Management Arrangements for Diversifying Rice Irrigation Systems in Thailand

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INTRODUCTION

RICE IS THE most important crop in Thailand. It is the main staple food of the population, and is ranked first in tenns of land utilization, planted area. number of farmers and export earning income.

Presently, out of the 23.65 M ha of agricultural land, 11.87 M or 50.19 percent is rice land (Table 1). Of the total 4.97 M fanners, 3.85 M (77 percent) are rice fanners. Out of the total area of rice land, 9.5 M ha were planted as the main crop in 1985/86 and 0.853 M ha as the second crop in 1989.

Region	Agricultural land (M ha)	Rice land		Fieldcrops (M ha)	Others (M ha)
		Area (M ha)	% of Agricultural land		
North	**5.443**	**2.712**	**49.82**	**1.881**	**0.850**
Central	**5.434**	**2.2%**	**42.25**	**1.644**	**1.494**
Northeast	**9.732**	**6.175**	**63.45**	**2.150**	**1.407**
South	**3.038**	**0.687**	**22.61**	**0.036**	**2.315**
Whole Kingdom	23.648	**11.870**	**50.19**	**5.711**	**6.066**

The rough rice output has varied from **16** to **18** M tons a year for the main crop and around **2-3** M tons for the second crop, making a total output of **20-21** M tons a year (Table **2).** Normally, **13 M** tons of rough rice are consumed domestically and **7-8** M tons rough rice or about **4-4.5** M tons rice are exported yearly. **1989** was an exception, when rice exports reached a record high of **6.04** M tons, accounting for **40** percent of the world market, and earning an income of **44,802.5** M bahts.

Thailand has been recognized as the world's largest rice exporting country, leading the **U.S.A.** Vietnam and Pakistan. During the last five years, the average yield of rice was **1,843.52** kg/ha for **the** main crop and **3,692.85** kg/ha **for** the second crop. In terms of total rice land, the main crop, rice, accounts for **93** percent while the second crop accounts for only **7** percent.

In Thailand, rice could be grown in any part of the country. but SO percent of the total area planted to rice is in the northeast, **22** percent in the north, **21** percent in the central region and **7** percent in the south (Table **3).** However, most of the rice planted land in the northeast is in the plateau, saline and sandy areas, and relatively unsuitable for rice. In addition, the northeast region is dry with rain occurring in 80 days or less of a year. Here, **only 0.62** M ha or **6.41** percent of the agricultural area is irrigated. Agricultural practices heavily depend on the weather and face high risks. As a result, the productivity of rice sown in this area has been lower than that in other parts of the country.

Only **4.12** M ha or **17.42** percent of the total agricultural land is irrigated, (Table **4).** Irrigation is concentrated mostly in the central region with **2** M ha or **48.62** percent of the total irrigated area.

In 1957, the Chao Phraya Dam was completed and equipped with its main water distribution system. The system, at the tertiary level, was started in **1963** with ditches and dikes designed for wet-season rice cultivation. The land consolidation program was initiated as a pilot project in **2,000** ha with support from the Goverment of the Netherlands. The master on-farm development program was launched in **1974** and expanded in **1982** to cover **0.63** M ha.

In 1969, high-yielding varieties of rice, which are non-photo sensitive, fertilizer responsive, and short-maturing were sown in the irrigated areas, as the second crop during the dry season.

Table 2. Rice planted are4 yield and production

Crop year	Planted area (M ha)	Yield (kg/ha)	Production (M ton)
Uain Crop			
198411985	9.266	1,864.34	17.275
198511986	9.510	1,864.34	17.930
198611987	9.271	1,864.34	16.826
198711988	8.626	1,864.34	15.272
198811989	9.499	1,864.34	17.882
Average	9.234	1,864.34	17.037
Second Crop			
198411985	0.706	3,725.21	2.630
1985/1986	0.638	3,658.31	2.344
198611987	0.580	3,520.69	2.042
198711988	0.730	3,794.52	2.770
198811989	0.849	3.982.33	3.381
Average	0.701	3,736.21	2.631

Such developments have made the central region the major rice bowl of the country producing large surpluses for export. New technologies for higher yields and lower production costs make Thai rice competitive in the world market.

Since one-third of the rice output is exported, world market prices have strongly influenced domestic prices. Overprotectionism and high export subsidies implemented in many countries have caused a decline in the world market price of rice.

Crop diversification programs have been launched in the central irrigated rice-based areas in Thailand in **1968** when a severe drought occurred. In some areas, the second-crop rice was grown while in others, low-water-requiring cash crops were introduced. Since then, the second-crop rice production has been regulated and limited to one crop every two years. Irrigation is alternately provided to each side of a canal.

The Ministry of Agriculture and Cooperatives (MOAC) heads the Committee for Dry Season Crop Production Acceleration. Before the beginning of the dry season, the committee plans the production targets for rice and other cash crops, the amount of water supply and the markets for those crops. In ***the*** past, diversification was not quite successful, owing to the nonfamiliarity of rice farmers to prices and market demands for other crops.

Table 3. ***Main-crop rice production by region.***

Region	1984/1985	1985/1986	1986/1987	1987/1988	1988/1989
	Planted area (M/ha)				
North	2.129	2.135	2.140	2.041	2.260
Central	1.964	2.009	1.954	1.947	2.004
Northeast	4.571	4.773	4.601	4.152	4.670
south	0.602	0.593	0.576	0.513	0.565
Whole kingdom	9.266	9.510	9.271	8.626	9.499
	Yield (kg/ha)				
North	2,393.14	2,389.23	2,357.48	2,215.49	2,507.96
Central	2,175.15	2,241.91	2,231.18	2,317.92	2,365.27
Northeast	1,524.61	1,548.71	1,387.52	1,362.72	1,423.28
South	1,559.80	1,573.36	1,526.04	1,245.61	1,546.90
Whole kingdom	1,864.34	1,885.38	1,814.91	1,770.46	1,882.51
	Production (M ton)				
	5.095	5.101	5.045	4.462	5.668
Central	4.272	4.504	4.518	4.513	4.740
Northeast	6.969	7.392	6.384	5.658	6.600
	0.939	0.933	0.879	0.639	0.874
Whole kingdom	17.275	17.930	16.826	15.272	17.882

Table 4. Irrigated area in 1988.

Region	Agricultural land area (ha)	Irrigated area (ha)	Irrigated area % of agricultural land area
North	5,433,323.6	1,088,037.2	20.02
Central	5,434,061.6	2,003,553.9	36.87
Northeast	9,732,399.2	623,501.0	6.41
South	3,038,319.6	405,792.8	13.38
Whole kingdom	23,648,012.0	4,120,884.9	17.42

IRRIGATION PLANNING AND COOPERATION FOR RICE-BASED SYSTEMS

The Chao Phraya and Maeklong Irrigation projects are the two largest irrigation projects in Thailand. This report is mainly about the Chao Phraya Irrigation Project, the larger of the two which covers approximately 25 percent of the whole irrigated area in Thailand.

Water Management System in the Chao Phraya River Basin

Large-scale development of irrigated agriculture in the Chao Phraya Delta, the largest granary of Thailand, started at the beginning of the 20th century and has continued lo function under the Royal Irrigation Department (RID) for almost a century. Thus, the irrigation and drainage systems in the delta vary: some being fairly recently constructed have been operational since the last three decades while others are about 90 years old. Some of these structures were constructed at the lower left bank in the 1930s, at the lower right bank in the 1950s and at the upper delta in the 1960s. The Chao Phraya Dam (diversion dam), Bhumibol Dam (storage dam) and Sirikit Dam (storage dam) were completed in 1957, 1964 and 1972, respectively (Figure 1).

Bhumibol Dam and Sirikit Dam were constructed to secure supplementary irrigation water in both wet and dry seasons and to support the Chao Phraya Project for flood control, navigation, hydropower generation, and salt water intrusion control as well as for domestic water requirements. The key diversion structure in Chao Phraya Basin is shown in Figure 2.

Tnday, the water supply from both dams cannot meet the increasing demands for dry-season rice. cropping, industrial development, and urbanization.

Water Allocation System in the Chao Phraya River Basin

The water allocation system in the Chao Phraya River Basin follows a nearly pyramidal organization with the O&M Head Office in the RID Headquarters at the top, followed by field offices, regional offices, project management offices and respective terminal organization. The basic concept of a water management systein is depicted in Figure 3.

The RID O&M Head Office, after receiving data/information from the field office via radio, makes analyses and judgements. Instructions on water distribution at the irrigation canals and operation of the facilities are sent back to each field office.

The project engineers assigned to each project office are responsible for the control of several branch offices. In each branch, a water master is responsible for an area of about 16,000 ha. Several zonemen assist the water master. One zoneman covers an area of 160 to 240 ha.

The present water allocation system was developed by the Canadian consultants, Messrs. Acres & Co., Ltd. on the basis of the aforesaid field-level system, and has been operational since 1982. This system has enabled the collection of data/information available at the zoneman level to the Water Management Center of the RID Headquarters. Information flow in the Water Operation Center (WOC) is schematically shown in Figure 4.

Figure 1. Chao Phraya Basin

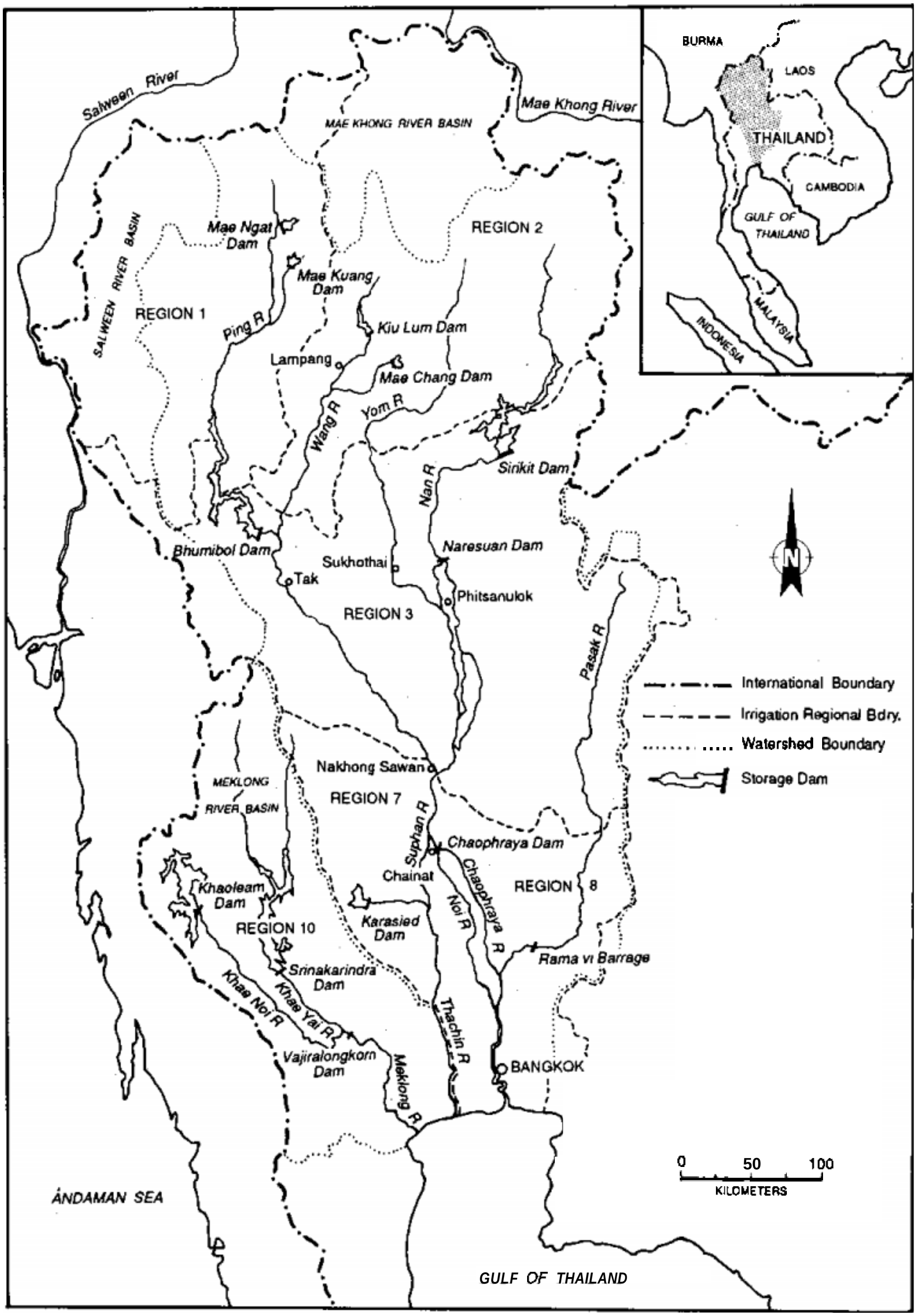
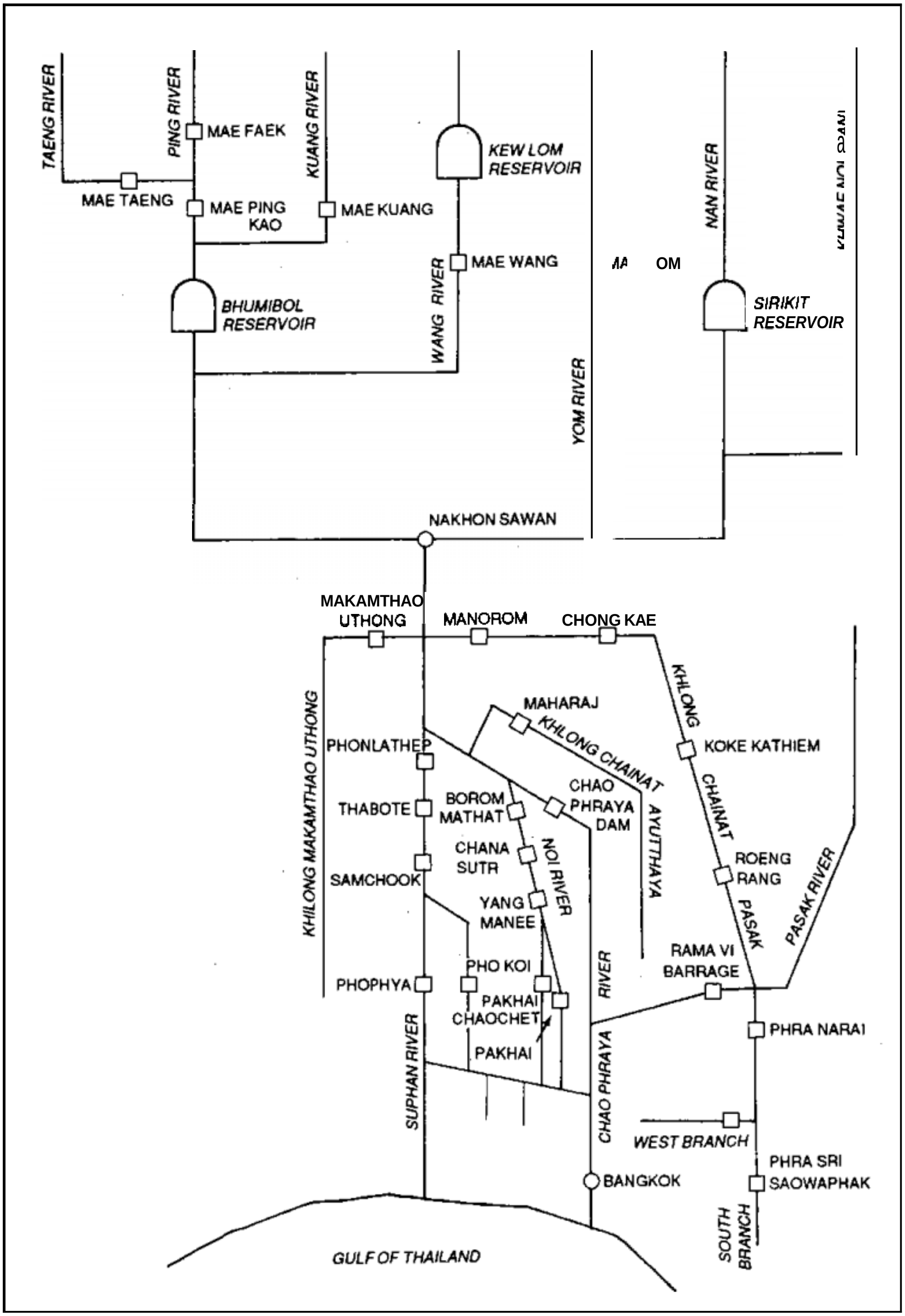
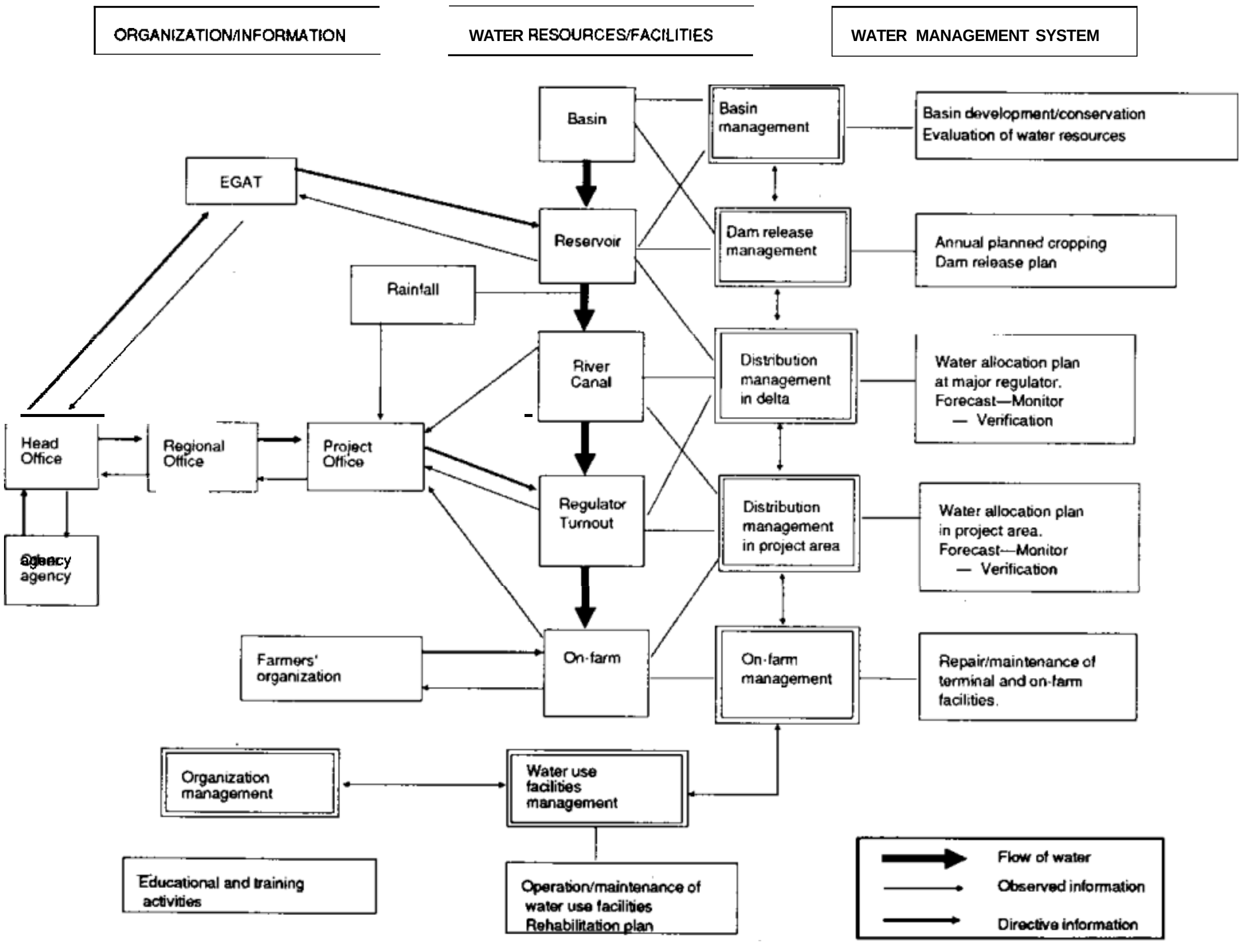


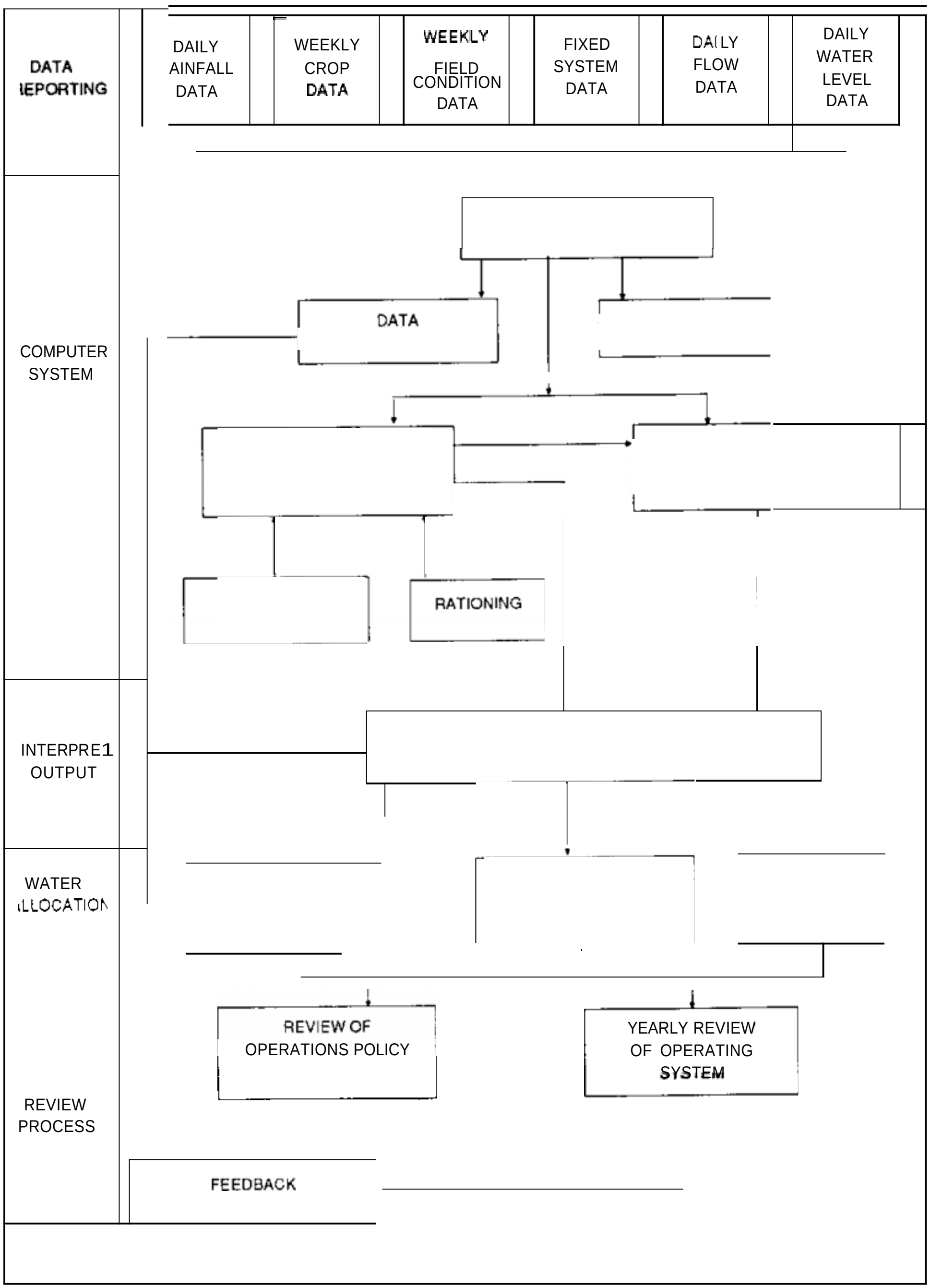
Figure 2. Key diversion structures in ChooPhraya Basin.





ORGANIZATION/INFORMATION
WATER RESOURCES/FACILITIES
WATER MANAGEMENT SYSTEM
Basin
Basin management
Basin development/conservation
Evaluation of water resources
EGAT
Reservoir
Dam release management
Annual planned cropping
Dam release plan
Rainfall
River Canal
Distribution management in delta
Water allocation plan at major regulator.
Forecast—Monitor
— Verification
Head Office
Regional Office
Project Office
Regulator Turnout
Distribution management in project area
Water allocation plan in project area.
Forecast—Monitor
— Verification
Other agency
Farmers' organization
On-farm
On-farm management
Repair/maintenance of terminal and on-farm facilities.
Organization management
Water use facilities management
Educational and training activities
Operation/maintenance of water use facilities
Rehabilitation plan
Flow of water
Observed information
Directive information

Figure 4. Information flow in the Water Operation Cenrer.



Assessing and Matching Water Supply and Demand

The total irrigation demand for the Chao Phraya River Basin is computed on a weekly basis. The computed total demand is combined with the releases required for the Bangkok Water Supply and the needs to maintain river navigation and salinity control. An estimate is made of the quantity of uncontrolled inflow expected to enter the system over the coming week and the net demand on the reservoir is computed by subtracting the estimated quantity of uncontrolled inflow from the gross demand.

The net demand value is conveyed to the Electricity Generating Authority of Thailand (EGAT) and it becomes the target reservoir release for the coming week. EGAT is free to release water during each day in a pattern suited to electrical demand requirement, with the understanding that the mean release over the week will be in accordance with the RID's request. In deciding the amount for the dry season the reservoir capacity at the end of November should be considered (Figure 5).

Irrigation Water Use for Chao Phraya Delta

The water resources of the Chao Phraya Delta are the water releases from the Bhumibol and Sirikitreservoirs, uncontrolled side flows, and direct rainfall in the Delta. Kiu Lom Reservoir in Wang River and other reservoirs in the basin only function to supply water to their own irrigation areas.

The amount of water received from resources of the Chao Phraya Delta from 1977 to 1986 is shown in Table 5.

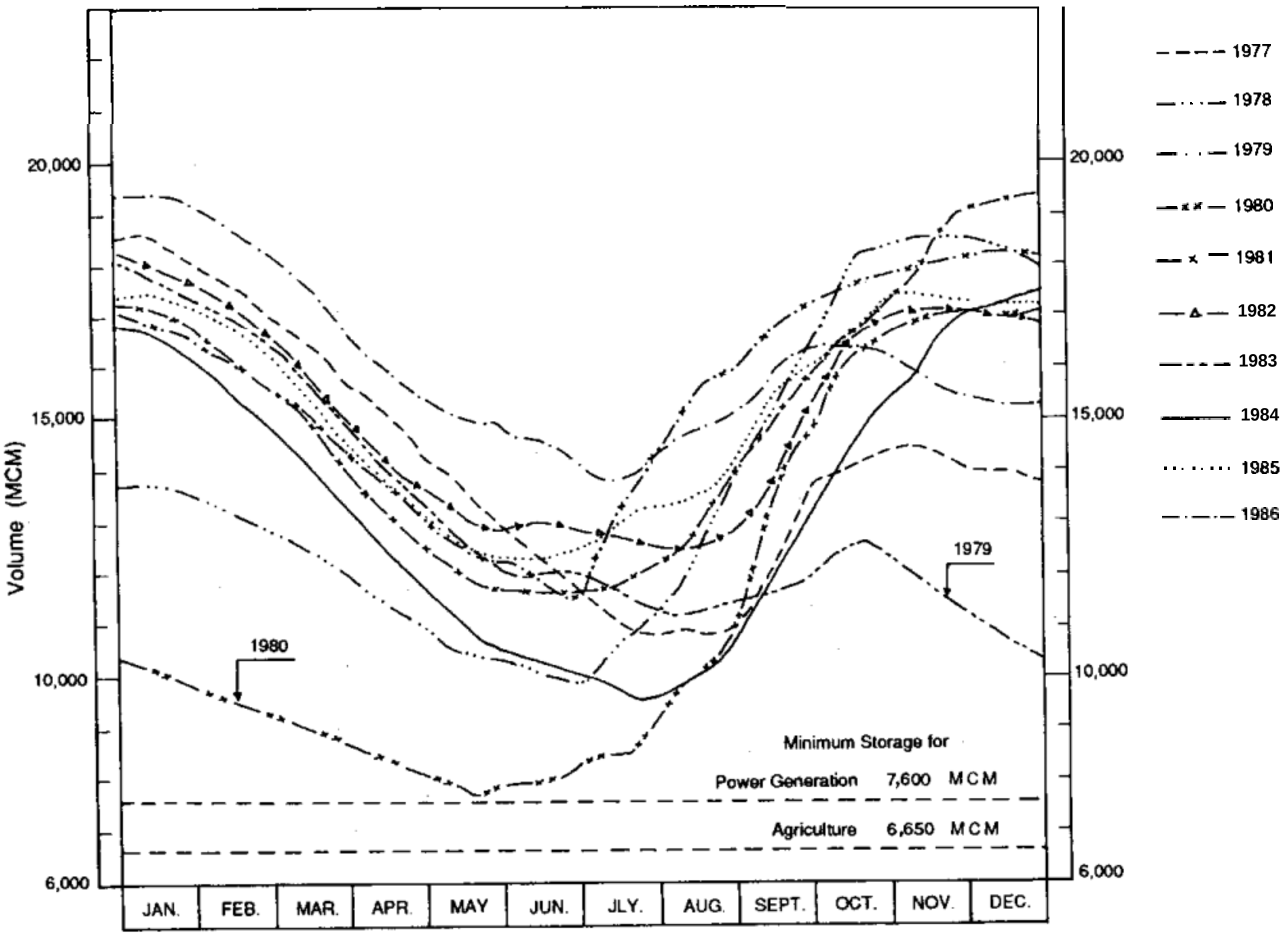
Table 5. Amount of water received from resources of the Delta

Season	Release from reservoir (MCM)	Side flow[a] (MCM)	Available water (MCM)
Wet[b]	3,800	14,700	18,500
Dry[c]	6,200	1,200	7,400
Total	10,000	15,900	25,900

[a]Side flow at Nakhon Sawan and Rama VI Barrage.
[b]From July to December.
[c]From January to June.

Water released from reservoirs amounts to 3,800 to 6,200 MCM or 25 percent to 90 percent of available water, during the wet and dry season, respectively. Side flows are not expected during the dry season especially from January to April, and most of the irrigation during this period depends on water released from the reservoirs.

Figure 5. ***Combined storage** of **Bhumibol and Sirikit reservoirs.***



Water Balance in the Chao Phraya Delta

The relationship between available water and water consumption in the Delta is shown in Table 6. The consumptive use and the effective rainfall for crops are estimated in a simulation model. It can be seen that available water is fully consumed in the dry-season. Storage of river flow and rainfall in the wet season is effective for extending dry-season crops. River flow in 1979 was less than in other years even in the wet season.

Table 6. Result of water balance study in Chao Phraya Della.

Year	Season	Irrigation area (ha)	Actual				Calculated	
			Intake (MCM)	Release (MCM)	Con-tive use (MCM)	Effective rainfall (MCM)	Requirement (MCM)	Storage (MCM)
1977	Wet	992,000	7,790	6,299	8,652	3,060	5,592	2,198
1978	Dry	336,000	2,772	2,217	4,597	855	3,742	- 970
	Wet	960,000	6,010	24,771	8,460	3,554	4,906	1,104
1979	Dry	512,000	5,343	3,268	6,142	816	5,326	17
	Wet	976,000	7,118	3,890	8,553	2,469	6,084	1,034
1980	Dry	208,000	1,967	3,370	3,183	432	2,751	- 784
	Wet	976,000	6,819	22,507	8,573	4,571	4,002	2,187
1981	Dry	496,000	4,535	3,627	6,375	1,295	5,080	- 54s
	Wet	976,000	7,319	15,009	8,645	5,241	3,404	3,915
1982	Dry	528,000	4,428	2,750	6,679	1,263	5,416	- 988
	Wet	976,000	7,374	8,747	8,621	3,797	4,824	2,550
1983	Dry	512,000	4,963	2,413	6,493	535	5,958	- 995
	Wet	976,000	3,387	20,332	8,609	7,227	1,382	2,005
1984	Dry	512,000	4,906	2,636	6,501	910	5,591	- 685
	Wet	992,000	7.798	6,528	8,759	4,834	3,961	3,837
1985	Dry	448,000	4,343	2,424	5,930	827	5,103	- 760
	Wet	1,008,000	7,054	14,701	8,820	4,933	3,887	3,167
1986	Dry	432,000	4,398	4,802	5,470	1,106	4,373	25
	Wet	976,000	6,990	4,813	8,588	4,782	3,806	1,184
Average	Dry	432,000	4,184	3,056	5,709	893	4,816	- 632
	Wet	976,000	6,703	12,760	8,632	4,447	4,185	2,518

Water Shortage in Dry Season Cultivation for Chao Phraya Delta

At present, water in Chao Phraya River Basin is completely utilized to cultivate the rice fields (320,000-480,000 ha) in the dry season. In collaboration with the IUD and Acres Company, the rice cultivation area in the dry season is determined considering the storage of Bhumibol and Sirikit reservoirs at the end of November and the necessity to maintain the water levels of both reservoirs at allowable levels (Figure 6). In the release of water from the reservoirs the maximum benefits have to be considered.

Due to water shortage for rice cultivation in the dry season, increasing irrigation efficiency will increase the cultivated area. Increase in irrigation efficiency requires better water management and related factors such as technology.

Possibility of Nonrice Crop Farming in the Greater Chao Phraya Project

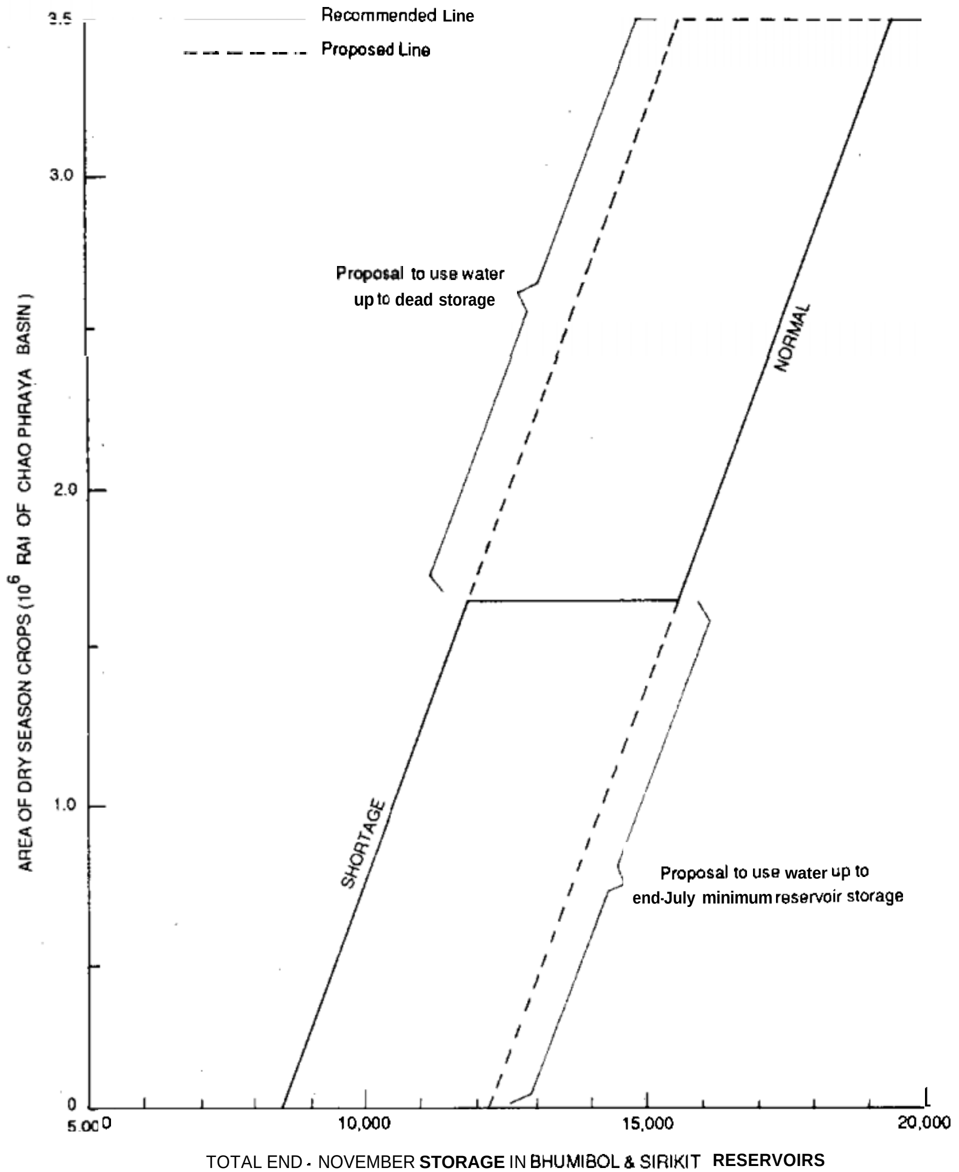
The major crop grown in the Greater Chao Phraya Project is rice because farmers still consume rice as their staple food while selling surpluses to generate income. If the farmers will grow nonrice crops instead of rice, the irrigation system will be affected, especially the capacity of the canal, water control and irrigation structures. Moreover, water control operations for nonrice crops will need more manpower. As such, the government has to consider:

1. Improving the main canal delivery of irrigation projects, including irrigation networks and on-farm facilities for nonrice crop fanning.
2. Organizing water user groups for operations which should be implemented by the IUD in the imgable area.
3. Strengthening cooperation among the Department of Agriculture, Department of Agriculture Extension, Central Land Consolidation Office, Bank for Agriculture and Agricultural Cooperatives.

Planning for the Cropping Season

Background. After the construction of the Chao Phraya Dam in 1957, the water stored has been used to support rice cultivation in the irrigation project area of 1.2 M ha. However, because of the limited storage, the total irrigated area in the rainy season was only 0.88 M ha. This was increased to 0.98 M ha with the completion of the Bhumibol Reservoir in 1964 and Sirikit Reservoir in 1971. In 1970, farmers started dry-season rice cultivation of 48,000 ha in Tung Chao Phraya and this increased to 0.48 M ha during 1981-1984. The increase in irrigation area causes water shortage as the storage is limited. Therefore, the water is distributed alternately each year so that all farmers at the upper part of the project who receive water under gravity are able to farm equally. In 1987, the irrigation area of Tung Chao Phraya was decreased from 0.48 M ha to 0.4 M ha. However, during 1988-1989 the price of rice went up and this stimulated fanners to grow dry-season rice in an area exceeding the target area. This caused severe water shortages and improper water management. Consequently, the following criteria were set to alleviate the constraints:

Figure 6. Typical dry-season cultivation area reduction in relation to storage level.



1. The area which was not cultivated for rainy season rice is given fust priority for dry season irrigated rice.
2. The area which suffered natural disaster with damage of more than 50 percent is given second priority.
3. The area which is the next in turn for irrigation is given third priority.
4. If more water can be used for dry season rice cultivation, the area could be increased accordingly.

With these criteria, target areas and reasonable rotational water distribution are determined. However, the problem of water shortage cannot be eliminated. This was compounded by the fact that Thailand experienced drought for four consecutive years resulting in diminished water reserves. The problem of water distribution often arises with stronger competition for water among farmers. A possible solution is to alter the practice of rice production to cultivate other cash crops that require less water and give higher returns. Therefore, a proper cropping system must be planned for both rainy and dry seasons. This includes the identification of crop boundaries.

The laud use record of Chao Phraya Project indicates a small area, estimated at 6 percent of the rice area, that has been used for upland cropping. Upland crops are mostly cultivated on the upper part of the project along the naturally raised bank of the Chao Phraya River where irrigation is done by gravity and the soil is well-drained. The major upland crops grown are mungbean, soybean, peanut, sugarcane and watermelon. Soybean is grown and consumed fresh or sold to the local market or to the central market in Bangkok. It is observed that upland cropping is practiced in some areas. In relation to rotational water distribution, fanners grow rice on the land to be irrigated and upland crops on the lands not scheduled to be irrigated.

The situation gives some idea of the changing pattern from rice cultivation to the cultivation of other cash crops. Alternative crops were selected according to their physical suitability and marketing potential. At the beginning, fanners were supported with production technology, inputs and price information. They were also informed of the limitation of reserved water and cautioned of possible critical shortages. Crop diversification was promoted by:

1. Introducing cash crops such as soybean, maize, etc., to replace dry-season rice.
2. Maintaining upland crop area, and preventing it from being used for dry-season rice by providing farmers with good varieties of peanut and mungbean seed which give higher yields and income.

Procedure. The yearly workplan includes the following:

1. The irrigation area is determined in proportion lo the amount of water reserved for both rainy-and dry-season cropping.
2. The cultivation period is set by adjusting the growing period of the rainy-season crop to that of the dry-season crop. The irrigation period is also adjusted to match the cropping schedule.
3. The cropping plan for the whole year is formulated to meet the requirements of topography, soil, water, and seasons.

4. Farmers are organized to ensure the start of planting operators at the same time, regulate irrigation timing and reduce couflicts among farmers.

As upland crops such as soybean, peanut, muiigbean, maize, sesame, and vegetables were introduced, many problems surfaced as fanners were not familiar with these crops. Technical assistance and other support services were therefore provided. These were:

1. Instruction to farmers on land leveling and proper land preparation, particularly, ridging.
2. Introduction of drainage canals around and inside plots.
3. Introduction of herbicides.
4. Introduction of postharvest technologies.
5. Coordination with the. private sector for marketing.

The cropping schedule of each crop was adjusted to start the growing season not later than December, especially for soybean. maize and peanut, with a view to harvesting in April. This would obviate harvesting during the rainy seasonand the attendant problem ofaflatoxin in peanut and maize.

CONCLUSION

The diversification of crops in Chao Phraya Project can be practiced in a small portion of the project area during the dry season as farmers in the projrct area prefer rice to other crops. The fanners do not want to reduce their rice area. Besides, the project area is mostly lowland with clayey soil and poor drainage capacity. An attempt at crop diversification is, therefore, made by:

1. Specifying the upland crop area for diversification by creating production zones.
2. Adjusting the water allocation system in a manner consistent with the production zones.
3. Introducing crop production technology.
4. Coordinating with the private sector for marketiiig and ensuring reasonable prices.

Summary/Highlights of Papers/Discussions: Country Reports

THE EIGHT PARTICIPATING countries presented their experiences on irrigation management for rice-based cropping as these relate to planning, implementation, monitoring and evaluation both at the systemand farmlevels. Constraintsandopportunities for cropdiversification and activities related to research and development (R & D), information exchange and dissemination, and funding and organization were discussed. Tbe direction in which these activities were beaded was highlighted.

Bangladesh

In Bangladesh, the agroclimatic conditions favor a rice-based farming system. Rice is the staple food and farmers will continue to grow rice to meet consumption demand. However, irrigated rice production is becoming less profitable and growing nonrice crops such as pulses, oilseeds and vegetables with partial or full irrigation in the dry season becomes a major strategy to increase farmers' income and improve soil fertility.

Tbe most important factor that influences crop diversification is the economic incentive to farmers in growing nonrice crops. To promote crop diversification, institutional support is needed in terms of credit and price incentives for nonrice crops, back-up services from irrigation-related agencies, and storage, processing and marketing of nonrice crops. More research and development are needed in the field of irrigation water management and varietal development of both rice and nonrice crops.

Government subsidies on farm chemicals and cost of power have been a major issue. Officially, there is a minimal subsidy on fuel and pumps and a subsidy of about 40 percent on chemical items, but none on fertilizers.

Strategies by which the government convinces the farmers to plant nonrice crops considering that returns on rice are higher, are: a) agricultural extension; b) distribution of seedlings/seeds; c) distribution of small-scale facilities; and d) providing access roads. However, the effectiveness of extension services still remains very low.

India

India attained self-sufficiency in rice production during the early 1970s with the introduction of high yielding varieties and extension of irrigation facilities. This bas resulted in declining farmers' income and a need to diversify the cropping system to nonrice crops. This requires changes in planning, water allocation, and operation and maintenance of irrigation systems which consequently need consideration of water control, agronomic and irrigation practices, economic risks, inputs, climatic requirements, socioeconomic constraints and institutional strengths. To address the above factors, strategies have to be identified by undertaking research in terms ofpolicy, and implementation of technical solutions tospecificconstraints. This could be carried out by ICAR institutions, agricultural universities and water and land management institutes in the country.

Indonesia

From a purely technical standpoint, crop diversification in Indonesia is not perceived as a major problem because the existing irrigation systems have been developed and operated for diversified crops in rice-field areas. The problem becomes complicated considering the technical-socioeconomic interactions between irrigation management practices and the crop diversification farming systems.

The government explicitly recognizes crop diversification as a major policy to improve, among others, productivity and income. Developing crop diversification and improving irrigation management practices can be addressed by conducting a well-planned program and well-structured implementation of research. To speed up development, a program approach in technology transfer is suggested.

Indonesia reached self-sufficiency in rice during 19841985. With the Special Intensification Program on nonrice crops of the Ministry of Agriculture and the marketing assistance provided, farmers were persuaded to shift lo nonrice crops.

Malaysia

The scale of current crop diversification on rice land in Malaysia is small. For the moment, there is no monitoring and evaluation in the operation of the irrigation system for diversified cropping. No major structural and managerial adjustments have been imposed on the system. Nevertheless, crop diversification ha5 been successfully practiced. Minor adjustments that were enforced and have potential application elsewhere include: a) reducing flow to below FSL so that the canal can function as a drain as well; b) deepening canals to increase storage for pumping; c) acquiring portable pumps lo provide flexibility in water management by farmers; d) having stable, reliable and predictable water supply to be augmented whenever necessary by farm ponds and tubewells at farm level; and e) improving the on-farm conveyance system by using concrete-lined canals or pipe system complemented with regulatory structures.

Malaysia is now gearing up for crop diversification in rice land. As this proceeds, complexities in irrigation management and production are expected to be encountered. The following strategies are adopted: a) identification ofsuitable schemes within the nongranary areas based on water resources, physical condition, marketability, and agronomic and socioeconomic criteria; b) implementing pilot projects for representative schemes; c) a coordinated multiagency implementation program with strong participation of fanners' associations in an inlegrated approach; d) research and development on system design and management, socioeconomic aspects of fanners' organization and production technology on rice land; and e) collection of basic data and information to establish a comprehensive database on the nongranaries and rain-fed rice fields.

Agricultural lands are classified as granary and nongranary areas, depending on the stability of water supply. The granary areas have met 70-75 percent of the production target. The nongranary areas with no stable water supply are the target for crop diversification. At the moment, small-scale crop diversification is already taking place in these areas. However, some farmers do not diversify because of low yields and the problem of pests and diseases.

Diversified land uses in the existing irrigation schemes under Category 3 are the areas relevant to crop diversification. This is where the rice-upland crop rotation is practiced. The possibility of expanding the areas for crop diversification is seen in Category 7 which is subject to land-use changes. Conversion of these areas to Category 3 is hindered by tenancy. However, if the farmers have no successors, then conversion is possible.

Diversified cropping areas are located near water sources. This provides the farmers easy access to water. Farmers want to be independent. and they can achieve this by having their farm near a water source.

In terms of design, canals are deepened to facilitate control of water and provide for temporary storage from where water could be pumped. There is, therefore, no need to maintain a head.

Nepal

Diversified cropping in the rice-based cropping systems in Nepal is not new. It is probably more than a century old and practiced partly due to farmers' diversified needs for food grains and other essential farm commodities and partly due to the small and scattered landholdings. The government's efforts to maximize cropping intensity and diversify cropping practices are very much a felt need. It is urgently needed to protect the environment. and maintain and increase the soil fertility by checking erosion and land degradation.

Vegetables, root crops and fruits, peas and fruit vegetables are given priority in crop diversification. In some areas, there is a surplus of rice, while there are shortages in some others. Transportation, being costly, is the major problem in the distribution of the rice surplus.

As proposed, crop diversification will be concentrated in areas where groundwater pumping will be done. The experience in Bangladesh has shown that farmers have grown diversified crops in similar areas and have realized its practicality. There is a need though to have joint pump ownership, particularly if the landholdings are small.

Philippines

In the Philippines, one identified factor which tends to push the diversified cropping system is the inadequate water supply during the dry season. In the national irrigation systems, only 1 percent is presently devoted to diversified cropping out of an estimated potential of about 30 percent. Except for those irrigation systems with vegetable production componeuts, nonrice crops are still not considered in the planning of irrigation operations. The programmed area for irrigation during the dry season has been based on predicted streamflows as against calculated net operation water duty.

Encouraging farmers to shift from rice to inigated nonrice crop cultivation to help alleviate recurring water shortages is not yet extensively done due lo know-how deficiency. Suggested research studies on water management for crop diversification deal with the generation and verification of more data on the planning, design and operation of irrigation systems. The characterization of the various factors that tend to hinder or promote crop diversification needs to be addressed.

Previous efforts at crop diversification have concentrated on the rain-fed areas. The National Committee on Crop Diversification (NCCD) considers crop diversification in a general perspective to include lowland irrigated areas and upland rain-fed areas.

Identification of priority areas for crop diversification should he done nationwide. This will help in identifying the need for research activities on water management, socioeconomic aspects and site specific factors affecting crop diversification.

Infomiation now available shows areas presently under crop diversification and at the same time identifies potential areas for crop diversification; the entire area of the country is considered in each of the pedoecological zones.

Sri Lanka

Crop diversification in rice fields in Sri Lanka, especially in the Mahaweli Project areas, has developed because of the following reasons: a) gradual banning of imports of subsidiary food crops; b) higher economic benefits for fanners through higher net returns and cost-benefit ratios with better product prices of some nonrice crops; c) water scarcities during the low rainfall season; d) bener extension services and improved communication between farmers and agency officials; e) shortfall in nonrice crops to meet the growing needs of the population and the resultant price increasesdueto higher demand; and f) institutional support for crop diversification and increased interest among policymakers.

Thailand

The diversification of crops in Chao Phraya Project in Thailand during the dry season can be practiced in only a small portion of the project area as farmers are accustomed to growing only rice. Besides, most of the area is low-lying and has poor drainage. Even if the price of rice decreascs, the fanners do not want to reduce the area devoted to rice. In attempting to diversify the area, the following should be considered: a) production zoning to identify the area for diversification; b) adjustment of the water allocation system lo consider irrigation timing and drainage; c) transfer of crop production and irrigation management technologies; and d) coordination with other sectors to provide the production inputs and markets for the products.

Thailand farmers continue to plant rice in spite of low yields. Rice is considered a secure crop and the government finds it hard to convince farmers to shift from rice to other crops. Although the yields are low, the farmers still make profits as the cost of production is also low and labor is cheap.

Thailand is able to export rice despite low yields. The reason must be big landholdings which average 4 ha.