Irrigated Agriculture in Southeast Asia beyond 2000

Irrigated Agriculture in Southeast Asia beyond 2000

Proceedings of a Workshop held at Langkawi, Malaysia

5 to 9 October 1992

Franz Heim and Charles L. Abernethy, editors

GERMAN FOUNDATION FOR INTERNATIONAL DEVELOPMENT

INTERNATIONAL IRRIGATION MANAGEMENT INSTITUTE

International Irrigation Management Institute. 1994. Irrigated agriculture in Southeast Asia beyond 2000: Proceedings of a Workshop, Langkawi, Malaysia, 5–9 October 1992. Colombo, Sri Lanka: IIMI; DSE. pp xi, 135.

water management / irrigated farming / institution building / technology / training / policy / research / education / social aspects / economic aspects / sustainability / priority setting / Indonesia / Malaysia / the Philippines / Thailand

DDC 631.7

ISBN 92-9090-307-4

DSE Reference Number DOK 1697 A/a / SE 770-060-93

Please direct inquiries and comments to:

INTERNATIONAL IRRIGATION MANAGEMENT INSTITUTE
P. O. Box 2075
Colombo
Sri Lanka

Contents

Foreword

IN 1987 THE German Foundation for International Development (DSE) arranged discussions with leaders of the public irrigation sector in four Southeast Asian countries (Indonesia, Malaysia, the Philippines and Thailand), to assess what kind of supporting programs in the areas of information and training might be found useful at the current stage of those countries' development. Out of those discussions emerged the idea of a five-year program with the broad title of "Dialogue and Training." The Government of the Federal Republic of Germany agreed to finance this program, and in 1990, DSE invited the International Irrigation Management Institute (IIMI) to collaborate with it in organizing this series of events.

The 23 events in the program dealt with many different aspects of irrigation management in the region, and involved over 600 participants. Some of the most interesting discussions occurred in workshops that addressed wide issues of irrigation policy, and to which senior people were invited from many different organizations related to irrigated agriculture.

The present volume contains the papers of one such workshop, held in October 1992, whose purpose was to try to look some distance into the future, to imagine what would be the outlines of the region's irrigated agriculture, perhaps twenty years from now, and to consider what adaptations of the existing management systems may be necessary in order to be better prepared for these envisaged future challenges and opportunities.

The workshop was, like all events in the program, very active, and it is not possible on the printed page to convey a full impression of the lively discussions that went on, sometimes far into the night. The Southeast Asian region is well known as a place of dynamic economic development, especially in the past decade, and this development (mainly in nonagricultural sectors) has put many new and unfamiliar stresses upon irrigated agriculture. Many changes are happening, in all the countries, and management has to be much more flexible and responsive in order to sustain the activities of the sector against quite severe pressures.

The regional dimension is of particular interest in the modern context. This region is physically rather homogeneous; most of it falls within one agro-ecological zone. Yet, as in other parts of the world, we find that irrigation management institutions and practices differ greatly from country to country. These management systems had evolved nationally, under various influences of politics, history, economics, education, and the administrative styles of colonial powers long ago, as well as the physical influences of climates, hydrology and soils. Now, worldwide, there is a quest for more general principles of irrigation management that may, in future, be shared by many or all countries. The workshop papers presented here may mark a step in the sharing of common ideas and experiences, at least for one vital region of the irrigation world.

DSE and IIMI are publishing the papers of the meeting, and hope that others, in other regions of the world, may find benefit in some of the ideas that were brought out during these discussions.

On behalf of IIMI, I would like to express our appreciation to the Federal German Ministry for Cooperation (BMZ) for the financial support to these workshops. Our special appreciation goes to Franz Heim for his patience and good humor in planning and organizing these 23 events. I am grateful to Charles Abernethy for coaxing our IIMI colleagues into contributing to the discussions. Their participation changed them into enthusiastic supporters of these discussions with leaders of the public irrigation sector, from whom we all have learnt a great deal. Both Franz

Heim and Charles Abernethy deserve our thanks as editors of this volume, which allows others also to benefit from the discussions at the Langkawi Workshop.

Jacob W. Kijne
Director for Research
International Irrigation Management Institute

Introduction

IN THE LAST years of the twentieth century, irrigated agriculture in Southeast Asia is facing many stresses and challenges. Populations and consumption of agricultural products are continuing to rise. Successes in other economic sectors are reducing the agricultural labor resources. There is growing attention to environmental questions, and growing awareness that water resources are finite. Budgetary pressures require that an increasing share of the costs of irrigation is contributed by its users. This, in turn, fosters a need for institutional reforms directed towards localization of management and decision making.

Can we look ahead and foresee the main features of irrigated agriculture and its institutions, ten, twenty or fifty years from now? Can we plan the needs in such areas as human resources development, socioeconomic adjustments, research, and regulatory frameworks, that are necessary in order to accomplish the transition smoothly? The Langkawi Workshop sought answers to such questions.

The Workshop was an important event in a 5-year program (1990-1994) of dialogue and training through which the German Foundation for International Development (DSE) and the International Irrigation Management Institute (IIMI) are working with irrigation professionals in Indonesia, Malaysia, the Philippines and Thailand to address various current issues in irrigation development throughout the region.

The Workshop was interdisciplinary and interdepartmental. Senior persons were invited from many governmental departments that are associated in some way with the planning and the impacts of irrigation, as well as with its operational management. There were also leading figures from universities, nongovernmental organizations and the private sector. From outside the region, international research institutes and donor organizations were represented. A total of 56 senior persons from national institutes, organizations and companies and resource persons from international organizations such as the International Rice Research Institute, the International Food Policy Research Institute, the Food and Agriculture Organization of the United Nations, the Ford Foundation and IIMI took part in the program. The list of participants is attached in the Appendix.

The objective of the Workshop was to develop options and recommendations, based on the present situation in each of the four countries, for policy, research, education and development of irrigated agriculture in the next century.

The Workshop addressed the following areas:

1. Present situation, present plans and trends of irrigated agriculture in the four countries, considering demand and supply, political, institutional and legal frameworks, economic and agronomic opportunities or constraints, technological innovations, social factors, and interactions with the environment.

2. Interrelationships of sustainability, growth, politics and economics, including investment costs, priority setting, operational finance, alternative uses of water and land, and legal and administrative frameworks regulating resource users.

3. Options, impacts and recommendations concerning policy, research, education, and development in irrigated agriculture in the next century.

The Workshop achieved its task through a mixture of subject-oriented and country-oriented sessions, leading up to the development of four country statements and one regional statement.

The outline structure of the week is presented below:

Day 1: Introduction

Country Papers on present situations and trends of irrigated agriculture

- *Indonesia* by Suprodjo Pusposutardjo (presenter) and Loekman Soetrisno
- *Malaysia* presented by Keizrul Abdullah
- *Philippines* by Rodolfo Undan (presenter) and Jose Galvez
- *Thailand* by Jesda Kaewkulaya

Day 2: Presentation and Discussion of Principal Problem Areas

- *Sustainability and Growth* by Charles Abernethy, IIMI (see Paper 1) Discussant: Dato' Shahrizaila bin Abdullah
- *Socioeconomic Trends in Irrigated Agriculture* by Mark Svendsen (presenter) and Mark Rosegrant, IFPRI (see Paper 2)
  Discussants: Manuwoto and Loekman Soetrisno (see Papers 3 and 4)
- *Legal Aspects of Irrigated Agriculture* by Stefano Burchi, FAO (see Paper 5)
  Discussant: Apichart Anukularmphai (see Paper 6)
- *Institutional Issues of Irrigated Agriculture* by Douglas Merrey (presenter) and Hammond Murray-Rust, IIMI (see Paper 7)
  Discussant: Manuel M. Lantin (see Paper 8)
- *Technological Innovations in Irrigated Agriculture* by Peter Wolff (presenter) and Rolf Huebener, University of Kassel (see Paper 9)
  Discussant: Jose Galvez (see Paper 10)

Day 3: Development of Country Vision Statements

The task was to develop a vision statement where the irrigated-agriculture sector should be in the next century. Issues to be considered included food supply/self-sufficiency, management of water resources, expansion/reduction of irrigated area, private/public institutions engaged at/in charge of all levels, technology of production, situation of producers, environmental pressures on irrigation, etc.

Day 4: Development of Means to Achieve the Country Vision

The task was to decide whether any adjustments in the vision statements were required in light of the plenary discussion.

The country groups were asked to focus now on the means to achieve the vision, identify changes required in such areas as policy (irrigated agriculture, water resources, others), laws and institutions (water rights and transfer, irrigation system ownership, water resources planning and monitoring, irrigation system management), human resources development (government officials, farmers, farmer organization officers), capital irrigation investment (public, private), and supporting infrastructure (markets, research capability, power, roads, etc.). They should state what kinds of information are needed to design and implement such a program of change and which types of issues should be addressed most effectively through domestic research, regional cooperation, and collaboration with international organizations.

Day 5: Presentation of Country Statements and Development of a Regional Statement

On the final day, each of the four country groups presented its plans to the full session. After detailed discussion of each country plan, a drafting committee assembled a draft regional statement, in which common features from the vision statements and the proposal program of the four countries were identified. The regional statement was debated and amended in detail by the final full session of the Workshop. It was then adopted and is presented later in this volume.

NATIONAL PAPERS

Present Situation, Vision and Means to Achieve the Vision for Irrigated Agriculture in Indonesia, Malaysia, the Philippines and Thailand

Indonesia

Suprodjo Pusposutardjo
and Loekman Soetrisno[1]

PRESENT SITUATION

Introduction

SINCE THE EMERGENCE of the New Order as the ruling government in Indonesia irrigation development has been one of the major development priorities of the country. For more than 20 years, during the first Long-Term Development Plan (LTDP-1), from 1968/69 to 1992/93, massive funds have been invested to rehabilitate and to construct new irrigation schemes. The success of the New Order Government in developing irrigation is well recognized as one of the main contributors in attaining prestigious agricultural development, as it is marked by self-sufficiency in food (rice), in 1984, which had never been achieved before.

Despite the gained benefits, the rapid physical development policy of irrigation schemes created many problems dealing with sharing responsibility with farmers in operation and maintenance (O&M). As a result, many irrigation structures lasted only a short time, the financial burden on the government for O&M becomes heavier, and water utilization is inefficient. These problems have to be overcome in the earliest stage of the second Long-Term Development Plan (LTDP-2), starting in 1993/94.

The country report contains an overview of irrigation development during LTDP-1, and the perspective of development for the coming LTDP-2 by considering all experiences gained during the past and the estimation of future conditions according to the given scenario.

Present Status of Irrigation Systems in Indonesia

Technical Status

The policy of irrigation development during LTDP-1 was tightly attached to the commitment of the government to achieve self-sufficiency in food (rice). Within the framework of the policy, the objectives of irrigation development were (a) to fulfill irrigation water demand for intensive lowland rice cultivation, and (b) to expand irrigated areas of lowland rice rapidly. In line with the objectives, the irrigation development program during LTDP-1 focused on physical works to improve service capability of the existing irrigation structures and to build new irrigation structures.

The existing irrigation in Indonesia covers a command area of roughly 4.5 million hectares (ha), comprising 3.8 million ha government-managed irrigation systems and the balance

---

1 Dean, Faculty of Agricultural Technology and Senior Lecturer, Rural and Regional Studies, respectively, of Gadja Mada University, Yogyakarta, Indonesia.

farmer-managed irrigation systems. In the areas where gravity irrigation was not technically feasible, pump irrigation systems have been developed for the sake of poverty alleviation. By 1990, 592 pump irrigation units comprising medium and deep wells have been developed with command areas of 30,140 ha (DGWRD 1990). The existing schemes mostly reflect the results of irrigation development during LTDP-1.

To date, the technical statuses of irrigation schemes are attributed to the following factors:

- the irrigated areas are concentrated in Java (2,535,000 ha or 57.8% of the total irrigated areas) comprising 31.5 percent technical irrigation, 10.5 percent semitechnical irrigation, and 15.7 percent simple irrigation (farmer-managed irrigation) (Haerah 1991);
- water demand of 10 river basins in Java and 3 river basins in Madura, Bali and Lombok have already exceeded the potential supply (DPP-DGWRD 1991);
- ineffective utilization of irrigated rice fields as indicated by low cropping intensity ranging from 64 percent (in Kalimantan) to 224 percent (in East Java) (Pusposutardjo and Sunarno 1990);
- the establishment process of newly developed irrigation schemes is very slow because farmers are not capable of developing rice fields by their own efforts due to constraints in finances and land properties rights; and
- the total number of irrigated rice fields in Java is steadily decreasing due to their conversion into industrial and living areas.

All of these technical attributes have to be considered as anticipated problems in LTDP-2.

Irrigation Management Status

Extensive irrigation development programs have been undertaken in Indonesia for more than 25 years. However, sharing responsibility for operation and maintenance (O&M) between farmers as beneficiaries and the government has not been established yet. Among the many factors influencing this situation are:

- the policy of irrigation development during LTDP-1 limited farmers' opportunities to participate in the implementation;
- at the early phase of irrigation development from 1967/1968 to 1982 there were no rules and regulations compelling farmers to share responsibility for O&M of irrigation schemes; and
- the time-framed program on physical works led the government to take over the construction works of the whole system, from main system to tertiary development.

Without any contribution from the farmers, the government was overburdened in carrying out O&M. For example, at present, the state is only capable of providing 50 percent of the real required funds for O&M (Soenarno ?). The results of this are:

- broken irrigation facilities due to improper O&M;
- poor service performance of the system; and

- unsatisfactory management of the system for farmers who try to shirk responsibilities in O&M.

The government, being aware of the existing unfavorable situation, starting in the fourth Five-Year Development Plan (FYDP-4) 1988/89, changed the policy of irrigation development from focusing on the physical works into improving O&M, including irrigation management as a whole. The steps of improvement cover: (a) strengthening and improving the organization of the Directorate General of Water Resources Development (DGWRD) with regard to O&M, (b) clarifying the right, authority, and responsibility of the agencies involved in the implementation of O&M, (c) enforcing rules and regulations on sharing responsibility for O&M between the government and the farmers including the funding of O&M by charging irrigation service fees, and (d) strengthening the function of irrigation committees in monitoring and evaluation of irrigation management performance. Recently, the government turned over the management responsibility for small-scale irrigation scheme (less than 500 ha) to the farmers (water users' association [WUA]).

By focusing the program activities on O&M, it is expected that the required funds for rehabilitation can be minimized, while the service capabilities of irrigation systems are being kept sustainable.

Agro-Economic Status

The effect of irrigation development on the performance of agriculture was remarkable. Reliable and sufficient water supply provided from improved irrigation schemes stimulated farmers to adopt new agricultural technologies. This resulted in an increase in the total harvested areas of rice (especially the area of the intensification program) and secondary crops as well as in steadily increasing yields per unit area.

From an agro-economic standpoint, the status of irrigation can be described as follows:

- investment costs per unit area of irrigated land (for construction of new schemes or for rehabilitating old schemes) are steadily increasing disproportionally to the revenue of food crop farming (Pasandaran 1991);

- degradation of the catchment area of the water source causes high fluctuation of flow discharge which often creates either water-shortage or water-excess problems on crops;

- the financial and social status of rice as the staple food in subsistence farming dictates farmers to grow rice with a high water consumption; and

- although the revenue from secondary crops in irrigated fields increased during the last 7 years, insufficient drainage facilities of irrigated rice-fields hinder farmers from adopting profitable farming practices.

Considering (a) the agro-economic status of the irrigated land, (b) resource availability for developing irrigation schemes, and (c) scarcity of water due to an increased number of different users and their respective requirements, a reconciliation of agricultural development with irrigation development is necessary. This reconciliation process began in the fourth Five-Year Development Program (FYDP-4) by a policy statement of the Ministry of Agriculture on four basic strategies of agricultural development.

These basic strategies are:

- sustaining and improving food self-sufficiency;

- increasing agricultural production in order to provide raw materials for industry and export;
- increasing farm productivity and the value of agricultural products; and
- increasing farmers' income as well as their welfare (Wardojo 1989).

The implementation of these four basic strategies is expected to decrease the pressure on O&M of irrigation systems during the dry season when water shortage is common.

Sociocultural Aspects

Despite all the success in irrigation development, the Government of Indonesia is currently facing a second-generation problem in irrigation development. This problem can be best stated in the interrogative: how can the government motivate the farmers who benefited from irrigation development to participate in sustaining the irrigation infrastructures built by the government?

There are several reasons for the emergence of the problem. First, the villages with irrigation have been experiencing quite a drastic change, culturally. In command areas of farmer-managed irrigation systems (FMIS) of Java for example, the traditional institutions and traditional laws used to manage the irrigation schemes were abolished by the colonial authority to meet the needs of the sugar industry, an industry which then became the backbone of the Dutch economic development.

The decision to abolish the old institutions and traditional laws on FMIS also brought to an end the management capacity of the Javanese peasants, including their capacity to manage the village irrigation systems autonomously. The Dutch colonial authority functioned as landlord making all the necessary decisions related to agricultural activities to allow the sugar industry access to the village agricultural resources—land, water and labor. The *subak* system in Bali remained intact because the physical natural resources of the island were not suitable for sugar cultivation. However, the subak system in this island experienced changes as a result of state interventions to increase the efficiency of the island's irrigation systems. Furthermore, the development process itself, in the last two decades, further weakened the peasants' agricultural management capacity. New regulations concerning the structure of village leadership introduced by the New Order Government practically made the village head the single development agent in the village. The village head is also the single decision maker in the village. As a result of all these changes, a strong dependent mentality towards government initiative emerged within the community. For example, peasants do not want to repair broken irrigation canals unless ordered to do so by the officials as they believe that irrigation maintenance is and has been the responsibility of the state.

Irrigated areas all over Southeast Asia including Indonesia are always characterized by skewed land distribution which is manifested in the high incidence of sharecropping. As sharecroppers realize that they cannot fully benefit from the increase in agricultural yields they are also reluctant to invest their time and labor to maintain the irrigation facilities within the village. The condition is further worsened as absentee landlordism is currently emerging in irrigated areas, the landlords detaching themselves from village customs and regulations.

Skewed landownership generated inequality of income between landowning and landless peasants which resulted in nobody being responsible for maintaining irrigation facilities in the village. The landowning peasants, particularly those who sharecrop their land, consider that it is the responsibility of their tenants to maintain irrigation facilities. On the other hand, the tenants think that it is the mutual responsibility of both the tenants/sharecroppers and the landowners to maintain irrigation facilities in the village.

Peasant communities in irrigated areas in Indonesia are usually the most monetized communities. Monetization created pressure upon peasants to earn more cash through working in nonfarm jobs in or outside the village. Consequently, peasants have less time to do communal work for the village. Traditional village irrigation (FMIS) maintenance was done through communal work. Peasants' reluctance to voluntarily do communal work negatively affects the village activities in maintaining irrigation facilities at the village level.

The Government of Indonesia established water users' associations for landowning peasants to take part in the O&M of tertiary systems of government-managed irrigation and the village irrigation (FMIS) facilities. Despite the good intention of the government, the organization has so far not achieved the objective set up.

Environmental Aspects of Irrigated Areas

In the last two decades of development in Indonesia, the environment of irrigated areas experienced major changes which might, in the future, affect irrigation development.

The first change in the environment concerns the steady decline of land used for farming. Most of the loss has taken place in Java where expansion in housing and factories in the vicinity of large cities has been more rapid than in the other islands. The Department of Agriculture has estimated that some 55,000 ha of agricultural land (mostly irrigated rice fields) are lost to other forms of land use every year while the Department of Public Works has estimated that 0.3 million ha out of 1.2 million ha of rice fields for which irrigation was provided between 1969 and 1985 are no longer being used for farming (Hardjono 1991). For example, the highly productive coastal plain of Northern Java, from the industrial complex of Cilegon in West Java to the manufacturing zone around Surabaya in East Java, is being rapidly transformed by the process of urban and industrial development. The construction of a toll road from Jakarta to Cikampek in West Java has resulted in the loss of thousands of hectares of rice fields in which considerable investment was made during the early 1970s, when an irrigation network was constructed to carry water from the Jatiluhur Dam.

Although the changes in the function of agricultural land appear at first glance not to have a direct impact on the environment, there are serious hydrological consequences (Hardjono 1991). One serious hydrological consequence is the increased frequency of wet-season floods, particularly in urban areas such as Jakarta and Semarang in Central Java. In the dry season, intrusion of salt water increases along the coastal plain areas.

Another factor contributing to the deterioration of the environment in irrigated areas in Indonesia is population growth. Direct consequences of population growth can be seen in the high rate of land degradation in Java and the outer island watersheds. This is caused mainly by deforestation. The annual deforestation rate in Indonesia is estimated between 600,000 and 1,200,000 ha (Potter 1991). Aside from population pressure, most of this deforestation is the result of other factors such as logging activities conducted by logging companies which receive concessions from the government. The result is extensive soil erosion which may affect the future sustainability of the irrigation systems in Indonesia. In South Sulawesi, erosion of the Bila and Walanae valleys reduced the capacity of Lake Tempe to provide irrigation water in the dry season. Sedimentation is making the lake increasingly shallow with the result that flood inundates the agricultural settlements near the river during the wet season. Increasing sedimentation also shortens the life expectancy of several dams in Java where huge amounts of money have been spent to build them.

Rapid industrialization that is taking place in Indonesia has changed the function of rivers in the country from being sources of municipal water and irrigation water into a waste dump of industrial residues. Some major rivers in Java are heavily polluted by industrial waste so that the water becomes unsafe for human use as well as for irrigation. Meanwhile, the large-scale tapping of groundwater, pumped up by individual companies for industrial purposes causes a drop of the water table every year (Hardjono 1991). In Central Bandung, according to Joan Hardjono, where factories extracted water by tapping groundwater, the water table dropped 25 meters between 1981 and 1986, while in the heavily industrialized region of Eastern Tangerang, the water table dropped by 0.4 meters a month. Polluted rivers and the drop in the groundwater table will create serious problems in the water supply for municipal as well as for agriculture uses.

Confronted with these environmental problems, the Government of Indonesia did not remain idle. Various programs, including the enactment of a strict Environment Protection Law were launched. Environmental problems in Indonesia cannot, however, be solved only through the provision of environment protection legislation and commitment from the government due to the many factors which generated the problems. One important factor is unemployment. People invaded the forests because there were no other employment opportunities available for them. Industries are mostly capital-intensive ones, thus absorbing only a few people while there are concerted efforts from both the public and the private sectors to industrialize the rural areas. Modern industries produce products which were traditionally produced by small-scale rural industries. Lack of alternative jobs outside the agriculture sector forced the unemployed and underemployed peasants to move to forest areas to open new land for agricultural activities or to the cities to find jobs.

Perspective of Irrigated Land Beyond 2000

In April 1993, the people and the Government of Indonesia will start phase two of the Long-Term Development Plan (LTDP-2) which is for the next 25 years. As a continuation of LTDP-1, LTDP-2 is still focusing on economic development with the priority to attain a balanced economic structure of the capability and the power of a developed industry, supported by the capability and the power of agriculture. Irrigation development, during LTDP-1, was one of the principal policy options to promote agriculture. Therefore, the national commitment on LTDP-2 is to promote the establishment of a developed industry while maintaining the capability for providing sufficient food and other basic needs.

Referring to the national commitment on LTDP-2, the prospect of irrigated land beyond 2000 will be reflected by the resultant influences of (a) the recent status of irrigated land at the end of LTDP-1, before entering LTDP-2, (b) the effect and the impact of the transitional process from an agricultural to an industrial society, (c) resource limitation, and (d) the increasing pressure for satisfying better environment quality.

Many problems in the development of irrigation systems during LTDP-1 have not been completely solved and have to be carried over to the coming LTDP-2. With the passage of time, these unsolved problems changed their priorities and created other associated problems. Among them are:

- deficit water supply in several irrigation schemes due to limited information (both in terms of quality and quantity) concerning water resources potential and demand;
- unbalanced progress between physical development of irrigation facilities and farmers' capability to utilize the provided facilities in a maximum way, as well as their willingness to share the O&M duties; and
- disagreement among different sectors on resources allocation and utilization resulting from unclear defined land unit concepts either in terms of the characteristics or the administrative boundaries or any form on conformity between the two concepts, at national as well as at regional level.

The policy of industrialization as the basis of future economic development will transform the agricultural society to an industrial one. Dissanayake (1990) noticed that this society transformation changes various aspects of community life. For example, the transformation process changes: (1) product orientation from food into goods, (2) production factor from land into capital, (3) actors from farmers/artisan into factory workers, (4) guiding factor of the economic activity from traditional into economic growth, and (5) the preferred rule in the community life from hierarchical/authoritarian into representative democracy. Attached to these society changes, the present status of irrigated lands and the corresponding irrigation system will also change.

Considering resources limitation, the need of having better quality environment, the attached problems of the existing irrigation system, and the effect and the impact of transformation from an agricultural society to an industrial one, the prospect of irrigated land in Indonesia beyond 2000 will depend on the following: (1) the policy option on agriculture sector development, (2) the status of Java island as the rice production center, (3) the private participation in the management and development of irrigation systems, (4) the adoption of the river basin concept as a land unit in regional development planning, and (5) the policy option in maintaining the functional status of the existing irrigation facilities.

The Policy on Agriculture-Sector Development

The Directorate General of Food Crop Agriculture (DGFCA), Department of Agriculture, estimated that by 2018 food (rice) self-sufficiency would require an area of 6,073-7,852 thousand ha. To attain this required area 1,684-3,464 thousand ha of new irrigated land (rice fields) have to be developed. Besides expanding the irrigated land, the cropping intensity index of the existing irrigated land has to be increased by 23 percent, from 152 percent to 175 percent (Haerah 1991) with additional water requirements between 28,308 and 58,195 million cubic meters per year.

Although the estimation of the required irrigated land by 2018 by the DGFCA is quite realistic, the objective of the policy seems very difficult to accomplish due to land and water constraints. Most of the remaining land (60.3%) is considered as less suitable for irrigated rice fields (marginal lands) or is located in the drier areas of Eastern Indonesia.

The Status of Java Island as the Rice Production Center

At the end of LTDP-1 Java as the rice production center provided shares 68.4 percent of the national rice production. The status of Java island as the rice production center will change as this island will become more industrialized during LTDP-2. As the agriculture and the industry sectors require the same resources of land and water, conflict on natural resources utilization may not be avoided. The conflict is underway as indicated by the high conversion rate of rice fields into settlement areas, urban expansion, industrial areas, and other nonagricultural uses (Jezeph 1992). Besides reduced rice field areas, rapid development of urban areas attached to industrial development will change the existing farming system from rice-based cropping into semiurban farming (Higgins et al. 1988).

In term of water balance, the DGWRD predicted that the ratio of demand to supply in Java and Madura by the year 2000 will reach 121 percent. Within this value of demand to supply ratio, it is impossible to keep the irrigated rice fields sustained.

Private Participation in the Management and Development of Irrigation Systems

Since 1987/1988 (the fifth Five-Year Development Plan - *Pelita V*), the policy in water resources development is to develop water resources in a planned and coordinated manner, taking into account the projected requirements and interdependencies of all the sectors of economic and social development which depend on the enhanced availability of water of suitable quality to meet their respective goals. Within this broad framework of policy, the government:

- facilitates private sector and community participation in water resources development and, to this end, strengthens the government's capacity to identify opportunities to regulate and to support private and community initiatives;
- institutes and gradually enforces the transfer of responsibility for O&M of infrastructure to the beneficiaries, based on contributions from them; and
- balances the distribution of resources for the development of physical infrastructure, its operation and maintenance (O&M) and improved administration of services to the public.

To facilitate the implementation of this policy the government decreed several regulations, dealing with water resources development, with irrigation, water pollution control, swamps, and with rivers. All of these regulations mention clearly the right and the responsibility of farmers, water users' associations (WUAs), or private enterprises in sharing the management and the development of water resources as a whole, including irrigation systems.

One of the policy implementations is turning over the O&M responsibility from the government to beneficiaries (farmers' groups - WUAs) in accordance with regulation No. 23/1982. Considering the present capability of WUAs in O&M, the transfer of management responsibility is only for irrigation schemes equal to or less than 500 ha. The policy for transferring O&M responsibility will be expanded to larger areas. Another example of privatization of water resources development is the establishment of two semigovernment enterprises with the assigned authority to manage river basins.

The Adoption of the River Basin Concept as a Land Unit in Regional Development Planning

The concept of the river basin as a land unit will be adopted in future regional development planning. Reasons for adopting this concept are:

- to encourage and to secure multipurpose and integrated water resources development based on formalized planning and with due regard to water balances and water quality requirements in the country's river basins, and in close coordination with land use plans and policies; and
- to maintain a clear separation of approaches between water resources development and user-sector development, and to ensure that user-sector development is consistent with water resources development.

Of the total 90 river basins, 6 river basins in Sumatra, 12 river basins in Java, one river basin each in Madura, Bali, Lombok and Sumbawa, as well as 3 river basins in Sulawesi have already negative water balances. These river basins with negative water balances are located in existing irrigation areas. By studying the water balance in each river basin, possible areas for rice field expansion can be identified.

Concluding Remarks

The future prospects of irrigated lands (rice fields) in Indonesia will be determined by the policy on food self-sufficiency. For reasons of national security and national economic stability the attained condition of self-sufficiency on food, with a certain value of either a negative or a positive balance between supply and demand, will be maintained for at least until the first decade of the next century. To achieve self-sufficiency on food, 2-3 million ha of new rice fields have to be developed. Besides expanding the existing irrigated rice fields, massive investment is also needed to increase the cropping intensity from 152 to 175 percent. This massive investment is required to:

- improve the physical infrastructures of existing irrigation schemes to be more compatible for crop diversification farming;
- improve O&M of the irrigation systems by strengthening the institution of WUAs and to enforce the sharing of responsibility on O&M according to their right in utilizing water; and
- increase the assurance in providing water by developing conjunctive irrigation pumping systems in gravity irrigation schemes.

The higher the increase in cropping intensity the fewer the required new irrigated rice fields.

Due to rapid industrial development in Java, its status as the center of national rice production cannot be maintained any longer. The remaining irrigation systems in Java have to be modified in such a way that they can facilitate the requirement of semiurban farming mixed together with rice-based farming. Strong pressure of efficient water utilization dictates the composition of those two farming systems.

In the coming LTDP-2, the rights and responsibilities of farmers, WUAs, and other private organizations on the management and development of irrigation systems as well as on the development of water resources have been legally defined. This means that more opportunities will be offered to the private sector and the community to participate in the management and development of irrigation systems with shared benefits corresponding to their contributions.

References

Dissanayake, W. 1990. Cultural integration in a global age. The world and I. January, 1990. pp. 84-93.

Directorate General of Water Resources Development. 1990. Groundwater development in Indonesia. Jakarta.

DPP-DGWRD. 1991. Kapasitas Sumberdaya Air Menjelang Tahun 2020. Makalah disampaikan pada Seminar Pengkajian Kebijaksanaan Strategi Pengem-bangan Sumberdaya Air Jangka Panjang di Indonesia. Bappenas, 4-5 December 1991.

Haerah, A. 1991. Perkiraan Penggunaan Air untuk Pertanian Menjelang Tahun 2020. Makalah disampaikan pada Seminar Pengkajian Kebijaksanaan Strategi

Pengembangan Sumberdaya Air Jangka Panjang di Indonesia. Bappenas, 4-5 December, 1991.

Hardjono, J. (ed.). 1991. Indonesia: Resources, ecology and environment. Oxford University Press, Oxford. 1991.

Higgins, G. M.; P. J. Dieleman and C. L. Abernethy. 1988. Trends in irrigation development, and their implication for hydrologists and water resources engineers. Hydrological Science Journal. 2/1988. pp. 84-93.

Jezeph, D.A. 1992. Summary of water resources availability and demand projections. Draft Report FAO UN. Rome, 1992.

Pasandaran, E. 1991. Pembangunan Pengairan Tahap Ke dua: Pemikiran Tentang Kebijaksanaan Investasi. Makalah disajikan dalam Seminar Kebijaksanaan Strategis Pengambangan Sumber-daya Air Jangka Panjang Indonesia. Bappenas, 4-5 December 1991.

Potter, L. 1991. Environmental and social aspects of fiber exploitation in Kalimantan, 1967-1987. In: Joan Hardjono, Indonesia: Resources, Ecology and Environment, 1991.

Pusposutardjo, S. and Soenarno. 1990. Management arrangements for diversifying rice irrigation systems in Indonesia. Makalah disampaikan dalam. The First Progress Review and Coordination Workshop on Management Arrangements for Accommodating Non-Rice Crops in Rice-Based Systems. Quezon City, Manila, 10-14 December, 1990.

Wardojo. 1989. Rice self-sufficiency: The Indonesian experience. Ministry of Agriculture, Republic of Indonesia, Jakarta.

VISION STATEMENT

1. The role of agriculture in the Indonesian national economy will relatively decline in the next century. However, agriculture will still be essential, and its scale will be similar to the present, or even should be increased, to ensure sufficient amounts of food in both quantity and quality terms for the majority of the people, supplying raw materials for the growing industries, and providing sufficient income and employment opportunities particularly for rural people. Therefore, its capability or power to exchange with the nonagriculture sector should be increased through increasing the efficiency in overall agricultural systems through seeking better institutional settings, improved technology, and improved or increased capacity of farmers' organizations to bargain with both private and public sectors.

2. Guided by the need to provide sufficient food for the people, Indonesia, as a large populated country, should minimize the risks and uncertainties in its food supplies at affordable costs, particularly costs associated with national stability. Therefore, various adjustments in the agricultural and food policies should be made to face the foreseeable problems of the near future. This notion implies that there will be an additional 90 million people by 2018, the increase of income per capita will be about the same as Thailand's current income level, and there will be a growing concentration on the urban population. Both food availability and food accessibility should still be considered as a high priority in the national policy agenda. This is due to the fact that even with the same level of income as Thailand, the share of rice expenditure in the household food budget will still be high.

   Accordingly, rice self-sufficiency will still be a major food policy issue. But at the same time, due to increased per capita income of the people that will open new demand opportunities, the food policy should be broadened, i.e., diversification in consumption should also be promoted. It means that the spectrum of food production should be broadened without sacrificing the capacity to produce rice. In other words, agricultural diversification should be a major policy but should not be interpreted as competing with the policy of rice production.

3. The largest proportion of almost all food production in Indonesia is in Java which is a highly urbanized region covering only about 7 percent of the total area of Indonesia. Most irrigation and its complementary infrastructure in Java are almost developed. Due to land limitation in Java, the expansion of irrigation in this island will not be feasible. Therefore, to meet future demand for food and other agricultural products, the outer islands should be developed based upon their own resource capacities to produce various food and agricultural products.

   Since the majority of land resources in the outer islands are dry land, peat and swamp technologies including irrigation that are appropriate for those resources require serious attention for appropriate future agricultural development. This land resources development should be able to compensate for the decline of irrigated land in Java due to land conversion to meet demand for other uses like housing, industry and other purposes. This implies that mechanization will become an important policy issue for increasing both the area of agricultural land and the capacity of farmers to intensify their utilization of land. In addition, to be able to cope with future food problems, short-duration varieties, postharvest technologies, and pest and diseases management should also be further developed hand in hand with irrigation.

4. The perception of irrigation development and management should be changed, i.e., irrigation development and management should not be separated from overall land and water resources development. Therefore, the allocation, distribution and utilization of water resources should be to manage water resources efficiently, justly and fairly. A watershed or a river basin is proposed as an appropriate unit of management to be responsible for allocation, distribution, utilization and conservation of water resources sectorally, spatially and temporally. This perceived change calls for changes in legal, institutional and operational issues for managing water resources. Even though some legal aspects of water resources development have been developed in Indonesia, extensive and intensive research on these areas are called for, in order to determinate what the legal and operational base of decision-making should be.

5. All changes in legal and institutional aspects of water resources in Indonesia should refer to UUD 45, the constitution of Indonesia. Since the state owns water resources according to the constitution, any changes in this aspect such as decentralization, privatization, and so on are both bound and promoted according to this constitution. Up to now, private institutions such as water users' associations are responsible only for operation and maintenance of tertiary irrigation of less than or equal to 500 ha. Planning, building main infrastructure, and legal and institutional development are mainly the responsibility of government agencies, especially in the Ministry of Public Works through coordination with the National Planning Agency. In the foreseeable future, to some degree, more decentralization in decision-making processes, implementation, and control and monitoring seems necessary. The decentralized organization that should be developed must fulfill the requirements that are mentioned in the earlier paragraph.

6. Future economic development should not only expand and deepen the agriculture sector, but should also create new opportunities for rural people. In this respect, irrigation will be an obvious means to expand production of agricultural commodities. Parallel to this, other dimensions of water resources development should be able to support the growth of agricultural industries that are located in the villages. Therefore, off-farm production employment opportunities should increase. Accordingly, local market demand for both agricultural and nonagricultural products should expand. Of course, investment, regulation/deregulation, price and other complementary policies should be directed to the above goals.

7. Farmers in developing countries such as Indonesia are mostly small farmers. Their capacity to adopt technologies to adjust to changes in the economic environment and to pursue long-term strategies are limited. On the other hand, they face an economic environment that becomes more and more competitive due to higher involvement in international agricultural markets. This implies that the government as the representative of the people should be able to help farmers to increase their welfare without disturbing the health of the economy. Therefore, some government assistance is necessary to be implemented through various policies such as price, investment, research and extension, credits, market development, information accessibility and welfare policies. More attention should also be given to landless farmers and the rural poor. Water resources development such as irrigation development, pricing policies, and others should also be able to improve their welfare.

8. Irrigation development and other water resources development activities usually occupy a large land area. This will change land use patterns, having far-reaching environmental implications which implies that irrigation development should be

carefully planned in accordance with the specific characteristics of each island. At the same time, the growing population, urban sprawl, and so on, will demand more land and will have significant impact on the existing irrigation. Increased irrigated land conversion as is currently occurring in Java is a case where surrounding environments decrease the irrigated land. In addition, within the irrigated land itself, the environmental problems may appear in the future in the forms of salt water intrusion, eutrophication, waterlogging, and groundwater pollution, particularly when groundwater pump irrigation expands.

9. Vision. Irrigated agriculture in Indonesia will continue to play an important role in:

   i. guaranteeing food security;

   ii. supplying raw materials for the growing industrial sectors;

   iii. providing sufficient income and employment opportunities; and

   iv. establishing farming systems which are environmentally sound.

Note: IRRIGATION IS ONLY THE MEANS, NOT THE END.

MEANS TO ACHIEVE THE VISION

Policy

An income-oriented policy balancing production needs with expanding incomes for the farmers to

- improve pricing policies towards more efficient resource allocation;
- improve technology to increase farm productivity;
- select subsidies to stimulate productivity and to increase/maintain income;
- improve terms of trade between agricultural and nonagricultural commodities; and
- achieve economies of scale of farm production.

Reduce regional disparities, particularly between the eastern and western parts of Indonesia through

- infrastructure development;
- decentralization
  - devolution
  - deconcentration
  - delegation; and
- transmigration.

Reinforcing legal and regulatory functions with the objectives:

- conflict management;
- deregulation/debureaucratization;

- promoting growth and equality; and
- irrigation management and integrated water resources management.

Government investment and management in irrigation

- improve performance for maintaining the service capacity of the existing irrigation facilities (O&M);
- diversification of water use through the improvement of irrigation systems; and
- broaden the scope of management from water use management to water resources development management, including management of the upper watershed.

Institutions and organizational development

- turnover of irrigation schemes less than 500 ha;
- provision of mechanisms and conditions for more active participation of water users' associations;
- improvement of market structure and strengthening of rural cooperatives; and
- increasing accountability, coordination and collaboration of all institutions in charge of water resources management.

Laws and Institutions

Water rights and transfers

- establish and reinforce operational rules to implement the existing laws and regulations governing water use.

Irrigation systems ownership

- no change.

Water resources planning and monitoring

- strengthening the existing mechanisms for planning and monitoring of irrigation systems.

Irrigation systems management

- increase participatory management by WUAs.

Information/Cooperation Needed (* = Collaboration with International Organizations)

Demand and supply projections of rice and other related commodities

- level and growth of per capita consumption of rice and other related commodities; and
- level and growth of production of rice and other related commodities.

Rate of depletion of irrigated land in Java

Actual and potential increase in production through improvement in irrigation

* *Trend in commodity prices in international markets*

* *Trend in demand for rice and other related commodities in the international market*

* *Trend in technological development*

* *Trend of socioeconomic changes at the village level*

River basin water balance in Indonesia

* *Trend and impact of global climate changes.*

Malaysia

Keizrul Abdullah[2]

PRESENT SITUATION

Introduction

MALAYSIA IS LOCATED between latitudes 1° and 7° North, and longitudes 100° and 119° East. The country comprises two regions, Peninsular Malaysia and the States of Sabah and Sarawak, separated by 640 km of the South China Sea. Together, the two cover an area of over 330,000 sq km. The population of Malaysia is approximately 18 million with an estimated growth rate of 2.6 percent per annum.

Malaysia enjoys a tropical climate influenced by the northeast and southwest monsoons. The former, prevailing between November and January, brings heavy rainfall, predominantly to the east coast of Peninsular Malaysia. The latter prevails during April and May for Peninsular Malaysia and between May and July for Sabah and Sarawak. Rainfall during these periods is generally less than during the northeast monsoon.

The annual average rainfall is 2,420 mm for Peninsular Malaysia, 2,630 mm for Sabah and 3,830 mm for Sarawak, the heavier precipitation being in the east coast of Peninsular Malaysia and the coastal regions of Sabah and Sarawak.

Temperature and humidity are consistently high, being 26°C and 80 percent, respectively. Daily temperature variations are about 5°C and monthly variations even less, of the order of 2°C. The mean annual open water evaporation varies from 1,800 mm in the north to 1,600 mm in the south, with the minimum in November and December.

About 22 percent of the land in Malaysia is utilized for agriculture. Townships, mining activities and other uses take up another 10 percent, leaving 68 percent under forest cover. Approximately half the agricultural lands are cultivated with perennial crops. The other half is taken up for annual crops, mixed horticulture, shifting cultivation and, to a much lesser extent, for fish ponds.

The Gross Domestic Product (GDP) in 1990 was M$ 79,103 million (at constant 1978 prices) with the major exports being electrical and electronic products, crude oil, rubber, palm oil, timber, liquid natural gas (LNG) and some manufactured goods.

The agriculture sector is targeted to be grown by 3.5 percent per annum during the next 10 years. While this rate of growth is relatively lower compared with other sectors of the economy, agriculture will continue to be important in the nation's development, particularly in the rural sector. In addition, it will provide the resources and the market to support the development of the other sectors of the economy, in particular the industrial sector, as agriculture becomes increasingly integrated with the former.

---

2 Director, Planning and Evaluation, Department of Irrigation and Drainage, Kuala Lumpur, Malaysia.

Presently, the agriculture sector contributes more than a quarter of the country's total export earnings, one fifth of the Gross Domestic Product and nearly one third of the total employment. Value added per worker in the agriculture sector however is half that of the manufacturing sector.

Policy

Agriculture, in particular, irrigated agriculture will continue to play an important role in the Malaysian economy. Irrigated agriculture producing food crops such as rice, vegetables and other short-term food and animal feeds as well as producing high-value floriculture crops will continue to be given focus for fresh consumption as well as for downstream processing into higher value-added commodities. The production of rice, the staple food of the Malaysians will be intensified in existing primary and secondary granary areas with suitable irrigation infrastructure, to fulfill a 65 percent self-sufficiency level. However, the production of all other food commodities would be market-led and domestic resource cost considerations will predominate. Even in the case of rice, the industry will be closely monitored and reviewed in tandem with research and development and other efforts to continually reduce both the cost of production and the comparative disadvantage. The formulation of a specific National Food Policy will guide the production of the various food crops, including irrigated food crops.

Irrigated Agriculture: The Present Situation

Irrigation development in Malaysia has gone through a number of distinctive phases which were directly linked to the changing trend of the rice industry in the nation.

Rice is said to have been cultivated in Malaysia for the last 2,000 years. The rice areas were generally located in small pockets in the flood plains adjacent to the banks of major rivers. Technically, the irrigation systems were rudimentary with dual-function channels, i.e., irrigation during the growing months and drainage towards the end of the planting season. Water distribution within the rice areas was from plot to plot with irrigation relying largely on rainfall.

Towards the turn of this century and in the early 1900s there were initial efforts by the government and private enterprises to develop irrigation infrastructure. There were also notable successes such as the Kerian Irrigation Scheme in the North Perak (23,400 ha) which had the first irrigation reservoir in the country and the Wan Mat Saman Scheme in Central Kedah (28,700 ha).

The food crisis in 1918-1920 and escalating import prices prompted the government to review the rice-deficient situation. Subsequently, a policy was formulated to increase rice production in the country.

In 1932, the Department of Irrigation and Drainage (DID) was formed and together with the Department of Agriculture (DOA), formed the basis of organized and systematic irrigation development. Apart from expanding the existing irrigation schemes, substantial new areas were also reclaimed for rice.

The new schemes were generally constructed by having separate systems for irrigation and drainage. The need for a separate drainage system was necessitated to carry away flood waters normally associated with the monsoon rains. This, in retrospect, must have been the most important move in irrigation sustainability, as it precluded the possibility of salinization, not withstanding heavy rainfalls.

The 1960s saw a shift of emphasis from purely food security aspects to the need to improve the socioeconomic status of the rural poor. Irrigation now was not just a means to increase rice production but also became a vehicle for rural upliftment. The government's development plans for the rural poor were through the development of irrigation to meet the twin objectives of poverty alleviation and food production.

The above objectives were largely met through the widespread introduction of double cropping in already developed schemes. Water resources development became an important component of irrigation projects. Storage dams, barrages and pumping stations were constructed. Irrigation canals were upgraded to meet the increased water demands for the off-season crops. More farm roads were constructed in line with the intensification of canals and drains.

With the general completion of the double-cropping program, yield increase per unit area per season was the next option to maintain irrigation sustainability. Thus, the momentum of irrigation development continued into the late 1970s and early 1980s.

In the late 1980s, the rice industry in the country faced a number of problems relating to labor shortage and escalating production costs. There was a competing shift of the available farm labor to industry resulting from the country's priority on industrialization. Consequently, the smaller irrigation schemes were affected severely and many were left idle.

The priority for irrigation development then, took a new dimension with the need to rationalize rice cultivation with production cost and profit considerations. Since Malaysia does not have a comparative advantage in rice production due to high investment and production costs, there evolved the policy to confine irrigation development to eight large irrigated areas, designated as Granary Areas where economy of scale could be practiced. Increasing productivity in these areas totaling some 210,500 ha became the main thrust.

These areas were developed under the concept involving not only engineering aspects but also social, agronomic, cultural and economic aspects. Irrigation and drainage facilities were intensified and extended to the tertiary level to provide good water management at the farm level enabling the cultivation of high yielding varieties. Farm mechanization was successfully adopted and more significant, direct seeding began to replace the labor-intensive transplanting method.

Farm mechanization and direct seeding necessitated some upgrading of the infrastructures in the Granary Areas. For mechanization, field drainage and farm roads had to be improved to allow easy machine movement in the farm. Land leveling and also on-farm drainage, became imperative due to the need for precise water distribution and control at the farm level necessary for direct seeding. Farm management also underwent fundamental changes in attempts to cope with labor constraints, irrigation scheduling and farm mechanization. Farmers had to be sensitized to the new system, adjusting their cultivation activities accordingly. Attempts were made to convert farms which had been traditionally operated by individual farmers to estate-type management for more organized and economical operation of the various cultivation activities. Rice production from these Granary Areas increased significantly to the current level of 5.7 tons per ha.

The small irrigation schemes (the Non-Granary Areas) were designated to be gradually phased out from rice to diversified land use such as more remunerative cash crops and aquaculture. The Crop Diversification Study in Non-Granary Irrigated Areas completed in 1990 had identified existing rice irrigation schemes totaling 54,000 ha for conversion, and this can be extended to other suitable rain-fed rice areas totaling 70,000 ha currently not served with irrigation facilities. These areas were revitalized through appropriate farming systems to support growth of selected crops. Provision and management of suitable irrigation systems and related infrastructure will be required to maximize production. Modern irrigation methods such as micro-irrigation systems (drip and trickle) and overhead sprayers will be introduced.

Malaysia has also embarked on a nation-wide program to rehabilitate idle rice lands. The rehabilitation program basically comprises numerous small Integrated Agricultural Development Projects where the construction of infrastructural facilities for irrigation, drainage and farm roads constitute an important component. In the program, rice landowners have been persuaded to revitalize their lands and they are encouraged to diversify cultivation for non-rice crops which can generate higher remunerative farm incomes.

During the period 1971 to 1990, about M$1,500 million have been expended on irrigation development, the bulk of which was to upgrade irrigation facilities for the eight Granary Areas. Under the Sixth Malaysia Plan (1991-1995) M$ 9,019 million or 16.4 percent of the total expenditure is allocated to agriculture and rural development. Of this amount, M$ 628 million are for projects in which irrigation is the main component. At the same time, some M$ 18.1 million will be spent on crop diversification programs in selected Non-Granary irrigated areas.

Needs

With farm-production objectives becoming more commercially oriented and to satisfy the expectations of the consumers for consistently high quality produce, irrigation is considered an agricultural input and its necessity will continue to increase in importance. This is especially so when the constituents of the "food basket" for the average Malaysian become more mixed and varied, with greater demand for protein-rich and fiber foods. Thus, more areas for a wider variety of food crops can be expected to be irrigated.

Estate-type management, commercial orientation and labor constraint will need farm sizes to be economically larger together with less labor-intensive methods of cultivation and better water management. Mechanization and automation will inevitably be the main features. With mechanization and better water management, land leveling will have to be an integral part of the overall farm infrastructural development. Subsurface drainage will need to be introduced to improve on-farm drainage in order to increase soil strength and structure and facilitate machinery mobility. Piped water distribution system too will reduce barriers to farm mechanization, provide flexibility of operation, minimize losses and allow for faster supply-response time compared to open channel systems. Pumps and on-farm storage facilities will become a standard feature at the on-farm level.

While surface irrigation systems will be necessary for rice, there will be an increasing use of modern irrigation methods such as micro-irrigation systems (drips and trickle) and overhead sprayers. Integrating the various components will also facilitate various degrees of automation at the on-farm level.

At the main system level, selected existing open channels will be replaced by piped conveyance and distribution networks. More irrigation water storage reservoirs will be constructed to complement water source management. Apart from improving efficiency, such a system will provide for better control of water use and facilitate regulating supply to the end users and possibly moving towards metering of water for those users. Again automation will be incorporated into the management.

For better accuracy and to improve water savings, irrigation prediction models, water demand forecasting models and efficient water-management systems will have to be developed. The use of the telemetry system is expected to be extended to all major schemes. Remote sensing applications in irrigation management are also likely be developed.

Issues and Challenges

While irrigation will continue to play an important role, future trends in its development will have to face a variety of issues and challenges.

Land Utilization Alternatives

The competing uses of available land for both nonirrigated agriculture and nonagricultural purposes such as industrial and housing needs pose severe constraints for irrigated agricultural farming. Consequently, the need to increase productivity per unit of land becomes increasingly important and pertinent in the context of irrigated agricultural farming. The whole issue of the economics of irrigated agriculture will have to be addressed.

Labor Shortages

Labor shortages are expected to continue to plague agriculture including irrigated farming. Whilst for the immediate run, foreign labor will be relied upon, mechanization, labor-saving techniques, modern machinery and technology-intensive farming methods and systems will be emphasized. The Human Resources Development Plan will embody the emphasis on farming and agrobusiness management and operation to complement the overall efforts.

Water Supply for Irrigation

Whilst labor shortages will be more acute, the shift of priorities of water use from irrigation to domestic and industrial demands imposes further stress on irrigation sustainability. Irrigation for agriculture is currently the largest consumer of water, amounting to about 75 percent of the total fresh water withdrawal in the country.

The issues to address will be related to quality and quantity. Since domestic and industrial sectors have higher priorities, irrigation may have to resort to lower quality water and also look into the use of groundwater and recycling of surface drainage water. Water harvesting techniques will have to be further developed and promoted. Water will have to be regarded as an economic good and every means of economizing water use will have to be taken up by incorporating automation and water-saving measures. Issues of pricing of water to reflect its scarcity value in the light of competing and sustainable uses will need to be addressed.

Water Demand for Irrigation

Actual consumption of crop water depends on systems efficiency, a product of efficiency during conveyance, distribution and field application. Generally, in Malaysia, the overall efficiencies are around 35 percent to 44 percent. Future rehabilitation and modernization programs must urgently address irrigation efficiency improvements at each level of the system. Such efforts include canal lining, control structures, improved irrigation methods and application, crop selection and diversification, water reuse and recycling.

Water Management

Water management must be addressed comprehensively at all 3 levels of the total system: resource management within the watershed and headworks, within conveyance and distribution systems and on-farm.

Each of these levels of management would require appropriate institutional arrangements both private and public with competent and committed participation, to enable the multiplicity of issues related to good soil and water conservation practices to be addressed. Complete databases, modeling techniques for systems operation and continued monitoring and control are essential elements in addition to education, training and extension.

Environment

All the proposed changes and developments will have to take into consideration the need for sustaining the environment, particularly the need to preserve the water ecosystems. Environmental issues resulting from greater usage of chemical pesticides, herbicides and fertilizers will also need to be addressed. It will be necessary for them to be changed to environment-friendly products. Irrigation, on the whole, will need to consider soil conservation techniques and management of farm chemical residues to preserve water quality, environmental and health issues.

Strategies

Rice production will continue to be concentrated in the Granary Areas. To cater to the increasing population which is projected to grow to 22.6 million by the year 2000, productivity of these areas will need to be increased, especially if the target production is to meet 65 percent of the local demand.

Designated areas would need to be developed to their full potential. Consideration must be given for structural changes, aimed at creating larger and more viable production units, through increased mechanization and improvements in the land-farmer ratio. This would call for rehabilitation and modernization of irrigation systems to support efforts in raising cropping intensities and crop yields.

Irrigation sustainability will depend on the ability to adjust within an industrialized economic environment. This could take the form of automation of irrigation systems, estatisation, efficient use of water through new irrigation technologies, diversification into more remunerative crops and greater flexibility of irrigation systems to cope with rapidly changing situations.

On-farm development will have to be undertaken by individual farmers and private enterprises. To accelerate the distribution of this responsibility, irrigation extension will need to be further developed. Research and development and capacity building through human resources development (training, education and extension) both in the public and private sectors cannot be overemphasized.

Management-related activities would require complementary enhancement of irrigation management training and extension involving both the users and systems operators, thereby paving the way for possible transfer to the users for entire operation, maintenance and management of completed systems. This will be applicable to those schemes operated by public sectors within the context of desirable cost-recovery efforts.

Future Directions

The wide range of management-, pricing- and technology-related challenges accompanying future trends in irrigated agriculture calls for concerted, integrated and coordinated efforts from departments and agencies involved in agriculture within the public sector, the private sector and the end-user (be it the individual farmer or the developer). The Ministry of Agriculture will continue to play the pivotal role in ensuring a balanced growth of the agriculture sector, whilst the private sector (both corporate and individual) is expected to lead investments in this sector.

Public-sector irrigated-agriculture programs involving participation of all departments and agencies as integrated components should be strengthened, expanded or suitably linked to involve the private sector, that will have a larger role to play in the future, especially in crop diversification and commercial farming ventures.

The emphasis will be on in-situ development, aimed at revitalizing existing cultivated or abandoned areas for fuller utilization of resources for agricultural production. This will involve mainly land consolidation, rehabilitation, replanting, drainage and irrigation as well as effective adoption of technology by farmers to modernize and commercialize the smallholder sector. Sustainable irrigated agriculture would require appropriate irrigation systems to be not only effective and efficient but also sufficiently flexible to support crop diversification programs and changing farming systems.

There is also a need to intensify agriculture by specializing in the production of high value-added and market-oriented crops.

Supporting programs on research and development, agricultural extension, human resources development and marketing will continue in tandem with implementation activities. Agriculture-related departments and agencies will need to interact with institutions of higher learning and the private sector through appropriate networking and cross-linkages. This will ensure timely interventions through active research on a continuing basis which can benefit the agriculture sector.

While maintaining close in-country links, there is an equal need to maintain and expand connections and interactions with external, regional and international organizations such as FAO, ICID, IIMI, IRRI and ESCAP as they serve as useful windows to facilitate the scanning and access to contemporary management and technological advances and developments in irrigated agriculture from around the globe. Collaboration and participation in regional and international programs and activities will continue to be encouraged.

VISION STATEMENT

Irrigated agriculture beyond 2000 shall be directed towards greater commercialization using appropriate technology and sustainability, and complemented by capacity building through human resources development programs.

Development of irrigated agriculture shall be achieved through the optimal and efficient use of resources in harmony with the environment to ensure sustainability.

Summary of Discussion of the Vision Statement

1. A vision statement on irrigated agriculture must be guided by the larger country vision and related economic, food and agriculture policies. For Malaysia, Vision 2020 is to achieve industrial status by the year 2020. For the medium term up to year 2000, the Second Outline Perspective Plan (1991-2000) targets the growth of the agriculture sector at 3.5 percent per annum. The National Agricultural Policy (NAP) for the period up to 2010 calls for a balanced growth with other sectors emphasizing a more commercial approach in agriculture, coupled with efficient utilization of resources. Hence, agriculture, and in particular, irrigated agriculture will play an important role in the Malaysian economy.

2. While competing with the manufacturing and service sectors in providing improved incomes for those remaining in the agriculture sector, complementary growth in agriculture must also ensure a reliable and sufficient supply of agricultural inputs to the other sectors. Against labor constraints, the thrust will therefore be towards the use of appropriate modern technologies in the production system while enabling products to be globally competitive through quality enhancement and to be used in downstream processing into value-added commodities.

3. For the staple food, rice, self-sufficiency levels shall be guided by those set by the NAP; currently the level is set to be not lower than 65 percent.

4. Rice production shall continue to be a main player in irrigated agriculture and shall be confined within existing areas. Areas irrigated for high-value crops shall be expanded, the production of which shall be market-driven.
5. With the accelerated growth of the industrial sector, greater competition in the use of available water resources is inevitable. Water as a resource with economic value must be efficiently utilized and use of lower quality water for agriculture may well become an option for consideration. At the macro-level, the formulation and implementation of a Master Plan for the planning, management and allocation of water resources are urgently required inclusive of accompanying legislation.
6. In moving towards greater commercialization, private-sector involvement shall be encouraged.
7. Irrigation systems, be it surface, overhead or micro, and associated technologies and techniques currently in use for increasing agricultural production, shall be expanded and upgraded through adaptive research and development to suit local conditions and towards greater water use efficiency.
8. Human Resources Development shall be focused on all aspects of improving the skills and capabilities of both the public and private sectors to operate and manage as a commercialized system of agriculture.
9. Development of irrigated agriculture should be balanced between the resources available and the environmental implications so as to achieve sustainable development.
10. Above all, irrigated agriculture shall also be targeted to improve the quality of life and contribute towards greater parity between the urban and rural population.
11. The Vision Statement is complete in itself. However, in order to avoid misinterpretation it requires appending definition of certain keywords like commercialization, appropriate technology and sustainability.

MEANS TO ACHIEVE THE VISION

Policy

1. There will be a need for periodic review of the agriculture policy especially in relation to rice sufficiency levels.
2. Rice land use must be flexible for diversified cropping. The choice of crops should permit easy reversal to rice, should the need arise.
3. A Master Plan for the planning and management of water resources on a basin-wide approach must be developed.

Legislation

In order to enable commercialization, efficient use of resources and protection of the environment, existing laws pertaining to land and water will need to be amended and strengthened. In formulating the legislation, the rights of the low-income farmers should be safeguarded.

Institutions

With greater involvement of the private sector, the role of the existing public-sector institutions in the long term shall be reduced to policymaking, regulatory functions and major resources development and allocation. The existing public institutions shall be corporatized in stages towards ultimate privatization. Farmers' institutions shall be strengthened to manage diversified businesses and to participate in the privatization process.

Human Resources Development

Human Resources Development shall be targeted both to the public sector and to the private sector. Training should focus on skills needed to manage commercialized farming.

Capital Irrigation Investment

1. Capital investment in irrigation at the farm level shall be borne by the farmers and shall be gradually extended to include the tertiary, secondary and the main systems. The capital investment for large-scale water resources development and bulk transfer shall still rest with the government.
2. To encourage farmers to venture into commercialized farming and agro-business, incentive packages shall be provided to cover for infrastructure and equipment.

Support Infrastructure

1. An efficient and effective marketing infrastructure shall be promoted and developed to address the need to continuously remain competitive, specifically oriented to changing market and land-consumer preferences, and responsive to market needs and opportunities.
2. Research capability shall be continuously enhanced and more public-private sector Research and Development programs will be promoted. The technology and knowledge developed shall then be in the public domain.

Cooperation/Information Needed

The issues that need to be addressed in attaining the vision targets are categorized as follows:

Issues	A Domestic Research	B Regional Cooperation	C Collaboration with International Organizations
1. Policy			
* Resource planning	x		x
2. Legislation and Institutions			
* Water-related legislation			x
* Institutional aspects of privatization	x		x
3. Human Resources Development			
* Entrepreneurship, technical, managerial	x	x	x
4. Supporting infrastructure			
* Water management for direct seeding	x	x	x
* Water management for diversified cropping	x	x	x
* Rice varieties for direct seeding	x	x	x
* Product quality enhancement for marketing	x	x	x

Philippines

Rodolfo Undan
and Jose Galvez[3]

PRESENT SITUATION

Introduction

THE PHILIPPINES IS a tropical country and an archipelago of 7,107 islands. The country stretches between latitudes 4.5° and 21° North, and longitudes 117° and 127° East. It is divided into three geographical areas: Luzon, the Visayas and Mindanao. It has 14 geopolitical regions, 73 provinces and 60 cities. The country has a total land area of 30 million hectares (ha). Of these, about 7.9 million ha are arable and permanent land, 11.35 million ha are forest land, and 1.16 million ha are permanent meadow and pasture land (ASEAN ADPC 1987).

As of 1992, the country's estimated total population is 62.7 million with a growth rate of around 2.3 percent. This is projected to reach 71.3 million by the year 2000. The Philippines has over a hundred ethnic groups and a mix of foreign influences which resulted in a unique Filipino culture. Filipinos are largely of Indo-Malay, Chinese and Spanish ancestry. Although Pilippino is the national language, English is widely spoken. Literacy rate is 89.8 percent.

The country has a climate that allows year-round cultivation. From December to May it is generally the dry-season and from June to November it is the wet-season. Average temperatures vary from 25 to 32°C (78 to 90°F). The average humidity is 77 percent. Typhoons hit the country on the average of 20 per year. Due to the wide scatter of the islands, there is regional variability in climate in the country. Four major climatic types are identified based largely on the distribution of rainfall.

The country's economy is highly dependent on agriculture. The two major food crops grown for domestic consumption are rice and corn. Rice is the primary major staple food of 85 percent of the population. Major export crops include coconut, sugar, abaca and tobacco. The major forest products exported are logs, lumber, plywood and veneer sheets. The forest, with some 3,800 known species, constitutes a natural wealth of the country.

Irrigated agriculture in the Philippines is synonymous with rice irrigation. Irrigation systems in the country are established primarily for irrigating rice which is the main (rainy season) crop in most farms.

This paper contains the current situation, present plans and trends of irrigated agriculture in the country.

---

3 Professor and Vice President, Research, Extension and Training, Central Luzon State University, and Assistant Administrator, National Irrigation Administration, respectively, of the Philippines.

Current Situation

At present, the country has a per capita gross national product (GNP) of US$725 and a gross domestic product (GDP) growth of 0.5 percent (Asiaweek, August 21, 1992). It has a total foreign debt of around US$29.6 billion. Total export earnings were increasing and as of 1991 these had reached US$8.8 billion.

Agriculture

The government's desire in promoting agriculture is to be self-sufficient in food, especially in such major crops as rice and corn. As of 1990, a combined total of 7.14 million ha of arable land were devoted to produce these two commodities (Bureau of Agricultural Statistics - BAS 1991). A total of 3.319 million ha were planted to rice during the year wherein some 2.01 million ha were irrigated. Corn was planted to 3.819 million ha.

The country produced 9.319 million tonnes of rice in 1990 (BAS 1991). The average yield was placed at 2.81 t/ha. The estimated yield in irrigated farms was 3.29 t/ha and in rain-fed areas it was 2.07 t/ha. Irrigated areas contributed 71 percent of the total *palay* production in 1990. These areas, however, are not made fully productive mainly due to lack of irrigation facilities.

Water Resources

An assessment of the national water resources supplies and uses for the period 1975-2000 revealed that water requirements of various sectors in the next decade in the Philippines can be adequately met by the existing naturally endowed water resources (Sosa 1985). The main task is to be able to tap these water resources and make these available to end users in the appropriate time and place.

Rainfall is considered bountiful in the country. The average annual rainfall varies from about 1,000 mm to a little over 4,000 mm. The country's annual point average rainfall is about 2,400 mm. Rain occurrences are induced mostly by the monsoons and tropical disturbances.

Rivers and lakes are major sources of surface water in the country. There are some 384 major rivers and 59 lakes with a combined area of 287,200 ha which compose the freshwater ecosystem. The country's river basins have drainage areas ranging from 40 to 25,649 sq. km (Bruce 1988). Annual runoff in six major river basins of the country indicates that about 46 to 73 percent of the rainfall goes as runoff.

Ample groundwater supplies are said to be present in large reservoirs covering some 50,000 sq. km and concentrated mainly beneath major river basins (National Water Resources Council 1976). Groundwater resources are used both for agriculture and domestic needs. Shallow groundwater and artesian water from shallow aquifers are observed to be sourced for the same purpose in the countryside.

Irrigated Areas

National Irrigation Administration (NIA) Monitored Systems. Rivers and creeks are the major sources of irrigation water in the Philippines. Irrigation systems are developed through installation of a) diversion weirs, b) pump systems, and c) dams and reservoirs.

The areas covered by irrigation systems under the NIA from 1964 to 1991 are given in Table 1 (Galvez 1992). A marked increase in irrigation service area of some 663,100 ha occurred from 1964 to 1980. As of 1991, some 1.5262 million ha were covered by the irrigation systems. The areas irrigated in 1991 were 2.82 times those in 1964. Currently, about 49 percent of the potential 3.126 million irrigable areas in the country is covered by irrigation systems.

Table 1. Development of irrigation service area, 1964-1991.

Year	Service Area ('000ha)	Area Increase		Area Index (1964=100)
		('000ha)	(%)	
1964	541.0	—	—	100
1975	985.3	444.3	82	182
1980	1,204.1	218.8	22	223
1981	1,245.9	41.8	3	230
1982	1,300.6	54.7	4	240
1983	1,350.9	50.3	4	250
1984	1,359.3	8.4	1	251
1985	1,385.4	26.1	2	256
1986	1,416.9	31.5	2	262
1987	1,422.2	5.3	0	263
1988	1,450.9	28.7	2	268
1989	1,469.2	18.3	1	272
1990	1,487.9	18.7	1	275
1991	1,526.2	38.3	3	282

Source: Galvez 1992.

The irrigation systems in the country are classified into two in terms of management: a) the government-owned national irrigation systems (NIS), and b) the farmer-managed communal irrigation systems (CIS). About 42 percent of the current service area is managed through the NIA.

In the NIS, operation and maintenance (O&M) are done through an irrigation systems office (ISO) headed by the irrigation superintendent (IS) and supported by O&M personnel. A joint management scheme with organized farmers' associations is also being implemented. This is to promote farmers' participation in the O&M and to motivate them in paying the irrigation fees.

Small Water Impoundments

There are many small natural watersheds in the country where the establishment of water impoundments is appropriate. The Bureau of Soil and Water Management (BSWM) of the Department of Agriculture indicated that some 546 projects were completed in 13 regions of the country from 1986 to 1990. A total of 20,047 ha were covered and 17,583 farmers benefited. Total project cost was US$1.755 million, the average cost of development per impoundment being US$3,215.

Small Farm Reservoir (SFR)

This is the smallest version of the small water impoundment which is also gaining wide adoption by farmers in some hilly lands in the Philippines for supplemental rice irrigation and inland fish production. The SFRs, whose dam heights are normally below four meters, impound excess rainfall coming from small catchment areas with no defined streams. Currently, about a thousand SFRs are estimated to be in place in the Central Luzon region alone. These reservoirs have average pond water surface areas of 500 to 2,500m^2. The catchment size is between 0.5 and 7 ha and the farm area served ranges from 1 to 5 ha. A National Program on Small Farm Reservoirs is currently being coordinated by the Philippine Council for Agriculture, Forestry, and Natural Resources Research and Development (PCARRD).

Shallow Groundwater Pump Systems

Hundreds of individually owned pump systems drawing from shallow groundwater aquifer are found in many rain-fed flatlands. Also, in tail-end sections of irrigation systems, water augmentation, using shallow groundwater with pump systems in growing non-rice crops, in the dry season was also observed and found feasible. Due to lack of monitoring, there is no accurate figure on the number and area coverage by these individually owned systems. Shallow groundwater pump systems are found appropriate for irrigating non-rice crops like corn, cotton, tobacco, onion, pepper, tomato and other vegetables in the dry season.

Shallow groundwater is sourced either through drilled tube wells or concrete-cased open dug wells. Pump systems are matched with 4 to 10 hp diesel engines. Lately, a National Shallow Tubewell Irrigation Program has been initiated through the Department of Agriculture to promote the use of groundwater for productivity improvement.

Irrigation Systems' Performance

The performance indicators of selected irrigation systems are given in Table 2. Compared to the project feasibility and project appraisal values, the average actual performances for the various indicators were found to be generally lower except in the incremental service area.

Table 2. Performance indicators of selected irrigation systems.

Indicators	Project feasibility study	Project appraisal	Average actual performance
1. Number of projects	14	14	14
2. Service area, ha	502,200	480,457	434,209
3. Incremental service area, ha	—	21,743	46,248
4. Irrigated area, ha			
Wet-season	487,900	451,500	320,871
Dry-season	314,850	314,400	253,477
5. Average yield, tons/ha			
Wet-season	4.41	4.40	3.95
Dry-season	4.25	4.25	3.92
6. Cropping intensity, %	160	159	132

Source: Galvez 1992.

The average O&M performance of National Irrigation Systems from 1980 to 1991 as evaluated through the NIA Central Office indicated that there was considerable increase in irrigated and benefited areas. While the total income rose from US$2.29 million in 1980 to US$15.28 million in 1991, the O&M expenses also rose from US$5.85 million to US$13.85 million in the same period.

Research Institutions and Network Supportive to Irrigation

PCARRD has established an R&D network consisting of 7 agencies/institutions mandated to do national and regional research on water resources. The two institutions which are given the national responsibilities in water resources R&D are the University of the Philippines at Los Banos (UPLB) and the Central Luzon State University (CLSU). In addition, a National Water Resource Commodity R&D Team under PCARRD, composed of expertise from various agencies, assists in the planning, coordination, evaluation, monitoring, and updating of the national directions of water resource research and development in the country in consultations with various agencies, farmers and end users.

Apart from the national network, two international institutions have been performing R&D activities in irrigation management in the country. These are the International Irrigation Management Institute (IIMI) and the International Rice Research Institute (IRRI), Soil and Water Science Division. Collaborative research work has been done jointly by the two institutes with the member institutions of the PCARRD Water Resource R&D Network.

Training

Various agencies in the Philippines are involved in training activities to improve irrigation water management. Among the more active ones are the NIA, IRRI, PCARRD, BSWM/DA and CLSU.

Comprehensive training programs on water management are being provided for the NIA O&M personnel of existing systems. Included are other related courses such as inventory management, record management, personnel advisory, financial management, heavy equipment operation, improved irrigation operation and maintenance and computer application. A major in-house strength developed in the NIA is its training program for farmers in organizing and developing Irrigators' Associations (IAs). Three major training courses dealing with basic leadership development, financial management and irrigation systems management are given in the program.

Currently, the Diversified Crop Irrigation Engineering Project (DCIEP) of the NIA is conducting a series of training programs for the NIA personnel and other clientele on irrigation and subjects related to crop diversification.

IRRI also conducts a regular yearly Irrigation Water Management and Rice Production Training Course for both local and international participants from irrigation agencies around the world. PCARRD and BSWM/DA occasionally conduct workshops and seminars on land and water resources conservation, water management, drought management and planning, and crop diversification in irrigated agriculture.

Legal Frameworks Regulating Water Resource Users

By virtue of a Presidential Decree No. 1067, the Water Code of the Philippines of 1976 was enacted and instituted (NWRC 1982). The decree revised and consolidated the laws governing the ownership, appropriation, utilization, exploitation, development, conservation and protection of water resources. Although this code is in existence, it is doubtful if water resource developers especially in the countryside are aware of the provisions of the code.

Current Plans

Agricultural Development

Agricultural development in the country is guided by the government's aim of making the Philippines self-sufficient in major agricultural commodities so as to provide a better life to the Filipino people and to become a newly industrialized country (NIC) in the year 2000.

In the next five years the four major development targets in agriculture in the Philippines are:

- poverty alleviation;
- improved production;
- priority crops; and
- policy and institutional reform.

In quantified terms, the agricultural development plan is designed to a) reduce the incidence of rural poverty from 50 percent in 1988 to 45 percent in 1992 and 40 percent in 1995; and b) increase the monthly average farm family income to US$148 by 1992, i.e., to a level above the current poverty line.

In production, the plan is to increase the gross value added (GVA) by an average rate of 3.91 percent per year in real terms from 1992 to 1995 and an average growth rate of 4.8 percent per year in all commodities.

The ten commodities that will be given top priority attention in the next five years are rice, corn, coconut, sugar, livestock and poultry, fisheries and aquaculture, fiber, fruits and vegetables, and ornamentals.

Under the new dispension, the Department of Agriculture indicated that among others, the following five specific major thrusts will be given priority in the next six years:

- irrigation development, maintenance and improvement;
- farm to market roads;
- fisheries resource management;
- market development; and
- postharvest facilities.

Irrigation Development

Under the NIA Corporate Plan for the period 1990 to 2000 (NIA 1990), it is planned to develop new irrigation facilities to irrigate an additional 530,000 ha of rain-fed areas in the next 10 years to a total service area of 1.858 million ha by the year 2000. The projected yearly increase in irrigated area is 48,300 ha. In addition, the NIA planned a collaboration with the Department of Agrarian Reform (DAR) to implement the Comprehensive Agrarian Reform Program - Irrigation Component (CARP-IC) which will generate some 223,800 ha during the same period. If the plan can be implemented fully, it is estimated that by the year 2000, the combined NIA and CARP-IC projects will provide an annual irrigation growth rate of 2.25 percent and increase the irrigated areas to 71 percent of the potential irrigable areas.

Rehabilitation of existing irrigation facilities was also programmed to cover 1.232 million ha from 1990 to 2000. This included the 129,610 ha programmed for rehabilitation under the CARP-IC for the same period.

The major constraint in the implementation of the development plan is the huge amount involved and where to source the total amount of Peso 60 billion.

Under the Bureau of Soil and Water Management, the target number of small water impoundments to be constructed up to the year 1995 was placed at 1,375 covering a total area of 53,990 ha. The target number of pump systems under the same period was relatively small and may stand revision depending on prioritization given.

Science and Technology Direction (S&T)

The central development philosophy of the Science and Technology plan revolves around harnessing R&D for increased productivity and sustainable development with the end in view of improving the quality of life of the people and the environment where they live.

The S&T directions in agriculture, environment and natural resources have been focused primarily to the development of profitable and ecologically sound production and post-production technologies. The priorities shall be given to sustainable development, rehabilitation, conservation, utilization, and management of resources and ecosystems.

To address the industrialization concern, the Countryside Agro-Industrial Development Strategies (CAIDS) are adopted as the centerpiece development strategy. These strategies include:

- increased production and stabilization;
- modernization and diversification;
- conservation and rejuvenation;
- countryside industrialization; and
- establishment of competitive, outward-oriented industries.

Problems/Constraints Related to Irrigation and Drainage

Competing Uses of Land and Water

Population pressure and urbanization continue to pose greater competition on the use of land and water. Agricultural lands in existing irrigation systems and proposed irrigation projects are being converted for commercial, industrial and residential uses. Many irrigation projects suffer from delays due to right-of-way problems resulting from land-use conflicts. On the other hand, highly urbanized areas get priority over available water to the detriment of irrigation.

Increasing Cost of Irrigation Development

The investment requirements for irrigation development are increasing per unit area. Earlier development concentrated more on areas which were relatively easier to develop leaving the areas which were farther away from access roads, having steeper slopes and requiring more complicated diversion and conveyance works unattended. The perennial insufficiency of funds for capital investment on top of higher cost per unit area further delays irrigation development and other infrastructure programs of the government.

Rapid Deterioration of Existing Facilities

Natural calamities, particularly typhoons, contribute to accelerated deterioration of irrigation facilities. To be able to cope with this, more funds have to be allocated for regular O&M and emergency repairs for damages resulting from natural calamities. As funds are usually scarce, yearly allocations are most often much lower than desirable and repairs have to wait for some time, when one or more cropping seasons have to be missed.

For the last three years for instance, an annual average of Peso 150 million was being spent for the repair of facilities damaged by typhoons. The damage brought about by the big earthquake in 1990 was estimated to be P 542 million while that of the volcanic eruption of Mount Pinatubo was about P 228 million. Some of the areas affected by Mount Pinatubo cannot be restored for a long time due to destruction of the agricultural land itself and deterioration of water sources due to sediments.

Irrigation Water Shortage and Excess

Irrigation systems, especially the run-of-the-river type, always have difficulty in providing adequate water to the entire service area during the dry season. On the other hand, excess water in low-lying areas during the wet season is also a big problem. Cropping intensity in irrigation systems' service area in the past decade was 134 percent on the average. Most of the problems encountered in the field were attributed largely to either the physical deficiencies or the social-institutional weaknesses.

Long Gestation of Irrigation Projects

Aside from the usual three or more years required to prepare project feasibility and detailed engineering studies, construction will take seven or more years for medium or large irrigation projects. Construction delays are quite common due to: a) insufficiency of funds to support cash flow requirements; b) civil disturbances; c) short construction period available each year; d) untimely fund support, i.e., funds being available in the heavy rainy months of the year; and e) frequent breakdowns or nonavailability of equipment and spare parts.

Pollution of the Freshwater Ecosystem

The role of the freshwater ecosystem as a life-support system is being threatened by development activities and man-caused pollution. Rivers and lakes are indiscriminately used as dumping grounds for domestic and industrial wastes.

The Department of Environment and Natural Resources (DENR) reported that 313 industrial firms along the river banks pour some 47 million liters of industrial wastes into the rivers yearly.

Some major rivers are also dumped with wastes from mining activities. Mine tailings transported along or across rivers are deposited in fertile farms via the irrigation water. It was estimated that some 140,000 tons of mine tailings are dumped on rivers daily causing serious siltation.

Watershed Denudation

The rehabilitation of watersheds deserves attention. Annual deforestation rate in the country was estimated to be 157,000 ha for the period 1934-1969, 357,000 ha for 1969-1976, 225,000 to 400,000 ha for 1976-1980, and 86,000 to 120,000 ha for 1986-1988 (Lustre, Jr. 1989). It was noted that denudation rate is much faster than the reforestation rate. Only about 20,000 to 50,000 ha are reportedly reforested every year. At this rate of reforestation, it is estimated that it will take more than three centuries to restore the forest cover of the current denuded mountains and watersheds.

Continued exploitation of forest and other natural resources has affected many watersheds of both existing and proposed irrigation systems. In many cases, watershed denudation has often resulted in flash floods, deterioration of water supply in both quantity and quality, pollution from mine tailings, sedimentation and siltation of reservoirs and waterways.

Existing irrigation systems require higher O&M expenditure because of the large volume of sediments entering the system canals due to upstream erosion and mine tailings. Dry-season water supply is significantly lowered particularly for systems which are direct river diversions due to denudation of the watershed. On the other hand, wet-season flood flows are higher than the design values resulting in bigger damages to facilities and more expensive restoration.

Reforestation efforts are largely confronted with social problems and difficulty in implementing forest rules and regulations.

Trends

Developing Small- and Medium-Scale Irrigation Projects

Due to heavy indebtedness of the country arising from foreign loans, construction of big irrigation systems becomes prohibitive. It becomes practical to develop small- and medium-scale irrigation or water resource systems which can easily be put up quickly using local resources. In small systems, better control of water, efficiency, and productivity of water use can be easily attained.

Improvement of Existing Irrigation and Drainage Facilities

In view of the fast deterioration of the irrigation facilities and the inefficiencies of water distribution due to defective structures, it becomes necessary to invest on the rehabilitation of the irrigation facilities. There is a need to improve the irrigation coverage of existing irrigation systems in both seasons.

Improved irrigation and drainage water management both at the systems and at the farm level were the objects of research and training efforts in the last one and one-half decades. Innovative techniques in water distribution and application were being tried. Farmers and technicians were being trained to use irrigation water economically, efficiently, and equitably.

Crop Diversification

For countries like the Philippines, where there are opportunities for year-round cultivation, cropping systems must incorporate crops which utilize less water but which offer good potential for profitability. Crop diversification is currently an object of study.

Use of Micro-Irrigation

With limited water and competing use with other sectors, agriculture will have to consider such micro-irrigation techniques as the drip or trickle irrigation which give marked improvement in yields. Countries with limited water like Israel have demonstrated that when this system is applied in conjunction with a good mix of cultural management, productivity is greatly enhanced.

Sustainability and Environmental Concern

Water pollution control and abatement should be a major concern if only to avert the deterioration of the quality of water supplies.

Augmenting Irrigation Systems with Shallow Groundwater Pump Systems

Irrigation systems relying on run-of-the-river type of source should encourage water augmentation using shallow groundwater at the tail end portion of the service area.

Continuous Involvement of the R&D Sector

Institutions and expertise in water issues and in the field of irrigation and drainage continue to get involved in research and development work. More and more capable manpower is available from various agencies to provide the R&D support.

In the next decade, the following systems/areas are the recommended subjects of R&D:

- small water impoundments/farm reservoirs;
- communal and national irrigation systems;
- crop diversification;
- irrigation water sources;
- drip irrigation; and
- watershed management.

Education/Training

The fact that most of the problems encountered with water utilization and conservation are man-made would suggest the need for the education of the people. The government must sustain the effort of creating consciousness among the users and managers of water regarding the conservation as well as the preservation of the quality of inland waters. Schools in various levels should continue including environmental lessons in the instruction materials of various curricula.

Concluding Remarks

The country should fully harness its bountiful water resources for irrigation and productivity without causing deterioration in water quality and significant depletion in quantity. Given the fertile land resource and the environment that will allow production throughout the year, investments in water resources development, conservation, and management for agriculture will surely increase farmers' productivity and consequently improve the nation's economy. At this point of difficulties, development of less capital-intensive water resources projects warrants consideration. Three small-scale irrigation systems are worth the priority for development: the diversion weir system, the small water impoundments including the small farm reservoir, and the shallow groundwater pump system.

There is a need, through education and research, to influence the water users, managers and policymakers/decision makers in the development and utilization of water resources projects that will be sustainable and productive but environment-friendly.

References

Asiaweek, August 21, 1992. Asiaweek Ltd., Bangkok, Thailand.

ASEAN ADPC. 1988. ASEAN statistical yearbook on food agriculture and forestry, 1978-1987. Bangkok, Thailand.

Bruce, R.C. 1988. Surface water resources in the Philippines. In: Proceedings FRS Forum, 3rd of a Series, PCARRD Book Series No. 75/1988. Los Banos, Laguna.

Bureau of Agricultural Statistics. 1991. Handbook of regional rice statistics, calendar year 1970-1990, Manila, December, 1991.

Bureau of Soil and Water Management. Five-year water resources development program, 1991-1995. Diliman, Quezon City.

Galvez, J.A. 1992. Country report on irrigation/water management for sustainable agricultural development. Paper presented during the Expert Consultation of the Asian Network on Irrigation/Project Management, Bangkok, Thailand, 25-28 August 1992.

International Rice Research Institute. Toward 2000 and beyond. Los Banos, Laguna, Philippines, 1989.

Lustre, P.M. Jr. 1989. Logging bank: Selective or total. In: Philippines Free Press.

National Irrigation Administration. 1990. NIA corporate plan: 1990-2000, Quezon City, May, 1990.

National Statistical Coordination Board. 1989 Philippine statistical yearbook. October, 1989.

National Water Resource Council. 1976. Philippine water resources. Report No. 19. Quezon City.

National Water Resource Council. 1982. Philippines water code and the implementing rules and regulations, Quezon City.

Philippine Council for Agriculture, Forestry and Natural Resources Research and Development. 1990. PCARRD Corporate Plan II (1990-2000), Los Banos, Laguna. PCARRD. 42. pp.

Sosa, L.M., 1985. Overview of the status of the small water-impounding projects in the Philippines. In: PCARRD: Small Water-Impoundments: Proceedings of the First National Workshop on Small Water Impounding Project Development and Management. 27-28 October. Calamba, Laguna.

Undan, R.C. 1990. Present situation, problems, and prospects in the utilization and conservation of inland waters for agriculture in the Philippines: Proceedings of Tsukuba Asian Seminar on Agricultural Education, University of Tsukuba, Tsukuba, Japan.

VISION STATEMENT

A Sustainable and Profitable Irrigated Agriculture that Provides Adequate Food Supply to the Population

By the turn of the century, we would like to see an irrigated agriculture sector anchored on a rice-based farming system with the following features:

- sustainable (physically, economically);
- makes efficient use of water resources;
- utilizes appropriate production technology/ies;
- with strong private sector involvement;
- institutionalizes the participation of organized farmers in O&M of irrigation systems;
- integrates all support services for profitable production, credit, market, postharvest facilities, other infrastructure, etc.; and
- environmentally sound.

This sector is envisaged to provide adequate food supply to the population and increase opportunities for exportable commodities.

Rationale for the Vision

- stability in food supplies;
- opportunity for increasing yield and cropping intensity in irrigation areas;
- significant contribution of the agriculture sector to the economy;
- environmental concern;
- need for private sector and organized farmers' participation; and
- profitability concerns of farmers.

MEANS TO ACHIEVE THE VISION

Policy

Accelerate and intensify current thrust of greater farmer ownership and management of irrigation systems to

- ensure greater productivity; and
- encourage better sustainability.

Priorities for system expansion shall be determined according to:

- responsiveness of project to food security objective; and
- establishment of balance between the improvement of the performance of existing systems and the construction of new systems.

Need to build more impounding systems

Law and Institutions

The Philippine water code covers all areas quite comprehensively. The problem is in enforcement and information.

With the new local government code, the level of enforcement should be greatly improved, so long as the Local Government Units are alerted to the revenue opportunities.

Human Resources Development

Skills and capability building are required, especially for farmers' groups. Attitudinal changes are required, especially for government officials.

Supporting Infrastructure

Markets

Prices (separate from physical markets)

- no price controls;
- competitive foreign exchange rate; and
- role of the national food authority.

Research

- greatly increase level of investment in research—especially operational funds.

Infrastructure

Road/transport: critical for linkages with markets, inputs/outputs, minimize transactions costs;

Electricity/communications: critical also for marketing and food processing; and

The inadequacy of infrastructure is a barrier to popular participation.

RESEARCH, COOPERATION AND COLLABORATION NEEDED

Regional/International

- groundwater identification, exploration and management;

- sharing of experiences; and
- training in technologies.

Domestic

- labor-use efficiency in irrigation;
- irrigation-oriented environmental problems (pollution, situation);
- alternative energy sources;
- recycling, processing, profitability; and
- irrigation management training.

Irrigation Is Feasible Only if Agriculture Is Profitable

Thailand

Jesda Kaewkulaya[4]

PRESENT SITUATION

Introduction

THAILAND COVERS SOME 513,000 km^2 of land being situated in the central part of the Indo-China Peninsula. The climate is tropical and monsoonal. Annual rainfall varies between 1,000 mm and 1,500 mm depending on season, altitude and location of the area in relation to mountain ranges. The temperature regime and radiation levels are generally favorable for year-round production of crops. The population is around 56.34 million (1990) with a growth rate declining from 2.8 percent in 1980 to about 1.6 percent in 1990.

The Thai economy had an average annual GDP growth rate of about 8.9 percent from 1980 to 1990, whereas the average GDP growth rates of agriculture and nonagriculture sectors were 3.4 percent and 9.6 percent, respectively. The change of the government policy to become a newly industrial country from an agricultural country, had much effect on the employment of the agriculture sector. In fact, agricultural employment has been decreasing for a long time and is now remaining about 60 percent of the tótal employment of the country. The value of agricultural exports was about 38.0 percent of the total domestic exports in 1990 which had decreased from 57.9 percent in 1986.

Living on agriculture is not attractive due to its low income. During the past ten years, per capita income of Thailand has almost doubled from US$559 in 1981 to US$1,103 in 1990. Regarding agricultural income, net farm and nonfarm cash income for the crop year 1987/88 were US$604.29 and US$594.90, respectively, whereas the household cash expense per farm was US$523.50. It indicates that the net farm income is slightly more than farm household cash expense. The farmers have to earn nonfarm income for their own living.

Irrigation and agriculture of the country have been developed simultaneously for sustainability reasons. Agricultural development policies are concerned with the productivity, marketability and suitability of resources utilization, whereas irrigation policies are related to project planning, construction, operation, maintenance and management, and personnel issues.

Land Utilization and Landholding

The total land of about 51.31 million ha is classified into farm holding (46%), forest (28%) and unclassified land (26%).

Rice fields constitute 50 percent of the average farm landholding. Upland crops and fruit trees and tree crops are the next two main areas with about 24 percent and 13 percent landholding,

4 Associate Professor, Kasetsart University, Bangkok, Thailand.

respectively. The remaining land is utilized for vegetables, flowers and livestock and as idle and other lands. The total number of farms is 5,244,643, the average farm size being 4.5 ha.

Farm landholding increased from 18.21 to 23.65 million ha during 1977-1988, whereas forest land decreased from 18.65 to 14.38 million ha within the same period. However, the rice field component decreased from 62 percent to 50 percent of the total, whereas the upland crops and fruit trees and tree crops increased from about 20.54 percent and 8.84 percent to 24.10 percent and 13.23 percent, respectively. These would show the gradual change of concept from monoculture of rice cultivation to multiple crops.

The Royal Irrigation Department (RID) is the main agency responsible for irrigation. These facilities have been primarily designed for supplemental irrigation of rice in the wet season.

Table 1. Present situation of land utilization in Thailand.

Description	Quantity (106 ha)	% of total
1. Land Utilization		
Total land	51.31	100.00
Forest land	14.38	28.03
Farm holding land	23.65	46.09
Unclassified land	13.28	25.88
2. Utilization of farm holding land		
Total land	23.65	100.00
Housing area	0.53	2.24
Rice land	11.88	50.23
Upland crops	5.72	24.19
Fruit trees and tree crops	3.12	13.19
Vegetables and flowers	0.16	0.21
Livestock farm area	0.76	3.21
Idle and other land	1.48	6.26

Source: Ministry of Agriculture and Cooperatives. 1991. Agricultural Statistics of Thailand, Crop Year 1990/91.

At present, the total irrigable area is about 4.53 million ha, accounting for about 19 percent of the total farm holding land. It can be distinguished on the project types as follows:

Type of Project	No. of Projects	Area Served (10^6 ha)
Large scale	66	3.30
Medium scale	598	
Small-scale	6,226	1.07
Pumping	656	0.16
Total	7,546	4.53

The pumping projects as indicated, are under the responsibility of the Department of Energy Affairs. During the past ten years, the irrigable area has increased by about 10 percent.

Water Availability and Utilization

There is no comprehensive inventory of either surface water or groundwater resources in Thailand. Surface water is usually of good quality and is suitable for irrigation. The exception is the high salinity levels that occur in the lower reaches of uncontrolled river or drainage systems in the dry season due to sea water intrusion at high tide.

Uncontrolled river flows follow the distribution of rainfall, with very high flows in the wet season and low or zero flow in the dry season. With the exception of rivers in the North and South which have small dry-season flows, no dry-season irrigation is possible without storage in dams, depressions or drainage systems. For this reason and to generate hydropower, a large number of storage dams have been built in Thailand.

On a national basis, less than 25 percent of the irrigable area is currently irrigated in the dry season. The general situation in some selected projects can be summarized as follows. After completion of the Phitsanulok Project, only about 35 percent of the irrigable land in the Chao Phya Plain can be supplied with sufficient water to grow dry-season rice. The Mae Klong Basin has sufficient storage to irrigate nearly 100 percent of the irrigable area in the dry season. However, future potential will be determined by releases for power generation and diversions to the Chao Phya Basin now being planned. Projects in the Northeast have potential to irrigate from 30 percent to 75 percent of the irrigable area in the dry season and in the Northern Region they have a potential to irrigate from 25 percent to 100 percent of the irrigable area in the dry season.

In summary, most of the projects do not have sufficient water to supply 100 percent of the irrigable area in the dry season. This does not pose any problems in the Northeast as only a fraction of dry-season water is currently used. However, in the Chao Phya Basin limited water supplies are being fully utilized, mainly for dry-season irrigated rice. Among the main questions arising in this situation are:

- To what extent can surface water supplies be supplemented by groundwater to increase cropping intensity and make better use of investment in irrigation and drainage infrastructure?
- To what extent can upland crops (crop diversification) be promoted instead of irrigated rice to spread the benefits of limited water supply over a large area? and
- Does allocating limited water to a particular section of a basin offer any special advantages (e.g., the Northern Region of the Chao Phya Basin which is more intensively farmed and geared to crop diversification, versus the South where the potential is almost exclusively for irrigated rice)?

The Secretariat Office of the National Water Resource Committee gathered data of projected water resource availability and use in Thailand for 1990-2000. The details of water demand are as follows:

Domestic Water

The Metropolitan Waterworks Authority will need an annual supply of 1,369 million cubic meters of water for the Bangkok Metropolitan Region by 2,000. The water supply for the Provincial Waterworks Authority will reach about 934 million cubic meters by 2000.

Irrigation Water

The irrigation water demand was 3,000 million cubic meters for the irrigation area of 4.24 million ha. The annual demand will increase up to 38,500 million cubic meters in 2000 if the irrigation area increases by 80,000-96,000 ha annually.

Industrial Water

The water demand in the industrial sector is about 35 percent of the whole demand and will increase up to 40 percent or about 2,339 million cubic meters in the Bangkok Metropolitan Region in 2000. Another major area of demand for this sector is the Eastern Seaboard Industrial Zone which will need a water supply of about 90.5 million cubic meters annually by 2000.

Others

The water demand for the other activities are also necessary, i.e., inland navigation and protection of sea water intrusion at high tide during the dry season, especially in the Chao Phya River. The water release for power generation is considered to be of lower priority.

In summary, there is an increasing demand of water in each region of Thailand. As it is too difficult to look for or build up new water sources, problems of water shortage will become serious in the near future.

Present Status of Irrigation and Drainage Systems

The Royal Irrigation Department classifies irrigation systems into four types, according to the level of development of irrigation and drainage infrastructure and on-farm development (OFD) work. These types largely define the quality of irrigation service and are as follows:

Type 1

The area developed with land consolidation, with a mix of intensive, semi-intensive and extensive OFD works as appropriate to topography, plot size, fragmentation of holding and flood risk.

Type 2

Refers to areas covered by the standard ditches and dikes program. Simple earthen ditches and dikes are constructed about every 400 meters along the lateral with a simple control gate to regulate the flow of water from the lateral to assist in distributing water.

Type 3

These areas are not clearly defined. They have a reasonable main and secondary distribution and drainage system but no OFD or ditches and dikes to assist water distribution and drainage.

Type 4

Systems in these areas are generally incomplete and do not have adequate water distribution, OFD or drainage facilities.

In theory, the four types of irrigation/drainage areas reflect the level of water control possible with the infrastructure provided. In practice, Types 3 and 4 are more common in flood-prone areas, so the influence of flooding may be more important in determining productivity than the level of water control that can be exercised with the irrigation system.

Rice yield differences are significant between Types 1, 2 and 3 but not between Types 3 and 4. Data on the irrigation area under the four types of irrigation and drainage systems along with comparative rice yields for the 1989/90 wet season are summarized below:

Type of System	Area (10^6 ha)	%	Average Yield (ton/ha)
Type 1	0.27	8	4.0
Type 2	1.32	42	3.3
Type 3 }	1.61	50	2.8
Type 4 }			2.7
Total	3.20	100	

Only 8 percent of the RID irrigable area is Type 1 (land consolidation areas) with good water distribution and drainage facilities. About 42 percent is Type 2 (the old ditches and dikes program) with minimal tertiary and OFD facilities in the form of simple ditches and dikes. Types 3 and 4 constitute some 50 percent with poor or essentially no irrigation and drainage facilities. This shows that only about half of the total irrigable area has a comparatively good water control, resulting in higher yields.

Irrigated Crop Production and Diversification

Irrigation systems in Thailand are primarily designed for rice production. Since rice is the main crop grown in both the wet season and the dry season, crop diversification is still new to farmers. Irrigated rice yields in Thailand average about 3.0 tons/ha, whereas the average nonirrigated rice yield is about 1.5 tons/ha. However, the yield is also affected by the degree of water control at different levels as earlier mentioned, e.g., rice yield in irrigated area Type 1 is almost 4 tons/ha and yield in irrigated area Type 2 is only 3.3. tons/ha.

During the past five years (1986-1990), the farm value of total rice production increased from US$697.9 million in 1986 to US$2,539.6 million in 1990, whereas the total rice export value increased from US$697.4 million to US$1,095.9 million in the respective years. Productivity may be improved both intensively and extensively. The expansion of irrigated areas will, of course, decrease nonirrigated areas. This would result in more production that can be expected from the expanded irrigated areas. The ratio of nonirrigable to irrigable areas in Thailand decreased from 3.43 in 1977 to 2.73 in 1988. An increase of irrigated areas made it possible for Thailand to increase rice production for self-sufficiency and to maintain the export capacity in the previous years.

Thailand is already practicing diversified cropping patterns during the dry season. The major crops include mungbean, soybean, groundnut, water melon, corn, sorghum, etc.; and vegetables; sugarcane; fruit trees; and perennial crops. In addition to the cultivation of these diversified crops, fish farming is carried out during the dry season. Only about 13 percent (426,000 ha) of the total irrigated area (3,294,000 ha) is used for diversified cropping and fish farming (Table 2). There is an increase, however, of the diversified cropping area and the area used for fish farming by 1.25 percent annually.

Table 2. Irrigated areas and areas used in diversified cropping and fish farming, 1987-1991 (in '000 ha).

Area	Year				
	1987	1988	1989	1990	1991
Rice	509	700	735	491	593
Upland crops	117	113	114	109	107
Vegetables	30	11	30	29	31
Sugarcane	67	109	107	108	125
Fruit trees	97	99	129	115	104
Perennials	59	43	31	21	24
Fish ponds	37	45	48	32	35
Total diversified cropping	407	420	459	414	426
Irrigated area*	3,114	3,180	3,201	3,226	3,294
Percentage of diversified cropping area	13.0	13.2	14.3	12.8	12.9

Note: *Irrigated area under large- and medium-scale projects.

Many factors influence the development of crop diversification. Suitable areas for diversified cropping are those with good soils which are suitable for upland crops, free from flooding and with a dependable water supply. Table 3 lists the constraints and the measures to overcome them. Among other factors not related to irrigation are marketing constraints and lack of farmers' participation.

Irrigation Policy and Relevant Strategies

The Ministry of Agriculture and Cooperatives (MOAC) laid down the overall policies for agriculture and irrigation development as follows:

Agricultural Production Policy

Farmers should have more participation in decision making on their production issues with information support from the government. The production program should be made from the village and channeled to the Central Government for budget support. This is similar to the construction program of small-scale irrigation projects.

Marketing Policy

The information system is of great importance for the marketing policy, which has to be implemented together with the Ministry of Commerce. An ad hoc committee should be set up to deal with any specific commodity. The private sector should come into the system, whenever the farmers are able to make decisions of their own.

Table 3. Constraints and promising irrigation management practices for relaxing constraints to diversified cropping.

Constraints	Promising Remedial Measures
Unreliability of water distribution	Better main system management; suitable control structures; intensive training.
Soil suitability problem	Research on soil suitability; advice to farmers.
Inadequate water storage	Study capacities for water storage; increase water use efficiency; advice on crops that require limited amounts of water.
Inadequate existing infrastructure	Improvement of infrastructure to meet changed objectives; improve flexibility.
Drainage problems	Improvement of drainage systems; advise on crops that are sensitive to waterlogging.
Lack of good quality seeds	Research for better varieties.
Cultural practices favoring rice cultivation	Increase farmers' confidence in irrigated crop diversification.
Salinity problems	Good drainage and water control.
Interference between activities	Water operation planning; study on the various activities.
On-farm development	Farmers' participation in cost sharing and maintenance program.

Natural Resources Development and Agricultural Environment Policy

Resources for agriculture include land, water, forest and fishery. Benefits derived from natural resources utilization should be maximized with no degradation or pollution.

The irrigation policy classified irrigation into 3 categories, i.e., project planning and construction, system operation and maintenance and management, and personnel issues.

Project Planning and Construction Policy

Water is not only getting scarce, but utilization of natural water resources may also sometimes affect the environment. The development of new irrigation projects, especially for large project construction, was often attacked and prevented by conservationist actions. Clarification of this problem to the public is therefore essential.

System Operation, Maintenance and Management Policy

Farm efficiency should be increased for water saving to partially compensate the need for new water resources. Water allocation should be adjusted in accordance with the rapid change of land use. Clarification of dry-season water availability is necessary for crop planning.

Training of zonemen and operational staff is necessary to ensure better understanding of water management issues. Importance of system maintenance should be foreseen by the Budget Bureau for the provision of a sufficient budget.

Personnel Issue Policy

Due to the large number of personnel, the administration should be done properly and carefully. Incentives and remunerations should be provided to technical staff to prevent brain drain to the private sector.

Concluding Remarks

To sustain reasonable growth rates in the agriculture sector, Thailand must intensify its agriculture by improving crop yields, as there is little scope for expansion of planted area. To maintain a competitive position in world markets, Thailand must also improve efficiency of production by reducing unit costs, and raising the quality of produce. This applies particularly to rice where there are indications of oversupply now and in the coming years. Thailand already supplies nearly 40 percent of the international rice trade and hence feels vulnerable to potential oversupply conditions. The government is, therefore, interested in crop diversification. In theory, irrigated areas offer good possibilities for achieving these objectives as they should offer a low risk environment conducive to the high use of inputs, high yields, efficient production, and flexibility in cropping patterns. In practice, this is not the case due to agro-ecological conditions, markets and marketing, and farmer attitudes. In addition, irrigation systems as presently designed and operated are well suited to rice and poorly to other crops. However, improvements in design and operation of both new and existing irrigation projects can be introduced to take better advantage of the potential created from past irrigation investments through higher efficiency and yields in rice production and through production of irrigated upland crops where conditions are favorable.

References

Japan International Cooperation Agency. 1990. Master plan on the upper central region study: The Royal Thai Government, National Economic and Social Development Board, Bangkok, Thailand.

Kanoksing, Prasert. 1991. Management of irrigation facilities in Thailand, Royal Irrigation Department, Bangkok, Thailand, June 1991.

Ministry of Agriculture and Cooperatives. 1991. Agricultural statistics of Thailand, crop year 1990/91: Prepared by Office of Agriculture Economics, Bangkok, Thailand.

Thongthawee, Nukool et al., Irrigation management for diversified cropping in rice-based system in Thailand.

The World Bank. 1985. Thailand irrigation subsector review, Working Paper 1.

VISION STATEMENT

Constraints and Opportunities

- competition for limited water resources;
- declining share of agriculture in GDP;
- pressure on land and labor;
- competition and protectionism;
- low income group and distribution disparity;
- heritage of agricultural oriented society;
- conflict between irrigation development and environmental conservation; and
- centralization and disunity in irrigation system management.

Vision

Irrigated agriculture will remain an important component of the national economy and food security in Thailand by the year 2016. Its role can be maintained by a high degree of participation of farmers and private sector involvement in irrigation system management with emphasis on agrobusiness orientation combined with highly efficient management of irrigation systems in order to enhance the balance of development and resource utilization to ensure sustainability.

Strategies

- reorganize and strengthen farmers'/local organizations to increase management and decision-making capabilities;
- define a clear role for the private sector to participate in the management and marketing of irrigated agriculture including R&D;
- promote, coordinate and strengthen human resources development programs;
- improve/reorganize irrigation system management to attain better performance;
- increase water storage based on social and economic viability;
- provide clear guidelines on priority of water resources allocation;
- organize land-use zoning and agricultural zoning in response to physical, ecological and market demand;
- promote agro-processing industries;
- introduce intensive application of higher agricultural technologies;
- enact a comprehensive water code;
- enforce environmental acts; and

- promote public awareness of environmental issues and encourage people participation.

MEANS TO ACHIEVE THE VISION

The overall policy (super policy) should be to change from rice-based to higher-value commodities, to promote commercialization and agro-industry, and to assist farm production enterprises of various forms.

The following components have to be considered:

- policy;
- development measures;
- research and study; and
- education and training.

The following *policies* have to be implemented to achieve the vision:

- recognition and encouragement of high degree of farmers' organization in all aspects concerning irrigated agricultural development (IAD);
- recognition and encouragement of high degree of private business actions in all aspects concerning IAD;
- reorganization of concerned agencies for better management of IAD;
- increasing water supply and better utilization of available water resources;
- introduction of land-use planning and higher emphasis of agricultural zoning;
- keeping a balance of sustainable environment; and
- giving emphasis on research and development.

Policy 1: Recognition and Encouragement of High Degree of Farmers' Organization in All Aspects Concerning IAD

Development Measures

- recognize/strengthen the abilities of farmers' organizations to handle decision-making matters and management of production, food processing, marketing, irrigation activities and own organizational affairs; and
- revise the existing laws and regulations which obstruct the independency and growth of farmers' organizations as well as passing new favorable bills/regulations.

Research and Study

- proper roles and structures of farmers' organizations.

Education and Training

- training program for farmers' organizations in management, food processing and marketing.

Policy 2: Recognition and Encouragement of High Degree Private Business Actions in All Aspects Concerning IAD

Development Measures

- define a clear role for private business in IAD; and
- encourage private business to be involved in irrigation system investment, O&M, administration of IAD (production, processing, marketing).

Policy 3: Reorganization of Concerned Agencies for Better Management of IAD

Development Measures

- promote coordination among various agencies concerned in terms of plan, budget, execution and personnel management; and
- appoint one agency to be in charge of water use for industrial and other purposes.

Research and Study

- organization and management model suited to IAD in the Thai context.

Education and Training

- human resources development programs for staff of concerned agencies (content/target groups).

Policy 4: Increasing Water Supply and Better Utilization of Available Water Resources

Development Measures

- increase of water storage;
- importation of water supply;
- reforestation program;
- monitoring of water availability and utilization;
- setting priorities for water allocation;
- revising water codes; and

- introducing intensive agricultural extension intervention.

Research and Study

- potential demand and supply of water resources both surface water and groundwater, irrigated agricultural commodities and engineering issues.

Policy 5: Introduction of Land-Use Planning and Higher Emphasis on Agricultural Zoning

Development Measures

- enforce the application of land-use/agricultural zoning through:
  - taxation systems;
  - incentives such as crop insurance, market place, infrastructure, availability, contract farming and price guarantee; and
  - introducing specific laws to ensure there is no misuse of irrigation area through land reform and consolidation.

Research and Study

- suitability of various farming systems in response to physical, ecological, socioeconomic and market demands.

Education and Training

- transfer appropriate technology to farmers in the area of agricultural production, water management and processing.

Policy 6: Keeping a Balance of Sustainable Environment

Development Measures

- control and enforce the environmental act; and
- promote public awareness on environmental issues.

Policy 7: Giving Emphasis on Research and Development

Development Measures

- linkage among beneficiaries, implementing agencies and researchers.

Additional Issues

Research

- how to prevent the land-fragmentation problem caused by inheritance.

Education and Training

- irrigation engineering curriculum should also include issues of irrigation system management;
- support skill training for farmers who will leave the agriculture sector; and
- concepts of scarce resources and environmental issues should be included at all educational levels.

Regional Cooperation and Collaboration with International Organizations

- exchange of information and technology within the region and internationally;
- establishment of an information network system;
- encouragement of joint research programs within the region; and
- holding workshops to settle some issues of regional concern, e.g., use of international water, prevention and control measures for environmental pollution.

Role of Thailand: Receiver and Giver

REGIONAL STATEMENT

Future Trends of Southeast Asian Irrigated Agriculture

THE FOLLOWING STATEMENT was developed at the closing session of the Langkawi Workshop.

Preamble

In their vision statements and implementation plans, the four country groups stressed that irrigated agriculture will continue to be an important sector of all the national economies. All countries aim to ensure that irrigated agriculture is a profitable enterprise and to expand the roles of private-sector participants. It was agreed that in this context the private sector encompasses individual farmers, farmers' organizations and commercial businesses.

Policies concerning food security and rice self-sufficiency, at both regional and national levels, are generally viewed as significant factors in determining the future prospects of irrigated agriculture.

It was agreed that, in the development of policies for increased private-sector roles, there should be safeguards for the interests of low-income groups in existing farm communities.

Areas of Common Concern for the Region

Common features of the discussions and statements of the country groups form two clusters:

- adjustments of the public/private sector balance and relationships in irrigated agriculture, in the direction of increased private-sector roles; and
- planning and management of water resources use, with particular reference to caring of the environment and to improving conservation and beneficial application of the water resources, with due regard to competing uses of water.

Roles and Relationships of the Public and Private Sectors

Common concerns in the first category included:

- enhanced participation by organized farmers in management decisions and actions;
- commercial involvement of private-sector firms;
- development of appropriate skills and attitudes suitable for new functional relationships among staff of irrigation agencies; and
- reduction of the operational role of public-sector irrigation organizations, accompanied by increased public-sector actions on strategic management.

Management of Water Resources

Common concerns in the second category included:

- efficient use of water, especially by raising the performance of existing irrigation systems;
- development of procedures (legal or regulatory) for allocation of access to water resources;
- mechanism for maintaining water quality, including control of applications of agricultural chemicals and of waste outflows from the growing industrial sectors;
- social and economic measures for maintaining upper watershed lands and forests in a condition that sustains the productive potential of downstream irrigated areas;
- identifying and pursuing environmentally sound goals in the disposal of surplus irrigation water; and
- identifying the social and economic value of water, and incorporating that intrinsic value into plans for its utilization.

Possible Actions at the Regional Level

Actions desired at the regional Southeast Asian level, in regard to these two main clusters of future concerns, are principally in the areas of information exchange and networked research. These actions may include the sharing and use of information and experiences from countries outside of, as well as within, the region.

Examples of the kinds of information needed include:

- evidence of the costs and benefits experienced under different models of public-/private-sector interaction in other countries;
- ways to enhance the availability of private capital to irrigated agriculture, without impairing the interests of traditional farm communities;
- impacts of alternative models of production relationships that may develop in the nongovernment sector, such as group farming and contract farming;
- organizational systems for optimizing the benefits and the rate of adoption of appropriate technological and management innovations;
- groundwater resources identification and utilization; and
- experiences of public institutional frameworks and laws for water resources allocation, monitoring and control.

KEYNOTE PAPERS
AND
DISCUSSION NOTES

Paper 1

Sustainability and Growth

Charles L. Abernethy[5]

INTRODUCTION

THE CONCEPT OF sustainability, or sustainable development, refers to the future. It requires us to attempt to make certain kinds of predictions.

The development planner or policymaker, wishing to be satisfied that current activities or new infrastructure schemes are sustainable, must formulate a reasoned response to a question of this sort: "Should we believe that this project—this irrigation system, for example—operated in the manner now current or proposed, can continue operating satisfactorily for as far ahead in time as we can forecast—say, 20 years from today? Or do we perceive reasons for doubting that it will survive, under its present operating policies?"

Any discussion of sustainability therefore involves forecasting of the future. In doing this we need to focus our attention primarily on those aspects which we believe are most likely to change during our forecasting timespan.

Because it concerns the future, sustainability is closely interlinked with growth. Many kinds of growth proceed in the socioeconomic structure of developing countries. Most of these growth patterns put additional stresses—new demands and new constraints—upon infrastructural facilities and resources. Growth changes the external context within which the system must function, so that what is proven to work satisfactorily at one period may be found unsustainable at some later period.

SOME DIMENSIONS OF GROWTH

Which kinds of growth have strong influence on the way irrigation systems perform? They include growth of population, growth of wealth, growth of demand for the products of irrigated agriculture, growth of the agricultural population, growth of their outputs and growth of resource consumption.

In the past two decades, wide regional and national differences have appeared in most of these classes of growth. As a result of such different growth histories, countries now face widely differing sustainability prospects. Statements about global averages or global trends are therefore likely to be poor guides to formulation of national policies.

---

5 Senior Technical Advisor of the International Irrigation Management Institute, Colombo, Sri Lanka.

Growth of Population

The growth of population continues to be a dominant feature, but almost everywhere in the world it is reducing, and it is not as overwhelming a consideration as it appeared 20 years ago. Table 1 shows the patterns that have emerged in a sample of five principal large regions and in ten developing countries.

Table 1. Growth of population (units: percent per year).

	1965–1980	1980–1989	1989–2000	2000–2025	GDP/person, 1989 (US$/year)
World	2.0	1.8	1.6	1.3	3,838
East Asia	2.2	1.6	1.5	0.9	577
South Asia	2.4	2.3	1.9	1.4	280
Latin America	2.5	2.1	1.8	1.3	1,921
West Asia/North Africa	1.9	2.0	2.0	1.7	1,819
Sub-Saharan Africa	2.7	3.2	3.2	2.7	337
Korea	2.0	1.2	0.9	0.5	4,998
Brazil	2.4	2.2	1.7	1.1	2,166
Malaysia	2.5	2.6	2.2	1.4	2,155
Thailand	2.9	1.9	1.3	1.0	1,258
Philippines	2.8	2.5	1.8	1.3	739
Indonesia	2.4	2.1	1.6	1.1	527
India	2.3	2.1	1.7	1.2	283
Nigeria	2.5	3.4	3.2	2.5	254
Bangladesh	2.7	2.6	2.1	1.4	183
Tanzania	2.9	3.1	3.3	2.7	107

There is a tendency for more affluent countries to have lower rates of population growth: the data for these ten countries show a negative correlation of about 60 percent between gross domestic product per person, and population growth. At the end of the colonial era, countries had rather more uniformity in these matters than they do today. In the period 1965-80, the coefficient of variation of population growth among these ten countries was just 11 percent. As they have evolved along different development paths, the variation now is about 38 percent, and is still widening rapidly.

Growth of Demand

Growth of demand for the products of agriculture does not depend only on the growing numbers of people. The other main driving force of agricultural demand is the growth of living standards.

People hope that in various senses, matters will be better next year than they were last year. Economists seek to measure this by the growth of gross domestic product per person (Table 2). In relatively poor societies, a high proportion of each additional unit of personal or family income is expended on the products of agriculture (Table 3). In affluent societies, where basic nutritional needs are well satisfied, the impact of an increment of income is different. Less of it is spent on agricultural products, and that fraction tends to be applied to diversification of the food intake, rather than to simple increase of its quantity.

Table 2. Growth of gross domestic product (GDP).

	GDP/person 1990 (US$/year)	Agricultural production as % of GDP	Growth of GDP 1980-90 %/year	Growth of agricultural production%/year
World	4,220		3.2	2.7
Korea	5,523	9	9.7	2.8
Brazil	2,753	10	2.7	2.8
Malaysia	2,369		5.2	3.8
Thailand	1,437	12	7.6	4.1
Philippines	713	22	0.9	1.0
Indonesia	602	22	5.5	3.2
India	300	31	5.3	3.1
Nigeria	300	36	1.4	3.3
Bangladesh	214	38	4.3	2.6
Tanzania	84	59	2.8	4.1

Table 3. Food consumption as percentage of total household consumption.

	Food consumption %	GDP per person 1990
Korea	35	5,523
Brazil	35	2,753
Malaysia	23	2,369
Thailand	30	1,437
Philippines	51	713
Indonesia	48	602
India	52	300
Nigeria	52	300
Bangladesh	59	214
Tanzania	64	84

Growth of Output

In recent decades there have been striking regional differences in the performance of countries in meeting these patterns of growing demand (Table 4). The countries of East and Southeast Asia have performed particularly well, with patterns of growth in food production and in agricultural production generally, that have been generally well in excess of population growth. This is different from the other major regions of the developing world, where food production per person has been rather static or declining during the 1980s.

Table 4. Index of food production per person.

Base: 1979-81 = 100

	1982-84	1985-87	1988-90
World	102.00	104.08	103.96
East and South Asia	108.64	113.86	120.44
Central + South America	100.10	100.45	102.65
West Asia/North Africa	97.27	100.81	96.16
Sub-Saharan Africa	95.78	98.13	97.33
Korea	101.54	98.95	101.63
Brazil	101.88	105.39	110.78
Malaysia	109.78	136.00	155.02
Thailand	103.50	102.31	105.17
Philippines	93.35	86.54	86.25
Indonesia	108.68	119.63	127.69
India	107.56	108.63	118.90
Nigeria	97.74	105.02	112.85
Bangladesh	98.17	95.14	96.50
Tanzania	95.23	92.31	88.28

The most successful of the major regions has been the one containing most of the world's irrigated land. That fact is encouraging for those involved in irrigation; but it would be very rash to claim that irrigation itself is the sole cause of the success.

The output growth pattern has not been at all uniform, however, in the region of South and East Asia, either in total food production or in the output of the major irrigated crop, rice (Table 5). Performance in this respect has varied from average increases of around 2.5 percent per year in India, Indonesia and Vietnam, to a decrease of 4.5 percent per year in Malaysia, where self-sufficiency was abandoned as a national policy goal early in this period.

Table 5. Paddy production per person.

Units: kg/person

	1979-81	1988-90
Bangladesh	228	233
India	108	132
Indonesia	196	241
Malaysia	149	99
Philippines	163	152
Thailand	363	367
Vietnam	220	278

Growth of Agricultural Population

Although the world's population is growing by about 1.8 percent per year, its agricultural population is not. Growth in that sector has dropped to less than half of this rate. As Table 6 shows, there is no country in our sample of ten where the proportion of people involved in agriculture has increased in the 1980s. Generally, the percentage has decreased by some 6 percent.

Table 6. Agricultural population.

Population	Growth in number of agricultural population		Agricultural population as % of total population	
	1980-89 %/year		1980	1989
Korea	-	1.32	36.4	25.7
Brazil	-	0.28	31.2	24.9
Malaysia	+	0.17	41.6	33.0
Thailand	+	1.33	70.9	65.0
Philippines	+	1.49	51.8	47.2
Indonesia	+	0.79	57.2	49.3
India	+	1.51	69.7	66.8
Nigeria	+	2.16	68.1	65.1
Bangladesh	+	2.11	74.8	69.2
Tanzania	+	2.42	85.6	81.4

This is a wealth-related process, as the table shows. In the richer countries, the percentage involved in agriculture is much less than in their poorer counterparts; and in richer countries, the pace of the exodus from agricultural occupations is greatest. The negative correlation between the GDP and the proportion of population involved in agriculture is about 79 percent.

Growth of Resource Use

The question, whether the satisfying of increasing demand has involved great increase in the resources used, is an essential one, but data at global, regional and (usually) national levels are very weak. Three kinds of physical resources need to be considered: land, water, and chemical inputs. It is difficult to make clear statements about any of these.

We have statistics about how much land is currently under crops, how much is irrigated, and so on. It is much more difficult to establish current utilization levels, or the extent of formerly cultivated land that may have been abandoned due to processes related to cultivation, such as waterlogging or salinization, or the amount by which shifting cultivation may have been reduced.

In principle, irrigation enables a society to satisfy its food needs from a smaller quantity of land, and thus reduces various land use stresses. Table 7 confirms that this seems to be true of East and South Asia, where the generally satisfactory food output performance of recent times has been achieved from a small and steadily reducing area per person. The two regions with highest reliance on irrigation have been able to keep their total land use for agriculture more or less stable, whereas it has continued to expand at rates of 0.50-0.75 percent per year in sub-Saharan Africa and in Central and South America.

Table 7. Land utilization.

	Cropped land (M ha)		% irrigated	Growth of irrigated area %/year 1979-89	Cropped land (ha/person)	
	1979	1989	1989	1979-89	1979	1989
World	1,452.3	1,476.7	15.8	1.07	0.332	0.284
East+South Asia	378.2	382.2	33.6	1.10	0.167	0.140
Central+South America	167.3	180.1	8.8	1.49	0.472	0.410
West Asia/North Africa	84.3	82.6	23.7	1.09	0.408	0.303
Sub-Saharan Africa	149.4	156.6	1.4	2.17	0.398	0.308
Korea	2.2	2.1	63.5	0.32	0.059	0.050
Brazil	69.0	78.6	3.4	4.73	0.582	0.534
Malaysia	4.8	4.9	7.0	0.70	0.354	0.280
Thailand	18.1	22.1	19.1	4.08	0.397	0.403
Philippines	7.7	8.0	20.3	3.33	0.164	0.131
Indonesia	19.4	21.3	35.5	3.49	0.131	0.118
India	168.4	169.0	25.5	1.24	0.250	0.202
Nigeria	30.3	31.3	2.8	0.54	0.400	0.298
Bangládesh	9.2	9.3	29.5	6.24	0.107	0.083
Tanzania	5.1	5.2	2.9	3.35	0.282	0.199

About trends in the use of agricultural water, our data (above the level of individual systems) remain distressingly weak except in countries that are seriously deficient in this resource, such as Egypt or North China. As a rough guideline we may say that countries, or provinces of countries, that have renewable water resources much greater than 1,000 m^3/person/year, do not seem to accord a high priority to economic management of this resource. In tropical and subtropical climates, the annual water requirement to grow sufficient basic foodstuffs for self-sufficiency is in the order of 500-600 m^3 /person/year. As Table 8 indicates, many countries are still operating well beyond these levels; but the provincial variations from these averages, and the year-to-year variations, are causing droughts with a sufficient frequency to develop a demand for better data on this vital aspect.

Table 8. Water resources and utilization.

	Renewable water resources m^3/person/y 1990	Estimated utilization for agriculture m^3/person/y	% utilization for agriculture
World	7,690	436	5.7
East and South Asia	3,729	448	12.0
Central and South America	3,566	428	12.0
West Asia/North Africa	1,446	659	45.6
Sub-Saharan Africa	8,010	120	1.5
Korea	1,450	196	13.5
Brazil	36,070	107	0.3
Malaysia	26,300	275	1.0
Thailand	3,210	581	18.1
Philippines	5,180	471	1.9
Indonesia	14,020	76	5.0
India	2,450	498	20.3
Nigeria	2,730	21	8.0
Bangladesh	20,391	224	1.1
Tanzania	2,780	25	0.9

SUSTAINABILITY

Like growth, sustainability has many dimensions, and many meanings in the minds of those who use the word. It is inherently unmeasurable, because it is in the future. We can however learn some lessons from past cases of unsustainability.

It is useful to think of sustainability in terms of its opposite. There are many cases of great irrigation systems, in Egypt for instance, or in China, that seem to have proved their sustainability by continuing to function over centuries. We should however look for cases which have not been continuously successful, or reasons why past success may change in the future.

We can identify the following major categories of reasons for potential unsustainability:

physical
resource base
institutional
economic
environmental

Let us examine these in turn, and identify some specific examples of unsustainability.

Physical Unsustainability

In this category we may place two main sorts of problem: irrigation systems which are operated in such a manner that their resource base (especially their land, but sometimes also their water) deteriorates severely in quality; and systems whose installed equipment or other facilities deteriorate to the point where they are far from being able to fulfill their intended purpose.

The first group contains most notoriously, systems subject to the related (but distinct) phenomena of waterlogging and salinization, as in large areas of southern Punjab and central Sind in Pakistan; parts of central and southern Iraq; various Central Asian systems; systems in the coastal plain of Peru; and some of the systems developed in the 1960s on the west flank of the Nile Delta. In all of these areas there are significant areas that have dropped fully out of cultivation, and seem unlikely to return. They are all located in areas of very low rainfall, to which irrigation water is conveyed by rivers and canals from relatively remote mountain rainfall zones.

There is probably a much larger amount of land on which the waterlogging or salinization processes have depressed output without actually bringing about unsustainability. In many such cases, however, that simply seems to push them towards our subsequent category of likely economic unsustainability.

Unsustainability of installations is also perhaps less common as a cause of complete collapse, but is more often a source of partial failure and weak performance. Probably the most common causes of this are deficient attention to maintenance, and choice of technology that does not suit actual capabilities for operation or maintenance. India and Sudan are examples of countries with significant difficulties in the first of these areas; the frequency of demands for system rehabilitations shows that many countries share the problem.

Unsustainable Resource Use

The principal external resource used by irrigation systems is water. Irrigated agriculture is, potentially at least, in competition with other users, notably domestic and industrial, for this resource. There is also increasing concern about the need to preserve certain water resources for wildlife and environmental needs. In countries with virtually no rainfall (for example, Egypt) irrigation uses between 80 percent and 90 percent of the gross water resources. In such circumstances, there is great and increasing pressure upon irrigation managements to adopt water-saving technologies, and policies are sought that may further enhance this pressure by treating all water as an economic good.

The situation however varies enormously from country to country, and within countries. As Table 8 shows, many countries with substantial irrigation networks have still great reserves of unutilized water. On the other hand, sometimes that water is in locations which are unpopulated or are unfavorable to irrigated agriculture.

The question of sustainability of water use should therefore be considered for each river basin or hydrologic unit separately. The irrigation organizations themselves are not the best authorities for judging this issue, since they are competitors for the resource. Regulatory frameworks, independent and strong enough to ensure that allocative decisions are genuinely adhered to, seem to be necessary.

Quality, as well as quantity, of water must be part of such processes. In this respect, irrigated agriculture is sometimes perceived as a significant polluter due to drainage return flows that are contaminated with surplus agricultural chemicals.

Unsustainability of Institutions

Svendsen has said that "over a period of ... a few seasons, no piece of infrastructure is stable or sustainable without institutions to operate, repair, adapt and maintain it."

This is an important observation, reminding us that sustainability can never be treated just as a physical attribute, or in any way an inherent attribute of an irrigation system.

Today, the institutions that govern irrigation are changing, quite rapidly in many countries. Ideas of privatization, commercialization, control by farmers' associations, financial autonomy, provincialization and much else proliferate.

In the discussion of sustainability, those developments can be viewed in two rather opposite ways. Some may say that we are seeing the unsustainability of national, centrally funded irrigation bureaucracies which cannot forever command tax-payers' financial inputs. Others may say that the sustainability of the emerging institutions is unknown, and that the process therefore carries great risks.

There is a certain amount of truth in both such views of the matter. It seems safe to predict that we shall have to be concerned and vigilant about the viability of irrigation institutions, especially the newer models, for the next decade or two.

Economic Unsustainability

The economic sustainability of irrigation has to be considered at several levels: its contribution to the national trade balance, and the financial viability of each managing unit, from the national or provincial agency through the local organization to the individual farmer. At each of these units cash flows must be sufficient to sustain operations, maintenance, investment and adequate rewards that motivate the participants.

Throughout the world, governments have been trying, during the 1980s, to introduce more financial autonomy at the higher management levels, and to reduce their dependence on central funding or subsidy. This has been accompanied by an emphasis on fee collection from users of irrigation facilities, and parallel emphasis on the intermediary financial role of users' associations, both as a transmission route for collected fees, and as a cost-cutting strategy through the transfer of tasks and (sometimes) staff to their control.

The correct balance of resource transfers between these various levels, in order to ensure that the whole enterprise survives and functions, has not yet (in many countries) become satisfactorily established and more change should be anticipated. It does not seem likely that users can find the means to defray all the charges of the former central bureaucracies.

In many countries, especially those higher in the World Bank's "middle-income" category (say, those where GDP per person exceeds US$1,500 per year) there seem to be increasing difficulties in sustaining farmers' motivation. This problem expresses itself first in declining cropping intensity, and later in abandonment of cultivation on individual holdings. In some countries of South America, Southeast Asia and north Africa, we are now seeing partial replacement of traditional peasant cultivators by urban investors, often growing more remunerative crops for which higher investment levels are required.

Environmental Unsustainability

The interaction of an irrigation system with its external environment operates in two ways: the environment may affect the irrigation system, and vice versa. In developed countries, especially the United States and Australia, there have been well-known cases of the second problem, such as changing of the hydrology of the Florida coastal lagoons, salt intrusion in the Murray River, and toxification of shellfish in California. Adverse effects of these kinds occur also in developing countries but may sometimes be obscured by data deficiencies. Such cases are likely to be brought to the attention of irrigation organizations more forcefully in the future as the effectiveness of environmental regulatory procedures increases. In some cases, as the United States experience has shown, these matters can lead to enforced abandonment of an existing irrigation system.

A special category of environmental problem is the diminishing of inland lakes, where abstraction of irrigation water from tributary rivers may be a contributing factor, as in the Aral Sea and Lake Chad, as well as in many smaller lakes and wetlands.

The developing countries have a greater proportion of cases where changes in the environment of the water-supplying catchment area may threaten the continued existence of an irrigation system, through sedimentation of its facilities or (less severely in most instances) through change of its hydrology. The costs of dealing with this process are generally much greater than an irrigation organization can obtain. Where this is common, as it is in most mountainous or even hilly countries, the sustainability of the irrigation system requires the evolution of new institutional processes (possibly including resource transfers) through which the human activities that cause the upper-catchment changes can be influenced and moderated. It has been amply demonstrated in the past that the application of law alone does not suffice to deal with this problem; and in the case of international rivers it lies beyond the reach of law.

SUMMARY

The following is a short synopsis of some of the major points above.

a. The developing countries have diverged on to widely differing growth paths.

b. Since sustainability of irrigation systems is largely a question of predicting impacts and responses to future growth, this means there are no generic solutions to the sustainability issue. Each country and each river basin must be considered on its own.

c. Many countries of East and South Asia have had high success in increasing food production significantly ahead of population growth throughout the 1980s. This can however lead to oversupply, price weakness, and reduced utilization of land.

d. Sustainability of irrigation is not a physical characteristic. It depends greatly upon having effective institutions.

e. There has been and continues to be much institutional change. The viability of the new bodies has, in most cases, not been clearly established. Some of the countries which have pioneered new institutional forms have thereafter exhibited a relatively weak record in respect of crop production, and therefore of basic earning capacity.

f. In several countries, usually at somewhat higher general economic levels, problems of farmer motivation are appearing, expressed as underutilization of irrigation facilities. These seem to reflect the lower earnings of agriculture relative to other economic sectors. The problem appears as economic choices (for the individual) become more numerous.

g. Competition for water threatens the viability of irrigation in water-deficient environments. It is not by any means a general problem at present, but the growth of populations and of economies means that it will become a problem in an increasing number of river basins.

Paper 2

Will the Future Be Like the Past?

Mark Svendsen and Mark Rosegrant[6]

INTRODUCTION

IRRIGATION HAS BEEN undeniably important in the development paths taken by most Asian nations since 1950. Irrigated area in Asia currently comprises about 143 million ha, more than 60 percent of the world's total, and more than one-third of Asia's cropland is now irrigated (Rosegrant and Svendsen 1992). The importance of irrigation was enhanced by the Green Revolution of the late 1960s and the 1970s, and irrigated agriculture today remains a central economic and food security pillar in the region.

And though industrialization proceeds at varying paces across the developing world,

> *...the agricultural sector will continue to play an essential role in efforts to accelerate economic growth and alleviate poverty and food insecurity in most of the developing countries, particularly the low-income ones. Although world market prices for food are low and although global food surpluses currently exist, low-income developing countries cannot afford to rely heavily on food imports to meet the needs of their people (Pinstrup-Andersen 1992).*

The purpose of this paper is to provide a generalized framework of socioeconomic issues relating to the future of irrigation in Southeast Asia as a backdrop against which individual country situations can be examined. In this paper we will (1) examine the pattern of recent growth in irrigation in Asia, (2) identify the larger forces for change which are at work in the region, and (3) speculate on their implications for irrigation in the region over the next one or two decades.

TRENDS[7]

Production

The introduction and rapid spread of high yielding rice varieties combined with heavy investment in irrigation and rapid growth in fertilizer use in the late 1960s and the 1970s resulted in strong output growth for these crops in Asia. Yield growth was the primary contributor to rice output

---

6 Research Fellows, International Food Policy Research Institute, USA.

7 This section of the paper draws heavily on Rosegrant and Svendsen (1992).

growth throughout these periods (Table 1). After growing at a rate of 2.3 percent per annum during 1966-74 and 2.9 percent during 1974-1982, growth in rice yields has slowed to 1.9 percent annually since the early 1980s. Area expansion contributed about one-third of Asian rice output growth in 1966-74, but virtually halted after that. The rate of growth in output in Asia therefore also declined in the 1980s, from an annual growth rate of 3.1 percent in 1974-82, to 2.2 percent during the period beginning in 1982. The pattern of growth, however, varied significantly by subregion, with China and Southeast Asia experiencing substantial declines in the rate of yield growth during the latter period (Table 1).

Table 1. Rice: Annual growth rates of area, production, and yield, Asia, 1957/59-1988/90 (units: %/ year).

Countries/ Regions	1957/59-1988/90	1957/59-1965/67	1965/67-1973/75	1973/75-1981/83	1981/83-1988/90
Asia Total					
Area	0.73	0.85	1.09	0.24	0.25
Production	3.08	2.60	3.37	3.09	2.16
Yield	2.36	1.74	2.27	2.86	1.91
Southeast Asia					
Area	0.93	1.73	0.35	1.51	0.72
Production	3.24	3.17	3.29	4.28	2.29
Yield	2.32	1.46	2.94	3.22	1.57
South Asia					
Area	0.89	1.26	0.61	0.88	0.25
Production	2.33	3.13	1.63	2.57	2.31
Yield	1.45	1.89	1.02	1.71	2.03
China					
Area	0.52	-0.58	2.25	-1.07	-0.38
Production	3.55	2.62	3.92	2.98	1.25
Yield	3.03	3.21	1.68	4.06	1.63
India					
Area	0.67	1.21	0.74	0.46	0.34
Production	2.49	1.95	2.90	2.22	3.62
Yield	1.81	0.74	2.15	1.57	3.23

Notes: South Asia includes Bangladesh, Nepal, Pakistan and Sri Lanka excluding India. Southeast Asia includes Burma, Cambodia, Indonesia, Laos, Malaysia, Philippines, Thailand, and Vietnam.

Source: World Rice Statistics, 1990, IRRI.

The slowdown in productivity growth for rice in Asia since the early 1980s has been caused by declining world commodity prices; factors related to the process of intensification of rice and wheat production; and broad policy reforms and structural changes in economies, which have altered relative factor prices and incentive structures.

Investment and Area

At the same time, irrigation investment has fallen precipitously. Aggregate lending and assistance for irrigation in Asia by the major international donors in the 1980s was only half as high as in the 1970s (Table 2). Total irrigation investment expenditures for the major rice-producing countries in Asia show similar declines in rate of investment in irrigation during this period (Table 3).

Table 2. Average annual lending and assistance for irrigation in Southeast Asia by World Bank, Asian Development Bank, U.S. Agency for International Development, and Japanese Overseas Economic Cooperation Fund (in constant 1980 prices).

Year	Lending and assistance to irrigation					
	World Bank (1)	ADB (2)	JOECF (3)	USAID (4)	Total of (1)+(2)+(3)	Total of (1)+(2)+(3)+(4)
	.............................US$ Million..............................					
1969-70	–	35	6	–	–	–
1971-73	–	61	7	–	–	–
1974-76	319	52	16	–	387	–
1977-79	467	134	29	18	630	648
1980-82	237	153	31	17	421	438
1983-85	147	87	59	5	293	298
1986-87	88	96	18	9	202	211

Sources: World Bank, ADB, JOECF, and USAID.

Table 3. Index of average annual public expenditures for irrigation development, 1976-80=100.

Time Period	Bangladesh	China[a]	India	Indonesia[a]	Philippines[a]	Sri Lanka	Thailand
1971-75	97[b]	70	60	20	25	37	88
1976-80	100	100	100	100	100	100	100
1981-85	143	74	94	192	125	92	151
1986-90	103	54	80	170	45	55	109

Notes: [a] For China, Indonesia, and the Philippines, the successive time periods are 1969-73, 1974-78, 1979-83, 1984-88, 1974-78=100.
[b] 1973-1975.

Sources: For India, Indonesia, Philippines, Sri Lanka, and Thailand: Rosegrant 1991, computed from Gulati 1991; Rosegrant and Pasandaran 1990; Azarcon 1990; Aluwihare and Kikuchi 1990; Rosegrant and Mongkolsmai 1990. For Bangladesh, Annual Development Programme of Bangladesh, various issues. For China, Ministry of Water Resources and State Statistical Yearbook.

The result of this investment decline has been a sharp drop in the growth of irrigated area in Asia (Table 4). Annual average growth rates over the full period, 1960-88, average 1.7 percent, led by Southeast Asia's 2.7 percent rate. In Asia as a whole, and in each subregion, there has been a sharp decline in the rate of growth in irrigated area in recent years. In Southeast Asia, the growth rate remained strong through the mid-1980s, but declined sharply from 4.1 percent from 1980-85, to 1.5 percent in 1985-88.

Table 4. Average annual growth rate of irrigated agricultural area in Asia, 1960-88 (in %).

	Total	South Asia	Southeast Asia	East Asia
1960-88	1.7	1.9	2.7	1.1
1960-65	2.0	1.8	1.6	2.2
1965-70	2.5	2.9	1.2	2.4
1970-75	2.0	1.8	2.8	2.1
1975-80	2.0	2.8	3.6	1.2
1980-85	1.2	1.8	4.1	-0.3
1985-88	0.4	0.1	1.5	0.3

Note: East Asia includes China, Hongkong, Japan, DPR Korea, Korea Republic, Macau and Mongolia. Southeast Asia includes Brunei, Burma, Cambodia, Indonesia, Laos, Malaysia, Philippines, Singapore, Thailand and Vietnam. South Asia includes Bangladesh, Bhutan, India, Sri Lanka, Maldives, Nepal and Pakistan.

Source: FAO.

What has caused this decline in the rate of irrigation investment? Contributing factors include the large public and foreign debt loads carried by most of the agriculturally based economies in the region; the declining share of unexploited irrigation development potential in many countries in the region; and political resistance from environmental interests and those displaced or otherwise negatively affected by irrigation development. However, recent studies show that the main reasons for declining investment are the decline in world rice prices and the increasing real costs per hectare of new irrigation development (Aluwihare and Kikuchi 1990; Rosegrant and Pasandaran 1990; Rosegrant and Mongkolsmai 1990; Ramirez and Svendsen 1990).

The decline in real commodity prices is shown in Figure 1. Table 5 summarizes trends in real capital costs for new irrigation systems in the five countries where the case studies were done. All countries show large increases in the costs per hectare of investment over the past two decades. In India and Indonesia, the real costs of new irrigation have more than doubled since the late 1960s and early 1970s; in the Philippines, costs have increased by more than 50 percent; in Sri Lanka, they have tripled; and in Thailand they have increased by 40 percent. The result of these increases in costs and declining prices is low rates of return for new irrigation construction. Aluwihare and Kikuchi (1990), for example, show benefit-cost ratios for new construction in Sri Lanka declining from 2.1 in 1970-74 to 0.7 in 1985-89.

Table 5. Real capital costs for construction of new irrigation systems, 1966-88 (in US$/ha).

Year	India (1988 prices)	Indonesia (1985 prices)	Philippines (1985 prices)	Sri Lanka (1986 prices)	Thailand (1985 prices)
1966-69	2698	1521	1613	1470	1419
1970-74	2368	1681	1882	2056	2584
1975-80	1656	3187	2263	2909	2366
1981-85	4033	3283	2688	5288	2276
1986-88	4856	4096	na	5776	2812

Sources: Computed from Gulati 1991; Rosegrant and Pasandaran 1990; Azarcon 1990; Aluwihare and Kikuchi 1990; and Rosegrant and Mongkolsmai 1990.

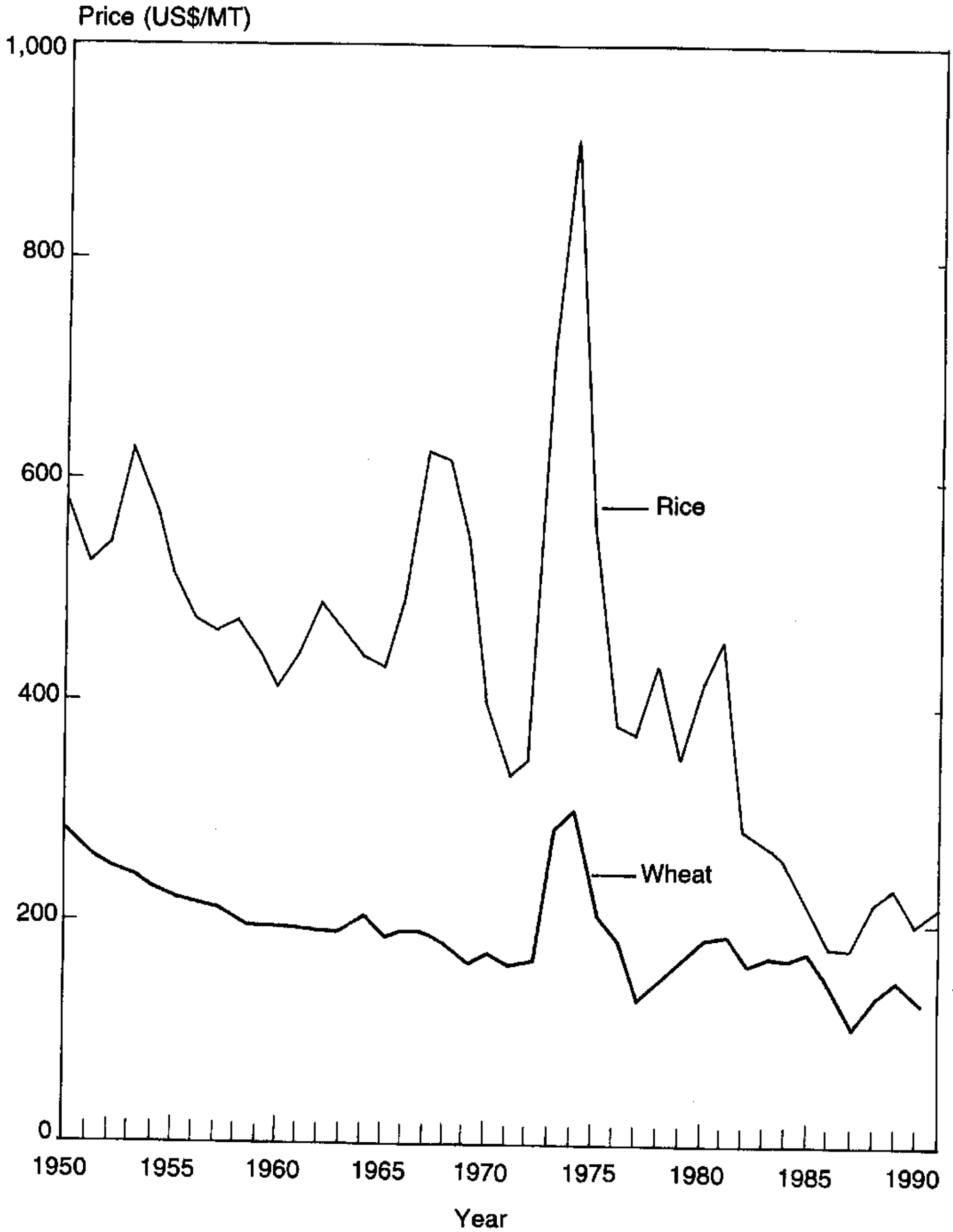
There are sharp differences of opinion on the desirability of the slowdown in irrigation investment in the past decade, and on whether significant increases in investment in new irrigation would be appropriate. Some observers argue that recent slowdowns in production growth are appropriate responses to changes in relative prices and government reforms. With continuing low prices of rice and increasingly high per hectare capital costs for new irrigation development, reductions in the rate of irrigation investment have been appropriate, and investment in new irrigation remains unattractive relative to alternative investments in agricultural research and technology. Other analysts argue that the impact on rice production of declining investments in the 1980s will be felt most strongly during the 1990s, further exacerbating the slowdown in new area irrigated and crop yield growth, so that it is essential to expand investments in new irrigated area in addition to improving existing systems, in order to maintain desired growth rates in grain production.

According to the latter argument, increased irrigation investment would be justified by extending cost-benefit analysis to incorporate endogenous world prices through feedback from the effect of total irrigation investment to prices, to better incorporate risk considerations, to incorporate the adjustment costs of irrigation agencies, and to take account of secondary benefits of irrigation.

Rosegrant and Svendsen (1992) conclude that the substantial cutback in public investment during the 1980s was, in general, an appropriate response to declining world rice prices and the rapidly increasing capital costs of irrigation. However, due to the endogeneity of world prices and asymmetric risk concerns, a modestly higher shadow price for rice and wheat could be utilized in evaluation of irrigation (and other) investments. These modified shadow prices would reflect the probable long-terms effects of the reductions in irrigation investment over the past few years. If shadow prices were revised slightly upward, the portfolio of cost-effective new irrigation projects would increase compared to current levels, moderately boosting expenditures on new irrigation. However, these adjustments would not be expected to result in a major outburst of irrigation construction activity.

One positive result of the decline in expansion of irrigated area may be increased viability of the decay of the existing irrigation base. Irrigation schemes are not permanent, and the irrigated area of any country or region is always in dynamic balance—with new area being added and existing area going out of production. When more area is being added than is being lost, we record aggregate growth, and when the opposite is true, we record contraction. When the growth rate is high, it tends to mask area losses because of the resulting high net growth rates. As construction activity declines these losses become more visible.

Figure 1. Real world rice (5% broken, FOB Thailand) and wheat (No. 1 WRS, FOB Canada) prices, 1950–90 (1985 prices).



Area can be lost from the base from a variety of causes (Figure 2). Reservoir siltation reduces storage capacity and ultimately results in reduced area irrigated, particularly during the dry season. Deferred maintenance and resulting system deterioration have the same effect. In addition to its indirect effect on rates of reservoir siltation, watershed degradation also affects irrigated area directly, in river diversion systems, by changing the shape of the river's hydrograph, making it "flashier" and less stable. Over-allocation results in shifting irrigation benefits from one location in a river basin to another without increasing productivity, all the while decreasing aggregate economic efficiency due to overinvestment. Wells decline in productivity and go out of service as strainers corrode, pumps wear, and watertables drop. Finally, waterlogging and salinization resulting from irrigation in arid environments, salinization of aquifers and coastal cropland due to salt water intrusion, tidal bores in rivers and drainageways have a major effect. It may now be possible to focus on the reversal of these effects and the resulting impact on irrigated area and productivity as an alternative investment opportunity to new construction.

Figure 2. Mechanisms causing loss of irrigated area.

CAUSES OF IRRIGATED AREA LOSS
Reservoir Siltation
Deferred Maintenance
Watershed Degradation
Overallocation
Well Failure
Waterlogging and Salinization

FORCES FOR CHANGE

In considering the near-term future, trends can be extrapolated to provide a sense of anticipated conditions. Extrapolations are far less reliable when dealing with the mid-range and longer-term future, however. In this case, it is useful to identify and examine fundamental forces and to speculate on their implications for change. We have identified four such forces—technology, economic and political liberalization, competition for water, and environmental concerns (Figure 3).

Figure 3. Forces for irrigation-related change in Southeast Asia.

FORCES FOR CHANGE
Technology
Economic/Political Liberalization
Competition for Water
Environmental Concerns

Technology

The employment of new technology in developing-country irrigation is a perplexing issue. Theory tells us that new technology is the way to improve the productivity of an economic enterprise and reduce its costs. Yet while there have been sweeping changes in irrigation technology in the West in the past 30 years, little of this development has affected Asian irrigation. Technology employed in many recently constructed canal irrigation systems in the region would be perfectly recognizable to a turn-of-the-century irrigation engineer. A principal reason for this lack of technology transfer is that the most important developments in irrigation technology have occurred in the area of water application and not in the area of conveyance and distribution.

In Asia where farms are far smaller than U.S. farms, and where irrigation schemes are often much larger than their U.S. counterparts, there has been little adoption of the sprinkler and drip technologies which are the principal targets of research attention there. In Asia, the greatest need is for improved technologies for water conveyance, delivery, and allocation, and not for water application to crops. This requires a type of research which is vastly different than the agronomy-related research models which have been introduced to the region from abroad. Such new models must be developed in Asia and must involve close linkages between technology assessment and adaptation and system management innovation. In addition, widespread adoption of new technologies at the main system level will depend on more sweeping sectoral policy and institutional changes before strong effective demand for them will emerge.

Economic Liberalization

Of the forces for change currently at large in the developing world, none is more significant than "economic liberalization." Recent changes in economic and political philosophy and policy in Eastern Europe, the former Soviet Union, South Asia and in most of Africa are profound and will shape the course of economic and political development in these countries for decades to come. Although applied in different forms in different countries, economic liberalization is characterized by market-oriented economic policies, realistic exchange rates, liberalization of international trade, a central role for private enterprise in producing goods and services, reduction of subsidies, and transparency in economic policy instruments, i.e., overt rather than hidden subsidization and taxation.

Restrictive economic policies, such as overvalued exchange rates or trade protectionism to maintain domestic prices above world prices, entail significant costs to national economies. Policies which protect some commodities or sectors at the expense of others can cause resources to shift from more efficient production activities to less efficient ones. Protective trade policies also penalize consumers through increased domestic prices. Proponents argue that rationalization of prices and removal of trade and other barriers will result in more efficient allocation of resources in production, and will provide net welfare gains.

The overall impact of continued economic liberalization on Southeast Asian countries is weaker than for the former Soviet Union and Eastern Europe, because many of the policies that liberalization suggests are already in place in one form or another. Still, some scope remains to reduce trade protectionism and overvalued exchange rates which have favored industry over agriculture. Continued economic liberalization will improve the relative competitive position of agriculture in the economy. However, liberalization also implies reduction of indirect subsidies to agriculture, applying further pressure for increasing the efficiency of irrigation and raising agricultural productivity.

Competition for Water

Water is a finite but renewable resource. What we are concerned with is the allocation of the average quantity of fresh water which will be replaced annually in the channels and aquifers of a country or region. As we close on the limit imposed by this level of annual replacement, we expect costs of exploitation to rise, as we saw earlier to be the case for canal irrigation systems, and for competition among various users to increase. This we are now also seeing across much of Asia, especially in the more arid central and western portions of the continent. Even in more humid Southeast Asia, however, competition is being felt, and can only increase as populations grow, per capita demand for municipal water increases, and industrialization—with its own often heavy water requirements—proceeds. Because irrigation is typically the largest consumptive user of water, because the priority of its claim on water is always lower than domestic use claims, and because its economic productivity is usually lower than in industrial uses, irrigation will be subject to increasing pressure to reduce its consumption to release supplies for competing uses and to pay the economic scarcity cost for water, rather than the current highly subsidized prices.

Environmental Concerns

Several kinds of environmental issues are of direct concern to irrigated agriculture in Asia. On the one hand, there are issues which directly affect irrigation, such as watershed deforestation and on the other, are externalities which result from irrigation or are exacerbated by it, such as rising water tables, salinization of irrigated land, or chemical contamination of groundwater.

In addition, though, there are several other categories of environmental issues associated with irrigation which merit consideration. One relates to the environmental damage associated with constructing new irrigation schemes, especially reservoir-based schemes, stemming from reduction in forested area and associated wildlife habitat, damage caused by construction activities in fragile mountain environments, secondary damage caused by opening up previously inaccessible areas, and submergence of prime valley bottom land. When manifested politically, these concerns can delay or halt new irrigation construction, especially of large projects, even where results of conventional economic appraisal are favorable.

The largely negative influence of this simple approach to environmental damage assessment is buffered, however, when the far more complicated set of human, economic, and environmental interactions stemming from a more comprehensive perspective are brought into view. For example, when the issue is expanded to address the problem of supporting a particular population level in a given region, tradeoffs between irrigation-based agricultural intensification in high potential areas versus more intensive use of fragile upland environments are encountered. This creates a situation which contains options, is far less clear-cut and less subject to ideologically based decision making, and is considerably more complex than the one outlined earlier.

Implications

We now turn to a review of some of the implications of the impact of these forces on Southeast Asian irrigation sectors. Because the forces mentioned above are interrelated, we will not, in general, attempt to associate impacts with particular forces. Nor will we pretend that this list of issues is a comprehensive one. We do contend, however, that these are significant issues which will have important influence on irrigated agriculture in the region over the next ten to twenty years.

Public Investment

Irrigation is losing its status as a privileged investment option. Henceforth, it will be subject to increasing scrutiny and more careful comparison with competing investment alternatives such as rural roads, power generation and agricultural research. At the same time, the range of investment options within the irrigation sector will widen to include investments aimed at restoring or preventing losses in irrigated area and productive capacity, more carefully targeted low-cost rehabilitation investments, and management and policy-based interventions. However, before being accepted, these alternative investments will need to show strong objective evidence of their effectiveness in increasing system output, something many have not done to date.

To the extent that new area is brought under canal irrigation, environmental concerns may bias project selection toward smaller-scale projects, which are generally regarded as having fewer and less-severe negative environmental consequences than larger projects. Such concerns will also strengthen the case for investments in existing projects which make them more efficient or which alleviate past environmental harm.

Private Investment

The expansion of private-sector tubewell irrigation in India, Pakistan, and Bangladesh is the most successful example of private-sector irrigation in the developing world, and the potential for further expansion in both South Asia and Southeast Asia appears substantial. Private tubewells have grown most rapidly in areas with reasonably good roads, research and extension systems, available credit, and accessible electric or diesel energy. In many locations, private tubewells have developed most intensively in and around the commands of large surface irrigation systems because of the availability of supplemental irrigation from the canal system and the aquifer recharge the canal system provides.

Rapid development of the private-tubewell sector, successful development of markets for water, and the underexploited positive externalities between canal and tubewell irrigation all indicate the potential for considerable expansion of this sector in Asia. The highly successful deregulation and privatization of the tubewell sector in Bangladesh in the mid-1980s suggests that the major role of the government in this process is as a facilitator, through provision of public goods, and a regulator, through enforcement of legal rights rather than as the direct implementor.

Performance of Existing Schemes

With the rapid escalation in the cost of developing new irrigated land, a logical alternative to further expansion is investment in improving the performance of existing irrigation schemes. Indeed, there has been high optimism in many quarters that this improvement process would provide very large production benefits and a concomitant increase in rural incomes. However, both the physical processes of surface irrigation and the empirical evidence related to rehabilitation and management reform for improved irrigation performance suggest more modest and highly variable benefits. Nevertheless, the prospect, at least, of relatively low-cost gains is real, and considerable effort will be focused on assessing performance of existing irrigation schemes and designing management and policy-based interventions for improving them.

To understand the range of options available for improving existing irrigation, it is useful to look at the three mechanisms through which improvement efforts based on a given water supply affect agricultural output. The first relates to the timeliness of irrigation deliveries to farmers—making the deliveries more predictable and more coincident with the timing of the water requirements of crops being grown. Such improvements reduce or eliminate periods of water stress on crops, increase their yields, induce use of higher levels of complementary inputs such as fertilizer and labor, and induce shifts to higher-valued crops.

The second, the impact mechanism, is the saving of water which is not used productively, and its application to unirrigated or underirrigated cropland. This mechanism acts on total production levels by expanding irrigated area rather than by increasing output per hectare. Along with the water saving itself, however, must go effective steps to apply the water where it will have the greatest impact in boosting yields. Otherwise, the potential impact on production will be lost. This effect can also be exploited by redistributing a fixed total volume of water within a command away from more generously supplied areas to areas where its marginal value will be higher. This has often been an objective of improvement programs emphasizing rotational irrigation and other forms of rationing. It is a difficult program to implement in practice, as it implies redistributing a fixed resource among individual users.

The third, the output-improving mechanism, works through the reduction of waterlogging and salinity problems. Waterlogging and resultant problems of soil salinization lead directly to reduced crop yields and to productive land going out of cultivation. These problems are exacerbated by overapplication of surface water to crops, and therefore steps taken to reduce overapplication of water can result directly in production increases due to reduced salinity levels and improved aeration in crop root zones.

In economic terms, performance improvements can also be realized by reducing system operating costs while, at least, holding output constant. However, interventions which do none of these things, though they may have aesthetic or political impacts, will not produce economic benefits and will be increasingly difficult to justify in the more critical evaluative climate expected to prevail in the future.

Water Prices

A central feature of the new economic policy regime establishing itself across Asia is adjustment of prices of agricultural inputs and outputs to levels consistent with a free market regime. This has resulted in higher prices for fertilizer and other production inputs and has provided a precedent and a rationale for increases in water tariffs as well. Increasing competition for water from other users may also tend to force water prices up. On the other side of the coin, continuing budget deficits make the public subsidy outlay for irrigation operation and maintenance an attractive cost-reduction target for government financial managers. The combination of these pressures can be expected to provide a strong push for substantial hikes in irrigation fee levels, which historically have failed even to keep pace with inflation in most countries.

Attention to irrigation cost-recovery systems can be expected to go beyond fee levels, however. The obsessive traditional concern on the part of resource economists with correct pricing levels for irrigation water is beginning to give way to a more relevant and realistic interest among a wider group of professionals in the broader topic of charging systems for irrigation water and their relationship with resource use efficiency. This trend is expected to continue and to extend into the realm of the institutional structure of irrigation managing agencies, with which it is strongly interrelated. A recent study (Small and Carruthers 1991) has shown that financial autonomy of a managing agency is a necessary condition for a strong linkage between irrigation fees and efficient irrigation service provision, and financial autonomy can be expected to be an increasingly important feature of irrigation management organizations.

Water Markets

Accompanying the rapid expansion of tubewells in South Asia are emerging markets trading in tubewell water. These markets increase access to well water on the part of smaller farmers and increase the utilization rates of pumping equipment. Little market development has occurred in areas served by public canal distribution systems, because of legal reasons related to water rights and because irrigation service supplied by public distribution systems is usually insufficiently defined, quantified, and controlled to permit transactions to take place.

As the scarcity value of water rises and as publicly distributed production inputs shift toward the private sector, some of these deficiencies will be remedied and the conditions for trading and selling of short- and long-term water rights will become more favorable. Still, the emergence of water markets in surface water is likely to be a slow and lengthy process. Meanwhile, markets in groundwater can be expected to continue to expand, since water-right and water-control issues are not significant problems here.

Water Costs

Marginal costs of providing irrigation service to entirely new areas will continue to increase, following the trend already established. To the extent that externalized costs of drainage remediation are brought into the cost structure for irrigation water supply, the cost of irrigation water could rise still further. There are few examples of this being successfully done elsewhere in the world, though, and such internalization is unlikely to occur in Southeast Asia over the period of interest. As alternative investment packages of system improvements are further developed and tested, marginal costs of water made available by them may well begin to decrease. Overall, costs of supplying irrigation water thus may not increase dramatically over the coming decade.

Power of Farmers

Economic liberalization also has strong democratic political overtones, and democratic political structures appear to be gaining strength and resiliency in Southeast Asia. As a result, farmers' organizations of various kinds, including irrigators' associations, may find an encouraging climate for growth. Although often a slow process, evidence from several countries in the region indicates that development of irrigators' associations can be accelerated by carefully designed interventions.

To the extent that farmer irrigation organizations multiply and grow stronger, several results can be expected. First, organized farmers can demand and receive greater accountability from irrigation agencies, presumably improving the quality of irrigation service. Second, they can be expected to assume responsibility for managing smaller systems and portions of larger systems themselves, replacing public control over these systems. This trend is already evident in several countries in the region. Third, they may gain added political clout, allowing them to request and receive additional public benefits in the form of rural infrastructure and services (including irrigation), and possibly subsidies on these services (including irrigation). This last feature may run counter to some of the other tendencies asserted here, which emphasizes the dynamic and political nature of many of the issues being considered.

Irrigated Crops

Although prices of basic food grains are expected to remain low over the coming decade, the same is not necessarily true of other crops. As a result, and as marketing infrastructure continues to improve in rural areas, shifts from staple grains to higher-value crops in irrigated areas can be expected. This will also make farmers better able to pay the higher water rates anticipated and reinforce their demand for higher quality (adequate, timely, reliable) irrigation service. Rising farm incomes which result will strengthen farmers' political clout, enhancing the prospects of the empowerment mentioned above.

New Government Roles

Changes outlined above imply reduced roles for government irrigation agencies in the provision of irrigation water to farmers. On the one hand, some government irrigation departments will be spun off into private or quasi-private entities delivering irrigation services for fees. Additionally, organized groups of farmers will assume greater responsibility and control over some schemes. The growing groundwater sector will remain firmly in private hands.

In the wake of these changes, governments will need to play new roles. Some of these roles are technical and might naturally fall into the realm of former irrigation management agencies. Others are new and will require skills and perspectives not usually found in irrigation departments. Some important examples are given below.

a. As pressure on the water resources increases, resources allocation and dispute adjudication will become increasingly important. Governments will need to strengthen their capacity to document and monitor water rights and settle disputes among rival claimants. Improvements in this area will also facilitate the development of macro-level markets in water rights.

b. As externality problems, such as waterlogging and salinization, expand, governments' role in this field will expand also. Because of the nature of externalities, public-sector involvement is usually necessary to address them. This function will include allocating costs of remediation among beneficiaries, those responsible for the externality, and society at large. With respect to positive externalities, a corollary function will be to recover some share of canal irrigation costs from those users of groundwater benefiting from aquifer recharge resulting from canal operations.[8]

c. A third new function falling to governments is to ensure the financial probity of the corporate and cooperative entities set up to deliver irrigation water instead of the government departments and agencies. Revenues previously moving through government channels will now course through public utilities and farmer cooperative organizations, and auditing systems and standards will need to be established and enforced. This is an extremely important function, essential to the success of privatization policies. It is not necessary for governments to be the implementing agencies for all audits and monitoring efforts, but they must establish auditing systems and ensure their effectiveness.

d. As water is reallocated in response to market forces, some traditional users will find themselves with less water or no water to work with. Governments have a strong responsibility to monitor and regulate market mechanisms to protect the interests and rights of less-powerful farmers vis-à-vis those more powerful. Additionally, governments must remain aware of the impacts of shifts in water allocation patterns, even those legitimately accomplished, on those who give up or lose allocations. While transfers may move the economy as a whole in the direction of greater efficiency, the welfare of vulnerable segments of the society must also be protected.

---

8 This can be a positive externality in fresh groundwater areas since it reduces groundwater extraction costs, or a negative one in saline groundwater areas since it can lead to land salinization.

WILL THE FUTURE BE LIKE THE PAST?

The answer to this question, unsurprisingly, is yes and no. Irrigation, and irrigated agriculture, will continue to be important as a principal source of agricultural growth and as an essential contributor to national food security in most Asian countries, including those of Southeast Asia. Public agencies will continue to play important, though changing, roles in irrigation development and management, while farmers remain the central actors at the productive end of the system, while becoming more important at higher levels as well.

Importantly, where irrigation policy once involved deciding how much money to invest in irrigation construction each year, and how to allocate it among districts, the number of policy questions and options have now expanded considerably. New sets of issues relating to the various modes of enhancing productivity in existing systems, appropriate organizational forms for managing entities, the role of farmers in higher-level management processes, selling and trading of irrigation water rights, intersectoral allocation and sale of water rights, and intensive cultivation/fragile lands trade-offs now demand consideration.

Many of these new issues can be captured as changes occurring in our concept of water itself.

First, irrigation water has traditionally been viewed in many societies as a "social" good, something the government was obliged to supply where possible, much like a road or drinking water. Water, including irrigation water, is increasingly being seen as an economic good, useful in a variety of productive enterprises, whose costs should be reflected in charging and allocation decisions.[9]

Second, there is a change in the perception of what an irrigation system is obliged to supply to recipients (or purchasers) in the system. The oldest view is that it provides facilities which can extract water from a river and deliver it to an area of agricultural land. This view places primary emphasis on construction of new facilities. A second stage view is that the obligation is to supply water to command areas. This view places greater emphasis on operating main system sluices and gates but is little concerned with the nature of the demand for water or actual patterns of deliveries.

The third stage view is that the system should supply irrigation service to farmers. In this stage, the temporal and spatial pattern of demand for water across the system is the critical factor driving the water supply process. Success is measured not in constructing, or in opening main gates, but in making particular patterns of water flows available across the system. Many agencies and systems in Southeast Asia appear now to be in transition between the second and third of these stages.

Third, there is a change in the concept of "rights" to water. Patterns here are as yet less clear, but changes will likely involve more precise specification of and accounting for rights to water, devolution of the rights from central government agencies to smaller lower-level producer-based units, increased transferability of rights from one use or group to another, and the valuation of these rights and the emergence of markets for both short-term and long-term water rights.

This is an interesting time in the history of Asian water resources development. It is one marked by more rapid, more sweeping, and more basic flux than the past three decades which saw tremendous growth, but little change in basic principles, assumptions, and concepts. How long this period of change will last is an open question, but the fact that change is on the way seems clear.

---

9 Agenda 21, the document growing out of the recent Earth Summit in Rio, recognizes it as such.

References

Aluwihare, P. B. and M. Kikuchi. 1990. Irrigation investment trends in Sri Lanka: New construction and beyond. International Irrigation Management Institute. Colombo, Sri Lanka.

Azarcon, Y. J. 1990. Public investments in irrigation in the Philippines. Unpublished M. S. thesis. Ithaca: Cornell University.

Gulati, A. 1991. Development cost of irrigation in India and subsidies therein. Mimeo. International Food Policy Research Institute.

Pinstrup-Andersen. 1992. Draft medium term plan. International Food Policy Research Institute, Washington, D.C.

Ramirez J. and M. Svendsen. 1990. Determinants of irrigation investment in the Philippines. International Food Policy Research Institute, Washington, D.C.

Rosegrant, M. and D. Mongkolsmai. 1990. Trends and determinants of irrigation investment in Thailand. Mimeo. Washington, DC: International Food Policy Research Institute.

Rosegrant, M. and E. Pasandaran. 1990. Irrigation investment in Indonesia: Trends and determinants. Mimeo. Washington, DC: International Food Policy Research Institute.

Rosegrant, M. and P. L. Pingali. 1991. Sustaining rice productivity growth in Asia: A policy perspective. Mimeo. Washington, D.C. and Los Banos, the Philippines: International Food Policy Research Institute and International Rice Research Institute.

Rosegrant M. and M. Svendsen. 1992. Irrigation investment and management in Asia: Trends, priorities, and policy directions. International Food Policy Research Institute, Washington, D.C.

Small, L. E. and I. Carruthers. 1991. Farmer-financed irrigation: The economics of reform. UK: Cambridge University Press.

Paper 3

Discussion on the Paper
Will the Future Be Like the Past?

Manuwoto[10]

PHILOSOPHICALLY, THE QUESTION which is adopted as the title of the paper presented by Mark Svendsen and Mark Rosegrant can easily be answered as "No, the future will not and should not be like the past." Why the future should be different than the past is because we are always undergoing a process of change. Change is unavoidable, and therefore we hope to live with it. The question is what kind of future we want to have, how can or should we manage and predict the change, so that we can aim our efforts toward the expected future goals.

Based on the abovementioned notion the discussion will be focusing on some policy implications, rather than on the process of change which has worked in the irrigated agriculture areas. Special reference is made to the situation and conditions in Indonesia.

Some important socioeconomic changes that characterized Indonesia during the past decades can be pointed out as follows:

- In the periods 1978-1983 and 1983-1988 the GDP has grown on an annual average of 7.4 percent and 6.0 percent, respectively.
- The agriculture sector has grown on an annual average of 5.5 percent and 4.8 percent, in the same periods.
- The labor force engaged in the agriculture sector declined from 68 percent to 55 percent of the total labor force in 1968-1988.

Taking into consideration the past performance of the Indonesian economy, combined with other external as well as internal factors, the economy for the period 1994–2018, is predicted as follows:

- The GDP will grow at an average of 6.4 percent annually, while the agriculture sector grows at an average of 3.5 percent annually.
- The contribution of the agriculture sector to the GDP will decline from 24 percent in 1988 to about 11 percent in 2018.
- The labor force engaged in the agriculture sector will decline from 55 percent in 1988 to about 40 percent in 2018.

10 Head, Bureau of Region 1, BAPPENAS, Indonesia.

- The per capita income will increase from US$500 in 1988 to US$2,000 in 2018.

Some constraints to be faced are availability of land and water, the possibility of technological breakthrough in rice agriculture and the availability of funds, especially "cheap money" in terms of soft and very soft loans. All of these constraints have to be faced in setting the priority of development activities, especially for rice production. It can be predicted that the increase in rice production will be more and more difficult and expensive. The policy implication is that in addition to the efforts that have been and will be made at the supply side we should also consider the demand side of rice agriculture. In this context some important policies will be emphasized, such as:

- Self sufficiency in food, which is not necessarily rice.
- Diversification of food crops.
- Better pricing for the rice crop.
- Encouragement of people and the private sector to participate in the development of food crop agriculture, especially irrigated agriculture.

Paper 4

Discussion Statement:
Is Food Self-Sufficiency Irrelevant?

Loekman Soetrisno[11]

IN THE LETTER which accompanied the paper of Mark Svendsen and Mark Rosegrant, Charles Abernethy has asked me to take a slightly different approach in looking at the issue which my two colleagues had taken in their papers entitled "Will the Future Be Like the Past ?" I will of course take Charles' advice in discussing my colleagues' paper.

Let me begin by commenting on the first issue that my colleagues have raised in their papers, namely the issue of the decline of the total irrigation investment expenditures and the causes that contribute to the decline. They have mentioned several causes one of which is the large public and foreign debt loads carried by most of the agriculturally based economies in the region. This is true. However, in reality the impact of this situation goes far beyond the decline of investment in irrigation by governments of agriculturally based economies.

The heavy debt load, to my mind, has created a feeling of "anti paddy" cultivation among these governments. Governments which had to face heavy debt burdens had been forced to boost their exports to generate more foreign currency to enable them to repay their foreign debts. Irrigation development or irrigation investment thus becomes an anomaly in the new development objectives. As irrigation development only generates food to be consumed by the people, rice cannot be exported because in the international market the price of rice is very low. It is better therefore to invest more in, say, tourism which generates foreign currency. It is therefore more profitable to turn *sawah* (irrigated rice-fields) into golf courses and use irrigation water to keep the golf course green to attract tourists to play golf in the country. Nobody ever questions what happens to the farmers who lose their land.

The "anti paddy" spirit also discriminates against farmers by, for example, stopping them from getting subsidy from the government, as farmers' subsidies are currently considered creating inefficiency in the national economy, while facilities are provided by the government to the big businesses and industries. I have to warn this workshop that if we are not careful and let the "anti paddy" spirit dominate the current development strategy, we are going back to the past, namely, we are going back to the situation where we were dependent on food aid, and this will bring various negative political implications. Political stability in Southeast Asia (SEA) is basically caused by the fact that most of the SEA countries are able to feed their respective peoples. Irrigation development is also important for SEA countries as it is basically a mechanism for equalizing development benefits.

My second comment concerns my colleagues' thought on political liberalization. Citing the case of Soviet Russia, my colleagues have said that what happened in Russia in terms of political

---

11 Senior Lecturer, Rural and Regional Studies, Gadja Mada University, Indonesia.

liberalization will also spread to SEA. In other words, democracy will be spreading to SEA. I personally hope so. But I doubt very much that democracy will spread and institutionalize in SEA the present "anti paddy" spirit. The "anti paddy" spirit as I indicated above will generate many political problems, for example, it will legitimate an authoritarian government rather than a democratic one. Farmers whose land was taken away from them will not remain idle politically unless they are suppressed by an authoritarian regime. People who are hungry must be governed by an authoritarian regime. Gorbachev made a fatal mistake when he introduced glasnost in his country when the Russians were hungry. I believe that there is a correlation between food security and democracy.

The next comment is on the issue of privatization and the role of the government. I believe that while we realize the importance of the role of the private sector in development, the role of the government must not stop at being facilitator only, but that it must have the role of regulator in the sense of setting up regulations to protect the right of the weak section of the society from being abused by private companies under the disguise of generating development. There is, at the moment, a tendency in the developing countries for the emergence of what I call "pseudo privatization" that is privatization which is implemented by the government only to meet the demand of the donor country, as privatization is currently becoming one of the prerequisites set up by foreign donors.

I really believe that protectionism is bad for the development of the developing countries. The irony is that it is not the Third World that is currently practicing a protectionist policy, but the industrialized countries. I believe that to protect our agriculturists and our infant industries we should provide protection to them. Japan is a good case in point in this context. Malaysia and Indonesia are currently facing problems because they cannot export their agricultural products such as palm oil because of the protectionist trade policy followed by some industrialized countries.

Paper 5

Legal Aspects and Issues

S. Burchi[12]

INTRODUCTION

LAWS AND THE institutions which administer them may constrain or facilitate the process of social adaptation to changed circumstances. In a somewhat oversimplified sequence, as the pressure for economic and social change translates into the review of policy and a reordering of society's priorities, implementation of society's revised agenda requires laws and administering institutions—at the governmental and nongovernmental level—attuned to the new needs of such agenda. If they are not so attuned, laws and institutions will act as a hindrance to change and will stifle economic and social development.

Laws and institutions for water resources development and management in general, and for irrigation development and management in particular, are no exception to this rule. As pressure on essentially finite amounts of available water resources mounts in response to economic growth and changing patterns of social behavior, and as dwindling public treasury finances become increasingly incapable of meeting all of the water sector's and the irrigation subsector's demands, the pressure for social adaptation to scarcity of natural and financial resources leads to a revision of water and irrigation policies and of implementing laws and institutions. This pattern is evidenced by a number of countries which have gone recently or are going through a process of policy and companion legal and institutional review in the water sector—and with special attention to the irrigation subsector—most notably, Spain, the Australian State of Victoria, Indonesia, Mexico and Chile. The collective experience of these countries points to a number of policy and related legal and institutional issues which other countries may encounter as they embark on the process of reviewing policy in the water and irrigation subsector and adjusting relevant laws and institutions to a new or revised set of policies. As the Southeast Asian Region shows all the symptoms which have resulted elsewhere in the world in a reorientation of policy, legal and institutional frameworks for the water resources sector in general and the irrigation subsector in particular, experiences elsewhere in the world may provide useful conceptual ammunition across cultural and geographical diversities.

Policy and related legal and institutional issues relevant to the irrigation subsector have been grouped and analyzed around a few main clusters. These have been further grouped in water sector-wide and irrigation-specific clusters, respectively.

---

12 Senior Legal Officer, Development Law Service, Legal Office, FAO, Italy.

POLICY AND RELEVANT LEGAL AND INSTITUTIONAL ISSUES AT THE "MACRO" (WATER SECTOR-WIDE) LEVEL

The development and management of irrigation cannot be viewed in isolation from the development and management of the natural resources which are at its core (i.e., water and land). Issues which are not specific to the irrigation subsector will nonetheless reverberate on it and have to be accounted for and anticipated—all the more so if one considers, in particular, that irrigation water accounts for a good two-thirds of water consumption worldwide, and that, as a result, this particular use is highly vulnerable to shifts in policies and priorities for the entire water sector. The main policy and related legal and institutional issues of particular significance to the irrigation subsector appear to be *security of water rights tenure, customary law and judicial mechanisms of conflict resolution, regulatory mechanisms, effectiveness of the government water rights administration, security of land tenure, and other land-related issues.*

Security of Water Rights Tenure

The issue of security of water rights tenure has a dual connotation. Traditionally, the first concern of water users in general, and of irrigation water users in particular, has been to be able to rely on a steady flow of water. As water resources have tended to become polluted, concern for dependable flows has been coupled with a concern for the quality of water arriving at the user's headgate, a steady flow of polluted unusable water being tantamount to no water being available at all. Under the former of these two different but complementary configurations, the issue—being a mixed one of policy and law—is, how secure, in a legal sense, an irrigation "water user", be it an individual farmer or a corporate farming enterprise or an irrigation project as a whole, is in his or its water entitlement, particularly when the water he or it is dependent upon is being dammed or simply siphoned off or just sought by somebody else, be it individual or corporate user or the government, upstream on the same river or drawn elsewhere on the same underground aquifer; or when his or its title is challenged. Under its water quality configuration, the issue is, how secure in a legal sense an irrigation water user is in his water entitlement when the water he has been using is being polluted above his headgate to a level which makes it unfit for irrigation use. Under all these circumstances, the issue of security of water rights tenure is borne out of conflict situations, and is best analyzed from the standpoint of the legal mechanisms provided by a legal system for conflict resolution.

Security of water rights tenure, however, is relevant also in a situation involving a commercial transaction between water users, such as a transfer of water rights from one user to another through a market mechanism, or between a water user and, say, a lending institution such as the taking of a loan from a bank, with the water right serving as collateral. In these nonconflicting situations, the irrigation water user wants to be secure that "his" water right is indeed his, and that evidence of this fact is readily available to support the transaction. This apparent preoccupation with the instrument of a water right belies a very basic concern for the certainty, clarity and availability of title. As uncertain, unclear or simply unavailable titles breed conflict, legal systems of water resources management have sought to address this particular configuration of the security issue in context with the provision of legal mechanisms for conflict resolution.

Customary Law and Judicial Mechanisms of Conflict Resolution

Overt conflict over water has been—and is at present in many countries, particularly in a rural context—handled by a variety of customary means of conflict resolution (i.e., by "customary" law). While a review of these is beyond the scope of this paper, suffice it to say here that customary law plays a significant role in many parts of the world. In the Moslem world, a very sophisticated body of customary rules in relation to water use has evolved from the Koran and its interpretations and applications by the different schools of thought. The Water Court of the city of Valencia, in Spain, has met once a week for the past one thousand years to adjudicate water disputes brought before it by irrigation water users for swift and inexpensive adjudication. In the absence of customary mechanisms of conflict resolution, formal litigation before a court of law has been—and is at present to a varying extent in virtually all legal systems—the most readily available mechanism for conflict resolution. Settlement of water disputes in a court tends however to be regarded as expensive, time-consuming and unpredictable in its results. Furthermore, its relevance in the cultural context of certain countries, particularly in the Southeast Asian region, may be debatable.

Regulatory Mechanisms

The more modern trend is towards the prevention or minimization of conflict via the government regulating the allocation of available water resources to different uses through the instrument of a permit, license or concession. Security of water rights tenure is achieved in the substantive sense that the permit shields its holder from attack by competitors by virtue of its operation, and in the formal sense that the permit guarantees certainty and dependability of title. This formal function of permits is enhanced by the recording of permits in registers available for public consultation. Through a permit mechanism, opportunities for conflict among water users are minimized through the governmental action of arbitrating among competing demands. Conflicts among competitors for the same water are dealt with and settled in the administrative process of granting a permit or the like, and they never reach the courts. Conflicts between the government and a user or prospective user who is dissatisfied with a given administrative decision affecting his water right or his expectation to obtain a water right are dealt with through the administrative appeal process, or before the courts of law in certain legal systems.

While ensuring formal security of title, and the maximum degree of substantive security consistent with the collective good pursued by the national community through its government, permit systems enable the government to allocate water resources and to manage allocation patterns with the desirable flexibility. Perhaps another mixed policy and legal configuration of the security issue in this particular connection is, how to reconcile security of tenure with the desirable flexibility of administrative action. In this particular respect, permits afford substantive security of tenure also from attack by the very government which granted it in the first place. This occurs when water which has been "frozen" under a permit is needed for a high-valued use, and is wanted back by the government. In these instances, security of title gives way to flexibility of governmental action, in return for compensation of the displaced permit holder.

Effectiveness of the Government Water Rights Administration

Effectiveness of the government water rights administration is complementary to security of water rights tenure insofar as security is enhanced by an effective government administration. It is of relevance to irrigation users, whatever their configuration, insofar as an effective government water rights administration will ensure that the water entitlements of irrigators, among other users, are met and protected from undue interference.

While the actual configuration of the government water rights administration will vary with the circumstances—constitutional, geophysical, development and others—of each country, there are certain parameters of general validity which can be of use in country-specific situations. A government water rights administration is akin to a central bank and functions along similar lines.

Like a central bank, it must be in a position to control withdrawals made from the total mass of available water resources by issuing and revoking water withdrawal permits. Like a central bank, it must also know at all times how much resources are "in circulation" through outstanding permits, and how much are left for withdrawal. Like a central bank, there must be a central unit within the structure of the government with authority to grant, revoke and alter permits, and to keep relevant records. Just as a central bank cannot tolerate competitors, so the function and authority abovementioned cannot be exercised by two or more units competing for the same authority within the structure of the government. Authority can be surely delegated to subnational levels of the government, but ultimately it must rest with one unit placed at the central or national level of the governmental system. Just as a central bank's scope of authority must cover the entire money supply mass, so does the scope of authority of the government water administration need to extend to all of the water resources available in a given country—from surface to underground and, depending on the circumstances, from aboveground to wastewater.

The issue which is fused with policy and institutional relevance, and which emerges in this regard appears to consist, in a majority of cases, in how to reconcile the inherent unity of the natural resource and of the manyfold management functions relevant to it with the reality of governmental bureaucracies patterned along use-specific lines (i.e., with separate administrations responsible for irrigation, water supply, energy, transportation), or along functional lines (with separate administrations responsible for water resources allocation and water pollution control, respectively), or even along different kinds of water resources (as with separate administrations being in charge of surface water management and underground water management, respectively).

Security of Land Tenure

This particular issue is of significance in the broader context of land reform and land redistribution programs inspired by social justice goals, and it does not necessarily emerge in connection with irrigation development. In this broader framework, security of land tenure entails, generally replacing precarious forms of tenure such as tenancy and sharecropping of agricultural land, including, in particular, land under irrigation, with full ownership rights. In addition, security of land tenure has emerged forcefully in connection with irrigation development of land hitherto cultivated by traditional means, where traditional cultivators have been displaced by newcomers claiming fresh title to the developed land. Legislation supporting irrigation development, particularly for the benefit of the commercial agriculture sector as opposed to subsistence agriculture, tends to introduce modern, commercially oriented instruments of land tenure, notably, written title, which ignore established customary practices. Whence the potential for conflict between customary occupants and statutory claimants of title, or between statutory occupants and claimants of customary titles.

The issue which is a blending of policy and law, in this respect appears to be how to reconcile modern land titling systems and processes with customary rights of occupancy. A key to addressing this issue in connection with the transition from traditional to modern agriculture in general, and in connection with irrigation development in particular, is to devise legal mechanisms aimed at evolving customary rights of tenure towards modern tradeable titles, thus bringing about, in a phased manner, a generalized system of land tenure based on written title.

Other Land-Related Issues

Other issues related to the tenure of agricultural land in general, and of irrigated cropland in particular, concern limitations placed by the law on the maximum size of holdings, and restrictions on the disposal of communally held land. Legal restrictions to the size, particularly of irrigated landholdings, and to the disposal of communal land tend to complement land reform programs, and are aimed at preventing the formation of large holdings by keeping the land with the smallholders who benefit from land reform. These restrictions become an issue whenever policies shift towards the mobilization of private investment particularly on-farm, and are no longer served by the legal framework enacted in response to different policies. Legal limitations on the size of landholdings and on the disposal of communal land are then perceived as constraints and call for adjustment to the changed circumstances. The issue then, having a policy and legal nature, can be configured as one of reconciling an existing framework of legal limitations with a changed policy environment.

Legal responses to this issue can range from an outright lifting of legal restrictions to more nuanced approaches involving the lifting of restrictions at the lower end of a scale of landholding sizes while maintaining them at an upwards-revised upper end. As to communal land, approaches include the partitioning of land into plots held and disposal by individual community members under full ownership, or the free disposal of usufructuary rights in communal land held in common by the community members.

POLICY AND RELEVANT LEGAL AND INSTITUTIONAL ISSUES AT THE "MICRO" (IRRIGATION-SPECIFIC) LEVEL

In addition to all of the above, irrigation development and management are liable to a number of policy and relevant legal and institutional issues which are specific to them, and which can be aggregated around the following main clusters.

Cost Recovery

The recovery from project beneficiaries of capital and/or operating expenditures incurred by Public Treasuries in connection with the development and management of irrigation networks has been a source of concern to all governments worldwide whose financial capability to cope with the subsector's demands has run thin. The essential policy issue of cost recovery has legal and institutional ramifications insofar as recovery is often hindered by impediments of a legal and institutional nature. A fairly frequent legal impediment to cost recovery of operation and maintenance expenditures in the irrigation subsector is the exemption of farmers from liability to levies and charges for the water they draw and the service they receive. Another is the unavailability or inadequacy of authority to levy, collect and enforce charges and arrears of payment. A frequent institutional impediment stems from the lack of mechanisms to ensure that revenues generated by the irrigation subsector are channeled back into the subsector and do not end up in the general cauldron of government revenues. A perhaps less frequent but no less powerful legal obstacle stems from water being legally regarded as a free commodity, which is at odds with the notion of having to pay for it.

All these obstacles need to be removed to accommodate a policy of cost recovery. Basically, a proper authority to levy, collect and enforce charges for the recovery of costs has to be in place, and legal privileges lifted. In addition, subsector revenues can be directed back to the subsector by setting up a special fund, or by enabling the utility-type institution operating the irrigation system to retain the charges it collects. In this latter regard, the issue of cost recovery overlaps with the issue of transfer of governmental responsibility to the users insofar as the long-term viability of such transfer depends on the ability of the transferee to recover from irrigation users its operating costs.

Transfer of Irrigation Systems to Users

In response to the growing inability of Public Treasuries to stem the drain of financial resources needed to develop, operate and maintain government-funded irrigation systems, the option of divesting the government of responsibility for the operation and maintenance of existing and new systems in favor of users is attracting much attention. A policy move in this direction raises a number of legal and institutional issues, most notably the following three issues:

The Ownership Status of System Works

Divestiture may entail transfer of the physical assets (i.e., the irrigation infrastructure) or it may stop short of it, with the government retaining ownership of the assets, while their "use" (i.e., operation and maintenance) is transferred to a third party.

The Instrument of the Transfer

If the transfer involves the use—as opposed to ownership—of the irrigation infrastructure, the government—in legal parlance, the "transferor"—may want to negotiate the terms and conditions governing the use of the governmental property involved. The necessary flexibility can be achieved through the instrumentality of, for instance, a concession or permit between the government and the users—in legal parlance, the "transferee."

The Legal Configuration of the Transferee

The transferee of irrigation systems tends to be the water users constituted as a group. Such users' groups need to have legal status, generally in the form of users' associations, with authority to levy and collect charges from their membership, to borrow money and with standing to sue and be sued. In large irrigation systems, more complex legal configurations of users' groups are evolving with users' associations providing operation and maintenance of secondary networks and below, and with a separate corporate entity set up by users' associations operating the primary irrigation network, to the inclusion or exclusion of the system headworks, on behalf of the parent associations. A two-tiered transfer of the irrigation infrastructure can thus take shape, with both tiers having to be provided with authority to raise and collect charges, respectively, from their member users or from their client users' associations to ensure the long-term financial viability of these arrangements.

Mobility and Transferability of Irrigation Water Rights

Mobility and transferability of water rights in general through the operation of market or administrative or mixed mechanisms are of particular significance in the context of irrigation water use—and have been classified among the irrigation-specific issues—in view of (a) their direct bearing on the irrigation-specific management issues of encouraging investment in water-saving techniques on-farm, and (b) the special bond which binds irrigation water to the land it serves.

Arguably, saving in irrigation water consumption at farm level is encouraged if the user can dispose of the water he saves, for on-farm or off-farm use. A policy objective of encouraging on-farm water saving can be constrained by legal provisions directing that less-than-full use of the water one is entitled to entails loss of right for the unused (i.e., saved) portion of water. Other constraints stem from tying irrigation water to use on a particular piece of land, to the exclusion of other uses on-farm and off-farm, and to the exclusion also of use to irrigate a different piece of land belonging to the same irrigator. Uses of saved water off-farm, whether to irrigate another holding of the saver's or somebody else's holding, or for nonirrigation use, are thus barred. All these impediments to the mobility of saved water may discourage an irrigator from being consumption-minded and from investing to consume less.

The issue of using saved water on some other piece of land than the one being irrigated, and for a nonirrigation use interfaces with the more general issue of the special bondage which tends to bind, in law, irrigation water to irrigated land. This bondage—referred to in legal parlance as "appurtenancy"—is particularly strong in the case of groundwater, and under conditions of generalized water scarcity. It results in water not being transferable separately from the land, and is aimed at preventing speculation in water rights. The same bondage is also evidenced in the tendency of permit systems of water rights to tie irrigation permits and the rights under it to use on a particular piece of land in pursuit, basically, of government-driven as opposed to user-driven and market-driven water allocation goals. Transferability of irrigation water rights to other kinds of uses or for the irrigation of other lands is thus effectively hindered. This general trend notwithstanding, water rights markets are known to exist, particularly in the United States West. Pure market-driven transfer systems, however, are rare. What tends to prevail are rather mixed systems of government-controlled markets. These are known to exist in the United States West, in Mexico, and are developing in the Australian State of Victoria, particularly for the trading in irrigation water rights. Protection of the interests of the area of origin of the water and of the area's irrigation development is the prime concern of, and justification for, the government mediating the operation of market forces. Where water markets as such do not exist, limited transfers have nonetheless been practiced by operation of the authority and under the direct control of the government water rights administrations. The government authority in these, which forms the vast majority of cases, serves essentially to screen a proposed transfer for consistency with public policy goals and with plans in effect, if any.

Pollution of Water Resources from Irrigation Runoff and Return Flows

Pollution of water resources—particularly groundwater—from the runoff of land under irrigation and from irrigation return flows has become a source of growing concern as a result of the increasing use of pesticides and fertilizers for the production of food and fibers. Legal responses to this fairly novel problem have tended to center on land use controls aimed at directing land use away from farming altogether, or at directing the manner of cultivating land towards nonpolluting or less-polluting practices. To these ends, mixes of regulatory restrictions and voluntary programs have been adopted in the legislation of the countries (the United Kingdom, the Netherlands, and the European Union to mention some) which have spearheaded approaches to this problem. Perhaps the single most complex legal issue which arises in this particular connection is, to what extent the legitimate property rights of cultivators can be restricted, as to how much of one's own land can be put under cultivation and by what means or practices it can be cultivated. Restrictions may result from administrative diktat and be compulsory, or may be agreed upon by the affected cultivator(s) through negotiation with the government and be voluntary. In either case, the corollary to the issue of compulsory or voluntary restrictions to the cultivator's legitimate property rights is the issue of compensation for the sacrifices imposed on or accepted by him and the means of compensation—i.e., in cash or in kind, such as by replacing idle land for cultivable land elsewhere.

Paper 6

Discussion on the Paper
Legal Aspects and Issues

Apichart Anukularmphai[13]

THE PAPER HIGHLIGHTS very important issues which were previously not apparent in the tropical countries due to abundant rainfall. However, due to expansion of population and quick expansion of other sectors such as industries and urbanization, competition for resources will be severe in future.

To solve present conflicts and future problems, legal aspects have to be considered and laws have to be enacted to ensure justice and preserve social order.

The paper can be linked with the current attention of sustainability in irrigated agriculture development. The issues can be grouped as follows:

Institutional Unsustainability

- Security of water right deals with the question of who has the right to water; can the right be transferred, etc.
- Effectiveness of the government water right administration deals with the enforcement of law and order or how to improve the present regulatory practices.

Resource Instability

- Security of land tenure deals with the legal ownership of land and how irrigated land can be conserved; is this possible legalwise?
- Other land-related issues deal with the transfer of irrigated land to other usages. What is the suitable farm holding? What usage falls under agriculture? How about golf courses or other activities which are more investment-intensive?

Economic Unsustainability

- Cost recovery deals with the sustainability of government funds for infrastructure. How much should be borne by users? How about differential rates for different purposes?

---

13 Director, Office of the National Water Resources Committee, Thailand.

- Transfer of irrigation systems to users deals with the inability of government agencies to maintain and operate the system. To whom can the responsibility be transferred? Can infrastructure be legally transferred? Can the private sector get concessions?

- Mobility and transferability of irrigation water rights deal with the question of whether the water is attached to landownership. Can the owner of land inherit the water right to use water for other purposes such as for a golf course?

Environmental Unsustainability

- Pollution of water resources from irrigation runoff and return flows deal with the problem of pollution from agricultural activities, and these generate mainly non-point source pollutions which are difficult and more costly to control. How can they be controlled? What measures should be taken to effect the implementation?

Paper 7

Institutional Adaptation and Institutional Change

D. Hammond Murray-Rust and Douglas J. Merrey[14]

INTRODUCTION AND SCOPE OF THE PAPER

THIS PAPER EXAMINES institutional issues that face irrigated agriculture in the Asian region in response to changes in the irrigated agriculture sector. The rapid developments in irrigated agriculture in the past three decades have been achieved with remarkably little change in the institutional setting for agriculture, in organizational arrangements, or in irrigation technologies.

It is unlikely, however, that this slow rate of institutional modification can resist change much longer. Dramatic changes in agricultural policy, the reduced profitability of foodgrain-based agriculture versus nonagricultural opportunities, the rapid increase in competition for scarce water and other resources, all lead to pressure on institutions to change. These changes will have to be of two types: internal changes in organization, procedures and general operational performance to try to keep irrigated agriculture profitable and an efficient user of scarce resources, and changes in the nature of the institutions themselves that will result in a variety of institutions very different from the traditional, paternalistic public works organizations.

During the coming decades there will have to be considerable experimentation with different modes of ownership of irrigation infrastructure and agencies and other services traditionally provided by governments. Possibilities include private corporations, farmer-managed commercial ventures, stronger links with agribusiness and decentralized planning and management bodies for water allocation and utilization, all of which contrast with current institutional arrangements.

INSTITUTIONAL RESPONSES TO CHANGES IN IRRIGATED AGRICULTURE

The 1960s marked the start of one of the greatest revolutions mankind has seen. Faced with the specter of mass famines throughout Asia, vast sums of money were provided for agricultural research, for production of improved inputs in the form of fertilizers, pesticides and other agricultural chemicals, and in the provision of millions of hectares of new irrigated lands.

---

14 Senior Irrigation Specialist and Senior Irrigation Management Specialist, respectively, of the International Irrigation Management Institute, Colombo, Sri Lanka.

The results of these investments were dramatic. By the 1980s many countries had moved from being net importers of rice (Indonesia was the world's largest importer of rice in the early 1960s) to conditions of rice self-sufficiency. With the overall threat of starvation effectively eliminated, at least at national level, countries began to experiment with a range of different scenarios for the irrigated agriculture sector.

Typically, these policy changes related to the production side of agriculture: crop diversification became a policy common to many countries in the region because rice was sufficiently abundant that prices stagnated, or were deliberately kept relatively low as a subsidy for urban consumers. Policies aimed at changing cropping patterns have not, by and large, been so successful as that of the simpler policy of national rice self-sufficiency. This is partly a reflection of soil and other physical conditions that make change from rice to non-rice crops difficult; partly because many farmers have chosen to continue to enjoy the relative security, albeit with low profits, of rice production; partly because of off-farm income opportunities or labor shortages; and partly because the institutional requirements to support crop diversification are different than those for intensive support for monocropping.

Monoculture is easy to support institutionally: the range of inputs required is limited; farmers can quickly adapt to a particular cropping technology; marketing and pricing can be relatively easily focused and controlled; and extension agents can focus on a single package of advice. But shifting to diversified cropping systems in the present institutional setting has proven difficult and disappointing.

At the same time, the glamour of large investments in agriculture began to fade: lending institutions began to seek alternatives such as support for privatization of government services and institutions, sector support rather than specific infrastructure projects, and structural readjustments that aim at reducing public service expenditures as a way of easing the debt burdens of most countries. Yet, in the agriculture sector, the response to these changes has been small compared to those in other sectors that have a more commercial, profit-making orientation.

The pressures that divert investment and interest away from a relatively conservative and slow-growing irrigated agriculture sector are only going to grow stronger: competition for profitable investments, the attraction of high returns in the industrial sector, the willingness to start to reduce subsidies for operation and maintenance of facilities for irrigated agriculture, greater awareness of the economic value of water in different sectors, are all forcing agencies concerned with irrigated agriculture to take a new look both at how they go about their day-to-day business, and at how they organize themselves to do this efficiently and effectively. The rest of this paper examines this latter problem.

The next section on *Institutional Modification to Meet Future Challenges*, presents a few options for reorienting existing irrigation management agencies through internal modification. Some of the options of this section could pave the way or accompany more fundamental reforms. The section on *Fundamental Institutional Change* (p 110) considers several options for more fundamental reform.

INSTITUTIONAL MODIFICATION TO MEET FUTURE CHALLENGES

The model of a public works-type of organization proved highly effective in meeting the expansionist challenges of the past two to three decades. In this type of environment much of the organizational dynamism was generated through the development of projects that carried with them opportunities to expand departmental budgets, increase staff and establishment, and the chance to see concrete results in a short period of time.

As the number of opportunities for projects diminishes, organizations find themselves facing a potentially difficult choice. Some organizations have attempted to continue to develop new project proposals, both because this is what they are comfortable with and because it is the only way in which staff levels can be maintained. No agency voluntarily cuts staff. However, the search for new money to finance new projects is difficult: money is scarcer, projects are frequently more complex, and they are often marginal in terms of economic returns compared to investments in other sectors.

Some organizations have taken the harder decision, namely, to try to make internal modifications that can help meet the challenges imposed on them from outside.

The following selection of internal modifications is not comprehensive, nor is it suggested that any one agency has to adopt all of them. They represent options or choices that policymakers at sector level and senior managers of concerned agencies can consider in an effort to keep their own organizations alive and responsive into the future.

Performance Responsiveness: Breaking the Administrative Mode

Many irrigation agencies have been able to continue to attract both project and recurrent funding support with little regard for actual performance levels. Effectiveness and efficiency of water use, of staff, or of the O&M budget are rarely assessed in an objective way, using feedback from reliable data on performance.

This general lack of responsiveness to performance is characteristic of agencies that are administrative or bureaucratic in nature. In these less-progressive institutions the concern is with the management of inputs and ensuring the conformity with rules and regulations rather than on whether a set of objectives is being fulfilled.

Any well-managed organization has some kind of cycle of objective setting, development of short-term operational targets, monitoring short-term performance to assure the targets are met, and periodic evaluation to determine whether the objectives were both appropriate and feasible. Yet it is common to find agencies that have great difficulty in defining their objectives clearly, and where targets have become routine and stereotyped. Under such conditions, performance data are rarely collected systematically, it is rarely accurate, and the gap between "formal rules" and "informal reality" steadily widens.

Responsiveness to performance is not limited to output from irrigation systems or the irrigated agriculture sector. It is also concerned directly with the performance of individuals in the agencies, in terms of their efficiency, their capacity to set objectives, fulfill targets, and be honest about their own inputs into the management process. This means not only a greater focus on human resources development, including management training that redefines roles and relationships within an agency; it also has to address rewards and incentives.

An administrative orientation is one that gives little reward for personal initiative and innovation. Promotion is based on longevity of service rather than on performance, and compliance with rules is given greater recognition than innovation. Salaries are based on rank and years of service rather than as a measure of contribution to the organization. There may be specific disincentives for those who try to work hard, try out new ideas, and search for change and dynamism.

The contrast with business is striking, yet it is the world of business and privatization that is attracting the greatest investment and interest these days. At least in part, this is because the financial risks and potential benefits can be more clearly identified, and there is less chance of supporting inefficient monopolistic style enterprises.

Assessing Performance

The shift towards a more performance-oriented organization requires useful and effective performance measures. Traditionally, there has been a great emphasis on the measurement of agricultural output, normally incorporating such indicators as irrigated area, yield, cropping intensity, or irrigation intensity. In part, this reflects the economic focus of new project development where there is significant pressure from donors or lenders to ensure that expected project benefits have been achieved; in part, it reflects the concerns of the agriculture sector objectives.

However, performance assessment measures for other aspects of the concerns of agencies are much less well developed. It seems surprising that with increasing concern over water resources, and the loss of water from the agriculture sector to other sectors, that measures of water use efficiency and water delivery performance are rarely developed or adopted by agencies. Methodologies for assessing water user efficiency and water delivery performance exist; if the objectives are specified, performance assessment measures can be readily identified. But these measures are rarely used in routine management—in fact, some agencies do less assessment of water delivery performance than they did in the past.

Similarly, with increasing concern over the level of funding, particularly for O&M, expressed at numerous forums on irrigation management issues, few agencies use financially based performance measures. This is the equivalent of a business continuing to produce a product without assessing the costs of production and distribution. Such "business" used to exist in the former Soviet Union. Irrigation management is big business; and basic business management principles need to be adopted for assessing and improving performance.

Changing Operational and Maintenance Procedures

Many irrigation agencies have found it difficult to modify operational or maintenance procedures in response to changing water availability or new agricultural policies. Although many countries have adopted policies of crop diversification away from rice to other potentially more profitable crops, the operational procedures of most agencies have not changed. The requirements for crops other than rice are sufficiently different in terms of overall water requirements and scheduling that alternative operational practices need to be adopted. These practices require more intensive operations and monitoring, with more precision in terms of the timing and amounts of water delivered. Agencies that do not make these changes in response to farmer interest in growing other crops end up delivering more or less the same volumes of water along canals irrespective of whether rice or non-rice crops are being grown.

A contributing factor to this situation is that agencies that continue to adopt a more administrative approach are more concerned with calculating likely requirements than assessing the situation in the field and making operational adjustments accordingly.

Maintenance procedures rarely change, even though the available budget may be inadequate or inappropriate. Instead, the quality, frequency and quantity of maintenance work are continuously reduced as budgets decline. Again, the expansion of recent years helped mask some of these problems because of the comparative ease of securing funds for rehabilitation of deteriorated systems. As these projects become less numerous, managers will be forced to be more efficient and focused in the use of limited maintenance budgets.

Technical Skill Development

A somewhat depressing characteristic of many agencies is that they are less well equipped to manage systems effectively than they were before the recent period of expansionism. This is partly because many staff of the agency have been more involved with the design and construction component than with the operational or maintenance aspects, and partly because the lack of concern with actual performance carries with it the lack of interest and capacity for using certain special skills.

This is probably seen most clearly in respect of hydrology and hydraulics within a number of irrigation agencies. The capacity to measure water, which was already scarce, has declined significantly in recent years. The capacity to utilize forecasting and other techniques to better assess probable water supplies is also noticeable by its absence. Irrigation management agencies cannot argue their case effectively for maintaining their share of scarce water supplies if they cannot measure it very well.

Similarly, few agency staff have experience or training in alternative scheduling arrangements, and thus are likely to follow routine procedures for canal operation rather than adopt innovations.

In another direction, the capacity to adopt modern technology is relatively limited. Only slowly are computers being adopted for day to day operational support; remote sensing or use of Geographic Information Systems is almost unknown, so opportunities for more rapid data retrieval and processing are being missed. This reflects the lack of interest in measuring performance, or improving efficiency of operation or maintenance, as well as the inadequate technical capacity of agency staff. There is a depressing record of projects that introduce modern conveyance and control technology in irrigation systems and then let it fall into disrepair because of the inability of agencies to provide adequate operation and maintenance.

Reorganization to Meet New Priorities

Changes in sector-level objectives and priorities have rarely been reflected in changed organizational structures of agencies. An institution intended to fulfill one set of objectives may be poorly equipped to meet changed objectives or priorities.

The rapid decline of new irrigation development and greater concern for water resource management issues and financial efficiency have not been reflected in organizational structures: design divisions still exist even where design work is limited or nonexistent. System design is frequently undertaken far away from the site itself thereby limiting opportunities for inputs by system managers and water users. It remains common for managers charged with system operation and maintenance to merely inherit a system without prior contact with the design staff, and for design staff to have had no operational experience which they can incorporate into their subsequent work.

A similar situation arises in respect of water resources allocation. Agencies charged with water resources planning are normally separated from the agency charged with operating and maintaining irrigation systems, yet the system manager is a major participant in the annual or seasonal cycle of water allocation to farmers and other users. Where water is scarce, then the planning, allocation and implementation of activities associated with water use have to be planned together rather than disjointed between agencies, or even within a single agency.

In many countries there is a strong trend towards promoting irrigation associations and turning over responsibility for management of lower portions of systems to farmers; some countries have also implemented joint decision making at higher levels of large irrigation systems. But few irrigation management agencies have reorganized themselves to work effectively with farmer organizations.

Research Capacity

In comparison with commercial enterprises with the same gross turnover, the irrigation sector spends remarkably little on research and development for new ways to improve service and resource use efficiency. The agriculture sector has, by comparison, spent a great deal more on seeds, fertilizer and plant protection technology research.

Where agencies do have a research wing it is almost inevitably hydraulic research or involved with determination of crop water requirements. In more recent times, there has been some acceptance of research that aims at improving existing procedures and activities. In a number of countries this is the type of research carried out by IIMI in its initial phase of work. However, this approach is limited in its capacity to bring about change: it may improve efficiency but there is little institutional change involved.

More fundamental collaborative research activities are much rarer. Typically, these would involve an agency articulating its long-term policies and objectives, and then sitting together with universities and other research institutions to try to find innovative solutions. The capacity of irrigation agencies to interact with research organizations is small, and there are few organizational structures that include opportunities for manager-researcher interactions. Irrigation agencies have limited capacity to identify research needs, determine what research has been done, and make use of research results. This is severely constraining the capacity to innovate and adapt to changing pressures.

Finally, there are few—if any—irrigation organizations that have "think tanks" or similar visionary groups that can help senior policymakers in their task of deciding what directions to pursue, and what the implications are of different alternatives.

FUNDAMENTAL INSTITUTIONAL CHANGE

In recent years, there have been a number of dramatic changes that fundamentally affect the very nature of irrigation organizations. These changes normally result from major changes in government policy towards the irrigated agriculture sector, the rural sector, or even in the basic philosophy regarding the appropriate role of the government itself.

Almost every country seems to be in the process of change or experimentation with innovative organizational forms in various sectors. Here again, the irrigated agriculture sector seems more conservative in Asia—though not in other regions of the world. Nevertheless, each of the following types of change in the irrigation sector is being attempted somewhere in Asia.

Decentralization

Decentralization refers here to the transfer of responsibility for irrigation management and provision of agricultural support services from central government to provincial, regional or even local level. This type of move has two sets of implications. The first is that control over staff responsible for operation and maintenance of systems may pass to the civil administration, taking them away from the relative security of a technologically oriented agency.

The second is that the same adherence to nationally developed regulations, guidelines and procedures may weaken. In principle, this provides an opportunity for greater flexibility and innovativeness by O&M staff. It may also provide fewer opportunities for transfer to lucrative postings, and more focus on the less-glamorous but essential O&M tasks because the smaller administrative center may generate fewer project funds. With decentralization, the central irrigation agency may survive, but with reduced resources and power, and with entirely new functions. Or it may not survive.

Turnover of Operational Responsibility

Joint management of systems has spread throughout the region to some degree or another. Although the process whereby responsibility for operation and maintenance of increasingly large portions of irrigation systems is transferred to farmers or water users seems at first an attractive solution to financial and manpower problems within agencies, this has proven an elusive goal.

A significant reason for this elusiveness relates to the changed role of agencies. When O&M responsibilities for farmers were confined to within a tertiary block, agencies had little direct incentive to involve farmers in true joint decision making. There were, and still are, nominal attempts at consultation, but in practice the technical concerns of the government agencies still outweigh the interests of farmers.

It will be a major change for most irrigation agencies to actually transform themselves from this rather paternalistic role to one of supporting democratic forums of irrigation districts or associations similar to those found in Northeast Asia, Europe or the United States. This involves sharing, or transferring authority and are entirely a new kind of relationship with farmers, who become active customers rather than passive supplicants.

It seems unlikely on present evidence that agencies are really capable of making such a dramatic change. There is little evidence to date that agencies have made the change in attitude in the policy-planning-resource allocation processes that precede and support routine operation and maintenance decisions. The same decision-making processes are unlikely to be effective in supporting a significant change in roles between agency staff and water users.

Privatization

A recent trend in certain countries has been the privatization of state monopolies. A few years ago it would have been almost inconceivable to imagine telephone companies, national airlines, water and other typical monopolies being offered for sale to private investors.

If irrigated agriculture is in principle profitable then it can also be considered a potential candidate for privatization. This is a complex issue, which cannot be dealt with fully here. It may involve changes in water rights, so that operating companies can charge for their services as wholesalers of water to individuals or groups of water users. It may conceivably involve creating companies, with farmers as owners (by owning stocks), which replace public works-type agencies entirely. These may acquire ownership rights to infrastructure or may lease them from the government.

Such changes are increasingly likely in respect of urban water supplies. Assuming that water resources as a whole are to be treated as a single commodity, then it is likely that irrigation water sales will be included in the total package. The experience of the United States and Europe is that it is very difficult to deregulate one part of the water industry (normally urban and industrial water) while protecting another (water for agriculture).

Commercialization of Irrigation Agencies

The ultimate change in irrigation institutions is the commercialization of the irrigation sector. This is another step beyond privatization of existing systems. It may be a likely route if there is demand to adopt modern irrigation technology. In Europe and the United States the growth of sprinkler, drip and trickle irrigation is almost entirely the result of individual farmers interacting with commercial companies. In addition to providing the irrigation equipment, the same companies are involved in providing extension advice, computerized irrigation scheduling programs, and other facets of the technological package.

This type of change may require larger farm sizes than those found throughout much of Asia at present, but if the trend of land abandonment continues, it is not impossible to envisage land consolidation into larger, commercially sized units directly linked to agribusiness concerns. Indeed, agribusiness may take over the operation of the land.

CONCLUSIONS

It is not possible to predict which course an individual country may choose to take. This will reflect the complexity of the social, political, cultural and economic conditions, and the way they interact with each other at different times.

Some countries may adopt a policy of general disengagement from control over resources, preferring privatization, market forces, or other economic theories to guide their policies. Others will feel that the need for continued food security, the desire to stem urban growth, or the continued support of the rural sector merit some elements of subsidy, control or centralized direction.

One thing, however, seems certain. Change is coming and it cannot be prevented. The recent rapid transformation of the economies of the Soviet Union and Eastern Europe has demonstrated that major changes in attitudes to publicly managed enterprises can occur in a remarkable short time frame. This does not mean that the same rate of change will occur in Asian countries, but it is incumbent on policymakers and planners to predict change, to help guide it, and to be prepared for whatever eventualities actually occur.

Paper 8

Comments on the Paper
Institutional Adaptation and Institutional Change

Manuel M. Lantin[15]

LET ME, FIRST of all, congratulate the authors, Drs. Murray-Rust and Merrey, for a well-written paper. From the standpoint of somebody like myself who has limited knowledge of or is not too familiar with the workings of irrigation agencies, I think that the paper gives a fairly comprehensive dissertation on the institutional issues facing irrigated agriculture today. At first, I was not sure if many or all of them are issues that are common to or shared by the four Southeast Asian countries; they are certainly some of the main issues confronting irrigated agriculture in the Philippines. After hearing the other country reports, yesterday, I could say that indeed many of them are common to the four countries. I think the insight of the authors was drawn heavily from their familiarity with past actual experiences in irrigation development and management in these countries.

I fully agree that institutional changes in irrigated agriculture are inevitable. The authors, I guess, were polite in calling them institutional changes rather than "institutional reforms" from the very start. One might still ask: If the institutions have worked well during the past decades and contributed substantially to the country's irrigation development, why do they have to undergo changes or reform? The reasons or factors prompting such changes were pointed out in the paper. A major observation is that the present institutions or institutional arrangements are no longer adequate, appropriate or responsive to meet the new challenges and needs of agricultural development.

The authors distinguished two types of changes: The first refers to internal modification in organizations, procedures and operational performance and the second is concerned with fundamental reforms or changes in the nature of institutions.

The first type of changes, for the most part, basically involves the key aspects of management of irrigation agencies. When one talks about performance responsiveness, performance assessment, adapting operational and maintenance procedures and human resources development then he is actually referring to the basic concerns of management. Any shortcomings in these aspects could be interpreted as management not doing well.

The authors, I believe, gave a fairly accurate presentation of the common inadequacies of irrigation agencies. I will not repeat them here. I would just like to comment on a couple of options that they suggest for internal modification. The first one is on performance responsiveness and the need to break away from the administrative mode. The lack of responsiveness to performance was pointed out as characteristic of agencies that are administrative or bureaucratic in nature—a typical reality in any government. The contrast with private business was pointed out. This was,

---

15 Under Secretary, Department of Agriculture, Quezon City, the Philippines.

of course, long recognized, i.e., perhaps from the very beginning. At least, it was in the Philippines where the defunct Farming System Development Corporation (FSDC) which had a great deal to do also with irrigation system development, and the National Irrigation Administration (NIA) have a corporate character and enjoy some prerogatives that are supposed to enable them to perform vital tasks with dispatch—i.e., precisely to enable them to be more performance responsive. There is of course a limit also to what can be done even given a wide latitude of corporate powers. As long as public funds (generated internally or sourced as loans from outside but guaranteed by governments) are used, then the agencies concerned will have to abide by certain government administrative or bureaucratic rules.

The other option which I would like to comment on is the need to reorganize to meet new priorities and effectively pursue new priorities and new thrusts. This sounds quite logical. The authors cited a few situations where some changes in organizational structure might be warranted. The decision to reorganize is certainly a major decision. In our case, it is something that is not the sole prerogative of the chief executive. Oftentimes, it requires a specific legal basis, i.e., a legislation, especially where the organization was created by law and governed by a specific charter. It is, therefore, at least in our case not a simple matter to tinker with the organizational structure. I am not, however, saying that it cannot and should not be undertaken. Wherever and whenever it is justified, I think it has to be done. It should however be kept in mind that in not a few cases, it is not the organization or its structure that is the problem. There are other causes of the problem.

This brings us to another set of institutional changes which fundamentally affect the nature of irrigation organizations or agencies. These changes were described by the authors in a sequence that proceeds from the least to the most radical type (use of the word radical is in relation to what is existing), and I believe that based on what have been presented specially in yesterday's session, some of these changes or institutional reforms are happening already in some countries. At least, in the case of the Philippines, I can say that decentralization and turnover of operational responsibility are currently happening. Our new local government code provides for devolution of certain functions and responsibilities of national agencies to the local government units. Our Department of Agriculture for instance, is developing the entire agricultural extension service. Extension workers will now be supervised by the local government officials. The irrigation services are to a certain extent also affected. The small-scale system will now be operated by the local government.

The turnover of operational responsibility to the water users of farmers' organizations is another step beyond the decentralization as applied in government operations. This, I believe, is happening with varying initial results in the Philippines and in a number of other countries as well. The limited experiences, however, I think point out a basis for intensifying efforts at institutionalizing the operations and maintenance of irrigation systems. The basic idea is to transfer gradually such O&M responsibilities to the water users' groups.

The issue of privatization of irrigation systems and commercialization of irrigation agencies rests much on the question of whether or not provision of irrigation services would be profitable. To a limited extent, private-sector participation in irrigation development is happening but in forms different from the usually thought mode of privatization, i.e., private companies or corporations taking over the operation of big irrigation systems. This has not happened in the Philippines. I guess, the overall thinking is that we are not ready for it yet. However, I believe that such an option should not be totally excluded in planning for irrigation development. The subject is of course complex and an in-depth discussion would probably require a full-day seminar or even a separate workshop.

Paper 9

Technological Innovations in Irrigated Agriculture

Peter Wolff and Rolf Huebener[16]

THE PROBLEM

IN MANY RECENT publications it has been stated that global population is expected to increase from about 5 billion today to at least 8 billion by 2025, with most of this increase being in the developing world. Agricultural production in the world will have to expand by at least 2 percent per annum to keep pace with population growth and related growth in income and changes in food habits. However, in many parts of the world, there is little land available for lateral expansion of agriculture and increases in output will have to come from improved productivity. According to Le Moigne and Subramaniam (1990) there are indications that as much as 80 percent of the required increase in food grain production over the next few decades must come from yield increase. Irrigation could play an important role in achieving and stabilizing such a yield increase. In fact, most of the required increase in food output is expected from the irrigation sector. But one has to recognize that competition from industrial and urban uses is rapidly limiting agricultural water supplies in many parts of the world, especially in the developing world. Furthermore, energy resources are finite and past experience has shown that irrigated agriculture can lead to land degradation through waterlogging and salinity, depletion of groundwater and surface water quality, fertilizer components and pesticides in return flows, saline water intrusion into groundwater, fertility depletion, increase in weeds and pests in irrigated areas, and/or serious public health problems through an increased incidence of water-borne diseases (Feyen and Badji 1992; Keller 1992).

Despite the abovementioned constraints it seems impossible to feed the increasing number of people in the developing world without irrigated agriculture. As a consequence, there is a need for action on many fronts in order to improve the performance of irrigated agriculture. In agriculture as a whole and in irrigated agriculture especially, pricing and other policies need to provide incentives for production. There must be cost-effective access to agricultural inputs and markets. Besides the improvement of the general conditions for an increase in agricultural production, it is more or less agreed these days that the expected improvement in yield from irrigated areas of around 3 percent per annum can only be achieved by administrative and technological innovations and, where relevant, adaptations. This paper will focus only on technological innovations in irrigated agriculture.

---

16 Head, Department of Irrigation Drainage and Soil Conservation, and Lecturer and Researcher at the Department of Irrigation and Drainage, both of the University of Kassel, Germany.

IRRIGATION TECHNOLOGY—STATE OF THE ART

Although many of the irrigation works built hundreds and even thousands of years ago are still evident throughout the world, and some are still in use, major changes to the water supply system and the traditional methods of surface irrigation took place only during the second half of this century. Most of the innovation has been in water lifting and in pressurized systems, where plastics, solid-state and computer controls have allowed significant advances. Only very recently has technological progress been achieved with respect to the water supply part of irrigation systems, especially in the development and physical improvements of flow control systems. A short overview is given below.

Technological Developments of Water Delivery Systems

The function of an irrigation water conveyance system is, according to Burt and Plusquellec (1990), to provide water in a timely and reliable manner so that water may be efficiently used for crop production. Furthermore, they state that the selection and management of water delivery systems affect agronomic and social aspects of projects. The control strategy must be compatible with the flexibility of the ultimate water supply, and the social, political, geographical and economic conditions under which it will be used.

According to Horst (1990) the crucial components of the irrigation system—the operational parts—are all structures for regulating, dividing and measuring the flows of water to the various parts of the project. Their type and characteristics largely determine the operability and subsequently, the manageability of the system. There is a great variety of structures available from simple overflow structures to automatically controlled systems. During the last decades, advances have been made mainly in terms of automation, and today systems are often based on automatic and remote control, computer models, advanced communication systems, micro processors, etc. Worldwide, the technology for microprocessor and computerized control of irrigation is much more sophisticated than its application. According to Horst (1990) the a priori choice of modernization by automation as a panacea for all irrigation problems should be considered questionable. It could even aggravate the managerial problem. Furthermore, this solution merely supports the never-ending struggle for farmer participation.

In many surface irrigation projects of the developed countries there has been a shift from small canals to pipelines for conveying irrigation water at secondary and tertiary levels. Pilot projects in Sri Lanka and Pakistan have shown that low pressure semiclosed and closed pipeline systems could solve many of the problems at the farm water level in developing countries by supplying water on demand (Merriam 1992).

Technological Developments of Farm Irrigation Systems

Water Lifting

For centuries, water lifting by mechanical means has been practiced around the world in irrigated agriculture. One of the most ancient, being the Archimedean Screw, is still in use on small farms in Upper Egypt. But there, as anywhere else around the world, farmers prefer to use motor-driven pumps to irrigate their fields, because motor pumps give farmers a greater spectrum of possibilities and more flexibility in irrigation.

The development of motor pumps has come a long way, but through improved manufacturing techniques, engineering principles, and new materials the performance of pumps has been dramatically improved while reducing the energy requirements due to increased efficiencies. Pumps are being produced in a great variety with a wide range of performance characteristics. There should be no problem for an irrigation farmer to find a pump and a motor, well adapted to the particular conditions of operation on his farm in order to obtain high efficiencies.

The centrifugal pump design has grown to become quite common in use for irrigation. It is very simple, durable, and relatively easily repaired and does a very nice job of pumping water within its design range of limited pumping head and flow.

Pumps are driven by internal combustion engines or by electric motors. Farmers prefer electric motors because of the ease of operation, low maintenance costs, dependability and the relatively long life. Frequent power interruptions and other uncertainties in power supply are major disadvantages associated with electric motors, especially in developing countries.

The cost of pumping irrigation water is governed to a large extent by the cost of energy. Since wind is a free energy source, its use to drive irrigation pumps has generated increased attention in recent years. In most cases, the use of windmills in pumping irrigation water has so far not shown to be economically feasible. This also applies to solar pumps.

Land Preparation and Water Recovery Technologies

Despite the tremendous increase of the area irrigated by pressurized irrigation systems, surface irrigation methods are still leading worldwide. They are expected to retain their popularity in the foreseeable future because of their:

- exclusive suitability in rice irrigation;
- low investment and energy requirements; and
- suitability to irrigate heavy soils like vertisols.

With the growing realization that comparatively high efficiencies can be achieved with surface systems, some significant advances can hopefully be expected in the near future. Developments during recent years include the following:

Land Grading

The introduction of heavy earth-moving machinery in irrigation land leveling and especially the introduction of laser-controlled leveling are probably the most significant advances in surface irrigation in the last 30 years. Fields can now be leveled to a near-perfect plane, allowing rapid application and removal of surface water. Moreover, leveled fields can be 'touched up' readily in succeeding seasons, after heavy fills have settled. The fitting of a plane or a mathematical curve to a land surface is most expediently done by computer calculation.

Tail Water Recirculation

Especially surface-irrigated fields frequently lose 10 to 30 percent and even more of the applied water as tail-water runoff, not to mention significant volumes of storm-water runoff. By the incorporation of the tail-water return system, comprising mainly of a channel or pipe to carry water from the lower end of the field back to the head of the system, the collected water can be used and the efficiency of the irrigation system increased.

On-Farm Storage

In Australia, according to Barrett (1985), the construction of large on-farm reservoirs has accelerated rapidly during the last two decades. Although most storages incorporate the tail-water return system, their prime purpose is for harvesting unregulated stream flows. The subsequent use of this water in producing various irrigated crops can be worthwhile, particularly if used in conjunction with allocated regulated flow. In addition, the storage provides the advantages of timeliness of application—especially for those irrigators with long lag times following water order—and the availability of a "buffer supply" for those occasions when ordered or allocated water does not arrive at all or is late. If water delivered is not required due to subsequent rainfall, it can be pumped to storage to avoid loss from allocation.

On-Farm Water Application Systems

Turnouts and Water Application Devices

The ancient and still prevalent method of releasing water from a delivery channel on to the field is to either allow water to overtop the channel banks or make a cut in the earthen embankment of the channel. These techniques allow the least control of the water. The result may be erosion of the embankment and complete loss of water control and because of this an uneven distribution of water from the delivery channel cannot be avoided. There is quite a large variety of turnouts available to overcome this constraint.

Remotely controlled devices have been developed for use with gravity irrigation systems. These devices include sliding, falling or rotating gates for controlling water levels in open channels, controls for pipe turnouts from channels, fixed overflow sills with appropriate water-level controls as well as devices for control of water level or individual openings in low pressure gated pipelines. Several valve configurations have been developed which require little or no external power to control flows from either underground or surface delivery pipes.

Siphons are increasingly and most successfully used in most advanced irrigation areas using surface irrigation, especially furrow irrigation. Here is a trend especially on larger farms towards the use of larger diameter siphons, up to 685 mm, or through-the-bank pipes (spills) of about 300 mm diameter, serving multiple furrows simultaneously (Barrett 1985).

During the last decades, several automated water application systems have been developed, cablegation being an example. Cablegation is an automated surface irrigation system in which a pipe is laid along the head of a furrowed field, with orifices drilled near the top of the pipe opposite each furrow. A moveable plug in the pipe blocks the flow of water, causing water to be emitted from a number of holes nearest the plug. The orifice nearest the plug delivers the maximum discharge, successively decreasing upstream. The initial furrow stream is therefore large, providing rapid advance. The furrow stream size continually diminishes with time as the cable plug advances along the pipeline. The plug is pushed downstream by the water pressure, with its speed governed by a braking device to which the plug is connected via a cable and reel. In general, the cablegation and other automated water application systems provide more uniform water application than is normally achieved with surface irrigation systems. The runoff is reasonably low and more readily useable because of its continuous nature. They are also intended to reduce the labor requirement and ease the work of the irrigation farmer.

Irrigation Methods

Level Basin Irrigation. Compared to other irrigation methods, relatively little progress has been achieved during the last decades, but still some interesting developments have taken place (Barett 1985; Huebener and Wolff 1990). Because of the developments in land leveling it became possible to apply level basin irrigation to larger fields or basins. Level basin irrigation is a method of applying water uniformly to a field by surface methods. It is used for crops planted on beds, furrows, corrugations or on the flat. Water is applied so that it will cover the basin relatively quickly. Dykes around the field keep the water within the basin so that all of the water infiltrates. Thus the water remains in all parts of the basin for about the same duration with only minor differences occurring because of the advance time required for the water to cover the basin completely. In low intake rate soils, predetermined depths of irrigation water can be applied precisely, resulting in high irrigation efficiencies. The method is limited to areas of low intensity or infrequent rainfall, due to surface drainage problems.

Surge Flow Irrigation. Under surge flow irrigation, water is diverted onto one set for 10 to 60 minutes; then diverted onto an adjacent set for a similar time period; and then again diverted back onto the initial set, etc. This technique results in the water advancing to the end of the field in roughly the same time as if the flow had run continuously, but with a substantial decrease in the volume of water needed. The method is most successfully used on silt loam soils resulting in a reduced variability between furrows and a higher distribution uniformity and all together leading to marked improvements in water application efficiency. The method may be of less benefit on cracking clay soils.

Sprinkler Irrigation. Sprinkler irrigation began early this century in the USA and Germany and was slowly introduced in other countries. Up to the 1960s, mostly portable handmove systems, stationary or to a lesser extent side-roll wheel move systems were in use. Traveling irrigators have become popular in many parts of the world from the mid-1960s. Although their use came under question following the rapid rise in energy prices during the 1970s and because of the problems in respect of the uniformity of application under windy conditions, the area irrigated by traveling irrigators has remarkably increased during the last three decades (Wolff 1988: Huebener 1988).

Probably the most significant development in sprinkler irrigation has come with the center pivot system. Early prototypes were developed in the 1940s, but it was not until the late 1960s and the 1970s that the most rapid expansion occurred, principally in the USA. The rise in energy prices in the 1970s forced a conversion from impact sprinklers to low pressure spray nozzles. Instantaneous application rates rose accordingly, causing problems especially on heavy soils. This problem has been overcome by fixing transverse spray booms under the lateral, again enlarging the wetted patterns. The center pivot provides high application uniformities and high efficiencies.

The limitations on farming and land utilization imposed by the circular patterns of center pivots have led to the development of side-move or linear-move systems. In addition to irrigating rectangular fields, linear-move systems can operate at lower pressures due to a constant rate of application along the lateral, compared to an increasing rate with a center pivot lateral. Water application and energy problems associated with center pivot and linear-move systems have led to a comparatively new concept in irrigation systems design, known as a low energy-precision application (LEPA) system. Rather than spraying into the air at moderate to high pressures, water is distributed directly to the furrow at very low pressure through drop tubes and orifice controlled emitters. This occurs as the system moves continuously through the field in a linear fashion. The system is used in conjunction with micro-basin land preparation which also optimizes the utilization of rainfall by minimizing runoff.

Sprinkler irrigation can also be used to protect tree crops from frost damage by coating the plant with ice. Since a stationary overhead sprinkler system is required covering the whole orchard to be protected, the costs of such protection measures are very high.

Drip Irrigation. Although the development of drip/trickle irrigation started shortly after World War II for irrigating crops in glasshouses, the use of this irrigation method in open fields began only in the 1960s. Under drip irrigation, plants are watered by means of low pressure pipelines (laterals) fitted with emitters, placed along the plant rows. A fixed system is generally used, and irrigation can be carried out frequently to maintain a minimum moisture stress and optimum growth. Labor requirements are low and the system lends itself readily to automation and the application of fertilizers and other chemicals through the system. The irrigation efficiency is high, since losses by evaporation are almost eliminated and percolation losses are low. Because of costs, drip installations are more or less restricted to wide-spaced crops, mainly orchards.

During the last three decades, the drip irrigation technology has been improved tremendously and other localized irrigation methods, like micro-jet and mini-sprinkler irrigation have been developed (Wolff 1987).

Drainage

Inadequate drainage followed by land degradation is a major problem associated with irrigation around the world, especially in arid and semiarid areas. In the last three decades, tremendous developments in the field of drainage technology have been achieved. Major developments in drainage technology include the use of durable, low cost plastics as replacement materials for clay and concrete drain pipes. Corrugation of the plastic pipe walls for increased strength/weight ratios, the use of flexible pipe to transfer live and dead loads to the encasing envelope of soil or other backfill material, longer lengths of drains, high speed trenchers and plows, and the standard use of laser grade controls have drastically changed drainage technology during the past decades. Computer programs also have been developed to solve complex and complete drainage system problems.

ADAPTABILITY OF MODERN IRRIGATION TECHNOLOGY TO DEVELOPING COUNTRIES

The Systems Context

The thrust of irrigation development in the industrial countries is on techniques that systematize management decisions, reduce labor inputs, and provide more precise and timely water applications. The socioeconomic factors driving irrigation technology development are the desire to reduce labor, management and resource input expenses and the need to increase agricultural output (Keller 1990). It has been shown above on an exemplary basis that new irrigation application hardware and software have been and still are evolving for managing, conveying and applying water to achieve these goals.

The question whether it makes sense to transfer those advanced irrigation technologies, which have been developed in a specific system context, to developing countries has been discussed most controversially on many occasions in the past and will most probably be so in the foreseeable future. A general answer to this question seems not possible since the conditions under which irrigated agriculture is performed in developing countries vary so widely and so does the feasibility of such a technology transfer. Therefore, each case has to be analyzed individually. One has to consider that technological innovations will only contribute to the development of the farming sector, and to the irrigation sector, especially if they can be integrated into the pertinent political, socioeconomic, cultural and ecological system context. An understanding of these systems is essential to identify problems on the technical, socioeconomic and scientific level and solve them through managerial and technological innovations and, where relevant, adaptations. Innovations which have not been deduced within a system context will probably not be transferable or will not bear the anticipated results.

In this respect, the system is the network formed through the interdependency of natural, technological and social factors. Agricultural production, especially in irrigated agriculture, takes place in a system context at international and national levels, at the level of the rural regions, at the irrigation project level, at the farm level and at the household level, the latter being of the greatest importance to start out from.

Technological innovations are translated into practice on the farms. Their practical application depends on the structure and function of the household and farming system, for example the family structure, availability of resources and individual function patterns. An analysis of economic and social systems in rural or irrigation areas provides knowledge of the total carrying capacity and of the capacity to absorb technologies in agriculture, especially in irrigation itself as well as in its upstream and downstream sectors. The national system, with its agro-policy, its agricultural constitution, service institutions, etc., strongly influences the willingness to accept innovation, but technology transfer cannot be induced solely by agreements and provision at the macroeconomic level.

Advantages and Constraints

Major advantages of modern over traditional irrigation systems in developing countries are, according to Keller (1990), potentially higher on-farm irrigation efficiencies and more precise control over water application. Coupled together, these can greatly increase crop productivity per unit of both land and water. Furthermore, this can be achieved with limited labor and drudgery and very little user expertise and skill. Precision irrigation requires money and management (of time and labor) with the latter playing the major role in traditional irrigation systems. For modern systems involving pressurization or precision leveling, money is traded for management and labor.

Despite the big advantages, modern irrigation technologies have their disadvantages, especially in third world countries. They usually require energy for mechanical pumping and special support systems to provide repair parts and mechanical services. These in turn require a continual and reliable source of fuel and maintenance. The more automated the technology, the more complex the required support structure for fuel, spares, repairs, etc.

Farmers who use modern irrigation technologies may not need much specific training to manage and operate them. However, they still must understand and adapt to the new principle involved and be aware of and follow through on the maintenance requirements. Furthermore, the technicians providing support services for complex irrigation machinery or components need special skills. This requires special training. In addition, the fuel, repair and maintenance required to operate modern systems cost money. Thus, the farmer must be involved in a cash economy or be continuously provided with fuel and mechanical services at public expense (Keller 1990).

According to Keller (1990) the principal dilemma in using modern irrigation technologies in developing countries is twofold. There is an apparent incompatibility with the management skills and a general lack of the necessary commercialization associated with diversified agriculture on small landholdings. The challenge is how to take advantage of the economics and benefits of modern irrigation delivery and application systems while preserving the vitality and human-initiative associated with privately operated small-scale farming enterprises.

By reviewing the field experience with modern irrigation technologies in developing countries the following three major lessons must be stated (Keller 1990):

1. Success often requires more attention than traditional farmers tend to give to the technical details required for equipment operation and maintenance;
2. For the successful uptake of modern irrigation there must be significant physical and agricultural advantages for using it, good market conditions, and considerable financial incentives for the users; and
3. Modern irrigation is not a panacea but it can play an important role in specific niches of irrigation development worldwide. The challenge is first to know when it is best

to use modern irrigation systems, then to select the ones with optimal fits and formulate the necessary institutional environment and supporting structures for successful operation when and where they are appropriate.

WHERE IS IRRIGATION TECHNOLOGY HEADING FOR IN DEVELOPING COUNTRIES?

James R. Moseley, the US Assistant Secretary of Agriculture for Natural Resources and Environment in the USA addressing a meeting of agricultural scientists in 1991 opened his speech with the following story. "Oliver Wendell Holmes, the distinguished U.S. Supreme Court jurist was once riding on a train and couldn't find his ticket. The conductor told him not to worry, he could send it when he found it. Holmes looked at the conductor with some irritation and said, 'The problem is not where my ticket is. The problem is where am I going?' " It seems to us that irrigation, especially irrigation technology in developing countries, finds itself in the same situation. Where is irrigation, especially irrigation technology in the developing world going to? Where should it go?

There are no quick answers available to the abovementioned questions. We do not have them either. But we have a hypothesis which we would like to put forward and discuss with you during this meeting.

Experts who predict world population trends tell us that the world's population is expected to reach over 6 billion by the year 2000 and over 8 billion by 2025. Most of the increase is expected to take place in developing countries; and what is even more dramatic is the fact that two-thirds of the total population growth is expected to occur in the cities. Big cities, particularly those with more than 2 million inhabitants, are growing ten times as fast in developing countries as in the industrial nations. Only more recently it has been recognized that the main cause of urban growth is not rural migration. Rather, it is the natural growth of existing urban populations. In rural areas of the developing world, a relative decrease of the agricultural population and an increase of the nonagricultural population can be noticed.

In our opinion the abovementioned trends will result in the following:

1. In the developing world, a relatively slow-growing agricultural population has to feed more and more people, especially people in and around urban areas. Therefore, the output of the agricultural labor force has to be increased by the introduction of appropriate technologies, including irrigation technologies which save labor and ease the workload of irrigation. Under no circumstances should irrigated agriculture be looked upon as having a capacity to absorb all the unemployed masses of people for which the national system is unable to provide enough industrial employment! The opposite will be the case.

2. Market-oriented production in agriculture will increase more and more, forcing the farmers to a more cost- and profit-oriented management. The need to reduce labor, management and resource input expenses and to increase the agricultural output will result in a drive to develop and use more sophisticated production technologies.

3. The necessary increase in food production will come, or has to come from land which is already under production.

4. The increase in food production will be achieved through

    a) an increase of inputs; and/or

b) a change from products of low energy output per unit area (grain) to products of high energy output per unit area (tubercrops).

Most countries will follow a) as long as possible.

5. In many countries, the increase of food production through an increase in inputs, will fairly soon reach a point where any further increase is going to be determined by the availability of water to the plants, so that irrigation will become a necessity if production is to increase. Water may become even more important than fertilizers.

6. Water as a production means will become increasingly scarce and expensive, making high on-farm irrigation efficiencies and precise control of water applications indispensable.

7. Because of the environmental problems associated with intensive agricultural land use one has to expect that traditional agricultural production practices including irrigation are being continuously questioned. An increase in the regulation of how to farm may be expected. Irrigation is not expected to be abandoned if sustainable land use is assured, which in most cases is only possible by applying advanced irrigation technologies.

8. With rising income expectations and standards of living, an increased agricultural yield level becomes necessary. This is why in the course of development, land which has been regarded up to this point, as fairly fertile, will become marginal land and the previous marginal land will go out of production. Agriculture and especially irrigated agriculture will concentrate more and more on highly productive land only. More food will be produced on an even smaller area. To obtain this more sophisticated production, technologies are necessary in developing countries.

From the assumptions mentioned above, it is concluded that more sophisticated irrigation technologies will have to be introduced into irrigated agriculture in developing countries in the years to come despite the problems of logistics. Since we cannot expect all the land being irrigated today to stay in production in the future, technological innovations will mainly affect irrigated agriculture on its most productive lands. Any investments on the more marginal lands will not be feasible.

So, irrigation in developing countries will, in our opinion, be heading towards the application of more sophisticated labor and land substituting irrigation technologies. This will not necessarily mean computerization and automation.

The trend to more sophisticated irrigation technologies may not be always clearly noticeable. Emphasis on irrigation technology is not static and is shifting as time goes by. This is because of the changing needs and desires of the society of the population. For example, during periods of surplus farm products, emphasis is on production efficiency; whereas, during periods of farm product deficits, emphasis is on increasing crop yields. During energy crises, emphasis is on energy efficiency, while environmental concerns result in placing emphasis on quality of soil, water and air. Because of this shifting emphasis one can notice ups and downs and changing directions in the technological developments in agriculture and especially in irrigated agriculture. Nevertheless, we are convinced that in the long run more and more sophisticated irrigation technologies have to and will be introduced into irrigated agriculture.

SUMMARY AND CONCLUSIONS

To innovate irrigated agriculture in developing countries towards sustainability is a serious concern of numerous research and development efforts. The approach has been so far twofold by distinction between managerial and technological concepts, with the former receiving lately more attention than the latter. In other parts of the world, irrigation technology advanced considerably during the past decades. After progress in water lifting and pressurized field application systems, i.e., optimized pump and well design, laser leveling, surge flow, localized irrigation, center pivot design, etc., very recently, notable improvements in water delivery systems have been achieved, i.e., automatized canal regulation, low pressure semiclosed or closed pipe delivery systems, delivery on demand, etc.

Now it seems to be the time to adapt these modern irrigation technologies to developing countries. Actually these processes have already started in several developing countries, for example the introduction of center pivot systems to Egypt, Burkina Faso, etc. Adaption really means a thorough process of transfer and modification to site-specific conditions, and for some cases the often misused definition of an "appropriate technology" must be revised. Action has to be taken in this respect at the farm level with all necessary considerations of the system context. Since agricultural production is based on the same rules of economics as industrial production, i.e., input optimization and profit maximization, it would be most contradictory to vote for labor-intensive irrigation in the long run, especially under conditions of low-food-price policies as in developing countries.

Sustainability in irrigated agriculture calls for a holistic approach with new, but precise initiatives and concepts combining technological and managerial measures.

Bibliography

Barrett, J.W.H. 1985. The contribution of science to Australian Agricultural Engineering - 9. Advances in irrigation Technology. The Journal of the Australian Institute of Agricultural Science Vol. 51 (4), 263-267.

Burt, C.M. and H.L. Plusquellec. 1990. Water delivery control. In: Hoffman, G.J. et al. 1990: Management of Farm Irrigation Systems. ASAE Monograph. The American Society of Agricultural Engineers, St Joseph, MI. (USA).

Feyen, J. and M. Badji. 1992. Environmental and health aspects of irrigation. Siphon—Newsletter from the Center for Irrigation Engineering (Leuven/Belgium) No. 12 (August 1992), 15-28.

Horst, L. 1990. Interactions between technical infrastructure and management. ODI/IIMI Irrigation Management Network Paper 90/3b.

Huebener, R. 1988. Entwicklungstendenzen der Beregnungstechnik im internationalen Vergleich. Zeitschrift für Bewasserungswirtschaft 23, 111-143.

Huebener, R. and P. Wolff. 1990. Fortschritte in der Technik der Oberflachenbewasserung. Z. F. Kulturtechnik und Landentwicklung 31, 34-43.

Keller, J. 1990. Modern irrigation in developing countries. Transactions ICID Congress on Irrigation and Drainage, Rio de Janeiro, Brazil 1990. Vol. I-E, Special Session (R1-R12), 113-138.

Keller, J. 1992. Irrigation scheme design for sustainability. In: Feyen, J. et al. 1992: Advances in planning, design and management of irrigation systems as related to sustainable land uses. Vol. 1. 217-234. Center for Irrigation Engineering (CIE), Leuven/Belgium.

Le Moigne, G. and A. Subramaniam. 1990. Technology research in irrigation and drainage. ODU Bulletin No. 19 (July 1990), 4-6.

Merriam, J.L. 1992. The need on the farm for a flexible water supply schedule. In: Feyen, J. et al. 1992: Advances in planning, design and management of irrigation systems as related to sustainable land use. Vol. 1. 147-156. Center for Irrigation Engineering (CIE), Leuven/Belgium.

Moseley, J.R. 1991. The challenge to agriculture. J. Prod. Agrio. Vol. 4 (3), 294-296.

Wolff, P. 1987. On the development status of micro-irrigation. Proceedings of the 3rd International Symposium on Mechanization and Energy in Agriculture, 26. 29.10.1987 in Izmir/Turkey, 261-274.

Wolff, P. 1988. The application of new sprinkler systems-soil mechanical and agricultural aspects. Current Practices in Dryland Resources and Technology Vol. 4. 233-242.

Paper 10

Discussion on the Paper
Technological Innovations in Irrigated Agriculture

José Galvez[17]

THE PROBLEM

THE AUTHOR HAS eloquently presented the big issue in food sufficiency for the ever-increasing population of the world against the finite land resources available for expansion of agricultural areas. This scenario indicates that increases in agricultural production to keep pace with population growth have to come mainly from intensification of cropping in presently cultivated areas and yield increases from irrigated areas.

In the Philippines, for instance, the country's estimated total population of about 62.7 million in 1992 will increase to about 71.0 million by the year 2000. Food supply for this fast-growing population has to come from its limited land area devoted to agriculture which is about 1/3 of its total land area of 9.0 million ha. Since only about 1/3 of this agricultural land is suitable for irrigation, serious efforts in improving the performance of existing irrigation systems and in increasing yields have to be made if sufficiency in staple food is sought. In addition, the remaining rain-fed land, but potentially irrigable, has to be provided with irrigation facilities if sufficient capital investment is available.

The Philippine scenario is probably not very different from the situation in other developing countries. The developing countries in the Asia-Pacific region, for instance, have a total land area of about 2,2000 million ha and the arable land is only about 1/5 of this or about 400 million ha (FAO-RAPA 1991). The total population of these countries in 1989 was nearly 2.8 billion yet only about 1/3 of the agricultural land in these countries is irrigated.

IRRIGATION TECHNOLOGY—STATE OF THE ART

While major innovations in irrigation technology have occurred in many industrialized countries particularly in water-lifting and pressurized systems, the developing countries in Asia are continuing to use traditional methods of surface irrigation. Sophistication and adoption of new technologies in automation and pressurized systems have been limited to a few privately owned and managed irrigation areas.

---

17 Assistant Administrator, National Irrigation Administration, Quezon City, the Philippines.

Irrigation development in developing countries remains a major responsibility of each government through its irrigation agencies. Most of these irrigation agencies operate on limited funding support from the government or compete with other infrastructure agencies for their capital investments. Although there are varying structural arrangements in the organization of these agencies, their primary concern is the provision of irrigation and drainage service to the country's agricultural areas at the most economical means. Adoption of more sophisticated technology requires more intensive investment and is therefore limited. Modernization of irrigation systems by automation of its water delivery, for instance, has been very seldom, if at all, adopted. Agency resources are rather invested in irrigation area expansion using the simplest and most economical schemes possible.

In the Philippines, system improvement and modernization have been limited to the provision of canal lining to curb excessive percolation losses, better control and measuring devices, sediment control structures and intensification of agricultural support services such as farm-to-market roads and facilities for irrigation associations.

Water Delivery Systems

In the Philippines, water delivery systems still follow the traditional gravity flow in open channels. Innovations in this area are concentrated in improving the reliability of regulating, dividing and measuring the flows of water to attain more equitable distribution of irrigation water to the various parts of the command area. Although rehabilitation and system improvement projects have been implemented in the past, disparity of water supply to farmers in the upstream sections and those in the tail end still exist. This is particularly significant during the dry season when there is limited river flow and only part of the command area is serviced.

The most important innovation in the Philippines to address the question not only on equitable water distribution but also on other problems in O&M is probably the implementation of farmers' participation program in irrigation development. While this may be considered more technical, it could be important in the application of modern technology. In this program, farmer-beneficiaries are organized to form Irrigation Associations (IAs). The officers and members of the IAs are provided with a series of training to develop their capacity in handling the O&M of the system and in running the affairs of the association. The IAs are then contracted in a joint management scheme in the agency-operated irrigation systems. In the agency-constructed communal irrigation schemes, the IAs take over the O&M of the system which they will eventually own.

In the National Irrigation Systems (NIS), the organization of IAs is oriented on the canal systems. The Turnout Service Area (TSA) covers 30-50 ha at the initial organization level. The TSA groups are then federated in a watermaster's division, in a lateral and then in the entire system. In the case of the Upper Pampanga River Integrated Irrigation System (UPRIIS), an integrated system covering some 100,000 ha, the organization of IAs follows the TSA (up to 50 ha), the watermaster's division (up to 1,000 ha), the zone engineer's area (up to 8,000 ha), the district level (up to 25,000 ha) and then the system-wide federation.

In the Communal Irrigation Systems (CIS), on the other hand, a single IA is organized for each CIS. As the CIS covers an area of generally less than 1,000 ha, the IA organization is much simplistic but because of a total turnover of the entire system the IA development is more thorough.

With the participation of farmers through the IA, coupled with improvement of the system's hardware as implemented since 1989 by the Irrigation Operation Support Project (IOSP), achievements in system performance signal a generally positive trend. This is shown by the two indicators: (1) the national average cropping intensity of all NISs gradually rose from 134 percent in 1987 to 140 percent in 1991; and (2) the collection efficiency of irrigation service fee has gradually increased from 47 percent in 1987 to about 60 percent in 1991.

Another positive impact of the farmers' participation is the progressive turnover to IAs of a substantial portion of the routine O&M activities within the IA areas. This would result in a gradual decrease in NIA's overall staffing at the field, and in overall O&M cost.

On-Farm Water Application Systems

The most commonly used method of on-farm water application in the Philippines is the gated turnout. This is an 18-inch or 12-inch concrete pipe laid out across the embankment of the supply canal and this discharges water directly to the farm ditch. Individual farmers in turn apply water to farms through cuts in the earthen embankment of the farm ditch and then through paddy to paddy flooding. The gated turnouts are installed in such a way that water could be diverted even at low water level in the supply canal. The assumption is that the farmers will voluntarily close the gates when water is not needed.

Today, some operation problems have been identified in the use of the gated turnout. Since there are periods when delivery of water in the supply canals becomes erratic, the farmers have, in many cases, tampered with the control mechanism of the gate so that it becomes open at all times and water could be diverted into their farm ditch whenever it is available at the supply canal. In this situation, excessive diversion becomes a common practice resulting in water shortages at the downstream section of the system and localized drainage problems in low-lying areas.

This problem is gradually being tackled through the more active involvement of the IAs. However, a tamper-free turnout that could satisfactorily deliver the water required would provide a more permanent solution. This is particularly important in developing countries where irrigation agencies deal with numerous farmers owning very small landholdings.

Irrigation Methods

Since irrigated agriculture in the Philippines is synonymous with rice irrigation, surface flooding is still the most commonly used method. Depending on the available water, the water application could either be simultaneous throughout the command area or intermittent or rotational.

Adaptability of Modern Irrigation Technology to Developing Countries

This issue was discussed thoroughly in the paper. I agree with the concerns raised on the adaptability of modern technology relative to irrigation. It must be realized that a major constraint in the adoption of these technologies by developing countries, particularly those dealing with automation and pressurized systems is the persistent insufficiency of capital investment. In many cases, therefore, most developing countries will opt for traditional but less-expensive technologies. In addition, as irrigation is particularly established for rice production, particularly in tropical Asian countries similar to the Philippines, traditional systems with improved flow-regulating and -measuring structures are considered sufficient up to a certain level of economic development.

Appendix

List of Participants

01. Mr. Keizrul Abdullah
Director, Planning and Evaluation
Department of Irrigation and Drainage
Jln. Sultan Salahuddin
Kuala Lumpur
Malaysia

02. Dato' Shahrizaila bin Abdullah
Director General
Department of Irrigation and Drainage
Jalan Sultan Salahuddin
50626 Kuala Lumpur
Malaysia

03. Dr. Emiliano A. Aberin
University Vice President
Bicol University
Lagazpi City
Philippines

04. Mr. Charles L. Abernethy
Senior Technical Advisor
IIMI, P. O. Box 2075
Colombo
Sri Lanka

05. Dato' Syed Azizan Al-Idrus
General Manager
Muda Agricultural Development
Authority (MADA)
Ampang Jajar
05990 Alor Setar
Kedah Darul Aman
Malaysia

06. Ir. Sardar Ali
Director of Irrigation
Department of Irrigation and Drainage
Jalan Sultan Salahuddin
50626 Kuala Lumpur
Malaysia

07. Dr. Apichart Anukularmphai
Director, Office of the National Water
Resources Committee
70/680 Prachanivez 2
Nonthaburi
Thailand

08. Ir. Hj. Wan Ismail Wan Awang
Civil Engineer
P. O. Box 127
Civil Eng. Division
Kemubu Agricultural Development
Authority (KADA)
Kota Bharu
Kelantan
Malaysia

09. Mr. Benjamin U. Bagadion
Irrigation Management Consultant
National Irrigation Administration
EDSA, Quezon City
Philippines

10. Dr. Mohd Zohadie Bardaie
Associate Professor/Dean
Faculty of Engineering
Universiti Pertanian Malaysia
43400 UPM
Serdang
Selangor
Malaysia

11. Dr. Sadiq I. Bhuiyan
Agricultural Engineer
Soil and Water Sciences Division
IRRI, P. O. Box 933
1099 Manila
Philippines

12. Mr. Suebpong Boonbrahm
Product Manager
Charoen Pokphand Eng. Co. Ltd.
36, Soi Yenchit, Chand Rd.
Yannawa, Bangkok 10120
Thailand

13. Dr. Radjakarina Brahmana
Head of Planning Bureau
Department of Home Affairs
Jl. Batu Sulaiman 12
Pulomas, Jakarta Timur
Indonesia

14. Dr. Kassim Buhiran
Head
Soil and Water Engineering
Agricultural Engineering Division
MARDI, G.P.O. Box 12301
50774 Kuala Lumpur
Malaysia

15. Mr. Stefano Burchi
Senior Legal Officer
Development Law Service
Legal Office
FAO Room B-304
Viale Delle Terme di Caracalla
00100 Rome, Italy

16. Mr. Kangsdarn Devahastin
Assistant Permanent Secretary
Ministry of Agriculture and Cooperatives
Rajadamnern Road
Bangkok
Thailand

17. Dr. Jose Galvez
Assistant Administrator
National Irrigation Administration
NIA Building EDSA
Quezon City
Philippines

18. Mr. Mohd Azhari Ghazalli
Principal
Water Management Training Centre
P. O. Box 246
15730 Kota Bharu
Kelantan
Malaysia

19. Dr. Soetatwo Hadiwigeno
Director General
Agency for Agricultural Research
and Development
Jl. Raya Ragunan 29
Jakarta 12520
Indonesia

20. Ir. Abu Haerah
Director
Directorate for Program Development
D.G. of Food Crops Agriculture
Jl. Aup Pasar Minggu
Jakarta Selatan, 12520
Indonesia

21. Mr. Franz Heim
Head, Agricultural Engineering Section
German Foundation for International
Development (DSE/ZEL)
Food and Agriculture Development
Centre
Wielinger Str. 52
D-82336 Feldafing
Germany

22. Dr. Jesda Kaewkulaya
Associate Professor
Kasetsart University
Bangkok 10900
Thailand

23. Dr. Surapol Kanchanachitra
Deputy Director General
Community Development Department
Ministry of Interior
Bangkok
Thailand

24. Ms. Norma Lange
Consultant
Meinerlzstrabe 31
D-6520 Worms
Germany

25. Dr. Manuel M. Lantin
Under Secretary
Department of Agriculture
Elliptical Road, Diliman
Quezon City
Philippines

26. Dato' Abu Bakar Mahmud
Director General
Department of Agriculture
5th Floor, Wisma Tani
Jalan Sultan Salahuddin
50632 Kuala Lumpur
Malaysia

27. Mr. Abdul Razak Abdul Manap
Senior Environmental Control Officer
Department of Environment
(Evaluation Section)
13th Floor, Sime Darby Building
Jalan Raja Laut
50662 Kuala Lumpur
Malaysia

28. Dr. Manuwoto
Head, Bureau of Region 1,
BAPPENAS
Jl. Taman Suropati 2
Jakarta 10310
Indonesia

29. Ir. Martono
Director, DGWRD
Directorate of Irrigation II
Jl. Pattimura 20
P O Box 20/KBY, Jakarta 12001
Indonesia

30. Dr. Douglas J. Merrey
Senior Irrigation Management Specialist
IIMI, P. O. Box 2075
Colombo
Sri Lanka

31. Mr. Jitti Mongkolnchaiarunya
Assistant Professor
Department of Community Development
Faculty of Social Administration
Thammasat University
Bangkok 10200
Thailand

32. Mr. Q. Raul Montemayor
Business Manager
Federation of Free Farmers
Cooperatives, Inc. (FFCI)
41, Highland Drive
Blue Ridge, Quezon City
Philippines

33. Dr. Hammond Murray-Rust
Senior Irrigation Specialist
IIMI, P. O. Box 2075
Colombo
Sri Lanka

34. Dr. Santiago R. Obien
Director
Department of Agriculture
Philippine Rice Research Institute
Maligaya, Munoz, Nueva Ecija
Philippines 3119

35. Dr. Agus Pakpahan
Agricultural and Resource Economist
Center for Agro-Socioeconomic
Research,
Jalan Jend. A. Yani 70
Bogor 16161
Indonesia

36. Mr. Cledualdo B. Perez
Executive Director
Philippine Council for Agriculture,
Forestry and Natural Resources
Research and Development
(PCARRD)
Los Banos, Laguna, 4030
Philippines

37. Dr. Suprodjo Pusposutardjo
Dean
Faculty of Agricultural Technology
Gadjah Mada University
Bulaksumur, Yogyakarta
Indonesia

38. Dr. Salim Said
Head
Department of Field Engineering
Universiti Pertanian Malaysia
43400 UPM, Serdang, Selangor
Malaysia

39. Dr. Hussain Mohd Salleh
Associate Professor
Faculty of Engineering
Universiti Pertanian Malaysia
43400 UPM, Serdang, Selangor
Malaysia

40. Ms. Zalilah Selamat
Engineer
Planning and Evaluation Division
Department of Irrigation and Drainage
Jln. Sultan Salahuddin
50626 Kuala Lumpur
Malaysia

41. Dr. Mahadi Sinambela
Head of Subdirectorate, Regional Development
Directorate General of Regional Development
Department of Home Affairs
Jl. Kramat Raya No. 132
Jakarta Pusat
Indonesia

42. Dr. Suzanne E. Siskel
Assistant Representative
The Ford Foundation
S Widjojo Centre
11th Floor, Jalan Jend.
Sudirman 71
Jakarta Selatan 12190
Indonesia

43. Dr. Loekman Soetrisno
Senior Lecturer
Rural and Regional Studies
Gadja Mada University
Yogyakarta
Indonesia

44. Dr. Mohd. Amin Mohd. Soom
Senior Lecturer
Department of Field Engineering
Faculty of Engineering
Universiti Pertanian Malaysia
43400 UPM, Serdang, Selangor
Malaysia

45. Dr. Mark Svendsen
Research Fellow
International Food Policy Research Institute
1200 17th Street NW
Washington D.C. 20036-3006
USA

46. Mr. Kanezo Takeuchi
Regional Water Development and Management Officer
FAO Regional Office for Asia and the Pacific
Phra Atit Road
Bangkok 10200
Thailand

47. Ms. Christiana Tharsis
Assistant Secretary
Planning and Policy Division
Ministry of Agriculture
Kuala Lumpur
Malaysia

48. Dr. Bruce J. Tolentino
Research Fellow
Philippine Institute for Development Studies
NEDA sa Makati Building
106 Amorsolo Street
Legaspi Village, Makati 1229
Metro Manila
Philippines

49. Prof. Dr. Rodolfo C. Undan
Professor and Vice President
Research, Extension and Training
Central Luzon State University
Munoz 3120 Nueva Ecija
Philippines

50. Dr. Tophong Vachanasvasti
Senior Expert on Planning
NESDB, 962 Krungkasem Road
Bangkok 10100
Thailand

51. Mr. Chamnong Vathana
Director, Division of Economic Program and Project Evaluation
Office of Agricultural Economics
Ministry of Agriculture and Cooperatives
Bangkok
Thailand

52. Ms. Gundula Warzinek
Training Consultant
Forstwiesenweg 16
D-8918 Diessen/Ammersee
Germany