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Country Paper

on

WATER RESOURCES PLANNING AND MANAGEMENT OF THE CHAO PHRAYA RIVER BASIN, THAILAND

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CONTENTS

CONTENTS (Continued)

LIST OF FIGURES

WATER RESOURCES PLANNING AND MANAGEMENT

CHAO PHRAYA RIVER BASIN, THAILAND

1. INTRODUCTION

1.1 GENERAL BACKGROUND

The Chao Phraya river basin is the largest and the most important geographical unit in terms of land and water resources development covering a large area in the North and Central regions of Thailand. The basin drainage area of 178,000 sq km extending from the northern border to the Gulf of Thailand occupies about 35 percent of the area of the whole country (see Figure 1).

There are four main tributaries, the Ping, Wang, Yom and Nan, joining together at Nakhon Sawan some 200 km north of Bangkok. The river becomes the Chao Phraya and follows a single course for about 60 km. The Chao Phraya river then splits into three branches namely the Suphan, the Noi and the Chao Phraya rivers. All of them flow southward through the Chao Phraya delta which is called "The rice bowl of the country". The Noi river then rejoins the Chao Phraya river near Ayuttaya and flows through Bangkok emptying into the Gulf of Thailand about 48 km further south. The Suphan, the downstream section called the Tha Chin, also flows into the Gulf some 30 km west of Bangkok.

Inland water ways has been historically one of the main routes for public transportation. Transportation of large shipment such as construction materials, agricultural product from the Central plain to Bangkok is being used extensively. Many towns and villages are situated on the Chao Phraya river banks. As a result, the development has tended to concentrate along the river.

In the last few decades, the highway network system has been much improved. Transportation by cars and trucks becomes popular. Nevertheless, large shipment of construction materials and others by barges is still being used in the lower part of the Chao Phraya river.

The water quality in the lower part of the river becomes polluted below acceptable national standards due to inadequate waste water treatments.[1] Short term and long term measures have been recommended to the Government. They are very costly and involving many agencies both government

and private sectors.

Since the water available for all users in the basin is limited and shortages of water have been experienced a few times in the last decade. A limited amount of water about 50-100 cms has also been transferred mainly for agriculture and domestic uses from the Meklong river basin since 1989.

A large storage dam on the Yom has also been proposed and now being under review.[3] The project faces some opposition headed by the conservation and environment groups. It is hoped that final decision could be reached in the near future.

It is quite certain that the role of water management improvement in the Chao Phraya river basin becomes increasingly important as it is relatively less expensive than the other approaches. Some activities have already started and shown some improvement.

1.2 CLIMATE

The basin is located in the tropical zone and dominated by the southwest monsoon which lasts from May to October. The temperature is high and relatively uniform throughout the year and generally favorable for year round cultivation. Peak temperature of about 40°C usually occurs in March and April with moderate temperature from November through January.

1.3 RAINFALL

The average annual rainfall over the basin varies from 1,000 mm to 1,400 mm. In any particular year, the amount of rain can be greater and smaller than the average, sometimes with large differences of 30-50 percent (see Figure 2).

About 90 percent of the annual rainfall occurs between May and October which sometimes causes heavy flood. On the contrary, the scarcity of rain between November and April makes it unfavorable for agriculture.

1.4 RUNOFF

At Nakhon Sawan, the confluence of the four main tributaries, the average annual runoff corresponds to about 226 mm of water over the drainage basin. In the upper basin the average annual runoff varies from 249 mm in the Ping basin to 448 mm in the Nan. The typical monthly flow pattern closely follows the rainfall pattern.

The total volume of water available, on the average, has been estimated at 31,300 mcm per annum. About 80-90 percent of the runoff occurs

in the month of May through October with peak flow in September and October. Typically, the flow starts to decrease in December and becomes minimum around April (see Figure 3).

It was reported in a study made by the EGAT in 1990 that there has been about 10% flow reduction at the Bhumibol reservoir due to land use changes and more development in the upper watershed, but no change was observed at the Sirikit reservoir.[3]

1.5 LAND USE AND AGRICULTURAL PRACTICE

The basin can be characterized geographically into 2 main parts, the upper and the lower basins.

The upper basin is mountainous with small streams and valleys. The forest land covers nearly 40% of the area, cultivated land 41.2%, and unclassified land 19.1%, respectively (see Figure 4). Agriculture has been traditionally practiced in the relatively small river valleys. Multiple cropping of diversified crops has been practiced mostly for local consumption where river flow is available all year round.

In the last few decades, shifting cultivation has been widely practiced among hill tribes and caused soil degradation and erosion in some areas as well as changed the hydrologic regime.

The lower basin is flat with gentle slope toward the Gulf of Thailand. It is the flood plain or delta of the Chao Phraya river basin. The soils comprise a broad band of medium to heavy impermeable clays and well suited to rice cultivation. With the combination of heavy rain in July - October period and high tides in the Gulf, a long duration of inundation normally occurs in the low lying southern part of the basin which sometimes lasts until November.

Farmers in this area traditionally grow floating rice because it can stand against long inundation and high water level. The yield is relatively low as compared to that of high yield variety rice.

After the irrigation water became available in the lower part of the basin in 1970's, the farmers have slowly changed their traditional practices from growing floating rice to high yield variety. Both transplanting and broadcasting rice are being cultivated in the area. The technique of broadcasting pregerminated seed it also being used in some areas which have adequate water control and good land leveling.

1.6 POPULATION AND SOCIO-ECONOMIC STATUS

The basin has the population of nearly 20 millions or about 30% of the population of the whole country. Nearly 80 percent of the population are farmers.
Rice is the main crop in the irrigated and rainfed areas.

The Government has spent an enormous amount of money for infrastructure and large scale irrigation project construction in the basin since 1950's, but per capita income is still relatively low as compared to other developed countries. The per capita income of the people in the lower part of the basin is slightly above the country average which is about US$ 964/year.[4] The people in the upper part of the basin have less per capita income due to smaller size of farm holding. The income from off-farm is slightly more than on-farm income.

The basin itself has good highway networks and extensive rural road and public services are made available to all villages. Inland waterways is being used extensively in the lower part of the basin both for public transports and large shipment of goods to and from Bangkok which is the largest harbor in the country.

2. WATER RESOURCES DEVELOPMENT

2.1 CULTURAL BACKGROUND

Small scale water resources projects have been developed for several hundred years ago in the upper part of the basin mainly for irrigation purpose. The projects were constructed by local farmers who lived in small valleys and organized themselves as water user groups. The operation and maintenance of the projects were also carried out by them normally on share labor basis. These projects are called "Muang Fai" or people irrigation projects.[5]

These activities have become traditional practices among farmers on the upper part of the Chao Phraya river basin. Water right has also been strictly observed not only among farmers who share water in the same project area but also among the upstream and downstream projects located in the same sub-basins.

On the contrary, the lower part of the basin is a flood plain and suitable for rice growing. Even though there is enough water in the wet season for rice cultivation but farmers often suffer losses due to shortages of water in the beginning and too much water at the end of the growing season.

Subsistence farming is widely practiced in the area. Hence the farm holding size is normally larger than the one in the upper part of the basin.

Supplementary irrigation and flood mitigation projects are normally implemented in the lower part. Many of them are relatively large and beyond the capability of a small group of farmers to handle the construction work like in the upper part of the basin. Moreover, the water is generally abundant in the wet season. The farmers therefore have no strong intention to form water user groups to be responsible for water allocation and management. They, however, form themselves into small groups to share labor on voluntary basis during transplantation and harvesting periods. These activities have been widely practiced and become traditional in the area.

2.2 HISTORY OF DEVELOPMENT

A large scale water resources development project in the Chao Phraya basin was first proposed in early 19th century, but due to unstable economic condition and lack of experienced personnel, the project implementation had been delayed for many years.

However, a number of canals were excavated in the lower part of the basin, mainly to serve as drainage canals, inland waterways and water conservation for domestic uses in the dry season. Dikes and control structures were constructed along the coast to prevent saline water intrusion into the paddy land.[6]

2.2.1 Supplementary Irrigation

In late 1940's, the Chao Phraya Barrage Project was reviewed and found justify for international financing. The project was originally designed for supplementary irrigation to increase rice production in the wet season not only for domestic consumption but also for export. To minimize the investment cost, all irrigation canals were unlined and natural drainage channels were incorporated in the design extensively (see Figure 5).

The service area served by the Chao Phraya Barrage is about 1.2 million ha which covers the area in the lower part of the river basin. The project area consists of more than 20 sub-projects all of which are hydraulically connected by unlined and natural canals. Some of the sub-projects were built in 1920's. By this nature, it is complex and very difficult to manage the system efficiently.

2.2.2 Multi-purpose Project

Two storage dams were constructed upstream of the Chao Phraya

Barrage namely, the Bhumibol Dam and the Sirikit Dam. The two dams were put into commission in 1964 and 1975, respectively. Both are multi-purpose dams which serve for irrigation, hydro-power generation, flood protection, inland navigation, industrial use, including prevention of salinity intrusion near the river mouth.

Following completion of the above two dams, it has been possible to control about 22% of the water in the Chao Phraya river basin, thereby the water could be regulated for dry season cropping in the lower part of the river basin for approximately 400,000 ha and generating annual energy of approximately 2 million MWh connected to the national grid.[7]

During that period, power demand had increased at a high rate and generation capacity of thermal plants was limited, therefore hydro-power generation from these two dams became major sources of electrical energy of the country. As a consequence, conflicts in the release of water for power generation and for irrigation often arose but could be easily resolved because the irrigation demand in the dry season was relatively low.

2.2.3 On Farm Development

In order to promote the utilization of water, particularly for dry season irrigation, improvements were made in some project areas, which originally had been designed for supplementary irrigation. The improvements included introduction of ditches and dikes facilities and land consolidation work in the Upper Chao Phraya Project. Since the works being new to the farmers, pilot projects of varying characteristics were also constructed for study and demonstration to the farmers that rice and upland crops could be grown if properly managed in the Chao Phraya Project area.

Unlike farmers in the upper part of the basin, cultivation of dry season crops were new to the farmers resided in the central part of the Chao Phraya river basin, it was difficult at first to motivate the farmers to make use of the water which became available in the dry season. The Ministry of Agricultural and Cooperatives launched a series of training programs and strengthening the extension services in order to promote agricultural production especially in the dry season.

As a result of concerted efforts made by all parties concerned, the area of dry season paddy thus increased ten folds in eight years, namely from 48,000 ha in 1970 to 480,000 ha in the year 1978, resulting in the shortage of water in the dry season and increasing the conflict between the water users particularly EGAT and RID as well as various groups of farmers (see Figure 6).

While development of irrigation projects were taking place in the

Chao Phraya river basin as discussed above, the Government was also involved in the development of a large scale project in the Meklong river basin west of the Chao Phraya river basin, and medium scale projects in other parts of the country. Nevertheless, the development in the Chao Phraya river basin would be regarded as the largest rice production area of the country which is of a very prime importance to the nation's economy.

2.2.4 Rural Development Program, Small and Medium Scale Irrigation Projects

Even though the Government has spent a large amount of money on large scale water resources development projects for economic growth of the country from 1950's to 1970's, the areas served under the projects were only a small portion of the total cultivated area. A large number of farmers still do not enjoy the benefits of irrigation water.

The Government therefore started the small scale development program in 1980's aiming at improving the living conditions of the people in the rural poor area and alleviating income disparity, and water resources development was part of the program.

Such policy has some impact on the water resources development priority. More emphasis, however, has been given to small and medium scale project development. About seventeen government agencies under six ministries have been involved and a central coordinating committee was set up attached to the Prime Minister Office.

As a result of this policy, improvement or rebuild of temporary weirs and control structures in "Muang Fai" or people irrigation projects by the Government have been carried out extensively. Since it become more difficult and take too much time for the farmers to do as the materials, particularly bamboo or timber and others, are no longer available in the nearby vicinity.

The projects must be first requested by Tambon Council, the smallest unit of administration, and submitted through the Local Administration Department to the National Rural Development Committee who will go through the projects and set priority for implementation. The projects will be assigned to the respective agencies who are responsible for the types of work which include small dams, weirs, ponds, low-lifting pumps, basic infrastructures and etc.

Under the program, the organization structure and traditional practices of the water user groups still remain the same. However, for new small scale projects, water user groups must be formed to be responsible for

the operation and maintenance of the projects.

Since people in the upper part of the basin have had long experience in working together and in irrigation practices for many generations. The performance of water user group is always exceptional as compared to the ones in the other parts of the country.

The size of small scale project is also limited by the construction cost. Since the project must be completed in one fiscal year, the maximum construction cost per project was first set at US$ 40,000. The cost was subsequently raised to incorporate escalation cost of materials and wages to US$ 160,000, US$ 400,000 and finally to US$ 600,000 in 1990.

More medium scale irrigation projects have also been implemented since 1980's. Some are the King's initiated projects, mostly located in the upper part of the watershed within the basin as part of the program against shifting cultivation and opium growing carried out by hill tribe people. Even though the projects are small but still being classified under medium scale project category.

The construction cost of a medium scale project was limited at US$ 8.0 million. But due to price escalation and changes of project classification criteria, the cost limit is no longer applied. The projects with storage reservoir capacity less than 100 mcm or irrigable area less than 12,800 ha are classified under the medium scale project category.

2.2.5 Flood Protection

Flood protection work in the lower part of the Chao Phraya river basin is another work that the Government considers an important task because it could cause millions of dollars damages of public and private properties. Flood protection facilities include construction of dikes along the Chao Phraya river to prevent over banks flow inundating the cultivating lands were constructed downstream of the Chao Phraya Barrage. Another aspect of flood protection work is the construction of the dikes on the eastern side of Bangkok which was built to keep flood water away from the residential areas in the land subsidence zone. In addition, a permanent pumping station consisting of 35 units of 3 cms each was constructed near the river mouth for drainage improvement in the low-lying area.

Flooding of the city of Bangkok and the suburban areas occurred very often during the last 10 years due to frequent heavy local rainfall and due to changes of land use from agricultural purpose to industrial estates, residential areas and etc. These have caused some changes of flow pattern and reduced the effectiveness of storage capacity of bund paddy field.

3. PRESENT DEVELOPMENT STATUS

As stated in the previous paragraphs, many projects has been developed in the basin for various objectives. They may be classified into three categories according to the project sizes namely:

3.1 LARGE SCALE PROJECT

The project having reservoir storage capacity of more than 100 mcm or irrigable area large than 12,800 ha is classified as a large scale irrigation project. The study on environmental impact assessment is required and must be submitted to the Sub-committee on Coordination of Dam Construction under the National Economic and Social Development Board for consideration and approval before implementation.[8] Most of the projects are multi-purpose in nature with main objectives for agriculture, hydro-power generation, flood mitigation, domestic use and etc.

The justification of project implementation is made mainly on the basis of acceptable overall economic rate of return and engineering soundness.

3.2 MEDIUM SCALE PROJECT

The project is smaller in size than the large scale project as stated above. No environmental impact assessment study is required by the National Environmental Board for consideration and approval as in the case of large scale projects. In general, the project objective was designed for gravity irrigation and domestic use.

The project justification is generally made based on socio-political consideration. However, the economic rate of return of the project is also taken into account.

There are more than two hundred medium scale projects scattered mostly in the upper part and central part of the basin. About 70% of them have irrigable ares less than 1,000 ha and storage capacity less than 5.0 mcm.[9]

3.3 SMALL SCALE PROJECT

The project was implemented on a yearly basis according to the requests made by Tambon Council, the smallest unit of local administration. Approximately 500 projects are constructed annually in all regions of the country by the Royal Irrigation Department. Since 1980, over 1300 projects have been constructed in the basin which is about 24% of the whole country. About 65% are located in the upper part of the basin, which has favorable topographic conditions and active farmers' participation. For small

reservoirs, the average size is about 340,000 mcm. The areas served under the small scale projects are designated as benefitted areas.[10]

The total irrigable area of the whole country is approximately 3.1 million ha, nearly half located in the Chao Phraya river basin. The area can be classified into four types according to the level of development of irrigation and drainage facilities and on-farm development work. The four types of irrigable areas reflect the level of water control possible with the infrastructure provided.

Type I, being under land consolidation projects, covers about 10.6% of the total irrigable areas, more than half located in the Chao Phraya river basin. Approximately 41.9% is type II covered by ditch and dike projects. Type III is the areas with main and secondary canals and drainage system covering about 32.9% and type IV, the areas with minimum irrigation facilities mostly located in the low-lying areas covers about 14.5% (see Figure 7).

Based on data collected by O&M division, RID, rice yield differences are significant between type I, II and III but not between III and IV.[11] This is partly due to the fact that type I and type II are located in the better drainage area and irrigation water distribution is better. On the other hand, type III and IV are more common in the flood plain areas and difficult to manage as the infrastructures and personnel are insufficient.

In the Chao Phraya river basin, the irrigable area covers nearly 1.5 million ha mostly located in the lower part of the basin or about 22% of the cultivated land in the basin. Rice is the major crop grown in the wet and dry season in the irrigable area. In 1989, the average wet season rice yield in the irrigable area is about 3.44 ton per ha and the dry season 3.75 ton per ha.[11,12] Total rice production in irrigated and rainfed areas is not only sufficient for domestic consumption but also enough for exportation.

3.4 PUMPING IRRIGATION

There are many pumping irrigation projects implemented in the Chao Phraya river basin. They can be classified as follows:

3.4.1 Large Pumping Project

The projects are normally implemented by RID, the operation and maintenance are also under the responsibility of RID similar to any other gravity irrigation systems. So far the farmers in the project areas do not pay any pumping cost or any other charges. The areas covered by RID pumping projects in the basin is about 57,000 ha.'

However, in the two pumping irrigation projects upstream of the Chao Phraya basin financed by the Asian Development Bank in recent years, the farmers had agreed in principle to pay partial cost of pumping before the completion of the project implementation. Water user groups were also formed during the project implementation to be responsible for the operation and maintenance at on-farm level. Unfortunately, after the project completion, the payment of pumping cost has been deferred due to unclear reasons.

3.4.2 NEA Small Pumping Project

The project was first proposed by the National Energy Administration (NEA) in 1965 to promote the use of electrical energy from pumping water for agriculture in the dry season in the Northeast of Thailand. The project was later extended to cover the other parts of the country including the Chao Phraya river basin. Each project consists of a small pumping unit and a system of concrete lined canals to irrigated an area of about 80 - 480 ha. The implementation can be carried out in stages and there are certain conditions that the farmers must agree before project implementation in particular to pay part of the electricity cost used for pumping water and to operate and maintain the system in good order.

In the basin, there are over 200 NEA small scale irrigation pumping projects mostly located along the rivers upstream of the Chao Phraya Barrage serving total areas of 48,000 ha or 52% of the total project areas.[13] The farmers in each project must form a cooperative, as a pre-condition of project implementation, to be responsible for the operation and maintenance of the irrigation system. The pumping cost paid by the farmers is about US$ 12.5 per ha in the wet season and about US$ 25.0 per ha in the dry season. This cost is partially subsidized by the Government. So far, the projects seem to receive fair response from the farmers as water in the dry season become scarce and it is the only mean to deliver water to their farm lands.

3.4.3 Private Pumping Unit

There are a number of private pumping units operated in the basin to provide water to the farmers for agriculture. The units are owned by individual farmers or operators or cooperatives. At present, they are freely operated because there is no law or regulation to govern such activity. This could create conflict among water users and could become a serious problem in the area where river flow is low in the dry season and no storage dam upstream.

The operator normally charges the farmers for the operating cost plus overhead and profit as agreed among them. At any rate, the total quantity of water being pumped at present is relatively small as compared to the other

uses in the basin.

3.5 GROUNDWATER DEVELOPMENT

There is a large groundwater development for irrigation in the basin, the Sukhothai Groundwater Development project. The objective was to construct a pilot development area comprising 104 tube wells irrigating nearly 6,000 ha of crops with rice being cultivated on the lowland, and other crops on the permeable upland soils.

The project's achievements have been quite substantial. The farmers pay for actual pumping cost on the average of 12.00 US$ per ha for rice in the wet season and much less for the other crops. The overall management at farm level and collection of money is under the responsibility of the cooperative.

In some small areas, the farmers sometimes pump water from shallow wells to supplement water supply from irrigation canals when it is inadequate. This has been practiced in Lamphun Province in the North and in the central part of the basin where groundwater is available.

Groundwater was pumped for domestic use and industries in area around Bangkok which causes land subsidence at a substantial rate in some areas. The Metropolitan Water Works Authority intends to terminate its use of groundwater and substitute it with water transferred from the Meklong basin. The use of groundwater for industries which have their own pumping facilities will be slowly replaced by water supply provided by either MWWA or PWWA. Groundwater development is under the control and supervision of the Mineral Resources Department, Ministry of Industry.

3.6 WATER SUPPLY

The Chao Phraya River is the principal source of raw water for domestic and industrial uses in the basin. The Bangkok Metropolitan Water Works Authority who is responsible for the water supply development in Bangkok Metropolitan area is the major user. At present, the raw water requirement from the Chao Phraya river is about 1,100 mcm per year. Apart from this, MWWA is pumping a certain amount of groundwater to supplement the requirement in some areas. Based on MWWA estimate, the requirement of raw water in 2000 will be double.

For water supply of other towns and municipalities which are mostly under the responsibility of the Provincial Water Works Authority, the total yearly requirement at present is about 140 mcm. Based on data provided by PWWA, the estimated requirement will be about 355 mcm in 2000.

The total water requirement for domestic use in the basin is therefore about 1,240 mcm/year which represents about 7.6% of the present total water use in the basin.

4. WATER MANAGEMENT

As previously stated, there are three types of water resources development projects located in the Chao Phraya river basin namely, large scale, medium scale and small scale projects. The management philosophy and responsible agencies of these projects are different.

For small scale projects, the operation and management of the projects is under the responsibility of water user group of each project. Since the storage capacity is relatively small, the project is generally operated independently but due consideration has always been given to water right of nearby downstream users in the same sub-basin as well as among the members. This philosophy has been practiced in the upper basin for a long time.

For medium scale projects, RID is responsible for the operation and maintenance. They are mostly located in the upper watershed and water is released mainly for irrigation purpose. The operation is generally carried out by the project personnel with closed cooperation with the water user groups and under overall supervision of RID regional offices. The responsibility of RID covers as far as the farm turnouts.

For large scale projects in the Chao Phraya river basin, the management is made more or less on joint responsibility arranged on project by project basis. For example, the operation of the Bhumibol and Sirikit reservoirs is mainly under the responsibility of the Electricity Generating Authority of Thailand (EGAT) who is also responsible for the power plant operation. The Royal Irrigation Department (RID) is responsible for the water allocation and management of irrigable areas and water allocation for other purposes downstream. These two dams with total storage capacity of about 23,000 mcm play a very important role in the basin water management.

On the other hand, the operation of the Mae Ngat Reservoir, which is about 265 mcm, is under the responsibility of RID. The power generation from a small power plant attached to the dam is, however, considered a secondary benefit and under EGAT responsibility. Since the reservoir is located upstream of the Bhumibol reservoir, the operation is made only to serve the irrigable area of about 4,800 ha downstream of the dam in the Chiang Mai valley.

The power plant at Bhumibol and Sirikit are operated as an integrated part of the national power system to maximize the overall benefits. The combined water release from these two reservoirs will serve irrigable areas in the Chao Phraya irrigation project of about 1.2 million ha in the wet season, about 0.5 million ha in the dry season and for inland navigation, water supply of Bangkok and towns located along the river, salinity intrusion control around the river mouth, industry and other domestic uses . A schematic diagram showing various water users is illustrated in Figure 8.

After a few years of operation of the two dams for multi-purpose objective, conflicts in releasing water for power generation to meet irrigation requirement downstream and others often arose due to some constraints in the operation and lack of experiences in the system operation. In fact, the whole project is a combination of many sub-projects which have to be operated in such a way that maximum benefit should be achieved.

Ad hoc committees were set up to look into the differences. The problem, however, was too complicated and required detail analysis before any concrete recommendation could be made. Due to lack of proper funding, the work had been delayed for a few years. In the mean time, some measures had been taken to remedy the problem.

4.1 BASIN MANAGEMENT AND OTHER STUDIES

In 1976, Phitsanulok Irrigation Project located downstream of the Sirikit Dam was proposed for implementation. The project consists of a barrage across the Nan River near Phitsanulok called Naresuan Barrage and a system of irrigation canals covering the phase I area of about 92,640 ha.

Recognizing the existence of conflict in water use, it became necessary that an overall basin study be carried out in order to avoid the above mentioned conflict and to determine the development potential of the basin in which the construction of a few large scale projects had been recommended.

An over all basin study was carried out in 1977 to determine the water resources development potential, development policy as well as operation guideline and etc.[7] Computer simulation models were used representing the hydro and thermal power plants in the national grid system, irrigation projects as well as water use for other purposes.

The simulation model was specially prepared for the computer facilities available in the RID office. The local counterpart personnel from RID and EGAT have actively participated with the consultant throughout the study period. As a result, the counterparts have been able to continue the

work after the completion of the study.

The study revealed that the regulated water supply of the Chao Phraya river basin was fully committed. Further development in downstream area which would have led to increased water use in the Chao Phraya river basin be postponed, until the rate of water use on existing projects had been significantly reduced. It was also recommended that the best way to reduce water use in dry years was to control the extent of dry season irrigation by reducing the area served and to inform the farmers before the dry season.

As a consequence, an operating guideline for the operation of the two reservoirs was adopted and has been put into practice with some modification as needed. The detail procedure will be discussed in the following paragraphs.

Flow measurement and calibration of major structures were carried out in 1978 in the Chao Phraya Irrigation Project, in order to determine the irrigation efficiency of the system. The result from the above investigation was used as a guideline for consideration towards proper improvement of the project infrastructures. It was reported that the estimated irrigation efficiency varied widely from project to project from 8% to 51% in the wet season and 17% to 70% in the dry season depending upon the physical condition of infrastructures and the availability of water supply.[14]

Several studies had been made also on system improvement including modernization and rehabilitation of some sub-projects under technical assistance programs.[15,18,23] But there are still many related issues required further consideration, for example, the adaptability of the farmers and the project staff to the new technology and etc. The technology which has proved to be successful in the operation in other countries may not be applicable for the prevailing conditions in the basin.

4.2 WATER ALLOCATION CRITERIA

The allocation criteria of water release for various purposes has been adopted as practical guidelines on priority basis as follows:[16]

1. Top priority is given to the domestic consumption as it is considered necessary for the living of the people. The water required for domestic use only accounted for about 7-8% of the total demand.

2. Water for irrigated agriculture to be made available during any dry spell or drought period in the early wet season in order to avoid damage to newly planted crops, and for dry season cropping.

Water demand for irrigated agriculture is highest among other users and equivalent to nearly 90% of the total demand.

3. Inland Navigation. In some of the instances when the water level in certain stretches of waterways become low preventing passage of navigation of large shipment, it become necessary to release extra water from the reservoir for a short period to make passage of the navigation possible. Delay of large shipment could cause heavy damage to the concerned parties. During the low flow period, barge operators have also been requested to lower the carrying capacity of the barges to reduce water depth required for passage of 2 m draft.

4. Salinity Intrusion. In order to prevent salinity intrusion into the Chao Phraya river near the river mouth causing damage to the fruit trees and orchards in the area surrounding Bangkok and to keep salt content below standard for production of potable water by the MWWA in the dry season, it is necessary to maintain the salinity at the Memorial bridge (48 km from the river mouth) at not more than 2 ppt.

At present, during the low flow period this problem has been well under control, but on the other hand, the water quality in the Chao Phraya river and canals around the city of Bangkok is below the allowable standard.[17] This is a major problem has yet to be solved without further delay. To release additional water for water quality improvement, however, is not practical at present because the supply is inadequate.

5. Hydro-power Generation. The hydro-power plants normally operate for peak power generation in the evening to supplement the power generation from other power plants inter-connected to the national grid. At present EGAT has sufficient reserved generating capacity from thermal-power plants to replace the deficit if required.

The above criteria have been generally accepted in principle by all concerned and used in the operation of the major reservoirs in the Chao Phraya river basin.

4.3 ADOPTED METHODOLOGY

As mentioned in the previous paragraph, the water resource in the basin has been used up to almost its limit. To avoid further conflicts among water users and unnecessary shortages which could damage the economy of the country as a whole, the Electricity Generating Authority of Thailand (EGAT) and The Royal Irrigation Department (RID) have coordinated their activities and adopted priorities in managing the reservoir as follows:

1. RID shall estimate weekly demand for irrigation and other downstream uses and inform EGAT the weekly demand in advance. Possible sideflows upstream of the Chao Phraya Barrage and rainfall over the area are also taken into consideration in the demand estimation.

2. The weekly demand shall be the target reservoir release for the coming week. There may be some instance when the release could not be made to meet the downstream requirements. EGAT will make up the difference later in the following period.

3. Around the end of October or beginning of November, a meeting of sub-committee on Programming and Promotion of Dry Season Cropping will be held to set target area for dry season cropping in the Chao Phraya river basin and others. The sub-committee chaired by the Director General of Department of Agriculture Extension (DOAE), shall recommend to the Committee on Promotion and Supervision of Dry Season Cropping chaired by the Minister of Agriculture and Cooperatives for concurrence and then the target area will be informed to the farmers in the project areas together with the Governors and representatives of concerned agencies.

Criteria for selection of dry season cropping area are as follows:[16]

1. first priority is given to the areas where wet season crop could not be cultivated in the previous season.
2. area with suffered crop damages by natural disaster
3. area scheduled to receive water in the coming dry season
4. other areas suitable for dry season cropping

The above operating guideline has been put into practice since 1980 and it is evident that overall management improvement has been made. Some shortages which would have caused severe damages to the country economy could be avoided.

4.4 OVERALL IMPROVEMENT

As shown in Figure 9, it can be seen that in the wet season the total volume of water diverted to the project area plus rainfall over the project area in the last four years (1987 - 1990) is less than the previous period (1980 - 1986). The saving for long term average year is about 15 - 17%. In the dry season, there is no significant difference (see Figure 10). This is due to concerted efforts made by all concerned but it is difficult to identify the impact of each activity. Further monitoring and analysis on this matter is essential to the overall improvement program.

Better water allocation at project level is due to closed coordination between RID and EGAT at all levels, shifting forward of crop

calendar in the lower part of the project area to make use of soil moisture after the wet season crop, re-use of drain water in the low-lying area by farmers' owns initiative and farmer awareness of possible water shortage in advance and others. They all contribute to the overall saving of water in the Chao Phraya project area.

Even though less water per crop season was used for irrigation in the wet season during 1987 -1990, the average yield of paddy in the project area remained more or less at the same level as in the previous period.[4]

5. OTHER ISSUES

5.1 NATIONAL DEVELOPMENT POLICY

As stated in the above, it is evident that the national policy on water resources development has been changed when necessary depending upon socio-economic condition and need of the people, political stability of the Government and the state of readiness of the farmers in the area.

In the early state of development in 1900's the main objective was for flood mitigation, inland navigation, supplementary irrigation and etc. The policy has been kept more or less the same until 1940's.

In 1950's when rice export was the major foreign currency earning of the country, the policy was emphasized on large scale project development where project justification was based on overall economic rate of return. On farm development and land consolidation projects were also justified for implementation when the price of rice was favorable.

In late 1970's, it was found that majority of the people who are farmers was still living under poor conditions with insufficient infrastructure and public utilities provided for by the Government. The development policy then switched to emphasizing on small scale project development as part of the Rural Development Program.

In the last few years the economy of the country being stable as never before, which creates new development in all sectors at unpredictable rate, particularly industries, real estate, resorts, infrastructure and public utilities development, tourism and etc. Irrigable lands have been used for other purposes which cause unnecessary double investment and overall agriculture production may not achieve as proposed. For example, resorts are being developed in the upper watershed without any proper overall planning, industrial estates being developed in the irrigable areas. Since there is no law prohibiting such changes of land use at present, it is most likely that

conflicts on water use will be inevitable in the future. Shortage of water for domestic uses, water pollution and flood drainage will be major problems to be tackled in the next decades.

Regarding the water resource development sector, water shortage have been experienced in many areas in the basin and outside. The construction of large storage dams to increase the supply of raw water in the basin has been supported by the Government but it probably requires a more thoroughly study on the environmental impact assessment and proper mitigation plans to make sure that overall environment will not be worsened.

In the next decade, water management improvement which includes hardware and software will become imminent and require special consideration. Efforts also have been made on the improvement of water management information as well as on the rehabilitation and modernization of existing irrigation projects which requires further detail study and training to make sure of its effectiveness.[18]

Industry development and tourism have been promoted in recent years, the demand of raw water and water supply for industries and resorts has been sharply increased. This could possibly create further conflicts on water allocation in the future.

In the 7th National Economic and Social Development Plan (1992 - 1996), improvement of basin planning and development is given high priority. Since there are several agencies being involved in the water resources development, clear policy guidelines and coordination become necessary to avoid and duplication of works and conflicts. The role and responsibility of the Secretariat Office of the National Water Resource Committee will be reviewed and institutionalized with legal support.

It has been generally accepted in principle at the policy level that water charges for industrial and other non-agricultural uses should be reviewed and put into effect as soon as possible. The matter is now being studied by the Ministry of Agriculture and Cooperatives. It is anticipated that a new policy on water charge and etc. will be formulated to the present Government for consideration in the near future.

5.2 INSTITUTIONAL ARRANGEMENT

At present, there are 24 departmental level agencies under 8 ministries involving in the water resource planning, development and management. Out of these agencies, 16 of them are involved in the construction of the projects, the others in planning, budgeting and personnel management.

At the national level, there are two national committees attached to the Prime Minister Office namely the National Water Resource Committee (NWRC) and the National Rural Development Committee (NRDC) who shall lay out the guidelines for development and to coordinate the activities of all agencies concerned. The NWRC more or less concerns in the overall development program whereas the NRDC concerns more in the overall coordination of small scale projects which is only a part of their responsibility.

At the ministerial level, to set up policy guideline and oversee the overall management of irrigated agriculture projects, there are several committees set up on ad hoc basis, but two of them are worth mentioning, namely the Committee on Policy and Agriculture and Cooperatives Development Plan and the Committee on Irrigated Agricultural Development. Both committees are chaired by the Minister of Agriculture and Cooperatives, and representatives of all departments concerned are committee members. The former concerns on policy matter while the latter on project implementation and provision of support services to the farmers in the project areas.

At the project level, a Subcommittee of the Irrigated Agriculture Development is set up where appropriate to do all the necessary coordination. The subcommittee is normally chaired by the Governor or the representative of MOAC, whoever appropriate, and all of the representatives of the departments concerned at provincial level become subcommittee members. The subcommittee shall work closely with water user groups and farmers.

On water quality and environmental aspects, the Government has established the Office of National Environmental Board (ONEB) in 1978. Environmental Acts were passed requiring the executing agencies to conduct the environmental impact assessment for specific sizes and types of projects. The enforcement on the executing agencies to conduct the proposed mitigation is, however, not strictly followed. This sometimes lead to the public outcry for the Government to look into the matter for more effective control.

A chart illustrating the organization of all related agencies and committee is shown in Figure 11.

5.3 RESPONSIBLE AUTHORITIES

The principal agencies in charge of the water resources development in the Chao Phraya river basin are as follows:

1. The Electricity Generating Authority of Thailand (EGAT), who is responsible for the construction operation and maintenance of the hydro-power plants, is in charge of the release of water for power generation, irrigation and others.

The operation has always been carried out in closed coordination with the Royal Irrigation Department.

2. The Royal Irrigation Department (RID), who is responsible for the water resource development, is also responsible for the water management of the irrigation system, and water allocation for other uses, such as water supply, inland navigation, prevention of saline water intrusion, and etc.

3. The National Energy Administration, who is in charge of the overall energy development policy, also carries out water resource development works mostly in the Northeast region and small pumping projects for irrigation all over the country as part of the rural development program. The activities of NEA in the Chao Phraya river basin is limited to small pumping projects along the rivers upstream of the Chao Phraya Barrage which require a fair amount of water for irrigation.

4. Agencies involved in the water resources development, water use and other related activities are shown in Figure 12. There are about 16 government agencies under 6 ministries involving in the small scale project construction whereas only 4 agencies in the large and medium scale projects construction.

5. The agencies involving in the nonagricultural use of water from the Chao Phraya river basin are the Metropolitan Water Works Authority (MWWA), the Provincial Waterworks Authority (PWWA), Harbor Department, Department of Fisheries, the Ministry of Interior, and the Ministry of Industry. The total water requirement of these activities is relatively small when compared to the total water demand for irrigation in the basin.

6. There are a number of government agencies who are associated with water resources planning and management. Such agencies contribute supporting services towards the agricultural development of the country as a whole. Most of these agencies are under MOAC namely: Extension Service Department, Cooperatives Promotion Department, Department of Agriculture, Department of Fisheries, Bank of Agriculture and Agricultural Cooperatives, Marketing Organization for Farmers, and etc.

Participation of the above agencies is in the form of committee members appointed by the Ministry of Agriculture and Cooperatives to carry out specific assignments mainly related to agricultural development, and policy planning.

5.4 COST RECOVERY AND WATER CHARGES

The Government has adopted as its policy to impose and collect

irrigation service fee for many years and indicated in the 6th National Economic and Social Development Plan (1986-1990) that all possible attempt should be exercised to impose and to collect the water charges and cost recovery charges from beneficiaries in the completed irrigation projects constructed by the Government. However, the progress has not been encouraging in the past.

At present, there exists two applicable laws which permit enforcement to collect the above charges, namely:[19]

1. State Irrigation Act B.E.2485 (1942) and its subsequent amendments No.2, 3, and 4 enacted in 1954, 1964, and 1975 respectively.
2. Agricultural Land Consolidation Act B.E.2517 (1974).

5.4.1 State Irrigation Act B.E.2485

This Act was first enacted in 1942, setting forth that land owner receiving the benefit from irrigation works in any irrigable area shall be subjected to payment of Irrigation Service Fee (ISF) at not more than 5 Baht per rai per year (US cent 12.5 per ha), and those who use water from irrigation waterway not more than 0.50 Baht (US cent 2.0 per m^3) for industrial purpose, waterworks, and others. It was required under this Act that it is the duty of the land owner or beneficiaries to pay the fee at the local project office of RID.

Although this law has been enacted for many years and amended as stated above but no real attempt has been made to collect the irrigation service fee. In 1987 another amendment was proposed to include the collection of irrigation service fee in the on-farm development projects which is under the responsibility of the Royal Irrigation Department as well as to leave the fee rates unspecified in the acts so that the rate can be adjusted according to the prevailing conditions of each project. Unfortunately, without clear reasons the draft amendment was subsequently withdrawn from the parliament for reconsideration by the Ministry of Agriculture and Cooperatives.

By amendment No.4 in 1975, it was stipulated that the Irrigation Service Fee shall be deposited into a Special Revolving Funds account and may be used only for operation and maintenance of the irrigation system in such manners set forth by the Ministry of Finance.

Before the State Irrigation Act is put into effect, the Minister of Agriculture and Cooperatives shall issue Ministerial Regulation designated areas to become Irrigation waterways subjected to pay irrigation service fee as stipulated in the said Act.

In 1975, the Minister of Agriculture and Cooperatives issued Ministerial Regulation No.11 prescribed for the first time the rates of water use for industries, waterworks, and others on volumetric basis as follows:

Less than 1,000 m^3/month or for public use as approved by Director General of RID	no charge
1,000 - 50,000 m^3/month	0.20 Baht or US cent 0.80
50,000 - 100,000 m^3/month	0.30 Baht or US cent 1.20
Over 100,000 m^3/month	0.50 Baht or US cent 2.00

In this Ministerial Regulation No.11, there is no mention about irrigation service fee for agricultural use of water.

A series of Ministerial Regulations were subsequently issued by the Ministry of Agriculture and Cooperatives in 1976, No.12 through 19 designated the irrigation waterways where the water taken is subjected to pay under the Act.

The total amount of irrigation service fee so far collected for industrial uses, waterworks and others is about US$ 1.1 million. This is due to the fact that only a small numbers of canals and reservoirs have been designated as irrigation waterways. Frequent changes of the Government also delay the issuance of Ministerial Regulation. The process normally takes about one year as it must go through several offices and endorsed by the cabinet before issuance of Ministerial Regulations become effective.

There are many reasons why collection of irrigation service fee has not been effectively imposed. The main reason may be that there has been no real political will to implement it. It is generally accepted that farmers are the lowest income group and need assistance. Therefore, it would not seem appropriate to put additional burden of collecting irrigation service fee on them which probably would cause unpopularity to the political party in charge of the Ministry of Agriculture and Cooperatives.

At present, total irrigable area in Thailand is approximately 3.1 million ha. The major part of the area has no on-farm facilities as most of the projects were designed for supplementary irrigation and water conservation. To collect irrigation service fee from the farmers at the rate of not more than five Baht per rai (US cent 12.5 per ha) as specified in the Act may be inappropriate at present because the fee was set up some fifty years ago. Further study on this matter is definitely required.

Attempts have been made recently to review the fee rate of water for industrial use as well as the areas designated as irrigation waterways. The matter is now being studied by the Ministry of Agriculture and Cooperatives.

The fee should at least reflect the investment cost as well as the operation and maintenance cost of the project.

5.4.2 Agricultural Land Consolidation Act B.E.2517

This Act was enacted in 1974 and applicable to the irrigable area where land consolidation works have been constructed. Such land consolidation area corresponds to about 9-10% of the total irrigable areas of the whole country.

Land owners in the land consolidation area are required under this Act to pay for the charges as follows:

1. To pay for part of the construction cost of land consolidation works, which the BAAC has been assigned to act as collecting agents and to pay the cost recovery charges to the Ministry of Finance.

2. To pay for the operation and maintenance cost which the water user's cooperative would be the executing and managing agents to be assured that the tertiary system will always be maintained and kept in working order at all time.

At present, the collection of cost recovery of land consolidation as well as operation and maintenance cost as specified in the Act have been carried out since 1984. The Act states that the subsidy to farmer shall not be less than 10% of the cost of land consolidation excluding land leveling costs. In practice, the subsidy varies from project to project depending upon the farmer's abilities to pay. As an example, in one project the subsidy is as high as 90%.

From statistics provided by the Office of Land Consolidation, MOAC, the areas approximately 269,315 ha are now under the land consolidation program located in 19 provinces of which 57.6% of the areas is in the Chao Phraya river basin. Demand notices to pay had been sent out to 58,963 farmers or 38.7% of the farmers. Under the program, only 57.9% has made payment to the Bank of Agriculture and Agricultural Cooperatives (BAAC) who has been given the responsibilities of recovering the money from the farmers. The payment could also be made by installment, with 12% interest and 2 years grace period.

In recent years, requests have often been made by the farmers through their local political representatives to defer the due payment and increase the percentage of government subsidy. The main reasons being that water delivery, as reported by the farmers, could not be made to their plots as needed and etc. which causes yield reduction below the target estimates. The price of paddy also being relatively low and could not be guaranteed by

the Government. All of these factors make it difficult for the farmers to pay the recovery cost.

As for the operation and maintenance cost of tertiary facilities, forty eight agricultural and water users cooperatives have been established and in charged for the collection of expenditures incurred from these activities. About 68% of the area is under the cooperatives' responsibility. The average O&M cost in 1990 collected by the cooperatives was about US$ 7.41 per ha.

Since the Government has been given high priority to the projects in the rural poor areas and the domestic price of paddy has been unstable in recent years, it is unlikely that the Government will launch a new program on land consolidation in the near future.

5.5 ENVIRONMENTAL CONSIDERATION

5.5.1 General

This section intends to describe the primary environmental setting in the Chao Phraya river basin together with the consequences due to recent development to cope with increased population. Major topics include, water quality, aquatic biology, groundwater, forestry and erosion. Finally, the future trend of environmental problems is predicted and the recommendations for mitigating those problems are proposed.

5.5.2 Water quality

(1) Water quality monitoring program. The water quality has been one of the most concerned environmental parameters which draws attention of most people in the country. The Office of National Environmental Board started monitoring water quality in the lower Chao Phraya river basin in 1981 covering a river stretch of 380 km from the river mouth.[17] A three-year monitoring program from 1985 to 1988 involved the measurement and the analysis of major water quality parameters such as :

- water and air temperature
- pH
- dissolved oxygen (DO)
- biochemical oxygen demand (BOD)
- chemical oxygen demand (COD)
- coliform bacteria
- total phosphorus
- Nitrogen group
- heavy metals
- Pesticide and insecticide and etc.

(2) Methods of water quality sampling. In general, the sampling conducted by the Office of National and Environmental Board (ONEB) followed the water quality standard sampling. Altogether 32 sampling stations were located over a distance of 380 km. The sampling was carried out on a monthly basis during the lowest ebb and highest tide of that month. The monitoring program has been implemented since 1981. Other agencies that are also involved in the water quality study include the Royal Irrigation Department, the Public Health Department, the Metropolitan Water Works Authority, the Provincial Water Works Authority, the Public Works Department and various academic institutions. However, their studies are not as extensive as those of the ONEB.

(3) Results of the water quality sampling. The critical period of poor water quality in the Chao Phraya river is found to occur from January to April of each year. Only the most critical value of each parameter of each year was presented as a function of distance from the river mouth.

The DO values were found ranging from 0 near the river mouth to 7 mg/l at the upper reach. These values correspond to the concentration of over 2300 industrial sites locating downstream in the region of the river mouth. These values seemed decreasing over the past 10 years. Similar results were confirmed by considering the BOD values which were ranged from 1 mg/l at the upper reach and 7 mg/l in the vicinity of the river mouth. The BOD values tend to increase over the past 10 years due to increasing waste load as a result of expansion of Bangkok metropolitan area audits activities. In 1987 the BOD value in the vicinity of Bangkok amounted to 183,622 kg/day. It was estimated that the sources of the BOD came from residential areas, business places, industries, and others with the contribution from each source in the order of 40%, 32%, 25%, and 2%, respectively.

The values of total coliform bacteria and fecal coliform bacteria which are the direct results from human's excretion have increased drastically particularly around Bangkok city from km 42 to the river mouth. In 1990 the value of each bacteria was well over 3,500,000 MPN/ml.

Heavy metals were found insignificant in 1981 with the range from 0 to 0.06 mg/l but became higher up to 0.15 mg/l in 1990. Such high values seem not to correspond to land use characteristics since there are not major industries in the area. Further investigation into this matter is to be pursued.

Pesticide and insecticide were rarely detected. However, dieldrin was found to be more than the allowable standard of 0.10 g/l at least at three locations corresponding to major irrigation areas. The peak value was measured at Pathumtani area which was recently promoted to become one of the major

horticulture area where higher values of dieldrin were used.

Salinity measurement provided a very interesting result. The recently measured salinity values were found to be less than 2.0 mg/l and became declining and not regarded as a parameter of great concern like in the past. Such decrease in the values of salinity might be caused by more waste water being discharged from Bangkok dwellers into the Chao Phraya river and pushed back that salinity wedge downstream.

(4) Water quality classification. As a result of the above findings the ONEB compared the measured values of water quality parameters with the standard values which resulted in a classification of the lower Chao Phraya river into 3 zones as follows:

Zone	Water quality	Conditions and usages
0 km - 62 km	class 4	fairly clean but require special treatment before consumption and good for industry
62 km - 142 km	class 3	medium clean but require ordinary treatment prior to consumption and good for agriculture
142 km - 379 km	class 2	very clean but require ordinary treatment prior to consumption and good for aquatic life and for recreation

5.5.3 Aquatic biology

(1) Macrophyte. A recent survey by a study team of Social Research Institute of Chulalongkorn University in 1987 indicated that only few species of macrophyte were scattered in the Ping and the Nan rivers, the two major tributaries of the Chao Phraya river.[20] Distinct species include Bichornia crassipes, Ipomea aquatica, Juocia repens, Mimosa pigra, etc. The Bichornia crassipes generally causes a retardation in water flow and may cause high loss of water through evapo-transpiration. Mimosa pigra, a giant weed, has become a nuisance to farmers due to its rapid growth. This has lead farmers to employ herbicide to limit the excessive expansion of weeds.

(2) Plankton. The species density of plankton in the Ping and the Wang rivers were found relatively high with 2-3 million and 0.5-1.5 cells per m^3 of water body in each tributary respectively. This indicated that the water resource was still highly productive as a source of nutrients for

aquatic life.

(3) Benthos. The species diversity of benthos was moderately low with 4-48 and 8-100 in numbers per square foot in the Ping and Nan rivers respectively. Dominant species include Limnoperna sp., Chironomus sp., and Lumbricula sp.

(4) Fish population. In 1987 a study team of Chulalongkorn university reported 34 and 31 species of fish found in the Ping and the Nan rivers, respectively. Most fish are in the Family Cyprinidae. The standing crop of fish found in the Ping and the Nan rivers amounted to 6-8 kg/ha and 1-3 kg/ha, respectively. In 1955 the department of fisheries conducted a survey of the fish-fauna in the Chao Phraya river from km 380 to the river mouth and resulted in 127 species of fish found. Such a big decline in fish species may be caused by increased water pollution and increasing use of fish for consumption to cope with increased population.

5.5.4 Forestry

The comparison of existing forest land and its periodic changes between 1976 and 1989 showed that the forest area in the northern part of Thailand is reduced from 102,327 sq km (60% of total area) to 80,222 sq km (47% of total area).[21] This rapid decline of forest area by 21% of the existing forest since 1976 corresponds to about 1.6% reduction per year. A rapid decrease in forest covered land may contribute to a very high rate of sedimentation of 1250-6250 ton per sq km per year as reported by the study team of Chulalongkorn University in 1987.

5.5.5 Groundwater

(1) Groundwater development. In the lower part of the northern Chao Phraya river basin there are some on-going groundwater development projects. In the lower part of the Chao Phraya river basin there is a good potential for groundwater development. Increasing use of groundwater for industry is popular as it is cheaper than piped water supplied by the Provincial Water Works Authority. However, increasing extraction of groundwater has resulted in land subsidence in the order of 5 to 20 cm per year, salinity intrusion into some aquifers and flooding. In 1985 the ground water Act was passed enforcing a reduction of groundwater extraction. At present less than 10% of water use in Bangkok came from groundwater.

(2) Groundwater quality. The Department of Mineral Resources conducted a study of groundwater quality in the early 1980's. It appeared that most substances were within the maximum allowable levels and the wells produced drinking water of suitable quality.

6. CONCLUSION

1. In the past, the Government has spent an enormous amount of money for water resources development with main objectives of increasing income of the people in the basin and improving overall economy of the country. Most of the projects have more or less achieved the objectives. Not enough attention was paid on environmental issues as the various resources were abundant and the population was much less than nowadays. However, the increasing competition for the exploitation of natural resources has resulted in an environmental degradation. The Government has given a special attention in the past ten years by passing several laws related to this matter. Gradually tightening of law enforcement is definitely required.

To prevent further degradation of limited natural resources, the external technical and financial supports as well as cooperation among all concerned are definitely required.

2. From the past development policy, it is evident that the justification of project implementation is not always based on the economic rate of return of the project but social and political considerations were also taken into account with the main objective of improving the standard of living of the people in the basin. Water allocation and management criteria was not strictly based on the economic value of water. In the past, higher priority was always given to the allocation of water for agriculture.

In the future, conflicts on water allocation will become inevitable. As industrial development is being promoted in the basin, a new criteria will probably be required. Detail study on water allocation and management criteria taking into consideration not only the social implication but also the economic value of water should be carried out.

3. As reported in previous studies, the regulated water supply of the basin is fully committed. Attempts have been made on improvement of water use efficiency since 1980. Operating guideline and procedure for the two large reservoirs and irrigable area were established and put into practice with slight modification as found necessary. Coordination among all parties concerned also was given special attention. As a consequence, some saving in overall water use is noticeable and encouraging particularly in the last four years. No reduction of average yield per ha was observed. The farmers also played an importance part in making efficient use of water by reusing of drained water for irrigation, forwarding the crop calendar in the dry season about two months and etc.

4. The construction of a large reservoir on the Yom basin has been proposed to increase the regulating water supply in the basin. The project

will probably receive opposition from the environment and conservation groups who want to save the teak forest and wildlife inhabited in the proposed reservoir area. At the same time, it becomes more difficult now to locate a large area suitable for resettlement of the people who are now living in the proposed reservoir area in order to conform the international financial institute guidelines. The conflicts of such nature become more and more concerned by the Government and probably require time and efforts to compromise the differences.

In fact, the Government has given supports to the project development because it is the only large reservoir left undeveloped in the basin with high development potential. The project will definitely require external financing and technical supports.

5. On project modernization for better O&M performance, many studies have been carried out since 1985 mostly under technical assistance programs provided by developed countries and financial institutes. Several ideas recommended in the studies have already been incorporated in the design of new projects on piecemeal basis without detailed analysis of the total system. There has been no progress made on the proposed recommendation on modernization submitted in the studies. This was partly due to the change of development policy of the last administration and change of some key personnel within the RID administration.

A small pilot project was implemented in one of the medium scale projects in the basin using downstream control regulator gates and etc., but no evaluation to assess the potential benefits of modern method on water management and staff requirement was made. Further assistance on this matter both technical and financial would definitely be required so that future improvement or modernization program could be properly formulated and implemented in the basin.

6. It was generally agreed in principle that the cost recovery and water charge should be imposed on farmers or beneficiaries in the irrigable area but so far there has been no political will to impose the charge. This can be confirmed by the fact that no progress has been made on imposing water charge on the farmers since the State Irrigation Act was enacted in 1942.

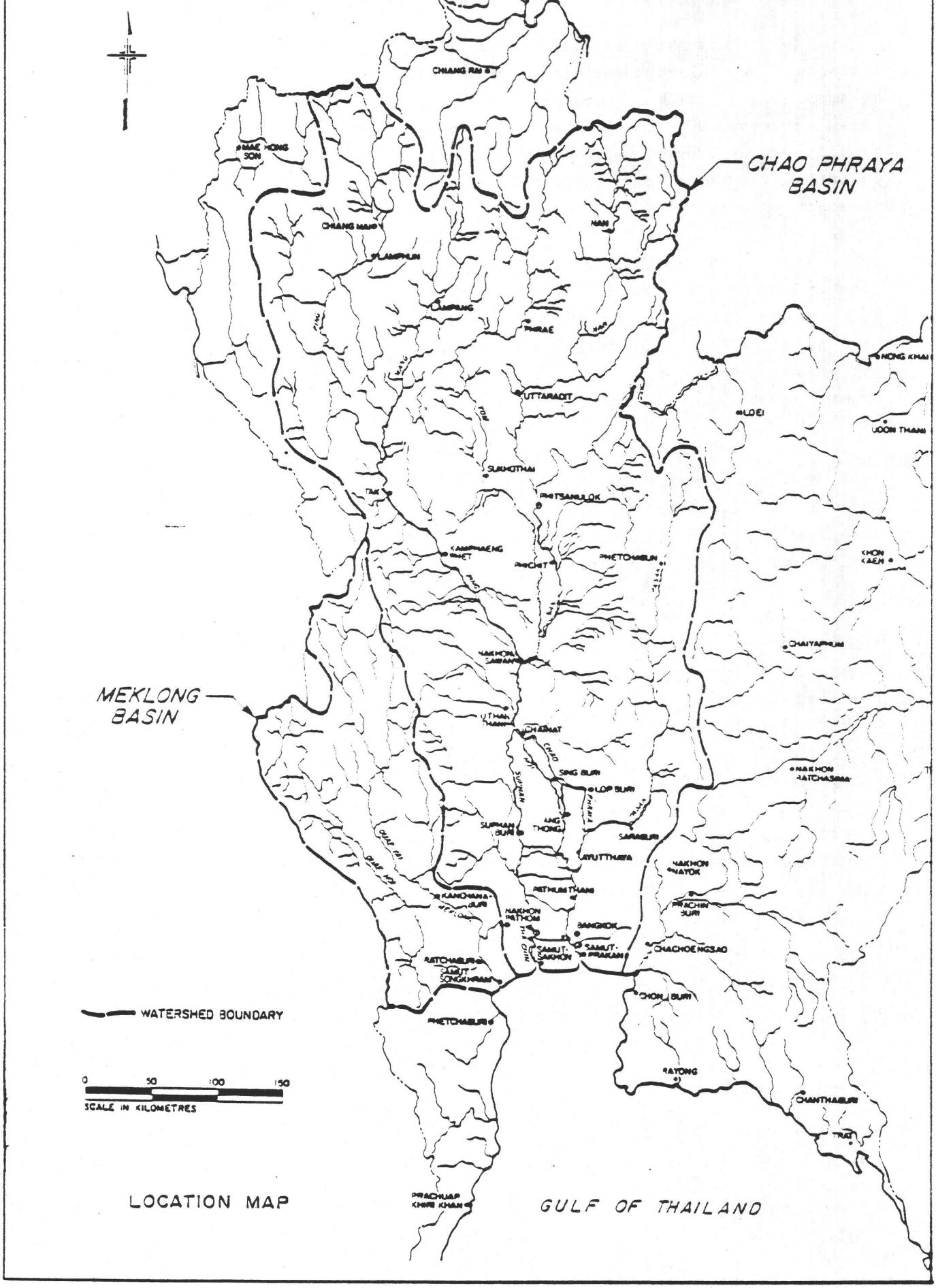
On the other hand, water charge for industrial use and others has been collected since 1976. It is also agreed in principle at the policy level that the charge should be increased to reflect the cost of construction as well as the operation and maintenance cost of the project. The matter is now being studied and expected that the recommendation will be submitted to the Government for consideration and approval in the near future.

Cost recovery has been imposed in all land consolidation projects. The collection so far is well in progress. Due to the unstable price of agricultural products and lower yield than estimated target, the farmers often requested through the local Member of Parliament House to raise the subsidy of the Government. These requests were generally accepted by the Central Land Consolidation Committee who are responsible for the overall development policy.

7. The institutional and organization arrangement seems to function more or less in accordance with the responsibility given. Definitely there are rooms for further improvement. The performance of each committee depends very much upon personnel appointed. The committee may work well during a certain period and no progress made at all during the others. It is rather difficult to make a general conclusion of the overall performance of the present set up.

It is generally felt that the establishment of the National Water Resource Committee with strong Secretariat Office should improve the coordination, better formulation and supervision of the overall water development policies. A study is now underway to legalize the Secretariat Office specifying the responsibility and its function.

8. On the environmental aspects, an extensive water quality monitoring program has been going on for the last decade. The results identified sources of pollutants and various remedial measures were proposed. The issues of agricultural waste upstream resulting in poor quality of raw water supply for the municipalities downstream requires further consideration in order to formulate an appropriate program for minimizing its effect. Future water resource development project should include watershed management activities as a necessary component of implementation of the project. Extra release of water from reservoirs for better control of water quality downstream as well as preservation of the eco-system of aquatic life should also be considered. Since these issues are relatively new in the region, technical assistance on this matter is urgently needed.


CHAO PHRAYA BASIN
MEKLONG BASIN
WATERSHED BOUNDARY
0 50 100 150
SCALE IN KILOMETRES
LOCATION MAP
GULF OF THAILAND
CHIANG RAI
MAE HONG SON
CHIANG MAI
LAMPHUN
LAMPANG
PHRAE
NAN
NONG KHAI
LOEI
UDON THANI
UTTARADIT
SUKHOTHAI
PHITSANULOK
TAK
KAMPHAENG PHET
PHICHIT
PHETCHABUN
KHON KAEN
CHAIYAPHUM
NAKHON SAWAN
UTHAI THANI
CHAINAT
SING BURI
LOP BURI
NAKHON RATCHASIMA
SUPHAN BURI
ANG THONG
SARABURI
AYUTTHAYA
NAKHON NAYOK
KANCHANA-BURI
PATHUM THANI
PRACHIN BURI
NAKHON PATHOM
BANGKOK
SAMUT-SAKHON
SAMUT-PRAKAN
CHACHOENGSAO
RATCHABURI
SAMUT-SONGKHRAM
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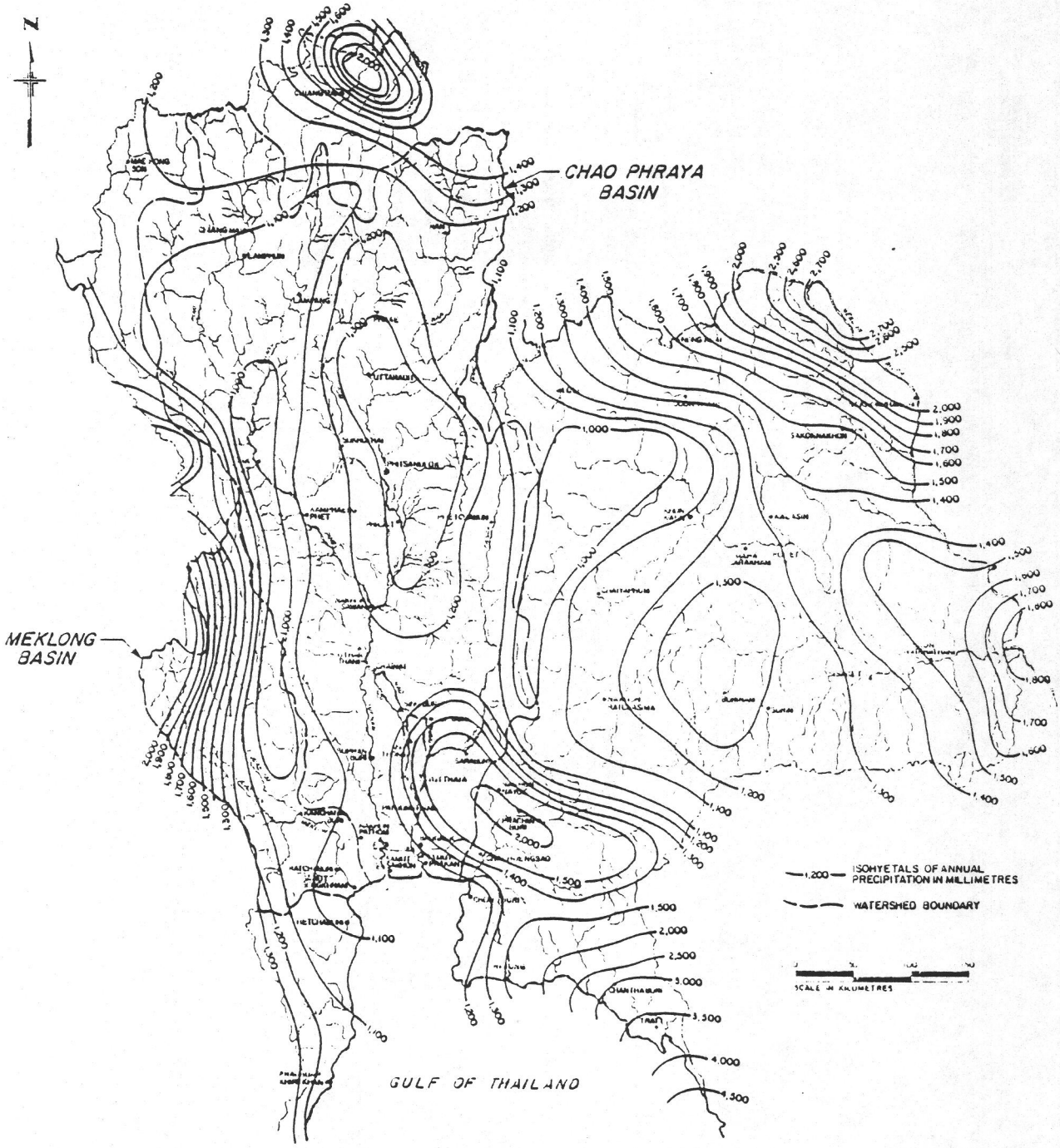
PHETCHABURI
RAYONG
CHANTHABURI
TRAT
PRACHUAP KHIRI KHAN

FIGURE 1

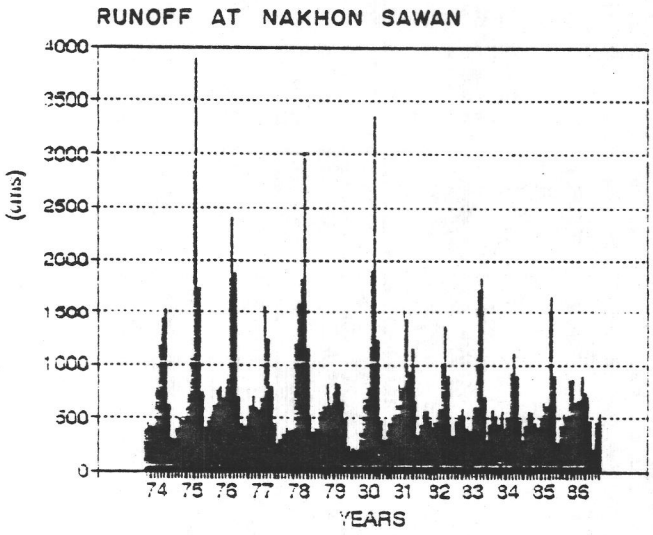


SOURCE:

MAP PREPARED BY METEOROLOGICAL DEPARTMENT, MINISTRY OF COMMERCE.

ISOHYETAL MAP

FIGURE 2


RUNOFF AT NAKHON SAWAN
(cms)
4000
3500
3000
2500
2000
1500
1000
500
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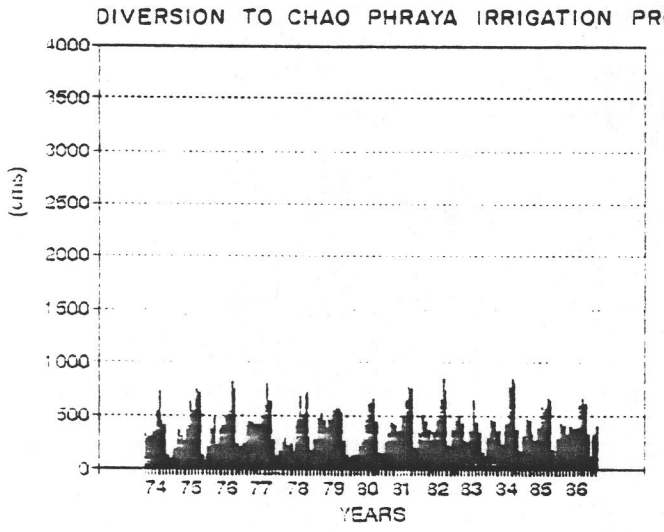
74 75 76 77 78 79 80 81 82 83 84 85 86
YEARS


DIVERSION TO CHAO PHRAYA IRRIGATION PROJECT
(cms)
4000
3500
3000
2500
2000
1500
1000
500
0
74 75 76 77 78 79 80 81 82 83 84 85 86
YEARS

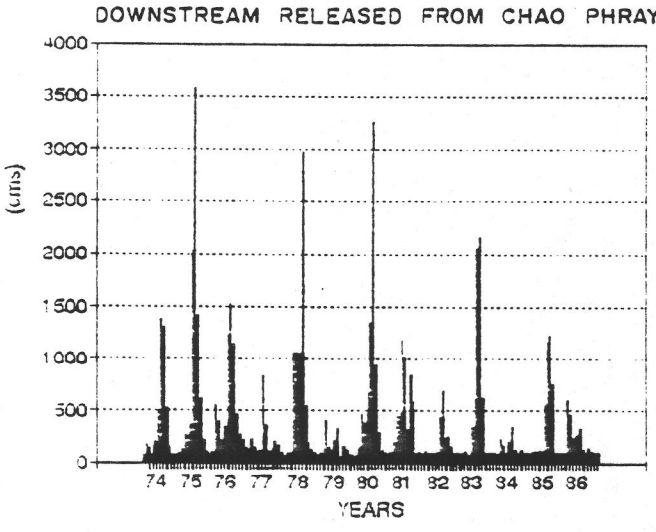
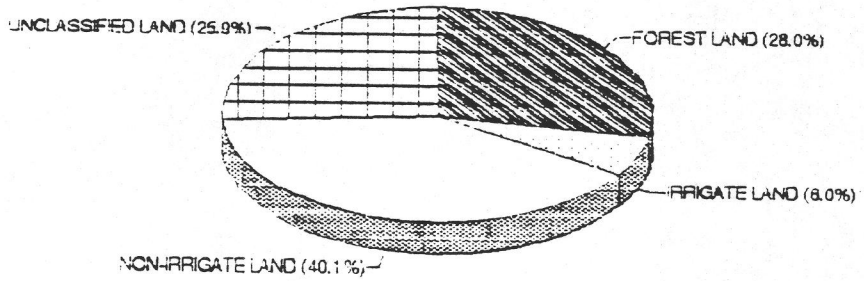
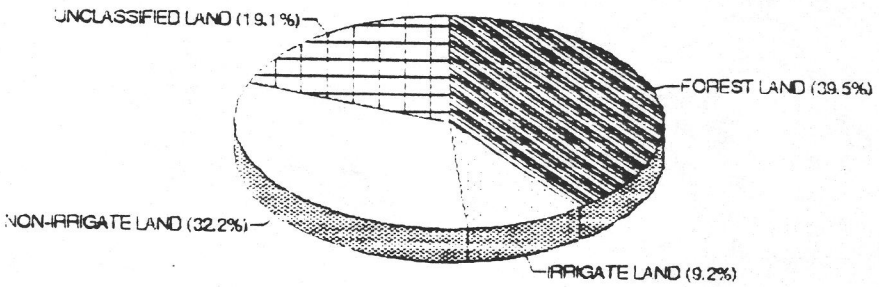

DOWNSTREAM RELEASED FROM CHAO PHRAYA BARRAGE
(cms)
4000
3500
3000
2500
2000
1500
1000
500
0
74 75 76 77 78 79 80 81 82 83 84 85 86
YEARS

FIGURE 3

LAND USE



WHOLE COUNTRY



CHAO PHRAYA BASIN

Source: 1) Agricultural Statistics of Thailand, Crop Year 1989/1990
2) Table showing water resources development in Thailand (large-medium scale projects) Royal Irrigation Department, May 1989

FIGURE 4

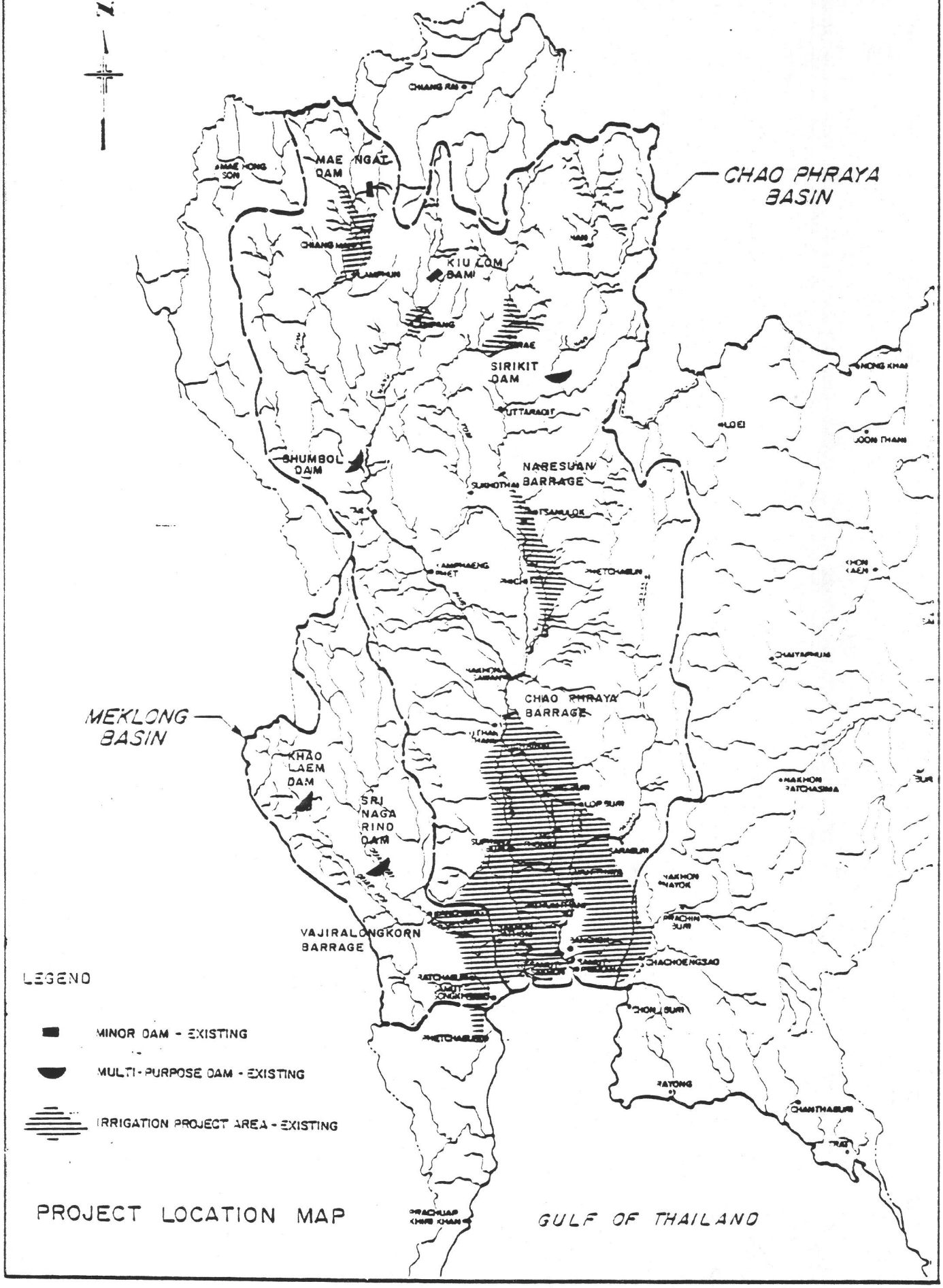

CHAO PHRAYA BASIN
MEKLONG BASIN
MAE NGAT DAM
KIU LOM DAM
SIRIKIT DAM
BHUMBOL DAM
NARESUAN BARRAGE
CHAO PHRAYA BARRAGE
KHAO LAEM DAM
SRI NAGA RIND DAM
VAJIRALONGKORN BARRAGE
LEGEND
MINOR DAM - EXISTING
MULTI-PURPOSE DAM - EXISTING
IRRIGATION PROJECT AREA - EXISTING
PROJECT LOCATION MAP
GULF OF THAILAND

FIGURE 5

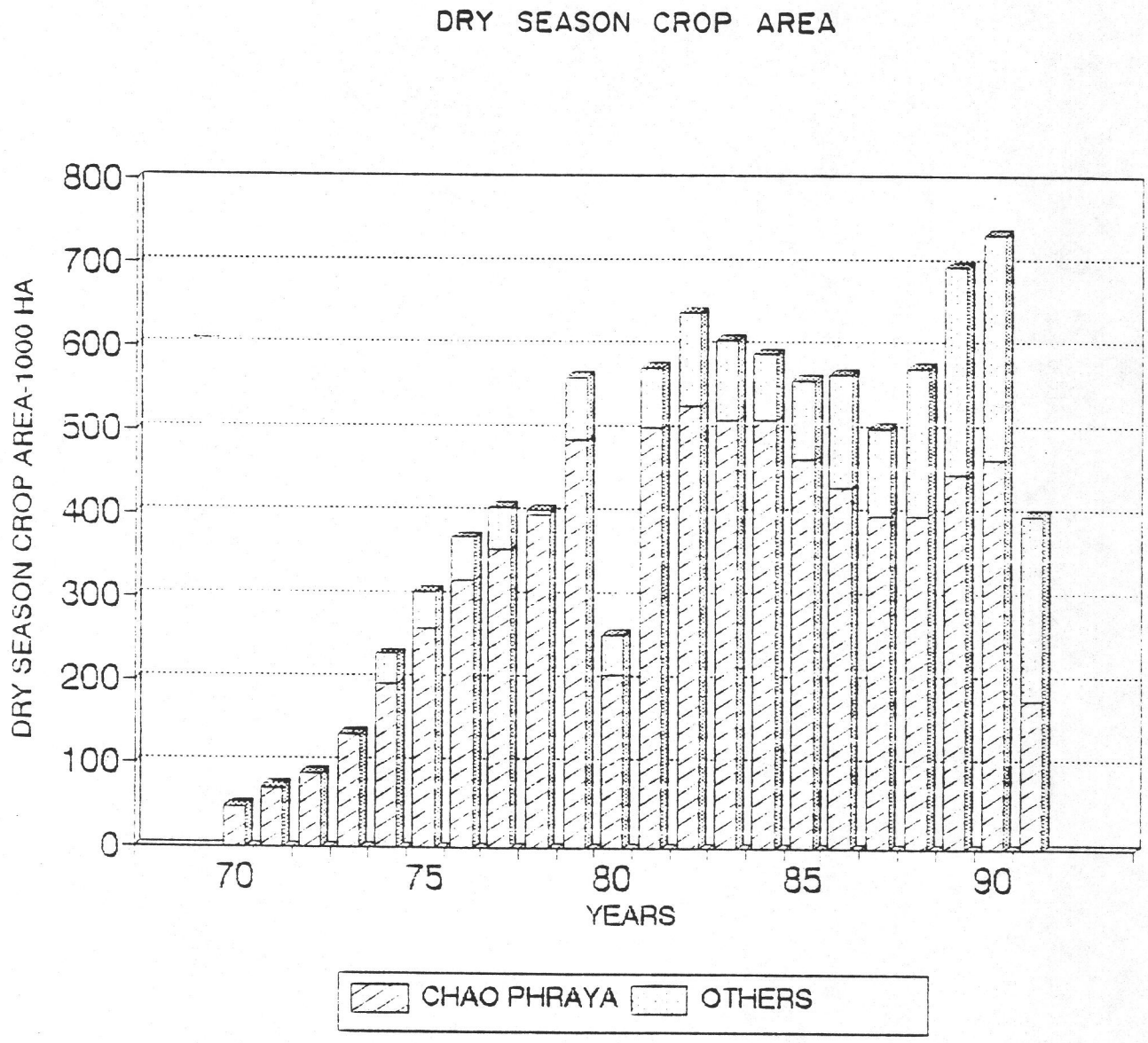
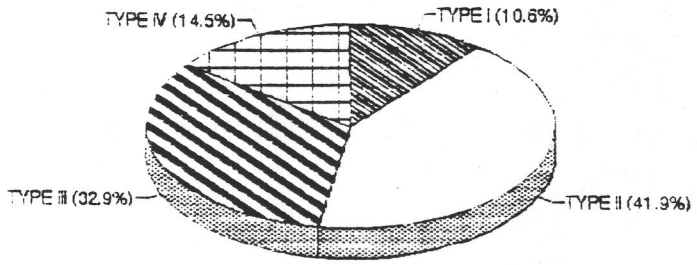
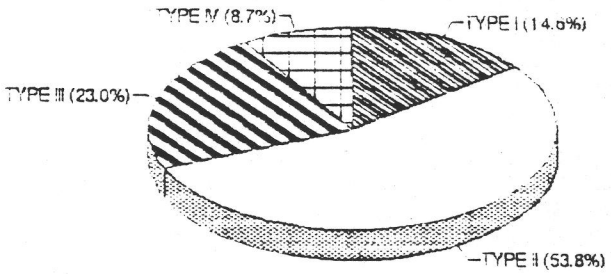

DRY SEASON CROP AREA
DRY SEASON CROP AREA-1000 HA
800
700
600
500
400
300
200
100
0
70
75
80
85
90
YEARS
CHAO PHRAYA
OTHERS

FIGURE 6

TYPE OF IRRIGATION
(CULTIVATED AREA)



WHOLE COUNTRY

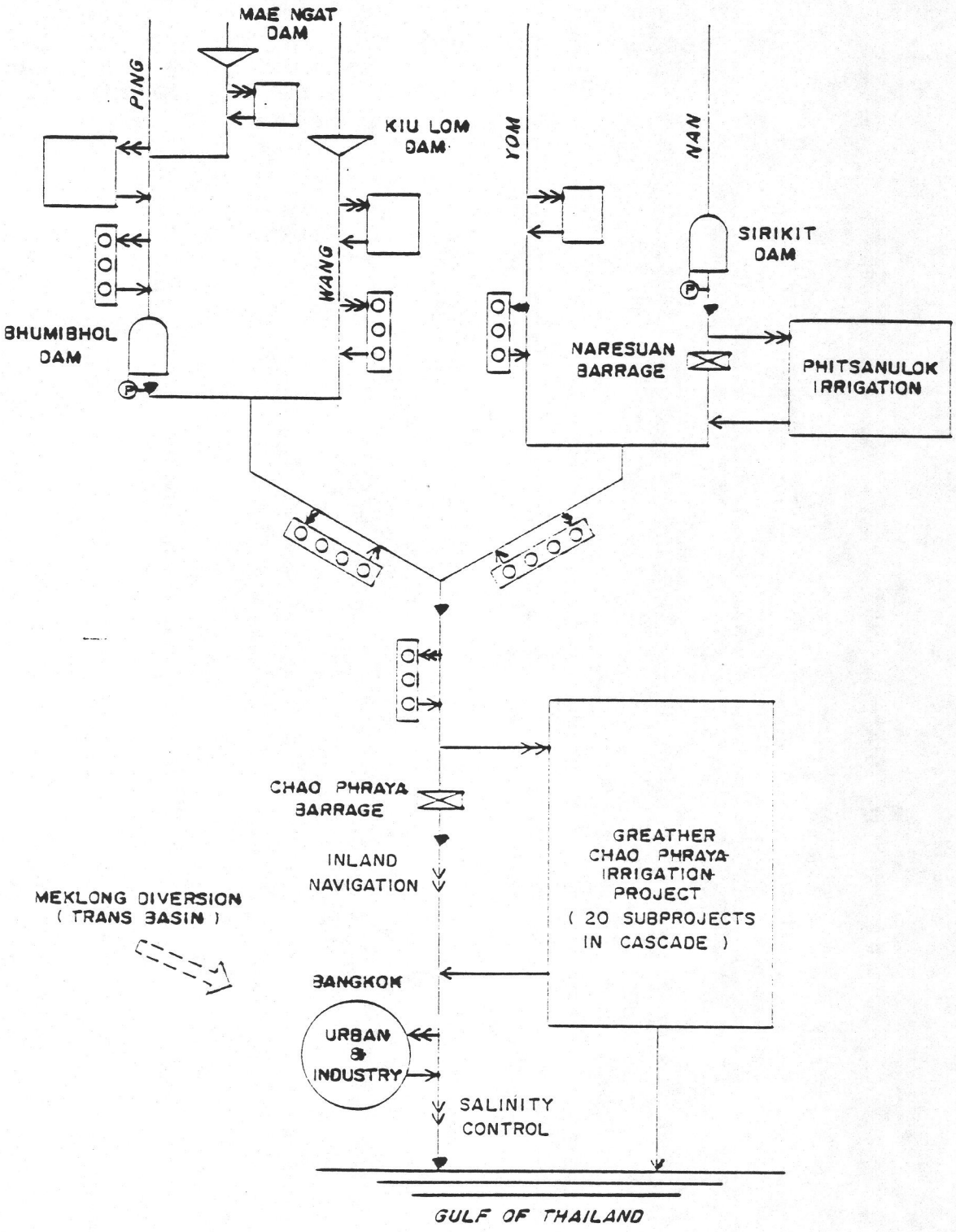


CHAO PHRAYA BASIN

Remark: Type I : Land consolidation
Type II : Ditch and dike project
Type III : Main and secondary canal
Type IV : Minimum irrigation facilities

Source: Report on crop area and yield (wet season) in irrigation projects, 1988/1989, O&M Division, RID.

FIGURE 7

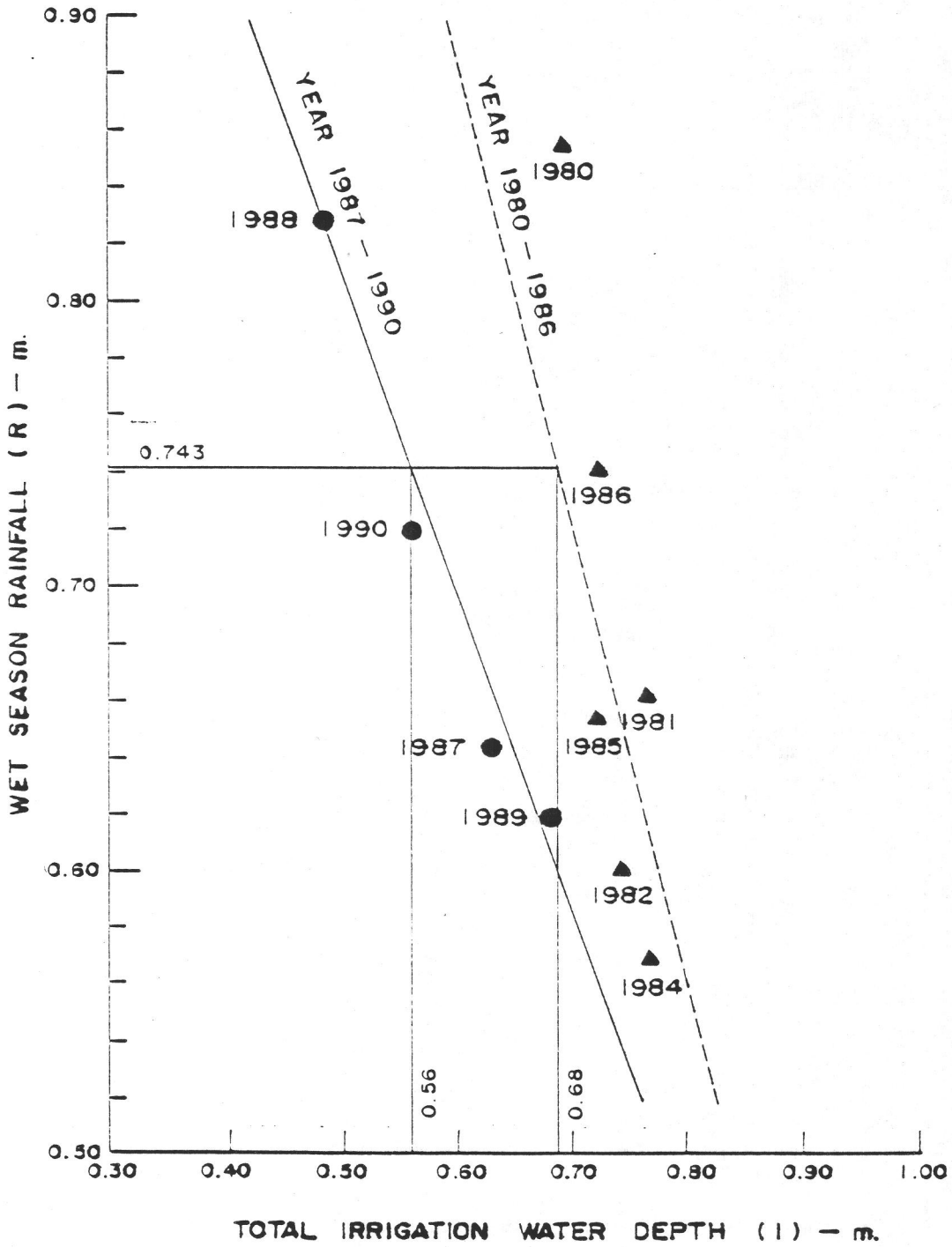


SCHEMATIC DIAGRAM OF CHAO PHRAYA WATER USE SYSTEM

FIGURE 8

Wet Season Paddy Cultivation Water Use (1980—1990)

Greater Chao Phraya Project

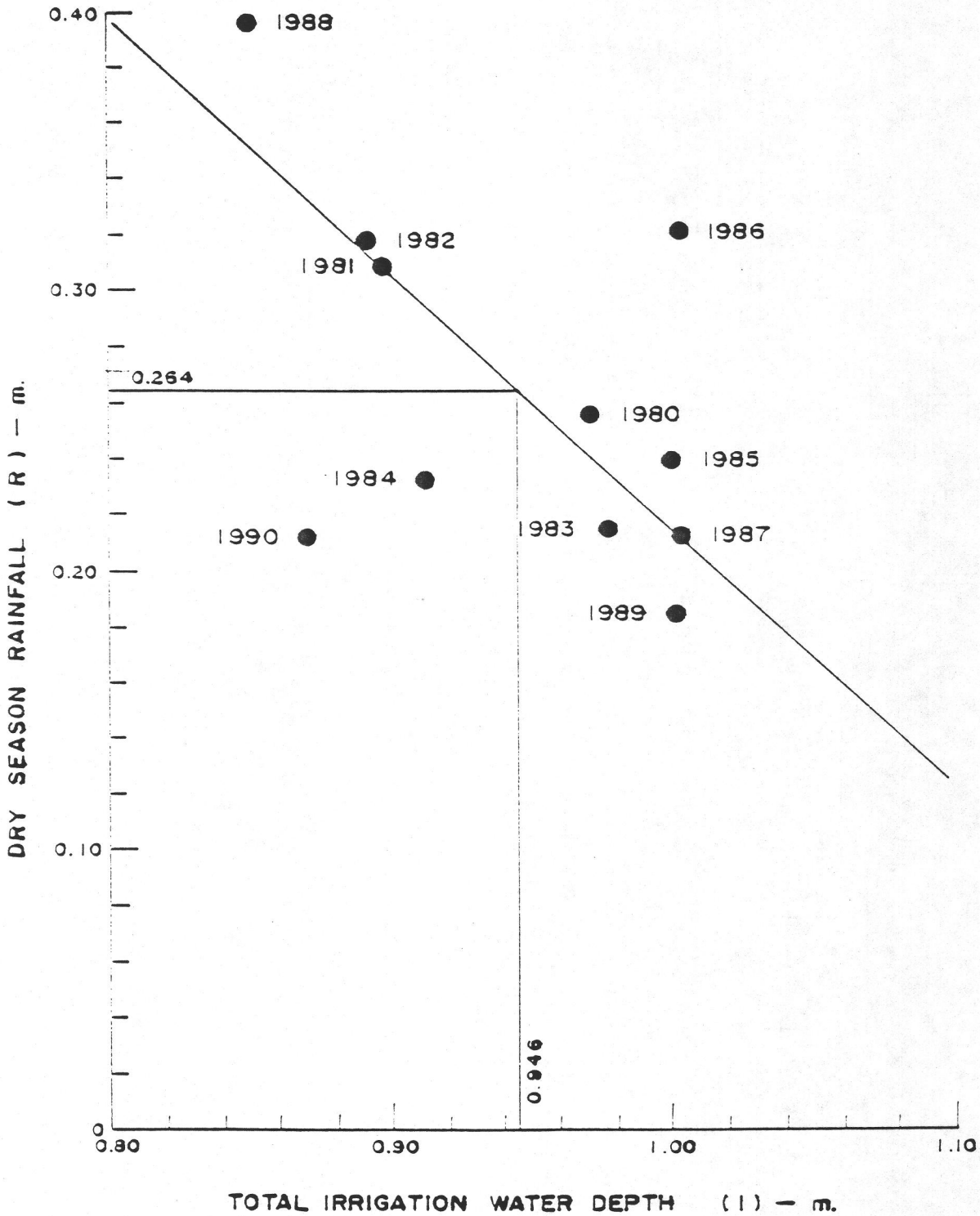


Water Operation Center
Apr. 30 , 1991 A.M.

FIGURE 9

Dry Season Paddy Cultivation Water Use (1980 — 1990)

Greater Chao Phraya Project



Water Operation Center

Apr. 30, 1991 A.M.

FIGURE 10

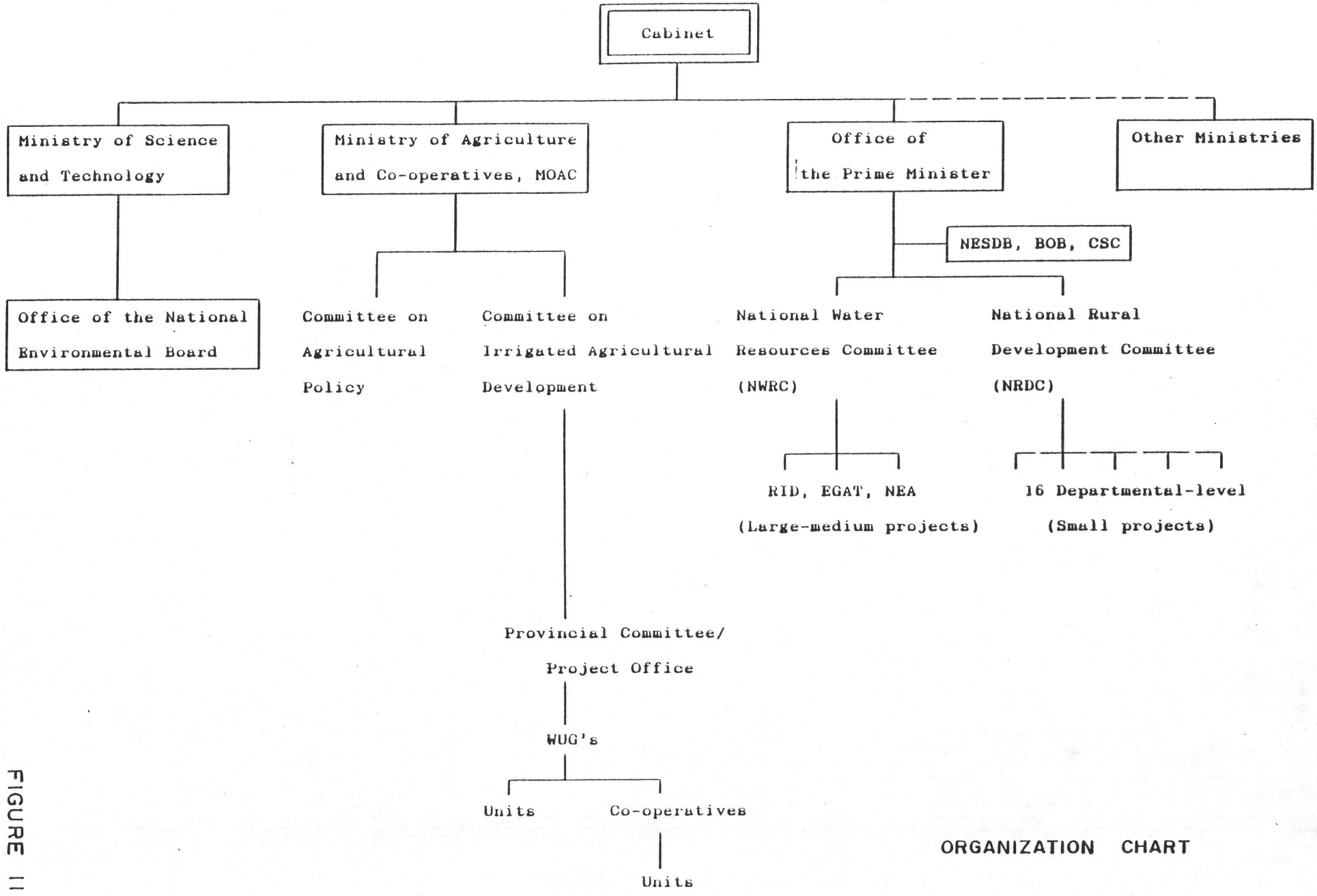


FIGURE 11 ORGANIZATION CHART

List of agencies involving in water resources development, water use and other related activities

Activities / Ministry / Department	A	B	C	D	E	F	G	H	I
Ministry of Interior									
Dept. of Local Administration			x					x	S
Public Works Dept.			x						S
The Office of Accelerated Rural Development			x						SM
The Community Development Dept.			x						S
The Metropolitan Water Works Authority*			x		x				-
The Provincial Water Works Authority*			x		x				S
Bangkok Metropolitan Administration			x		x			x	-
The Provincial Electricity Authority*		x							S
Ministry of Public Health									
Dept. of Health			x			x			S
Ministry of Industry									
Dept. of Mineral Resources			x						S
Dept. of Industrial Works					x	x			-
The Industrial Estate Authority of Thailand*			x		x				-
Ministry of Agricuture and Cooperatives									
Royal Irrigation Dept.	x		x	x	x	x	x	x	SML
Land Development Dept.	x								S
Dept. of Fisheries	x					x	x		-
The Royal Forest Dept.	x								S
Dept. of Agriculture	x								-
The Cooperative Promotion Dept.	x								S
Agriculture Land Reform Office	x								S
Dept. of Livestock Development	x								-
Ministry of Science, Technology and Energy									
The National Energy Administration	x	x	x						SM
Ministry of Transport and Communication									
The Harbour Dept.				x					-
Ministry of Defence									
National Security Command Division	x		x						S
Royal Thai Army (Second Army Area)	x		x						S
Office of the Prime Minister									
The Electricity Generating Authority of Thailand*		x				x		x	L

Note: A = Irrigation and agriculture B = Hydropower C = Domestic D = Navigation
E = Industry F = Water Quality G = Fishery H = Flood Alleviation
I = Implementation (L:Large, M:Medium, S:Small Project)
* State enterprise agency

FIGURE 12

Translation of an excerpt from State Irrigation Act B.E.2485

Article 8. The Minister shall have the power to collect Irrigation Service Fee "ISF" from owner or the person who has in his possession the land in the irrigation service area, or from the person who makes use of the water in the irrigation system, regardless of whether the beneficiary is inside or outside of irrigation area. Collection of the said Fee shall be imposed by announcement of the Ministerial Regulation to the effect stating the followings:

1. Each of the irrigation waterways or irrigation service area which is subjected to collection of ISF shall be identified in the map showing its boundary limit.

2. The area and locality which are included in each of the irrigation service area subjected to collection of ISF shall be stipulated and exhibited in the map showing its boundary limit.

3. Rates of ISF which shall be collectible from the owner or the person who has in his possession the land in the irrigation service area or from the person who makes use of the water for agricultural purpose outside the irrigation service area.

4. Rates of ISF which shall be collectible from the person who makes use of the water in factories, water works, or for other purpose, inside or outside of the irrigation service area.

5. Guidelines, regulations and procedures applicable to the collection or payment of the ISF including the waiver, reduction or method to make installments on the ISF.

Maximum ceiling of the rates of ISF collectible from the owner or the person who has in his possession the land in irrigation service area, or from the person who makes use of the water for agricultural purpose outside the irrigation service area shall not be higher than 5 Baht per rai per year.

Maximum ceiling of the rates of ISF collectible from the person who makes use of the water in factories, water works, or for other purposes shall not be higher than 0.50 Baht per m^3.

(N.B. the original text of Article 8 was amended by Article 4 of the State Irrigation Act (Amendment No. 4) in 1975 as revised above)

Article 8 Bias. A revolving funds shall be established in the Royal Irrigation Department which shall be called " Revolving Funds for Irrigation Purpose A/C."

The ISF as collected under the stipulation in Article 8 shall be deposited to this Revolving Funds for Irrigation Purpose A/C instead of paying into the Treasury being national income.

Payment from the Revolving Funds for irrigation purpose is subjected to the regulations to be adopted by the Minister with the consent of the Ministry of Finance.

Within a period of ninety days following the end of each government fiscal year. The Minister of Agriculture and Cooperatives shall declare and publish the receipt and payment details of the Revolving Funds for Irrigation Purpose A/C in the Royal Gazette,

Financial Report described in paragraph 4, once it has been checked by the National Audit Council for presentation to the Parliament for information.

(N.B. The above Article 8 Bias was added by Article 5 of the State Irrigation Act (Amendment No.4) in 1975)

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