4.2 Water Resources Management

As explained in the above 4.1 "Water Resources Development", the water resources in the upper Chao Phraya is very limited as shown in Table 4.1.12 and Table 4.1.13. The Table 4.1.13 shows the average annual runoff of 20,000 MCM in the recent years at the Chai Nat barrage site collecting all runoff of the Nan, Yom, Wang, ping and Sakae Krang basins, while the Table 4.1.12 shows the water demand for irrigation and other uses in the above basins amounting to 10,000 MCM at present and increased to 19,000 MCM in future. Accordingly the potential water resources at the Chai Nat barrage in future will decrease to 11,000 MCM from the present 20,000 MCM.

It can be predicted that the Chao Phraya Delta using the water resources at the Chai Nat barage will face a critical water shortage problem near future and could not maintain sustainable agricultural productivity and socio-economical development due to decreasing water resources in the upper Chao Phraya basin.

The water resources development to provide reservoirs, canal systems, pumping facilities, etc. has been preoccupied in the upper Chao Phraya basin due to accelerated irrigated agricultural development in the basin but the water resources management has not been considered carefully. Most of the developed water resources by the projects have not been effectively and accurately managed yet at present stage. It is therefore necessary to improve the existing water resources management including basic concepts and rules, practical methods and institutions in order to ensure effective and optimum use of valuable water resources.

The phrase "Water Resources Management" or "Water Management" has pervaded in many countries and has become an important keyword in the resent years. However the water resources management has been discussed in most of the cases, without common understanding of its classification and content.

The water resources management covers a wide range of field and for different purposes and roles as explained below. The water resources management will be classified into five (5) categories for discussion namely; (1) Watershed Management, (2) River Flow Management, (3) Water Sources Management, (4) Water Diversion and Distribution Management and (5) Water Use Management.

4.2.1 Watershed Management

Rainfall is the sole source of the water resources and it is impossible to manage the rainfall by the might of man-kind. Although the potential water resources in the basin are different depending on the rainfall, intensity and duration, quantity and quality of the water resources will be largely changed by the watershed conditions. Although the northern mountain area of the upper Chao Phraya basin is covered with dense forest area to foster the water resources, the middle and lower reaches of the area are mostly formed with plateau and farm areas wherein the rain water can be easily lost by evaporation and water consumption. A part of forest and farm lands has been devastated by slush-burn farming, tree cutting, soil erosion and land sliding and can't foster the water resources. The watershed management accordingly, shall be carried out to preserve the good watershed to foster rain water and to produce the proper runoff yield.

(1) Survey and Study Items

The following survey and study will be required to implement the proper watershed management.

(a) Division of River Basin

The river basins of Nan, Yom, Wang, Ping, etc shall be divided into the sub-basins and small sub-basins in order to grasp and judge the watershed features and potential runoff yield. For example, the Nan basin can be divided into the upper Nan consisting of 8 sub-basins and the lower Nan with 7 sub-basins as shown in the Supporting Report.

(b) Land Use

Land use shall be studied applying the Sattelite Image analysis method in order to grasp the natural conditions in the watershed. Forest area classified into dense forest, thin forest, devastated forest. etc, farm area into paddy and field crop, fruit yard, grass land, etc. and other area into wetland, bear land, lake and swamp, urban and village, etc are to be analyzed on the small sub-basin basis. All areas of the above categories of land use shall be measured by the Sattelite Image analysis. For example, the land use of the Yao sub-basin in the upper Nan and the Kok-Ing lower basin is surveyed by the Sattelite Image analysis by JICA Team and the result is shown in the Supporting Report.

(c) Devastated Watershed

Devastated watershed conditions such as slush-burn farming area, wasted forest and fallow land, erosion and land sliding area, etc are also surveyed by the Sattelite Image analysis. Flow conditions such as rapid flow, peak flood, sediment transport, river course erosion, etc in the tributaries flowing down in the devastated watershed shall also be surveyed by the reconnaissance survey team.

(d) Runoff Yield

The potential runoff yield shall be analyzed on the divided sub-basins taking into account the rainfall intensity, topography, land use conditions, observed discharge data, etc.

The runoff yield in the representative basins and at the control points has been studied by JICA Team and summarized in Table 4.2.1.

Table 4.2.1 Runoff Yield at Representative Basin

Basin	Basin Area (km^2)	Annual Rainfall (mm)	Annual Runoff (MCM)	Runoff Yield (mm)
1. Nan Basin				
Upper Nan, Yao	770	1,400	355	458
-do- N17	1,160	1,500	677	586
-do- N1	4,610	1,300	2,642	573
Sirikit Inflow	13,130	1,200	4,753	362
Sirikit Outflow	13,100	1,200	4,326	329
Naresuan, Inflow	19,500	1,300	4,961	254
Naresuan, Outflow	19,500	1,300	4,082	209
Khwae Noi	5,780	1,400	1,945	274
Phitsanulok, N5A	25,290	1,400	7,610	245
Phichit, N7	29,150	1,300	8,056	276
Nan Whole Basin	33,330	-	7,852	229
2. Other Basin				
Bhumibol Inflow	26,100	1,200	5,000	191
Bhumibol Outflow	26,100	1,200	4,430	170
Wang W4A	10,510	1,100	890	85
Ping, P7A	42,700	1,200	6,120	143
Ping & Wang Whole Basin	44,700	-	6,380	143
Yom Y14	12,130	1,000	2,280	188
Yom Whole Basin	23,600	-	3,260	138
Nakhon Sawan	110,570	1,000	19,170	173
Chai Nat Inflow	119,000	1,200	20,000	168
Pasak	16,290	1,000	2,530	156

Remark; Annual runoff in the above table is average one in the recent years from 1985 to 1996.

- The runoff yield at Yao, N17 and N1 in the upper basin shows high value because of rich rainfall, large forest area of 3.4 million rai (40% of the basin area) and small farm area of 1.1 million rai (14%) and paddy area (4%). However, a part of rich runoff in the wet season is lost by evaporation in the large flood plain locating at the downstream of N1 station and as a result, the runoff yield at Sirikit dam decreases to 362 mm.
- Although the Sirikit outflow with the yield of 329 mm and the side flow with the yield of more than 400 mm from tributaries flow down to the Narasuan barrage site, the runoff yield at the Naresuan shows the low value of 254 mm because of water use by the pumping irrigation projects along the river reach between the Sirikit dam and the Naresuan barrage. Since the Phitsanulok project with irrigation area of 667,000 rai uses the Naresuan inflow, the outflow yield at the Naresuan decreases to 209 mm.
- Although many sideflows with the yield of 250 to 300 mm flow down from the tributaries and empty into the Nan mainstream, the runoff yield of whole Nan basin at the conjunction points of the Yom river is small value of 229 mm due to water use for agriculture in a large farm area of 5.7 million rai (43% of the total basin area).
- The runoff yield at the other basins such as the Ping, Yom, Wang, etc is small as shown in 100 to 180 mm because of low rainfall intensity in the basin as compared with that in the Nan.

(2) Implementation Program

In accordance with the above survey and study result, the following implementation program will be set up and carried out.

- Setting up the reserved forest and national park areas and their preservation management.
- Setting up the reforestation program and restoration plan of wasted, follow and grass land areas and their implementation.
- Provision of the fire fighting activities for forest fire.
- River training works and flood control facilities in the devastated tributaries.
- Monitoring peak flood, sediment transport, water quality, etc of the tributaries in the mountain area to judge variation of watershed condition.

4.2.2 River Flow Management

River flow will be changed not only by rainfall intensity in the basin but also by water resources development and water use. In the upper Nan basin and upper Ping basin, the river flow has decreased year by year due to water use for irrigated agriculture, and as a result, the reservoir inflow of the Sirikit and Bhumibol has largely decreased in recent years. In the lower Nan, the river flow including Sirikit outflow has decreased by water use for the Phitsanulok irrigation project and many pumping irrigation projects by DEDP. The river flow will further decrease in future by the proposed many irrigation projects. However, the variation of the decreased river flow has not been carefully monitored and evaluated, although discharge at some gaging stations in the river has been observed.

Accordingly river flow management shall be carried out to monitor and evaluate the flow conditions and control the water use under proper water allocation rule. The future water resources development and water use in the river shall be planed and implemented by evaluation of available river flow and potential water demand at various stages of water use in each river.

(1) Survey and Study Items

(a) Preparation of River Ledger

River ledger showing catchment area, river length, river slope, annual runoff in average, wet and dry year, maximum and minimum discharge, sediment transport etc is not existing at present and shall be prepared urgently to grasp and judge the river characteristics and flow conditions.

(b) Setting up Control Points

A number of gaging stations for water level and discharge measurement are installed and operated well by RID and DEDP in the river system. However, the control points to judge the flow conditions are not selected yet. The gaging stations shall be classified into 1st class, 2nd class and 3rd class control points depending on their importance. 1st class control points will be selected from the gaging stations installed at the mainstream of the Nan, Yom, Wang, Ping, etc. The Sirikit and Bhumibol dam and Naresuan and Chai Nat barrage also becomes the important 1st class control points to monitor and evaluate the inflow and outflow. 2nd class and third class control points will be selected from tributaries in the sub-basins and small sub-basins.

(c) Evaluation of Flow Condition

Water level, discharge, peakflood, sediment transport, etc. are being well observed by RID and DEDP and their data are properly compiled by their hydrological divisions. However, the evaluation work for flow conditions has not yet been carried out sufficiently except the inflow and outflow of the Sirikit, Bhumibol and Chai Nat. For example, runoff yield of the important control points in the Nan, Yom and Ping rivers is not coincide always with the rainfall intensity and watershed conditions. It is assumed that the runoff yield of the major control points in the upper Chao Phraya basin will be changed year by year by the water use condition in each river, because the basin is covered with a large paddy area which consumes the large amount of rainfall and river water. Accordingly, it is necessary to evaluate the runoff yield at all control points taking into account rainfall intensity, watershed conditions and water use conditions in each sub-basin and small sub-basin.

(d) Control of Water Use

Water use from the river between control points shall be controlled by monitoring and evaluating the flow conditions at both control points, otherwise the upstream beneficiary over uses the river water and the downstream beneficiary faces water shortage problem. For example, a number of pumping stations are installed in the lower Nan mainstream and use the water released from the Sirikit dam without control and as a result, the inflow into the Chai Nat barrage will be decreased and its outflow and diversion water to the Delta area decreased as well.

Since the pumping irrigation will further increase in future in the upper Chao Phraya basin, regulation and rule to control river water use shall be urgently set up.

(e) Water Allocation

The potential water resources in the upper Chao Phraya basin are quite limited, while the water demand in the basin has been increasing year by year and will be continued to increase in future. Accordingly, the water allocation plan to use the river flow at each control point shall be set up through careful study for potential water demand and water resources on the sub-basins and small sub-basin basis.

(f) Flood and Inundation

River maintenance water shall also be allocated at each river reach taking into account ecological condition for fish and aquatic plant in the river.

Large flood often takes place in the lower Nan, Yom and near Nakhon Sawan area, as a result, large inundation area is used to form at the lower land along the river course. Water level, discharge, inundation scale, duration of flood etc shall be monitored and evaluated.

Peak flood discharges at control points will decrease year by year due to future development of many large and medium dams and their flood control measures. It will be necessary to evaluate the decreasing flood condition in order to use evaluation result for the future river training works, improvement of reservoir operation rule, etc.

(2) Urgent Need of River Flow Management in Nan Basin

The Nan river has the largest potential water resources and water demand in the upper Chao Phraya basin as shown in the following table, and will give the largest influence to the water use in the Chao Phraya Delta.

Basin	Water Demand			Water Resources	
	Existing ①	Future ②	Increased ③=②−①	Existing ④	Future ⑤=④−③
Nan Basin ①	3,800	7,740	3,940	7,850	3,920
Upper Chao Phraya ②	10,150	18,970	8,820	19,170	10,350
Rate ①/② %	37	41	45	41	38

As is shown in the above table, the water demand and water resources in the Nan will be largely changed in future. Accordingly, it is urgently necessary to carry out the river flow management including the following items.

- Establishment of control points in the main river and tributaries in sub-basins including the Sirikit and Naresuan points.
- Hydrological analysis at each control point to grasp flow conditions.
- Potential water demand study based on the potential farm area and irrigable area in the sub-basins.
- Water balance study at each control point based on the river flow and water demand.

4.2.3 Water Sources Management

A number of large, medium and small scale dams in addition to the Sirikit and Bhumibol dams are being constructed or proposed so as to store a rich wet season runoff and use it in the dry season. Those dams will further increase the irrigation area in the basin. However reservoir water of many existing dams has been operated without the proper operation rule.

Even in the Sirikit and Bhumibol reservoirs, the stored waters have not been well operated due to decreasing reservoir inflow and unsuitable existing rule curves for reservoir operation. The other large and medium dams are mostly operated without the operation rule curve.

Reservoir operation rule is to be set up in principle with the following concepts.

- Suitable reservoir capacity based on the water balance study between average inflow and outflow (water demand), taking into account the flood control and carrying over storage capacity for water use in the dry year.
- Rule curve is normally established after detailed reservoir operation study of the inflow and

outflow. The upper rule curve is the upper limit of operation when the large inflow appears in reservoir in the wet season. The lower curve is the lower limit, based on the small inflow in the wet season. The reservoir shall be operated so as to make the water level lower than the upper rule curve during the wet or flood season and higher than the lower rule curve even in the dry year.

The rule curves for the Sirikit and Bhumiphol dam were established when the dams were constructed and have not been modified so far. Due to successive occurrence of decreasing inflow into the reservoirs, difficulties in operation and unknown reasons, the actual reservoir operations had deviated greatly from the rule curves. Many of the actual operation curves showed that the dams have been operated at near or below the lower curve. This shows also the difficulty of operating the dams with the present rule curves when the inflow is decreasing and the demand is increasing. It warrants therefore, a high priority to review the rule curves. With revised and modified rule curves, the operation of the Sirikit and Bhumiphol dams can be rectified to adapt to the real-time change of inflow and demand in the future.

Reservoir operation study for many of the medium scale dams had not been conducted when they were constructed. The actual operation of the dams is carried out without a rule curve. This has resulted in uncoordinated and immature operation and unexpeoted water losses. To enhance coordinated water sources management within a basin, the medium scale dams must also be provided with operation rule curves.

The total reservoir capacity of the existing dams excluding that of the Sirikit and Bhumibol is 2,000 MCM, which will increase to 7,800 MCM in future. In order to use the valuable reservoir water effectively and properly, the reservoir operation rule shall be set up with the following survey and study.

(1) Survey and Study Items for Reservoir Operation

(a) Reservoir Inflow

The reservoir inflow at the existing dam shall be reviewed taking into account the hydrological conditions in recent years and the water use in the upstream basin.

(b) Irrigation Water Demand

Irrigation water demand in the existing reservoir is estimated mainly based on the wet and dry season paddy and cropping intensity of 100% and 20 to 30% respectively. The cropping intensity of paddy in future will be reduced to 80 to 90% in the wet season and less than 10% in the dry season because the areas for perennial crops such as sugar cane, fruit, fish pond and grass land for livestock, etc. and the second crops such as field crops and vegetables will increase in future according to the promotion of the diversified agriculture supported by the Thai government and the agro-industrial enterprises. Accordingly, the existing irrigation water demand shall be revised. Irrigation water demand for the diversified crops will be smaller than that for the paddy.

(c) Reservoir Losses

Reservoir losses in the largest dam of Sirikit and Bhumibol will be estimated at about 10% of the reservoir capacity in accordance with the difference between the inflow and outflow, which is slightly higher because of low reservoir inflow as compared with the large reservoir capacity. Reservoir losses in the medium and small scale dams will reach to the larger rate of 15 to 20% because the evaporation losses of 1.0 to 1.5 m depth takes place during the dry season for the shallow reservoir depth of 10 to 20 m.

(d) Reservoir operation Study

Reservoir operation study shall be carried out in the existing all large and medium dams taking into account the following conditions;

- The reservoir will reach the full water level at the end of wet season (November) and approach to the lowest water level at the beginning of wet season (June to July) because the reservoir water is to store rich inflow during July to October and release mainly in the dry season as well as in June and July at the beginning of the wet season when a large irrigation water for land soaking in paddy field is required.
- If the reservoir water level does not reach the full water level at the end of November, the proposed irrigation area can't be fully irrigated and will be reduced depending on the available reservoir water at the end of November.
- The carrying over capacity in the reservoir to supplement the small reservoir inflow in next dry year will be studied also by the operation study.
- The flood control to store the peak flood discharge occurred during August and September shall be studied. The upper rule curve shall be set up based on the reservoir operation for flood control.
- As for the small scale reservoir, it will be not necessary to carry out the detailed reservoir operation study but in stead to prepare the reservoir operation guideline.

(e) Reservoir Operation Practice

The reservoir operation practice shall be done after the operation study, monitoring the reservoir inflow, flood, variation of reservoir water level, outflow, etc. The monitoring result will be evaluated by comparing the operation study result and the final operation rule will be set up.

(2) Urgent Need of Reservoir Operation Study in Nan and Ping Basins

The existing reservoir capacity of the large and medium dams in the Nan and Ping basins excluding the Sirikit and Bhumibol dams is about 85 MCM and 644 MCM respectively, which will increase remarkably to 2,490 MCM and 1,350 MCM in future. The increased reservoir capacity by the future dams will bring about various effcts such as decrement of wet season river flow, reduction of peak flood, increment of available water in the dry season, etc and will give a large influence to the existing reservoir operation of the Sirikit and Bhumibol dams and flow conditions in the lower Nan and lower Ping.

It is urgently needed therefore, to carry out the reservoir operation study for the existing and proposed dams. Otherwise, it is very difficult to carry out the river flow management in the Nan and Ping rivers and the water supply management at the Chai Nat barrage to the Delta area.

4.2.4 Water Diversion and Distribution Management

Water diversion management is carried out at weirs and regulators to monitor inflow and outflow and to control diversion water to the beneficial area. Water diversion is conducted based on the allocation rule for diversion water and downstream outflow for maintaining water level at the constant water level at the weirs and regulators by gate operation. It is very important to take the scheduled diversion water for ensuring the downstream water use.

Water distribution management is carried out in the irrigation canal system based on the water demand at the turnouts in the beneficial area. It is necessary to ensure a stable water diversion to the canals from the weirs and to distribute irrigation water to the beneficial areas by maintaining a constant water level at the regulators and turnouts.

(1) Problem at Barrage and Regulator in the dry Season

The Naresuan and Chainat barrages are very important water diversion facilities in the Chao Phraya basin.

Both barrages are facing the following water management problems.

(a) Fluctuation of Inflow

The Naresuan inflow fluctuates hourly and daily by the power outflow of the Sirikit dam taking into account peak power demand. Since the barrage has not sufficient reservoir capacity to reregulate the peak power outflow, it is rather difficult to carry out accurate gate operaton at the barrage and intake under fluctuated water level.

(b) Control of Diversion Water in the Dry Season

Water diversion at the Naresuan and Chainat barrages in the dry season does not correspond to the water demand in the beneficial area. In most of the cases, water diversion is carried out under insufficient inflow. At the Naresuan barrage, water diversion management is bound by the priority of releasing sufficient water to the downstream area, especially the Delta, instead of diverting sufficient water to the beneficial area in the Phitsanulok irrigation Project. At the Chainat barrage, the situation is similar; again the priority here is to allocate sufficient water to the Bangkok Metropolitan and industrial area as well as for river maintenance in the Lower Chao Phraya river. Only the surplus water can be used for irrigation for dry season crops in the Delta.

(c) Water Level at Barrage and Head Regulators

Since the dry season inflow at the Naresuan and Chai Nat barrage sites is small, it is very difficult to carry out the gate operation under the designed water level. When the designed water level is kept at the barrage site, the backwater of the reservoir induced by the design water level reaches many kilometers upstream. This is not recommendable because huge water loss will occur in this stretch of back water.

Accordingly, the gate operation at barrages and regulators in the dry season has to be carried out at the lower water level than the designed one causing difficulty in water diversion from the intake into the canals.

(2) Problem at Canal System in the dry Season

- The main and secondary canals in the large irrigation project of Phitsanulok and 25 large irrigation projects in the Delta are extremely long. Only one or more regulators are installed in the main canals to raise the water level for turnout of water into the secondary canals. In all cases there is no regulating reservoir in the long main canal for temporary storage and regulation of the excess water or night flow. Accordingly the large operation loss will take place.
- Since the upper districts of the Delta are designed to be irrigated by a complex irrigation canal system and the downstream districts are the conservation areas, a large part of the losses in the main canals in the upper districts are utilized in the conservation area. Thus the delta as a whole could achieve a reasonable high irrigation efficiency. As for the Naresuan barrage, the losses in the main canal are also re-utilized, though at the locations much further downstream, not in the command area of the project.
- As a future improvement, the large command area along the main canals can be re-organized into an appropriate size and provided with an appropriate turnout structure. Water distribution management should include the factors such as the time lag and conveyance water losses.
- The design capacity of the main canals are very large in the Phitsanulok and Delta areas. In the wet season when the canals are operated at the maximum capacity the loss of water is about 10%. This is usually not a serious problem because water is abundant in the wet season. In the dry season the meaning is different. In the dry season, the canals are operated at a fraction of its maximum capacity. For example, in a canal with a maximum capacity of 200 m^3/s and a loss of 20 m^3/s, a dry season diversion of 40 m^3/s after checking-up to raise the water level will result in a loss of 20 m^3/s by assuming similar condition of water loss. This is about half of the amount of water diverted and can become a serious problem in the dry season when the available water is scarce. Therefore, raising water level by check gate and keeping a constant level for turnout is not practical in the dry season. In most of the cases in the dry season, the canal is operated by opening regulator's gates to lower the water level and taking water by pump to turnout in order to minimize the water loss in the canal. If the main canal is operated at 70% of its maximum capacity, turnout into the secondary canals will be relatively constant.

(3) Necessity of Water Demand Evaluation in Irrigation System

The existing dry season discharge diverted from the intakes of diversion weir, regulators and turnouts of the canal system is mostly estimated by the water demand for the dry season paddy. This discharge shall be changed in future in accordance with the water demand for the diversified crops to be converted from the dry season paddy. It is necessary to review urgently the discharge variation on weekly basis at the intake points and turnouts based on the cropping pattern and unit irrigation water requirement for diversified crops.

4.2.5 Water Use Management

Water use management is carried out by water user's group based on irrigation rotation rules. It is necessary in proper water use management to consolidate proper on-farm facilities and to control water at farm ditches and farm plot. Water use management in the wet season is slightly complicated by influence of various degrees of effective rainfall, while water use management in the dry season is not complicated, as there is no or little rainfall.

Paddy field and upland crops such as orchard are operated on different rotation schedule. For paddy cultivation it is about 5-7 days and for upland crops 7-15 days depending on the type of crops, soil and depth of root zone. Rules on irrigation rotation must be established. Other activities such as fertilizer application must be adjusted to the irrigation rotation, especially in the wet season to avoid wash out by rains.

With the trend of promoting crop diversification, it is necessary to assure the farmers the availability of irrigation water. To increase irrigation efficiency, investigation in irrigation methods such as the sprinkler and drip irrigation through pipeline system must be conducted also.

In the conservation districts of the Chao Phraya Delta, the water management in the paddy field shall be studied taking into account the following important function;

- Flood mitigation by storing rainfall in paddy field
- Groundwater recharge and salinity protection by inundation of wet season water in paddy field
- Effective water use by use of return flow from upper districts

4.2.6 Others

(1) Water Charge

Ever since the government started investment in the state irrigation project, collection of water charge has been placed high priority in the government policies. The primary concept of water charge collection is to use as one of the means to create funds for long term investment in the project construction. However the immediate purpose is to recover operation and maintenance costs and a portion of construction cost so as to emphasize participation of the beneficiaries in the water resources development and utilization.

Thailand has three (3) irrigation laws enacted during the past. The State Irrigation Act of 2485 (1942) and subsequent amendments stated that land owners receiving benefit from irrigation works shall be subject to payment of irrigation service fees to the local project offices of not more than 2.5 Baht/ha (or equivalent to 0.125 US$/ha), while the Act specified also the application of volumetric water charges to industrial and other uses at not more than 0.4 Baht/m^3 (or equivalent to 0.02 US$/$m^3$). A BE 2518 (1975) amendment stipulated that the collected fees be deposited in a special revolving fund that could be used for future operation and maintenance. For collection of irrigation fees from the beneficial farmers, the Act stipulated also that the minister of MOAC shall designate the areas as irrigation service area subject to collection of irrigation service fees. So far only a small area has been designated at present, therefore, only the charges for industrial and other uses were prescribed in the BE 2518 ministerial regulation but no charge for irrigation service has yet been specified.

There are many factors to cause collection of irrigation fees not been effectively implemented, among which the main factor may be that the Thai farmers are considered as the lowest income group not bearable to impose any additional fees upon them. In addition, frequent changes of government have also delayed issuance of regulations. Notwithstanding such a situation, attempt has been made to revise the water rates for industrial use and to designate the irrigation service area. The fees should at least, reflect the investment cost as well as the operation and maintenance cost of the project.

With past implementation as above stated, it can be concluded that collection of water charge in future shall be considered in the light of existing national laws and government policies. To set the standard of fees based on the ability of beneficiary shall be given first consideration and amendment of the laws and regulations to enable such collection shall be conducted along with establishment of proper channel of implementation.

(2) Institution of Water Management

Water management in the Chao Phraya basin involves nine (9) major items of activity which inter-relate each other in their daily operation. These 9 items are; irrigation and agriculture, hydro-power generation, domestic water supply, navigation, industrial water use, water quality control, fishery, flood alleviation and construction work. Altogether 25 government agencies belonged to 8 ministries/office take charge of management/administration works of each item at present, among which RID involves all 9 items of activity except the hydro-power generation. Therefore, for effective water management in future, RID shall play the key role though it requires a single policy making agency at the cabinet level for guidance, coordination and supervision.

Major justification for RID to take key role in future water management in the Chao Phraya basin can be further identified as follows.

- Irrigation and agricultural water use share 80 to 90% of whole water resources utilization in the Chao Phraya basin.
- RID has regional and provincial offices established which are equipped with experienced O&M staff to take change of daily operation and management of existing major irrigation projects for promotion of irrigated agriculture.
- O&M Division of RID Head Office has sufficient and qualified staff to carry out water management as mentioned above.
- Irrigation Engineering Center in the RID Head Office can assist in carrying out special tasks for river flow analysis and reservoir operation study etc.

Aside from RID, the following government agencies shall participate in the water management coordination work particularly for their specific items of concerned as mentioned below;

- DEDP: Pumping irrigation project in the Chao Phraya as well as Kok-Ing basins
- EGAT: Reservoir operation of the dams with a function of hydro-power generation including mainly Sirikit and Bhumibol reservoirs.
- RFD: Watershed area management especially for forest area conservation
- DLD: Watershed area management especially for farm land conservation
- DOF: In-land fishery development and wet land protection
- OEPP: National environment conservation and water pollution prevention
- Other agencies concerning water use and allocation

Figure 4.1 Land and Water Resources in Southeastern Asian Countries

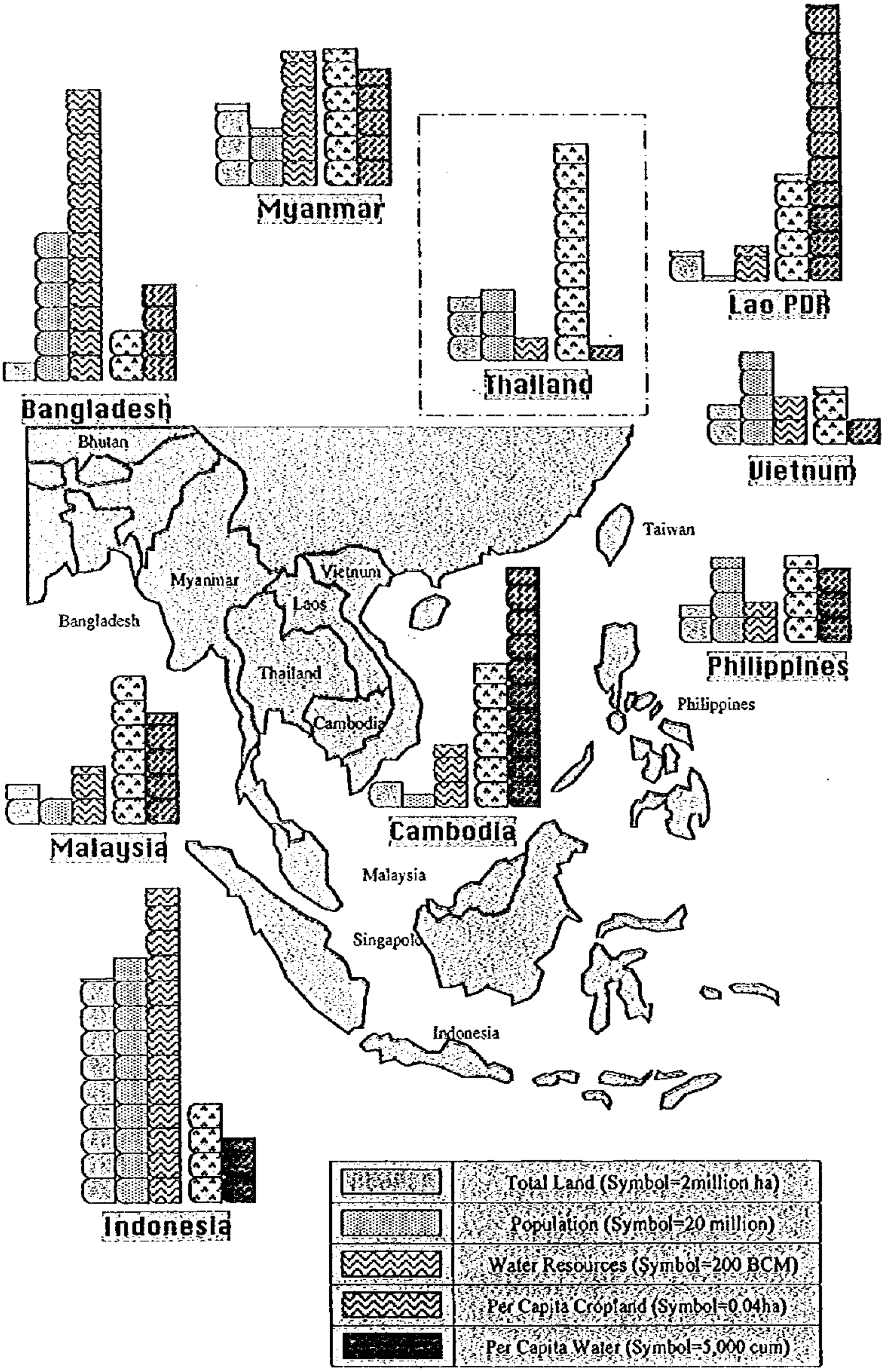


Figure 4.2 Land and Water Resources in Thailand

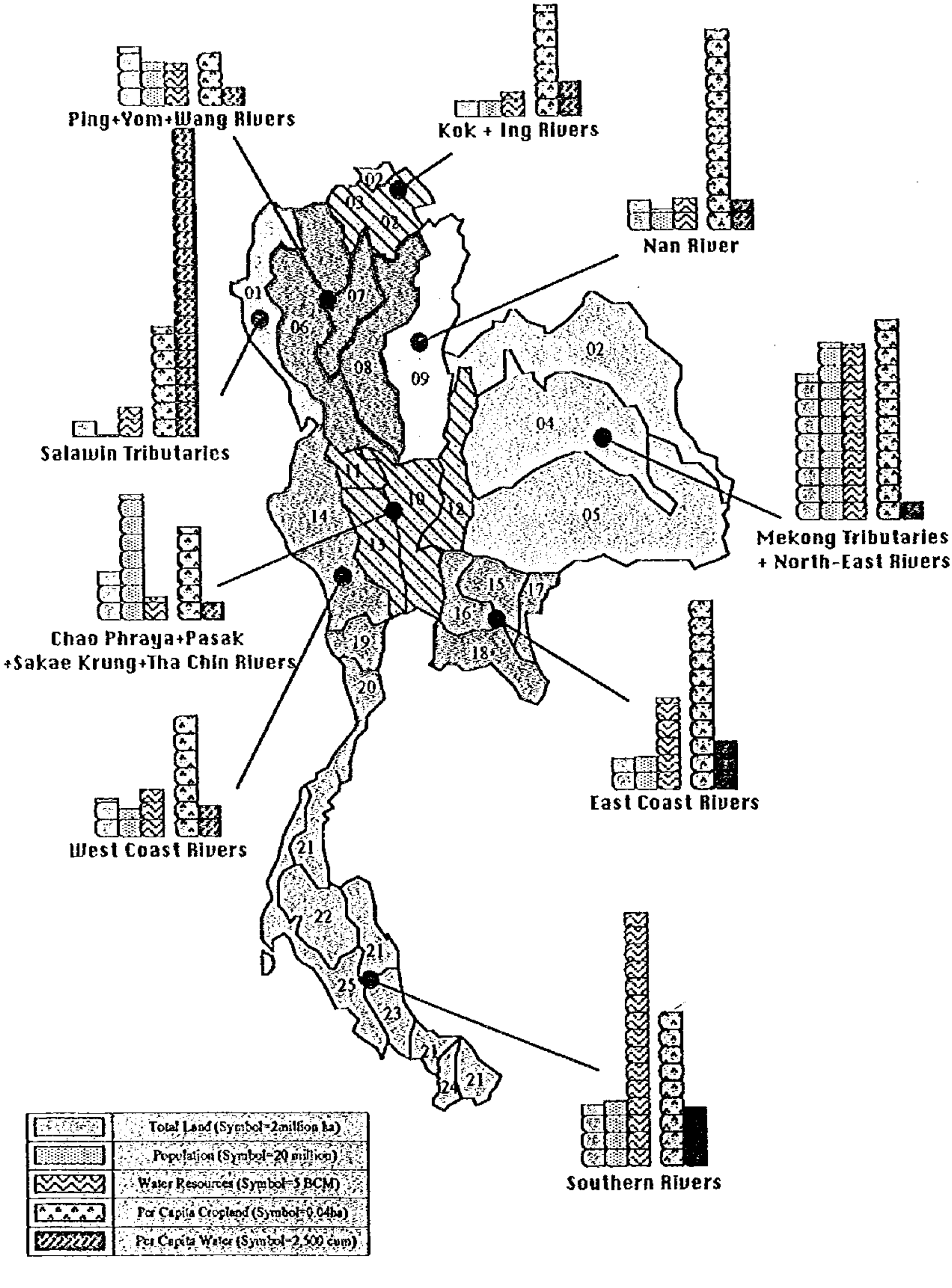


Figure 4.3 Basin Development and River Runoff in Three Basins

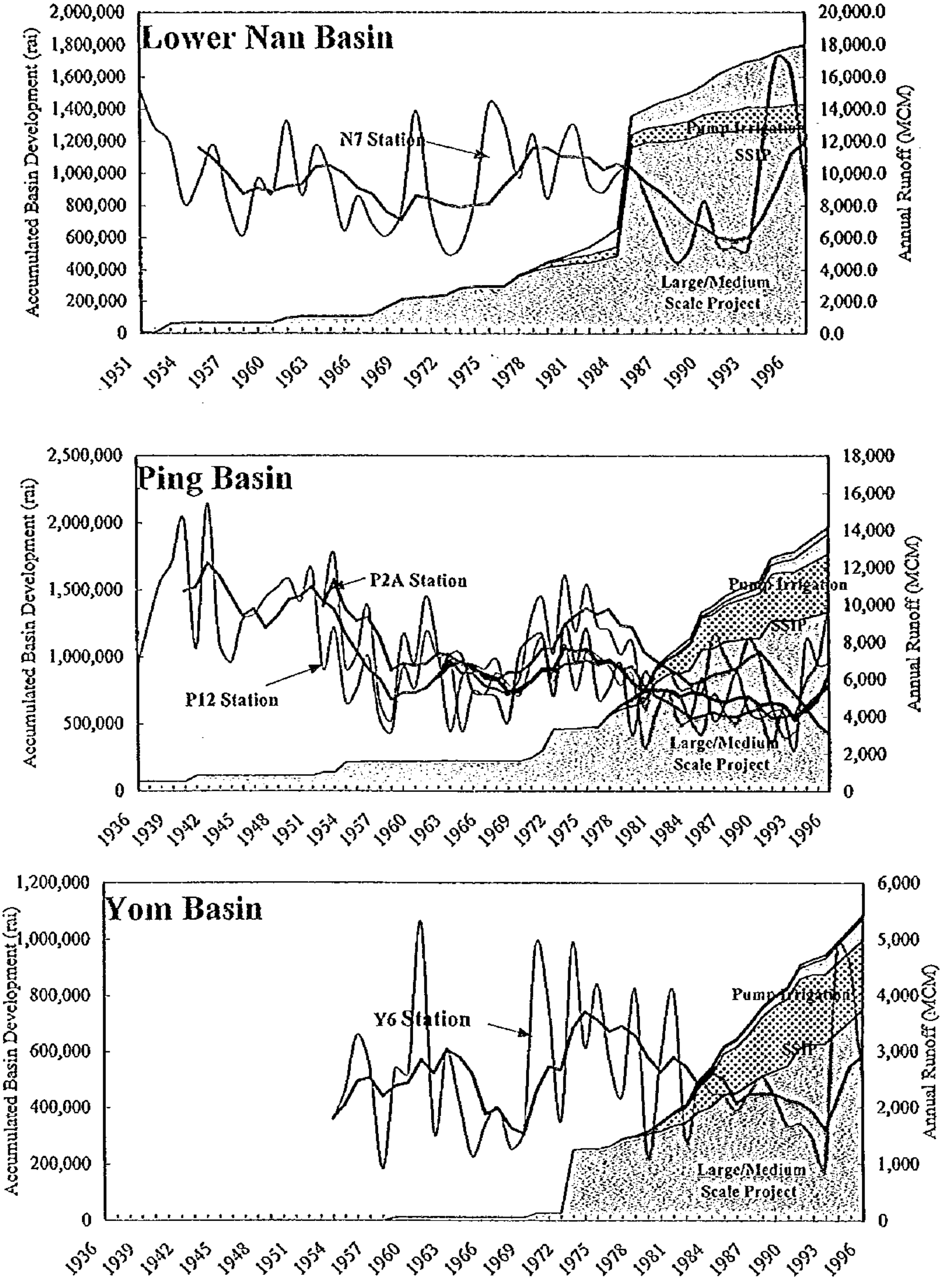


Figure 4.4 Development of Upper Chao Phraya Basin and Flow of Chao Phraya River at Nakhon Sawan

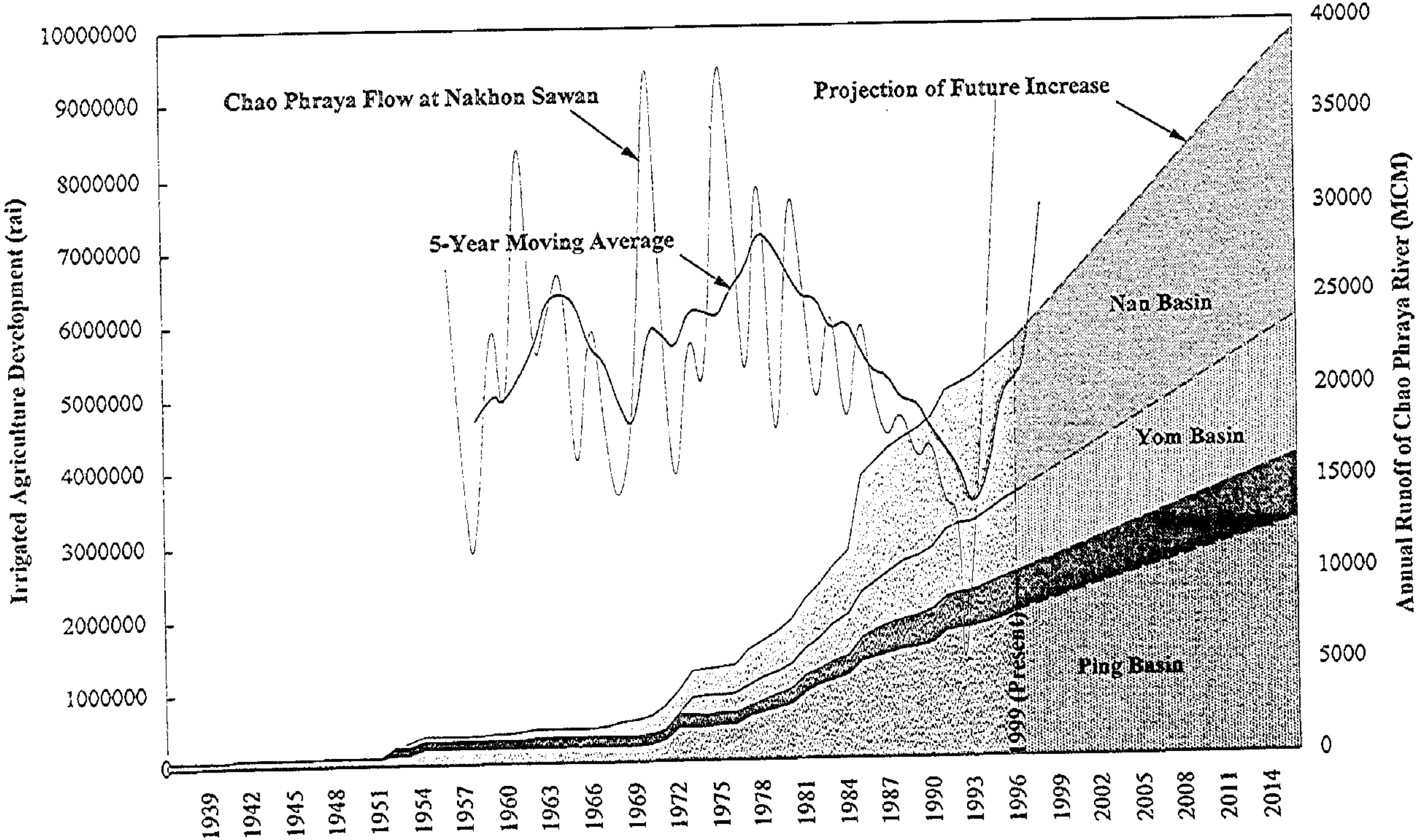


Figure 4.4 Development of Upper Chao Phraya Basin and Flow of Chao Phraya River at Nakhon Sawan

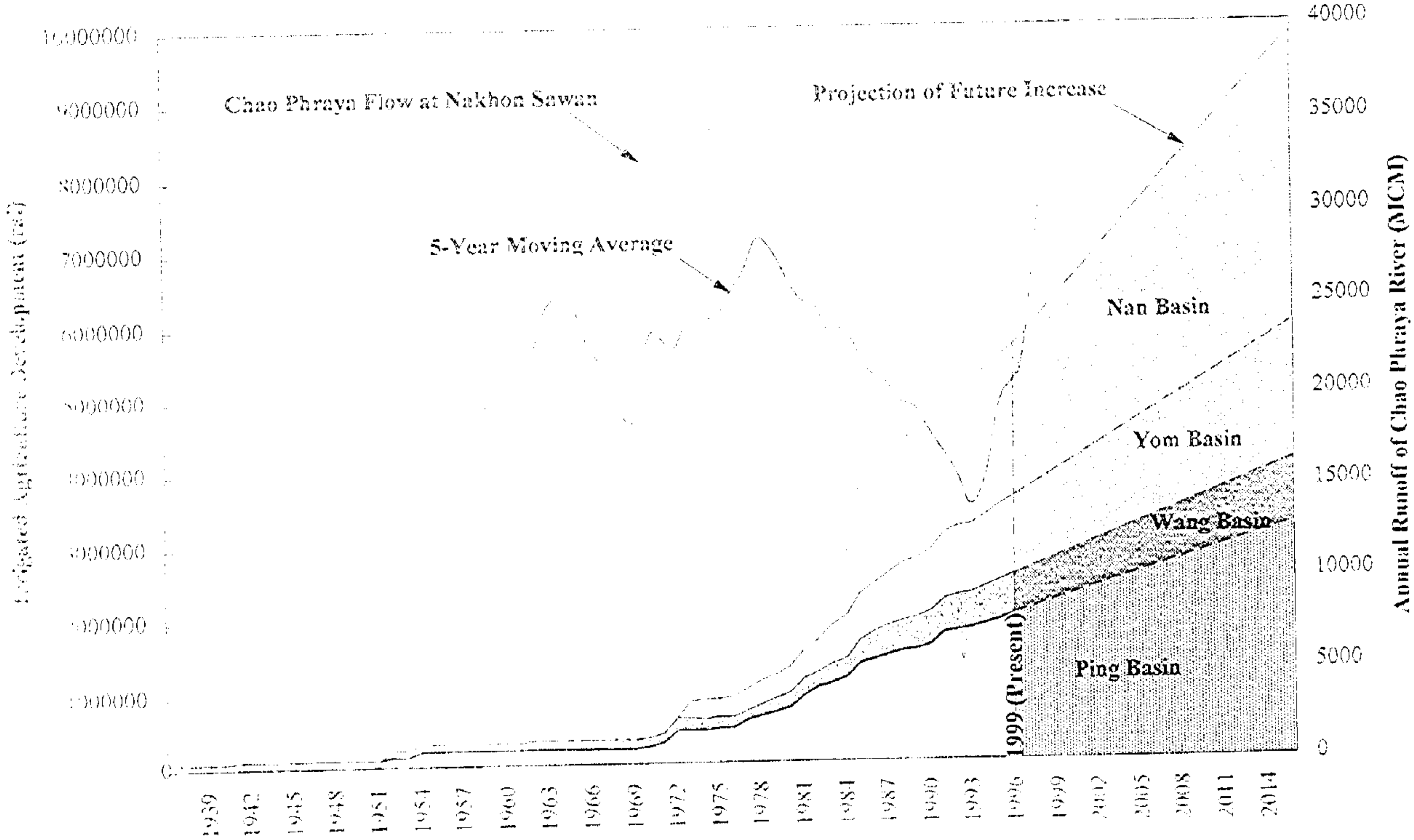


Figure 4.5 Schematic Diagram of Wet and Dry Season Flow in the Chao Phraya River

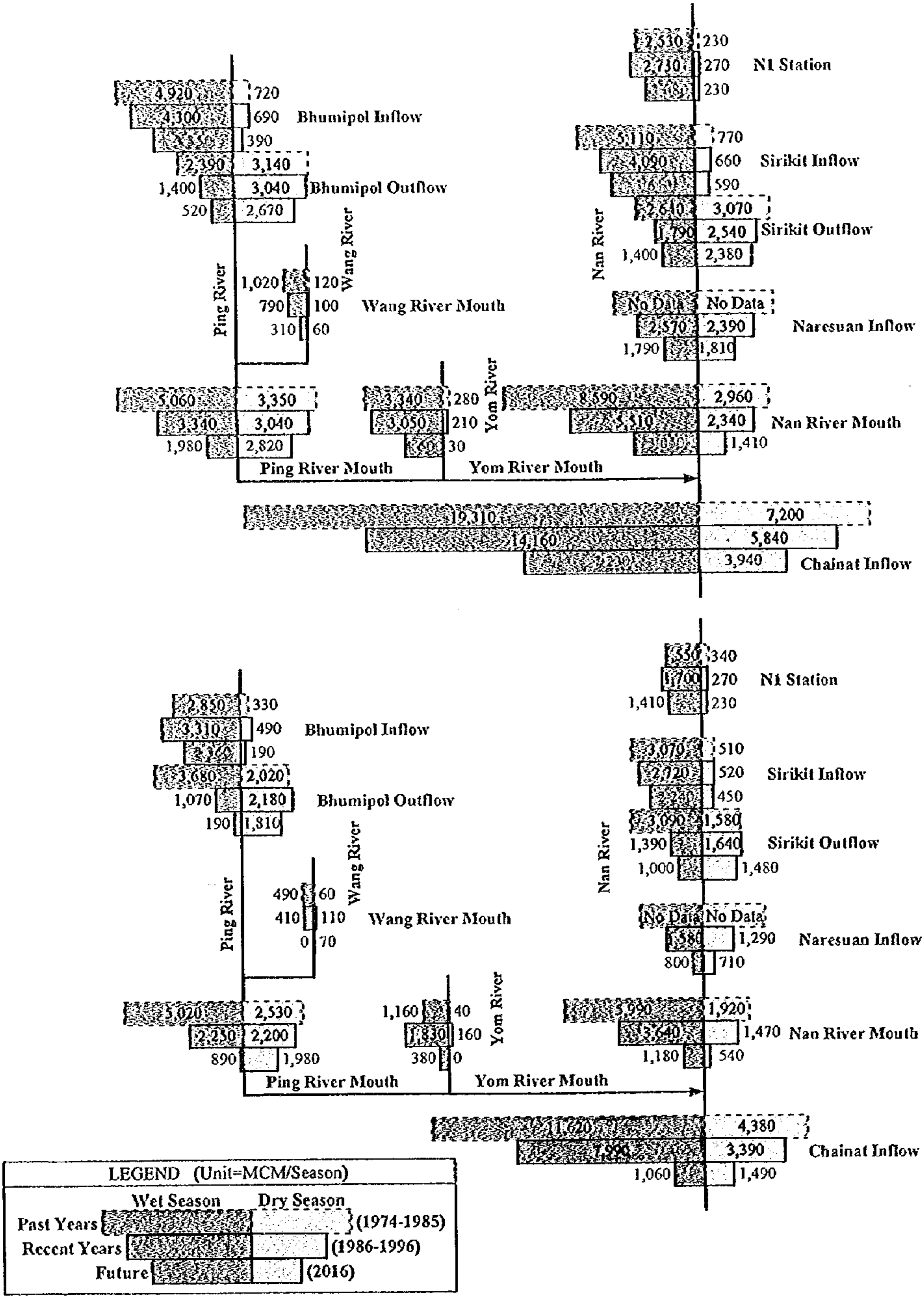


Figure 4.5 Schematic Diagram of Wet and Dry Season Flow in the Chao Phraya River

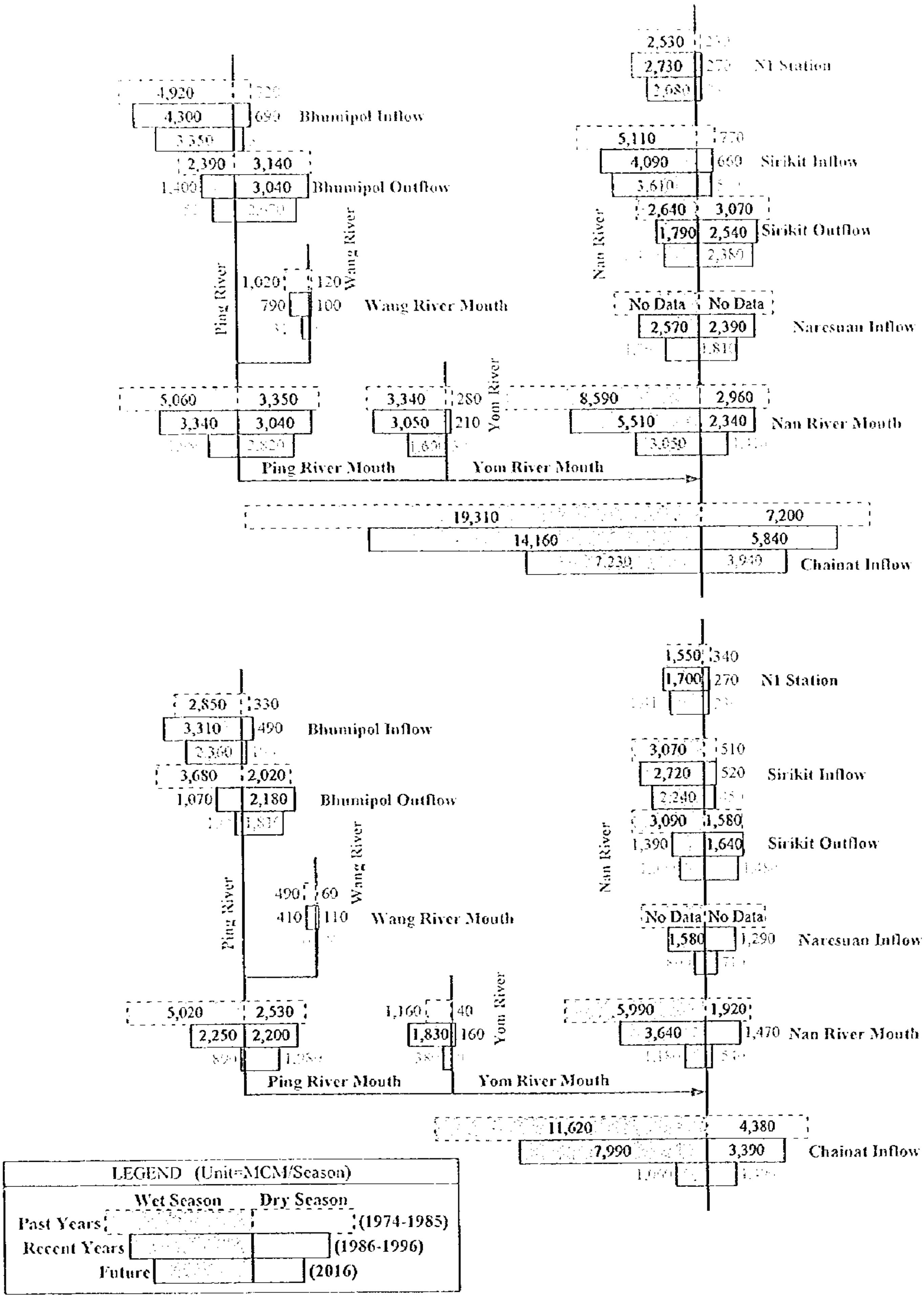


Figure 4.6 Large Empty Space of Storage in the Bhumipol and Sirikit Reservoir

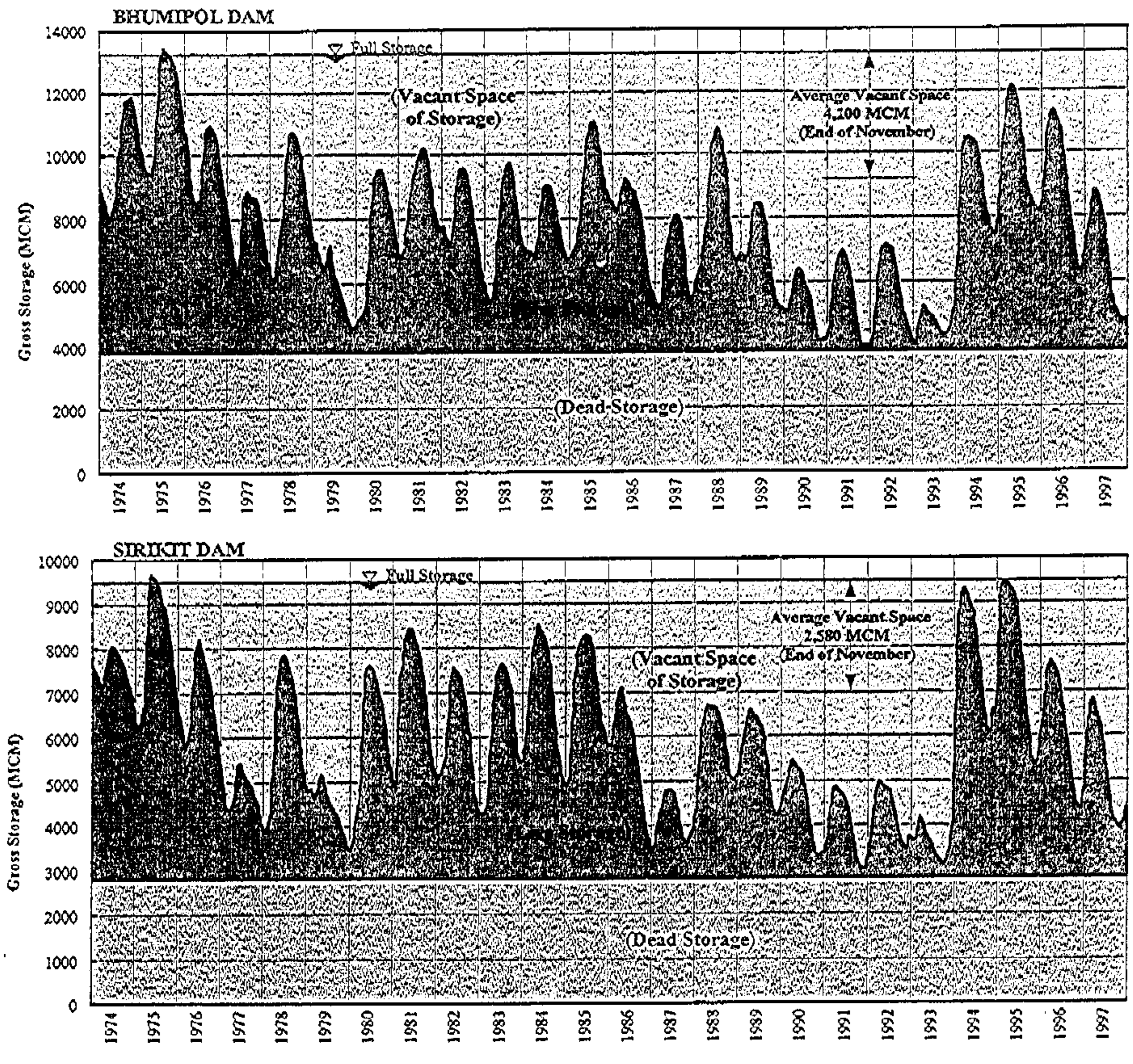


Figure 4.6 Large Empty Space of Storage in the Bhumipol and Sirikit Reservoir

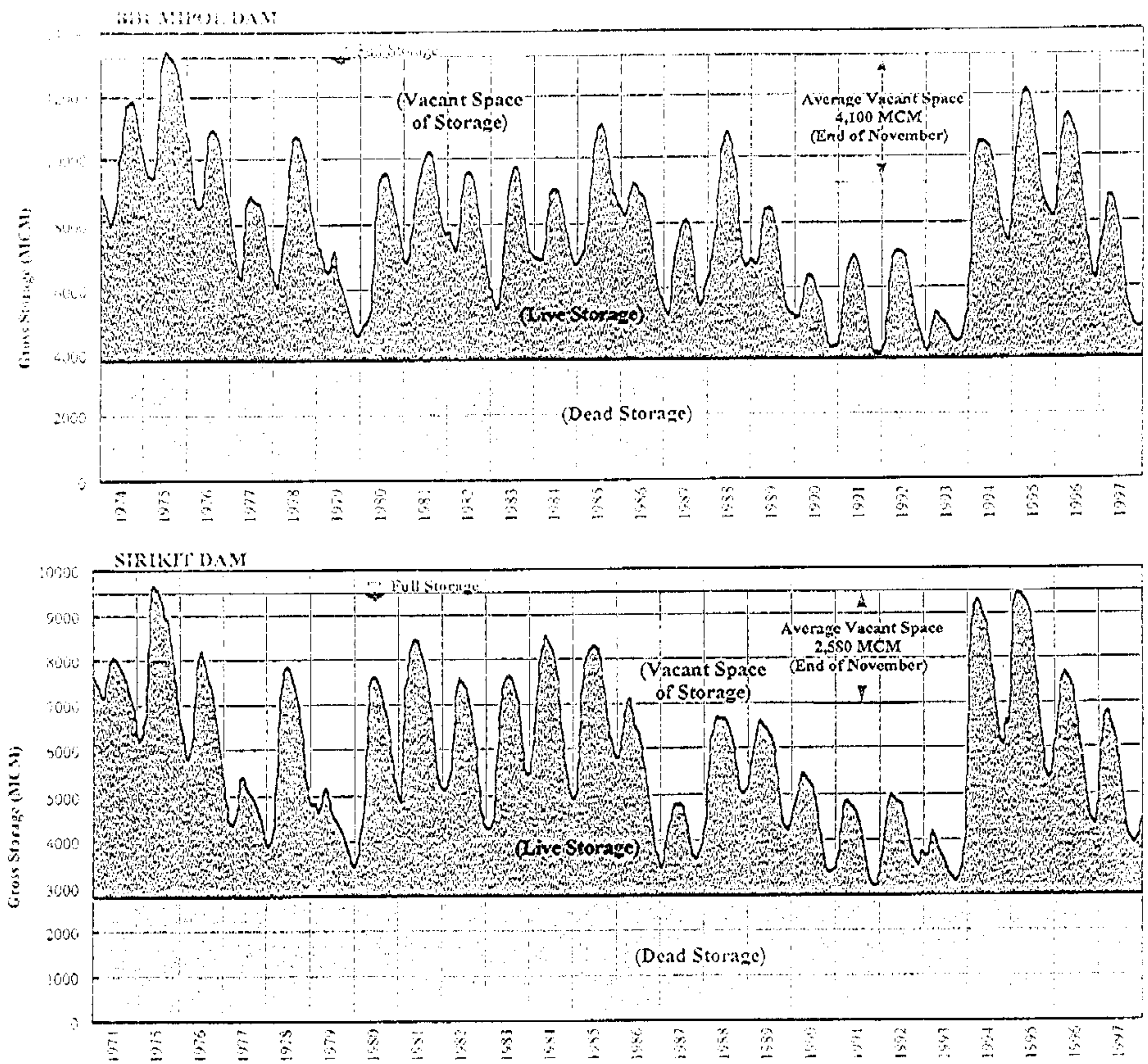


Figure 4.7 Functions Involved in Water Management

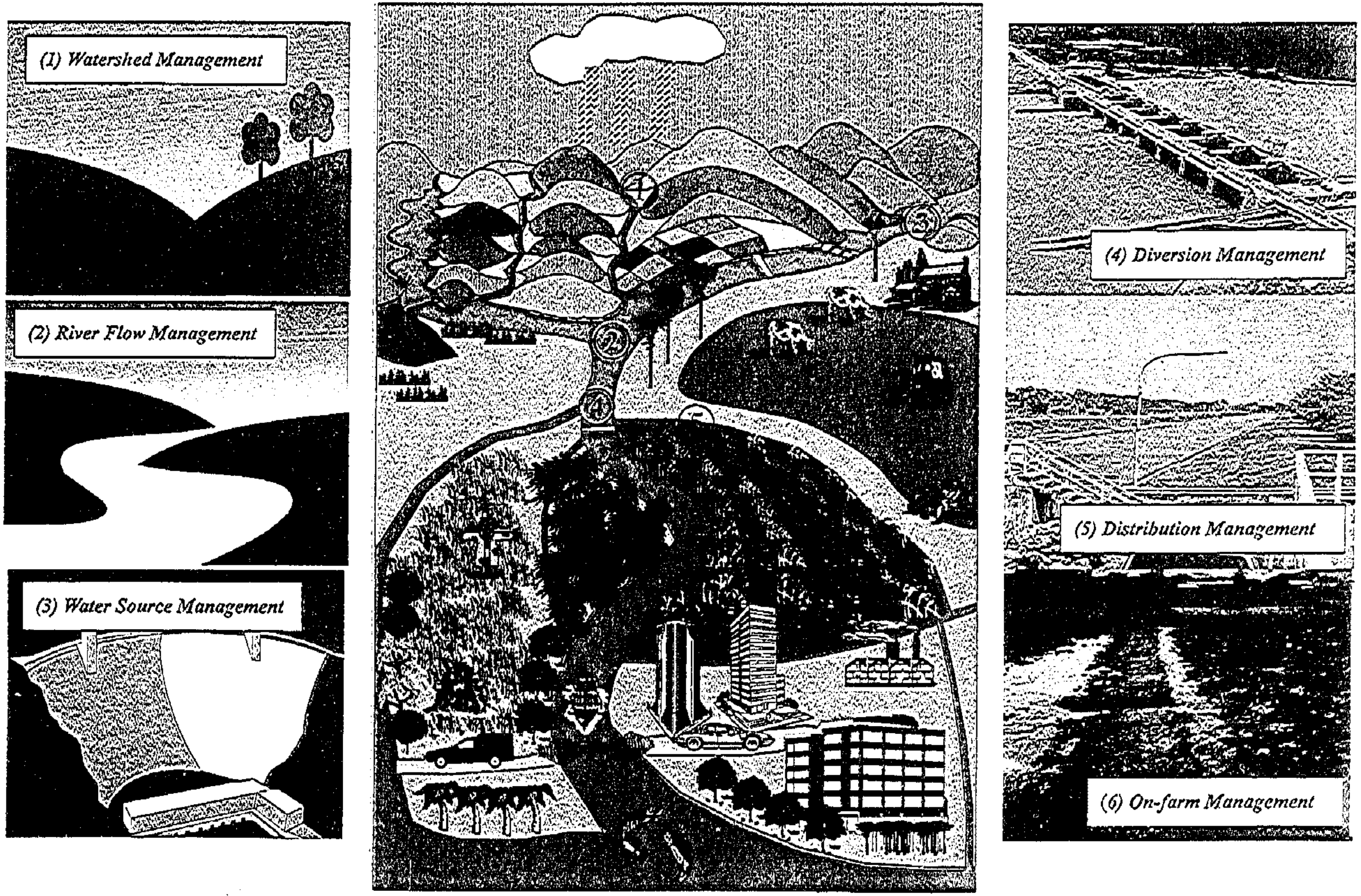
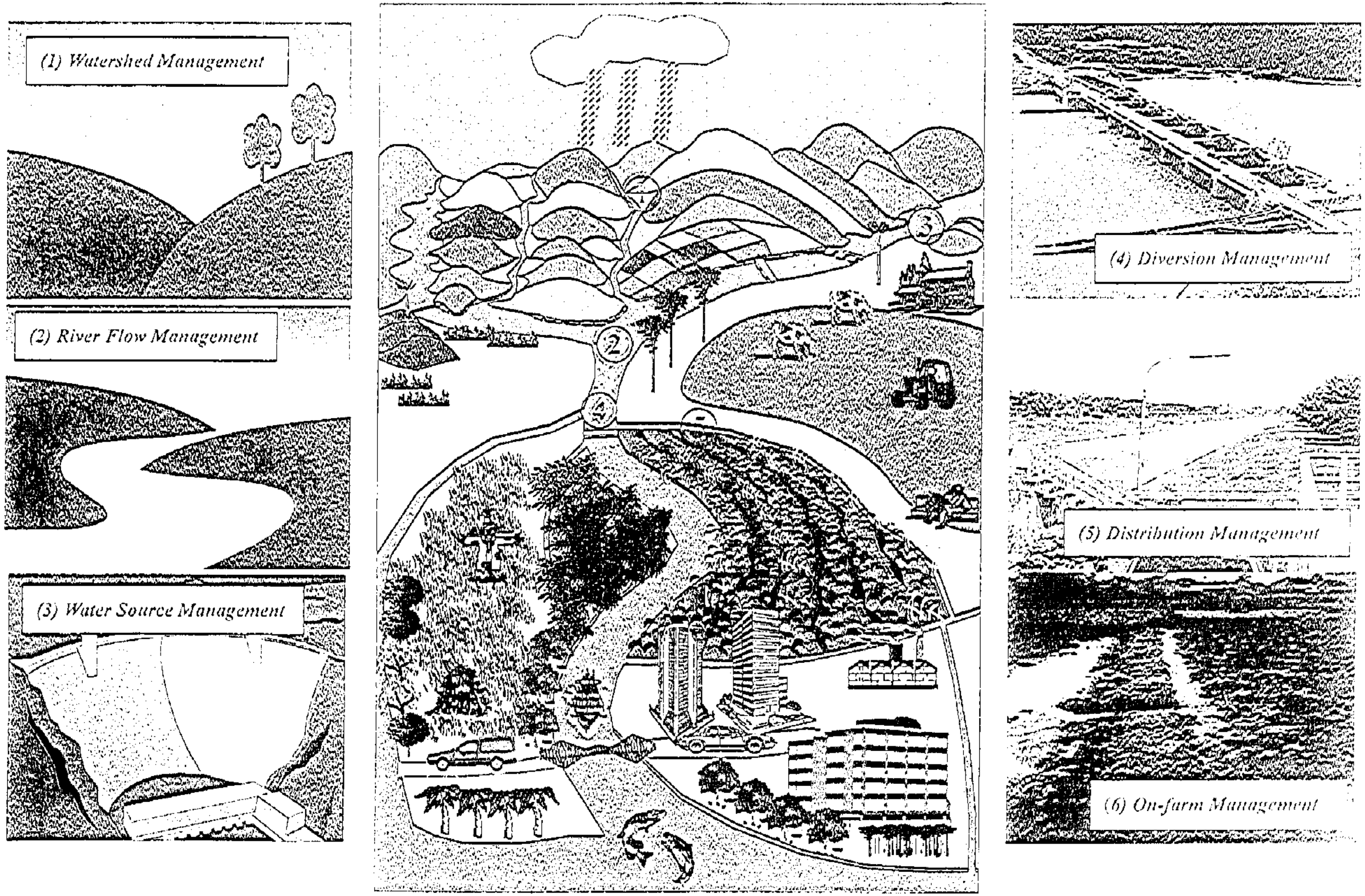


Figure 4.7 Functions Involved in Water Management



CHAPTER 5.

WATER DEMAND PROJECTION IN THE BENEFICIAL AREAS

CHAPTER 5. WATER DEMAND PROJECTION IN THE BENEFICIAL AREAS

5.1 Introduction

Assessment of water demands aims to describe an extent of additional water demands for the present and future irrigation projects/schemes and for domestic and industrial sectors and livestock use which can possibly be served by the proposed Kok-Ing-Nan Water Diversion Project under which water is delivered to the Lower Nan and Lower Chao Phraya basins located immediately downstream of the existing Sirikit reservoir. In this concern, additional water demands are estimated under the conditions that there is no constraint of the additional water supply sources. This study is developed on the basis of actual achievement of irrigation practice through evaluation and analysis of unit area water demand for various crops, agricultural policy of the country especially on crop diversification, needs of paddy cultivation even in the dry season in the delta, importance of water supply over the conservation area throughout a year, etc.

In connection with a thorough review of the World Bank-assisted Chao Phraya Basin Water Management Strategy (CPBWMS, October 1997) report, it may be noted that the water resources development scenarios are discussed in the CPBWMS study without any expansion of the long-proposed irrigation systems. More particularly, four demand scenarios examined in each of the time horizons of 1996, 2006, 2016 and 2026 were modelled for the special purpose of identifying the water demand and supply conditions for the "Do Nothing" case, and specific sub-basins where there are particular water demand and supply imbalances and then to suggest how these might be improved. It should be kept in mind that this CPBWMS's direction may be related with the discussion of adequate water resources and use management strategies with a help of the water demand scenarios; therefore, these scenarios could not be directly applied to those for the Kok-Ing-Nan Project because of different objectives between the two.

As regards the Chao Phraya delta where about 7.34 million rai of irrigated farmland exists, potential source of surface water is the flow of the Chao Phraya river at the Chainat barrage. Supplied by the release of water from the strategic storages of the Bhumipol and Sirikit, the delta has achieved a cropping intensity in the dry season of around 40% in the recent 6 years from 1991 to 1996 under the current "Command and Control" system. This is due a great extent to the excessive rainfall in 1994 and 1995, showing obviously the potential demand of water in the delta whenever water is available. The potential source of water from the major tributaries of the Chao Phraya river, such as the Nan, Ping, Wang and Yom, has been decreasing rapidly as described in Chapter 4. This decrease of usable water for the delta would be accelerated more and more in future accompanied with the development of water resources in the upper Chao Phraya sub-basins. The CPBWMS study allows the present achievement of irrigation in the delta without any consideration of water shortage problems prevailing the area. The agricultural statistics show a decreasing tendency of rainfed paddy in wet season, however also show the increasing tendency for irrigated paddy especially in dry season, when the years 1995-95 and after are involved. Domestic consumption and export demand of rice are not likely as the CPBWMS study assumed. The acceleration of the crop diversification program would need the most stable supply of irrigation water, especially during dry season.

In due consideration of the above, the JICA study performs the future projection of water demand on the basis of evaluation of the present situation of all of water user sectors including irrigation, domestic and industrial water supply and livestock water use. Special importance of the delta for the national economy has been grasped in Chapter 3 together with comprehensive overview of the national necessity of agriculture. Inventory survey is made involving all of the existing and future proposed development of water resources. More details on the comment for the CPBWMS study is given in the paragraph 5.5.

Special Considerations Involved in the Chao Phraya Delta Irrigation

In the Chao Phraya delta, there is a considerable imbalance in the cropping intensities among 25 sub-projects, and it is understood that this has resulted from the historical and political reasons and also from the shortcoming of irrigation infrastructure investment. It is intended that this defect may be eliminated taking an opportunity in line with the implementation of the K-I-N Project in order to achieve more equity and income distribution for 25 sub-projects as a whole. It is also assumed that the investment for rehabilitation and improvement of existing 5 sub-projects with less cropping intensity may be gradually made for the period of the years 2006 to 2016 so that the K-I-N water will impartially make a contribution toward upgrading of the cropping intensity for each sub-project.

Inclusion of New Irrigation Sub-Projects in the Lower Nan Basin

Under the K-I-N Project, there would be a potential of incorporating new irrigation sub-projects over the Lower Nan basin with a start of these irrigation operation in the year 2006 and/or 2016. An inventory of new irrigation sub-projects so far identified is explained later.

5.2 Project Beneficial Areas

The direct beneficial area denotes the area where dry season water can be directly served by the Kok-Ing-Nan Water Diversion Project for irrigation and other purposes under the gravity water conduction system. The area is hence situated along the main courses of the Nan and Chao Phraya rivers located downstream of the Sirikit reservoir, namely the lower Nan sub-basin and the lower Chao Phraya sub-basin (delta).

5.2.1 Chao Phraya Delta

General Features

After the World War II, the world-wide huge demands for cereals led the FAO and the World Bank to support the development of the Chao Phraya delta. The Greater Chao Phraya Project was elaborated for irrigation of the northern part of the delta on the basis of a diversion dam at Chainat, and its implementation was made during the period from 1952 to 1962. This project encompasses the upper (old) delta and flood plains together with the fan terraces located on these sides. Branching from the Chainat dam where the water level of the Chao Phraya river is artificially raised, several trunk canals take the way to south and on the heights constituted by the natural levees of Chao Phraya and Noi rivers. It is explained that the project was implemented with the complementary irrigation concept, and the quality of canal construction is currently at downgrade for canal lining and design capacity below the full supply requirements for dry season, as compared with the recently-completed Greater Mae Klong and Phitsanulok Irrigation, Stage 1. Under this situation, the project improvement works are gradually being carried out. Location of 25 sub-projects under the Greater Chao Phraya Irrigation Project is shown in Figure 5.2.1.

It is common in the country that the lower Chao Phraya sub-basin (delta) is parted to west and east by the Chao Phraya river and upper and lower by the irrigation system (gravity in the upper delta and conservation in the lower delta).

Table 5.2.1 Sub-division of the Chao Phraya Delta

Bank	Irrigation Sub-Project	Irrigable Area (10^3 rai)	Cropping Intensity (1991-96)	
			Wet Season	Dry Season
Upper West	No.1 - No.10	2,299	92.4	41.5
Lower West	No.11 - No.14	1,447	65.6	63.6
Upper East	No.15 - No.21	1,657	105.8	16.9
Lower East	No.22 - No.25	1,939	64.0	41.2
Total	25	7,342	82.6	40.2

In general terms, the water operation and management in the upper delta appears to be hindered by the deficiency in design and regulation especially for delivery smaller than full capacity, and by the complexity of network itself such as numerous side and return flows, independence of waterways, etc. Nevertheless, an overall conditions for agriculture with respect to the water availability can be considered advantageous when compared with the irrigation projects in other regions of the country. It is explained that the limited water resources and insufficient design of some canals to meet the dry season water requirements have led to the establishment of a yearly rotation system, water being delivered alternately between two halves of the project. And also, the drastic water shortages during recent dry season have led the RID to restrict water delivery in the project area to domestic water use only.

In the lower Chao Phraya delta (or young delta), no gravity irrigation is possible because of its flatness; therefore, the water control improvement has been composed of (1) expanding canal excavation to turn water available by pumping to the whole area where many of these works at secondary and tertiary level are achieved by the farmers themselves, (2) constructing regulators to keep water in dry season and to protect farmlands from salt water intrusion, (3) dredging existing canals, and (4) constructing dikes for flood protection, since retaining the fresh water coming through rivers and canals from the northern upper delta is a main task to ensure water supply, this lower delta is referred to as "Water Conservation Area", in opposition with "Gravity Area" for the upper delta.

Over the "Water Conservation Area", the water management is carried out mainly by the control of gate opening that is made according to the water level measured at upstream or downstream reaches of the structure. Since the longitudinal slopes of canals (Khlongs) are extremely flat and affected by backwater of the tail regulators, the system operation by controlling discharge would not be practical; hence, the concept of operating the system by controlling standing water volume that is represented by water depth in the canals has been introduced. It is considered that this system of operation and management is suitable to the water conservation typed-project. A drawback is that the farmers should pump water into their farmland, and this is additional burden to them financially, but an advantage could be realized by a fact that they tend to use water efficiently. It is reported that the project irrigation efficiency over the conservation area is about 70% for wet season and 80% for dry season, and these figures are higher than those for the upper delta under the gravity system which ranges from 40% in wet season and 60% in dry season.

On-Farm Development

The rapid completion of the Greater Chao Phraya Irrigation Project indicates that the construction works had concentrated on the main and secondary distribution networks under the assumption that the on-farm development would partly be carried out by the farmers themselves; however, this did not turn out to be satisfactory enough since the water access or control was reported low in many places. Thus, the RID launched the Ditches and Dikes Program between 1963 and 1969. Further to this, the Land Consolidation Program under the Agricultural Land Consolidation Office (ALCO) was promoted in 1974; however, in the last years, less or little attention has been paid to this on-farm development. It may be noted that about 40% of the project area has no on-farm development, but most of such areas are in the water conservation area over the lower delta where it is less relevant due to the direct access to water by pumping. The RID Regional Offices explained that the water control in many places of the Ditches and Dikes area would be insufficient or poor due to the lack of maintenance, and little would be known of the on-farm works achieved by farmers themselves.

Water Delivery in Dry Season

Agriculture is still the highest water consuming sector in the Chao Phraya delta with an average of 80% of the total amount of diverted water. The evolution of dry season rice cultivation has been developed due to the water regulation allowed by the Sirikit storage (1972) and peaked at around 3 million rai before collapsing in the 1990 to 93 period. The water availability in the dry season, thus, is far from matching a demand which is pulled upward by the predominance of rice cultivation. On the other hand, in parallel to a process of crop diversification, the agricultural system in the delta had to respond to an increasingly diversified demands from the urban and international markets. Besides the traditional area of fruits and vegetables in the lower west bank of the delta, other several spots of crop diversification have mushroomed with a large range of the diversified produces. Some areas around Bangkok, such as Rangsit area (lower east bank: sub-projects No. 22 & 23) for example, have experienced the deep transformation in cropping patterns. This trend is currently being supported by the Government policy aimed at changing the structure of traditional rice-based agriculture, and this policy is due to the need to offset the loss of regional competitiveness in rice cultivation and to enforce the water saving cropping activities in the delta.

Diversification of the rice-based agricultural systems is probably the most prominent feature of current dynamics in the Chao Phraya delta. In the future, the rice cultivation, on the other hand, is likely to maintain itself, although the reduction in acreage due to the encroachment of urban areas and diversification will probably continue.

As is seen as a whole, the dry season cropping intensities are at a level of 40%, in which those for the lower banks are in a position of rather high intensities. On the other hand, the cropping intensities for the upper east bank is at a low level of 17%.

More particularly, the west and east banks stand in a sheer contrast, with the overwhelming prevalence of the west bank. Several reasons can be raised to explain such contrast;

- The west bank benefits from better water conditions, especially with the Tha Chin river in its mid-course where a significant flow is maintained to satisfy the downstream requirements for irrigation, navigation and combating salt water intrusion, thus allowing water diversion. On the other hand, water in the east bank can only be diverted from the secondary canals on which the RID controls. In addition, the water level in the Chainat-Pasak canal is often insufficient for some of its reaches (at Roen Rang and Chong Kae), because the discharge falls under 110 m^3/sec, minimum value to ensure proper regulation. The control of water allocation is also stricter than in the west bank, because the downstream area mainly relies upon its water supply.
- The west bank is a traditional region of rice cultivation where rather intensive agriculture prevails. The east bank, on the contrary, is influenced by the situation prevailing in the neighboring area of extensive traditional rice cropping, where the worker migration is prevalent both for long period and seasonally, because single rice cultivation demands only a short period. Multi-activity is the rule, and the opportunities for work are numerous for the urban and industrial areas of Lop Buri, Sing Buri, Saraburi and Ayutthaya. This difference is also noted in the land tenure patterns, the west bank showing a high rate of full owner-farmers in contrast with the east bank where tenancy is predominant. Therefore, the demand for dry season water supply is less strong in the east bank than in the west bank, and the latter area may also get the political backing.

<u>Tung Wat Sing Irrigation Project</u>

Apart from the Greater Chao Phraya Irrigation Project, there is a RID-medium scale irrigation project called "Tung Wat Sing" which is located immediately upstream of the upper west bank of the delta. Water demand for this area is however excluded from the study in order to avoid useless complexity.

5.2.2 Lower Nan Sub-Basin

The Nan river originates in the Luang Phra Bang mountain range in Nan province with its total length of 650 km. The Nan river basin, which covers about 33,000 sq.km of catchment area and more than 1,100,000 ha of plain area. The Nan Basin Development Plan has been divided into 3 phases viz. Phase I: Sirikit Dam Project, Phase II: Phitsanulok Irrigation Project, and

Phase III: Uttaradit Irrigation Project. Apart from the Sirikit Dam Project as completed in 1972 and currently managed by the Electricity Generating Authority of Thailand (EGAT), the Phitsanulok Irrigation Project was completed only for the Stage 1 in 1985, and the Phitsanulok, Stage 2 (on the Nan left side with an irrigable area of 500,000 rai) and the Uttaradit Project (immediately downstream from the Sirikit storage) are not implemented yet being under consideration of the Government on water shortage problems in the Lower Chao Phraya basin.

The Phitsanulok Irrigation Project, Stage 1 consists of a reinforced concrete diversion dam called "Naresuan", canal distribution network, drainage system, flood protection dikes and on-farm development. At present, this project is managed dividing into four sub-projects : (1) Naresuan Dam which is located on the Nan left side in Amphoe Phrom Phiram and Wat Bot, Changwat Phitsanulok, (2) Phlaichumphon on the Nan right side in Amphoe Phrom Phiram, Muang, Bang Rakam and Bang Krathum, Changwat Phitsanulok, and Amphoe Sam Ngam and Muang, Changwat Pichit, (3) Dong Setti on the Nan right side in Amphoe Muang and other four, Changwat Pichit, and (4) Tha Bua on the Nan right side in Amphoe Muang and other four, Changwat Pichit and Amphoe Chum Saeng, Changwat Nakhon Sawan which is southernmost in the project.

The RID Regional Office 3 explained that there would be no major problem on O/M of the Phitsanulok Irrigation Project, Stage 1 except for the flood damage to some extent by the Yom river along the periphery of Don-Setti sub-project and rather extensive mode for the on-farm works in the Naresuan Dam sub-project. It is also mentioned that the project farmers are encouraged to practice the crop diversification program by the Government, but its progress is rather slow and immature at this stage. In accordance with the available water release from the Sirikit storage, it is likely that the dry season cropping intensities over 50% for the project are held every year under the consultative meeting of the Government agencies concerned. Although two sub-projects such as Naresuan Dam and Phlaichumphon are closely located to the center of Changwat Phitsanulok, there has been no land conversion to urban and industrial use to date; however, vigorous city expansion may invade its irrigable area for the coming 10 to 20 years to some extent.

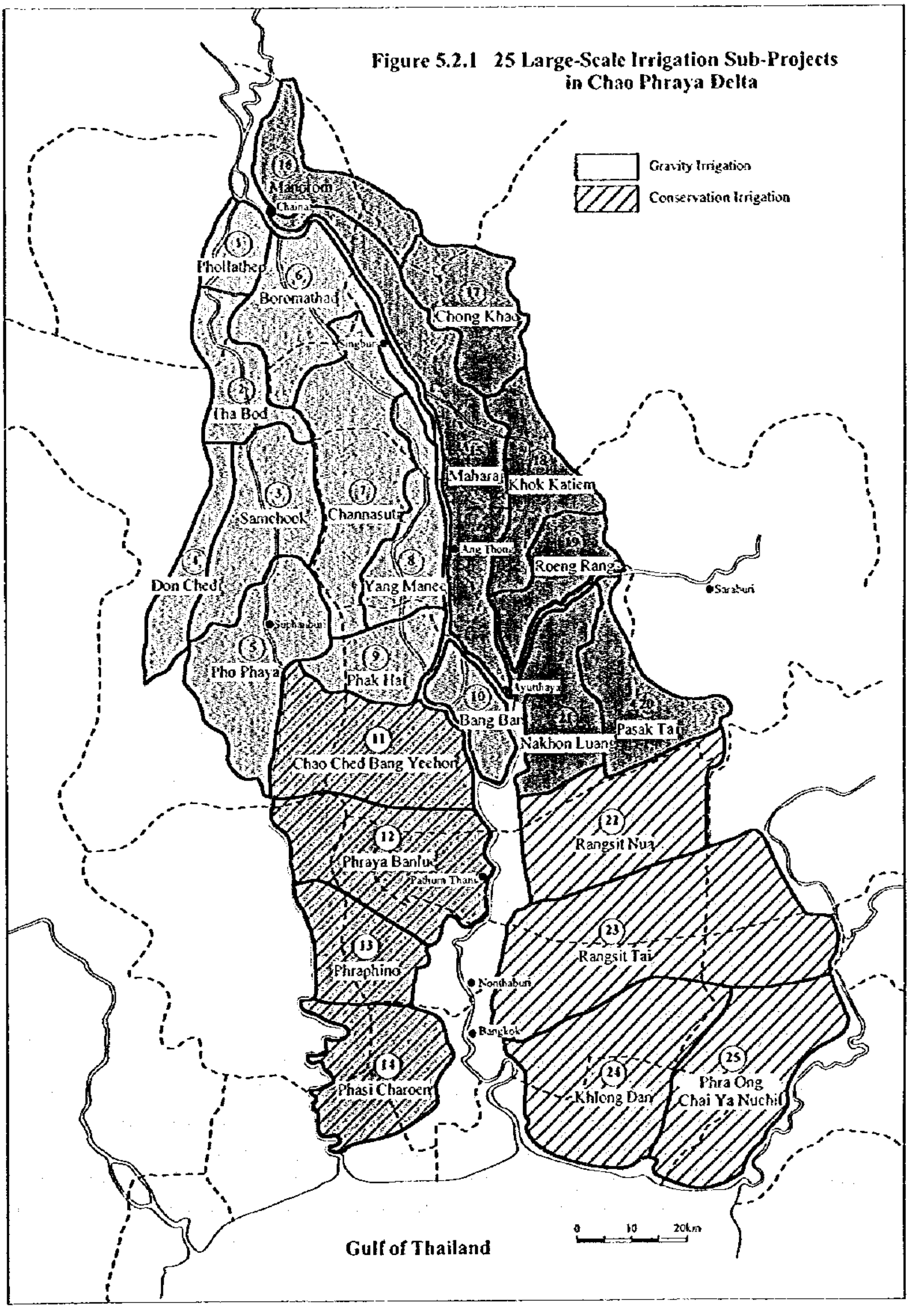


Figure 5.2.1 25 Large-Scale Irrigation Sub-Projects in Chao Phraya Delta

デルタ平面図(A4)

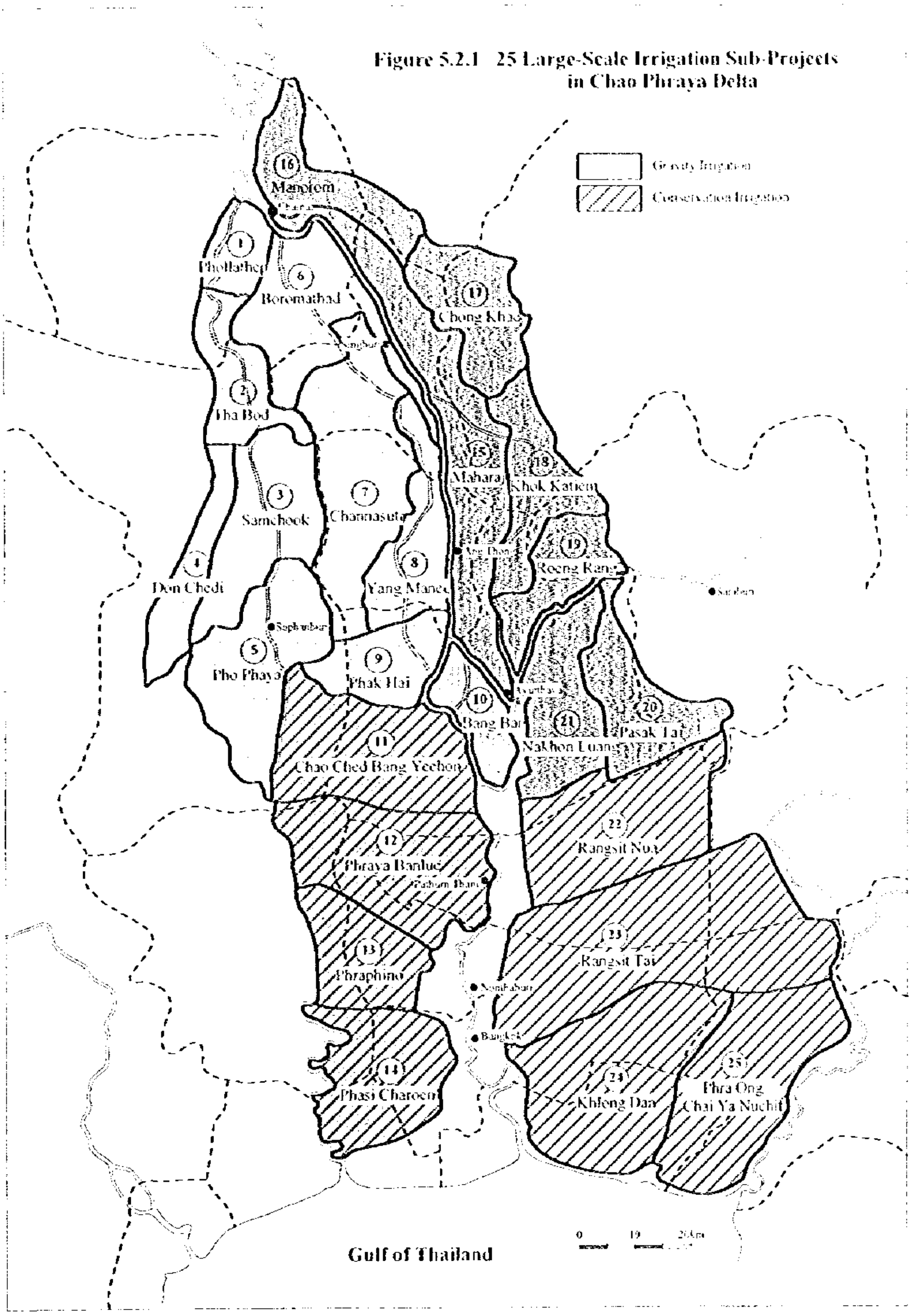


Figure 5.2.1 25 Large-Scale Irrigation Sub-Projects in Chao Phraya Delta

デルタ平面図(A4)

5.3 Current Situation and Future Trend of Irrigated Agriculture

Because that irrigated agriculture shares more than 80% of the total water demand from the surface water resources, the current situation of irrigated agriculture provides primarily the scale of water surplus and/or shortage in the area at present and, probably, in future. The Study conducted a detailed inventory survey on the current situation of irrigation in the existing 25 large-scale irrigation sub-project areas extended over the delta and also Phitsanulok Stage 1 area with data/information collected by the RID O/M Division and Regional No.7, 8 and 3 Offices. The results of inventory survey, as summarized in Table 5.3.1, are the sole basis of the Study since remarkable variations in harvested areas for dry season paddy and other diversified crops read from such results give an account of useful measures to solve water shortage problems at present and in future. More details are given for each sub-project in paragraph 5.3 of the Supporting Report.

The "Agricultural and Irrigation Patterns in the Central Plain of Thailand, DORAS" report prepared by the Kasetsart University in association with ORSTOM in 1996 also provides useful information on the irrigated agriculture facilitated with achievement of irrigation practice shown in plan view. Apart from actual achievement of irrigated agriculture in the field, descriptions regarding to agricultural policy in the 8th National Socio-economic Development Plan, discussions made with RID and Agro-economy and Extension Divisions of MOAC also show future trend of crop diversification as explained briefly as follows;

<u>Sugarcane</u>

Sugarcane is cultivated mainly in the upper west zone of the delta where supply of water is rather sufficient and risk of flood inundation is rather small. A large extension of farmland exists in the upper east zone of the delta, however, sugarcane is not planted in a larger scale in this zone because of water shortage problem. Almost no farmland for sugarcane cultivation has been found in the lower west and east zones because of high groundwater level and frequent inundation in wet season. Sugar mills and processing factories are distributed in both upper west and upper east zones as shown in the Supporting Report. As mentioned in 3.2.3 "Diversified Crop Cultivation", production of sugarcane in Thailand has increased largely from 40 million tons in 1993 to 58 million tons in 1996 together with rapid increase of export value from 13,400 million Baht in 1993 to 31,600 million Baht in 1995. The existing cultivation area of 175,000 rai for sugarcane is planned to expand to 290,000 rai in future (2016) as shown in Tables 5.3.2 and 5.3.3.

<u>Fruit Trees</u>

Cultivated areas to fruit trees are well distributed over the delta as shown in Table 5.3.2 as well as on the DORAS figures in the Supporting Report. In the lower west and east zones, such areas are counted at 93,500 rai and 162,200 rai occupying about 80% of the total harvested area in the delta. Although suitable area for fruit plantation is limited in the lower zones due to higher groundwater level and inundation, high ridges are provided to protect the area from inundation supported by sufficient supply of irrigation water with a priority even in a draughty period and high market demand from the Bangkok Metropolitan area. On the other hand in the upper zones where a large extent of suitable farmland for fruit tree cultivation exists, harvested area is as small as 67,600 rai or 20% of the total harvested area in the delta, because of absolute lack of stable supply of irrigation water.

It is noted here that the existing total area of 323,300 rai mentioned in Table 5.3.2 is the averaged value for the period from 1991 to 1996, and the recent figures in 1995/95 shows much larger value of 436,000 rai, showing 137,000 rai or twice as much value of the past record especially in the upper zones. This is due to strong demands from both domestic and foreign market as well as farmers' needs for higher incomes. The export value of fruit products has increased from 500 million Baht in 1991 to 5,000 million Baht in 1997 in accordance with the "Trade Statistics and Economic Indicator of Thailand".

The above 323,300 rai of harvested area still haven't counted the nursery (young tree) area and the cultivated area to fruit trees will increase to 500,000 to 600,000 rai in future when young trees have grown up to yield fruits. Accordingly the future area of fruit plantation is estimated in moderation at 530,000 rai for the whole delta accounting for 1.6 times of the present achievement. Such increases will occur mainly in the upper zones showing 142,000 rai in the upper west zone and 118,000 rai in the east zone.

Fish Culture

The existing fish pond area for fresh water fishes is 137,000 rai on the average from 1991 to 1996, of which 121,000 rai is concentrated in the lower zones provided by sufficient water in both wet and dry seasons. There exists many locations of suitable fish culture mainly near the villages in the upper zones, however, these are not developed due to lack of stable water supply in dry season. In future, fish culture will also expand largely in the upper zones in response to the market demands for local consumption and urban export. As shown in Table 5.3.2, fish culture area has increased to 206,000 rai in recent year from the averaged value of 137,000 rai. Accordingly the future area is estimated at 191,000 rai in total, inclusive of 62,000 rai in the upper zones which is about four (4) times of the current achievement.

Field Crops

In general, field crops are cultivated as the second crops in dry season followed by wet season paddy in the upper zones. In the lower zones however, cultivation of field crops in paddy fields is difficult due to soil texture and groundwater level unsuitable for field crops cultivation. Major field crops grown in the delta are soybean, mungbean and maize. At present harvested area of field crops is 67,000 rai on average consisting of 64,000 rai for the upper zones. As shown in DORAS figures in the Supporting Report, rapid growth of field crop cultivation in recent years is found in the upper east zone.

The field crop cultivation has not been accelerated enough until now in the delta because of no profitable crop due to low farm gate price, lack of irrigation water in the dry season, no stable market and a large amount of import with lower price. This situation around field crop cultivation has however been altered since the devolution of Baht value after the economic crisis in 1997 and current and future trend of domestic demand of fodder crops required for livestock breedings. Accordingly field crop cultivation will become more profitable for farmers and will be accelerated more and more in future. The area of 181,000 rai is estimated for field crops in future compared with 67,000 rai of present achievement. This increase of cultivation area will be allocated in the upper zones when natural conditions are fully considered.

Vegetable

Currently a large farmland for vegetable cultivation locates in the areas near the Bangkok Metropolis in the lower west zone accounting for 34,000 rai occupying about 80% of the total harvested area in the delta. Vegetable cultivation is not popular in the lower east zone because of inundation problems. In the upper zones, harvested area of vegetable is as small as 4,600 rai in the west zone and 3,300 rai in the east zone on average, however the recent data show rapid growth to 10,600 rai and 7,000 rai in 1995/96 due to increasing domestic consumption of varieties of vegetable. This growing situation of vegetable cultivation is clearly seen in the upper west and east zones as presented in the DORAS figures in the Supporting Report. In future, vegetable will be cultivated in 85,000 rai of farmland as a whole, consisting of 50,000 rai in the upper zones. In the lower zone, existing area of 34,000 rai will not be expanded because of limited land suitable for vegetable cultivation.

Dry Season Paddy

The harvested areas for dry season paddy vary largely from year to year depending on the availability of irrigation water. In the wet year of 1996, the largest cropped area of 1.4 million rai in the upper west zone and 760,000 rai in the upper east zone was recorded which was supplied by sufficient amount of irrigation water from the Chainat dam. On the contrary in the dry year of 1993 and 1994, cropped areas of dry season paddy decreased considerably to 400,000 rai and 28,000 rai due to absolute lack of water. In the lower zones, there is no significant difference in cropped areas in wet and dry years indicating 650,000 to 800,000 rai in the lower west zone and 500,000 to 600,000 rai in the lower east zone.

The lower zones are called the "Conservation Area" provided a function to prevent saline water to intrude the area by means of impounding water on paddy fields as well as fish ponds during dry season. Flood water is also spread over the area even in wet season in order to leach out the salt water and to foster groundwater sources. It is therefore required to maintain 600,000 to 700,000 rai of dry season paddy cultivation at least in both lower west and east zones even in the critically dry year. Although paddy cropped area in dry season largely depends on the availability of water in the upper zones, it is estimated under the proposed water diversion project that 700,000 rai is planted to dry season paddy in the upper west zone where almost same order of cropping intensity in dry season has already been accomplished and 500,000 rai in the upper east zone that is about twice of the existing achievement.

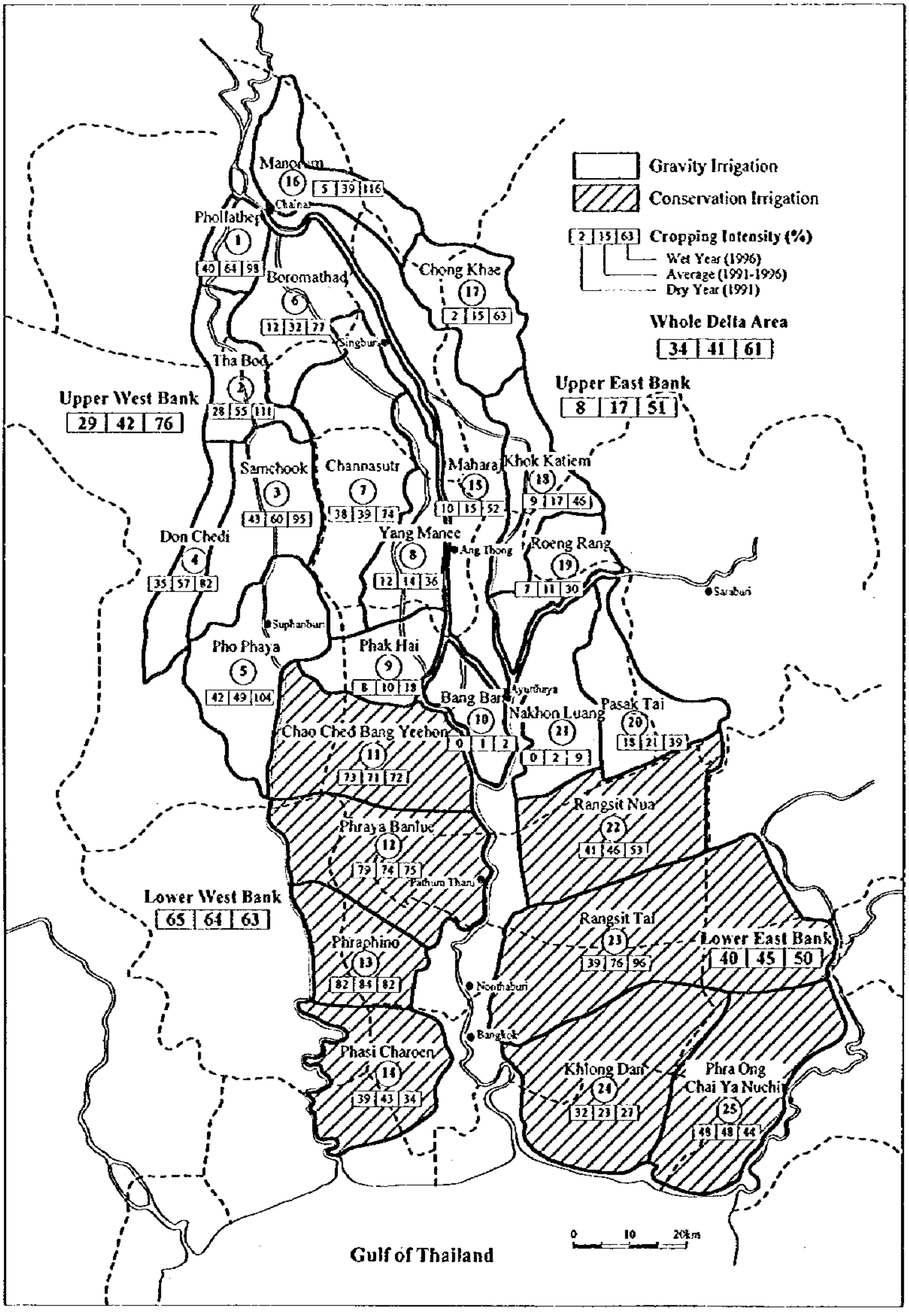
Livestock Breeding

As shown in the paragraph 3.2 of this text and the DORAS figures in the Supporting Report, livestock breeding for cow, pig and chickens has been developed considerably in the upper east zone. Cultivation for fodder crops in this zone is hence to be expanded in future.

Rural Job Creation

As are presented in the DORAS figures named "Work Outside the Village" and "Place of Out-Working" in the Supporting Report, considerable numbers of farmers especially in the upper zones have been working outside their villages. In order to create new jobs in their places, it is urgently needed to promote aforementioned diversified agriculture and to develop agro-industry to process products from diversified agriculture. It is essential that irrigation water in the dry season should be supplied stably in order to achieve this target.

Figure 5.3.2 Dry Season Cropping Intensities in 25 Large-Scale Irrigation Sub-Projects in Chao Phraya Delta



'able 5.3.1(1) Summary of Harvested Area of 25 Irrigation Projects in Chao Phraya Delta (1/:

(Unit = 10^3 rai)

Year	Wet Season Paddy	Whole Year Crops				Dry Season Crops				Total Harvested		Crop Intensity	
		Sugar Cane	Fruit Trees	Fish Pond	Sub-Total	Dry Paddy	Field Crops	Vege-table	Sub-Total	Wet	Dry	Wet	Dry
1. West Delta													
1.1 Upper West Delta (Projects 1 to 9, Total Irrigable Area = 2,299,000 rai)													
1986	2034.6	49.2	10.4	4.6	64.2	927.0	34.0	4.8	965.8	2098.8	1030.0	91.3	44.8
1987	2013.5	54.1	9.2	16.1	79.4	839.2	33.8	3.0	876.0	2092.9	955.4	91.0	41.6
1988	1970.4	48.7	19.7	22.7	91.1	824.7	18.9	1.4	845.0	2061.5	936.1	89.7	40.7
1989	1992.1	61.1	2.0	23.9	87.0	1094.8	10.0	2.0	1106.8	2079.1	1193.8	90.4	51.9
1990	1974.2	56.2	3.2	10.9	70.3	992.2	18.7	1.6	1012.5	2044.5	1082.8	88.9	47.1
-860.1	(1997.0)	(53.9)	(8.9)	(15.6)	(78.4)	(935.6)	(23.1)	(2.6)	(961.2)	(2075.4)	(1039.6)	(90.3)	(45.2)
1991	1890.4	146.4	6.6	8.4	161.4	465.7	29.4	6.8	501.9	2051.8	663.3	89.2	28.9
1992	2010.3	157.7	44.4	14.2	216.3	551.8	37.2	1.7	590.7	2226.6	807.0	96.9	35.1
1993	2013.0	171.1	28.6	13.4	213.1	460.8	27.0	4.3	492.1	2226.1	705.2	96.8	30.7
1994	1871.0	121.3	27.7	11.6	160.6	403.8	23.5	4.4	431.7	2031.6	592.3	88.4	25.8
1995	1840.1	175.9	40.6	13.2	229.7	965.8	13.5	4.2	983.5	2069.8	1213.2	90.0	52.8
1996	1832.2	198.7	90.7	15.8	305.2	1428.5	6.2	5.7	1440.4	2137.4	1745.6	93.0	75.9
-910.1	(1909.5)	(161.9)	(39.8)	(12.8)	(214.4)	(712.7)	(22.8)	(4.5)	(740.1)	(2123.9)	(954.4)	(92.4)	(41.5)
1.2 Lower West Delta (Projects 10 to 14, Total Irrigable Area = 1,447,000 rai)													
1986	732.0	0.4	102.4	23.1	125.9	880.3	12.3	46.0	938.6	857.9	1064.5	59.3	73.6
1987	823.4	0.8	95.2	29.0	125.0	828.6	6.3	47.1	882.0	948.4	1007.0	65.5	69.6
1988	911.3	1.9	99.4	23.4	124.7	772.9	5.5	40.1	818.5	1036.0	943.2	71.6	65.2
1989	939.2	0.2	82.7	43.1	126.0	797.0	3.9	47.7	848.6	1065.2	974.6	73.6	67.4
1990	913.5	1.9	83.4	28.3	113.6	825.7	1.9	46.6	874.2	1027.1	987.8	71.0	68.3
-860.1	(863.9)	(1.0)	(92.6)	(29.4)	(123.0)	(820.9)	(6.0)	(45.5)	(872.4)	(986.9)	(995.4)	(68.2)	(68.8)
1991	907.3	2.5	79.3	31.7	113.5	800.6	1.4	24.7	826.7	1020.8	940.2	70.5	65.0
1992	788.8	3.5	85.7	30.3	119.5	806.7	2.1	38.8	847.6	908.3	967.1	62.8	66.8
1993	870.1	2.5	91.8	27.4	121.7	786.5	2.2	40.2	828.9	991.8	950.6	68.5	65.7
1994	838.1	1.7	102.1	31.5	135.3	766.4	2.8	30.0	799.2	973.4	934.5	67.3	64.6
1995	739.9	1.7	113.3	31.5	146.5	643.4	2.1	29.8	675.3	886.4	821.8	61.3	56.8
1996	797.1	1.7	88.5	29.7	119.9	746.7	2.6	37.3	786.6	917.0	906.5	63.4	62.6
-910.1	(823.6)	(2.3)	(93.5)	(30.4)	(126.1)	(758.4)	(2.2)	(33.5)	(794.1)	(949.6)	(920.1)	(65.6)	(63.6)
1.3 Whole West Delta (Projects 1 to 14, Total Irrigable Area = 3,746,000 rai)													
1986	2766.6	49.6	112.8	27.7	190.1	1807.3	46.3	50.8	1904.4	2956.7	2094.5	78.9	55.9
1987	2836.9	54.9	104.4	45.1	204.4	1667.8	40.1	50.1	1758.0	3041.3	1962.4	81.2	52.4
1988	2881.7	50.6	119.1	46.1	215.8	1597.6	24.4	41.5	1663.5	3097.5	1879.3	82.7	50.2
1989	2931.3	61.3	84.7	67.0	213.0	1891.8	13.9	49.7	1955.4	3144.3	2168.4	83.9	57.9
1990	2887.7	58.1	86.6	39.2	183.9	1817.9	20.6	48.2	1886.7	3071.6	2070.6	82.0	55.3
-860.1	(2860.8)	(54.9)	(101.5)	(45.0)	(201.4)	(1756.5)	(29.1)	(48.1)	(1833.6)	(3062.3)	(2035.0)	(81.7)	(54.3)
1991	2797.7	148.9	85.9	40.1	274.9	1266.3	30.8	31.5	1328.6	3072.6	1603.5	82.0	42.8
1992	2799.1	161.2	130.1	44.5	335.8	1358.5	39.3	40.5	1438.3	3134.9	1774.1	83.7	47.4
1993	2883.1	173.6	120.4	40.8	334.8	1247.3	29.2	44.5	1321.0	3217.9	1655.8	85.9	44.2
1994	2709.1	123.0	129.8	43.1	295.9	1170.2	26.3	34.4	1230.9	3005.0	1526.8	80.2	40.8
1995	2580.0	177.6	153.9	44.7	376.2	1609.2	15.6	34.0	1658.8	2956.2	2035.0	78.9	54.3
1996	2629.3	200.4	179.2	45.5	425.1	2175.2	8.8	43.0	2227.0	3054.4	2652.1	81.5	70.8
-910.1	(2733.1)	(164.1)	(133.2)	(43.1)	(340.5)	(1471.1)	(25.0)	(38.0)	(1534.1)	(3073.5)	(1874.6)	(82.0)	(50.0)

DeltaCropIntensity6/7,99

'able 5.3.1(2) Summary of Harvested Area of 25 Irrigation Projects in Chao Phraya Delta (2/

(Unit = 10^3 rai)

Year	Wet Season Paddy	Whole Year Crops				Dry Season Crops				Total Harvested		Crop Intensity	
		Sugar Cane	Fruit Trees	Fish Pond	Sub-Total	Dry Paddy	Field Crops	Vege-table	Sub-Total	Wet	Dry	Wet	Dry
2. East Delta													
2.1 Upper East Delta (Projects 15 to 21, Total Irrigable Area = 1,657,000 rai)													
1986	1810.4	0.0	6.7	0.4	7.1	241.3	62.5	2.1	305.9	1817.5	313.0	109.7	18.9
1987	1834.5	0.5	12.0	0.7	13.2	159.7	58.1	4.4	222.2	1847.7	235.4	111.5	14.2
1988	1613.2	0.5	8.4	0.0	8.9	278.2	26.7	3.0	307.9	1622.1	316.8	97.9	19.1
1989	1821.7	0.0	8.0	1.4	9.4	139.0	28.3	0.4	167.7	1831.1	177.1	110.5	10.7
1990	1701.7	0.2	21.4	3.7	25.3	479.2	37.5	2.1	518.8	1727.0	544.1	104.2	32.8
-860.1	(1756.3)	(0.2)	(11.3)	(1.2)	(12.8)	(259.5)	(42.6)	(2.4)	(304.5)	(1769.1)	(317.3)	(106.8)	(19.1)
1991	1731.9	8.7	17.4	1.9	28.0	39.2	54.0	3.7	96.9	1759.9	124.9	106.2	7.5
1992	1783.8	6.5	19.4	1.9	27.8	101.2	57.2	3.3	161.7	1811.6	189.5	109.3	11.4
1993	1798.8	9.7	20.4	2.4	32.5	28.5	48.0	4.6	81.1	1831.3	113.6	110.5	6.9
1994	1708.6	13.3	23.1	3.8	40.2	27.6	34.4	3.1	65.1	1748.8	105.3	105.5	6.4
1995	1689.6	14.0	43.4	3.7	61.1	205.0	36.7	3.0	244.7	1750.7	305.8	105.7	18.5
1996	1552.2	14.4	42.8	3.4	60.6	756.8	19.4	1.7	777.9	1612.8	838.5	97.3	50.6
-900.1	(1710.8)	(11.1)	(27.8)	(2.9)	(41.7)	(193.1)	(41.6)	(3.2)	(237.9)	(1752.5)	(279.6)	(105.8)	(16.9)
2.2 Lower East Delta (Projects 22 to 25, Total Irrigable Area = 1,939,000 rai)													
1986	1475.9	0.0	144.3	148.3	292.6	710.5	2.7	2.1	715.3	1768.5	1007.9	91.2	52.0
1987	1413.1	0.0	117.0	153.0	270.0	645.3	2.6	1.6	649.5	1683.1	919.5	86.8	47.4
1988	1346.5	0.0	125.3	170.0	295.3	622.6	0.2	1.1	623.9	1641.8	919.2	84.7	47.4
1989	1336.6	0.0	141.5	165.8	307.3	738.8	2.5	2.1	743.4	1643.9	1050.7	84.8	54.2
1990	1274.2	0.0	148.7	89.4	238.1	642.5	0.2	0.2	642.9	1512.3	881.0	78.0	45.4
-860.1	(1369.3)	(0.0)	(135.4)	(145.3)	(280.7)	(671.9)	(1.6)	(1.4)	(675.0)	(1649.9)	(955.7)	(85.1)	(49.3)
1991	1131.2	0.0	143.5	97.9	241.4	470.5	0.2	0.9	471.6	1372.6	713.0	70.8	36.8
1992	1073.4	0.0	158.8	32.8	191.6	606.7	0.4	0.6	607.7	1265.0	799.3	65.2	41.2
1993	1040.5	0.0	167.8	116.6	284.4	595.3	0.3	0.4	596.0	1324.9	880.4	68.3	45.4
1994	952.7	0.0	172.4	106.5	278.9	467.8	0.3	0.6	468.7	1231.6	747.6	63.5	38.6
1995	923.1	0.0	159.8	73.5	233.3	521.1	0.5	0.2	521.8	1156.4	755.1	59.6	38.9
1996	807.5	0.0	170.9	118.4	289.3	606.0	0.0	0.2	606.2	1096.8	895.5	56.6	46.2
-900.1	(988.1)	(0.0)	(162.2)	(91.0)	(253.2)	(544.6)	(0.3)	(0.5)	(545.3)	(1241.2)	(798.5)	(64.0)	(41.2)
2.3 Whole East Delta (Projects 15 to 25, Total Irrigable Area = 3,596,000 rai)													
1986	3286.3	0.0	151.0	148.7	299.7	951.8	65.2	4.2	1021.2	3586.0	1320.9	99.7	36.7
1987	3247.6	0.5	129.0	153.7	283.2	805.0	60.7	6.0	871.7	3530.8	1154.9	98.2	32.1
1988	2959.7	0.5	133.7	170.0	304.2	900.8	26.9	4.1	931.8	3263.9	1236.0	90.8	34.4
1989	3158.3	0.0	149.5	167.2	316.7	877.8	30.8	2.5	911.1	3475.0	1227.8	96.6	34.1
1990	2975.9	0.2	170.1	93.1	263.4	1121.7	37.7	2.3	1161.7	3239.3	1425.1	90.1	39.6
-860.1	(3125.6)	(0.2)	(146.7)	(146.5)	(293.4)	(931.4)	(44.3)	(3.8)	(979.5)	(3419.0)	(1272.9)	(95.1)	(35.4)
1991	2863.1	8.7	160.9	99.8	269.4	509.7	54.2	4.6	568.5	3132.5	837.9	87.1	23.3
1992	2857.2	6.5	178.2	34.7	219.4	707.9	57.6	3.9	769.4	3076.6	988.8	85.6	27.5
1993	2839.3	9.7	188.2	119.0	316.9	623.8	48.3	5.0	677.1	3156.2	994.0	87.8	27.6
1994	2661.3	13.3	195.5	110.3	319.1	495.4	34.7	3.7	533.8	2980.4	852.9	82.9	23.7
1995	2612.7	14.0	203.2	77.2	294.4	726.1	37.2	3.2	766.5	2907.1	1060.9	80.8	29.5
1996	2359.7	14.4	213.7	121.8	349.9	1362.8	19.4	1.9	1384.1	2709.6	1734.0	75.4	48.2
-900.1	(2698.9)	(11.1)	(190.0)	(93.8)	(294.9)	(737.6)	(41.9)	(3.7)	(783.2)	(2993.7)	(1078.1)	(83.3)	(30.0)

'able 5.3.1(3) Summary of Harvested Area of 25 Irrigation Projects in Chao Phraya Delta (3/:

(Unit = 10^3 rai)

Year	Wet Season Paddy	Whole Year Crops: Sugar Cane	Whole Year Crops: Fruit Trees	Whole Year Crops: Fish Pond	Whole Year Crops: Sub-Total	Dry Season Crops: Dry Paddy	Dry Season Crops: Field Crops	Dry Season Crops: Vege-table	Dry Season Crops: Sub-Total	Total Harvested: Wet	Total Harvested: Dry	Crop Intensity: Wet	Crop Intensity: Dry
2. Whole Delta Area (Projects 1 to 25, Total Irrigable Area = 7,342,000 rai)													
1986	6052.9	49.6	263.8	176.4	489.8	2759.1	111.5	55.0	2925.6	6542.7	3415.4	89.1	46.5
1987	6084.5	55.4	233.4	198.8	487.6	2472.8	100.8	56.1	2629.7	6572.1	3117.3	89.5	42.5
1988	5841.4	51.1	252.8	216.1	520.0	2498.4	51.3	45.6	2595.3	6361.4	3115.3	86.6	42.4
1989	6089.6	61.3	234.2	234.2	529.7	2769.6	44.7	52.2	2866.5	6619.3	3396.2	90.2	46.3
1990	5863.6	58.3	256.7	132.3	447.3	2939.6	58.3	50.5	3048.4	6310.9	3495.7	86.0	47.6
-860.1	(5986.4)	(55.1)	(248.2)	(191.6)	(494.9)	(2687.9)	(73.3)	(51.9)	(2813.1)	(6481.3)	(3308.0)	(88.3)	(45.1)
1991	5660.8	157.6	246.8	139.9	544.3	1776.0	85.0	36.1	1897.1	6205.1	2441.4	84.5	33.3
1992	5656.3	167.7	308.3	79.2	555.2	2066.4	96.9	44.4	2207.7	6211.5	2762.9	84.6	37.6
1993	5722.4	183.3	308.6	159.8	651.7	1871.1	77.5	49.5	1998.1	6374.1	2649.8	86.8	36.1
1994	5370.4	136.3	325.3	153.4	615.0	1665.6	61.0	38.1	1764.7	5985.4	2379.7	81.5	32.4
1995	5192.7	191.6	357.1	121.9	670.6	2335.3	52.8	37.2	2425.3	5863.3	3095.9	79.9	42.2
1996	4989.0	214.8	392.9	167.3	775.0	3538.0	28.2	44.9	3611.1	5764.0	4386.1	78.5	59.7
-910.1	(5431.9)	(175.2)	(323.2)	(136.9)	(635.3)	(2208.7)	(66.9)	(41.7)	(2317.3)	(6067.2)	(2952.6)	(82.6)	(40.2)

DeltaCropIntensity6/7,99

Table 5.3.2 Existing Harvested Area of Diversified Crops at 25 Irrigation Projects in the Delta (1991~96 Average)

(Area Unit: 10^3 rai)

Item	Irrigable Area	Perennial Crop						Dry Season Diversified Crop				Dry Season			
		Sugar Cane		Fruit		Fish Pond		Field Crop		Vegetable		Total Area		Crop Intensity	
		Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max
1 Upper West District															
(1) Phollathep	95.0	1.2	2.1	0.6	0.7	0.2	0.3	0.5	0.8	-	-	2.5	3.9	2.6	4.1
(2) Tha Bod	161.0	9.3	18.7	1.3	2.9	0.3	0.5	0.7	3.2	-	-	11.6	25.3	7.2	15.7
(3) Sam Chook	305.0	39.4	52.9	8.0	12.0	1.8	2.1	2.5	6.3	0.7	3.0	52.4	76.3	17.2	25.0
(4) Pho Phaya	370.0	-	-	11.5	16.0	3.5	5.9	2.3	5.2	0.5	0.8	17.8	27.9	4.8	7.5
(5) Don Chedi	133.0	12.8	19.0	3.9	18.9	1.5	2.0	1.0	2.2	1.2	1.8	20.5	43.9	15.4	33.0
(6) Boromathad	365.0	14.8	19.8	0.1	0.6	0.4	1.2	10.1	17.5	0.1	0.5	25.5	39.6	7.0	10.9
(7) Channasutr	475.0	84.0	92.0	3.0	8.4	1.3	2.5	3.3	4.7	0.9	1.3	92.5	108.9	19.5	22.9
(8) Yang Manee	210.0	0.5	0.6	9.3	29.1	0.6	1.8	1.2	2.1	0.6	1.0	12.2	34.6	5.8	16.5
(9) Phak Hai	185.0	-	-	2.2	4.4	3.2	4.1	1.3	2.5	0.6	2.2	7.3	13.2	4.0	7.1
Sub-total	2,299.0	162.0	205.1	39.9	93.0	12.8	20.4	22.9	44.5	4.6	10.6	242.3	373.6	10.5	16.3
2 Lower West District															
(10) Bang Ban	137.0	-	-	-	-	-	-	0.1	0.3	-	-	0.1	0.3	0.1	0.2
(11) Chao Ched Bang Yihon	406.0	0.1	0.2	8.8	10.0	17.0	18.2	1.8	2.1	1.1	1.5	28.8	32.0	7.1	7.9
(12) Phraya Banlue	438.0	-	-	23.0	23.9	7.9	9.0	0.4	0.7	7.7	9.2	39.0	42.8	8.9	9.8
(13) Phra Phimon	266.0	2.2	3.3	26.0	34.9	0.7	1.3	-	-	8.8	14.0	37.7	53.5	14.2	20.1
(14) Phrasi Charoen	200.0	-	-	35.6	46.5	4.7	7.0	-	-	15.9	21.2	56.2	74.7	28.1	37.4
Sub-total	1,447.0	2.3	3.5	93.4	115.3	30.3	35.5	2.3	3.1	33.5	45.9	161.8	203.3	11.2	14.0
3 Upper East District															
(15) Maharaj	422.0	2.7	3.8	1.6	3.3	0.1	0.3	18.1	32.1	0.5	0.8	23.0	40.3	5.5	9.6
(16) Manoyom	192.0	6.9	8.1	1.3	2.1	0.1	0.1	3.9	10.4	0.1	0.3	12.3	21.0	6.4	10.9
(17) Chong Kae	238.0	0.6	1.2	0.6	1.6	0.2	0.4	3.0	7.0	0.6	1.8	5.0	12.0	2.1	5.0
(18) Koke Krathiem	196.0	0.1	0.2	0.1	0.2	-	-	7.0	12.5	0.9	1.3	8.0	14.2	4.1	7.2
(19) Reang Rang	163.0	0.8	2.5	1.8	5.5	0.3	0.9	6.9	9.0	0.9	1.6	10.7	19.5	6.6	12.0
(20) Pasak Thai	226.0	-	-	21.5	28.9	1.6	1.9	2.5	5.4	0.3	1.1	25.9	37.3	11.1	16.5
(21) Nakhon Luang	220.0	-	0.1	0.8	2.2	0.6	1.2	0.4	1.0	-	0.1	1.8	4.6	0.8	2.1
Sub-total	1,657.0	11.1	15.9	27.7	43.8	2.9	4.8	41.8	77.4	3.3	7.0	86.7	148.9	5.2	9.0
4 Lower East District															
(22) Rangsit Nua	454.0	-	-	136.2	151.5	3.6	4.2	-	-	0.1	0.2	139.9	155.9	30.8	34.3
(23) Rangsit Thai	450.0	-	-	26.0	32.0	9.3	12.2	0.3	0.5	0.4	0.8	36.0	45.5	12.0	15.2
(24) Khlong Dam	525.0	-	-	-	-	50.5	86.1	-	-	-	-	50.5	86.1	9.6	16.4
(25) Phra ang Chaiyan Nuchit	510.0	-	-	-	-	27.5	42.7	-	-	-	-	27.5	42.7	5.4	8.4
Sub-total	1,939.0	0.0	0.0	162.2	183.5	90.9	145.2	0.3	0.5	0.5	1.0	253.9	330.2	13.1	17.0
Total	7,342.0	175.4	224.5	323.2	435.6	136.9	205.9	67.3	125.5	41.9	64.5	744.7	1,056.0	10.1	14.4

Table 5.3.3 Proposed Area of Diversified Crops at 25 Irrigation Projects in Delta

(Area Unit: 10^3 rai)

Item	Irrigable Area	Perennial Crop						Dry Season Diversified Crop				Total	
		Sugar Cane		Fruit		Fish Pond		Field Crop		Vegetable			
		%	Area	%	Area	%	Area	%	Area	%	Area	%	Area
1 Upper West District													
(1) Phollathep	90	10.0	9.0	5.0	4.5	1.5	1.4	5.0	4.5	1.0	0.9	22.6	20.3
(2) Tha Bod	153	10.0	15.3	5.0	7.7	1.5	2.3	4.0	6.1	1.0	1.5	21.5	32.9
(3) Sam Chook	289	20.0	57.8	5.0	14.5	1.5	4.3	2.0	5.8	1.5	4.3	30.0	86.7
(4) Pho Phaya	351	-	-	5.0	17.6	1.5	5.3	5.0	17.6	1.5	5.3	13.1	45.8
(5) Don Chedi	126	15.0	18.9	15.0	18.9	1.5	1.9	2.0	2.5	1.0	1.3	34.5	43.5
(6) Boromathad	346	10.0	34.6	5.0	17.3	1.5	5.2	5.0	17.3	1.0	3.5	22.5	77.9
(7) Channasutr	450	20.0	90.0	5.0	22.5	1.5	6.8	2.0	9.0	1.5	6.8	30.0	135.1
(8) Yang Manee	200	5.0	10.0	15.0	30.0	1.5	3.0	3.0	6.0	1.5	3.0	26.0	52.0
(9) Phak Hai	175	-	-	5.0	8.8	2.5	4.4	5.0	8.8	1.5	2.6	14.1	24.6
Sub-total	2,180	10.8	235.6	6.5	141.8	1.6	34.6	3.6	77.6	1.3	29.2	23.8	518.8
2 Lower West District													
(10) Bang Ban	123	-	-	-	-	-	-	-	-	-	-	-	-
(11) Chao Ched Bang Yihon	365	0.5	1.8	3.0	11.0	5.0	18.3	0.5	1.8	0.5	1.8	9.5	34.7
(12) Phraya Banlue	393	-	-	6.0	23.6	2.5	9.8	0.1	0.4	2.0	7.9	10.6	41.7
(13) Phra Phimon	239	1.5	3.6	12.0	28.7	0.5	1.2	-	-	4.0	9.6	18.0	43.1
(14) Phrasi Charoen	180	-	-	20.0	36.0	3.0	5.4	-	-	9.0	16.2	32.0	57.6
Sub-total	1,300	0.4	5.4	7.6	99.3	2.7	34.7	0.2	2.2	2.7	35.5	13.6	177.1
3 Upper East District													
(15) Maharaj	400	3.0	12.0	5.0	20.0	2.0	8.0	5.0	20.0	1.5	6.0	16.5	66.0
(16) Manoyom	182	5.0	9.1	5.0	9.1	2.0	3.6	5.0	9.1	1.0	1.8	18.0	32.7
(17) Chong Kae	226	5.0	11.3	5.0	11.3	1.5	3.4	7.5	17.0	1.5	3.4	20.5	46.4
(18) Koke Krathiem	186	5.0	9.3	5.0	9.3	1.5	2.8	10.0	18.6	1.5	2.8	23.0	42.8
(19) Reang Rang	154	5.0	7.7	10.0	15.4	1.5	2.3	10.0	15.4	1.5	2.3	28.0	43.1
(20) Pasak Thai	214	-	-	20.0	42.8	1.5	3.2	5.0	10.7	1.0	2.1	27.5	58.8
(21) Nakhon Luang	208	-	-	5.0	10.4	2.0	4.2	5.0	10.4	1.0	2.1	13.0	27.1
Sub-total	1,570	3.2	49.4	7.5	118.3	1.8	27.5	6.5	101.2	1.3	20.5	20.2	316.9
4 Lower East District													
(22) Rangsit Nua	410	-	-	35.0	143.5	1.0	4.1	-	-	-	-	36.0	147.6
(23) Rangsit Thai	405	-	-	7.0	28.4	2.5	10.1	-	-	-	-	9.5	38.5
(24) Khlong Dam	475	-	-	-	-	11.0	52.3	-	-	-	-	11.0	52.3
(25) Phra ang Chaiyaa Nuchit	460	-	-	-	-	6.0	27.6	-	-	-	-	6.0	27.6
Sub-total	1,750	-	-	9.8	171.9	5.4	94.1	-	-	-	-	15.2	266.0
Total	6,800	4.3	290.4	7.8	531.3	2.8	190.9	2.7	181.0	1.3	85.2	18.8	1,278.8

Table 5.3.4 Summary of Existing and Proposed Cropping Area and Intensity of Beneficial Area in Dry Season

(Area Unit; 10^3 rai)

Beneficial Area	Irrigable Area	Sugar Cane		Fruit		Fish Culture		Field Crop		Vegetable		Sub-total		Dry Paddy		Total	
		Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%
1. Existing (Past 6 years Average, 1991 - 96)																	
1.1 Delta Area																	
(1) Upper West	2,299.0	161.9	7.0	39.8	1.7	12.8	0.6	22.8	1.0	4.5	0.2	241.8	10.5	712.7	31.0	954.5	41.5
(2) Upper East	1,657.0	11.1	0.7	27.8	1.7	2.9	0.2	41.6	2.5	3.2	0.2	86.6	5.2	193.1	11.7	279.7	16.9
Sub-total	3,956.0	173.0	4.4	67.6	1.7	15.7	0.4	64.4	1.6	7.7	0.2	328.4	8.3	905.8	22.9	1,234.2	31.2
(3) Lower West	1,447.0	2.3	0.2	93.5	6.5	30.4	2.1	2.2	0.2	33.5	2.3	161.9	11.2	758.4	52.4	920.3	63.6
(4) Lower East	1,939.0	0.0	0.0	162.2	8.4	91.0	4.7	0.3	0.0	0.5	0.0	254.0	13.1	544.6	28.1	798.6	41.2
Sub-total	3,386.0	2.3	0.1	255.6	7.5	121.4	3.6	2.5	0.1	34.0	1.0	415.8	12.3	1,303.0	38.5	1,718.9	50.8
Total	7,342.0	175.3	2.4	323.2	4.4	137.1	1.9	66.9	0.9	41.7	0.6	744.2	10.1	2,208.8	30.1	2,953.1	40.2
1.2 Lower Nan Basin																	
(1) Phitsanulok 1	667.0	0.0	0.0	0.0	0.0	0.3	0.0	20.4	3.1	0.2	0.0	20.9	3.1	383.7	57.5	404.6	60.7
(2) DEDP Pump	392.0	0.0	0.0	0.0	0.0	0.1	0.0	4.9	1.3	4.9	1.3	9.9	2.5	107.7	27.5	117.6	30.0
Total	1,059.0	0.0	0.0	0.0	0.0	0.4	0.0	25.3	2.4	5.1	0.5	30.8	2.9	491.4	46.4	522.2	49.3
Grand Total	8,401.0	175.4	2.1	323.2	3.8	137.5	1.6	92.2	1.1	46.8	0.6	775.1	9.2	2,700.2	32.1	3,475.3	41.4
2. Proposed (2016)																	
2.1 Delta Area																	
(1) Upper West	2,180.0	235.6	10.8	141.8	6.5	34.6	1.6	77.6	3.6	29.2	1.3	518.8	23.8	680.2	31.2	1,199.0	55.0
(2) Upper East	1,570.0	49.4	3.1	118.3	7.5	27.5	1.8	101.2	6.4	20.5	1.3	316.9	20.2	468.1	29.8	785.0	50.0
Sub-total	3,750.0	285.0	7.6	260.1	6.9	62.1	1.7	178.8	4.8	49.7	1.3	835.7	22.3	1,148.3	30.6	1,984.0	52.9
(3) Lower West	1,300.0	5.4	0.4	99.3	7.6	34.7	2.7	2.2	0.2	35.5	2.7	177.1	13.6	649.9	50.0	827.0	63.6
(4) Lower East	1,750.0	0.0	0.0	171.9	9.8	94.1	5.4	0.0	0.0	0.0	0.0	266.0	15.2	609.0	34.8	875.0	50.0
Sub-total	3,050.0	5.4	0.2	271.2	8.9	128.8	4.2	2.2	0.1	35.5	1.2	443.1	14.5	1,258.9	41.3	1,702.0	55.8
Total	6,800.0	290.4	4.3	531.3	7.8	190.9	2.8	181.0	2.7	85.2	1.3	1,278.8	18.8	2,407.2	35.4	3,686.0	54.2
2.2 Lower Nan Basin																	
(1) Phitsanulok 1	634.0	0.0	0.0	44.4	7.0	9.5	1.5	50.7	8.0	9.5	1.5	114.1	18.0	291.7	46.0	405.8	64.0
(2) DEDP Pump	685.6	0.0	0.0	48.0	7.0	10.3	1.5	54.8	8.0	10.3	1.5	123.4	18.0	219.4	32.0	342.8	50.0
(3) Phitsanulok 2	500.0	0.0	0.0	35.0	7.0	7.5	1.5	40.0	8.0	7.5	1.5	90.0	18.0	160.0	32.0	250.0	50.0
Total	1,819.6	0.0	0.0	127.4	7.0	27.3	1.5	145.5	8.0	27.3	1.5	327.5	18.0	671.1	36.9	998.6	54.9
Grand Total	8,619.6	290.4	3.4	658.7	7.6	218.2	2.5	326.5	3.8	112.5	1.3	1,606.3	18.6	3,078.3	35.7	4,684.6	54.3