tat

Seeds	Yield (kg/ha/crop)	No. of households growing the variety
CR203	1,326	19
Tap giao 5	2,140	40
C70	2,290	30
Chiem den	1,120	5
Local seeds: Khau khuong, khau pha tro	1,112	5

collected in our 1998 survey.

Swiddens can be divided into several types, as follows:

Rice swidden

In 1998, there were 12.5 ha of rice swidden fields, occupying 19.92 per cent of the hamlet's total swidden area, which amounted to around 5,400 m^2 per household, on average. Rice swiddens are planted in late May and harvested in November.

The crop varieties planted in the swidden areas are rather diverse. We found twenty-two varieties of rice (both non-glutinous and glutinous), but most households plant only five or six varieties in their swidden fields. All are local varieties. Small quantities of squash, pumpkin, taro, maize and other vegetables are interspersed with the rice around the field hut in the swidden.

Beyond their labor input and seed, local people do not make any investment in manure or chemical fertilizer in their rice swiddens. The yields of rice swiddens fall dramatically after the first year. On good soil, in the first year people can harvest about 1.5 ton of dry grain/ha. In the second year they get about one ton, and by the third year, they get only about 0.4 to 0.6 ton/ha. On poor soil, in the first year people can get about 0.8 ton of dry grain per hectare, but in the second year they get only about 0.1 ton per hectare, or even less.

Corn and canna swidden

Corn and canna have similar yields and economic value. Recently, since people learned of the great demand for canna (which is used to make a clear noodle that is a very famous traditional food in the lowlands), they have begun to grow canna for sale on a large scale.

The area of corn is estimated to be about 15 ha, which amounts to, on average, about 1,750 m^2 per household. Varieties of corn are local varieties. They are usually cultivated in fields with good soil located near a stream or other water

Table 23.2 Area and productivity of different types of swidden in 1998 in Ban Tat

Swidden type	Area per household (m^2)	Productivity (ton/ha)
Rice	5,400	0.85
Cassava	1,900	9.70
Corn	1,750	0.50
Canna	1,550	6.80
Ginger	420	3.40

source. Beyond labor and seeds, people do not invest in any fertilizers for their fields. They do not yet use high-yield varieties, because new varieties need investment for both manure and chemical fertilizers. Productivity is also low if compared to the Red River Delta. It is around 0.5 ton of dry grain per hectare, but in some areas it can reach 1.2 ton per hectare. Seeding takes place in March and harvesting in mid-June.

Canna first appeared in the hamlet more than ten years ago, beginning with a small area. Now most households in the hamlet cultivate it. The total area for canna in the hamlet is 2.7 ha, which amounts to around 1,550 m^2 per household. Productivity is around 6.8 tons of fresh tuber per hectare. There are two main varieties: one is *dot* (local name), that has tubers that look like ginger tubers; the second one is called *hoang tinh* (local name). Almost all areas for canna are cultivated with *dot*. People usually plant it in February and harvest it from November to December to sell to traders from the lowlands.

Cassava swidden

Cassava is often planted on nutrient-depleted soils. It is always planted on the swidden fields after one or two crops of corn and canna have been harvested. Before 1986, when there was still some old-growth forest and the soil was still good, villagers would grow cassava in the third year of their agricultural cycle after one or two years of growing rice. At that time, cassava was grown for household consumption, winemaking, pig fodder and for sale to the government through the cooperative system. The villagers also used cassava to pay their taxes, using a certain amount of cassava to substitute for the standard amount of rice. Today, because of easier access to the market, villagers grow cassava for sale and purchase rice with the money they make, since they prefer to eat rice. Even though the price is low and the market is unstable, the villagers still grow cassava for sale.

All households in the hamlet cultivate cassava, planting a total area of more than 15 ha, which amounts to around 1,900 m^2 per household. People usually plant cassava after the Tet holidays, in February, and harvest it in November. On average, productivity is around ten tons of fresh roots per hectare. In good soil, people can get up to fifteen tons of roots in the first year, and about 10 tons per hectare in the second year. All of the leaves and stems are deposited on the fields. As in other swiddens, apart from their own labor input, people only add seedlings cut from cassava stems.

Ginger swidden

Villagers often grow a small amount of ginger in their swidden fields and in home gardens. But in 1995, there was a large demand for ginger in Japan and the price went up to VND 2,000 per kg. At that time, many households planted their entire swidden fields with ginger for sale. Soon after that, however, the price of ginger rapidly fell to only VND 700 per kg, due to instability in the Japanese market. This sudden drop in the price of ginger caused economic difficulties for the many local people who had allocated much of their crop land to ginger production. Theft of ginger roots from unguarded swiddens is also a constraint on production of this crop.

Two varieties of ginger are planted, both from the lowlands. One is normal ginger (*gung te*), and the other is glutinous ginger (*gung nep*).

The area for ginger is now about 1.6 ha, which amounts to, on average 420 m^2 per household. Productivity is around 3.4 tons of fresh tubers per hectare. Beyond labor and pieces of tuber used as seed, people do not add anything to their ginger fields. Ginger is planted in February and harvested in December.

Minor swidden crops

In addition to the above-mentioned crops, the villagers also grow taro, pumpkins, squash, beans and green vegetables in their swiddens. Taro is sold and its leaves are used for pig food. In the past, taro was sometimes planted with swidden rice or corn. Now it is grown separately and in small quantities, because there is no market for it. Most minor crops are cultivated for home consumption.

Tree gardens (or forest gardens)

Some households have established tree gardens in the lower parts of hills located just above their houses or near streams. Some of the tree species observed were melia, palm, styrax, and bamboo, among which melia is predominant. Melia is grown for use at home and for sale. Palm leaves are grown as a roofing material. Melia is planted at the same time as the first year rice crop. Later, people grow cassava, following the rice crops in between the small trees. Thereafter people stop cultivating agricultural crops, as the trees become bigger and their canopy shades the spaces between the tree rows. Melia takes about seven to eight years before it can be cut. Some farmers have shown interest in tree gardens. Others, however, who have large families, continue to swidden. Households have tree gardens with areas between 140 m^2 and 4,000 m^2 per person.

Home gardens

Almost all households have small home gardens. Home gardens are located around houses. A variety of trees make up the home garden and the biodiversity is rather high. Some of these trees include litchi, longan, jackfruit, orange, mandarin, bananas, papaya, pomelo and lemon. Some vegetables can be found in the gardens, but they are not popular. The economic benefit that households get

Table 23.3 Forest products collected by households

Kind of forest product	Per centage of households utilizing forest product for different purposes		
	For sale	For home use	For sale and home use
Wood	30	40	30
Fuel wood	0	100	0
Bamboo	47	18	35
Bamboo shoot	16	32	51
Mushroom	7	46	47
Medicinal herb	5	95	0
Broom grass	66	17	17
Other (leaves,...)	80	0	20
Wild animals	0	57	43

from these gardens is very low. Some households also apply manure and phosphorous to the fruit trees in their home garden. People do not know about the productivity of their trees in the home garden and almost all products from home gardens are for home consumption.

The local government, with support from some development projects, is just starting to try to improve home gardens by introducing suitable fruit trees that can contribute to the household economy.

Collection of forest products

All households in the hamlet collect many products from the forest. When we walk around the hamlet, we frequently meet people carrying firewood, medicinal herbs, bamboo shoots, bamboo or bundles of broom grass. Some of the many forest products collected and the uses that are made of them are presented in Table 23.3.

From observation we came to realize that many Tay men have become illegal loggers, seduced by the easy money they can get from outside timber dealers. Young men want to purchase motorbikes, TVs and the other manufactured goods that they see that the lowland people have. Perceptions of life styles in the lowlands have a serious influence on the people of Ban Tat.

The increasing need and desire of Tat hamlet people for cash has changed the character of the collection of forest products in recent years. Bamboo shoots and mushrooms were formerly collected primarily for home consumption. But now, because of the stronger connection to the wider world, people mainly sell them to traders. The aromatic root of one kind of forest tree, called '*vu huong,*' was neither used nor sold before. But since 1997, we have met many men who go to the forest to look for these roots in order to sell to Chinese traders, who sell them for medicinal purposes. Within a period of one month, there were almost no '*vu*

Table 23.4 Cash income and sources per year of the Tay

Source	Per centage of income in hh's total income	Average income per hh (VND'000)
Agricultural crops	22.1	738
Livestock	20.7	690
Timber from tree garden	1.1	38
Timber from forest	4.0	133
Non-timber forest products	23.6	786
Wage labor	1.7	56
Handicraft	0.1	32
Shop and service	9.3	310
Government salary	10.0	333
Government pension	2.2	74
Government assistance	4.2	138
Total	100.0	3,328

huong' trees remaining in surrounding forest areas. The collection of forest products used to be orderly and limited. But now people gather whatever resources they think will bring benefit to them. This is a very big and very important change that has taken place in a very brief period of time.

Sideline occupations

A small per centage of households engage in some sideline occupation on a part-time basis. Sideline occupations include working as cadre for the government (7 per cent of households), shop keeping (7.1 per cent), wage labor (12 per cent), motorbike-for-hire drivers (2.4 per cent), and production of handicrafts. It is obvious that without connection to the outside world, no such jobs would exist. This leads to corresponding changes in the labor structure of agricultural activities.

Household incomes

It is impossible to meaningfully compare the incomes of the Tay in Ban Tat - a remote highland community - to those of people in the lowlands. However, the sources and the size of Tay incomes usefully reflect the changes in this community since the increase of both economic and social relations with other people in different places. Table 23.4 shows us their cash incomes and the sources of these incomes per year (data collected in 1998).

Of various cash income sources, the sale of timber and non-timber forest products is the most important, accounting for 27.6 per cent of the total income of a household. But these figures include amounts from the sale of illegally logged timber. Sale of agricultural crops is the next in importance, accounting for 22.1 per cent of total income. Of this amount, 55 per cent is derived from swidden crops and 45 per cent from wet rice agriculture.

Conclusion

As an important part of its national development strategy, the government of Vietnam has directed special attention to the problems of upland development. Very significant resources have been devoted to a large number of ambitious programs and projects in the uplands of Vietnam. At the heart of these efforts has been a sustained effort to encourage ever-closer connections between people living in remote mountainous areas and the people and activities of the lowlands.

These efforts have had a very big impact on the uplands and, in recent years, the rate and extent of change resulting from this effort have dramatically increased. The mountainous region is developing day by day. The lives of most upland people are improving in many ways. And people living in communities that just ten years ago were relatively remote and isolated are now adjusting their productive activities in response to distant markets. These growing linkages between communities like Ban Tat and the outside world are leading to great changes in the mountainous regions of Vietnam. Farming systems are changing, as we have discovered in Ban Tat. But change is extending far beyond farming systems.

This broader change is beyond the scope of this chapter, but it has become very clear to us that change is taking place in the entire livelihood system of Ban Tat. The composite swiddening system we have been studying must be understood within this broader context. Labor structure, consumption patterns, how people dress, the entire way of life and the nature of the community itself are changing.

It has also become clear to us that, while bringing much improvement to the lives of the people of Ban Tat, these changes are exacting a high cost. There are negative impacts on the natural resource base, on levels of biodiversity and on the maintenance of soil fertility levels. At the same time, changes are also taking place in the social structure, in aspirations and even in identity. Integration into the market system is only one dimension of a much larger set of interconnections with the outside world that are transforming Ban Tat and threatening its environment. As its people are driven to more and more intensive exploitation of the natural resources around them, they are creating an imbalance in the ecosystem on which they depend for survival.

Through our studies, we have come to appreciate an increased need for awareness and understanding of this growing interconnectedness and of its impact. The types of changes that are taking place in Ban Tat are happening all around the world. Attention must be directed beyond market relations, consumption patterns and the technology required to keep intensifying production. People in Ban Tat, and many millions of other people like them in the northern mountain region, need the benefits that development can bring. But it must be recognized that this quest for a better standard of living brings with it a growing need for more widely shared concern with sustainability and a more widely shared awareness of the growing extent to which we are all dependent on each other and on the complex web of relationships that constitutes our environment.

Acknowledgements

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24
Development Process of Cash Crops in the Northern Mountains Region of Vietnam: A Case Study in Moc Chau District of Son La Province, Vietnam

YANAGISAWA Masayuki

Moc Chau District of Son La Province, which is located along the boundary between Vietnam and Laos, has produced two recipients of the Vietnamese government's highly prestigious Labor Hero Prize (*anh hung lao dong*). One was the director of the Moc Chau Tea Company and the other was the head of the Tan Lap Commune. The former was honored for his contribution to the economic reform of the company which was formerly owned by the state, and the latter for promotion of land use methods to institute rapid changes from a subsistence economy to a market-oriented economy. These awards had two implications: one was that the government recognized the rapid changes in upland farming in the mountains' region; and the other one was that the government actively tried to promote the changes. Indeed, the past two decades have witnessed rapid and profound changes in upland farming in all of the mountainous regions of Vietnam.

The backdrop for these changes was the adoption of the renovation policy (*Doi Moi*) in the late 1980s, which brought about major changes in Vietnamese agriculture. Land use strategies implemented by the government and the development of a market-oriented economy worked together to transform the mountainous region of northern Vietnam. Using geographic information systems (GIS) techniques, Thomas Sikor and Dao Minh Truong (2000) clearly showed that the area used for upland rice for home consumption in the province of Son La in the *Tay Bac* area, in the northwestern part of the mountainous region, has rapidly shifted to commercial maize since the 1990s. Similarly, Castella and Dan Dinh Quang (2002) demonstrated the rapid changes in upland farming in the province of Bac Kan in the *Viet Bac* area, in the northeastern part of the region.

Rapid land use changes have been observed in all regions of Vietnam. Many factors, such as the intrusion of the market-oriented economy, ethnicity, government policy and natural settings, play a large role in determining these processes.

If we look at the agricultural development at the commune level, however, it can be seen that all factors do not drive the changes to the same extent. How much these factors affect changes depends on the regional conditions. Not only listing up, but also identifying key factors in the local context, therefore, becomes important because it can help to avoid a standardized policy implementation and can contribute to solving the local problems arise within the processes of agricultural transformation.

This chapter, therefore, focuses on 1) describing the development process of the agricultural production systems in a mountainous region of Vietnam, 2) identifying regional differences in those processes in terms of agricultural intensification and diversification, and 3) attempting to clarify the reasons for the regional differences. Moc Chau District in Son La Province was selected as the study site. As the awards symbolically shows, the agricultural changes in Moc Chau are characterized by a drastic shift from subsistence upland rice cultivation to a market-oriented economy through the adoption of various kinds of cash crops. This chapter discusses the agricultural development processes in Moc Chau in terms of both intensification and diversification as indices of development.

Research method

Moc Chau District is located 120 km west of Ha Noi or four to five hours by car. Three communes in the district of Moc Chau- Van Ho, Chieng Khoa and Tan Lap - were selected for a comparative study highlighting regional differences in the development process (Table 24.1). Van Ho is located along National Road No. 6, Chieng Khoa is 12 km from the road, (less than one hour by car), and Tan Lap is 20 km or three hours from Road No. 6. The road away from the National Road is not paved, and muddy conditions during the rainy season make it difficult for cars to make the journey; the road to Tan Lap is passable only by trucks with large wheels once the rains have started.

Villages usually consist of a single ethnic group, and communes are comprised of several villages. Muong and H'mong villages in Van Ho, and Thai

Table 24.1 Overview of Van Ho, Chieng Khoa, and Tan Lap communes in Moc Chau district

Commune	Van Ho	Chieng Khoa	Tan Lap
Population	3,246	3,900	6,525
Major ethnic groups	H'mong: 76% Muong: 19%	Thai: 72% Kinh: 6%	Thai: 38% Kinh: 33%
Area (ha)	5,600	6,811	9,840
Elevation (meters above sea level)	950-1280	320-600	400-880
Distance from Road No.6 (km)	0	12	20

and Kinh villages in Chieng Khoa and Tan Lap were selected for this study.

The data and analysis in this study are based upon my fieldwork, which was carried out with the cooperation of the Vietnam Agricultural Science Institute (VASI), one of the largest agricultural research institutes in Vietnam. VASI conducted a questionnaire in 56 households in the six villages of the three communes during May and June 2001. An interview survey was performed with the commune and village heads concerning the development history of each village. We then conducted a further survey in 20 households in each village.

Outline of Moc Chau district

According to the district administrative office, the population of Moc Chau District in 2000 was 131,480 people. The residents of this district consist of several ethnic groups: Thai, 43,714 (33%); Kinh, 38,787 (30%); Muong 20,966 (16%); H'mong, 18,919 (14%); Dao, 8,123 (6%); and others, 971 (1%).

The center of Moc Chau is an undulating plateau located at 1,000 m above sea level. The elevation decreases from the plateau towards the Da River to an elevation of 300 m. The Da River flows from north to northeast of Moc Chau, and the temperature in the lowland area along the Da River is higher than in the plateau area. The monthly rainfall and average temperature in the Moc Chau Plateau are shown in Figure 24.1. The average annual rainfall is 1,648 mm averaged over nine years from 1990 to 1998. The mean temperature was 22 ℃. The temperature in winter is quite low and reached 0.7 ℃ on 26 January, 1998. This warmer lowland climate has enabled the introduction of double cropping of maize in recent years, while low winter temperatures on the plateau area limit maize to a single crop each year. In the three communes of this study, double cropping of maize was observed only in the lower part of Chieng Khoa.

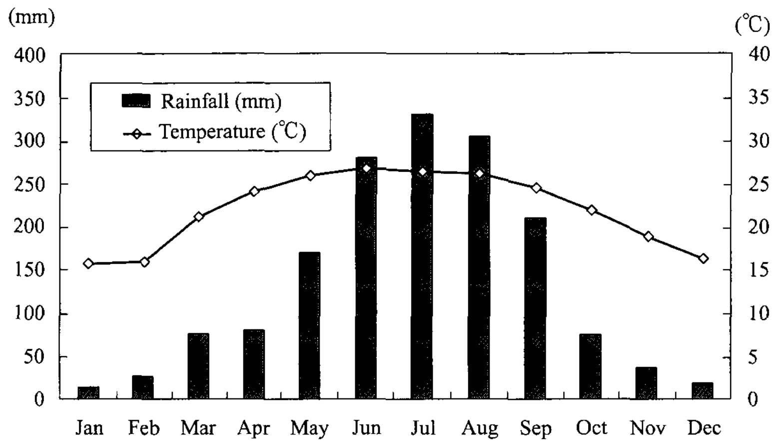

Fig 24.1 Monthly rainfall and average temperature in Moc Chau district
Source: Meteorological station in Moc Chau
Note: This is the average of 9 years from 1990 until 1998

Table 24.2 Land use in Moc Chau district in 2000

(unit: ha)

	2000*	%
Agricultural land	32,793	16.0
Forest	67,682	32.9
Residence	951	0.5
Wasteland	96,641	47.0
Other	7,446	3.6
Total	205,513	100

Source: *Administrative office of Moc Chau district

The region's fertile soil profile originates from the limestone which is present across the Moc Chau Plateau. According to soil maps, the plateau is covered with acrisol, using the FAO/UNESCO taxonomy of 1988 (Nguyen Tu Siem and Thai Phien. 1999). This is testament to the soil's suitability for maize, beans and fruits. The CEC (Cation Exchange Capacity) and calcium content are very high in this area (Dao Quang Minh 2001). The local average CEC was 17.7 me/100g, compared to an average of 10 to 15 me/100g in the Red River Delta. The calcium content is 11.7 meq/100g on average.

Thus, the chemical properties of the soil are favorable. However, it is difficult to keep water on the ground because of the high permeability of the karst landform typically found in limestone areas (Le Ba Thao 1997). Water easily

Table 24.3 Agricultural land in Moc Chau district

(unit: ha)

	1994	2000
Annual crops	16,008	24,558
Maize	3,300	8,079*
Paddy Rice	1,450	1,622
Cassava	1,265	1,430
Canna	422	1,185
Other	9,571	12,242
Perennial crops	1,457	3,259
Other	4,616	4,976
Total	22,081	32,793

Source: Estimates based on statistical data on the basic situation and infrastructure of the rural region in Vietnam and information from the Administrative office of the Moc Chau District.

*: This value is different from that in Figure 24.2 because of a different data source.

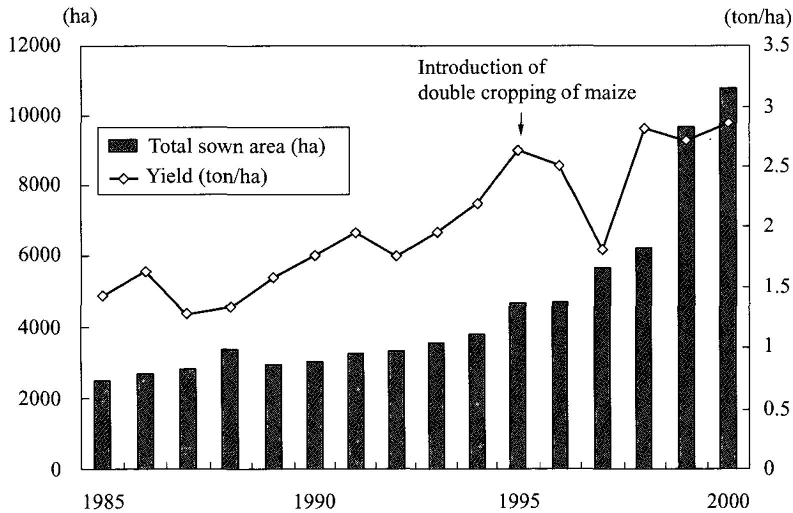

Fig 24.2 Total sown area and yield of maize in Moc Chau district since 1985
Source: Agriculture and Rural Development Office, Moc Chau district

flows into caves underground through intake holes. In this way, the soil structure poses several significant challenges to using water for household consumption and represents one of the largest constraints to the expansion of paddy culture in this area.

Land use in the district of Moc Chau in 2000 (Table 24.2) shows that wasteland and forest areas hold a large share of total area. However, in practice, upland crops were planted in these lands as well as in the agricultural land, suggesting that the actual area planted with crops would be larger than the official statistics indicate.

Agricultural land use is broken down in Table 24.3. The major annual crop in Moc Chau was maize, which was planted mainly on sloping land. Traditionally, maize was a minor crop in this area, planted for home consumption and animal feed in the third and fourth year shifting cultivation fields. As seen from the table, crop land planted with maize more than doubled between 1994 and 2000. The reasons for this shift are explored in detail in the following section of this chapter.

In addition to maize, cassava is also planted on sloping land for starch processing and animal feed. After harvesting, cassava is powdered and sold to Ha Noi as a basic starch. Alternatively, farmers cut the cassava into small pieces and dry it in the sun. Several days later, the dried cassava is sold as animal feed.

Various kinds of fruits are included in the perennial crops shown in Table 24.3. Due to the high elevation and low temperature, temperate fruits such as plum (*man*), apricot (*mo*) and peach (*dao*) are grown. The plum, in particular, is a new introduction that has been successful in bringing benefits to farmers. Tropical fruits such as mango, longan and others were planted in the lower fields along the Da River, as they are better suited to the warmer climate of the valleys.

Area expansion and intensification of maize cultivation

As indicated above, one of the biggest changes in agricultural production in Moc Chau since the 1980s was the transition from cropping of upland rice for subsistence, to maize cropping for sale in the market. Previously, maize was only grown in small fields of shifting cultivation for animal feed and as supplemental food for human consumption. But since the late 1980s, maize has gradually become a cash crop. The turning point in the expansion of the maize area was the construction of an animal feed processing factory by the CP group of Thailand in 1995. The factory is located along National Road No. 6 in the province of Ha Dong, about three to four hours by car from Moc Chau and less than one hour from Ha Noi. Consequently, maize became one of the main cash crops in Moc Chau. The area planted with maize has rapidly expanded along National Road No. 6, from the Hoa Binh to the Son La Provinces, including Moc Chau.

At the same time, introduction of new varieties of maize and chemical fertilizers resulted in an increase in maize yields. Although the first hybrid (F1) varieties were introduced in the early 1990s, in most cases they were not widely

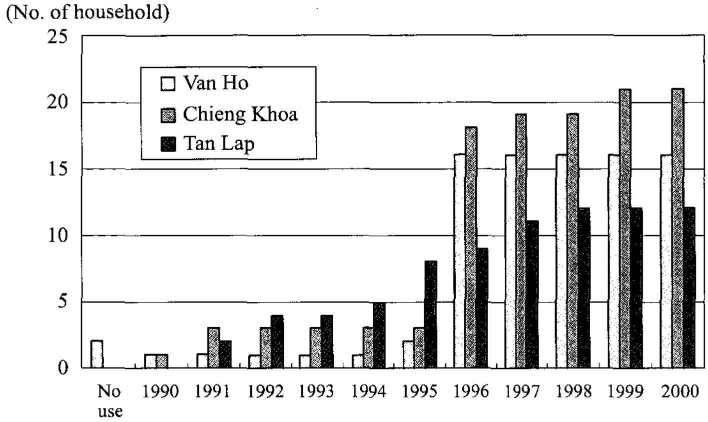

Fig 24.3 The number of household using F1 varieties of maize
Source: Field survey
Note: F1 Varieties include DK888, DK999, LVN10, and bioseed9698.

Table 24.4 Changes in the amount of urea application for maize cultivation by village

(unit: kg/ha)

Commune	Ethnicity	1991	1995	2000
Van Ho	Muong	12.6	68.3	72.3
	H'mong	32.0	163.5	152.7
Chieng Khoa	Thai	0	3.2	2.8
	Kinh	151.3	252.1	201.1
Tan Lap	Thai	0	0	38.8
	Kinh	187.5	183.6	240.0

adopted until 1996. The spreading of F1 varieties occurred at basically the same time in all three communes (see Figure 24.3). Brokers from the private sector brought new seeds to the farmers, resulting in the concurrent expansion of the cultivated area in all three communes.

However, the intensification of maize cultivation did not occur at the same time in the study villages. Urea was first applied at different times in the villages and the levels of application were similarly varied, as shown in Table 24.4. In the Thai village, farmers did not apply chemical fertilizers for maize cultivation until a few years ago, but then application levels for F1 maize still remained low. In the Kinh village, on the other hand, farmers used urea fertilizer before the introduction of F1 maize and applied much more than the other villages.

Interestingly, there was no significant difference in maize yields between the villages. The average yield was three to four ton/ha in Van Ho and Chieng Khoa, and four to five ton/ha in Tan Lap in 2000. The Thai villagers achieved high maize yields without applying chemical fertilizers by planting maize in fertile soil on relatively flat land, typical for karst landform areas.

Diversification of crops and farmers' strategies for agricultural development

As described above, the spread of the F1 maize varieties was observed at the same time in each of the Moc Chau communes. Selection of other crops, however, was different among the villages (Table 24.5), and these differences characterized the key diversification strategies in the area. This section will provide an indicative view on these diversification strategies through three crops: paddy rice, canna and plum.

Table 24.5 Planted area per household by crop in six villages

(unit: m^2/person)

Commune	Ethnicity	Maize	Paddy (single)	Paddy (double)	Upland rice	Cassava	Canna	Mulberry	Tea	Plum*	Total
Van Ho	Muong	2109	498	0	194	129	1126	577	0	52	4633
	H'mong	1768	312	0	258	0	586	0	351	58	3275
Chieng Khoa	Thai	2012	424	277	102	216	553	0	9	3	3593
	Kinh	2717	0	0	0	0	1900	0	87	12	4704
Tan Lap	Thai	3085	673	0	381	145	167	0	679	23	5130
	Kinh	4917	0	0	0	111	290	727	0	38	6045

Note: * Unit is the number of trees/person.

Paddy rice

There are three types of rice cultivation in this area, single cropping of wet rice, double cropping of wet rice, and single cropping of upland rice on sloping land. Double cropping of rice was seen in the Thai village of Chieng Khoa, which is located in the lowlands and enjoys a relatively high temperature along the Da River. Single cropping of rice was observed in all communes, but not in all villages.

In the Kinh villages of Chieng Khoa and Tan Lap, there are no paddy fields. The reasons for this are closely related to their history of migration. The Kinh people have been migrating from the Red River delta to the mountainous area since the 1950s. The first generation to migrate in those days was comprised mainly of ex-soldiers who had stayed in this area to fight against the French. After the war, they came back to stay in Moc Chau because they had seen there

Table 24.6 Amount of urea application for wet rice cultivation

Commune	Village	Urea application (kg/ha)
Van Ho	Muong	153
	H'mong	0
Chieng Khoa	Thai	37
Tan Lap	Thai	40

were abundant, promising good and vast 'unoccupied' areas that could be settled. After that, Kinh migrants spontaneously followed the first generation. The government also started to promote migration by establishing new economic zones and state farms in the mountainous area. As a result, the number of Kinh people gradually increased in this area.

This area, however, was not always 'unoccupied'. Native residents such as the Thai people already lived in the area, occupying the flat valley bottoms and other areas conducive to irrigation for wet rice cultivation. When the Kinh migrants arrived, they had to settle in other more marginal places. As a result, the Kinh did not have access to paddy land and had to plant upland crops on the undulating or sloping land. As shown in Table 24.5, the H'mong village in Van Ho has relatively small areas for paddy culture, while the Muong village in Van Ho and the Thai villages in Chieng Khoa and Tan Lap have larger areas of paddy to supplement their upland rice fields.

These factors caused differences in levels of self-sufficiency in rice production. The average rice yield was 1.5 to 2.0 ton/ha in the H'mong village and 3.5 to 4.0 ton/ha in the other villages, so that rice production per capita was estimated 80 to 90 kg per person in the H'mong village, 200 to 220 kg per person in the Moung village and 260 to 320 kg per person in the Thai villages.[1] If the amount of rice to meet self-sufficiency needs in a year was 300 kg per person of unhusked rice on average, the degree of the self-sufficiency in rice was 26 to 31 % in the H'mong village, 66 to 74 % in the Muong village and 86 to 105 % in the Thai villages. Although there was a large gap between the Muong and the Thai villages, the difference in rice yield was partly because of the amount of chemical fertilizers applied (Table 24.6).

All of the villages started applying chemical fertilizers to paddy rice at the beginning of the 1990s, with the exception of the H'mong in Van Ho. The fertilizers used included urea, phosphorus and compound fertilizers. Intensification of rice cultivation was started at the same time in all villages and continued to intensify in the 1990s, underscoring the transition from shifting cultivation to the permanent farming of cash crops.

Canna

Canna was formerly planted in small plots by the Thai and Dao peoples for animal feed, but has recently gained popularity among many ethnic groups as a viable crop for sale. According to the executive staff of the agricultural division of Moc Chau District, canna was most extensively grown in Chieng Khoa and To Mua communes, which are located adjacent to Chieng Khoa.

Canna is another example of a cash crop expanded by migrants. Canna cultivation was commercially initiated by a Kinh migrant in To Mua commune who arrived from the province of Ha Tay in the 1970s. He introduced a processing machine to dry the harvested canna in 1984. After this point, canna cultivation areas began to expand throughout the region. Table 24.5 shows the area of canna cultivation by village. After harvesting, canna is processed in the village and sold to the so-called 'So So' village in Quoc Oai District in the province of Ha Tay through brokers. The Kinh migrants knew that So So village was famous for producing noodles (*mien*) made from canna starch, because it was near the town from where they migrated. The introduction and widespread adoption of canna demonstrates how human relationships can bring about the rapid transformation of rural landscapes and local market dynamics.

Plum

Plum is not native to Moc Chau; it was first introduced by a Kinh from Nong Truong Moc Chau town. In 1990, he traveled to Bac Ha in the province of Lao Cai, which was famous for plum cultivation, and brought back a branch from a plum tree. After that, the plum growing area was rapidly expanded, especially in the plateau area in Moc Chau. Van Ho now has a large area for plum cultivation.

The reasons for the rapid expansion included several factors. First, plum, a temperate fruit, can grow at high elevations, so it was suitable for the Moc Chau Plateau. Second, the government promoted plum cultivation as an alternative to poppy in H'mong villages. With the economic opportunity offered by plums, it was hoped that the cultivation of poppy to make opium would cease. Thirdly, the location of Van Ho along the national road was advantageous, because it was easy for brokers to come to the villages to buy plum fruits and send them to markets in Ha Noi.

However, plum production has been vulnerable to price shifts in the market. At the beginning of the plum expansion period, the farm gate price of plum fruit was VND$3000 to 4000 per kilogram in 1993. By 2000, the price had dropped to VND$700 per kilogram. In response to these market signals, other fruit crops, such as apricot and peach, were adopted and have been on the rise ever since.

Concluding remarks

This chapter has discussed the development process of the agricultural production systems in the district of Moc Chau from the beginning, in the late 1980s, to the present. In the early 1990s, Moc Chau's agricultural systems drastically began to shift from a subsistence economy based on upland rice cultivation to a market-oriented economy. This transformation was brought about through the introduction of various kinds of cash crops, and can be observed as a dynamic process of farmer responses to the opportunities presented by increased information, market access, new technologies and the natural environment. Specifically, this chapter has analyzed the process of intensification and diversification involved with this shift.

Regarding the adoption and spread of F1 maize varieties, the study has shown that there was no difference among the communes of Moc Chau. Introduction occurred at the same time, and the new varieties spread evenly despite different natural and socio-economic variables - such as distance from the main road, ethnicity and infrastructure.

On the other hand, the spreading of canna and plum culture was traveled different routes in the communes of Moc Chau. The first in introduction of these new crops was from a migrant Kinh. But the following development did not proceed along ethnic lines or according to infrastructure, as there were no particular developments in road access or information availability. Given this situation, how can we explain the differences between the contemporary generalized spreading of F1 maize and the area-specific introduction of canna and plum?

Generally speaking, the strategy of agricultural development and differences in areas of intensification is often explained by ethnic factors, infrastructure and land suitability. In the Moc Chau experience, these factors were not significant in bringing about the changes. Instead, the author considers that the information on cash crops, market demand, and the historical process of obtaining land directly affected the process of agricultural development in Moc Chau. A brief review of the historical processes will assist in making conclusions about the study.

The Thai already occupied the land before the 1950s. They cultivated paddy rice in the basin areas and upland rice on sloping land that had relatively fertile soil conditions. Following the new migration policy, the Muong and the Kinh began to arrive in Moc Chau in the 1950s. Since the area is characterized by limestone landforms, little land was suitable for wet rice cultivation in Moc Chau, The migrants had no choice but to establish livelihood systems centered on upland rice cultivation on sloping land. Therefore, the major crop until the 1980s, especially for the Muong and Kinh peoples, was upland rice for their own consumption.

After the late 1980s, the development of the Vietnamese economy directly affected Moc Chau agricultural practices by increasing the demand for cash crops. The Kinh network in Moc Chau provided linkages with the lowland areas, including Ha Noi, and information about cash crops began to broaden local farmers' choices. As a result, a variety of cash crops, such as maize, cotton, Job's tears, canna, mulberry, plum, apricot, coffee and various medicinal plants were introduced, and enjoyed cultivation booms for each during a short period of time. In the end, farmers made their decisions about crop selection based on opportunities perceived in the market. Particularly, maize for sale has spread to the entire area of Moc Chau. This was mainly because the range of environmental adaptation was wide, a large demand was created in the area and the selling price was more stable than other crops. This led maize to dominate the agricultural landscape of Moc Chau. On the other hand, farmers adopted other cash crops such as canna and plum were in certain areas. The natural setting was the primary factor in these decisions.

In both cases - the spreading of F1 maize varieties and an area-specific introduction of canna and plum - information, market demand, and the historical process of land acquisition were the key determining factors in the process of agricultural development since the late 1980s. Moreover, networking through the Kinh immigrants and the promotion activities on the part of the government were important factors in accelerating the expansion of these cash crops. Price fluctuation of agricultural products is an inescapable reality of the market-oriented economy, and farmers cannot escape a certain degree of vulnerability to more or less short-term boom-bust cycles for cash crops. Broad networks help farmers to reduce this risk by providing access to information and technology, which farmers can then translate into alternative crops. The experience of agricultural development in Moc Chau suggests that dynamic local decision-making processes based on these network linkages have enabled farmers to effectively respond to their environmental conditions and economic opportunities.

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Note

1 Average yield of upland rice was assumed 1.2ton/ha in all villages. Average yield of spring rice in the double cropping rice fields achieved the same yield as that of summer rice in each village. Rice yield shows the value of unhusked rice.

25
Upland natural resources management strategies and policy in the Lao PDR

Phouang Parisak PRAVONGVIENKHAM

Upland situation analysis

The general situation

The Lao PDR is characterized by a dual economy, comprised of the flatlands lining the Mekong corridor and the sloping lands and valleys of the interior upland areas. The flatlands of the Mekong corridor are entering a period of agricultural transformation in which market forces are beginning to deliver agricultural inputs through commercial channels. Households are consuming part of their farm production and marketing the rest. In the upland slopes and valleys, however, agriculture is more closely tied to subsistence production and farm households appear to be caught in a poverty trap. The main factors behind this difference are summarized in Table 25.1

Fully 85 per cent of the land of the country is in the uplands. The topography in the uplands varies from flat on the uplifted plains and valley bottom, to gently rolling on the lower or intermediate hillsides, to steep on the upper, more mountainous slopes. The uplands are where the poorest and most marginal people are found. Compared to the people of the lowlands, the upland people of the Lao PDR have:

- lower population density
- higher birth rates
- lower life expectancy
- higher rates of infant and mother mortality
- lower per capita income
- lower access to credit
- lower road-density
- lower access to health services

Table 25.1 Contrasting conditions in the flatland and the sloping lands

Flatland conditions (Markets functioning)	Sloping land conditions (Markets not functioning)
Good road linkages and access	Poor and non-existent road linkages
Adequate agricultural technology flows from regional markets	Very limited or non-existent agricultural technology flows
Rural savings mobilization and agricultural lending mechanisms beginning to function	Limited or non-existent rural savings mobilization and credit
Domestic and regional markets interacting	Little domestic and regional market interaction
Market information and price signals operative in many areas	No market information mechanisms
Monetized rural economy	Basically non-monetized rural economy with predominantly subsistence agriculture and barter transactions
Free access for local and foreign entrepreneurs	Free access for local and foreign entrepreneurs, but little incentive because of non-functioning markets in most areas
Agro-geographic conditions favoring flatland farming systems	Agro-geography in high relief requires balanced sloping land farming systems and integrated environmental management

Source: MAF 1999

- lower access to education
- lower access to electricity
- lower access to clean water
- less involvement in the market economy
- higher illiteracy
- lower school attendance
- deeper attachment to ancestral traditions.

Marginalized by their remoteness and inaccessibility, and made vulnerable by the vagaries of nature and by their differences from the lowland population, the people of the uplands have the highest poverty and lowest quality of life indicators in the country.

The specificities of upland ecology have led to the strong prevalence of a swidden-based (slash and burn agriculture) livelihood system in the different ecological zones of the uplands in the Lao PDR. The predominant feature of the livelihood system, including the more accessible areas and irrespective of ethnicity, is an economy that still functions at the subsistence level. The economy revolves around the practice of *hai* (shifting cultivation producing mainly upland rice) and, to some extent, reliance on paddy lands and/or other non-rice resource components (such as home gardens, maize gardens, livestock,

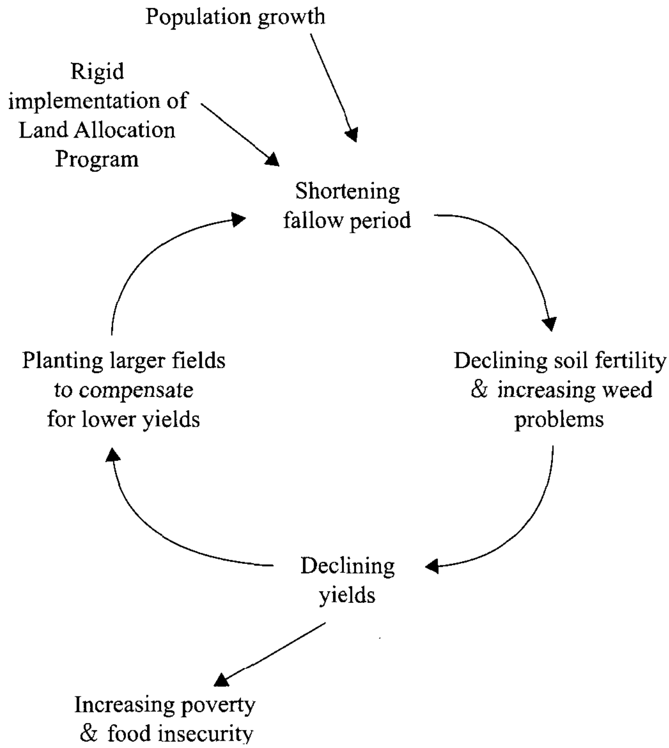

Fig 25.1 The swidden degradation syndrome, a vicious cycle of accelerating poverty that becomes hard to stop.

fish catch and culture, exploitation of forest resources), non-farm activities (dominated by the small cottage industry) and off-farm activities (dominated by wage labor).

While cash incomes are limited in most upland areas, attaining basic food security is still a serious problem for many shifting cultivators in the uplands. Many households can only produce enough rice for seven to nine months of the year. The situation is worsening as fallow periods within the traditional shifting cultivation cycle drop below the sustainable limit and the classic swidden degradation syndrome begins (Figure 25.1).

Findings of up-to-date research studies show that the types and combinations of economic enterprises undertaken are dependent on resource endowments, population pressure, land tenure systems and land use policies, past political events, social organization and local regulatory systems, intra-village and inter-village solidarity, local indigenous technical knowledge, external support (infrastructure, access to market, flow of information and credit) and, to some extent, ethnicity. Although evidence from existing studies shows that differences in farming and resource use among ethnic groups reflects resource availability in different agro-ecological zones. Such differences tend to disappear with the movement of population to other ecologies. At the farm level, key factors are the land resource base, labor availability, individual skills/initiatives, entrepreneurship of the family and individuals and socio-economic status. In most cases, however, resource endowments, socio-economic status, internal initiatives (such as social organization and community-based resource management traditions) and exogenous opportunities were considered the key determinants for shaping the diverse combinations of economic activities.

In upland most remote areas incipient environmental problems are now becoming apparent. The number of people needing food is growing faster than production rates per unit land area. People have moved into fragile ecosystems less favorable to agriculture, where the prospects for sustainable agriculture in the future are low. More than 1.5 million people in the Lao PDR rely on shifting cultivation for their subsistence. The consequences are serious both environmentally and economically due to the destruction of wide tracts of timber for a small yield of food grains, plus the risk of soil degradation and watershed damage. By way of example, the value of standing timber in a high quality pristine forest lies in the range of US$ 10,000 to US$ 20,000 per hectare. One 'pioneer' swidden family can slash-and-burn one hectare of such forest per annum in order to produce US$ 500 worth of rice (natural forest regeneration costs US$ 50 to US$ 100 per hectare, with mean annual incremental timber growth at approximately two m^3 per hectare).

Rural poverty is directly related to land degradation and, in the sloping lands of the uplands, solutions to soil degradation are harder to find than in the lowlands. Lao-IRRI (International Rice Research Institute) studies have shown that yield decline in continuous cropping of upland rice cannot be overcome simply by the substitution of inputs, as in the lowlands. In order to replace lost organic matter, which restores the soil's ability to hold and use nutrients efficiently, a fallow rotation of some type, or some other method of replacing lost organic matter appears to be an inescapable requirement for sustainable agricultural under upland conditions in the tropics.

Attempts to substitute more sustainable farming systems and to shift the rural economy toward cash-cropping alternatives are constrained by the lack of road and market access in many areas. In order to cope with the situation, most upland households follow a 'multi-livelihood strategy': engaging in a wide variety of on-farm and off-farm activities, combining hunting and gathering with agriculture, horticulture, animal husbandry and forestry to piece together an adequate living. A recent study of household livelihoods in a village in the Nan

District of Luang Prabang found that households engaged in no fewer than eight and as many as fifteen distinct livelihood activities. Gathering of non-timber forest products (NTFPs) is a critical component of household survival strategies in most areas, providing a source of subsistence and cash income to offset seasonal food shortages that is second only to livestock production. Figures of 40 to 60 per cent of household income derived from NTFPs are typical for the remote upland areas. But over-harvesting and depletion also threaten this important livelihood source.

In upland areas where road access is sufficient to support cash cropping, farmers have sometimes demonstrated a remarkable responsiveness to market signals. But weaknesses and distortions in poorly developed markets can play havoc with farmers' motivations. A well-known case in point is the recent boom and bust phenomenon in the market for Job's tears in Luang Prabang. A survey on innovations in the Thong Khang area revealed that adoption rates for Job's tears as a cash crop had reached as high as 90 per cent of the households during the boom phase in 1998. Prices dropped from 1000 kip per kilogram to as low as 350 kip per kilogram in 1999. Now, following the crash, it is difficult to find many farmers interested in taking the risk on Job 's tears again. For many of these farmers this was their first venture into a cash crop. It takes much more than roads to foster market development that farmers can put their trust in. In view of these factors, the hesitancy of risk-averse upland households to venture wholeheartedly into the market economy seems prudent.

Table 25.2 summarizes the main profiles of diversification in livelihood systems in selected study areas, evaluated on a cross-section basis, across the different agro-ecological zones with differentiation by ethnic groups and socio-economic status.

Findings in Table 25.2 clearly highlight that the stability and sustainability of the swidden-based livelihood system are ensured by a diversified economy. However, diversification here does not mean over-specialization in any particular type of economic activity, but emphasizes rather incremental modification of many different components of an extremely complex survival strategy. A number of resources are produced to make up for deficiencies in the main subsistence sector, the hai, while other resource components directly serve to accumulate cash reserves. The different patterns of diversification are determined by both endogenous and exogenous factors. It is important to reiterate that, from the examples given above, distinct differentiation in diversification by ethnic group is not evident.

This broad-spectrum of adaptation appears to be relatively sustainable, since it has ensured long-term stability of the system up until the present time. However, it should be noted that a number of 'artificial' exogenous factors, for example,

Table 25.2 Main profiles of diversified livelihood systems across selected study areas

District	Luang Prabang (Luang Prabang Province)	Viengkham (Luang Prabang Province)	Viengthong (Houaphanh Province)	Phoukout (Xieng Khouang)
Ethnic group	Lao loum and Lao theung[1]	Lao theung and Lao soung	Lao loum and Lao theung	Lao loum and Lao soung
		Socio-economic status		
Poor	1[1]. *Hai* 2[2]. Goats, cattle, lowland paddy and fish 3[3]. Pigs	1. *Hai* 2. Buffalo, cattle, pigs and fish 3. Buffalo, cattle and pigs	1. *Hai* 2. Cattle, pigs, fish and lowland paddy 3. Cattle and pigs	1. *Hai* 2. Cattle and fish 3. Cattle and fish
Average	1. *Hai* 2. lowland paddy, cattle and goats 3. Pigs, non-farm activities and forest resources	Same as above but buffalo and cattle holdings are greater	1. *Na* 2. *Hai*, cattle, pigs and fish 3. Cattle and pigs	1. *Hai* 2. lowland paddy, cattle, goats and fish 3. Cattle and fish
Better-off	1. lowland paddy 2. *Hai*, cattle and goats 3. Goats, non-farm activities and forest resources	Same as above but better-off farmers have the largest holdings in buffalo and cattle	1. lowland paddy 2. *Hai*, cattle, pigs and fish 3. Cattle and pigs	1. lowland paddy 2. *Hai*, cattle, goats and fish 3. Cattle and fish
Remarks	Cattle husbandry not allowed by district land use policy	Lao soung rear more cattle and have more interest in fish culture	Cattle husbandry restricted in the more accessible villages, and fish culture is traditional	A district endowed with the greatest potentials in cattle production, and fish culture is traditional

Source: MAF field survey, 1997.
Note specifications:
1. The major economic activity
2. Compensating economic activities with the primary role to make up for deficiencies in subsistence economy
3. Direct cash resource generating economic activities.

district land use policies, appear to have detrimental effects on specific resource components - such as restricting cattle husbandry in Luang Prabang and in some parts of Viengthong.

The question that faces us now is: what development strategies need to be devised to best respond to such highly diversified livelihood systems, and that meet the broadest range of needs of the greatest number of people in the most sustainable way? Particular attention needs to be paid to improving the productivity and the stability of existing swidden-based livelihood systems so as to increase the present level of carrying capacity and secure greater ability to cope with various endogenous and exogenous factors.

One important issue, among others, is related to the fact that different cultural communities have different absorptive capacities when it comes to adopting new land management technology. There are many reasons for this: cultural patterns and prevailing land use intensity. Traditional technology is often richly embedded with symbols of spiritual life and cultural identity. Any fundamental change of technology sends ripples of change throughout the whole network of traditional relationships that lie at the foundation of the village social order. Nevertheless, as already mentioned earlier, the upland people of Lao are fully capable of adaptive innovation and change. But those changes must make sense to them and offer viable alternative means for achieving their objectives. The process of facilitating technical change has often been unnecessarily complicated by precipitous attempts to introduce exogenous technologies that have little or no connection with the indigenous technological tradition. The 'one solution fits all' approach to extension does not work under the diverse environmental and socio-cultural conditions of the uplands of Laos; neither does the 'solution in search of a problem' approach.

Past policies and development approaches

The major policy issues of the uplands have been:

- swidden-based livelihood system or shifting cultivation that is seen as an increasingly unsustainable land-use system
- deforestation due to shifting cultivation and unsound logging practices
- accelerated soil erosion and deterioration of downstream hydrological regimes
- rural poverty.

The cornerstone of past policies to deal with the uplands has concentrated on the eradication of shifting cultivation, which is perceived as the root cause of upland poverty and environmental degradation. Solutions tend to be based on 'lowland approaches', emphasizing the restriction of cultivation on slopes exceeding 25 per cent and the relocation of upland populations to lower land niches where irrigation can be provided for rice paddies. The strategy of shifting from upland rice to paddy rice cultivation is a sound move, as far as it goes. The nature of fertility maintenance mechanisms under anaerobic soil conditions in rice paddies makes them one of the two most sustainable cropping systems for low-input conditions in the tropics (the others are tree crops and other perennial-based cropping systems).

Land allocation and land use zoning have been the main policy instruments for effecting this change. Robust land use planning and land allocation methods have been developed for this purpose and are undergoing extensive trial and refinement. These procedures have been applied in conjunction with development activities under the government's 'focal area approach.' Activities included under this approach are:

- allocation of agricultural and forest land using the eight-step methodology developed by LSFP (Lao Swedish Forestry Program)
- improving livelihood systems through watershed development and management strategic framework, with special consideration to shifting cultivators
- harnessing the uplands' development potentials through the diversification of upland land use and farming systems
- expanding irrigation facilities and improving agricultural practices in niche areas within the uplands
- promotion of forest regeneration and afforestation in degraded areas through participatory community management of the natural resources
- establishment of necessary support activities to promote sustainable farming systems. Among other factors, this includes establishing an efficient and demand-driven extension system and a rural financial system, as well as investing in basic social activities (primary care and education).

Unfortunately, the expansion of irrigation facilities only worked in areas where sufficient irrigable flatland for paddy development exists, and the amount of irrigable land in the lower landscape niches is simply too limited for this strategy to have much effect.

Technological approaches to improvement of upland rice yields have thus far also met with very limited success. Systems like 'hedgerow intercropping' (including such variations as the Sloping Agricultural Land Technology (SALT)) have tended to dominate thinking about the alternatives. These systems, which have demonstrated technical and economic viability in researcher-managed trials, are enormously appealing to researchers and extension agents seeking a final solution to the problem of soil erosion. Unfortunately, they have not met with widespread adoption among farmers. This is so not only in Lao, but also worldwide in the majority of situations where they have applied. The same holds true for terracing with earthwork bunds and other relatively labor-intensive physical 'infrastructural' interventions.

There are three main reasons for this. First, these technologies, whatever their technical merits, all tend to be far more labor-intensive than other available options. They are suitable only for the most intensive land use situations and tend to run afoul of local standards of labor efficiency in low population density areas where attitudes toward unnecessarily hard labor have been incubated for many generations under extensive agricultural conditions. Second, they fail to connect with anything recognizably familiar in local indigenous technological traditions. And third, even where population pressures are high enough that such technologies might have a chance of adoption, the extension methods that would be required to give such 'outlandish' technologies a fair trial in the court of local opinion are far more sophisticated than what is currently practiced by extension workers in Lao. More importantly, the promotion of high-investment single-shot solutions runs counter to the risk-aversive multi-livelihood strategies of uplanders who might respond better to a menu of options that provides scope for individual choices.

Other factors in the non-adoption of exotic solutions include the fact that some solutions address conditions that are not locally perceived as problems. Soil erosion is a good example of a process that is neither perceived nor recognized as a serious problem. Consequently, no solution is envisaged. No doubt this will change over time, but at the present time uplanders simply have too little experience with sedentary agriculture to have developed much of a feeling for these problems. Under the old transfer of technology paradigm, insufficient attention has generally been given to trying to understand local perceptions of 'what the problems are' and not enough time has been spent in facilitated discussions with villagers exploring the causal factors behind perceived problems and identifying appropriate entry points for problem-solving interventions. Even when outside analysts and locals agree on the definition of problems, they may have widely divergent ideas about what constitutes an appropriate solution. Exotic approaches that fail to connect with the indigenous technological tradition ignore one of the axioms of farming systems research: 'Existing farming systems are the base onto which improvements can be grafted.'

It doesn't matter how technically correct or economically viable a technical solution might be if it is not adopted by the intended users. Nutritionists recognize an analogous point when they note that the nutritional value of a food that is not eaten is zero.

Low intensive and gradual investments in uncomplicated tree crop planting activities tend to meet with greater acceptance. But this option is constrained by the lack of roads and easy market access. It is noteworthy that most of the smallholder teak plantations in Luang Prabang are located on flat lands adjacent to roads. Alarmed by the proliferation of smallholder teak plantations on prime agricultural land along roadsides, public officials in Luang Prabang eventually had to withdraw the tax incentive initially given to promote teak plantations in order to halt what they saw, from a public welfare point of view, as an unwise trend in the use of scarce agricultural land.

Livestock enterprises have been found to offer a more adoptable alternative in many remote areas, especially large stock that can walk to market. But livestock-based farming system developments have not yet received the focal attention they deserve in upland development efforts.

In remote areas of Laos, as in other countries over the world, roads have shown themselves to be magnets for development. Spontaneous relocation of households, and even whole villages, to new roadside locations is a widespread phenomenon. A recent student survey of income generating activities for households at varying distances from roads and at varying distances from market centers in Luang Prabang, revealed an amazing variety of enterprises mounted by local people. Proximity to roads, however, was only one of the variables. Attitudes and market skills also played an important role. Interestingly, one of the most enterprising villages with one of the highest rates of market earnings was a remote hilltribe village accessible only by footpaths. There women had become very successful in producing low-volume and high-value traditional handicrafts for the tourist market.

This example demonstrates how the skillful selection of appropriate products for the market can sometimes overcome seemingly insurmountable transport constraints. It also suggests the complexity of the 'access' issue, which encompasses not only the 'hardware' of roads, but also the 'software' of market information and the variety of choices that can be made with regard to product type and appropriate transport technology. Given the richness of environmental niches in the uplands of Laos, just imagine what could be accomplished if Laos were to take a systematic approach in assisting villages to identify locally appropriate market niches. This has been done in the remote mountainous areas of Nepal, for example, where development of marketing channels for high-volume, low-value products (often medicinal plants and other NTFPs) has been systematically pursued.

In summarizing the government's own critique of past policies and development approaches, it has been shown that there is no evidence that the conventional approaches have resulted in major gains in rural welfare or even in slowing forest degradation and other problems. It has been recognized that the major reason for this lack of significant impact is that these interventions have not taken into account the diversity and complexity of the uplands and upland livelihood systems.

The government of Laos has identified decentralized land management as the key national strategy toward the eradication of poverty in the upland areas. Even though a number of policy and legal frameworks and different decentralized land management approaches, mechanisms and modalities have been formulated, adjusted and tested to support these efforts of decentralization, there are still a number of constraints in filling the institutional vacuum that has emerged from this decentralization process. Major deficiencies concern the absence of a demand-driven, decentralized extension system and the limited capacities at the central, provincial and district levels for carrying out management and development activities at the local levels. Training on how to do this is needed at the central, provincial and district levels. One critical need is for training on the interpretation of data so as to be able to identify the appropriate 'focal sites' and the 'recommendation domains.' The initial round of focal site identification generated an unsystematic collection of around sixty 'focal' sites of uncertain representatives; far too many to be useful.

Research and training is also needed for regular monitoring and evaluation of the work done to ensure successful implementation. The wisdom and enduring value of the 'focal area' approach as a strategic way of concentrating limited development resources and engaging local people in their own development cannot be denied. The solution lies in improving it.

New policies and development approaches

The strategic vision

That is exactly what the 'Government's Strategic Vision for the Agricultural Sector' sets out to do. The revised 'focal area' approach starts with a more systematic method for defining a manageable number of representative 'core' focal sites for major pilot activities (or one or two districts or watersheds per province), but the approach has to be flexible and adaptable to local circumstances. The main point of the overall approach is to enable the decentralization of power to the district level, and empowerment at the village level so that development activities and management of natural resources can be taken up directly by local institutions. It also involves the recognition that

The essence of the focal site approach

- Concentrate limited human and financial resources effectively
- Interventions to be tailored to specific area needs
- Integration of sector inputs at the district level to respond to diversified needs and recommendation domains
- Devolution of power to the district
- Local empowerment at the village level
- Promoting locally owned centers for change and learning
- Increase food and commodity production
- Create employment opportunities
- Improve living standards
- Most sustainable and socially acceptable alternatives for the uplands are to be developed through improvement of livelihood systems within existing settlements

improvement of livelihood systems within existing agro-ecosystems is the way toward more sustainable and socially acceptable alternatives for upland development.

The vision of the Ministry of Agriculture and Forestry (MAF), a decentralized and demand-driven approach to extension, aims at supporting villagers to take initiatives for self-help. The capacity of the districts and provinces will be upgraded to support farmer participation in adaptive research trials and demonstrations in order to develop a menu of production choices in concert with local needs, opportunities and market signals. A key element of the plan for accomplishing this is the new roles identified for the provincial and district extension staff. The vision calls for the District Agriculture and Forestry Office (DAFO) staff to be trained as farming system extension workers, supported by subject matter specialists in the Provincial Agriculture and Forestry Office (PAFO), and connecting with volunteer village development workers. The idea is that the DAFO staff will be trained to operate as extension generalists or extension agents who can simultaneously cover relevant aspects of agriculture, forestry, livestock and fisheries. Subject matter specialists based in the PAFOs, who in turn will be supported by researchers from the National Agriculture and Forestry Research Institute (NAFRI) will support them. Implementation of this vision implies a massive program of capacity building at all levels, supported by human resource development by means of formal and on-the-job training through direct implementation activities in pilot areas.

The indicative ten-point 'Strategic Matrix for Sloping Land Initiatives' given in the 'Strategic Vision' (MAF 1999) constitutes a basic menu of options that can serve as a starting point for thinking about new program initiatives:

(1) land use zoning based on bio-physical and socio-economic parameters
(2) participatory land allocation and land-use occupancy entitlement
(3) participatory community management of natural resources
(4) farming systems diversification and agro-forestry development through adaptive research
(5) farmer demand-driven extension
(6) sustainable land use management with soil erosion control, afforestation, plantation forestry and conservation management
(7) rural savings mobilization and micro-credit extension
(8) competitive rural finance system development with market determined interest rates in most areas with subsidized rates in some areas, to promote technology adoption among the poorest socio-economic strata
(9) strengthening the capacity and legal framework of state-owned commercial banks in commercial banking transactions
(10) opening community market access through feeder road upgrading and

Legal framework for the new approach

The main legal framework consists of the Land (1997), Agriculture (1998), Water and Aquatic Resources (1996) and Forest (1996) Laws and Decrees, in particular:

- Regulations prepared by MAF for the implementation of promulgated laws and decrees
- Decree 102 (1993) on the Organization and Management of the Villages which identifies the rights, duties and responsibilities of the village community in the use and management of natural resources.

expansion and market information delivery

Area-based livelihood systems approach

Refinement and further development of the government's area-based policy framework has resulted in the emergence of a powerful unifying concept: Area-based livelihood systems. This concept embodies a sophisticated understanding of what actually drives development. It attempts to optimize exploitation of the natural upland potential, taking into consideration the complexity and spatial diversity of natural resources and local socio-cultural realities. It is not a new approach, but rather a conceptual elaboration and simplification of the area-based development approach. It provides a simple, unifying concept for development that recognizes the role of local people in the development process. It entails the recognition that the systems we are dealing with are, technically speaking, 'human ecosystems,' or hybrid systems of people, technologies and natural resources that are organized by humans in order to meet their livelihood requirements. The power of the concept arises from the fact that the simplest and most direct way to understand and improve these systems is to analyze the decision making behavior of the human organizers (system managers) and assist them to identify more productive and sustainable ways of structuring their livelihood systems to achieve their objectives.

As stated in recent MAF policy advocacy documents, the key characteristics of the programs organized around the area-based livelihood systems approach are:

Holism, which is needed to deal with the complexity of upland livelihood systems and the need for inter-agency coordination

Spatial variation in programs, including decentralization to district and village levels, in order to deal with the diversity of different local situations

Increased *community participation* with more flexibility to establish partnerships that build on existing knowledge and local level institutions

Rethinking extension approaches

An indication of how government will proceed in implementing the new vision is seen in the recent establishment of the National Agriculture and Forestry Extension Service or NAFES as a 'decentralized' agency under MAF, with a mandate for taking a more realistic and flexible approach to technology delivery and other interactive processes directly with the local communities. The new agency regroups all extension work of related institutions and human resources that were previously under different departments to one consolidated umbrella.

This form of institutional arrangement allows the extension system to follow a holistic approach to service delivery. Beside this, the major mandate set for NAFES is to prioritize its interventions at the district and village levels. This would ensure that the extension system becomes a more demand-driven agency. This implies that major restructuring has to take place from the MAFs central level down to the district level. The central technical department's main responsibilities toward agricultural development are more of a facilitatory and regulatory role. At the provincial level, there will be more line divisions to represent the respective central departments at the MAF level. These divisions will turn into two 'agencies', with the first one playing the regulatory role, as in the case of the technical departments, and the second agency being the extension coordinating office, with the major role to ensure harmonization of extension activities at the district level. At the district level, the main mandate will be extension activities. All district workers are to be 'turned into' farmer systems' extension workers, with knowledge in practical agriculture and in communication skills.

It is now also recognized that the local development effort cannot succeed unless issues of poverty reduction, alternative livelihoods and security of land tenure are addressed simultaneously along with improvements in essential services like health, education, road and market access. Thus, besides the establishment of a demand-driven extension system, refinement of the land allocation process and revision of options for determining general land use before allocation is also part of the new approach.

Turning away from reliance on simplistic 'lowland approaches' to upland development, the new extension approach in the case of upland development is based on the idea that you have to work with shifting cultivation systems in order to improve them and eventually make it possible to transform them into something more sustainable.

It is important to understand that in no way does the new approach back away from the fundamental concerns of the government to protect and sustain the environment and natural resource heritage of the country and pass it on in good condition to future generations. On the contrary, it provides a more effective approach for actually achieving this objective by enlisting local people as partners and allies in the effort. Among the technological approaches now considered promising are:

- improvements in fallow productivity
- integration of livestock into fallow-management systems
- removal of key constraints and enhancement of cash crop, non-timber forest products, livestock and fish production
- promotion of fruit and other tree crops for local consumption and as raw materials for non-farm processing activities
- provision of flexible support services (both group and individual based) in credit, extension advice and training.
- ancillary development activities such as health, education and family planning.

Specific tasks of NAFES will be to support provinces and, especially, districts to develop and operate their own tailor-made approaches and institutions for agricultural extension. Some of these approaches are:

- development of methodological and procedural approaches for a flexible participatory and sustainable extension system
- training, coaching and monitoring of the extension services and extension staff at the provincial and district level
- training the trainers necessary for the support functions at the central and provincial levels
- advising the government on policy in the domain of agricultural extension and others.

A lengthy preparatory phase has been proposed for this initiative that will:

- survey and assess already existing efforts of extension in Laos
- establish procedures for further developing suitable extension methods
- identify suitable ways for supporting the provinces and districts
- give indications based on concrete experiences on how to scale up
- give indications based on concrete experience on how to link with various programs and projects involved in extension work in the country.

The initiative is conceived of as a 'learning project' that will attempt, through active networking, to access, evaluate and synthesize all of the various approaches to extension being practiced in the Lao PDR. This is the kind of programmatic activity that will assist the government to coordinate and enhance the efforts of multiple partners and harness them more effectively to the country's development aspirations. Consistent with the government's policy of decentralized development, the effort is predicated on the recognition that there is no single 'correct' way of doing extension work and that diverse environmental, social and economic conditions in Laos dictate that each province and district will need to experiment with its own particular way of organizing and running extension services. It also recognizes that people who design and implement extension programs at the local level must have the chance to study useful ideas and experiences in other places. This broader knowledge can then be adapted and incorporated into the construction of the system most useful for each particular situation. With an emphasis on donor-coordination and proactive networking, one improvement that this central coordinating activity will bring to the current situation is an enhanced assurance that the valuable experiences of numerous pilot programs mounted by the government in cooperation with different donors will all be documented and receive due and adequate representation in an emerging menu of options for a decentralized and pluralistic approach to extension. Contrary to donor's fears about 'duplication,' the watchword of this kind of initiative might be 'enhancement' of donor efforts.

Reorganisation of the national research system and the role of NAFRI

Prior to the reorganization of the national agricultural research system, numerous institutions had some involvement in research. However, few of them dealt exclusively with research, but were involved to some degree in research under separate departments of MAF, the National University, the Science, Technology and Environment Agency, Department of Geology and Mining, National Geography Department, Medicinal Plant Research Center of the Ministry of Health, and various other projects and NGOs. The main research activities were organized within the line departments of the government and have often been characterized by fragmented efforts; project-oriented focus; poor response to user's demands; absence of long term strategy and direction; unclear division of labor between research and extension; and poor institutional memory. Prior to reorganization, no national effort had been made to identify research needs at the national level or to attempt to ensure integration and avoid redundancy.

The 4th Five Year Plan for National Socioeconomic Development focused greater attention on research. Within MAF, an integrative approach to research was made a priority. A systematic reorganization of the national agricultural research system was undertaken, culminating in the National Agriculture and Forestry Research Institute (NAFRI), which was formed in 1999 to provide overall leadership and coordination for agricultural and forestry research. NAFRI's mandate is to address problems of poverty and environmental degradation through integrated multidisciplinary research. The 'Strategic Vision' accords NAFRI an important role as a source of improved upland technologies and research information to support demand-driven extension. NAFRI is expected to be active on the following fronts, among others:

- coordination of interdisciplinary multi-institutional research
- socio-economic and policy analysis
- comprehensive study and classification of the characteristics and dynamics of swidden-based land use and upland livelihood systems
- systematic assessment of the potential role of different farming systems relative to swidden-based livelihoods and evaluation of the possibilities for improvement
- study of spatial variation of resources and distribution of factors affecting the performance and adoption of alternative technologies.

For the first time in Laos, there now exists a national organizational structure with ambitions to support a long-term programmatic approach to research based on the needs of the country.

Some of the conceptual milestones in the development leading to NAFRI have been: a call for decentralized research; action research and networking; the adoption of an *adaptive research* strategy and recognition of the need for an efficient information support system; the need to strengthen linkages with the stakeholders of research, especially the PAFOs; a decentralized 'farming systems' approach to research in 'focal points' throughout the country, with consideration of the potential and actual socioeconomic environment and agro-ecological zones in order to enable poverty alleviation and income generation without environmental degradation; and regional networking with international organizations and research centers on a MAF-approved research agenda.

The current situation with NAFRI can be summed up by saying that the policies and the organizational *structures* for a programmatic approach to agriculture and forestry research are now substantially in place. But the *processes* needed to bring these structures to life are still in an early stage of development. No doubt additional fine-organization will be needed to institutionalize the feedback mechanisms to steer research and keep it relevant. But these feedback structures will be more robust and effective if they are allowed to evolve from processes originating in the field through interaction with farmers, extension agents and provincial and district partners, rather than be created by fiat from the top within a single institution. The priority now is for NAFRI to gain experience with a demand-driven holistic approach to research through activities at pilot sites in the field.

In support of this objective, following a series of workshop exercises leading to the development of a long term plan, NAFRI has recently developed a systematic strategy and program of research for the uplands of Laos, which has been approved by MAF and submitted as a proposal to SIDA (Swedish

Table 25.3

Research areas	Research support and coordination
• Farming systems research	• Research-extension linkages
• Forestry research	• Information services
• Land management research	• Capacity building
• Socioeconomic research	

International Development Cooperation Agency). Briefly summarizing, the proposed program addresses both the letter and spirit of the 'Strategic Vision' in supporting the development of a demand-driven research system that works hand in hand with farmers and extension agents giving recognition to the diversity of needs and opportunities in the uplands of the Lao PDR and prominence to income generating alternatives, while putting highest priority on food security and poverty alleviation. The proposed new Lao-Swedish Upland Agriculture and Forestry Research Program has four research and three research support and coordination components (Table 25.3).

Walking on two legs

The guiding image behind the MAF-supported research program is that it is conceived as the 'research leg' of a two-legged (two program) structure for

PRONAM in a nutshell

The aim of PRONAM is to provide decision makers on the macro level at the provincial and central level with a sound tool for sustainable management of natural resources and to provide end users of natural resources with guidance and support.
It is not intended to support the development of blueprints or master plans for the provinces, but rather to provide provincial and central planners and researchers with a dynamic tool to identify critical issues and areas and to create a context for expression of new ideas and other inputs towards a continuous planning-implementation-learning process for gradual improvement of natural resources management (NRM) and linked socioeconomic development. As currently conceived, the PRONAM methodology will involve eight steps:

Step 1. Provincial natural resources (NR) analysis and strategic planning
Step 2. Strategic NR projects/activities
Step 3. Formulation of provincial NRM policy, strategy and guidelines
Step 4. Training, extension and other NR support
Step 5. NRM planning
Step 6. Annual planning work
Step 7. Implementation
Step 8. Monitoring and evaluation

Source: The natural resources management initiatives: a general description for technical users and policy makers. National Agriculture and Forestry Research Institute.

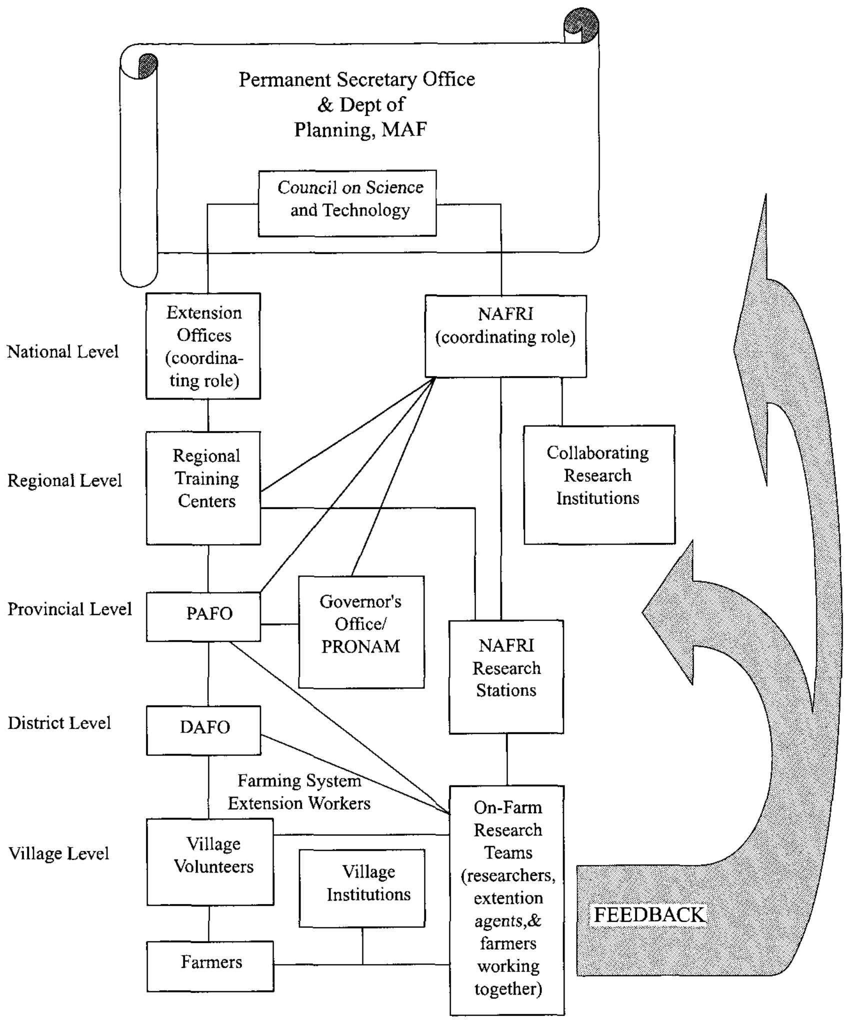

Fig 25.2 Research and extension linkages in a demand-driven approach to research and extension.

The on-farm research and extension venue is the natural meeting ground of farmers, researchers and extension agents and the main source of organizing information and feedback for the whole network. Another key node is the PRONAM activity at the provincial level, which receives inputs and feedback from research and extension and uses this information to plan and manage provincial natural resources. Overall coordination of the two-legged program is directed from the coordination units housed in MAF (Permanent Secretary Office and the Department of Planning), NAFRI and the council on science and technology for policy oversight and coordination.

seeking support for natural resource management and poverty alleviation in the Lao PDR. The envisaged support also includes an 'extension-cum-development leg'. The idea embodied in this image is that with two legs the national development effort will be able to walk the path toward development. Of course, this will only happen if the action of the two legs can be skillfully coordinated (Fig. 25.2, Table 25.4).

It is envisaged that a major contribution to the need for coordination will be made by the development of a proposed Provincial Natural Resources Management system (PRONAM). PRONAM began during the past year as a new activity within MAF. PRONAM is thus conceived as an element of both programs.

The development of the PRONAM methodology and database is envisaged as a subcomponent of the proposed research leg, while its deployment as a management tool by the provinces is seen as a component of the development leg. When the whole system is up and walking, the on-going output of the research program, in the form of new natural resource management options (technologies, land use and policy recommendations), can continue to provide input to the on-going provincial NRM planning and management process using PRONAM as a tool.

Within the 'research leg,' the methodological development and support activity for PRONAM is planned as one subcomponent of a component on 'research-extension linkages.' Within the proposed concept for the 'development leg', PRONAM falls within the planning component and is the major vehicle for provincial level natural resource management.

The future Lao Agriculture and Forestry Research Program has been specifically designed to interface with a complementary upland development program of some kind. This new concept for a Lao Upland Development and Poverty Alleviation Program is proposed as a basis for designing the development component. The expectation is that the two programs will be compatible and mutually supportive, and that coordination between the 'research leg' and the 'development leg' will be sufficient to enable the joint programs to walk the path toward development indicated by the *Agriculture and Forestry Strategic Vision* (MAF 1999).

References

Ministry of Agriculture and Forestry (MAF). (1999)*The Government's Strategic Vision for the Agricultural Sector*, Vientiane: Ministry of Agriculture and Forestry, Lao PDR.

Table 25.4 Roles of the main stakeholders in demand-driven research and extension.

Level	Stakeholders	Role
National	Permanent Secretary Office and Dept. of Planning, MAF	Policy guidance, supervision, planning, coordination, monitoring and evaluation, harmonization of resource allocation and international aid assistance (all P).
	NAFRI	Coordination (P), On-farm and on-station research (P), Training (S)
	Collaborating res. inst.	On-farm (S), On-station research (P)
	Extension offices	Coordination (P), Extension (P), Training (P), On-farm research (S)
	Science and technology council	Coordination of research-extension-policy linkages (P), Evaluation of technologies (S)
Regional	Regional training centers	Training of DAFO and PAFO staff (P)
Provincial	PAFO (subject matter specialists)	Coordination (P), Extension support (P), Training of provincial and DAFO staff (P), Research (S)
	Governor's office (planning)	Planning, coordinating, monitoring and evaluation of provincial natural resource management (P)
District	DAFO (Farming systems generalists)	Extension (P), Training of communities, farmers and interested groups or individuals (P), On-farm research (S)
Village	Village volunteers	Extension (P), Training (S), On-farm research participation & facilitation (S)
	Farmers	On-farm research (P), Farmers-to-farmers contacts (P), Evaluation of technologies (P)

(P) = primary leading role, (S) = secondary support role

26
Changing Aspects of Shifting Cultivation in Northern Laos: Land Allocation Policy and Commercialization of Crop Production

KONO Yasuyuki, OKADA Hisaya, NAWATA Eiji and TOMITA Shinsuke

Shifting cultivators in the mountainous regions of mainland Southeast Asia, including the northern parts of Vietnam, Laos, Thailand and Myanmar as well as the southern parts of the province of Yunnan in China, face two problems. The people are poor, and they face environmental deterioration.

These farmers, in most cases, are among the poorest in each country. The economic differences between shifting cultivators and others are becoming more marked. Lowland farmers receive new technology to increase agricultural productivity, diversify their farming and get additional income from the expanding urban sector markets. Shifting cultivators do not have these opportunities, as population growth enhances their risk of food shortages and the intrusion of the market economy into these remote areas increases their demands for cash.

The mountainous regions of mainland Southeast Asia, when compared not only with other parts of the region, but also with other parts of the world, are rich in environmental resources such as forests and wildlife. Yet, the mountain environment is vulnerable to human disturbance. The soil is heavily weathered, and the steep slopes further heighten the risk of soil erosion and nutrient loss. Over-exploitation of the environmental resources, causing immediate environmental deterioration, happens across the entire region. The urgent need for environmental conservation in this region is widely recognized by the local people and the national governments, as well as international agencies. However, there are striking differences among them regarding why the environment must be conserved, who should be the major actor within environmental conservation efforts, and how exactly the environment should be conserved (Sato 2002).

Importantly, poverty and environmental deterioration in this region are thought to be mutually interdependent phenomena. According to this reasoning, poverty causes over-intensification of shifting cultivation and overuse of the forest resources, which then results in lower productivity and the deterioration of the environment. This deterioration accelerates with the resulting over-intensification of shifting cultivation and the overuse of the forest resources.

The present chapter focuses on this vicious downward spiral, examining the problem using a micro-level village study. We discuss how the downward spiral can be stopped and reversed into an upward spiral. Our objectives are:

(1) to examine the recent changes in the economy of the shifting cultivator;

(2) to analyze the impacts of the intrusion of the market economy and its policies, as related to environmental protection; and

(3) to discuss measures to achieve sustainable eco-resource management.

We selected a village in Oudomxay Province, northern Laos, and carried out field surveys for two years over the period from 2000 to 2001. The survey included interviews with resource persons, a questionnaire of all of the households and observations in the field. This is an ongoing study and the current chapter is intended to serve as an interim report.

The study village

Lak 15 Village is located 15 km north of Muang Xay town, the capital of Oudomxay Province (Figure 26.1). The village was established in the mid-1970s when villagers moved to the roadside area from small hamlets scattered on the nearby mountain slopes under a government-sponsored program.

According to the village elders, the original village was called Lang Luang and was established more than 200 years ago. Several households moved out of this village and established new hamlets such as Deang Din and Ouk Hu in the 19th century, and Dong, Kiu Kok and Huay Lae Tai in the first half of the 20th century. Lang Luang village disappeared in 1945. These small hamlets have repeatedly merged and separated because of the spread of epidemic diseases and the disturbance of war. When the present village was established, all of the households of Deang Din, Ouk Hu, Kiu Kok and Huay Lae Tai hamlets, numbering 25, 17, 9 and 9, respectively, moved to Lak 15 and settled down.

By July 2000, the population of the village was 592 and was comprised of 86 households. All of the villagers except one person are ethnically Kamu. All of the households are engaged in shifting cultivation, with upland rice as the dominant crop.

The village is located along the road connecting Muang Xay and Phongsali.

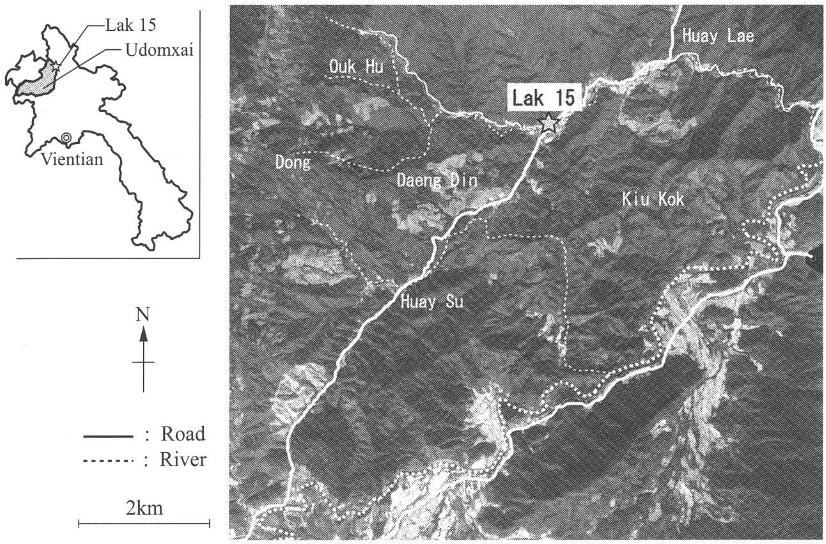

Fig 26.1 Location and settlement-movement of the study village

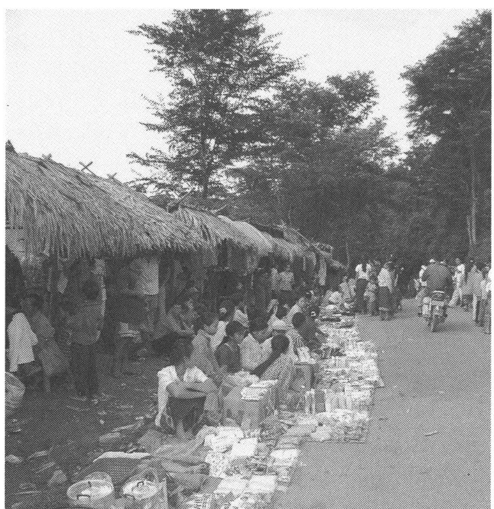

Photo 26.1 Periodic market in the study village

The road was just a footpath until 1973 when it was paved. Since then, traders have moved around this area to purchase non-timber forest products such as cardamom, and opium and rice and to sell daily commodities. A periodic market was opened in 1993 in the village (Photo 26.1), paving the way for the intrusion of the market economy. The small-scale exchange consists of upland crops and forest products for meat, clothing and other items.

Land management

Before the mid-1970s, shifting cultivators lived in small hamlets of approximately ten to twenty households. These hamlets were scattered on the slopes. Each hamlet had a mutually-recognized territory, but the boundary between two hamlets was treated as a buffer zone rather than a demarcation line. They rotated land from cropped to fallow for shifting cultivation within their territory, suggesting that they had sufficient land for shifting cultivation.

Previously, shifting cultivation was, in most cases, practiced cooperatively by all the households of a hamlet. After selecting a slope in January every year, they divided the slope for each household based on available labor and the household requirements for rice. They slashed the forest of the designated area in February and burned it in April (Photo 26.2). It was the duty of each household to contribute labor for this cooperative work. After sowing in April (Photo 26.3), weeding was continuously practiced from sowing to harvest (Photo 26.4). The harvest was carried out in October and November by a subgroup that consisted of several households that exchanged labor. Each household got all of the rice production from the field that it was allocated before the cropping season. They then selected a new area for the next year and repeated the same procedure. These findings indicate that the concept of land holding at the household level was rare and the land was communally managed by the hamlet.

This situation changed when the government established the present Lak 15 village. At first, the territories of the old hamlets were maintained after they moved to the new village, but the definition of the territories gradually changed from an exclusive land use right to just the name of the location. This happened because farmers used lands located closer to their residence more intensively than land located further. Secondly, working groups for shifting cultivation, called '*nuay*' and consisting of ten to fifteen households, were formed with households whose original hamlets were different. And thirdly, the village received several immigrants, mainly due to the good road access. The original inhabitants had to provide land for shifting cultivation for the new arrivals. These changes resulted in the creation of a new custom for land use among the

Photo 26.2 Burning shifting cultivation field

Photo 26.3 Sowing upland rice

Photo 26.4 Weeding of upland rice field

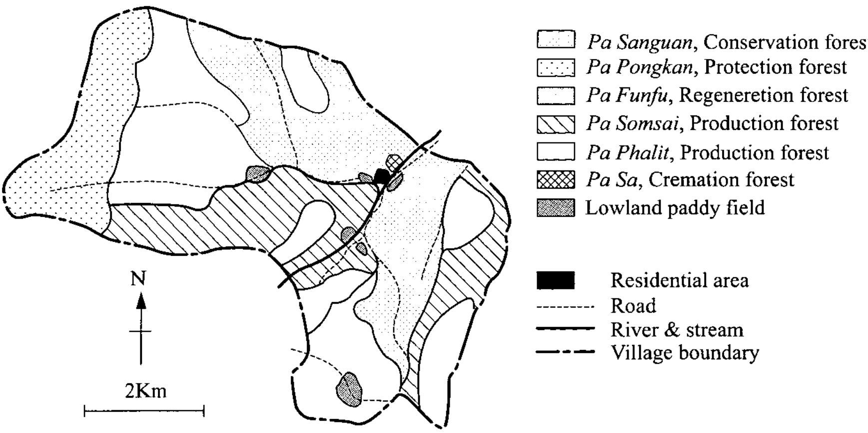

Fig 26.2 Land use planning

villagers. Under the new system, any portion of the forest land, except for some conservation, protection and cremation forests, could be used for shifting cultivation. The previous cultivators enjoyed priority use of the land if the fallow period was not excessively long. Anybody who wanted to cultivate regenerated forest land had to get permission in advance from the previous cultivator and then be endorsed by the village authority. The new practice maintained the village-based land use management system, but an individual interest in land holding had emerged.

The present village territory was finalized in 1996 when the District Agriculture and Forestry Office set up a land use plan for this village (Figure 26.2). The village land was divided into paddy fields, a residential area and forest land. The forest land was further divided into five types: conservation forest (*pa sanguan*), protection forest (*pa pongkan*), production forests (*pa phalit and pa somsai*), regeneration forest (*pa funfu*), and cremation forest (*pa sa*). According to this classification, only production forest could be used for shifting cultivation. Access to conservation, protection and cremation forests was strictly limited (Work Bank *et al.* 2002). This was the first intervention by the government into village land use, and the government plans to allocate production forest to each household as the next step in the land use planning process (Pravongviengkham 2003).

Recent changes in villager's economic activity

The opening of a periodic market in the village in 1993 accelerated the inflow of the market economy. Implementation of the land use plan in 1996 legally limited the villagers' access to forest land and the forest resources and products that provided the basis for shifting cultivation. We next studied how the villagers responded to these external stimuli in terms of their economic activities.

Paddy production

The shifting cultivation area was more than 110 ha in 1996, but decreased to less than 100 ha in 1997 despite the fact that the village population increased by an annual rate of roughly 2 per cent. Villagers reported that 1997 was the first year of cultivation after the implementation of the land use plan, so they tried to follow the plan strictly. However, beginning in the second year, the shifting cultivation area sharply increased (Figure 26.3), with the annual growth rate of 18 per cent over the three years from 1997 to 2000. This increased the total upland rice production from 175 tons in 1997 to approximately 290 tons in 1999 and 2000.

Villagers have also engaged in lowland paddy production (Photo 26.5), although shifting cultivation continues to be their major method of paddy production. The area of lowland paddy fields was about 15 ha when the village

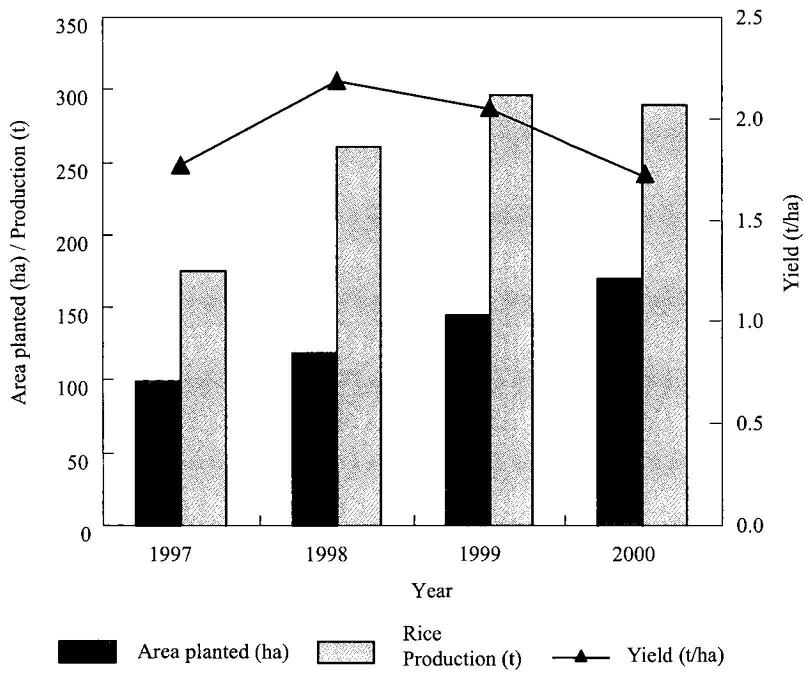

Fig 26.3 Changes in shifting cultivation of upland rice

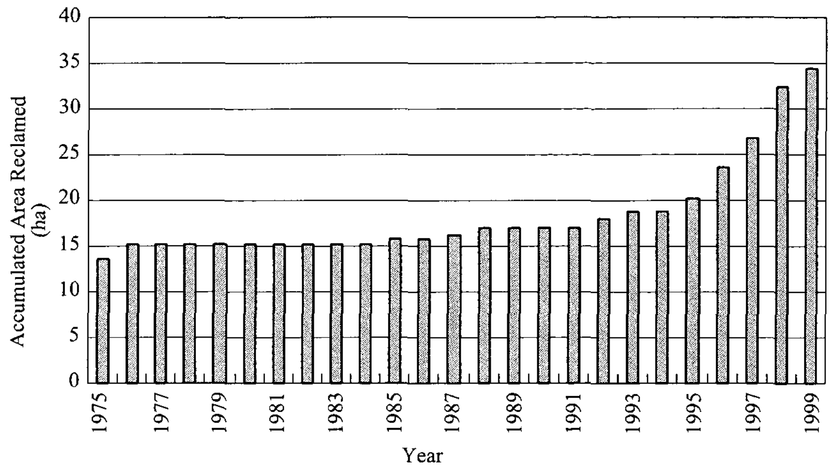

Fig 26.4 Growth in the area of lowland paddy fields

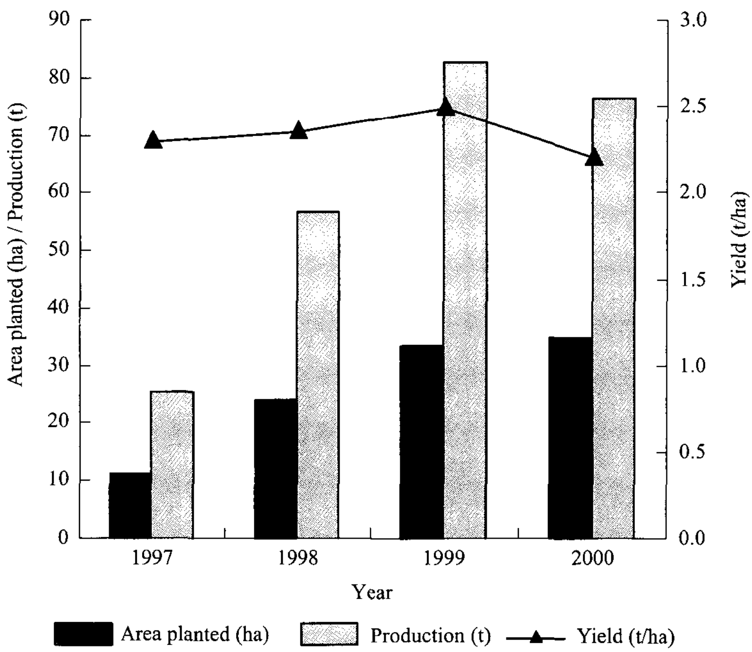

Fig 26.5 Changes in lowland paddy production

Photo 26.5 Lowland paddy field along valleys

was established in the mid-1970s, but expanded rapidly since the mid-1990s reaching nearly 35 ha by 1999 (Figure 26.4). The expansion of lowland paddy fields was partly a response to government promotion efforts, but was mainly due to the villagers' fears that they might have to prepare for a ban on shifting cultivation in the near future. Since 1995, the village authorities have also supported the expansion of lowland paddy fields by encouraging a labor exchange for field reclamation. Lowland paddy occupied 17 per cent and 21 per cent respectively, in terms of agricultural land and paddy production for the village (Figure 26.5).

Rice balance

The increase in total rice production using both upland shifting and lowland cultivation drastically changed the rice balance in the village (Table 26.1). The annual per capita rice consumption, including all kinds of use, such as local wine making and animal feed, was estimated to be 500 kg per person, based on the results from the questionnaire. Villagers less than fifteen years of age and more than fifty are counted as 0.5. Paddy production was just self-sufficient in 1997 when the shifting cultivation area was slightly smaller than the previous year. Then, per capita production jumped to 768, 902 and 853 kg in 1998, 1999 and

Table 26.1 Changes in rice balance in the study village

	Item	1997	1998	1999	2000
Village total					
production (t)	glutinous	199.0	310.1	363.6	349.2
	non-glutinous	1.5	6.3	15.5	17.0
	total	200.5	316.3	379.1	366.2
consumption	population	557	568	579	592
	calibrated population[1)]	404	412	420	430
	per capita consumption (kg)	500	500	500	500
	total (t)	202.1	206.0	210.0	214.8
surplus		-1.6	110.3	169.0	151.5
Per capita					
production (kg)		496	768	902	853
surplus (kg)		-4	268	402	353

1) The villagers aged less than 15 and more than 51 are counted as 0.5.

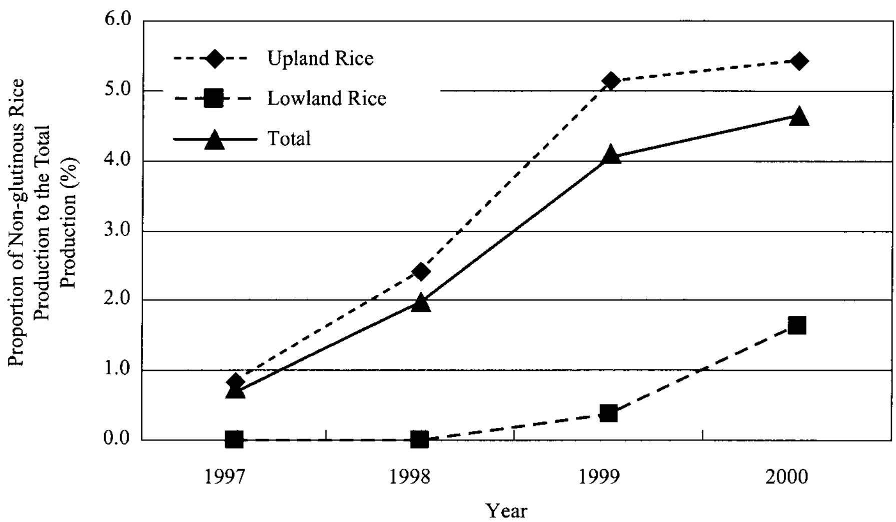

Fig 26.6 Emergence of non-glutinous rice production

2000, respectively. This indicates an obvious change in the villagers' attitude toward paddy cultivation. Before, the villagers sold rice only when they needed emergency money. But now, they recognize that rice is an important and reliable source of cash income, as rice prices are much more stable than other commercial products produced by the village. This view is supported by the fact that non-glutinous rice production is gradually increasing (Figure 26.6). The daily food for the villagers is glutinous rice and the price of non-glutinous rice is 10 to 20 per cent higher than that of glutinous rice. Therefore, for commercial purposes, non-glutinous rice production is more beneficial.

Another important point is that the increase in rice production is attributed solely to the expansion of the cultivated area. During the study period, the rice yields per hectare did not show an increasing trend (Figures 26.3 and 26.5). The villagers also reported no technical changes in paddy cultivation. There may actually be a decrease in paddy yields, particularly for shifting cultivation, due to insufficient labor for weeding if they were to expand the cultivated area even more.

Non-paddy sources of cash income

Field and garden crops, livestock, forest products (including both timber and non-timber) and off-farm jobs, including rice processing, were sources of non-paddy income for the villagers. Livestock is the major non-paddy income source (Figure 26.7). In 1999, 86 per cent of households had income from the selling of livestock that included water buffalo, pigs, chickens and ducks. This livestock income contributed 62 per cent of the total non-paddy income for the village (Table 26.2). The number of livestock raised in the village has fluctuated yearly because of the spread of animal diseases, presenting a constraint to the increase of animal husbandry in the village. In addition, non-timber forest products were also important income sources, of which paper mulberry (*po sa*) was the most popular. Collection of non-timber forest products is labor-intensive work. If these plants were cultivated, they might be a more reliable source of income.

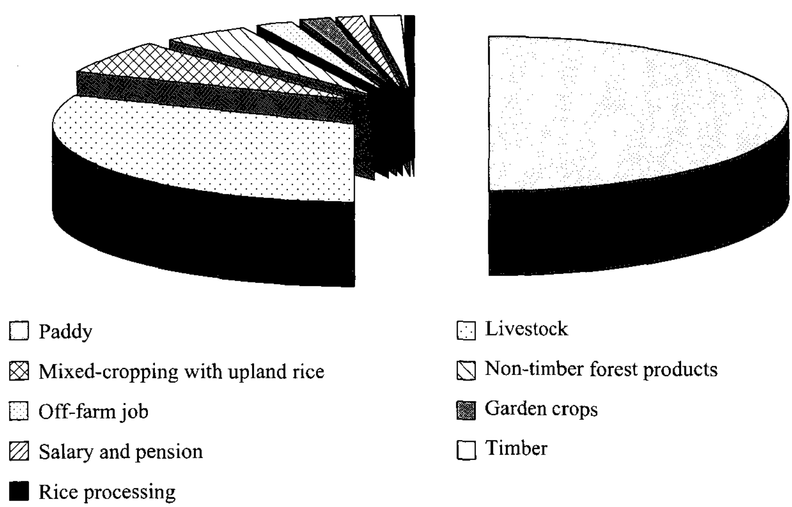

Fig 26.7 Sources of cash income (1999, village total)

Table 26.2 Non-paddy sources of cash income of the study village in 1999

Income sources	Household engaged in		Annual income (1,000 kip)		
	Number	(%)	Village total	(%)	Average of the households engaged in
Mixed-cropping with upland rice					
groundnut	35	41	2,746	2	78
sesame	71	83	10,159	6	143
chili	54	63	3,927	2	73
tobacco	9	10	970	1	108
banana	36	42	2,815	2	78
sugarcane	3	3	160	0	53
job's tear	40	47	2,696	2	67
sub-total	81	94	23,473	14	290
Garden crops					
pineapple	14	16	1,255	1	90
orange	8	9	4,375	3	547
lime	2	2	47	0	24
sub-total	19	22	5,677	3	299
Livestock					
water buffalo	17	20	58,000	34	3,412
pig	33	38	26,250	16	795
chicken	61	71	18,420	11	302
duck	28	33	2,727	2	97
sub-total	74	86	105,397	62	1,424
Timber					
logging	23	27	3,364	2	146
timber	15	17	1,575	1	105
sub-total	33	38	4,939	3	150
Non-timber forest products					
paper mulberry	78	91	5,780	3	74
taro	70	81	4,689	3	67
cardamon	23	27	1,600	1	70
bamboo ware	18	21	1,954	1	109
firewood	38	44	2,399	1	63
sub-total	82	95	16,423	10	200
Rice processing					
sale of rice liquor	20	23	797	0	40
sale of rice spirit	17	20	1,389	1	82
sub-total	29	34	2,186	1	75
Off-farm job					
rice mill	6	7	3,500	2	583
general shop	5	6	1,250	1	250
TV and video shop	2	2	1,000	1	500
sub-total	11	13	5,750	3	523
Salary and pension					
school teacher	9	10	4,380	3	487
pension	4	5	1,080	1	270
sub-total					
Overall	86	100	169,305	100	1,969

Summary

Surplus paddy production in 1999 was estimated to be 169 tons. The rice price that year was around 1,000 kip per kilogram, though it has fluctuated from season to season from 800 to 1,100 kip per kilogram. The surplus production was, therefore, equivalent to about 170 million kip. The total non-paddy cash income in 1999 was also estimated to be about 170 million kip. This finding clearly shows the importance of paddy production, particularly by shifting cultivation, as a source of income.

The villagers' demand for cash has quickly grown due to the inflow of the market economy into the village where their efforts to earn money has mainly concentrated on paddy production. Increase in rice production was achieved only by means of the expansion of area cultivated, and yield increase could not be observed, reflecting no technical innovation.

The land use plan might be meaningful in the sense that the villagers recognize the territory of the village and the features of their natural resources. It is, however, doubtful whether the land classification set by the land use plan is effective .

Economic disparity among the households

Increase in rice production has helped the villagers catch up with the inflow of cash into their economy. However, it is expected that some villagers can join this economy successfully, while others will experience much more difficulty. The following household-level analysis focused on the economic disparities among households and attempted to identify the requirements for sustainable eco-resource management.

Eighty-six households in the village were divided into three types on the basis of rice balance. Types A, B and C are the rice-deficit, rice-subsistence and rice-surplus households, respectively. Their four year-average (1997 to 2000) per-capita surpluses are negative, between 0 and 500 kg, and more than 500 kg, for A, B and C, respectively. There were 17, 54 and 15 households classified as types A, B and C, respectively.

Rice production was, needless to say, different among the types (Table 26.3). The farm size of type C is two times larger than that of type A. The paddy yields of type C were also two times higher than that of type A. Both factors, therefore, caused a different rice balance between the types. It is surprising that the percentage of non-glutinous rice cultivation is significantly larger in type A than the other types, indicating that some type A households sell non-glutinous rice and buy glutinous rice in order to secure their sustenance.

Table 26.3 Differences in paddy production between rice deficit and surplus households

	A (deficit)	B (subsistence)	C (surplus)	Average
Per-capita farm size (ha)				
upland	0.26[a]	0.33[a]	0.48[b]	0.34
lowland	0.03[a]	0.06[ab]	0.09[b]	0.06
total	0.29[a]	0.39[b]	0.57[c]	0.40
4 year average yields (t/ha)				
upland	1.4[a]	1.9[b]	2.8[c]	2.0
lowland	1.5[a]	2.4[a]	2.7[a]	2.3
% of non-glutinous rice production	8.3[a]	4.4[b]	2.1[b]	4.8

Note: Values marked by the different letters are significantly different at the 5% level.

Table 26.4 Differences in family structure between rice deficit and surplus households

	A (deficit)	B (subsistence)	C (surplus)	Average
Family size (person)	7.4[ab]	7.2[a]	5.4[b]	6.9
Age of household head (%)				
20s	47	20	33	28
30s	35	32	40	33
40s	18	24	7	20
50s & 60s	0	24	20	19
Age composition				
% of mambers aged between 15 and 50	52[ab]	44[a]	56[b]	48
% of members aged between 10 and 60	63[a]	63[a]	72[a]	65
Birthplace of household head and his spouse				
in situ (%)	59	74	60	69
outside (%)	29	17	33	22

Note: Values marked by the different letters are significantly different at the 5% level.

A typical family structure of type A was a large family with numerous young children (Table 26.4). Labor shortage obstructs them from expanding the farm size. It also adversely affects upland rice yields because of insufficient weeding. Another typical household of type A is a new family that does not hold enough fields. This is particularly seen when either the husband or wife moved into the village because they could not inherit land from their parents. Most of type C households have two to three grown children who work with their parents.

Differences can be observed in non-paddy cash income by family type, though some are insignificant (Table 26.5). Types A and B have a significantly smaller non-paddy cash income than type C. Therefore, the paddy income is not only indicative of the total income, but also includes all other income sources as

Table 26.5 Differences in non-paddy cash income between rice deficit and surplus Households

	A (deficit)	B (subsistence)	C (surplus)	Average
Mixed-cropping with upland rice				
% of household	82	98	93	94
per-capita income (1,000 kip)	28[a]	63[b]	90[b]	61
Water buffalo				
% of household	12	22	20	20
per-capita income (1,000 kip)	35[a]	160[a]	341[a]	167
Pig				
% of household	29	37	53	38
per-capita income (1,000 kip)	51[a]	65[a]	128[a]	73
Poultry				
% of household	71	80	67	76
per-capita income (1,000 kip)	37[a]	56[a]	62[a]	53
Non-timber forest products				
% of household	88	98	93	95
per-capita income (1,000 kip)	19[a]	37[a]	94[b]	43
Off-farm, salary and pension				
% of household	12	28	20	23
per-capita income (1,000 kip)	15[a]	26[a]	30[a]	25
Total per-capita income (1,000 kip)	193[a]	439[a]	782[b]	450

Note: Values marked by the different letters are significantly different at the 5% level.

well.

These findings imply that the same constraints, such as land and labor limits, are at work for both paddy production and non-paddy income sources. This is not contradictory to the recent general understanding that non-paddy sources of income, particularly the collection of non-timber forest products, provide economic insurance for the shifting cultivators so they can survive during the pre-harvest months and poor harvest years (Raintree and Soydara 2002). Even if there are labor shortages, non-paddy opportunities provide some sort of safety net.

Conclusion

The shifting cultivators in the study village quickly responded to the entrance of the market economy since the mid-1990s. They commercialized agriculture and tried to maximize their income by exploiting their environmental resources. The modes of food production and income generation are, however, totally dependant upon the available land and labor that also existed before the market economy occurred. Except for the expansion of lowland paddy production, there were few advances in information and technology from the outside. This has caused two limitations. First, the labor productivity is not high enough to yield satisfactory surpluses and income. Second, the expansion of the shifting cultivation area is expected to hinder sustainable production in the near future due to insufficient labor for weeding and the necessary shortened fallow period.

The land use plan was effective in the sense that it formulated the concept of a village territory, provided the village authorities with a legal basis to regulate natural resources within the territory, including tillable land, and contributed to popularizing the idea of forest resource conservation among the villagers. However, it is doubtful whether the basic idea of this centralized policy, the separation of land for production and natural resources protection, will be accepted by the villagers or the village community.

We observed a positive response to the intrusion of the market economy and found increased cash income, but at the same time saw income disparity among the villagers. Diversification of income sources seems to further increase the disparity. Introduction of the market economy could be a strong tool in achieving sustainable economic growth at the village level, but we cannot overlook its effects on the weaker and poorer villagers.

What is happening in the study village is an unbalanced response to the outside world. Negotiating local land use customs and the centralized land use policy under the newly-spreading conditions of the market economy is the most crucial issue for poverty mitigation and environmental conservation.

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27
Management of Non-timber Forest Products in Laos: Fallow Forest Growing Styrax tonkinensis *for Benzoin Production*

TAKEDA Shinya

Laos still holds vast areas of forest that produce not only timber, but also non-timber forest products (NTFPs) such as benzoin, damar, cardamom, rattan, eagle-wood and others (Table 27.1). This chapter discusses benzoin production in light of recent changes that occurred as a result of the government land allocation program.

Benzoin is a balsamic resin obtained from the Southeast Asian trees of the genus *Styrax*. Siamese benzoin from *Styrax tonkinensis* and Sumatran benzoin from *Styrax benzoin* are the most commercially important kinds of benzoin. It is used as incense in some Islamic religious ceremonies. It is also used for medicines and cosmetics. It may be applied topically to wounds and ulcers to protect and disinfect the skin. It can also be used as an inhalant for coughs, colds and bronchitis. It acts as a carminative when taken internally and is rapidly absorbed. It is also mildly expectorant, diuretic and antiseptic for the urinary passages.

Benzoin was an historically important item for commerce in Southeast Asia. '*Styrax* trees were cultivated in large plantations alongside hill rice in northern Sumatra, Laos, and northern Cambodia. Cambodia exported 270 tons of it a year in the 1630s, which probably included the 18 tons reported in Laos a few years later. It was used all over Asia as incense - Persia alone imported about 60 tons a year in the 1630s.' (Reid 1993).

In 1641, when the Dutch East India Company (VOC) visited Vientiane, they 'envisaged purchasing approximately 123kg of gold, 18,500 kg of the best quality benzoin, 9,250 kg of sticklac, plus copper gongs and other articles from

Table 27.1 Important non-timber forest products in the Annamese Cordillera

Extracts and exudates	*Polygonum multiflorum*
Essential oils and incense	*Cinnamomum camphora*
Cinnamomum cassia, C. loureirii	*Artemisia annua*
Cananga odorata (ilang ilang)	*Strychnos nux-vomica*
Melaleuca leucadendra (Cajeput oil)	*Momordica spp.*
Illicium verum (Star Anise)	*Smilax glabra*
Aquilaria crassna (Eaglewood)	*Drosera rotundifolia*
Jasminum sambac	*Dioscorea deltoidea*
Fokienia hodginsii (Pemou oil)	*Zanthoxylum rhetsa*
Homalomena aromatica	*Amorphophallus campanulatus*
Litsea cubeba	**Fibers**
Resins and gums	Rattan
Pine oleoresin and derivatives	Bamboo
Liquidambar formosana	*Broussonetia papyrifera*
Styrax tonkinensis (Benzoin)	**Edible plant products**
Damar	Edible oils and nuts
Canarium spp.	*Sterculia lychnophora* (Malva nut)
Industrial oil	*Sterculia foetida*
Aleurites montana (Tung oil)	*Aesculus chinensis* (Chestnut)
Tannins and dyes	*Bassia pasquieri*
mangrove species	*Thea oleosa*
Insecticides	Spices
Azadirachta indica	*Amomum villosum* (Cardamom)
Persea kurzii	*Alpinia officinarum*
Medicinal plants	**Animal products**
Amomum aromaticum (tsao kwa)	Honey and Wax
Hibiscus sagittifolius (sam nam)	Sticklac
Morinda spp.	

Lan Xang every two years.' (Stuart-Fox 1998). Northern Laos has long been famous for Siamese benzoin since very early times.

S. tonkinensis occurs naturally in the northern parts of Laos and Vietnam. In northern Laos, benzoin production from *S. tonkinensis* is integrated into a shifting rice cultivation cycle. Clear-felled mature forests are burnt during the dry season. On the forest floor, the seeds of *S. tonkinensis* are stimulated to germination from the heat of the burning. During the following rainy season, seedlings sprout densely among the upland rice. After harvesting the upland rice, the fallow land is covered with *S. tonkinensis*.

The land allocation program initiated by the government in 1996, however, considerably shortened the shifting cultivation cycle, resulting in clear effects on benzoin production.

Table 27.2 Main NTFPs in K village

Benzoin	*Styrax tonkinensis*
Cardamom	*Amomum ovoideum*
Papermulberry	*Broussonetia papyirfera*
Bamboo	*Bambusa* spp.
Rattan	*Calamus* spp.
Makkhaen	*Zanthoxylum rhetsa*
Makkhar	*Alpina malaccensis*
Khaem	*Thysanolaena maxima*

Site and methods

The research was conducted at K village, Nam Bak Distict, Louang Prabang Province, Laos, located some 100 km north of Louang Prabang, the capital of the province. The elevation is approximately 750 m. Villagers collect the various NTFPs shown in Table 27.2.

To evaluate the occurrence of *S. tonkinensis* in the study area, four quadrats were set: (A) a 1st year shifting cultivation plot; (B) a 3rd year fallow plot; (C) a 5th year fallow plot; and (D) an 8th year fallow plot. In each plot the locations of trees were mapped, the trees were identified, and the DBH and crown size were also measured. Interviews were also carried out with the villagers.

Photo 27.1 K village surrounded by *Styrax tonkinensis* forest

Structure of the fallow forests with benzoin tree stands

The structure of the fallow forests with *S. tonkinensis* is summarized in Table 27.3 and a crown projection diagram is shown in Figure 27.1.

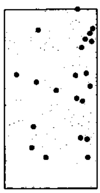
In plot A, the seedlings of *S. tonkinensis* are scattered over the upland rice field. This plot was in an eight-year-old fallow forest prior to clearing last February, where it was dried for about two months before burning in April. Upland rice was planted in June. When the mapping of the plot was underway in July, the upland rice was two-months-old and weeding had been performed once. The number of *S. tonkinensis* was 5,250 seedlings per hectare. Besides upland rice, cassava, sesame and maize were also planted. *Celosia argentea*, which is especially significant ritually as it is used in the harvest ceremonies, and chilli pepper (*Capsicum frutescens*) were planted near the huts in fields.

Plot B was three year fallow land where the height of *S. tonkinensis* is about 5 m. The forest floor is covered with *Eupatrium odoratum* at 2 to 2.5 m. The number of *S. tonkinensis* was 2,900 per hectare.

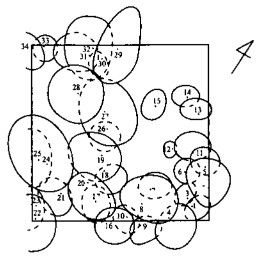
In plot C, a five year fallow, the density of *S. tonkinensis* was estimated at 1,175 per hectare and the height was about 11 m. New stumps were observed,

Table 27.3 Structure of a fallow forest with *Styrax tonkinensis*

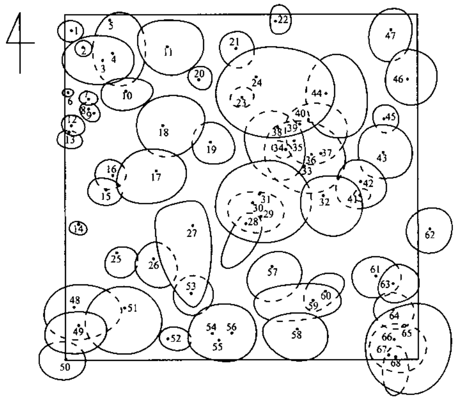
Fallow period	Tree species	Density (/ha)	Mean DBH (cm) (range)	Basal area (m^2/ha)	Basal area (%)
The first year	*Styrax tonkinenssis*	5,250	-	-	-
The third year	*Styrax tonkinenssis*	2,900	4.6 (1.7-7.2)	5.22	91.3
	others	500	3.5 (2.2-4.0)	0.50	8.7
The fifth year	*Styrax tonkinenssis*	1,175	7.0 (0.7-11.0)	5.03	80.6
	others	500	5.3 (3.4-10.4)	1.21	19.4
The eight year	*Styrax tonkinenssis*	975	14.2 (6.3-21.0)	16.57	98.3
	others	50	8.5 (6.9-10.0)	0.29	1.7
The fifth year (including stumps)	*Styrax tonkinensis*	1,425	7.0 (0.7-11.0)	6.11	83.4
	others	500	5.3 (3.4-10.4)	1.21	16.6



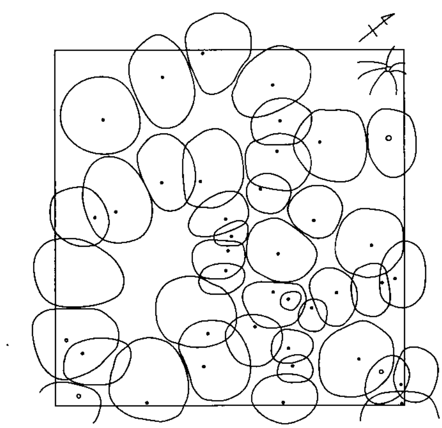
A: The first year sifting cultivation plot (5m × 10m)
(• =upland rice, ● =seeding of *Styrax tonkinensis*)



B: The third year fallow forest (10m × 10m)



C: The fifth year fallow forest (20m × 20m)



D: The eighth year fallow forest (20m × 20m)

Fig 27.1 Crown projection diagram of a fallow forest with *Styrax tonkinensis*

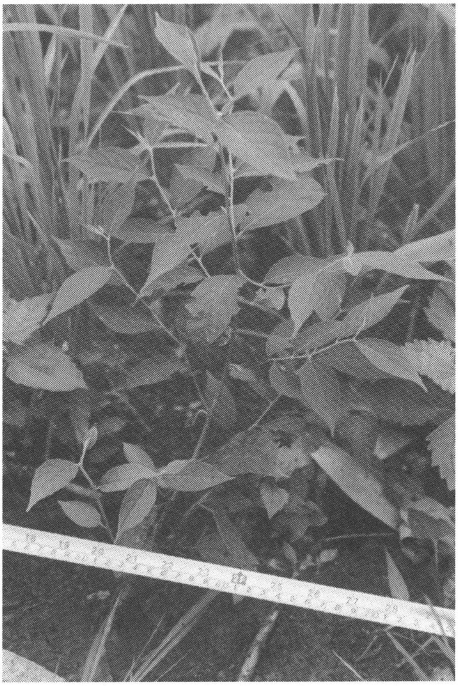


Photo 27.2 Seedling of *Styrax tonkinensis* in upland paddy field in July.

Photo 27.3 *Styrax tonkinensis* sapling after the harvest of upland rice in December. Tops of *Styrax tonkinensis* are picked, as farmers believe that this increases the yield of benzoin.

Photo 27.4 Forest fallow with *Styrax tonkinensis*.
1st year shifting cultivation just after upland rice harvest is in the middle. 3rd year follow is in the right and 6th year fallow in left hand sides.

showing trees that were being cut. This occurred because *S. tonkinensis* timber was used for rebuilding houses after the village was destroyed by fire in 1999. The number of *S. tonkinensis* was 1,450 per hectare if the stumps were included. Villagers begin harvesting benzoin from this plot in the sixth year of fallow.

Plot D was eight years fallow, with a density of *S. tonkinensis* estimated at 975 per hectare where the basal coverage area was 16.57 m^2 per hectare. It is nearly a pure stand of *S. tonkinensis*, occupying 98.3 per cent of the total basal area.

The average DBH of *S. tonkinensis* was 4.6 cm during the three fallow years, 7.0 cm for five years in fallow and 14.2 cm for the eight year fallow land. *S. tonkinensis* is a fast growing, light demanding pioneer species. It is the dominant tree species on fallow lands where shifting cultivation is practiced.

Harvesting of benzoin

The harvesting of benzoin observed in K village is as follows. Tapping of the tree trunk is carried out between August and October. The tapping is done at about 30 cm intervals along the trunk from 50 cm above the ground or higher. Then benzoin is harvested in March and April. The average yield of benzoin is

Photo 27.5 Benzoin exudinsg eeping from tapped trunk of Styrax tonkinensis

about 0.5 kg/tree. Middlemen come to the village to buy the benzoin and take it to Louang Prabang.

More than 60 per cent of households in the village own some fallow forest with *S. tonkinensis*, but only six households are actively engaged in harvesting benzoin. Many households hesitate to harvest benzoin as its price is low. Even so, it is still an important source of cash income for the households, in particular for the poor. Nevertheless, those households that stopped tapping would restart if the price becomes more attractive.

Conclusion

In an agroforestry system, there should be some advantages or merits for combining agriculture and forestry. In the case of using fallow management with *S. tonkinensis*, fire during sifting cultivation breaks the dormancy and they germinate among the upland rice and grow as pioneer trees during the fallow period. After the harvest of benzoin, the *S. tonkinensis* is cut down and the next cycle of shifting cultivation starts. There are two advantages to using such a combination of benzoin production and shifting rice cultivation. Initially, the heat from fire breaks the dormancy of *S. tonkinensis* seeds and they grow up as light-loving, fast growing pioneer trees. After that, intensive harvesting of benzoin can only be done for two or three years when the trees are aged seven years or more.

However, in abiding by the forest land allocation policy of the government of Laos, each household is allocated pieces of land that are enough for only four years of fallow. It was observed impossible to harvest benzoin under this land allocation policy, as it can only be harvested when the trees are at least seven years old. At the moment, the market demand for benzoin is limited and the price is low. The agroforestry system, with *S. tonkinensis* culture for benzoin production, is facing difficulties with the rigid policy of the land allocation program and also market problems. Flexible implementation of land allocation projects and governmental support in marketing should be considered.

Even at the low price of benzoin at the moment, villagers are taking care of seedlings of *S. tonkinensis*, as shown in Figure 27.1, for future production. The villagers continue to collect diverse types of NTFPs to secure their income against the market price.

Collection and cultivation of tree crops by local farmers on a small scale has been a common practice in Southeast Asia for many centuries. Secondary forest or fallow land has been a source of many NTFPs, most of which are light-loving, easy growing pioneer species such as *S. tonkinensis*, *Broussonetia papyrifera* (for paper-making) and others like rattan. They regenerate after a disturbance such as in shifting cultivation, forest fire and floods and are highly adaptable. If we over 'conserve' (that is, adopt a 'keep off utilization' policy) with these 'reserve' forests, the trees of useful NTFPs will gradually disappear because it is difficult for them to regenerate in heavy shade. This will lead to severe consequences affecting local livelihoods. Those forests with NTFPs should be maintained by utilizing them, and not through legislation preventing their utilization.

Forest land allocation and forest-zoning programs should include these considerations and their programs should be implemented with flexibility.

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PART 4

Indigenous Knowledge and Eco-Technology

Introduction to Part Four

In Asia there is an awareness of the disparity between traditional value systems and modern ones. Ecotechnology is a concept which suggests an alternative strategy for mitigating modern, often destructive development processes. Part IV presents four chapters depicting an adaptive and constructive way of development. It uses an ecology-based and community-based resource management technique (ecotechnology) that has sustained people's efforts in seeking sound environments in Asia.

Momose and Shimamura classify villages on the lowland plain of Sumatra into four different types and show that they are well adapted to their unique habitat or niche. These villages are river ports at the foot hills, river ports at river confluences, migrant villages in the tidal zone and fisher villages in the tidal zone. They all rely on conserving the peat swamp forests because the resources they gather from them are their sole means of sustenance and survival. Over-exploitation of these resources is prevented by networking, which enables exchange of local products among villages. Another reason why the forests still remain is that the Malays, the dominating ethnic group, have prevented immigrants from devastating the close interaction they have with the forests.

Fish constitutes the major source of animal protein for most Laotian peasants. They fish for home consumption using varieties of indigenous fishing gear. Most of the places where they fish are the village common areas, where the community holds a traditional usufructuary right. Villagers abide by indigenous local regulations concerning aquatic eco-resources management and conservation. They have noticed that the aquatic eco-resources are diminishing owing to several causes, including bombing and the spraying of defoliants during the Vietnam War, dam construction, irrigation development, increased soil erosion and increasingly unstable river regimes as a result of forest degradation and, more generally, to over fishing. The usufructuary right of the common area has been converted to private ownerships and some villages have adopted exclusive rules.

While the Laotian government has had high expectations in aquaculture and has promoted the artificial production of fingerlings to cope with the diminishing fish resources in natural waters, local people are now trying to conserve the dwindling aquatic eco-resources by imposing more strict fishing regulations and banning the use of non-indigenous fishing gear and methods. Two chapters are in agreement that conservation requires local people to use their own good indigenous technology for farming fish resources in a continuous and modest manner.

Ecotechnology is one of the most important elements for a sustainable development in which indigenous knowledge plays a key role. There is a surge to understand the structure and processes of indigenous knowledge. Ecotechnolgy is characterized as a pro-poor, pro-woman and pro-nature approach to sustainable development. It represents a paradigm shift from a growth model based on economic criteria to one based on concurrent attention to the principles of ecology, equity and employment in eco-jobs.

Balasubramanian examines the social construction of indigenous knowledge on the local taxonomy of soils using a case study in a southern Indian village. He observes that the women and the landless laborers seem to have limited access to 'indigenous' knowledge and argues that acquiring indigenous knowledge has been hampered by social stratification in the society as to class, gender, age and education. He warns that notwithstanding that ecotechnology is pro-poor, pro-woman and pro-nature, it requires better understanding of the social construction of the indigenous knowledge before applying this method to rural development.

The Green Revolution technology in Asian rice broke the vicious cycle of the Malthusian crisis in the post-war era. After a lapse of about forty years since the inception of the Revolution, Asian agriculture has found itself somewhat stagnated, facing a 'quadri-lemma' (four dilemmas) namely; (1) a stagnated yield of rice and other cereal crops; (2) monocultured rice species; (3) environmental disruption using large doses of chemicals with the overuse of energy and waste of plastics; and (4) a widening economic gap between the haves and the have-nots. Asian agriculture in the post-Green Revolution stage is now seeking new breakthroughs in two different development vectors. One is to further develop super-crops by modern breeding technology and the use of biotechnology to overcome the present stagnated crop yields. The other is to try to re-adopt locally available, safe and time-tested technologies to ensure crop diversity in sustainable cropping systems. Asian small farmers are increasingly interested in doing this for better economic sustenance. This would not only diversify the cropping systems but also increase the job opportunities by creating more agriculture related 'eco-jobs'.

Kaida observed a number of interesting ecotechnologies that are being used in Asian agriculture, particularly emphasizing how the land and water are used. He evaluated them from the standpoint of (a) a local response to imported and often destructive technology; (b) applicability for communalizing rural development; and (c) their usefulness in beautifying the rural landscape. On the basis of this study, in collaboration with his Asian colleagues, he proposes enlarging the 'Asian Ecotechnology Network' in various different areas. These include cropping and farming systems, forest management, fisheries, irrigation and drainage, ecological resources management — particularly of land, soils and water — and home economics, including food processing and marketing. The networking group advocates that many of the ecotechnologies are the local people's cultural assets, whose intellectual rights must be protected by publicizing and registering them through concerned scientists.

Although the four chapters in Part IV deal with different topics, they carry a common underlying message, that is, the employment of locally available, time-tested ecotechnology in resource management can help conserve environmental resources.

28
Malay Riverbank Communities in Peat Swamp Forests of the Sumatran East Coast: Environment, Network and Transformation

MOMOSE Kuniyasu and SHIMAMURA Tetsuya

Many of the past studies on villages in the coastal peat swamps of the outer islands of Indonesia focused mainly on migrant villages, overlooking the fact that different types of villages are distributed in different kinds of environments (Furukawa 1992; Sumawinata 1992, 1999; Abe 1993, 1997). In these papers it was emphasized that the exploitation of lowland plains often led to destructive development. The authors show many occasions in which local residents living in the coastal swamp areas have developed their unique way of adapting to and using the widely variable local environments. We do not just admire local traditions, but we present our observations of how people have adapted to the given environments, and how they developed unique strategies to live in a tropical peat swamp. We are also interested in their behavior and their ability to retain their ecological resources; namely how they have kept the coastal peat swamp forest from being over-exploited.

This chapter summarizes and integrates major findings which include descriptions of vegetation and people's subsistence strategies that are reported in our two related papers (Momose and Shimamura 2002, Momose 2002).

Zonation of the environment and vegetation in peat swamp forests

Furukawa (1992) divided the lowland plains of peat swamp forests in Sumatra into three zones: flood, central and tidal (Table 28.1). The flood zone occurs at the periphery of the lowland plains and is covered mainly with freshwater

Table 28.1 Relation of large scale zoning and vegetation of peat swamp forests

Zone and belts	Vegetation type	pH	EC	Soil	Dominant species
Tidal zone					
belt 1	mangrove forest	high	extremely high (brackish water)	mud	*Rhizophora apiculata*
belt 2	mixed peat swamp f.	low	moderately low	thin peat	*Koompasia malaccensis*
Central zone					
belt 1	mixed peat swamp f.				
belt 2	méranti paya f.	low	low	thick peat	*Shorea teysmanniana*
belt 3	padang suntai f.	low	lowest	thickest peat	*Palaquium buruckii*
Flooding zone	freshwater swamp f.	high	moderately high	mud	*Alstonia angustiloba*

swamp forests. The central zone features the sequential zonation of mixed peat swamp forests, *meranti paya* forests, and *padang suntai* forests. The tidal zone is covered either by mangrove forests or mixed peat swamp forests.

Among the three zones, the flood zone is the most suitable for cultivating rice. Lands covered with mixed peat swamp forests (mainly the tidal zone) can be transformed into coconut plantations and rice fields if man-made channels are provided for proper drainage. However, a large part of the tidal zone far inland from the river courses is difficult to convert to farmland (Furukawa 1992).

In the central zone, land which is suitable for farming is limited. Only small areas along rivers that are covered with mixed peat swamp forests (within 100 m from riverbanks) can be used in the same way that the tidal zone is. In the central zone, huge areas covered with *meranti paya* as well as *padang* forests cannot be converted to agricultural land for the following reasons. First, peat is extremely nutrient-poor, lacking some trace minerals including copper and many others elements that are essential for rice cultivation (Kyuma 1983). Second, tree crops are normally unable to develop better root systems than many of the wild trees that have wide and horizontally spread root systems as well as well-developed finer roots extending deep into peat to act as anchors. Tree crops, including oil palm, planted in deep and purely organic peat easily fall before reaching a productive stage. Third, once desiccated, deep and purely organic peat easily catches fire and is hard to extinguish. Finally, the beds of mineral soils underlying peat are concave (Anderson 1964), where its elevation in the lower areas is lower than the riverbanks. As the peat layer diminishes quickly under drained conditions as a result of shrinking, fire, and decomposition, the area becomes ill-drained and finally water-logged.

Distribution of villages in lowland plains of the Sumatran east coast

The Kampar River originates in the central Barisan Mountains and flows

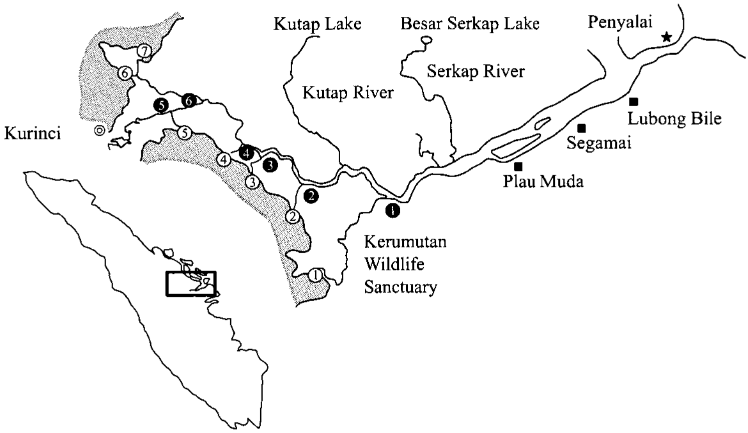

Fig 28.1 Distribution of Villages within a Lowland Plains along the Kampar River, Riau, Sumatra

Notes: Dotted areas are hills, and areas without dots are plains. Numbers in white circles indicate small Pangkalan villages along branch streams: ① Kapau, ② Pangkalan Panduk, ③ Merbau, ④ Pangkalan Bunut, ⑤ Talayap, ⑥ Pangkalan Dolik, ⑦ Pangkalan Balai. Outlined numbers in black circles indicate muara villages: ❶ Tuluk Meranti, ❷ Muara Panduk, ❸ Sungai Ara, ❹ Muara Tolam, ❺ Seren, ❻ Pelalawan. Squares indicate migrant villages (sepontan). The star indicates a fishing village (bagan). Names of migrant villages and fishing villages appear on the map

through large peat swamps to finally drain into the Malacca Straits (Figure 28.1). The river reaches below Kurinci, a town 160 km inland, flowing through lowland plains are covered mainly by peat swamp forests. Seventeen villages are found within the lowland plains along the main and branch streams of the Kampar River. These villages are categorized into four types: foot hill villages, confluence villages, migrant villages and fishing villages.

Foot hill villages

Foot hill villages are in the flood zone at the foot of hills. They are river ports settled by the Malay people. For the past several centuries, the rivers in East Sumatra have been important trading routes that connect the inland agricultural societies (the Minangkabau highlands, for example) with the world beyond the Malacca Straits. The villages are located at landing points where roads cross rivers. All of the seven foot hill villages indicated in Figure 28.1 are along tributary streams where the streams emerge from hills into the lowland plains.

The foot hill villagers are engaged in trading, fishing, rice growing in the plains, and rubber plantations on the hillsides. Before the 1920s, when the rubber plantations expanded, the hills had been used for shifting cultivation (Marsden 1811). From the 1980s to the present, oil palm plantations have been replacing rubber on the hillsides; and more and more villagers are now being employed in the oil palm plantations.

Small foot hill villages on tributaries once served as ports for trading products from plantations and forests. The forest products included *kapur baros*, *gharu*, *julton*, rattans, and woods. In Pangkalan Panduk along the Panduk River, a small tributary of the Kampar River, *gharu* and *julton* were traded until the 1980s. Today, products of the hills are usually transported by roads rather than by rivers and the small foot hill villages have now been reduced to tiny fishing villages, losing their significance as ports.

Confluence villages

Confluence villages are river ports at the confluence of main and branch rivers and are settled by the Malay people. They are often found in the central zone of the peat swamps and are closely connected to foot hill villages. For example, Pangkalan Panduk is located on the upper stream of the Panduk River, and Muara Panduk is located at the confluence of the Panduk and the Kampar rivers (Figure 28.1). The role of the confluence villages in the transit trade was to connect foot hill villages to the main trading routes along the main streams.

However, the shift from river to road transportation has weakened the connection of the two groups. On the other hand, as trading of woods and freshwater fish from peat swamps has developed rapidly, the function of confluence villages has shifted to the export of forest products from the peat swamps.

As good farmlands along riverine levees are limited, villagers are engaged in trading, fishing, hunting and the collection of forest products. In the confluence villages, a large number of people and forest interactions are still performed and were observed.

Migrant villages

Migrant villages are categorized into two types: *sepontan* and *transmigrasi* villages. The *sepontan* villages have been settled since the 1880s by autonomous migrants of the Banjar people from Central and South Kalimantan (Banjar is regarded as a sub-tribe of Malay) and the Bugis people from Sulawesi, as well as Malay from the foot hills, confluence, and fishing villages in the neighboring areas. The development of the Kampar riverine lowlands began later than other peat swamp regions as these villages were established in the 1960s or 1970s. Banjar, Bugis and Kampar Malay people reside in these villages, but are separated along different drainage channels within the same villages.

The migrants have transformed mixed peat swamp forests in the tidal zone into coconut plantations or rice fields after the excess water was drained by excavating drainage channels. As Furukawa (1992) and Sumawinata (1992, 1999) stated, *sepontan* villagers' technologies which are being used in their farming are often very adaptive to changes in the ecological conditions of the region.

Transmigrasi villages were settled by government-run projects where the immigrants (mainly from Java) have been introduced to undeveloped areas since the 1960s. No *transmigrasi* villages are found along the Kampar River.

Because most of the areas suitable for farming were already opened by *sepontan* migrants, the *transmigrasi* projects were said to have opened poor peaty soils that were unsuitable for agriculture. Details of the difficulties that the projects have encountered are fully described by Furukawa (1992). As a result, a considerable number of *transmigrasi* villages have been abandoned.

Fishing villages

The fishing villages of the Malay and Orang Laut people are in mangrove areas which are on the outer edges of peat swamps in the tidal zone. Penyalai is a fishing village near the mouth of the Kampar River. Aquatic products are usually traded with the Chinese (Furukawa 1992). The Orang Laut people in Penyalai are basically fishermen, but they also hunt wild boars in the peat swamp forests. Because no primary forests remain in the tidal zone, these hunters go to the central zone on a day's trip by boat seeking the game. The boars are sold to the Chinese traders. The population of wild boars is large in the peat swamp forests (there are no exact estimates, but herds and footprints can be seen there much more frequently than in other types of tropical vegetation). Because the residents of the lowland plains are Muslim, these non-Muslim hunters can monopolize the rich population of wild boars.

Although Penyalai was established as a fishing village, migrants from differ-

Table 28.2 Habitats and land use of four types of villages.

Village type	Zone	Original vegetation	Land use
Pangkalan	Flood	Freshwater swamp f.	Rice fields
		Hill dipterocarp f.	Plantations, shifting cultivation
Muara	Central	Mixed peat swamp f.	Rice fields, Plantations
		Meranti paya f.	Hunting and logging
		Padang suntai f.	Hunting and logging
Migrant	Tidal	Mangrove f.	
		Mixed peat swamp f.	Rice fields, Plantations
Fishing	Tidal	Mangrove f.	Fishery
		Mixed peat swamp f.	

Box

Ethnobotany

The term "ethnobotany" first appeared in a lecture delivered by Harshberger at the University of Pennsylvania Archeological Association in 1895. He stressed four points: a) The study of ethnobotany aids in elucidating the cultural position of plants; b) An ethnobotanical study throws light upon the past distribution of plants; c) An ethnobotanical study helps us to find the ancient trade routes; d) Ethnobotany is useful as it suggests new lines of manufacture for the present day.

According to a broad definition by Balick and Cox (1996), ethnobotany is the study of the relationships between people and plants. Documentation of traditional botanical knowledge (TBK) is the basic approach. Interpretation or analysis of TBK is also an important part of ethnobotany. Ethnobotany has shed light on theoretical studies in local sociology. In addition, ethnobotany is not only a subject of academic interest or a tool to discover new products that would benefit industries, but also a useful approach for resource conservation and rural development.

The main study areas and methodologies are summarized as follows: Quantitative methods were developed by Prance et al (1995) to assess the usefulness of a forest, species or a plant family as demonstrated by the local people. Ethnopharmacology is the scientific evaluation of traditional medicines, and traditional phytochemistry is the study of plant chemicals used as poisons, dyes, pigments, fragrances and food additives. Some related areas are ethnomedicine, the study of native systems of recognizing health conditions, and medical-dental ethnobotany that pursues local curing methods on the basis of the local medicinal plant resources.

Ethnoecology is the study of how local people interact with natural environments. Its subjects may include plants, animals, landforms, forest types, and soils. The managements of plants or vegetation by local people are typical topics of ethnobotanical studies with ecological aspects. Studies of traditional agriculture concerns diverse subjects such as methods and technologies of traditional agriculture, including germplasm management, environmental knowledge which relates to agriculture, social factors which affect agricultural practices, productivity or efficiency of traditional farming systems, and distribution, variation and origins of domesticated plants.

Archaeoethnobotany is the study of archaeological remains of wild and cultivated plants and their relationship to the life and development of primitive societies. It also deals with the evolution of agricultural plants. Historical ethnobotany is the study of written accounts from earlier times. Cognitive ethnobotany is the study of how local people perceive plants or vegetation. Analysis and interpretation of local classification systems of plants or vegetation is a popular approach.

Conservation and management of ecosystems cannot be achieved only from top-down planning, but participation of local people is necessary. Thus, scholars and governmental or non-governmental planners must understand how local people recognize, use, and manage environments. On the other hand, great findings in academism could also be achieved from close interactions between scholars and local people through the practical projects of conservation or management.

Conservation of rich flora and fauna

Biodiversity of terrestrial ecosystems should be conserved in two ways. The first is to protect primary vegetation. The second is to manage secondary vegetation properly. Tropical primary forests contain extremely rich flora and fauna per unit of area. They are usually protected as national parks or some other kinds of protected areas. Human activities are excluded to some extent where only traditional and sustainable use of plants and animals are allowed.

It is unavoidable that extinctions of plants and animal species occur by chance even if the protection is carried out perfectly. The probability of extinction will be reduced if some patches of protected primary forests are connected through secondary vegetation so that plants and animals can migrate. For some animals that move long distances, migration may be possible within their lifetimes, but for most plants and animals, it takes several generations to move from one patch of habitat to another. Thus, secondary vegetation surrounding primary forests or connecting them is also necessary for conservation of biodiversity.

There is another reason why management of secondary vegetation is important. Local people rely for their livelihood heavily on forest resources. They may be lured to exploit protected primary forests illegally unless secondary vegetation is maintained properly to provide for resources they need for their sustenance. In this connection, large secondary forests under proper management are required to protect relatively small and oftentimes fragile primary forests.

For better management of secondary vegetation, the local residents' knowledge base must be employed rather than applying top-down planning for the conservation. Through their experiences, they must develop adaptive technologies of properly managing secondary vegetation and also enhance biodiversity. These systems do not always have a long tradition; rather many of them are newly evolving to catch up with rapidly increasing population. This suggests that planning experts need to work in close collaboration with local residents.

(MOMOSE Kuniyasu)

ent areas have expanded the village. The mangrove forests remain, but the mixed peat swamp forests behind them have been converted to coconut plantations just the same as in migrant villages. Thus, today, the composition of the ethnic groups of Penyalai is similar to that of migrant villages, except for the presence of the Orang Laut fishermen.

The patterns of land use are summarized in Table 28.2.

Characteristics of confluence villages

Abe (1993, 1997) stated that peat swamp forests showed no trace of historical long-term human activity, but rather they have been populated recently by migrants in a rapid development in modern times. We do not agree with all of his opinions. Abe considered only the migrant villages in peat swamp forests and thereby overlooked the existence of foot hill and confluence villages. Different types of villages are found in different habitats and they are all interconnected by a network. The relationship between the foot hill and the confluence villages are especially tight. In the central zone, where clear sequential forest zonation is observed, lands suitable for agriculture are limited to extremely small areas of mixed peat swamp forests, leaving all other areas covered with *meranti paya* and *padang suntai* forests usable only as forests.

Farming practices of the migrants, both the *sepontan* and *transmigrasi* migrants are relatively labor-intensive. A large outlay of capital is required for the *sepontan* migrants to reclaim the land (Furukawa 1992). In contrast, the land use of the Malay people in confluence villages is rather extensive and their practices are both labor saving and capital non-intensive. Their extensive farming has much smaller impacts on the environment in comparison to the migrants, although the population carrying capacity is much less. In our opinion, as described in more detail in later sections, such labor saving and capital-saving practices require a much more intensive understanding of their environments. Therefore, we can observe and compare the two different ways people live in peat swamps. In this section we shall investigate the knowledge-intensive practices of the confluence villagers, as the labor intensive and capital-intensive practices of the migrants have been reported elsewhere (Furukawa 1992; Sumawinata 1992; Abe 1993, 1997).

As is usually the case in trade-based societies, the disparity in wealth is great. In the case of Tuluk Meranti, where the Kampar and the Kerumutan rivers come together, out of approximately 1500 households, only eighteen are categorized in the richest class. All of the eighteen household heads are respected as *haji*. On the other hand, a large number of people have no savings and their only estates are houses on small lots. The majority of the villagers earn petty cash either by day labor (sawmill workers, porters, sailors and shop assistants), or fishing, hunting and collecting forest products.

In the following sections, we shall describe the agriculture, fishing, hunting, plant usage and logging methods that we observed in Tuluk Meranti, in order to show the relationships between the people and the forests.

Agriculture

The traditional agriculture of the confluence villages is very simple: the planting of sago on the riverbanks. Once planted, sago palms regenerate from rhizomes. In the Kampar region, sago was a long-established staple food until the 1950s. Thereafter, rice has become the staple and sago is seldom eaten today.

The shift in the staple food occurred at the time when rubber plantations arrived and the exploitation of forests began. Rice cultivation was introduced, along with the rubber plantations, in the limited but most fertile areas along the river. While the rubber plantation continued only for a decade because suitable lands were limited, the rice cultivation persisted.

Rice is cultivated in back swamps behind riverbanks. Rice fields are called '*ladang*', which is the same term applied in the upland rice fields where a shifting cultivation is practiced. Villagers say that the rice fields of confluence villages are not *sawah* (wet rice fields). As described below, the tools and techniques used in cultivating *ladang* rice are similar to those used in upland shifting cultivation.

The processes of opening the rice fields are as follows: first, mixed peat swamp forests are felled using chain saws, axes (*kapak*), and long hatchets (*parang*) in the driest season of July to August. This work is called '*tobe*'. One month after the clearing, the cut trees are burnt. Rice seeds are broadcast on the peat soil without any tillage as soon as the fire is out. The process of seeding the rice is called '*manyambang*'. The rice varieties are the same as those cultivated in the upland shifting cultivation of the foot hill villages, or they are the same as those grown both in dry and wet conditions in foot hill villages. Rice grows under non-flooding or temporarily flooding conditions.

The villagers have no more farm work until the harvest (*manuai*), five months after seeding. Ears of rice are harvested using *tuwa*, the ear cutters. Ears with grains are placed on a *bidai pengil padi* which consists of a sieve, 2 to 3 m^2. A frame made of wood and bamboo supports the sieve 3 m above the ground. The sieve is made from the cut wood of *linau* palm trees (*Cyrtostachys renda*, Palmae) stitched together with rattans (*Korthalthia paucijuga*, Palmae) at equal intervals to make slits of 3 mm wide. A woman stands on the *bidai pengil padi* and rubs the rice ears with her feet so that rice grains drop through the slits to the ground 3 m below the sieve. This footwork for threshing and screening rice is called '*iyik*'.

In the second year, bush and grass are cut using a *parang* in August (this work is also called '*tobe*'). After two weeks, cut grasses are burned and the rice seeds are broadcast. The other tasks are the same as in the first year.

In the third year, the peaty soils are planted with rubber or coconut saplings with provisional drainage channels, while rice cultivation continues in the clay soils. Small drainage channels are provided when land levels have fallen as a result of the peat disappearing through repeated burning. Because weed infestation increases over years, rice seedlings of 40 days (30 cm long) are transplanted in the main field right after clearing (*tobe*) and burning. Nurseries are prepared in a portion of the main fields in July. The seedlings are removed from the nurseries and their leaf tips and root tips are cut off. Planting holes 5 to 10 cm deep (deeper in dry habitats) are made using a stick called a '*tugal*', which is also the name used in upland fields for planting rice seedlings. The seedlings are placed in the holes and pushed into the mud or muddy peat by hand. Harvesting is done in the same way as above.

In the upland shifting cultivation, fallow periods are necessary because weeds increase over the years of continued cultivation. Whereas in swamps of the central zone, rice can be cultivated in the same fields every year because the muddy habitat allows transplanting. Transplanting is the standard method used in the *sawah* (wet rice fields) of the flood zones where the foot hill villages are located. The transplanting continues over a few months. Seedlings are planted as the fields emerge, as water levels recede gradually after the end of the rainy season. In confluence villages, however, where the range of water level fluctuation is much smaller than in foot hill villages, such a close relation between transplanting and changes in water levels are not observed. The reason for using transplanting as opposed to direct seeding is solely to compete with the weed infestation.

Fishing and hunting

The boundary between the flood zone and the central zone is where seasonal lakes appear. This is the best place to catch freshwater fish. In the case of the Kerumutan River, a branch stream of the Kampar River, a small settlement of fishermen called 'Sungai Boba' is located at the boundary separating the flood zone from the central zone. The residents of Sungai Boba usually have their main houses in Tuluk Meranti (a confluence village on the Kerumutan River) or Kapau (a foot hill village on the Kerumutan River). Normally, newly-married couples live in Sungai Boba until their children enter schools and then they move to one of the main villages. They try to save money by living in the fishermen's settlements and they use their savings to start a business after moving to a main village. Fish are sold in Tuluk Meranti or Kapau that are visited every week by Chinese or Minankabau traders from Pekanbaru, the capital of the province.

Fishing tools and techniques are summarized in Table 28.3. There are no taboos about which fish to eat or not to eat, but tortoises (*kura kura*) and soft-shelled turtles (*labi labi*) that have been caught in fish traps must be avoided. If caught, they are released or sold to the Chinese.

The most popular game that the villagers hunt is the deer (*rusa: Cerbus unicolor*). There are three methods in deer hunting: *bulu* (hunting using dogs), *jerat* (traps) and *tembak* (shooting). The hunting of the mouse deer (*perandok: Tragulus javanicus;* and *napuh: T. napu*) using small traps is less popular, but this game is the most abundant. The populations of gibbons (*ungko: Hylobates syndactylus*), macaques (*kera: Macaca fascicularis, book: Macaca nemestrina*), and wild boars (*babi: Sus scrofa*) are very high and are potential sources of food for the villagers. However, it is taboo for Malay people to eat these and other mammals (Table 28.4), reptiles and amphibians. Medicinal uses of these animals are noted below.

The taboos against eating mammals are rather simple: only deer and mouse deer may be eaten. In contrast, the taboos against eating certain species of birds

Table 28.3 Tools for fishing observed in Tuluk Méranti, Sumatra.

Name	Type	Materials	Caught fishes	Methods
embatan lintan	fishnet with a folding flame lens shape: ca. 6 × 3 m with sensor strings	aur bamboo (*Bambura vulgaris*)	tapa (catfish)	ambush fish going down small streams after spawning
amboi	fishnet with a folding flame lens shape: ca. 4 × 2 m	sowik bamboo (*Gigantochloa rostrata*)	various	scoop fish at small streams or along riverbanks
langian	like amboi but smaller ca. 2 × 1 m	sowik bamboo	small fishes for baits	like amboi
jaring (1)	oblong gill net, large mesh		patin (*Pangasius*)	set across the river, sunken to river bed
jaring (2)	oblong gill net, fine mesh		teakan (*Helostoma*) lais (*Kryptopterus*)	set along flooding forests of Syzigium, where fish lay eggs in rainy season
pukat	oblong net		various	both ends are held by two persons fish are driven to riverbanks
jala	cast net		various	cast from canoes, the net does not reach the bed the net must be twisted on pulling up
serampang	spear	sowik bamboo	tapa, toman (snake-head fish)	in nighttime, used with a torchlight (suluh)
juli	harpoon, the arrowhead is released from the rod	sowik bamboo	patin, belido (carp)	same as serampang but larger fish are caught
pangile	trap, made from fish net and rectangular wood flames		various	put in small streams or along riverbanks with the mouth downstream, without baits
pangile tumbang	same as pangile		various	set with cut coconut fruits inside as baits
campiai	trap, fig-shaped	buluh jaleh bamboo (*Schizostachyum gracile*)	various	set with cut coconut fruits inside as baits
luka	trap, cylindrical	buluh jaleh bamboo, rattans (*Korthalsia flagellaris, K. paucijuga*)	various	set with cut coconut fruits inside as baits
taju	fishing line		toman	young catfish or snake-head are used as living bait
awai	consists of many taju connected to a horizontal rope		toman	same as taju
kail	fishing rod, ca. 3 m long with a sinker	buluh cino bamboo (*Bambusa multiplex*)	various	boiled casaba roots, earthworms, or small fishes are used as baits
smbuang	fishing rod, ca. 3 m long with a float	buluh cino bamboo	buju (snake-head fish, smaller than toman)	living fishes are used as baits
popa	fishing rod, ca. 1.5 m long without sinkers and floats	buluh cino bamboo	various	same as kail

Table 28.4 List of birds and mammals found in KWS.

Vernacular names	Scientific names
Edible birds caught with river side traps	
buung ule	*Ardea purpurea*
buung kompil	*Bubulcus ibis*
bangau	*Egretta eulophotes*
buubg pucung	*Butorides striatus*
bibikit	*Ciconia stormi*
bajubolang	*Ciconia episcopus*
uak uak	*Amaurornis phoenicurus*
bobokik	*Numenius madagascariensis*
Edible birds caught with forest floor traps	
menkout	*Rhizothera longirostris*
pengior	*Rollulus rouloul*
puyu	*Turnix suscitator*
ambang	*Lophura erythrophthalma*
Edible birds caught with birdlime	
punai beruke	*Teron curvirostra*
punai tasi	*Teron fulvicollis*
punai utong	*Teron griseicauda*
punai jambu	*Ptilinopus jambu*
pagam	*Ducula aenea*
baram jambi	*Streptopelia bitorquata*
ketitian	*Geopelia striata*
limbuan	*Chalcophaps indica*
cawai	*Dicrurus aeneus, D. remifer, D. sumatranus, D. paradiseus*
bibiik	*Merops viridis*
pinatau	*Aegithina viridissima*
buron daun	*Chloropis cochonchinensis*
sapoca	*Pycnonotus melanoleucos*
ketilang	*Pycnonotus aurigaster*
boba	*Pycnonotus tympanistrigus*
mulai batu	*Copsychus malabaricus*
sangkarak	*Acrocephalus orientalis*
bungosam	*Orthomus sutorius*
cincilak	*Prinia inorata*
injik taik	*Motachilla cinerea*
incit baldu	*Nectarina calcostetha*
coce	*Arachnothera longilostra*
bung incit	*Prionochilus thoracius, P. maculatus, P. percussus, Diceaeum agile, D. trigonostigma*
incit api api	*Zosterops chloris*
pipit pinang	*Lonchura striata*
pipit puntung	*Lonchura leucogastroides*
pipit uban	*Lonchura maja*
tempuo	*Ploceus hypoxanthus*
Birds of taboo to eat	
elang	eagles (species list incomplete)
bayang	*Psittacula longicauda*
saindit	*Loriculus pusillus*
mompoling	*Eudynamys scolopacea*

punai ondu	*Phaenicophaeus sumatranus*
pokup	*Centropus sinensis*
elang kucing	*Ketupa ketupa*
pungguk	*Ninox scutulata*
binti	*Alecedo meninting, Ceyx rufidosa*
mangkako	*Pelargopsis capensis, Lacedo pulchella*
rankong	*Buceros vigil*
ongangboguk	*Aceros corrugatus*
tauda	*Mealaima chrysopogon*
dundun	*Mealaima rafflesii*
papiye	*Colorhamphus fuliginosus*
pelatu	*Picus miniaceus*
palanau	*Eurylaimus ochromalus*
tanau	*Calyptomena viridus*
tiung tana	*Pitta moluccensis*
mulai tabu	*Pitta venusta*
layang layang	*Delichon daypus*
ompak ompak	*Rhipidura javanica*
tiung	*Gracula religiosa*
Mammals hunted for diets	
rusa	*Cervus unicolor*
napuh	*Tragulus napu*
pelanduk	*Tragulus javanicus*
Mammals used as medicine	
tenggiling	*Manis javanica*
kubung lumut	*Cynocephalus variegatus*
Mammals of taboo to eat	
kukui	*Echinosorex gymnurus*
tupai	all treeshrews and squirrels (species list incomplete)
tupai jonjang	*Callosciurus prevostii*
kubung ati	*Petaurista petaurista*
moncit	all rats (species list incomplete)
landak	*Hystrix javanica*
keluang	*Pteropus vampyrus*
kalilawar	all bats except keluang (species list incomplete)
kukang	*Nycticebus coucang*
kera	*Macaca facilicularis*
book	*Macaca nemestrina*
koka	*Trachypithecus cristatus*
ungko	*Hylobates syndactylus*
beruang	*Ursus malayanus*
musang	*Martes flagula, Priondon linsang*
musang air	*Lutra perpicillata*
omui	*Artonyx collaris*
kucing utan	*Viverra tangalunga, Paradoxurus hermaphroditus, Hemigalus derbyanus*
imau	*Panthera tigris*
imau daan	*Prionaliurus bengalensis*
Mammals of taboo to eat and touch	
babi	*Sus scrofa*

are many, and the criteria to distinguish taboo species from non-taboo species are complex. This difference in complexity between taboos on mammals and on birds is paralleled by the naming systems: the system by which mammals are named is rather simple (for example, all tree shrews and squirrels are *tupai*), whereas that by which birds are named is much more specific and is at the species level (Table 28.4).

The scales of pangolins (*tenggiling: Manis javanica*) are used as an antidote. When someone suddenly falls ill, the villagers usually suspect that he or she has been poisoned by somebody, so they administer one of their various antidotes. In the case of pangolins, their scales are boiled and the broth is taken as the antidote. The roasted hearts of flying lemurs (*kubung lumut: Cynocephalus variegatus*) are also believed to be an antidote.

Birds are caught and usually eaten by the hunters themselves. Some birds are caught using traps of the same construction as the ones used for the mouse deer. Marshes that dry up during the dry season are good sites for trapping herons, storks and water hens. If nests of terrestrial birds are found on the forest floor, traps are set near the nests to catch adult birds. Smaller birds are caught using birdlime. In this method, the sap of *Artocarpus scortechinii* (*towap*: Moraceae) is collected by cutting the bark. The sap is boiled and plastered onto the tips of rods, which are placed where birds perch. It is taboo to eat certain birds (Table 28.4).

Plant use

Full descriptions of flora with their vernacular names and a complete list of useful plants are presented in a separate paper. The present chapter presents only a summary (Table 28.5). Among 254 plant species collected, 41 per cent were used by the villagers as timber, non-wood materials, food, medicine, or as indicators of trap sites.

Villagers who are particularly knowledgeable about forest plants are respected as medical doctors. The daily work of rural doctors includes fishing, hunting, and collecting woods or rattans and a bit of farming. Patients bring small gifts such as sweets when they come to see the doctors. The doctor does not charge fees unless the treatment requires a drug containing rare and precious herbs or other medicinal materials. After the patients have recovered, they present the doctor with a gift of fowl in return for the successful medical services.

Until the early 1990s, rattans were the most important forest products in terms of commercial value. However, the wild rattans are no longer traded because cultivated rattans have become abundant in the markets in Kalimantan. Among the three rattan species commonly found in forests, only *Korthalthia paucijuga* (*rotan*; Palmae) has commercial value. Unlike the other two rattan species found

Table 28.5 List of useful vascular plants collected in KWS.

Used for timbers
Alstonia angastiloba Miq.
Arcidendron bubalinum (Jack) Nielsen
Calophyllum rigidum Miq.
Campnosperma coriacea (Jack) Hall. f.
Durio lowianus Scort. ex King
Evodia aromatica Bl.
Gardenia pterocalyx Valeton
Gonystylus bankanus (Miq.) Kurz
Koompasia malaccensis Maing.
Memecyron acuminatum Sm.
Neoscortechinia kingii (Hk. f.) Pax et K. Hoffm.
Palaquim burckii H. J. Lam
Parartocarpus forbesii (King) FM Jarrett
Parastemon urophyllum A. DC.
Polyalthis glauca (Hassk.) Boerl.
Pternandra galeata Ridl.
Shorea macrantha Brandis
Shorea platycarpa Heim
Shorea teysmanniana Dyer ex Brandis
Shorea uliginosa Foxw.
Swintonia glauca Engl.
Syzygium acuminatissimum (Bl.) Merr. et Perry
Syzygium claviflorum (Roxb.) Wall. ex AM et JM Cowan
Syzygium cymosum (Lam.) DC.
Syzygium decipens (K. et V.) Amsh.
Syzygium dyeanum (Bl.) Merr. et Perry
Syzygium fastigiatum (Bl.) Merr. et Perry
Syzygium incarnatum (DC.) Merr. et Perry
Syzygium lineatum (DC.) Merr. et Perry
Syzygium magnoliaefolium (Bl.) DC.
Syzygium operculatum (Roxb.) Merr. et Perry
Syzygium rhyzophorum Boerage. et Kds.
Syzygium sexangulatum (Miq.) Amsh.
Syzygium stenosum King
Tetramerista glabra Miq.
Tristania sub-auriculata King
Vatica pauciflora (Korth.) Bl.
Used for non timber materials
Alstonia angastiloba Miq.
Areca catechu L.
Artocarpus scortechinii King
Bambusa multiplex (Lour.) Raeuschel ex JA & JH Schultes
Bambusa vulgaris Schrad ex Wendl.
Carallia brachiata (Lour.) Merr.
Cyrtostachys renda Bl.
Daemonoropus angustifolius (Griff.) Mart.
Dracaena gracilis Wall.

	Etlingera elatior (Jack) R. M. Sm.
	Gigantochola aff. *rostrata* K. M. Wang
	Hornstedtia caryphera (Koenig)
	Steud*Hypolytrum nemorum* (Vahl) Spreng
	Korthalthia flagellaris Miq.
	Korthalthia paucijuga Becc.
	Pandanus atrocarpus Griff.
	Pandanus helicopus Kurz
	Polyalthia hypoleuca Hk. f. et Th.
	Schizostachyum gracile (Munro) Holttum
	Tracostachyum sumatranum (Miq.) Kurtz
	Xylopia malayana Hk. f. et Th.
Used for foods, including seasonings and nonessential grocery items	
	Areca catechu L.
	Artocarpus dadah Miq.
	Bambusa vulgaris Schrad ex Wendl.
	Barringtonia racemosa Roxb.
	Barringtonia reticulata (Bl.) Miq.
	Campnosperma coriaceum (Jack) Hall. f.
	Campnosperma squamatum Ridl.
	Chisocheton patens Bl.
	Cyrtostachys renda Bl.
	Curculigo capitulata (Lour.) Kuntze
	Daemonoropus angustifolius (Griff.) Mart.
	Dendrocalamus asper Backer
	Eleiodoxa conferta (Griff.) Burret.
	Etlingera elatior (Jack) R. M. Sm.
	Evodia aromatica Bl.
	Ganua mottleyana Pierre ex Dub.
	Garcinia balica Miq.
	Garcinia bancana Miq.
	Garcinia tetrandra Pierre
	Glochidion borneense (Muell Arg.) Boerl.
	Hornstedtia caryphera (Koenig) Steud
	Korthalthia flagellaris Miq.
	Korthalthia paucijuga Becc.
	Litsea gracilipes Hk. f.
	Mangifera foetida Lour.
	Mangifera macrocarpa Bl.
	Medinila hasseltii Bl.
	Microcos riparia (B. et Kds.) Burr.
	Palaquim burckii H. J. Lam
	Parkia timoriana Merr.
	Physalis minima L. var. indica Clarke
	Stenochlaena palustris (Burm. f.) Bedd.
	Sterculia javanica Br.
	Uncaria glabra DC.
	Willughbeia angustifolia (Miq.) Markgarf
	Zingiber griffithii Baker

Used for medicine	
	Alstonia angastiloba Miq.
	Canthium didymum Gaerm. f.
	Curculigo capitulata (Lour.) Kuntze
	Dianella ensifolia (L.) DC.
	Dillenia suffruticosa Wall.
	Entada phaseoloides (L.) Merr.
	Eurycoma longifolia Jack
	Ficus aurata Miq.
	Ficus fistulosa Reinw. ex Bl.
	Hibiscus macrophyllus Roxb.
	Ilex cymosa Bl.
	Ilex pleiobrachiata Loes.
	Jackia ornata Wall.
	Knema intermedia (Bl.) Warb.
	Melastoma malabathricum L.
	Nepentes ampullaria Jack
	Nepentes mirabilis Durce
	Parastemon urophyllum A. DC.
	Peronema canescens Jack
	Psycotria obovata Wall.
	Psycotria ridleyi King
	Quassia borneensis Nooteboom
	Syzygium fastigiatum (Bl.) Merr. et Perry
	Syzygium lepidocarpum Wall.
	Syzygium zeylanicum (L.) DC.
	Timonius flavescens Baker
Used for indicators of trap sites	
	Elettariopsis smithiae Y. K. Kam
	Stenochlaena palustris (Burm. f.) Bedd.
	Tetramerista glabra Miq.

in mixed swamp forests (*danan; Korthalthia flagellaris* and *rotan guta; Daemonoropus angustifolius*), the *Korthalthia paucijuga* species is found in *meranti paya* and *padang suntai* forests, far inland from the rivers.

Recently, timber has become the most important commercial product, replacing the rattans. The *ongka* method, a method of logging using wood rails and sleighs, is widespread in the Indonesian peat swamp forests. In the Kampar region, the Chinese (Fuchenese) wood traders introduced this method in 1991. Today, not only Malay villagers, but many people from outside Riau Province (people from Java, Lombok, North Sumatra, Aceh and Nias) are also engaged in logging.

Large trees (usually over 40 cm in diameter) are cut by chain saws. The felled trees are cut to 4 to 7 m lengths so that they can be carried (thick and heavy trees are cut into shorter timbers, and the rest are cut into longer timbers). The thick bark, like that of *meranti* (*Shorea*; Dipterocarpaceae), is removed by axe. Wood rails are constructed from the site of the felled trees to the riverbank. These rails are made from the wood of several common subcanopy tree species. A sleigh (called an *ongka*, about 2 m long) made from the wood of *kompas* (*Koompasia malaccensis*; Leguminosae) is placed on the rails. Timber is raised onto the *ongka* using levers (*wacai*) made from *kelat* and hooks (*locat*). It takes six people to pull the timber and sleigh to the riverbank. After the timber has been kept there for more than one month for drying, the logs are tied into rafts. The rafts are pulled by diesel-powered boats to sawmills near the confluence villages.

Logging is hard work and knowledge of trees and forests may help them to improve labor efficiency. For example, woodcutters climb trees to observe the types of trees around them and thereby decide where the timbers should be gathered and where to place the *ongka* rails. The expensive *suntai* (*Palaquium burckii*: Sapotaceae) and *ramin* (*Gonystylus bankanus*: Thymalaeaceae) trees are found in groups in deep peat. Excessively deep peat, however, does not sustain rich forests. In order to find the shortest route to forests dominated by large *suntai* and *ramin* trees, the woodcutters must be able to read the trends in the change of forest types as a reflection of peat depth. Thus, even non-Malay newcomers learn a lot of plant names and their ecological characteristics.

Discussion

Forest conservation

The confluence villagers have the closest interaction with peat swamp forests. The majority of them can be categorized as traders rather than subsistent hunter-gatherers. As is often found in the trader societies, the disparity between the rich and the poor is very pronounced. Importantly, the forests sustain the livelihood of those who have no economic assets. In other words, property in the form of money is not essential for earning a living in the forests. Instead, collective knowledge and experience on the forest are the vital assets on which these communities depend.

Why must the forests be conserved? They have a number of useful ecological functions, such as exchanging gases, conditioning the climate, supplying water and avoiding erosion. They are valuable as a form of biological heritage. They are important as genetic resources. A fourth reason to conserve forests is important as well. That is to secure the nomadic hunter-gatherers a right of living (Manser 1997). However, the population of nomadic hunter-gatherers is shrinking, and almost all will become settled sooner or later. It is not only the hunter-gatherers who rely on the forests, but also many capital-poor people. Securing the right of living of these capital-poor people can be the most important reason for us to conserve the swamp forests.

The most efficient protective policy should be the closure of the swamp forests and to stop exploitive human activities. Abe (1993) argues that peat swamp forests are nothing more than obstacles to the proliferation of development for migrants. However, the relationship that Abe supposed between people and peat swamp forests is an exclusive one that rules out others. Because securing people's right to live is an important reason to conserve the peat swamp forests, it follows that some human activities should not be completely excluded from them.

Today, no visitors come to Kerumutan because there are neither roads nor accommodation. However, within the next five years, roads will be built and Kerumutan may become a sightseeing destination. The visitors may wake up in the morning to the sounds of gibbons, and may enjoy watching the colorful kingfishers, hornbills, storks, monkeys and apes, as well as the beautiful flowers. Plants listed in this chapter and some rare plants are still unlisted as endangered but may need to be saved from extinction. Forests may be explored as sightseeing resources and conserved as a biological heritage and a treasury of genetic resources. However, it must be noted that in addition to these advantages, forests have different kinds of material and spiritual significance to the everyday life of the local people. Seeking ways to conserve such significance for the local people is an important subject for ethno-biologists and students of area studies to pursue.

In protected areas of the Kerumutan Wildlife Sanctuary, commercial logging is prohibited but daily use for subsistence is permitted. However, because of the recent political crises, the government's protection of the forests has become unreliable. Nevertheless, the forests still remain. Why? Our answer is that the Malay people do not allow newcomers to destroy the Malay way of life in which people interact closely with the forests. With the declining protection by the government, the protective movement by local communities that utilize the forests still persists.

The next question is why are the Malays influential (in the sense that newcomers must more or less obey their customs, and Malays can keep their lifestyles even when a number of migrants come)? In our opinion, the disparity of wealth contributes to this influence. The poorer villagers depend on the forests, whereas the very rich members of the same community have economic and political powers that they are obliged to use in order to help the poorer members. For example, hunters or foresters who know forest plants well are often respected as rural medical doctors. But if all community members were hunters or foresters, none would be wealthy, and thus the group as a whole could not be influential against newcomers. Therefore, an important point may be that people with very different economic fortunes are nonetheless connected in the same community.

Adaptation to environments

How can people adapt to changes in their environments? No doubt in many cases adaptation is the result of trial and error repeated through a long history. This is the reason why tradition is respected. However, it also must be noted that a long history is not always required. For example, the rice cultivation system of the confluence villages in the Kampar region has become established within a single decade, the 1950s. How were these villagers able to adapt so quickly to the change in their environment? In our opinion, the network of trading, marriage and migration have played great roles in the quick adaptation.

Through trading, confluence villages are closely connected with foot hill villages located upstream. Malay society is matrilineal, and many men come from foot hill villages to find spouses in the confluence villages. Foot hill villages have traditions of upland shifting cultivation. Thus, it is understandable that rice cultivation in the swamps of confluence villages is modified from upland shifting cultivation. The rice transplanting in mineral soils, a method used in rice fields, was brought from the cultivation of *sawah* practiced by the foot hill villages and was adapted to the conditions in the confluence villages. Fruitful and quick adaptations are a result of a spontaneous processes mediated through the network connecting the different types of villages.

Avoiding over-exploitation and the Malay network today

How is over exploitation avoided? The network may also be a key to this issue. Confluence villagers open only those forests that are suitable for agriculture. After the mixed peat swamp forests in the central zone were developed, some Malay people moved to the tidal zone relying on their relatives in the fishing villages. Upon arrival, they found that wide areas of the tidal zone were covered with mixed peat swamp forests, so they were able to use the knowledge of forest logging that they had developed in the central zone. The confluence villagers did not have to develop lands that were unsuitable for agriculture because they could locate better lands easily owing to their network.

The use of the network to find better lands can last only as long as the frontiers remain. Once these frontiers have disappeared through development, what will these villagers do? There may be two solutions. Today, the Malay network is spreading to the cities. The expansion of the network, whose economic power is far less than that of the Chinese network, depends in part on cash earned by logging. For the Malay network to survive in the cities, parts of their population must be assimilated into the urban society. On the other hand, the Malay people in the tidal zone are now familiar with the intensive agriculture developed by Banjar and Bugis migrants. Thus, considerable numbers of Malay people will be engaged in intensive agriculture in the tidal zone.

The Malay network today includes diverse strategies for survival: 1) the knowledge-intensive ways of hunters, fishermen and foresters in the central zone; 2) the labor-intensive ways of farmers in the tidal zone; and 3) the capital-intensive ways of traders in the cities. Because Malay society is matrilineal, boys seldom inherit their fathers' jobs but seek suitable jobs by themselves. Most Malay boys go through a number of different jobs or lifestyles, as mentioned above, until they find their niche. In this process of deciding what line of work they want, they usually find spouses who are compatible with their abilities, careers and experiences. This is an important process in forming the Malay network. In addition, they do not hesitate to change jobs when social or environmental conditions change. Thus, before their living conditions decline through over-exploitation, they will be able to find other ways to live, as long as the Malay network is kept sound.

Conclusion: what is the Malay network?

The lowland plains include various environmental conditions forming zonations where different types of villages are established. The villages are not self-sufficient, but require intensive trading connections to the other types of villages. Movements of people among the differing types of villages are also frequent in forms of marriage and migration.

The Malay network of trading, marriage and migration will sustain relationships between people and forests when considering four points. Firstly, poorer members and richer members are included in the network. The former have a closer relationship with forests, and the latter have economic and political powers to protect the lifestyles of poorer members even when large numbers of newcomers immigrate. Secondly, techniques of land use developed under various conditions are well mixed and quick adaptations to environments are enabled. Thirdly, before a certain area is devastated by over-exploitation, people can find other ways to live and migrate to other areas. Fourthly, after the disappearance of the frontiers, the Malay network has recently been expanding to cities, and intensive ways of land use developed under the Malay network may help to avoid over-exploitation of the lowland plains.

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29
Aquatic Eco-resources Management and its Changes in Laos

IWATA Akihisa

About ninety per cent of the land of Lao PDR is in the Mekong River basin, the major source of natural bounty that this country is endowed. Of the average animal protein intake of 22.5 kg per person per year, about 40 per cent is supplied by aquatic products, which amounted to 42,800 tons in 1998 (Modadugu et al.2000). The Japanese, who are renowned fish eaters, consume 6.4 kg of fish products, or 20 per cent of their total animal protein intake of 31.4 kg per person annually (Fisheries Agency 2001). The Laotian government plans to increase per capita animal protein intake to 20 to 23 kg by the year 2020. Since pressure from fishing on natural water bodies is almost at the upper limit, the government has very high hopes for aquaculture promotion (Modadugu et al.2000). This chapter, first of all, explains the general features, utilization and management of aquatic eco-resources on the basis of information collected in Savannakhet Province, southern Laos. Next, it discusses some related causes affecting aquatic eco-resources and, finally, it focuses on expected methodologies for future management of aquatic eco-resources.

Features of aquatic eco-resources in Laos

Aquatic eco-resources in Laos are comprised of many varieties of species, including Crustacea, Mollusca, Amphibia, and Reptilia as well as fish. One of the striking features of fish in Laos is the high ratio of the superorder OSTARIOPHYSI. This superorder is comprised of carps, loaches and cat fishes and are characterized by a special structure of the first to fourth vertebrae, and their high diversity of habitat and body size. Baird (1999a) reported that out of 318 freshwater fish species in southern Laos, 243 species, or 78 per cent belong to OSTARIOPHYSI. Many species of this superorder are seasonal migrants. In the rainy season, small and middle sized fishes go into temporal water areas; namely paddy fields and road-side canals and ditches, which go dry in the dry season. Consequently, there are a large number of fish around human habitation. These fish are caught easily by simple fishing gears. On the other hand, many large fishes also swim up main stream of rivers. Such fish are caught by more skillful fishing techniques. This matter supports high diversity of fisheries. In the dry season, people continue to fish in rivers and ponds. However, the yield is much lower than that of the rainy season. The frog is one of the very important aquatic eco-resources for people during this season.

Fishery in Laos

Claridge *et al.* (1997) categorized fishery in Laos into 20 types: scoop nets and scoop baskets (5 different gears included); nets with handles (4); cast nets (2); large nets (6); scissor nets (2); horizontal cylinder traps (5); upright basket traps (3); plunge basket (1); branch-bundle fish attractant devices (4); drop-door traps (3); hook and line gear (9); current filtering gear (6); box enclosures and fences (2); pit trap (1); spears (3); guns (1); catching by hand (1); emptying wetlands (2); poisons (2); explosives (1). The author recognized fishery in Savannakhet Province as follows: scoop nets and scoop baskets (2); nets with handles (2); cast nets (1); large nets (2); scissor nets (2); horizontal cylinder traps (4); upright basket traps (3); plunge basket (1); branch-bundle fish attractant devices (1); drop-door traps (2); hook and line gear (3); current filtering gear (3); box enclosures and fences (1); emptying wetlands (1) (Figure. 29.1, Table 29.1).

Many people, male and female, young and old, invariably do practice fishing in various degrees in various types of wetlands. Different methods and gear are used in different places and occasions. *Sawing* (scoop net), *sadong* (square net) and *gneng* (net with two handles) are used in paddy fields, shallow ponds or small rivers mainly by women and children. *Bet pak* (small-scale angling) is a type of fishing gear normally used by boys in paddy fields and shallow ponds. *Bet piak* (large-scale angling), *he* (cast net), *mon* (gill net), *jip* (long bag set net), *katong* (scissor net), *lop* (horizontal cylinder trap), *sai* (horizontal cylinder trap), *toum* (upright basket trap), *kha* (branch-bundle fish attractant device) and *jan* (drop-door trap) are operated by adult men at some fishing grounds, such as, the large and deep ponds or rivers far from their settlement. Collaborative, group fishing using one particular method and involving many people is rarely seen, because large-scale fishing is not popular. Some people gather to establish a *li* (small-scale fish weir). When all of the village folks are seen catching fishes in a communal pond, it is normally for preparing their annual festival.

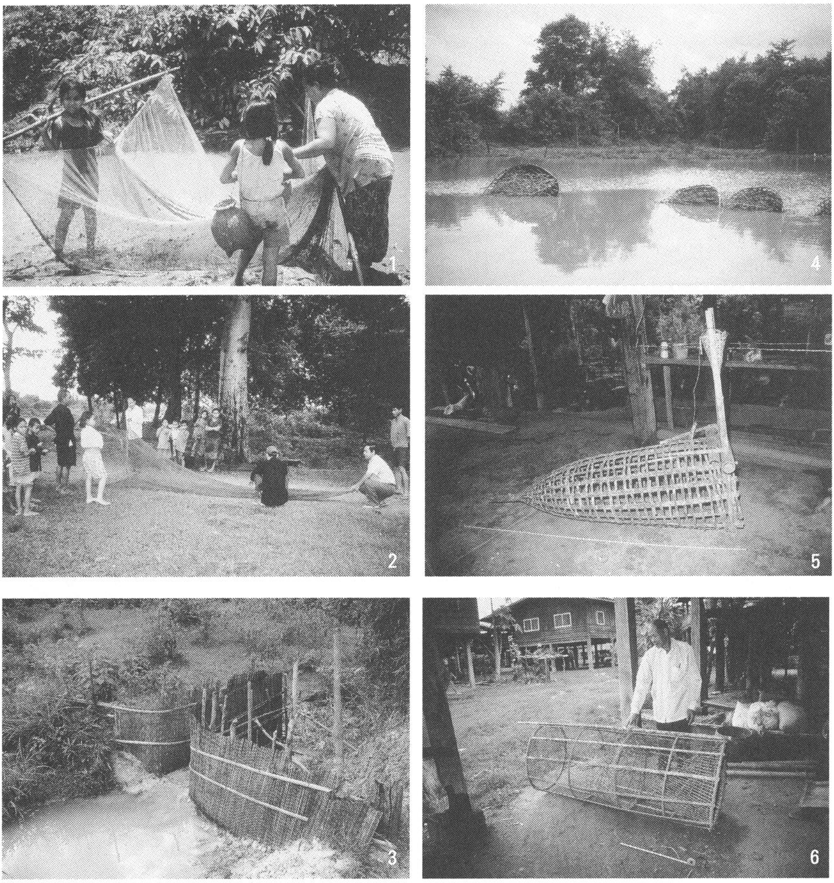

Fig 29.1 1 *Gneng* (Large net); 2 *Jip* (Scissor net); 3 *Li* (Current filtering gear); 4 *Jan* (Drop-door trap); 5 *Kha* (Branch-bundle fish attractant devices); 6 *Lop* (Horizontal clinder trap)

Management of aquatic eco-resources

Laotian villages are categorized into three groups on the basis of relative elevation or distance from rivers or large ponds: *ban xe* (river village), *ban thong* (plain village), and *ban khok* (hill village). They are loosely associated to each other by way of barter trade and by sharing common local markets(Mushiake, personal information). It is interesting to note that such a unit shares the usufructuary right of catching aquatic eco-resources in certain water bodies in the area. For example, the usufructuary right for three ponds in Lahanam-Thong village, named Nong Oho, Nong Thaifua and Nong Pa Tyap are shared by five *ban xe*

Table 29.1 Fishing types and methods in Laos

All area	Savannakhet province**	
Category*	Fishing gear	Local name
Scoop nets and scoop baskets (5)	1	*Sawing*
Nets with handles (4)	2	*Sadung* *Dang tong*
Cast nets (2)	1	*He*
Large nets (6)	2	*Mong* *Gneng*
Scissor nets (2)	2	*Jip* *Katong*
Horizontal ctlinder traps (5)	3	*Lop* *Sai* *Sai gop*
Upright basket traps (3)	3	*Toum lan* *Toum ian* *Toum pa kot*
Pluge basket (1)	1	*Sum*
Branch-bundle fish attractant devices (4)	1	*Kha*
Drop-door traps (3)	2	*Jan* *Jan pa ko*
Hook and line gear (9)	2	*Bet pak* *Bet piak*
Current filtering gear	2	*Li* *Sone*
Box enclosures and fences (2)	1	*Pheuak*
Pit trap (1)	1	*Lum*
Spears (3)	0	
Guns (1)	0	
Catching by hand (1)	0	
Emptying wetlands (2)	1	*Kaso*
Poisons (2)	0	
Explosives (1)	0	

* Clasification categories and number of fishing gears (in parenthesis) of all the area of Laos followed Claridge *et al.* (1997).
** author's observation.

and *ban thong* in the area and, interestingly, the right is extended to cover twelve more *ban khok* during the dry season. The reason behind this practice is that all of those concerned know that the people in *ban khok* will suffer from severe shortage of animal protein, notably fish.

Box

Fish ecology and local knowledge of fishery

Southeast Asia yields many freshwater fishes both in the number of wild species and species in the standing rice fields. None of the fishes in the Mekong river have been studied thoroughly enough to clarify their life histories and ecological characteristics. On the other hand, local knowledge on fish ecology has played an important role in sound aquatic resource use and management. Here is some local knowledge of fish ecology collected in southern Laos.

Twenty-five types of fishing gear are recognized in Savannakhet Province, southern Laos,. Each one of which was found to reflect the ecological character of the targeted fishs. A gill net (local name, *mong*) is usually set in standing water in the afternoon and evening, and it is drawn up the next morning. Because nocturnal fishes move at night and even diurnal fishes become more active at twilight times, they are netted. Middle to large sized cyprinid fishes and swiftly swimming catfishes have a tendency to school at the junction of rivers where the flow is strong and turbulent. The people know their ecology and a gill net is so set to drift into such points. A kind of scissor net (*jip*) is used to catch spawning schools of the large catfish, Wallago attu. This fish runs into temporal water areas e.g., oxbow lakes from the Mekong main stream when water level rises rapidly after heavy rains at the beginning of the rainy season. People can predict the spawning time of this fish that occurs only two to three times per year and set the *jip* at a small creek connecting the oxbow lake with the river. Horizontal cylinder traps (*lop*) and the drop door basket (*jan*) are set in migratory channels for the nocturnal large catfish and snakehead. A different kind of horizontal cylinder trap (*sai*) is the fishing gear to catch fish that swim in the rapids of the creeks. Various kinds of baits are placed in upright basket traps (*toum*) to lure targeted fishes into them. People know the feeding habits of each fish and change baits accordingly. They also change baits for angling (*bet*). Earthworms are used in the paddy fields and so are shallow swamp dwellers, e.g., *Anabas testudineus, Clarias batrachus* and *Channa striata*. On the other hand, living small fish such as Clarias batrachus are hooked to a thread to catch large catfishes in the mainstream. Fish luring baskets (*kha*) are filled with a bundle of leafy bamboo and sticks because many small fishes and shrimps are lured to such kinds of shelters. A kind of fence filter trap (*li*) is set to receive overflow water from the paddy field. Some kinds of small cyprinid fishes, cobitid fishes, snakeheads, spiny eels, swamp eels, *Anabas testudineus, Clarias batrachus* and shrimps run into paddy field in the rainy season to reproduce and/or grow up there, and migrate out again with the draining water and are trapped.

Fig 29.2

The recognition of diminishing resources and an awesome feeling toward the natural spirit (*phi*) shared invariably among the local people has helped them shape regulations to conserve their aquatic eco-resources. Two pools, Wan Gen Li and Wan Morn and a pond, Nong Morn, in the Champhon River near Lahanam-Thong village are a protection zone, and fishing is prohibited from January to June. Regulations agreed upon in Nong Hong village are that all of the fishing methods are prohibited except for *sawing*, *gneng* and *bet pak*, which are all fishing gear used by women and children. Peoples of the same ethnic group, called '*ghatan*', (Mai, Dong, Bomg Khan Hou and Kamshida villages) also had usufructuary of this pond. Nong Me Harn pond in Kengkok village was strictly prohibited to any kind of fishing to protect the aquatic eco-resources, but according to village children, alligators have kept villagers away anyway (Figure. 29.2). Actually, villagers catch fish that flow down from this pond. The people of Nakhou believe in a *phi* named '*Jao Ban*' (village head) who lives in their pond (Nong Khou). They do not dare to fish in this pond, except for one day a year when they prepare food for the annual festival. All of the villagers are allowed to catch fish in the protected pond on this special day. In case of Dondeng village, any ponds in which soft shell turtles are found are the protected ponds, as they are believed to be the *phi* there.

Change in the quantity of aquatic eco-resources

The Vietnam War seriously affected the aquatic eco-resources in this country. As much as 1,595 m^3 of 2-4-T and 2-4-D were sprayed between 1965 and 1969

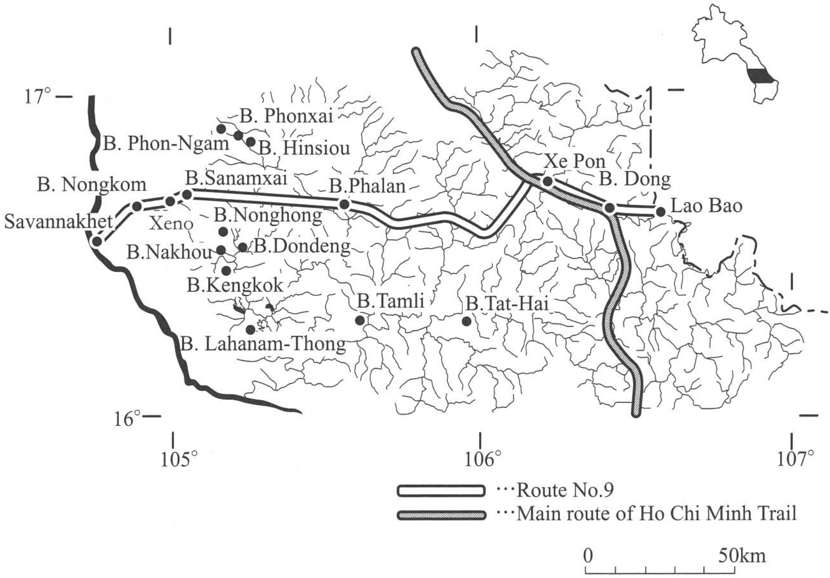

Fig 29.3 Xe Bang Hiang Basin

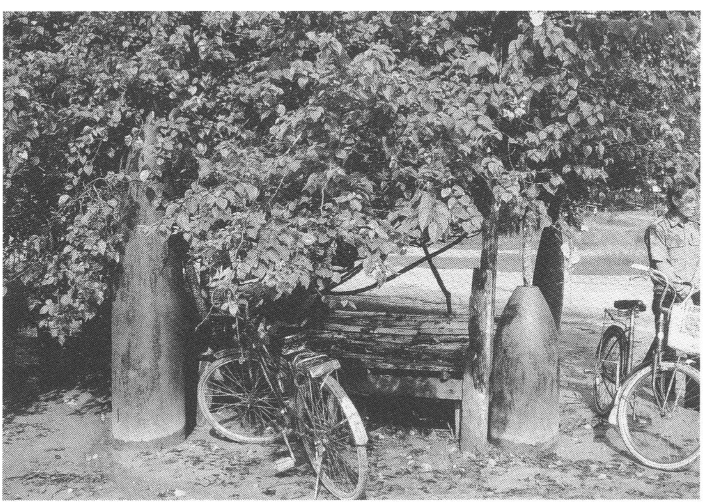

Fig 29.4

and 2.2 million tons of bombs were dropped (Furukawa 2001). In Savannakhet Province, many kinds of bombs were used to destroy the Ho Chi Minh route, a part of which runs through northeastern area of this province (Figure. 29.3 and 29.4). All of the informants from this area said that many of the river courses became very shallow due to sand and mud deposits, and the quantity of fish was seriously reduced during and after the war. After the revolution in 1975, aquatic eco-resources declined continuously because of over-fishing and the combined effects of the use of strong nylon gill nets, ice and cool boxes, improved roads and better marketing (including export to Thailand), which were all associated with the incoming market and monetary economy. Dam construction resulted in serious changes in the habitats of aquatic eco-resources as well as in the general basin-wide ecosystem (Anonymous 1999). The development of an irrigation network has also brought about drastic changes in aquatic eco-resources and deforestation has caused environmental degradation (as stated in earlier paragraphs).

Change of local rule

The government promoted *beng din beng paa* (land and forest allocation). Although water bodies were not included in this new allocation policy, some villages reformed their traditional rules of fishing in accordance with this policy, and even adopted an exclusive rule. For example, Nong Hong village, which used to permit other villages belonging to the same ethnic group to fish in the pond, has now decided to exclude other villagers.

Aquaculture project

Aquaculture is not a new venture in this country. It started in the French colonial period, when two aquaculture stations were established at Nong Teng, near Vientiane and Pakxe. After the withdrawal of France in 1954, the US rehabilitated the two aquaculture stations, and established another similar station at Luang Phabang. Tilapia (*Oreochromis niloticus*) which were introduced from Thailand, and the common carp (*Cyprinus carpio*) were major species cultured in the stations. The US project continued until the advent of Vietnamese army in 1971. Several more hatcheries and aquaculture centers were established with the support of China and Vietnam in this period.

After the revolution, experts from the USSR released the African species *Clarias geriepinus*, which reaches 1.5 m in maximum body length, in the

Table 29.2 Aquaculture and related projects after revolution of Lao PDR.

Cooperating Agency	Project Name	Duration
Interim Mekong Committee	Rahabilitation of Nong Teng Fish Farm	1977-1978
Interim Mekong Committee	Tha Ngon Pilot Fish Farm	1978-1988
Interim Mekong Committee	Aquaculture Training Center	1983-1984
FAO	Rehabilitation of Fish seed farms and Fish culture development	1978-1989
FAO	Provincial aquaculture development	1997-2000
FAO	Telefood project	1997-1998
Asian Institute of Technology	Outreach project in Savannakhet	1993-cont
CARE	School Nutrition Pilot Project	1992-1995
ACIAR/IDRC	Indigenous fishery development and management in Lao PDR	1996-1998
ACIAR	Small-scale wetland indigenous fisheries management in Lao PDR	1999-2001
IDRC	Indigenous fishery development project	1990-1993
AusAID	Community activities scheme: providing small-scale support to backswamp fisheries development	
Marine Resources Assessment Group	Reservoir fisheries management, Savannakhet Province: comparative study of effect of aquaculture and irrigation on fisheries	1995-1997
Marine Resources Assessment Group/RDC	Community pond project	1999-2002
Imperial College, London	Impacts of irrigation and aquaculture development on small-scale aquatic resources	1998-2000
UNDP	Introduction of aquaculture to reduce opium cultivation	
GTZ	Food for work program: pond constuction	
EU	Microcredit: loans to farmers to dig ponds in Luang Phabang	
EU	Forests conservation and rural development support of fish culture	
World Concern	Hatchery construction in Luang Namtha	
Save the Children	Credit for pond culture in Saravane and Bolikhamxay	
Japanese government	Construction of Xekong aquaculture station	1992-2000
Japanese government	Aquaculture Improvement and Extention Project	2001-2004

Abbreviation
FAO: Food and Agriculture Organization of the United Nations, CARE: The Humanitarian Organization Fighting Global Poverty (CARE), ACIAR: Australian Center for International Agriculture Research, IDRC: International Development Research Center, AusAID: The Australian Agency for International Development, RDC: Regional Development Center, UNDP: United Nations Development Programme, GTZ: Deutsche Gesellschaft für Technische Zusammenarbeit, EU: European Union

aquaculture ponds. Other aquaculture projects carried out after the revolution are summarized in Table 29.2(modified from Modadugu et al.2000).

In 2001, a big project called the 'Aquaculture Improvement and Extension Project' started under the support of Japan (JICA). This project was aimed at increasing condition factor of parent fish by 30 per cent and minimizing mortality rates of larvae and juveniles. The project selected two alien species as parent fish, the common carp and tilapia as well as two native, *Puntius* and *Clarias* species (Taki, personal information). It is estimated that 500 million fingerlings are required to increase the fish supply by 10 kg person per year.

Discussion

Management of aquaculture

A large amount of fingerlings of aquaculture fish will be produced for release into water bodies suitable for aquaculture, which are ubiquitous and plentiful. However, we have to be careful to keep the aquaculture seeds in a strictly artificial environment and be sure not to let any of them escape into the natural aquatic eco-systems. We have observed in many places and on many occasions in many countries, however, that aquaculture seeds easily spill over into the environment, causing serious damage to natural aquatic eco-systems. Some countries, such as Australia, offer cash rewards to people who help catch and remove the common carp which is causing serious environmental nuisance (Baird 1999b). Genetic disturbances in association with contamination by cultured native fish are also noticeable. On the other hand, we hesitate to clear forest, bush and plain in a large scale to make more rooms for modern fish ponds, because local people collect various kinds of timber and non-timber forest products in such areas, and this constitutes the subsistence sustenance for local cultures. Under this circumstance, paying more attention to paddy field aquaculture is worth noting. Small and medium-sized wild native fish such as *Esomus metallicus* can be cultured with larger aquaculture fish if paddy plots have different water depths and each plot is separated by fences (Figure 29.5). *Li* may be used effectively to keep all of the fish confined in the paddy fields. It is also possible to keep different fish species in a plot by providing a deep ditch(es) in a central part. Stock ponds will be necessary to keep fish in the dry season. Never use protected pond where conserve native aquatic eco-resources for stock pond of aquacultured fish. When the seeds of cultured native fish are released in the natural eco-system, they must be fingerings of the same genetic structure as those with natural water body to minimize genetic disturbances.

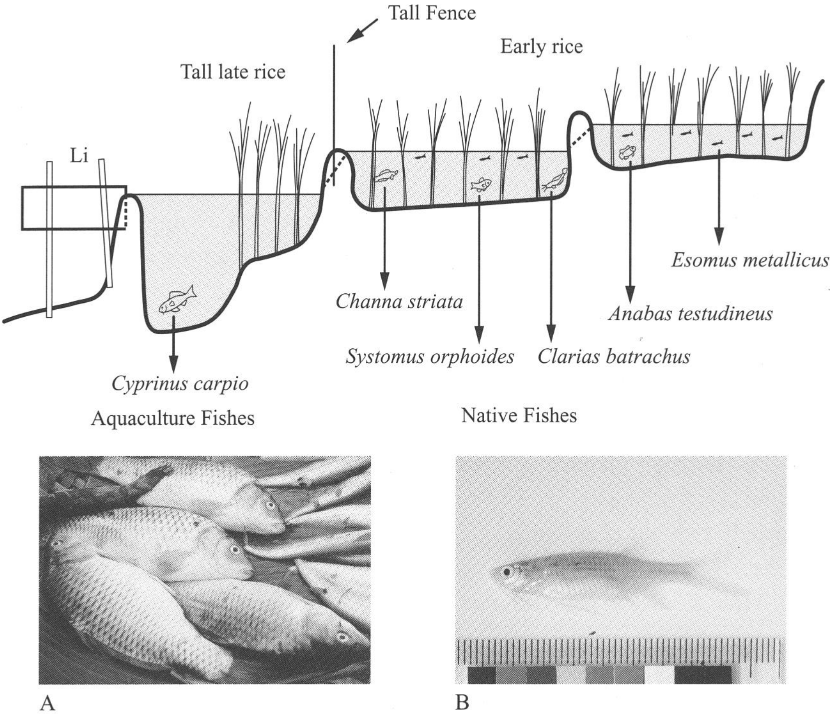

Fig 29.5 Schematic figure of paddy field aquaculture for coexistance aquaculture and native fishes. Note combination of different water depth paddy fields and rice types, and presence of Li and Tall fence. A: Aquaculture fish, *Cyprinus carpio*. B: Important native fish in paddy field, *Esomus metallicus*.

Management of natural aquatic eco-resources

Related to aquatic eco-resources management in Laos, Article 3 of the Decree on the protection and Management of Wild Life and Fisheries reads as follows: 'the uses of military arms, explosives, poisoning, chemical substances, and destructive devices are strictly prohibited', and 'the hunting and fishing of wild animals and fishes categorized in restricted species list, fishes of spawning season, pregnant animals, etc. are strictly prohibited'. This is the only national law. While there are many useful local customary rules to conserve natural aquatic eco-resources. These rules will be more expected and become important in managing natural aquatic eco-resources in the future. Scientific research in the areas of fish taxonomy and habitat ecology must be carried out to support these rules.

As Ishige and Raddle (1990) note, *padek*, fermented fish, are not only a very important food for people's livelihood, but also constitute basic food culture in this country. *Padek* is made from small and middle-sized natural fishes. The

Box

Multipurpose land use in Laos

Agroforestry has won keen interest as a new technique for multipurpose land use in the tropical region. Laos abounds in multipurpose land use using a bit different method and traditional modes. Here are some typical examples.

People have carved out rice paddy plots in a large expanse of dry dipterocarp forest that extends over the hilly regions encompassing southern Laos and northeast Thailand. They are basically rain-fed and have quite a number of trees that remain standing. This interesting landscape characterizing the area was named "rice producing forests" by Takaya and Tomosugi [1972]. The rice producing forests produce not only paddy rice but also timber. Greenstaff et al [1986] recognized 54 species of plants in this type of rice paddy field. Yasuyuki Kosaka counted 18 tree species in similar fields in southern Laos and reported that all of these trees except one were used not only for timber and charcoal, but also for food, tableware, resin, medicine and compost. Mushiake et al [2002] found in a southern Laos rural market as many as 97 different plants were sold after collecting them from similar rice producing forests.

In the rainy season, the flooded fields becomes the habitat of many fishes. For example, striped flying barb (*Esomus metallicus*), chevron snakehead (*Channa striata*), climbing perch (*Anabas testudineus*), and the walking catfish (*Clarias batrachus*) are seen commonly where the standing rice crops are very high. People catch these fishes for daily food using *li*, a kind of fence filter trap made by many kinds of woods available in the forest. Threads of a cast net are treated with the barks of some trees in the fields e.g., *Careya sphaeriva* (*kadon*) and *Peltephorum dasyrachis* (*safang*) to make them water resistant. In the dry season, the frog lying hidden under ground to escape desiccation is another important animal protein source. The rice producing forest provides important habitat for birds, mammals, reptiles and insects, all of which nourish the local people with rich animal protein. Even salt can be made out of salt-bearing soils found on the surface of the paddy fields.

The people's knowledge and wisdom based on the ecological resources have resulted in the multipurpose land use.

high diversity of aquatic eco-resources, including many species of small and middle-sized fishes, maintains the Lao culture (Hubbel 1999). The best way to conserve aquatic and environmental eco-resources is, paradoxically, to have local village people continue to catch as many species of fish as possible for their home consumption and sustenance, abiding by local regulations regarding aquatic eco-resources conservation.

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30

Social Construction of Indigenous Knowledge: A Case Study of Villagers on the Taxonomy of Soils in South India

K. BALASUBRAMANIAN

In areas such as biodiversity and agriculture, there is a great interest in understanding indigenous knowledge. The manifestation of modernization theory in agriculture led to approaches such as participatory research and farming systems research, which aim at blending traditional knowledge with science. Many international development agencies, universities and research institutions are focusing on indigenous knowledge and have incorporated its use in their development perspectives. Such initiatives are taking place because we fear that indigenous knowledge will be lost to the modern world. Cox (2000) points out, 'Few indigenous societies have been able to withstand the onslaught of western culture.' Asian scientists have asked UNESCO to protect indigenous and civilization knowledge systems (Jayaraman 1999). The globalization process and intellectual property rights are other issues which threaten indigenous knowledge systems. The limitations on intellectual property rights in recognizing indigenous knowledge has led to strong reactions such as: 'The perception that intellectual property is only recognizable when produced in laboratories by men in lab coats is fundamentally a racist view of scientific development' (Mooney 1988). The United States government has guaranteed that a substantial portion of the royalty income from an antiviral drug called 'prostratin' be given to the people of Samoa; since the principle behind the drug emanated from the indigenous knowledge of Samoa (Cox 2000). A large number of books, research articles, journals and newsletters have been published during the last two decades where governments have begun to recognize the role of indigenous knowledge in the development process.

Indigenous knowledge and the sociology of knowledge

Sociologists attempt to discern the structure and the process of knowledge in society. Robert K. Merton states that the sociology of knowledge is 'primarily concerned with the relations between knowledge and other existential factors in society and culture' (1957). *The Structure of Scientific Revolution* (1962) by Thomas S. Kuhn was a pioneering study in the sociology of knowledge where Kuhn argued that scientific knowledge is socially constructed. The postmodern social studies emphasize that social facts have evolved through human construction and, therefore, reality and meaning are socially constructed. In this process, these studies stress the need to focus our attention more on the local and the particular character of indigenous knowledge (Watson-Verran and Turnbull 1995).

As per the postmodernist school, social life not only defines the experiences, but also determines the manner in which the experiences are interpreted. Social structure, function and processes distinguish social life. Social structure and functions are characterized by social stratification in which significant social and cultural distances separate groups within a specified society. Thus, stratification assumes an importance in the social construction of knowledge since different groups may have a different interpretive framework for experiences.

Indigenous knowledge has always been contrasted with modern scientific knowledge (Dusseldorp and Box 1993). There is a dichotomous model of indigenous knowledge and modern scientific knowledge that was perceived as the cause for underdeveloped localities. Hence there are efforts being made to develop a continuum between these two systems. Participatory research and the 'farmer-back-to-farmer' model (Amanor *et. al.*. 1993) are some of the attempts towards establishing such a continuum of knowledge. Fields such as ethno-botany study try to understand indigenous knowledge to establish a relationship with modern pharmaceutical science.

Scholars like Levi-Strauss (1966) argue that the indigenous knowledge emerged out of the intellectual need to classify the natural world because human beings 'inherent a demand for order.'. Diamond (1972) stresses utilitarian value as a reason for the development of knowledge. Berlin (1992), in his pioneering work on ethno biological classification claims that 'the observed and structural substantive typological regularities found among systems of ethno biological classification of traditional peoples from many different parts of the world can be best explained in terms of human beings' similar perceptual and largely unconscious appreciation of natural affinities among groupings of plants and animals in their environment-groupings that are recognized and named independently of their actual or potential usefulness or symbolic significance to humans'.

Berlin (1992) also described the cognitive variations in ethno-biological knowledge on the basis of sex, age and social status. In his study of Aguaruna's ethnobiology, Berlin found that men have greater knowledge of rarely seen birds than women. Berlin attributes the social roles of males as hunters as a reason for the differences in knowledge among males and females. Other scholars like Ellen (1979) and others have discussed the variations in the indigenous knowledge in simple societies based on age, gender, kinship affiliation, ideology and literacy.

Variations in indigenous knowledge in complex societies are not adequately studied. Caste and class are the important social stratification system in India. While one school of Indian sociology believes that caste is to be perceived in terms of cultural relations such as pollution, purity, inter-dining, intermarriages and customary and behavioral perception, another school of thought argues that caste should be seen within the framework of a production relationship. Mukerjee (2000) argues that 'Today, in India, caste in class depicts the reality, and not caste per se or caste and class'. Whatever the nature of the debate, caste and class define the access to economic, social and cultural resources today in India. Caste and class determine skills, access to education and occupations. Thus, the social stratification influences the evolution and management of knowledge. Socialization and social heredity (the process of learning) take place within a particular socio-cultural realm which is determined by class and caste (or caste in class). Gender is another important component in the social stratification. New emerging perspectives on gender argue that the social differentiation processes are on the basis of biological differences. Studies have shown limited access and agencies for women in areas such as education, occupation, employment, wages and household and community level decision making powers. As per the classic statement of Marx, 'environment determines the consciousness' where individuals gain and manage knowledge depending on the position of their group in the social hierarchy.

The study

Soil and indigenous knowledge

This chapter studies and discusses the social construction of indigenous knowledge in an agricultural community in the southern Indian state of Tamil Nadu. This village represents a heterogeneous community with strong market linkages. We focus on the knowledge of the soil as the major thesis of this report. There are very few studies on the ethno-taxonomy of soils. In one study, indigenous knowledge of soil classification by an Iraqw community in Tanzania was studied using participatory rural appraisal (Msanya *et.al.* 1998). Similarly, Kamangira (1997) documented the soil preferences of farmers in Africa and used the indigenous knowledge to develop integrated soil fertility management technologies for the different soil types. However, most of these studies have looked at the community as a homogenous group and hence the cognitive variations in classifying soils have not received adequate attention. We will look into the variations in the pattern of knowledge of soils in terms of class, gender, age and education. The role of caste will also be discussed while attempting to discern the variations in indigenous knowledge.

Methodology and the study area

This study uses multiple tools to study indigenous knowledge of soils. The conventional survey method and anthropological tools such as participant observation and participatory development tools with focus group discussions were used. The conventional survey was employed to study the classification of soils by selected sample households in the village. Each household was given a separate questionnaire and were canvassed based on gender. The data was analyzed using statistical tools such as the ordinal scale correlation.

Anthropological tools such as participant observation were used to study the inner meanings and metaphors of terms. Folklore, folksongs and proverbs were studied to get a better perspective of the indigenous knowledge. Focus group discussions helped to elaborate the soil classification system. Through a process of deduction, the views expressed in the focus group discussions were consolidated and a soils classification was made using indigenous knowledge.

The study was conducted in the village of Arasamarathupatty in the Reddiyarchatram block of Dindigul district, Tamil Nadu. The village lies in a semi-arid zone that receives less than 900 mm of rainfall per annum. Most of the land is rain-fed. Pulses of vegetable and commercial crops such as cotton are the major agriculture for this village. It is a multi-caste and multi-religion village. Hindus of various castes including the scheduled castes, who have been discriminated against for centuries, live in the village. Muslims live on the periphery of the village. The village lies next to a major state highway where the major market and the district headquarters are within 20 km of the village. The agricultural commodities produced in this village are sold in the nearby market and district headquarters. Infrastructure facilities such as high school, primary health centers, retail markets, commercial and cooperate banks and film theaters are available within a radius of 5 km. Regular public transport facilities

Box

Ecotechnology

ECO.TECH.NIE / ek-o-tek-ne,n:
(From Greek: oikos, home + tekne, the craft of useful beauty)

A new approach to decision-making that integrates economics, technology, the natural and social sciences in an effort to consider management alternatives and the long-term consequences of development. (Cousteau, Jacques-Yves, 1996, at Asian Regional Workshop on Ecotechnology and Shaping the Future, Chennai, India)

The term "ecotechnology" is defined as "technologies, which combine the best in frontier technologies with the best in traditional technologies and in the ecological prudence of rural and tribal communities" (Swaminathan, M.S., 1994, Reaching the unreached: Ecotechnology and rural employment. A dialogue. Madras: Macmillan India Limited.)

This concept represents a fusion of the "technology" with "ecology" in the broadest sense, as well as its basic principle of cycles and regeneration, and the system of symbiosis. (National Institute for Resources and Environment, http://www.aist.go.jp/NIRE/eco_tec_e/yakuwari_e.htm)

If we are to attack the severe lack of jobs in rural areas, it is essential that we preserve the employment intensity and ecological strengths of traditional technologies and enrich them with the consumer and market value of modern technologies. (Swaminathan, M.S. 1994, Reaching the unreached: Ecotechnology and rural employment. A dialogue. Madras: Macmillan India Limited.)

Indigenous Knowledge

Grenier defines Indigenous Knowledge (IK) as the unique, traditional and local knowledge existing within and developed around specific conditions of women and men indigenous to a particular geographic area as the basis for decision-making pertaining to food security, human and animal health, education, natural resource management, and other vital activities. The development of the IK systems, covering all aspects of life has been a matter of survival for the peoples who generated these systems. IK systems are also dynamic, new knowledge is continuously added. Such systems do innovate from within and also will internalize, use and adapt external knowledge to suit the local situation. (Louise Grenier, Working with Indigenous Knowledge: a guide for researchers, IDRC, Ottawa, 1998.)

The oral, rural and 'powerless' nature of indigenous knowledge has made it largely invisible to the development community and to global science. Indigenous knowledge has often been dismissed as unsystematic and incapable of meeting the productivity needs of the modern world. As a consequence, indigenous knowledge has not been captured and stored in a systematic way, with the implicit danger that it may become extinct. Fortunately this situation has changed. Since the last decade of 20th century, one may witness an explosive growth in the number of publications on the relevance of indigenous knowledge in a variety of policy sectors and academic disciplines.

Indigenous knowledge should be further integrated in the work of scientists as a complementary contribution to all efforts of science and technology in its search for solutions and strategies to combat poverty and to generate sustainable development. It is therefore fortunate to observe that global science has acknowledged the relevance of indigenous knowledge as well. The World Conference on Science (Budapest, 1999) recommended that scientific and traditional knowledge should be integrated in interdisciplinary projects dealing with links between culture, environment and development in such areas as the conservation of biological diversity, management of natural resources, understanding of natural hazards and mitigation of their impact. Local communities and other relevant players should be involved in these projects. Development professionals consider indigenous knowledge as an invaluable and under-utilized knowledge reservoir, which presents developing countries with a powerful asset. (About Indigenous Knowledge, Nuffic Homepage, 2002)

are also available. From nearly 120 households, we randomly selected 42 households from residential lists using the random numbers method, and questionnaires were sent.

The questionnaires and discussions studied the knowledge of the number of soil types known to the respondents, description of the soil types, qualitative characteristics, and rankings of the soil types. During the study, information regarding soil testing was also collected. The focus group discussions helped us to understand the latent perceptions towards indigenous knowledge. Folksongs and folktales played a key role in consolidating this understanding. The study was conducted as a prelude to participatory research in soil-nutrition management and precision farming. The villagers played a crucial role in conducting the study. The field workers were from the villages where the study was conducted. A specific focus on women's ideas helped to get a better understanding of the gender dimensions in indigenous knowledge. Before conducting the survey, a focus group meeting took place in the neighboring village where many farmers, men and women, and agricultural laborers from neighboring villages came together to prepare a chart classifying the soil types in the region. The characteristics of the soils were cross-checked and consolidated using a process of consensus. This chart became the reference point for the survey to compare the responses of the respondents from neighboring Arasamarathupatty. According to the neighboring villagers, the soil types occurring in Arasamarathupatty were more or less the same as theirs.

Indigenous knowledge of Arasamarathupatty village

Most of the respondents in this village were thirty-one to sixty years of age (Table 30.1). The educational level was lower among women than men. However, very few had higher education for either men or women (Table 30.2). Cultivators dominate the occupations. Small and marginal farmers and landless laborers dominated the occupation pattern of the village (Table 30.3). During the survey, it was found that males own the title deed for the land of all of the farm households. Except for three farm households, the women respondents are actively involved in most of the activities of the farm. Similarly, among the landless laborers families, except in two households, women are actively involved as agricultural workers.

The respondents were asked to identify the number of soil types known to

Table 30.1 Age distribution of respondents in Arasumarathupatty village

Age group	Male %	Female %
Below 30 years	19	24
Above 30, below 60 years	62	69
Above 60 years	19	7
Total	100	100
Number of respondents	42	42

Table 30.2 Educational level of the respondents

Education	Male %	Female %
No education	14	48
Up to middle school level	48	31
Secondary school level	33	21
Colleges and higher education	5	0
Total	100	100
Number of respondents	42	42

Table 30.3 Landholding among males in Arasumarathupatty

Types of farmers	Percentage
Small and marginal farmers (with less than 5 acres)	38
Medium farmers (between 5 to 10 acres)	19
Large farmers (with more than 10 acres)	14
Landless agricultural laborers	29
Total	100
Number of observations	42

them and to describe at least two of their characteristics. Any response, which indicated the name but did not describe the characteristics of the soil were not used for the analysis. The study showed that there is a substantial amount of variation in knowledge regarding soils. While many respondents could hardly classify the soil into two or three types, a substantial number of the respondents could classify four to seven types of soil. In some cases, different respondents called the same type of soil something different. Therefore, while conducting the analysis, such cases were carefully studied and combined together under a single type. Efforts were made to find out why they called the same type of soil a different name. Males were able to identify a larger number of soils than females (Table 30.4).

The variations in the indigenous knowledge of soil were statistically analyzed with the help of ordinal measurements. Using the method of Kendall's tau-b', the study was statistically correlated for each of the grouped categories. The results showed there is no significant correlation between the age of males and their knowledge of the various types of soil. Similarly, the study could not establish a significant correlation between education of males and indigenous knowledge. However, a significant negative correlation was observed between the class of males and indigenous knowledge. Similarly, a significant negative correlation is seen between gender and indigenous knowledge (Table 30.5).

Table 30.4 Number of soil types identified by males and females in Arasumarathupatty

Number of soil types identified by the respondents	Male %	Female %
No knowledge of any type of soil	0	19
Less than 3 types of soil	50	67
Identified 4 to 5 types	38	12
Identified 6 types or more	12	2
Total	100	100
Number of respondents	42	42

Table 30.5 Correlations of various types of groups and awareness of the number of soil types among males

Variable	Kendall's tau-b
Age	.188
Class	-.218 **
Education	-.122
Gender	-.422*

* *p<0.01* ** *p<0.1*

Table 30.6 Correlations of various types of groups and knowledge of the number of soil types among females

Variable	Kendall's Tau-b
Age	.002
Class	-.115
Education	.237*

* *p<0.1*

The data was further analyzed to study the variations among females in indigenous knowledge. According to tables 30.4 and 30.5, females identified fewer soil types as compared to males. Among females there is no significant relationship between age, class and knowledge of soil types. However, a significant positive correlation exists between education and soil types (Table 30.6).

Cognitive variations in indigenous knowledge

Gender and indigenous knowledge

The social roles of men and women are patterned by their position in the social hierarchy. In addition to the inter-group or inter-class, the social hierarchy operates at the intra-group or at the intra-class level. Thus, a woman in a scheduled caste in India is discriminated against on the basis of gender within her own caste as well as in the overall society; she is discriminated against as the member of one of the exploited castes. The vertical and horizontal stratification operating in this society define the access to various resources, including cultural and natural resources. The differences in such access influenced the process of socialization and social heredity among the different groups in different manners. The access to various resources, socialization and social heredity processes, thus define the learning process for indigenous knowledge within this or a given society.

In Arasamarathupatty, the most important difference in the knowledge regarding the soil was based on gender. During the focus group discussions with the males, discussions were directed towards the knowledge of females regarding soil. The males constantly said that females do not know much about soil. They also said that the females need not know about the soil since they play a very limited role in the soil management. They are not involved either as decision makers or as laborers in activities such as plowing or soil amendment. The decisions regarding soil nutrient management are made by males and the male laborers. These decisions are made to determine when to apply organic or chemical fertilizers to the soil. Even for women heading households, farming decisions regarding soil management are determined by men. The focus group discussion with females revealed that women share more or less the same view as that of men. In rare cases, when women purchase agricultural lands, male help is sought to discuss the quality of land, particularly the soil. Interestingly, our cultural heritage considers the land and soil as female. Soil is seen as a manifestation of mother earth.

Mannukku maram barama?
(Can a tree become a burden to soil?)
Petredutha thaikku kuzhandai barama?
(Can a child become a burden to its mother?)

The above song in the Tamil language became popular through films and was quoted many times during the discussions. This reflects the metaphor of the soil as the mother. This metaphor is extended to the social role of the female as one who 'belongs' to the husband's house and therefore has a limited role in protecting and managing her 'mother'. The son has more responsibilities to his mother and, similarly, the male has more responsibility towards the soil. Such social and cultural perceptions reinforce the productive and reproductive role of women, which in turn influence the access and management of various cultural and natural resources. The indigenous knowledge, which is shaped and transmitted through this process of socialization, is bound to vary between male and female.

It is interesting to note that class, which has a significant role in the indigenous knowledge of soil among males, was not significant in the case of women. Their educational level seems to influence the indigenous knowledge pattern among females.

Class and indigenous knowledge

The variations in the indigenous knowledge among men emerge clearly when the pattern is analyzed in terms of class (Table 30.5). A majority of the landless laborers among males identified less than three types of soil. In contrast, cultivators, particularly small marginal farmers and medium-sized farmers, were able to identify a greater number of soil types. The small and marginal farmers use more family labor in operations, like traditional plowing using bullocks. Large farmers use tractors and hence they do not employ manual labor for soil management activities. Therefore the opportunities for male landless laborers to make soil management decisions such as plowing are restricted. On the other hand, the female landless laborers and women from small marginal farms are actively involved in operations like weeding and they are able to closely interact with the soil. They are able to classify the soil because the soil texture determines the workload. For instance, weeding in black soil is more difficult than weeding in red soil and hence demands more labor.

The metaphorical treatment of soils seems to vary from one community to another. The agricultural community predominantly views soil as female, except for the case of mud, which is considered male. A discussion with a group of potters' families in a neighboring village revealed that the potters consider mud as female and normal soil as male. For potters, mud is the primary source of occupation. In a potter's family, males and females are actively involved in the occupation. Women are involved in mixing various types of soil and men are involved in shaping the pots and using the wheel. They use mud from black clay soil and mix it with red soil and sand. The potter families are able to classify up to three types of soil (black soil, red soil and sand). Whereas the agricultural community at Arasamarathupatty was able to classify up to nine types of soil. The continuous interaction with the environment and the nature of the interaction thus become crucial factors in the evolution of indigenous knowledge. Such an interaction is defined by the stratification system and hence the variation in knowledge takes place on the basis of the stratification system.

Indigenous knowledge and its application

Class and gender were able to influence the pattern of indigenous knowledge in Arasumarathupatty. Interestingly, variables such as age and education (except in the case of women) have not shown any significant relationship with acquisition of indigenous knowledge. The nine types of soil that were mentioned by the villagers were analyzed in our soil laboratory. The classification of soil by the villagers more or less corresponded to the classification of modern soil science (Table 30.7).

The soil classification at Arasamarathupatty was based on the surface characteristics of soil. Most soil names end with the word *mann* which means 'soil' in the Tamil language. The adjectives precede the word *mann*. Red soil is called *semmann* and black soil is called *karisalmann*. The word *sem* and *karisal* indicate red and black, respectively. Interestingly, the English word 'color' is being used in *colourman*, which denotes soils with different shades of a single color or sometimes a soil with different colors in various layers. In the case of *kalimann*, *uppumann*, *sukkamann* and *manalmann* the soil texture precedes the word *mann*. *Kali* refers to clay, *uppu* refers to salt, *sukka* refers to lime and *manal* refers to sand in the Tamil language. The word *poochu*, as in *poochumann*, indicates the plastering quality of the soil. The word *vandal* as in *vandalmann* denotes sediment. Thus color, texture and utility are the three criteria used as the basis of soil classification. There are two major types of soil: black (*kalimann*, *karisalmann* and *uppumann*) and red (*semmann*, *colourmann* and *poochumann*). Another important characteristic which is used to distinguish the soil types is the water-holding capacity of the soil. The ordinal rating of soil as having a high or low water-holding capacity has influence on cropping patterns and the value of the land. *Karisalmann* and *semann* are the two types of soil that were identified by most of the villagers. According to them, *karisalmann* is the dominant soil type in the region. Interestingly, *vandalmann*, which is considered the best soil suited for all crops, shows a very low water-holding capacity when tested in the laboratory.

Most of the farmers use organic and inorganic fertilizers for nutrient management in the soil. The organic base and increased vitality of the soil are considered as the outcome of efficient management of soil. Thus, even though *uppumann* is considered as unfit for cultivation, crops such as sugar cane and chili peppers are raised in this soil. Farmers bring tank silt (*vandalmann*) from the lake banks and amend the soil. Green manure is also applied and limited

Table 30.7 Soil taxonomy in Arasamarathupatty

Srl No	Soil name	Characteristics as described by the villagers	Soil lab. classification	pH	E.C. (M.mhos.cm)	WHC (%)
1	*Kalimann*	Black in color, high water holding capacity. Becomes hard during dry period and cracks. Under irrigation it is fit for growing paddy and banana. Under rain-fed condition it is unfit for cultivation.	Black, clay	8.0	0.15	51
2	*Colourmann*	Partly red in color with variations (a variation of *semmann*) and more water holding capacity compared to *semmann*.	Red, sandy loam	8.2	0.14	37
3	*Poochumann*	Hard red soil with a binding effect. High water holding capacity. Used for building constructions. Fit for crops like millets, pulses and groundnuts under dry land conditions.	Red, loam sand	8.0	0.31	42
4	*Semmann*	Red loose soil with very little water-holding capacity. Good soil for agriculture and horticulture demanding more irrigation.	Red, sandy loam	8.0	0.27	33
5	*Karisalmann*	Black but loose when compared to black clay soil mixed with sand, but a hardy soil when compared to red soil. High water holding capacity. The predominant soil in the region. Suitable for cotton, sugarcane, paddy and horticulture.	Black, clay with loam	8.2	0.31	48
6	*Vandalmann*	Soil from lake banks and banks of reservoirs. Loose soil with dull color between black and red. Very poor water holding capacity. Suited for all crops.	Alluvial, sandy loam	7.7	0.15	27
7	*Uppumann*	Highly saline, black with substantial white patches, sometime called pottal, a word signifying the barrenness or limited water holding capacity. Unfit for agriculture. Used by village level traditional washermen for washing clothes.	Black, clay loam	8.2	1.05	38
8	*Sukkamann*	Between white, red and gray in color with a lot of stony and limy particles, coarse grained, sticky during rainy season. Suitable for millets and sorghum.	Laterite, sandy loam	8.0	0.25	34
9	*Manalmann*	A lot of sand, fine grained, loose soil with low water holding capacity. Fit for crops like ground nuts.	Sandy loam	8.1	0.21	31

Table 30.8 Soil amendment and soil testing: the response of male farmers

Response	Soil amendment*	Soil testing**
Yes	37%	47%
No	63%	53%
Total	100	100
Number of observations	30	30

* During this year, did you bring soil from outside and apply it to your land?

** During this year, did you test your soil in the laboratory?

irrigation is given.

Nearly 37 per cent of the farmers amended the soil with soil from outside (Table 30.8). About 47 per cent of the farmers tested their soil using the results to plan their agriculture. More than 50 per cent of the male farmers who tested their soil in the laboratories were also able to describe more than five types of soil. Thus, the male farmers with a high degree of indigenous knowledge are not averse to modern technology and try to get the best using 'both worlds'. Most of these farmers are familiar with concepts of soil microorganisms, vermicomposts and bio-fertilizers. Some of them are using bio-fertilizers. The major reasons cited for the lack of large-scale application of these materials were the management costs, the lack of supply of the materials and the quality of the products.

Women from farm households are much less informed about soil testing even on their own land. Men make the decisions regarding soil testing or applying different soils. Women during the focus group discussions pointed out that men sometimes inform them but do not consult them in making or implementing decisions. Table 30.9 describes the process of decision-making in the farm households of Arasamarathupatty.

According to the above table, men in the farm households of Arasamarathupatty generally do not share information with the women regarding soil testing or soil amendment. The gendered division of labor has assigned women to activities like transplanting, weeding and harvesting, whereas plowing, fertilizer application, irrigation and pesticide application are considered as activities of men. Even among women who knew about the soil testing or soil amendment, the men did not consult with them before making decisions. They were either informed or came to know about the activities from the laborers. Coonrod (1998), quoting a study of the World Bank, argued the assumption made by the exten-

Table 30.9 Decision-making process in the farms households

Srl No	Decisions	Soil testing	Soil amendments
1	Women who knew that soil testing or soil amendment have taken place on their land.	6	4
2	Women who did not know that soil testing or soil amendments have taken place on their land.	6	6
	Number of observations	12	10

sion workers that information within a family was transmitted to the women by men is a false assumption. Her arguments seem to be valid in the case of Arasamarathupatty, where men have not communicated their decisions to women regarding soil management activities. One of the men during a discussion pointed out that jobs like plowing belong to men and he quoted the Tamil word '*uzhava*'" as a term denoting 'plowing' literally means the male who ploughs the land. He argued that there are no corresponding terms in Tamil for a female who plows the land. Sankaranarayanan (2001), while describing the gender bias in the Tamil language, also points out the lack of corresponding terms for the female, indicating an inherited language-based gender bias in this society.

Overview

Indigenous knowledge is one of the important elements of ecotechnology. There is an increasing demand to have the 'best of both worlds' or a blending of indigenous knowledge and modern science to define the path for development. Many countries have begun to institutionalize indigenous knowledge for charting the course for a sustainable development. While these efforts are remarkable, there is also an increasing concern over the conceptualization of indigenous knowledge. In a thought provoking paper on *Archaic Formations of Agricultural Knowledge in South India*, Ludden (1996) traces the history of agricultural knowledge in South India and argues that the agricultural knowledge is influenced by productive power relationships and agro-ecological conditions. He has categorized the agricultural knowledge between the regions of Tamil and Telugu and stresses that differences among regions arose from their histories as agrarian environments. Earlier in this chapter, a reference was made to studies in tribal communities regarding differences in knowledge based on the social role of males and females.

The present study points out the differences in the indigenous knowledge of soil existing within a community. The indigenous knowledge of soil plays a crucial role in the input investment, cropping patterns and in defining the value of the land in Arasamarathupatty. However, the differences in indigenous knowledge are visible in terms of gender and class. The women and the landless laborers seem to have limited access to indigenous knowledge. The social stratification, the cultural norms and access to resources influenced by the production relationships are creating conditions to exclude certain portions of the community in the sharing of indigenous knowledge. Social life thus defines the experience of individuals and groups and develops a framework for interpreting the experiences. Ecotechnology is based on a pro-poor, pro-woman and pro-nature approach that requires an understanding of the social construction of the indigenous knowledge before applying this method to rural development.

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31
A Proposal for Asian Ecotechnology Networking for Eco-Resource Management

KAIDA Yoshihiro

It was almost thirty years ago that Schumacher brought forward the famous notion that 'small is beautiful'. However, the technologies used in regional development projects have remained virtually unchanged during the past thirty years. They have been and still are dominated by large technologies. Whereas most of the technologies used in farming are of the sort of small technologies. Nevertheless, pursuits in agricultural research and modern extension workers have directed farmers towards large and modern technologies. Many people are aware that the future mode of civilization depends largely on a *modus operandi* where powerful technologies are put under control and are ecologically adaptable to local sustainable technologies. This desired transition from the technology-based to the ecology-based mode of development is alarmingly slow.

Technology has progressed for technology's sake. It has become increasingly powerful in a rather aggressive way, as it has been blindly applied to regional developments that modify the earth's surface on a large scale. Contrary to this approach, progressive ecologists advocate nature conservation to save the natural environment without considering economic development. Ecotechnology is proposed as an alternative approach to development by integrating the two parallel pursuits (technology and ecology) on the basis of economic viability and social acceptability (UNESCO). I am interested in revisiting modern as well as local, traditional technologies used in rice-based farming systems in monsoonal Asia. I seek genuine technology that can be applied to regional agricultural development on a more sustainable basis.

Asian agriculture has found itself somewhat lethargic through, facing: (1) a stagnated yield of rice and other cereal crops; (2) environmental disruption through a large dose of chemicals, over use of energy and non-degradable

Table 31.1 Components of ecotechnology

Environmental resource management method	Agriculture, forestry and fishery	Home economies
Soil and land conservation —Erosion / fertility conservation —Land use and land use planning Water management Flood / irrigation and drainage / on-farm water management / water quality Forest management Marine resources management	Cropping and farming systems Production technologies —Fertilizing / crop protection —Agronomic adaptability / varietal improvement —Machines and tools Forest management Fishery management	Post harvest technology Food processing Food marketing Farmers involvement in agro-industries.

plastics; (3) quasi-monoculture of rice that makes peasants' subsistence economy adhere to a more cash-oriented economy; and (4) there is a widening economic gap between the haves and the have-nots. We need to try to readopt locally available, safe and time-tested technology to ensure crop diversity in sustainable cropping systems. Using the 'Asian Ecotechnology Network' to investigate and exchange ideas of 'ecotechnology', we found in the different areas in the region ways of getting out of the 'quadri-lemma', and of promoting a diversified rural livelihood. The participants are particularly interested in the unique local farming systems preserved through centuries-long practices. They are considered as the local people's cultural assets and their intellectual rights must be protected. They will, in due course, publish their findings according to the components of ecotechnology, Table 31.1.

From the group field work discussions, the author presents some of the findings related to land and water management in sustainable farming systems in South and Southeast Asia.

Some interesting ecotechnology used in land and water management

The 'Green Revolution' technology has swept almost all of the rice growing zones in Asia. Nonetheless, there still remains the 'ecotechnology' nurtured by the local farmers. In this chapter, several interesting examples of ecologically sustainable, time-tested, local technologies in relation to land and water use will be presented and discussed.

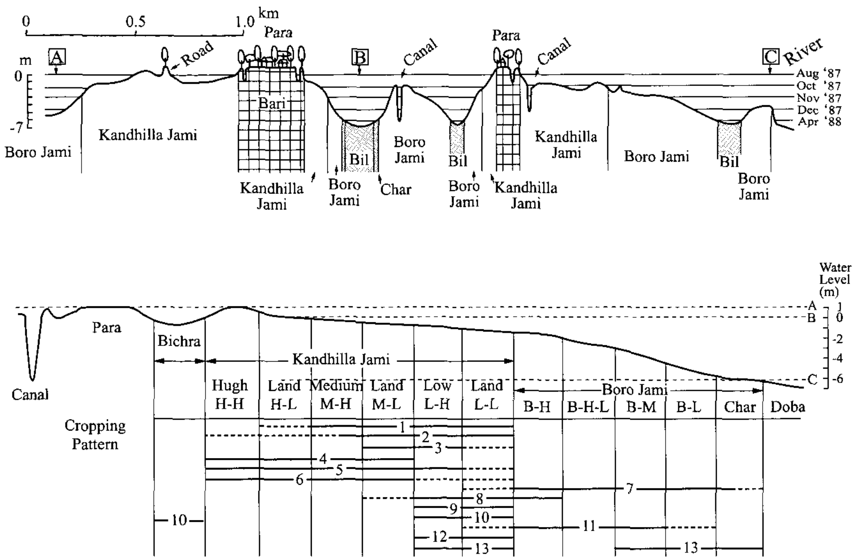


Fig 31.1 Local vs. modern taxonomy of microtopography: local people give exact naming characterizing every slight variation in microtopography. The local taxonomy often times reflects real topo-sequences better than a scientific, but sometimes too mechanical classification scheme.

Taxonomy of micro-topography and soils

Local farmers do not possess any academic knowledge of topography or soils taxonomy. However, every slight difference in micro-topography and soil characteristics is more or less rightly termed using local names that reflect actual conditions and are as good as the corresponding scientific taxonomy. This is called the 'local taxonomy of micro-topography and soils'. A schematic cross-section of a gently sloped land on the fringe of the *haor* in Bangladesh is shown in Figure 31.1 using both local and a scientific mechanical taxonomy (Tanaka, *et al.* 1990).

Controlling acid sulfate soils in the Mekong Delta

The Mekong Delta farmers know precisely the depth of a layer where pyrite and/or jarosite appear, and thus they scoop up uncontaminated surface soils to make ridges of about 45 cm high and 80 cm wide, as shown in Figure 31.2. The ridge may be unplanted in the early part of the first rainy season to ensure leaching of its acidity. The first crop to be planted may be yam, followed by cassava or pineapples which are both relatively acid-tolerant. At the start of the third season, the leached-out ridges are almost acid-free and by this time will

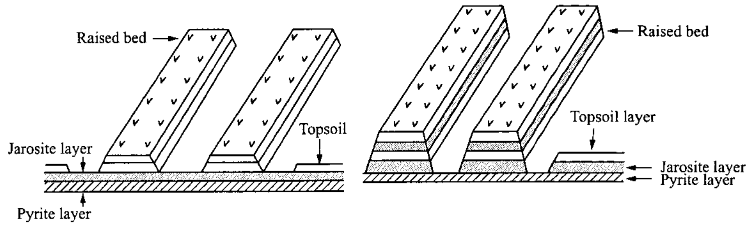


Fig 31.2 Local technology using acid sulfate soils, Mekong Delta, Vietnam: blocks of surface soils free from jarosite are carefully piled up to make low ridges on which acid-tolerant crops can be grown.

support any kind of crops, including long yard beans and sugarcane (Chiem 1994).

Replacing floating rice using double rice system without controlling the flood

The flood prone trough in the Mekong Delta bordering Cambodia used to be planted with a single crop of floating rice that occupied the land for almost nine months before being reaped in January. Since the *Doi Moi*, however, farmers have established a double cropping of pre-flood rice and post-flood rice, replacing the floating rice without implementing any flood control measures. They know the growth habits of the high yield varieties (HYV), which are non-photo-sensitive (Chiem 1994). The farmers live in villages established on safe river levees far from the rice fields. However, during the harvest seasons, the farmers hastily move to their individual makeshift cottages built along the canals and roads in the rice fields and reap the first pre-flood rice before the fields are rapidly submerged in the rising water of the heaviest rainy month of August. Drying, storing and carrying their harvest are big problems since the rice land is totally submerged under deep water when they finish reaping the rice (Kaida 1995). The second, post-flood rice is planted in October or November when the flood recedes.

Intensifying small ditches along with major canalization in the early 20th century in the Chao Phraya Delta

Many of the deltas of tropical monsoonal Asia, such as the Chao Phraya, the Mekong, the Ayeyawardy and the Cauvery deltas, have been reclaimed as major rice producing land using canalization. This was implemented either by governments or by private investors. The main canals provided the early pioneer settlers with drainage, boat communication, banks on both sides on which to build their makeshift cottages, and safe drinking water for humans and cattle.

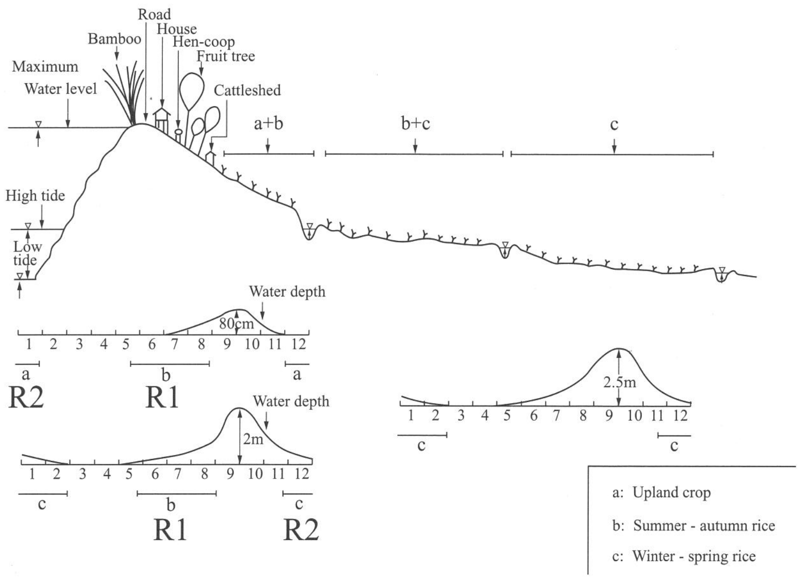


Fig 31.3 Converting floating rice to double rice sytems without flood control (Mekong Delta, Vietnam) : non-photo-period sensitive modern rice varieties can be grown twice a year, one in the pre-flood and the other in the post-flood seasons. Post-harvest pocessing, notably drying, however, poses major problems to the pre-flood cultivation.

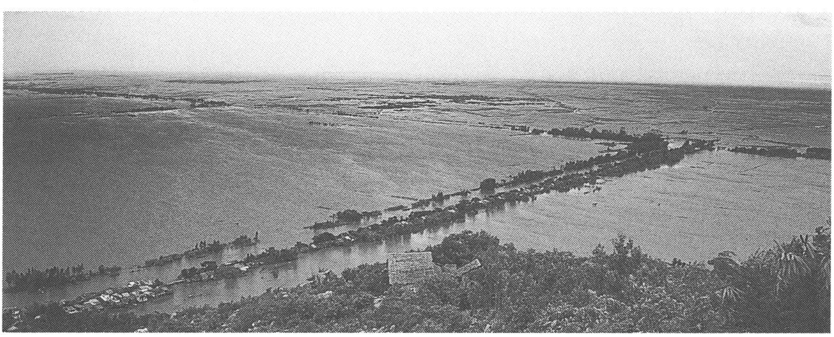
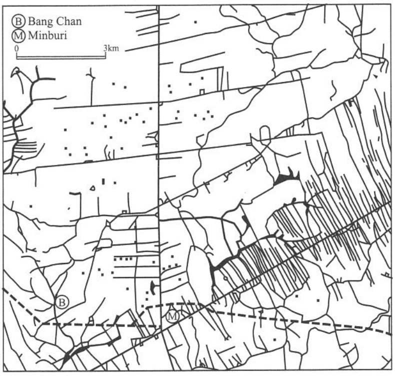


Fig 31.4 Flood at Vietnam-Cambodia border, Mekong Delta: in high flood, floating rice (dots in the water) is seen growing in Cambodia (far back) while it is just an expanse of water in Vietnam.

Once settled safely along the main canals, the hinterland offered the farmers great potential for opening rice fields. The potential was actually realized by digging many small comb-like ditches into the hinterlands, without which one cannot reach the farmer's paddy land. The only transportation was by a small

Plain of Reeds, Mekong delta



Chao Phraya delta in 1910s

Fig 31.5 Early settlement for rice cultivation: banks of canals provide homesteads for pioneer settlers. Main and lateral canals were the lifeline not only for cultivation and transportation of rice, but also for their living and sustenance.

boat going along the ditches. All of the ditch digging was all done by the manual labor of those early settlers (Takaya 1987). Another example of where 'small' technology yields huge benefits.

Complex garden culture in polder dikes

In many of the Asian deltas where fresh water is readily irrigable and drainable, poldered complex garden farming flourishes. This has occurred on the lower Chao Phraya Delta (Kaida 1991), the active, fluvial mid-part of the Mekong (Chiem 1994; Kaida 1995) and major parts of the Zhujiang deltas in southern China (Kaida 2000). A part of a farmer's one acre rice land is poldered by building high dikes at four sides, and in the polder, high and wide ridges of 60 cm high and 4 m wide are dug out and banana may be planted along with various fruit saplings of commercial value. Nearby the homestead along a canal, coconut trees may be planted to provide comfortable shade and a few fish ponds are dug to rear some fish for home consumption. In the ditches between the fruit ridges, fish can also be reared for home and for market. In a few years, the banana grove will become the dense green foliage of fruit trees. The most basic requirement for this complex land use is the easy irrigation and drainage from and to the adjoining canal.

In Vietnam's case, one or two heads of pig are reared, whose excrement provides fish meal, and in turn the scooped-out mud from the fish pond bottom

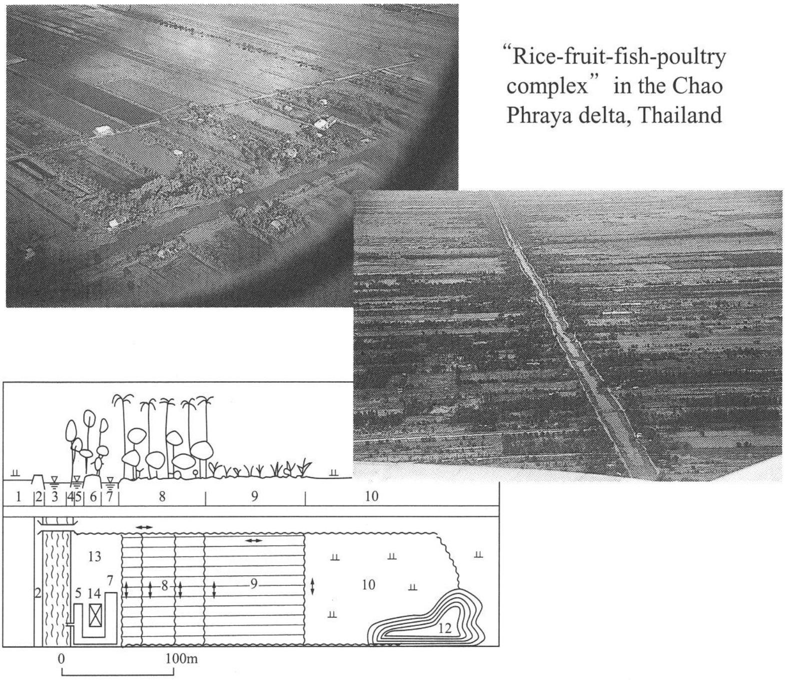


Fig 31.6 "Rice-fruit-fish-poultry complex" in the Cho Phraya Delta, Thailand: this intensive, complex land use system has its roots in the Damnoen Saduak since late 19th century and has flourished in the 1970s-90s, but has been declining recently. This complex farming is yielding its way to mono-cropping farming that can earn quick cash.

will be dressed on the ridges to fertilize fruit and vegetables. This complex land use on the basis of nutrient-recycle is called 'VAC', or 'VACR' if including rice. In the Chao Phraya Delta, Kaida named it the 'rice-fruit-fish-poultry complex' garden (Kaida 1987). This is an amazing 'ecotechnology' yielding a complete nutritious diet for the practitioner.

Sumatra's transmigration canals

Figure 31.9 (a and b) is a set of two maps showing the canal layout in South Sumatra, Indonesia, for reclaiming the dense coastal jungle into crop land to settle transmigrants. The first is an 'eco-approach' and the second is the modern large engineered approach:

1. A local shallow canal system was dug to reclaim rice fields along an active river and coconut grove inland. First, a small and shallow ditch of approximately 2 m wide and 60 cm deep was dug into the jungle at a right

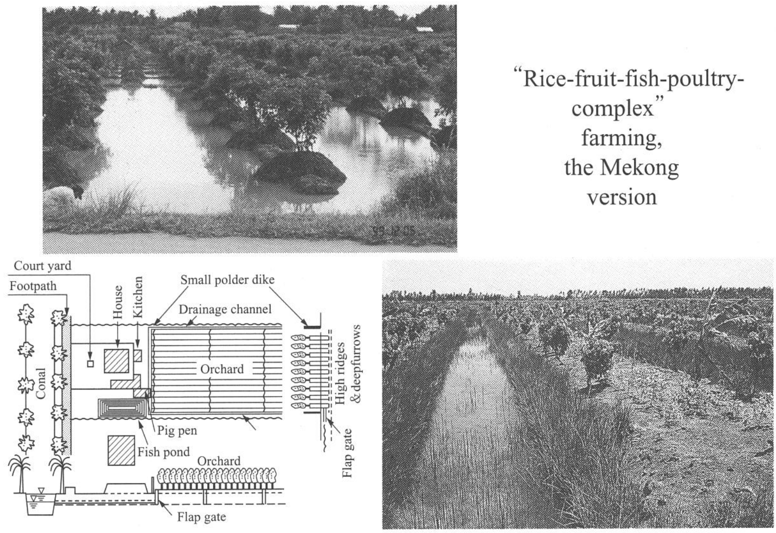


Fig 31.7 "Rice-fruit-fish-poultry complex" farming evolving in the Mekong Delta, Vietnam: to catch up with the Chao Phraya Delta farmers, Mekong Delta farmers are expanding the complex land use in poldered plots.

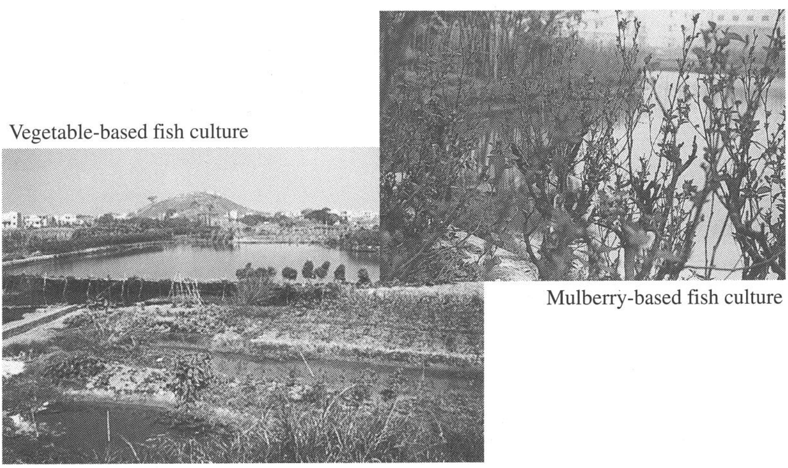


Fig 31.8 Combined vegetable and fish culture, Zhujiang (Pearl River) Delta, China: mulberry-based fish culture and vegetable-based fish culture in the Zhujiang Delta flourished as a system assuring material-recycling. These systems were the proto types of similar complex land use seen elsewhere nowadays in Southeast Asia.

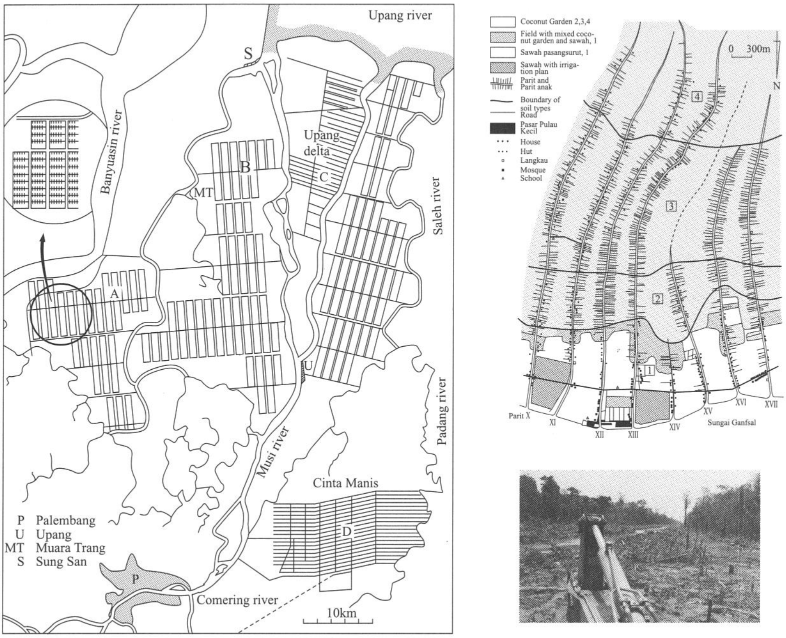


Fig 31.9 Two different modes of coastal peat-swamp development on Sumatra Island, Indonesia: a large and geometrical layout of drainage canals alignment in a state-sponsored transmigration project.

angle from an active river. They were enlarged by erosion using the rushing-in and rushing-out of the current which is induced by the high tide reaching about 2 m high in the adjoining river. Paddy fields opened along the active river may be irrigated and drained by 'tidal irrigation' (*pasan-surut*). Peaty soils in the hinterland are opened to coconut groves as acidity is leached easily by the drain ditches (Tanaka 1986).

2. Modern machine-excavated deep canals ensured drainage and were allowed and organized for state-sponsored transmigrants from Java and Madura. This method has proven, in many of the cases, to be unsustainable because the deep drains have irreversibly desiccated peat layer resulting in peat loss and acidification (Kaida 1979). Many of the rice lands that once flourished at the early stage of deep canalage are now being abandoned.

Southern India's cascade tanks

Since the second century, from the lower slopes of the Deccan Plateau to the river plains in southern India, a series of cascading tanks has existed. The shallow tanks store irrigation water for downstream use, and every tank bottom itself is a rice field when the water recedes. The tank floor, after it has dried up, becomes a browsing ground for cattle herds. These are the typically traditional land and waterscapes in southern India, which is very contrasting to the square sacred ponds attached to every temple. Possibly, the bimodal rainfall patterns in this region ensure the efficient use of this cascade tank system. This is an instance in which ecotechnology has existed for nearly two millennia.

Northern India's combined use of canal and ground water

I was surprised when I found that the irrigation canal command areas of the famous Ganga Irrigation Systems almost exactly overlap shallow tube well (STW) irrigated tracts. This is because tertiary or quarterly canals in the lower reaches are not capable of conveying the right amount of water at the right time. Farmers install dug-wells or STWs driven by motors to pump ground water (possibly replenished by seepage from the canals).

The original skeleton of the Ganga Irrigation System was built in the mid-19th century. The system, at its tertiary and quarterly levels, is like a human palm; its finger bones radiating as the irrigation ditches, and the finger flesh is the actual irrigation land area it commands. The canal system's 'inter-finger' area is potentially irrigable, but is actually the ground water irrigated zone. In the areas out of the canal irrigated zone there exists in the inter-finger zones the same intensive, diverse and intricate cropping as in the canal irrigated areas. Kaida has termed this practice 'domestic response to foreign impact', in praise of local farmers' exquisite wisdom for making the best use of the conditions given to

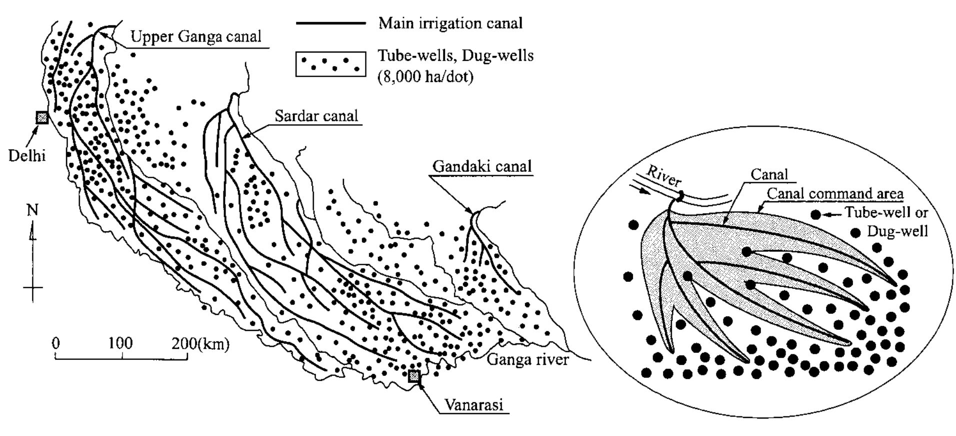


Fig 31.10 Combined use of canals and STWs in northern Indian plain: water distributed to a large region by the giant canal networks is actually used at field level through SDWs (shallow dug-well) or STWs (shallow tube-well) sunk in the individual farms.

them (Ueda and Kaida 1994; Kaida 1997).

What ecotechnology can do

31.2.1 Domesticating technology

An engineer who works in land, water and agriculture-related fields can become more moderate and humble and think twice before applying any powerful engineering. The engineer needs only see that micro-topography and soils are equally correctly classified by the local peasants' taxonomy as they are by using modern scientific classification schemes (Figure 31.1); acid-sulfate soils are utilized successfully by employing local wisdom and without implementing a major engineering project (Figure 31.2); and floating rice can be replaced by double rice cropping before and after the flood without trying to control the flood (Figure 31.3). Perhaps the engineers' wisdom would better be used in this last example to help the farmers to manage the drying and storage of rice harvested in the midst of heavy rain and in harsh competition with the oncoming flood.

When an engineer encounters North India's combined use of canal and ground water (Figure 31.10), he may not so strictly regulate local farmers to abide by rules of water delivery and distribution. Rather, he may change the original design criteria of maximizing water delivery efficiency, and try to plan and design a more flexible irrigation system on the basis of the farmers' practices which have been observed. This is the first step toward 'domesticating' technology.

Communalizing agricultural and rural development

In many of the ODA-related agricultural and rural development projects in developing countries, a group of engineers, both home and foreign educated, are employed in the planning, design and supervision of the implementation of the project. They normally start their jobs by making maps where necessary, installing rain and water gauges to collect hydrologic data, drilling test bores for ground water prospects and sampling soils to determine soil characteristics. This routine work may be done even for a small-scale agricultural or rural development scheme. However, by excluding the local people in these stages of survey, planning and designing, they alienate the people from the scheme.

Referring to the local taxonomy of micro-topography of the local people (Figure 31.1), the local taxonomy was not necessarily superior to its modern counterpart, but it was good enough to serve the purpose of the planning of a development scheme. The importance I would like to attach here is that the

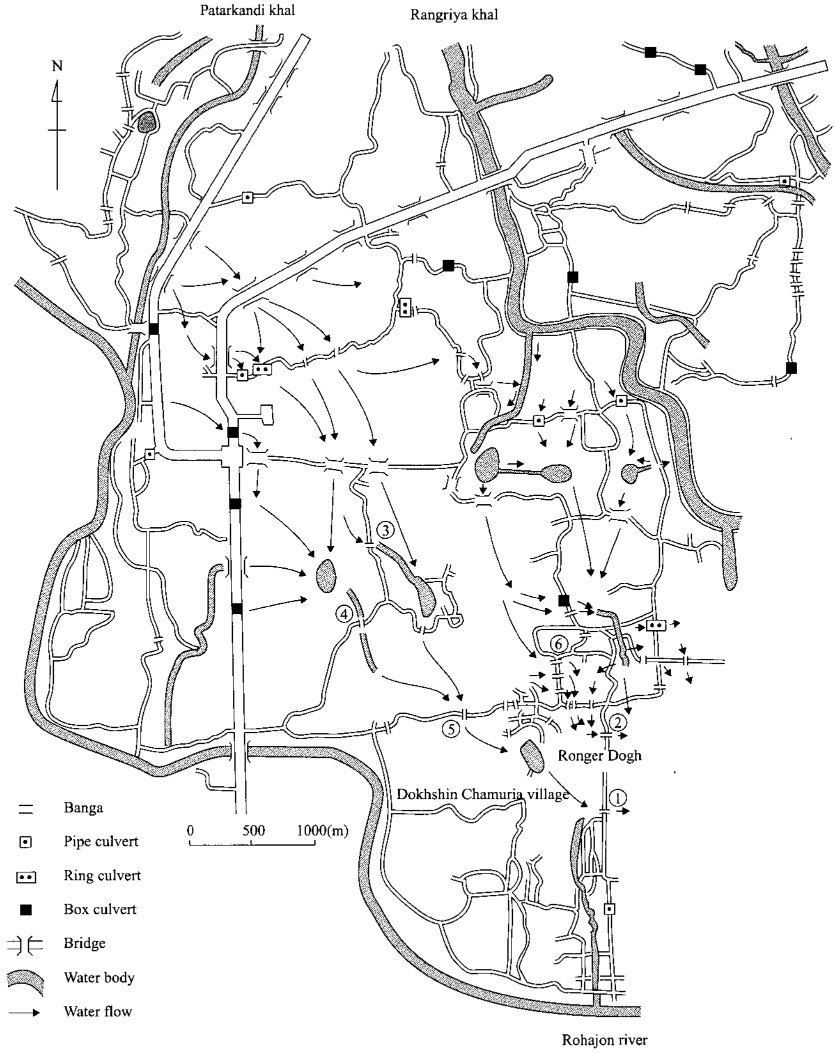


Fig 31.11 Rural hydrology: a water condition map, generated on the basis of local people's observation and information, assures people's participation when local micro-infrastructure schemes are planned and designed on it.

scientific investigation and survey precludes the local peasants from joining the planning of the project; whereas, the adoption of the local soil taxonomy would encourage them to participate in the project from the start.

To further incorporate the local people, Figure 31.11 shows a simple drawing, a 'rural hydrology' that indicates the directions of flood flows and *banga* (water-

Box

Fudo

"*Fudo* is formed through history and it is not simply determined by the original environmental conditions themselves (*Fudo*, Japanese: close to "milieu" in French; human-nature interaction). The natural environment is transformed to *fudo* by the effort of human beings who confronts the environment" (Tamaki, A. and I, Hatate 1974).

"The forest yields water, nourishes the soil and rears the fish. And it is the human being that grows the forest." (Tomiyama, K., *Water, Forest and Soil*, 1974)

Keiji Iwata introduced us to a unique lifestyle, attitude and concept of nature among the Khmer minority in Laos, in which man and his natural surroundings, including trees, grasses, worms and fishes, are always perceived to be at the same level and in the same category of existence (Iwata, K., *Anthropology of the grass, tree, worm and fish*, 1976).

The concept of *fudo* by Hiroshi Kurihara, an agronomist who has specialized in *konnyak* (devil's tongue) in particular, is also quite unique. He sees "a crop shapes up to its joy and sorrow according to its shape, through adopting and adapting to *fudo* in which it grows". Agriculture is the art to foster or cultivate this "shape" (Kurihara, H., 1988).

Fudo Engineering

"The present era is at the stage when quasi-static agricultural civilizations are about to shift to quasi-static industrial civilization for the 21st century. The level at which we can place future static industrial civilizations depends on the nature of the engineering that we use. Of the various types of engineering, the land, water and agriculture-related engineering which have an enormous, significant dynamic moment will largely decide the appearance of the landscape of this planet in the 21st century industrial world. Where will we be able to make a soft-landing in the industrial civilization of the coming century and with what type engineering in our hands? *Fudo* engineering may be one of the desirable formats." (Tomita, M., 1993)

"*Fudo* Engineering is one possible approach and methodological system toward a soft rural engineering and encompasses methods to (a) avert superficial adoption of modern powerful technologies, (b) enhances locally available time-tested technologies, (c) encourages participation of local people in project planning and design, (d) and shares resources and energy, which we all know is limited, equally, among the haves and have-nots. In the end, *Fudo* Engineering still is a basic tool for sustaining "development" and not renouncing it." (Kaida, Y., 1996) washed points in the roads and flood embankments). This map was drawn using (a) foot, a bicycle, or a motor-cycle at the best; (b) eyes to see the reality; (c) ears to listen to what the local people say; and (d) flexible mind to try to interpret how the local people evaluate the situation. Neither tools nor scientific equipment may be required to draw this type of local-scale resources map (Uchida *et al.* 1995). Through the process of making the 'rural hydrology' map, engineers will be able to rouse public interest in the forthcoming project, and enhance local people's sense of ownership. In my own experience, by the time the simple map was completed, a consensus had already been reached as to which *banga* should be refilled and reinforced, which bridges were to be repaired and where new bypass roads and bridges were to be installed. I term this 'communalizing' of the project planning process to ensure local people's participation in and ownership of a local development project.

A botanist helped by the villagers compiled a plant book that described the full inventory of plants and their uses in the village. In the process, she has noticed that the villagers became increasingly interested in joining this project and became increasingly proud of their rich plant resources and their knowledge of them. This project further encouraged the villagers to start an exchange program of plant strains among themselves for seeding and grafting in their gardens.

As in the case of North India's combined use of surface and ground water (Figure 31.10), if engineers had carried out survey and noticed the ubiquitous dug-wells and shallow tube wells in the canal command zones, they might have had an alternative idea in designing this conjunctive system. They do not need to persuade local people to organize themselves into an irrigation users' association to better manage the canal system. This is the case of a foreign-induced and forcibly organized irrigation association would not be workable at this moment (and never will be); whereas, the traditional irrigation system that actually exists will be workable into the future. In this case, the individual irrigation method in use by way of combined use of canal and ground water is a very 'communal' way of using water.

Landscaping agricultural and rural development

Many of the traditional Japanese irrigation systems used on farms had multiple uses before being channeled into the rice land: the clean water diverted from a stream weir, ran first through the settlements, providing water for such domestic uses as rearing carp and other fish, washing household utensils, washing clothes, washing vegetables for marketing and fire-fighting. Water and the irrigation landscape were kept clean for these minor uses. Many of these practices, Bali's Subak weirs and their gurdian temples

Fig 31.12 Bali's Subak and their guardian temples: Subak weirs, large and small, are always associated with their guardian temples. These artificial structures are fused completely into the environment.

however, have been abandoned with 'modernization' in the past thirty years, resulting in polluted water and 'poor' irrigation landscapes. Modern rationalism in planning of irrigation has bypassed traditional multiple water uses with the considered single objective of making water delivery more efficient. Only recently has the old notion begun to be revived from the standpoint of restoring and improving the water landscape and also enhancing the recreational utility of irrigation facilities for fishing, bathing and boating.

Ms Tomiyama Kazuko, a renowned critique on water-related culture and environmental conservation, writes the following poetic phrases, capturing a beautiful rural scene at Asuke, Aichi, Japan, which was pictured by the famous photographer, Maeda Shinzo (Figure 31.13).

Since the early 1990s, we, Japanese engineers, have been trying to adopt the 'biotope' concept that originated in Germany and is being backed by a citizen's movement to restore Japan to what Ms Tomiyama advocates. The engineers are now trying what they claim to be 'near-natural' engineering to restore the secondary nature with which we had been plentifully endowed before we 'modernized' farming practices and rural infrastructures, especially in irrigation and drainage.

We have many lessons to learn from the small irrigation systems in Southeast

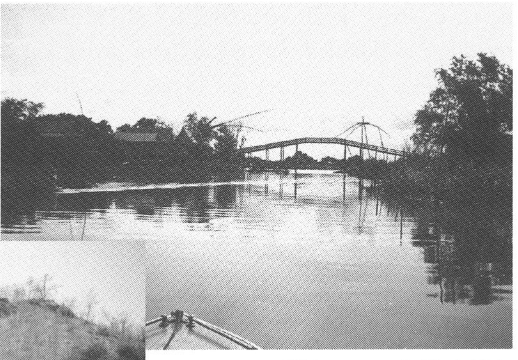
A brook in spring

Streams in the homeland have surely flowed like this since rice first was grown in the Yayoi Period. Such channels, as the songs say, teemed with crucian carp and loach and were home to schools of killifish. Warerways like this once were as much part of the lives of children as the songs they now sing.

In the twinkling of an eye, the clear brooks, which from the upland to the seashore, flowed to every corner of our land, have all but disappeared. A single generation of neglect has wasted what was maintained for millennia. We need to restore the pure water of hometown streams and make them everywhere flow into the lives of children agin. To do this we all have to support the farming families who manually labor to maitain the land and water. (Tomiyama &Maeda, 2001)

Fig 31.13 A brook in spring, Japan: in the twinkling of an eye, the clear brooks, which from the upland to the seashore, flowed to every corner of our land, have all but disappeared (in Japan).

Waterscape in Thailand



Water course in Phak Hai

Annual repair of a communal weir, Chiangmai

Fig 31.14 Serene waterscape in Thailand: serene waterscape in Pak Hai, a floating rice zone in the delta; and annual repair work of a communal weir in a stream in Chiangmai, Thailand.

Asia. Irrigation networks in the volcanic foothill slopes in central Java and in Bali, for example, are all designed to serve multiple purposes. The water runs down through settlements and homestead gardens and is used for watering gardens, daily washing and bathing and other purposes, then runs into the rice land behind the homestead forests and gardens. I have been fascinated by this multiple use of irrigation water and people's ingenuity in making engineering structures and works a part of the 'landscape' by fusing the natural and man-made landscapes into one. I view this 'irrigation water running through homestead woods and gardens into the rice land behind them' as a typical and desirable irrigation landscape in small farms on the volcanic foothill slopes.

Asian ecotechnology network

The 'Network' collects ecotechnology in their respective regions and countries. The group members meet once a year in a country (or two) to carry out joint fieldwork to collect ecotechnology. Each member is encouraged to organize a national group for those who have like concerns in protecting and promoting the ecotechnology network. Not only researchers, but also many practitioners in agricultural and rural development are encouraged to participate in the national groups. Some of the outcomes have already been published on the Internet homepages of the individual institutions, such as the M.S. Swaminathan Research Foundation. When all of these data have been collected, analyzed, collated and classified more systematically, the findings will be published in a series of books.

The main objectives of the network are not only compiling interesting ecotechnology, but also reorienting ourselves toward an alternative mindset regarding 'technology'. The Network will try to advocate for ourselves, agronomists, engineers and planning specialists, in the area of agricultural and rural development, to change the modern mindset and, at the same time, to revise textbooks, planning and design criteria in the respective areas of specialization on the basis of ecotechnologies. When and wherever ecotechnology can be applied, they must replace conventional technologies. The prerequisite for actually carrying this out is the involvement of local people and the employment of local wisdom.

We have to meet the challenge of the population for balancing the need for food and having a multi-use environment. Whether the technocrats will join this battle with us is the most pressing issue to be answered. With only ecotechnology, our production level will have to remain at a relatively low (albeit sustainable) level. If we employ modern technology alone, exemplified by energy-consuming, chemical-based and gene-manupilating technology, we can enjoy high-level production and consumption. This 'we', however, will exclude the majority of poor Asian and African peasants as well as the urban poor, because this technology may trickle down to 'better-off' people alone while skipping the poor. It was very impressive to me when Professor Swaminathan stated that India would be able to produce plenty of food - enough to feed its growing population in the coming decades - if India was allowed to let innovative large farmers mobilize all the modern and high technologies available; but the poor people, who might account for almost 30 per cent of the total population, must starve in affluence because they have no means of access to the abundance. Moreover, there is no guarantee for the globe against catastrophe at any moment as a result of environmental disruption.

Hot issues for us to pursue with no delay are: to evaluate to the highest possible extent resources that can be transferred from the haves to the have-nots; to establish sustainable rural life-style-based diversified farming systems; and to enhance economic, social and cultural interaction between villages and local urban centers on the basis of rural dwelling. In spite of rapid urbanization, three quarters of the population still live in the villages in monsoonal Asia. The population-to-food-to-environment issue in monsoonal Asia is a more rural-oriented issue, rather than urban issue. Ecotechnology has a big role to play here.

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Concluding Remarks

The aim of this book is to examine the environmental changes that have accompanied war and rapid economic growth in Asia. The authors argue to what extent such changes have altered the region's identity by disturbing the homeostasis between natural ecology and human society. While primarily focused on interactions between people and nature, the book also covers a wide range of related topics and as such offers a factual and challenging overview of this transitional phase in relations between natural environments, human health and rural communities in Asia. In response to an emerging call for studies on indigenous ecological knowledge, the book also provides a detailed discussion of the long-standing Asian tradition of eco-technology. Ultimately, it presents substantial evidence of the need for us to change our militaristic and anthropocentric mind-sets in order to achieve symbiotic relationships with other life forms, environments and our human neighbors.

This conclusion is based on the assessment of several of the articles contained in the book, which reveal that war and economic development has disrupted the region's ecological homeostasis to a dangerous degree, one that has destabilized many rural communities. Critical factors under discussion include: chemical pollution, the destruction of forests and land degradation, the emergence of pandemics and the spread of pathogens, and the eco-resource issues surrounding the continental Asian mountains.

I Chemical Pollution

The quality of water, air and food in Asia has been seriously degraded. Among the polluting agents, organochlorine compounds have attracted particular concern due to their global distribution, their toxicity as carcinogen and endocrine disrupters, and the serious and long-lasting damage to the human reproductive system that they have been shown to have caused in Vietnam.

Papers reporting on the aftermath of the US's Vietnam war operation, Ranch Hand, found that 20 years after the operation the toxic ingredient, dioxins, was not detectable in soils in Vietnam, except those found in the former US base camps. Analytical data gathered by several researchers confirm this and reveal that in 1973 high concentrations of dioxin were measured in river mud and in snakes and catfish in Vietnam, but that these were quickly leached from the environment by unknown means.

Curiously, despite this swift disappearance of dioxin, reproductive abnormalities in Vietnam increased dramatically after 1976. These reproductive abnormalities are congenital anomalies, such as hydrocephalic babies, anencephalic babies, conjoined twins, abortions, premature births, fetal deaths, malformation of fingers and limbs, harelips, hydatidiform moles and choriocarcinoma. Amazingly, between 1986 and 1988, the congenital anomaly rate alone exceeded 30 per cent in many villages on the Mekong Delta. A follow up of US and Korean veterans reveals that they too have been afflicted by numerous diseases, of which only five have been officially acknowledged as being related to an exposure to the herbicides. Furthermore, many children of Vietnam veterans have suffered from such diseases as spina bifida, acute myelogenous leukemia, and many others, of which only the former two are officially and conditionally recognized as associated with exposure to herbicides.

Although in most cases the US government denies a direct association between these diseases and herbicide exposure, articles in this book claim that there is ample epidemiological evidence to establish a causal link. One author acknowledges that the passing of twenty years makes the situation less clear, but remains convinced that an act of genocide has been committed (see Chapter 6, Part One). In the context of this book, those innumerable patients and dead fetuses indicate that the mechanism for human self-regulation has been destroyed and that human homeostasis has been endangered.

Based on hemisphere-wide surveys, one article reveals the toxic effects of persistent organochlorine compounds on marine mammals and provides further evidence of the critical pollution levels that threaten ecological homeostasis in the sea (see Chapter 17, Part Two). Chemicals released from industrial plants and through warfare are ingested by marine mammals through the food chain. The article detects a sharp rise in rates of sterility, miscarriages, stillbirths, mass mortalities, abnormal strandings and a reduction of testosterone (male hormone) in marine mammals after the 1980s. These are interpreted as indicating endocrine disruption caused by critical levels of organochlorine compounds.

The threatening potential of chemical pollution becomes evident when we list the number of toxic substances present in the environment. Substances discussed in this book represent a mere fraction of the 100 or more endocrine disrupters found to be present. This list becomes even more alarming if we add to it other substances consumed and released into the environment that effect the health of humans and other life forms, substances such as mercury, arsenic, tin, lead, chromium, cadmium, their organic compounds, radioactive elements, as well as an enormous number of pharmaceutical products. It is an unmistakable fact that the toxic effects of these substances are not confined to human beings, mammals, birds and fish. We must presume that all life forms are effected by the decline in the quality of water and air. Given this, who can guarantee that smaller and simpler life forms such as bacteria, invertebrates, plankton and plants will be immune to genetic mutation? And if genetic mutation explodes in these primary producers and decomposers, what will happen to secondary consumers? A West African proverb points to the essence of our predicament: 'Filthy water cannot be washed'.

II Swift Spread of Pathogens

With regard to the above speculation, the emergence of new pandemic pathogens and the swift spread of endemic diseases seems a worrying trend, one worthy of our attention. According to findings presented in two chapters of Part Two (Chapters 10 and 11), Vibrio cholerae and Vibrio parahaemolyticus have attained genetic mutation and the new strains have emerged as pandemic pathogens that have rapidly spread across the globe. The host population for *Vibrio cholerae* has been identified as copepod (a kind of freshwater zooplankton), while for *Vibrio parahaemolyticus* the host appears to be the bloody clam. Although these papers do not mention the causes of the genetic mutation in the pathogens, it is implied that unknown environmental factors are responsible. As a layman, it seems reasonable to speculate that the chemical pollution mentioned above may have played some role in causing changes to host communities and, in turn, the mutation of pathogens and the facilitation of the new clone's domination of existing clones. From an ecological perspective, a new or exogenic form cannot totally replace an existing one because of selection pressure. Therefore, if such dominance occurs, it must have been accompanied by a drastic change in the environment. Hence, there is compelling circumstantial evidence to support my speculation.

The paper that investigates a fatal infectious disease among pigs and pig-rearers in Malaysia (Chapter 15, Part Two) presents evidence of a specific zoonotic infection by the Nipah virus, which seems to justify the more general thesis. I will not here reiterate the process of infection and the sequence of clinical disease that led the researchers to find the new virus, since the paper itself does this with commendable clarity. Rather, I will reiterate the authors' warning against people intruding into undisturbed and remote natural habitats that have established a long-standing balance between the wildlife and their disease agents. This should become a fundamental principle in human interactions with nature. To that end, I wish to applaud the decisive stand of the Malaysian administration, which insisted on the eradication of one million pigs; a deplorable but indispensable measure to ensure prevention of the spread of the infection. Similarly impressive was the administration's implementation of systematic counter-measures designed to prevent any recurrence of the infection. This is particularly noteworthy, given the lax treatment of BSE (bovine sponge form encephalopat, or mad cow disease) in certain other countries.

If the uncontrolled destruction of the environment is allowed to continue as a consequence of this current development mind-set, then we will have ignored nature's warnings and the transformation of latent infectious diseases into active epidemic diseases will recur at an increasing rate. Importantly, we need to stop the 'pinching game', the vicious cycles of new medicines that cause new resistant pathogens, and new disease-resistant crop varieties that invite new diseases, and new insecticides that activate new insecticide-resistant insects. Perpetuating this vicious cycle seems to strengthen the toxicity of pathogens and the resistance to them of "weeds", "insects", "fungi", and "pests". Serious reflection on these vicious cycles has prompted the use of diverse ecological methods in agriculture, such as integral pest control, the use of natural predators, duck weeding, the introduction of infertile male insects, organic agriculture, non-tillage farming and many other ecologically sound methods. The common aim of all these methods is to replace the chemical control of diseases and pests with natural forms of control.

The urgent need for such practices in the medical clinic is underlined by two papers (Chapters 13 and 14, Part Two) that trace the post-war history of the fight to eradicate malaria. The World Health Organization (WHO) declared that by using a combination of DDT to eradicate the vector mosquito and pharmaceuticals to control the parasites malaria would be exterminated by the late 1960s. Instead, though, malaria reappeared, this time with drug-resistant parasites and insecticide-resistant mosquitoes. In 1978, WHO changed its official policy from malaria eradication to malaria control. The authors of these papers demonstrate the present practice of malaria control, which combines the vector control using bed netting and measured medicine treatments, and also integrates these practices with environmental management. The control of endemic disease seems to represent a border field among the various disciplines, requiring an integrated approach with the *topos*.

III Forest Destruction and Land Degradation

Since time immemorial, forest clearing has been the exploit of heroes. Residents of the rain forests of tropical Asia needed to clear forests in order to establish settlements and open up farming lands to sustain themselves. There is, however, a dramatic difference between this traditional form of forest clearing and the feverish, destructive forms of forest consumption that have taken hold in the last few decades. It is important to note the significant ecological and historical differences between continental and maritime Southeast Asia. The former, which experiences less rainfall, was typified by savannah forests and grain crops cultivated by peasant communities ruled by military kings. The latter, which has a much higher rainfall, was dominated by dense forests; its tree crops and maritime resources utilized by indigenous communities that were exploited by Javanese merchant kings. By the end of colonial rule, the deltas of the continent had developed into major centers where peasants grew wet rice. The mountains too had lost much of their dense forests, the trees having been replaced by open rice terraces and slash-and-burn fields. In maritime Asia, places like Java and Bali had developed into major centers for the cultivation of wet rice and tree crops, while the outer islands preserved extensive forested areas, with some large plantations and sporadic open forests for shifting cultivation.

Several papers in this volume report on and discuss the accelerated rate of forest clearance during the last few decades. Significantly, the authors of these papers do not subscribe to the conventional view that forest destruction is the result of shifting cultivators desperately trying to alleviate their poverty. The fact is, most forests on the continent have been transformed into permanent farming fields in order to support a domestic population that has doubled in size since 1960s, as well as to meet the rapidly increasing export demand for corn and cassava to feed livestock in developed countries. Hence, blame for forest destruction should be re-directed towards the insatiable stomachs of people living in developed countries. Besides, poverty has not caused shifting cultivation. Shifting cultivation was traditionally performed as a way of adapting to the primary ecological settings of savannah forests and rain forests. When not over used, this was the most ecologically sensitive way of utilizing the forest ecology. The prolific growth of secondary forests makes the fallow land dark and thereby eradicates weeds without labor or herbicides. The presence of various forests with differing canopy densities surrounding cropping plots of 1 to 2 ha facilitates the persistence of diverse flora and fauna, while still enabling good harvests. Historically speaking, unlike their counterparts in the US, Russia and Brazil, shifting cultivators in Asia were never tempted to clear-cut their forests in order to make corn fields that cover several hundred thousands hectares.

Similarly, the recent widespread destruction of forests in Indonesia cannot, in large part, be ascribed to the work of shifting cultivators. In fact their role in this devastation has been quite small. The government and large companies were mainly responsible. The government's transmigration policy facilitated joint projects with corporations to establish large-scale plantation estates for coconut palm, oil palm and pulp. The cause of the forest fires and resultant smoke haze during 1997/98 was attributed to a dry spell during El Nino, with the finger of blame pointed firmly towards shifting cultivators. In fact, though, the blame actually lay with the government, which had embarked on a program of forest clearing in Kalimantan and Sumatra for the purpose of creating transmigration sites and estate projects.

Chapters 1 and 2 of Part One investigate the Indonesian government's transmigration projects and reveal a tragedy wrought by an obsession with economic growth. Of the two types of immigration sites, the upland sites appear less problematic, since the soils, though of poor quality, can be made fertile by painstaking labor; something Javanese and Balinese farmers seem willing to expend. By tilling, adding organic manure, burning weeds, and digging drainage, it is possible to improve upland soils. Similarly with regard to forest clearing, the upland sites have caused less environmental destruction because most of these forests were scrub, secondary forests or rubber jungles. The greatest damage was done at sites located in the coastal swamplands. Vast closed forests were lost over a short period of time and swamplands were drained by a network of drainage canals that caused rapid drying and the loss of the peat, which in turn released sulfuric acid from the underlying mangrove mud. Many foreign companies collaborated with the government in the design and construction of these projects. The total amount of land obtained through governmental transmigration projects is estimated to be about 2.5 million ha, only a tiny fraction of which has been successfully reclaimed. Most reclaimed lands are left idle, with many immigrants having returned to their former homes or working for a wage in a nearby town or mine. Very few use the land for agriculture. This has resulted in the tropical rain forests and peat swamps becoming acid-soaked, barren wastelands and the sponsored immigrant communities being left without hope.

Close examination of the bureaucratic structures of the Sukarno and then the Suharto administrations (see Chapters 3 and 4) reveals a never-ending series of name changes and reconstructions of the departments and ministries. Inevitably, this resulted in confusion and unnecessary duplication. Viewed from a bureaucratic standpoint, the transmigration policy produced many seats for ministers and deputy-ministers, helped the government to keep spinning its revolving doors, and provided a convenient pretext for the government to talk with foreign donors and for the donors to reap enormous profits from the resultant contracts. The last stage of the peat swamplands reclamation, the Mega-Rice Project, collapsed together with the Suharto administration. This collapse, though, should not be seen as irrelevant to other eco-systems and other areas, nor does it exempt other countries from their complicity in the crime. Hopefully, this will act as a warning that the human impact on the environment has reached the critical level where, unless the dominant mind-set is changed, nature's homeostasis will be threatened, along with the survival of humanity.

Another example of large-scale forest destruction occurred during the Vietnam War. In this instance it was caused by the widespread spraying of herbicides and was motivated from a military rather than a profit-making mind-set. As for the Mekong Delta, where acid sulfate soil is prevalent, Chapters 7 and 8 identify two possible responses. One, kill the vegetation, using the sulfate acidity released from the soil through draining and drying. Or, two, spray it with herbicides. Herbicidal spraying was selected, probably because of its greater effectiveness and efficiency. It seems the only consideration in an ethos of violence is the effectiveness of the means of destruction. The after effects on human health, the pollution of the environment and the erosion of public morality after thoughts, if they are thought of at all.

The development mind-set and the military mind-set have had similarly disastrous effects on the ecological homeostasis basic to the continuance of all life forms. Both adopt an up-front, confrontational approach, both separate one side from another with a border and view everything on this side as right, true, civilized and human and everything on the other side as wrong, false, primitive, and inhuman. Blind discrimination of this kind has resulted in the destruction of both the natural and social environment. The truth is that in terms of *topos* identity there is no such border between this side and the other side. The border between separate *topos* functions in such way as to demarcate the interacting *topos*; all of which can be both right and wrong, true and false, civilized and primitive, human and inhuman. These are the lessons to be learnt from the large-scale destruction of forests and lands in Indonesia and Vietnam; devastating events in recent Asian history.

IV Eco-resource Issues in the Continental Mountains

Along with the deltas and plateaus, the continental mountains represent one of the distinct *topos* of Southeast Asia. The mountains were once the autonomous realm of mountain dwellers who freely roamed across borders arbitrarily drawn by the French colonial government. This situation persists today, largely because of the difficult, steep terrain, the high rainfall and traditional institutions governing the use of eco-resources, such as land, water, forests, foods, and other items essential to life. Despite these factors, however, this *topos* is about to encounter the 'modernization' and development-oriented mind-sets that have dominated the lowlands for the past forty years. The ensuing changes might lead to conflict between various mountain communities and to further degradation of the environment. Such issues are discussed in the essays collected in Part Three.

The economic mainstay of the indigenous people has been cultivation of upland subsistence food crops. This has been supplemented by various commercial, non-timber forest crops on the higher hill slopes and wet rice cultivation in the narrow valley bottoms of small basins (cf. Chapter 23). Shifting cultivation and grazing have also been practiced extensively. Contrary to conventional opinion, traditional shifting cultivators have conserved the forests by using them as a natural predator of weeds in the cultivating cycle. The appearance of extensive barren grasslands in the northern mountains of Vietnam was due to the spread of Chinese cultivation techniques, in which farmers make permanent fields by digging up tree roots and tilling fields. This broke with the practices of indigenous cultivators who do not traditionally till fields and who preserve the tree roots to ensure a swift recovery of secondary forests during the fallow part of the cycle.

As some of the chapters in this section illustrate (for example, Chapter 27), shifting cultivators have also developed an integrated cultivation system that rotates fallow land with forests crops such as styrax trees, used for producing benzoin, the host trees of stick lac, cassia (Chinese cinnamon) and tea. Shifting cultivators are generalists in cultivating the land and have comprehensive knowledge and experiences of ways to both cultivate and conserve valuable eco-resources. Problems arose, however, when a huge number of immigrants arrived in the mountains during, and particularly after, the war. It was at that time that the government began allocating forestland to these immigrants who knew nothing about the traditional ways of cultivating it. In both Vietnam and Laos, these policies were designed to bolster national security, provide the immigrants with a means of meeting their immediate needs and to achieve economic development and the rehabilitation and/or protection of these natural environments. As revealed in many of the papers in Part Three, some of these measures have caused tensions regarding the management of eco-resources between the government and native residents.

The papers in Part Three contain both optimistic and pessimistic views of the future. Both views acknowledge that changes in local institutions predate the national policy and that local authorities and residents have secured wide-ranging discretionary powers that have enabled them to adjust the national policy to suit their local conditions (cf. Chapter 22 and 26). These powers are underscored in a statement made by an official who says that existing farming practices are the basis upon which improvements can be grafted, and that decentralization of power to the district and village levels will institutionalize local empowerment. The real task remains to find ways to empower the area-based livelihood approach (see Chapter 25). Such a task seems to fit with our desire to strengthen the *topos* identity; with the concept of an ecological homeostasis of nature and a human homeostasis of traditional, indigenous minds and practices.

Some research, however, suggests that changes to crop selection and land use are occurring so rapidly and to such a degree that there is little room for optimism. From this pessimistic perspective, global market forces have already encouraged the cultivation of export-oriented food crops, which have both increased the use of fertilizers and pesticides and have come to occupy a substantial percentage of the region's cultivatable land (cf. Chapter 24). Some authors anticipate that the flexibility and enterprise of some of the farmers involved will transform the communities from ones of shared poverty to ones divided between rich and poor, and at the same time steadily increase the pollution of the environment. Therefore, we need to make available to these people accounts of our experiences, so that they can avoid our mistakes and prevent the ecological destruction of their *topos*.

V Conservation of Topos Diversity

After reading the articles in this book, we are obliged to reflect on the aftermath of war and the impact of economic development on nature and societies in Asia over the past five decades. In addition, we must reflect on the meaning of military victory and the meaning of happiness and progress offered by the development mind-set. To assist us in this last task, the four final papers in Part Four remind us of traditional concepts of happiness and progress. Indigenous residents of the peat swamps of Sumatra subsist on a modest consumption of resources. Instead of clear-cutting the swamp forests, they depend on a pinpoint exploitation of the environment, one enabled by a precise and collectively shared knowledge of their environs (cf. Chapter 28). Laotians, in their land-locked country, have contrived a method of exploiting freshwater fish, which multiply in the wet rice fields and irrigation canals that act as virtual tributaries to the major rivers, thereby keeping them well stocked with fish. This system enables Laotians to eat, on average, 3 kg more fish annually than the Japanese, who are themselves renowned fish eaters (cf. Chapter 29). A deep knowledge of the ecological balance of nature informs indigenous eco-technology. Along with many other papers in the collection, Chapter 31 provides examples of eco-technology in Asian agriculture. It is the authors' firm conviction that eco-technologies have nurtured the primary industries of different indigenous peoples and have permeated the cultures and institutions of these traditional societies. The long histories of these peoples have fostered a diversity of *topos* throughout the world.

The principle of modern development seems to have been utilitarian: action is held to be right if it appears to promote happiness (i.e., pleasure) and to be evil if it enhances unhappiness (i.e., pain). This became a central tenet of British liberalism in the 19th century, along with the belief that the pursuit of individual profit was the primary source of social development. This in turn molded the materialistic concept of development still in vogue today. Another of its constitutive influences was neoclassical economics, which advocates an integrated global market economy mediated by free trade. The reality is that this model of development has swallowed up almost all alternative economic systems and approaches. The result has been the rich minority's maximization of happiness at the expense and sacrifice of the poor majority's maximum unhappiness. And it is worth contemplating if Bentham would even agree that the lives of this rich and powerful minority are worthy of being called 'happy'. As the minority came to dominate the global market, the rich became steadily richer, the poor increasingly poorer. In the process, the poor majority's communities' respect for the environment has typically been treated with disdain and neglect and, as a result, nature, which is the ultimate sink for human deeds, has been stained, fragmented, disordered and degraded.

As such, the authors of this book propose to respect *topos* diversity, which is far more essential for sustaining a sound environment than the simpler concept of biological diversity. *Topos* is characterized by diverse interactions among diverse life forms. Therefore, a specific *topos* is sustained when the diverse life forms within it successfully complete and maximize their life cycles. Thus, if various *topos* sustain diverse life cycles, develop unique identities, and create new forms of relatedness, then the world, as an integral *topos*, will be able to sustain itself.

We also propose a reexamination of the concept of development. While it remains defined by a utilitarian view that, particularly in recent times, has itself been dominated by large and rapid economic growth, 'sustainable development' will be impossible to achieve. Put simply, this is because the earth is not an infinite resource. As Gandhi correctly pointed out, while nature can meet our human needs, it cannot bear the burden of our greed. If all nations behave like Japan, which consumes 30 per cent of the world's material flow (as measured by ton·mile units), if all farmers in the world behave like their Brazilian counterparts, whose farms consume several tens of thousands of hectares of land, and if all industrialized countries aim to behave like the US, which emits 25 per cent of the world's greenhouse gases, then there is no doubt that planet earth will soon be bankrupt, its resources exhausted. Development should encourage our minds and institutions to interact in harmony with nature, to seek more symbiotic and peaceful relations among communities and countries, and not to exploit nature beyond our needs and in defiance of the subtle realities of ecological homeostasis.

We hope that the facts, overviews and reflections presented in this book will inspire further, like-minded studies of Asia. Beyond this, we hope this leads to an integration of people's experiences and the knowledge systems of other scholarly fields regarding *topos* diversity.

FURUKAWA, Hisao

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