9. Project Water Allocation Plan

9.1 Water Demand and Supply Scenarios

9.2 Table 9.1 Dry Season Deficit of Water in the Direct Beneficiary Areas

Dry Season Minimum Cropping Intensity (%)	Water Deficit in MCM			Total Deficit under Increased Case of Water Use in Upper Chao Phraya Basins		
	Irrigation	Non-Irrigation	Total			
	Moderate Normal High	High Normal Low	(1) 0% =0 MCM	(2) 30% =570MCM	(3) 50% =950MCM	(4) 100% =1,900MCM
20%	136	1,113	1,249	1,819	2,199	3,149
	40	825	865	1,435	1,815	2,765
	-22	578	556	1,126	1,506	2,456
30%	499	1,113	1,612	2,182	2,562	3,512
	447	825	1,272	1,842	2,222	3,172
	386	578	964	1,534	1,914	2,864
40%	1,118	1,113	3,048	3,618	3,998	4,948
	1,067	825	2,708	3,278	3,658	4,608
	1,761	578	2,339	2,909	3,289	4,239
50%	1,935	1,113	3,048	3,618	3,998	4,948
	1,883	825	2,708	3,278	3,658	4,608
	1,761	578	2,339	2,909	3,289	4,239
60%	2,989	1,113	4,102	4,672	5,052	6,002
	2,937	825	3,762	4,332	4,712	5,662
	2,873	578	3,451	4,021	4,401	5,351
70%	4,152	1,113	5,265	5,835	6,215	7,165
	4,100	825	4,925	5,495	5,875	6,825
	4,035	578	4,613	5,183	5,563	6,513
80%	5,415	1,113	6,528	7,098	7,478	8,428
	5,363	825	6,188	6,758	7,138	8,088
	5,298	578	5,876	6,446	6,826	7,776
90%	6,739	1,113	7,852	8,422	8,802	9,752
	6,689	825	7,514	8,084	8,464	9,414
	6,634	578	7,212	7,782	8,162	9,112

Note: Increasing water demand in the upper Chao Phraya basins is projected as 1,900 MCM at 2016 if all of irrigation development projects proposed have been implemented.

Projection of water demand required from various water users including irrigation, domestic and industrial water supply and livestock was analyzed applying various cropping intensities from 20% to 90%, and three degrees of development in promotion of crop diversification program for irrigation, namely 1) highly promoted, 2) normally promoted and 3) moderately promoted cases, and three growing cases for water demand other than irrigation, namely 1) high growth, 2) normal growth and 3) low growth cases. The study reveals that there exists shortage of water for irrigation at present and the shortage will continue in future, however, water demand itself will decrease as the crop diversification program advances, since most of the diversified crops consume less water than dry season rice. The above table summarizes that current order of the Chao Phraya flow at Chainat together with 2,800 MCM of water additionally released from the Sirikit reservoir in dry season under the proposed water diversion project would meet 50% at most of the minimum cropping intensity in the direct beneficiary area. The minimum cropping intensities to be secured by the proposed water diversion project would be some 40% if 30% of the proposed water resources development projects in the upper Chao Phraya

basins have been implemented, and some 35% if 50% of the proposed projects have been implemented. On the other hand, only 20% of the minimum cropping intensity can be guaranteed under the average year condition in the direct beneficiary area if 100% of the proposed water resources development projects in the upper Chao Phraya basins have been implemented. In this case, about 865 MCM of water to be available additionally under the project will be allocated only to the growing demand of water supply sector providing no contribution to irrigation in the delta. The Chao Phraya flow at Chainat in a dry season in an average year will decrease to 3,900 MCM which is almost equivalent to the present dry year condition. In a dry year, the flow will decrease to about 1,500 MCM resulting a crucial water shortage over the delta area.

The above consideration suggests a strong possibility that water shortage problems would prevail over the whole Chao Phraya basins providing hopeless damages in the social and economic development. At present, water allocation and operation in the Chao Phraya delta seem to be done well making the best use of its scale merit, however, even greater efforts may be required in effective irrigation water use especially in wet season. The current tendency of increase in per capita demand for water supply sector may be one of the important target for saving. The risk of water shortage even in wet season in future should be fully recognized by all of water users. The disordered and unlimited development in the upper Chao Phraya basin will result the serious water crisis in future in the delta, and therefore a proper rule of water operation and management should be established at the National level inclusive of restriction of development activities.

A series of water balance scenarios within a possible range have been studied for further consideration of appropriate actions by the Thai government. However, a possible scenario can be explained as a sample which is selected among various alternatives focusing on the current policy of the agricultural development in Thailand;

A Sample Scenario of Water Demand and Supply

Demand projection for irrigation was made based on the estimates of appropriate limit of crop diversification which are determined through discussions made with the MOAC taking into account limitation from topography, land use, water availability and domestic and export market demands. In addition, stable supply of water throughout a year is absolutely necessary to maintain perennial crops such as fruit trees, sugarcane and fish ponds. Important figures are extracted from Table 5.3.4 as follows, and figures given for the case with "highly promoted crop diversification program" are therefore considered to set an upper limit of land use for crop diversification.

Table 9.2 Proposed Areas for Diversified Crops in the Delta

Crop Diversification Program	Sugar Cane	Fruit Trees	Fish Pond	Field Crops	Vege-table	Total	Remarks
Highly Promoted	348.5	637.6	229.1	217.2	102.2	1,534.6	120%
Normally Promoted	290.4	531.3	190.9	181.0	85.2	1,278.8	100%
Moderately Promoted	232.3	425.0	152.7	144.8	68.2	1,023.0	80%

On the other hand, promotion of crop diversification also envisages to save water for dry season irrigation, because that most of the diversified crops consume less water than rice. Even so, the

government intends in the 8th 5-year plan to maintain 3.0 million rai of dry season rice cropping from view points of export demand and necessity of water supply in the conservation area (lower delta). Cropping of dry season rice needs irrigation, and 70% to 75% of the national products were harvested actually in the delta in the past. Out of 3.0 million rai, therefore, some 75% or 2.25 million rai may be allocated to the delta where a large extension of irrigated farmland exists. From the above consideration, appropriate limit of crop diversification plus some 2.1 million rai of rice would form the upper limit of dry season cropping in the delta.

Table 9.3 Upper Limit of Dry Season Cropping in the Delta in Future

Crop Diversification Program	Irrigable Area (1,000 rai)	Diversified Crops (1,000 rai)	Rice (1,000 rai)	Total (1,000 rai)	Cropping Intensity (%)
Highly Promoted	6,800	1,534.6	2,250.0	3,784.6	55.7

The above 2.25 million rai of dry season rice cropping corresponds to the total area of 1.3 million rai in the lower delta which has been maintained even in a critical dry year to protect the area from saline water intrusion and 0.9 to 1.2 million rai in the upper delta where water supply for dry season irrigation is always restricted depending on the availability of water. About 45% of dry season cropping is necessary in the delta even when the national target of dry season rice cropping is lowered to 80% and normal promotion case of crop diversification program is adopted, showing a lower limit in a practical meanings.

Table 9.4 Lower Limit of Dry Season Cropping in the Delta in Future

Crop Diversification Program	Irrigable Area (1,000 rai)	Diversified Crops (1,000 rai)	Rice (1,000 rai)	Total (1,000 rai)	Cropping Intensity (%)
Normally Promoted	6,800	1,278.8	1,800.0	3,078.8	45.3

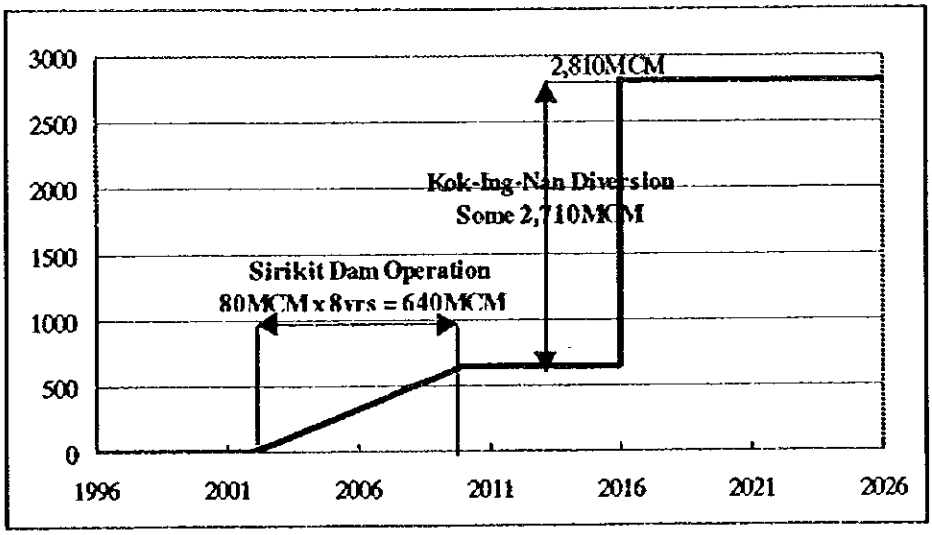
Accordingly, realistic range of the minimum cropping intensity in dry season in the delta will be between 45% and 55%, and adoption of 50% of the minimum cropping intensity to be secured is, therefore, reasonable since it produces the mean intensity of some 54% over the delta. On the other hand from the water supply side, about 2,800 MCM of water, comprised of 2,000 MCM diverted from the Kok and Ing rivers and 800 MCM generated by improvement of the Sirikit reservoir operation, will be the maximum taking the availability of water in the Kok and Ing basins, regulating capacity of the Sirikit reservoir and construction cost of diversion facilities into consideration. The cropping intensity of 54% over the delta can be achieved with 1,985 MCM of additional water supply for irrigation in dry season, after taking 825 MCM of water from 2,800 MCM for water supply uses in advance.

9.2 Scenarios of Water Allocation

Projection of water demand for various water user sectors with various parameters given above was made without any relation to additional water supply or without any limitation of additional water supply. It may correspond to the needs and identification of the proposed water diversion project

showing the current and future water shortage problems during the period of dry season particularly in the Chao Phraya delta. The water allocation plan on the contrary, works out the water demand allocation under the proposed water diversion where additional water supply capability in the dry season is preliminarily scheduled at about 640 MCM at around the year 2006, produced from the Sirikit reservoir by means of improvement of its operation, and at 2,810 MCM in 2016 due to water diversion from the donor basins. Figure 9.1 shows a water supply curve in terms of additional supply of water brought from the proposed water diversion project.

Figure 9.1 Water Supply Scenario



The analysis indicates that at the target year 2016, water demands exceed the potential water supply when the minimum cropping intensity is taken at more than 50% for the case when expansion of new irrigation system in the lower Nan basin is included and 60% for the case if system expansion is excluded, both for the normal case of promotion of crop diversification program. Consideration given in the previous paragraph explains that about 52% of the minimum intensity for dry season cropping would be maximum even when requirement from crop diversification program as well as necessity of rice cropping especially in the conservation area is fully taken into account. More water would promote more cropping to rice, however, tightness of supply and demand of water would not allow such an extravagant plan to be implemented. A plan lowering the present achievement of dry season cropping is also meaningless, and therefore a plan with a minimum intensity of 50% would be the best selection under the current policy of irrigated agriculture development.

Since the water use for non-irrigation sectors keeps a priority over the irrigation, available water is first allocated to non-irrigation sectors where three cases of growth in water use are considered. Residual water after withdrawn by these sectors is usable for irrigation. For irrigation purpose, two alternative cases of water allocation; namely allocation to the existing irrigable area in the direct beneficial area only (Case B) and allocation to the areas including new system expansion along the left bank of the Nan river (Phitsanulok Stage II Area)(Case B), can be considered. Six cases in total of scenarios of water allocation are thus produced as seen in the following table.

Table 9.5 Six Scenarios of Water Allocation Plan for Dry Season Use

Growing Scenario of Non-Irrigation Water Use	Agricultural Development	
	System Expansion Included	System Expansion Excluded
High Growth Case	A-1	B-1
Normal Growth Case	A-2	B-2
Low Growth Case	A-3	B-3

Allocation of water for six cases of scenario is tabulated in Table 9.6.

Table 9.6 Allocation of Water by Scenarios

Scenario of Water Allocation	Water Availability (MCM)	Power Generation (MCM)	Non-Irrigation Sectors (MCM)	Irrigation	
				Irrigable Area (1,000 rai)	Water Demand (MCM)
A-1	2,810	2,810	1,103	1,032.5	1,707
A-2	2,810	2,810	825	1,182.8	1,985
A-3	2,810	2,810	578	1,639.8	2,232
B-1	2,810	2,810	1,103	1,032.5	1,707
B-2	2,810	2,810	825	1,182.8	1,985
B-3	2,810	2,810	578	1,639.8	2,232

10. Irrigated Agriculture Development in the Kok, Ing and Upper Nan Basins

(1) Necessity of Irrigated Agriculture Development

Successful implementation of the proposed Kok-Ing-Nan Water Diversion Project inevitably needs participation and cooperation of the people who live in the donor basins of the Kok and Ing and the upper Nan basin where diverted water of 175 cu.m/sec at maximum continues to flow down through the Yot, Yao and the main stream of the Nan river. Agriculture is the major means of livelihood for the people in the basins, however because of still lacking water resources development projects, basins are being left undeveloped with low agricultural productivity and per capita GBP of more or less 16,000 Baht which is considerably lower than 137,000 Baht in the lower Chao Phraya basin. Under this situation, implementation of the regional development especially for irrigated agriculture prior to the Kok-Ing-Nan Project is strongly requested by the local governments and people.

The inventory survey was conducted to identify the existing and potential development of the irrigated agriculture in three basins as summarized below;

Table 10.1 Existing and Potential Irrigable Area in Three Basins

(Unit: 10^3rai)

Basin	Potential Farmland	Existing Irrigable Area	Potential Irrigable Area
Kok	1,288	464 (36%)	939 (73%)
Ing	1,761	713 (40%)	1,187 (67%)
Donor Basin Total	3,409	1,177 (40%)	2,126 (70%)
Upper Nan	1,120	305 (27%)	617 (55%)

- Irrigable area in the above table denotes the area under supplemental irrigation in wet season and the area is rarely cultivated in dry season.
- Potential irrigable area denotes the area which is possible to be developed served by medium/small scale dams and the "Associated Project" area to be implemented related

directly to the proposed water diversion project.

(2) Irrigated Agriculture Projects Studied by Thai-Side

Among numbers of the proposed and potential projects involved in the inventory, feasibility studies for the following three projects are made by the Thai-side in parallel with the water diversion Project;

- Improvement project of the Nong Luang swamp which locates in the Kok basin near the Chiangrai city. The project consists of fish culture development in the Nong Luang swamp and irrigated agricultural development at the downstream area.
- "Community Irrigation Project" in the upstream reaches of the Ing basin to rehabilitate the existing weirs constructed and managed by the people irrigation system.
- "Nam Samun Project" in the upper Nan basin to construct the Nam Samun dam with irrigation service area of 12,000 rai.

(3) Associate Irrigation Project

A preliminary study was made under the JICA Study to identify the "Associate Irrigation Project" which can receive direct contribution of the proposed Kok-Ing-Nan Water Diversion Project to supply irrigation water conveyed in the dry season from the Kok river through the proposed diversion facilities. As given in Table 10.2, 200,000 rai and 50,000 rai are to be irrigated respectively in the Kok/Ing and the upper Nan basins. These projects may be implemented prior to or in parallel with the Kok-Ing-Nan Project in order to bring agricultural benefit in the Kok, Ing and upper Nan basins.

Table 10.2 Associate Projects in Kok, Ing and Upper Nan Basins

(Unit: 10^3rai)

Item	Irrigable Area	Dry Season Irrigation Area	Irrigation Intensity (%)
Kok Area along Water Diversion Route	3,000	1,200	40
Tak Area along Water Diversion Route	7,000	2,800	40
Lower Ing Area Served by Canal, Weir and Pump	190,000	76,000	40
Total	200,000	80,000	40
Area along the Nan River	50,000	20,000	40

In addition to the above agricultural development, the area can be benefited by promotion of fish culture that may be extended in the water surface area of 44,000 rai to be created on the Ing river with an elevated water level created by a series of weirs and 13,000 rai generated by the proposed Yao flood control dam.

11. Project Facility Plan

11.1 Basic Plan of Project Facility

The Project facility is studied based on the following basic plan;

- Maximum design water diversion capacity;

Kok-Ing water diversion system, 140 cu.m/sec
Ing-Nan water division system, 175 cu.m/sec

- The water diversion from the Kok-Ing basin to the Nan basin shall be carried out in the wet season from June to December. The dry season water in the Kok and Ing rivers shall not be diverted to the Nan basin but used for irrigation of the dry season crops in the Kok-Ing basins.
- The designed discharge of 175 cu.m/sec shall be diverted firstly from the Ing river flow to mitigate the existing inundation problem at the area along the lower Ing river. When the Ing river has not sufficient water to meet the designed water of 175 cu.m/sec, the deficit water will be diverted by the Kok river.
- The water conveyance will be carried out with the gravity system, without pumping and pressure system.
- The regulators and turnouts shall be provided in the open canal crossing the Kok and Ing basins to supply the irrigation water from the canal to the beneficial areas of the associate projects.

11.2 Outline of Project Facility

The preliminary design of Project facility is conducted paying the particular attention the environmental impact and its mitigation measures. The outline of the Project facility is as shown in Table 11.1.

Table 11.1 Outline of Project Facility

Project Facility	Outline
(1) Kok Weir	Use of existing Chiang Rai weir
(2) Kok Intake	Maximum diversion capacity of 140 cu.m/sec, Retention water level of 388 m
(3) Kok-Ing Diversion Canal	Maximum diversion capacity of 140 cu.m/sec, Total length of canal 54.6km consisting of the open canal of 38.6km, culvert/siphon of 7.5km and two tunnels of 8.5km
(4) Ing Weir	Rubber weir, Maximum diversion capacity of 175 cu.m/sec, Retention water level of 363.5m
(5) Ing-Yot Canal	Maximum diversion capacity of 175 cu.m/sec, Total length of 13.5km consisting of the open canal of 1.8km, culvert/siphon of 9.7km and a tunnel of 2.0km
(6) Ing-Yot No.2 Tunnel	Maximum diversion capacity of 175 cu.m/sec, main tunnel length of 50.9km, 7 inclined adits total 17.4km in length
(7) Yao Flood Control	Rockfill type dam, effective capacity of 32 MCM, Dam height of 57m, Dam length of 300m
(8) Yao River Training	River length of 41.9km

(1) Diversion Water

The Kok-Ing has a rich annual runoff of 8,000 MCM, of which 2,000 MCM is diverted to the Nan basin in the wet season. Although the Kok river has fairly rich dry season flow of 600 MCM, it shall not be diverted to the Nan basin but will be used for irrigation in the Kok and Ing basins.

The water diversion of a large discharge capacity of 175 cu.m/sec in the flood season of August to September could mitigate the flood damages at the lower basins of the Kok and Ing rivers. Moreover, the Mekong river used to bring about a large flood of 5,000 to 7,000 m3/sec at Chiang Saen station, near the Kok river mouth and course a large erosion problem by floods for both river banks in Thai and Lao sides. The water diversion of the Project can mitigate the above

flood damages.

(2) Kok Intake

The Kok intake is proposed at 3km upstream of the existing Chiang Rai weir and designed with diversion capacity of 140 cu.m/sec and the retention water level of 388m. Since the Kok river brings about large sediment materials, a sediment depositing pond with a large area was provided in front of the Kok intake to prevent invasion of the sediment transport into the Kok canal. The location of intake is selected at public land without any land acquisition problem.

(3) Kok-Ing Diversion Canal

The Kok-Ing diversion canal passes through the Kok, Tak and Ing basins and reaches the Ing Weir. The canal consists of open canal, culvert, tunnel, etc. and is designed with the following conditions;

- The open canal route is selected so as to cross rainfed paddy areas avoiding valuable land such as urban area, orchard garden, people irrigation area, etc. The spoil bank of excavated materials is selected at depression and wasteland along the canal route. The existing rainfed paddy area and spoil bank along the route will be converted into orchard yard, vegetable and flower gardens, green park etc. and used for recreation of urban peoples and tourists visiting Chiang Rai province.
- Since the culvert is designed at the deep exacerbation with a depth of more than 20 m at hilly area the route is selected far from the village areas to avoid environmental disturbance. The construction plan for culvert with deep and large excavation volume shall be specially set up taking into account excavation method, spoil bank, drainage method, etc which shall not damage the natural environment.

(4) Ing Weir

- The Ing weir is planned to regulate the diversion water from the Kok river and runoff of the Ing river and to divert them to the Ing-Yot No.2 tunnel. The weir site is selected 2km upstream of Thoeng bridge in the Ing middle basin.
- The runoff of the Ing-Lao river which joins with the Ing mainstream at the Thoeng bridge site, shall not be used for diversion to the Nan basin but for irrigation area in the lower Ing basin.
- Reservoir is provided at the upstream river channel of 10km by the Ing weir and could be used as fish culture pond.
- Green belt area is provided along the dikes of reservoir bank and will be used for recreation area.

(5) Tunnel

There are four kinds of tunnel, the Kok-Ing No.1 and No.2 tunnels with design discharge capacity of 140 cu.m/sec and the Ing-Yot No.1 and No.2 tunnels designed with the capacity of 175 cu.m/sec. The Ing-Yot No.2 tunnel has a long distance of 50.9km and requires seven inclined adits for tunnel construction as well as for future maintenance. All tunnels are designed with the following counter-environmental impact and its mitigation measures.

- The tunnel inlet and outlet as well as the inlet of inclined adits are selected at the locations avoiding the national park and reserved forest area I nominated by the R.F.D.
- Tunnel excavation will be carried out with the tunnel excavator which does not use dynamite in order to avoid any danger and noise disturbance for the peoples living in the villages near by the tunnel inlet and outlet and for wild animal and birds living in the mountains.

- Water treatment facility to treat the poluted drainage water in the tunnel shall be installed at the inlet and outlet of tunnel to release the treated clean water to the rivers.
- Spoil banks of tunnel mucks shall be arranged so as to the able to use as orchard or flower garden, grass land for cattle breading, recreation area of the village peoples, etc.

(6) Yao Dam

- The upper basin of the Yao river is formed with steep mountain areas and has a rainfall with high intensity which can bring about a large peak flood of more than 200 cu.m/sec. The villages along the downstream river course have been suffered from flood damages every year.
- The flood control dam to control to floods together with the diversion water of the Project is proposed which is designed to be a rock fill type with the effective capacity of 32 MCM at the Yao upstream reach. The designed maximum outflow capacity is 200 cu.m/sec.
- The Yao dam is also used for irrigation water supply in the dry season after filling the reservoir by the diversion water and river flow during October and November.
- The Yao dam is selected at the site which has no resettlement problem at all and does not belong to the national park and reserved forest area I.
- The reservoir high water level is designed so that the back water does not cause any influence to the upstream villages.

(7) Yao River Training

- The river training works consisting of expansion of the river width, protection of river bed and banks, drops and weirs together with the energy dissipating facilities, etc. are designed along the river of 40km in order to release the discharge of 200 cu.m/sec.
- Water supply facility, flood protection dikes, bridges crossing the river, etc shall be provided at the village areas. Pumping facility will also be installed to supply irrigation water released from the Yao dam in the dry season to the existing farm area.

(8) Construction Plan

The Project facility will be constructed dividing into 11 construction lots due to a huge scale works. It takes about four years for construction of canal, weir and dam but seven years for Ing-Yot No.2 tunnel with a long distance of 50.9km.

11.3 Project Cost

The Project cost for the water diversion works is 43,386 million Baht classifying into the foreign currency portion of 31,416 million Baht and the local portion of 11,970 million Baht as shown in Table 11.2.

The Project cost including the other related costs such as associate irrigation project, environmental impact mitigation measures and development of the beneficial areas in the lower Nan and Delta is estimated at 59,563 million Baht for the Plan A with new irrigation Project in the lower Nan.

Table 11.2 Summary of Project cost

(Million Baht)

Item	A Plan			B Plan		
	F.C	L.C	Total	F.C	L.C	Total
(1) Kok-Ing-Nan Project	31,416	11,970	43,386	31,416	11,970	43,386
(2) Associate Irrigation Project	2,500	1,313	3,813	2,500	1,313	3,813
(3) Environmental Impact Mitigation Development of Existing	380	420	800	380	420	800
(4) Beneficial Area	0	944	944	-	944	944
(5) Development of New Beneficial Area	7,000	3,620	10,620	0	0	0
Total	41,296	18,267	59,563	34,296	14,647	48,943

Remark; A Plan includes the development of new beneficial areas in the lower Nan (with new beneficial areas), while B Plan is without new areas.

12. Project Implementation Program

(1) Implementation Program is prepared as shown in Table 12.1 under the assumption that the EIA study and the Cabinet approval for the project implementation will be completed by the end of 2001. It takes about 12 years to complete the whole proposed project including the detailed design and construction works. However, the construction of the Kok-Ing diversion canal including the Kok intake and Ing weir will be completed at BE2551 (2008) with the construction period of four to five years. The associate irrigation projects to be developed by the diversion water will also be implemented and completed at the same period.

(2) Averaged disbursement per annum is about 6,000 million Baht in total classifying into the foreign currency partion of 4,000 million Baht and the local portion of 2,000 million Baht. RID has a large annual local budget of about 26,000 million Baht for the project implementation in BE 2541 (1998), which is sufficient to cover the local currency portion of 2,000 million Baht. The foreign currency portion will be provided by the loan from the international lending agency.

13. Project Evaluation

13.1 Raw Water Cost at Sirikit Dam

The raw water cost for the diversion water of 2,000 MCM developed by the project is 1.3 Baht/cu.m at the Sirikit damsite under the following conditions;

- Project cost is 44,186 million Baht consisting of the water diversion works and environmental impact mitigation measures.
- Repayment period of 50 years and annual interest of 5%.

13.2 Economic Evaluation

The economic evaluation is carried out for two alternative Plans of A and B with and without new irrigation project in the lower Nan and three cases of High, Normal and Low growth for A and B respectively.

(1) Incremental Net Economic Value of Project

The incremental net economic value for six alternative Plans is summarized in Table 13.1.

Table 13.1 Incremental Net Economic Value of Project

(Unit, Million Baht)

Alternative Plan	Municipal & Industrial Water Supply	Agriculture	Hydropower	Total
1. Plan A with New Irrigation Project				
A1 High Growth	3,698	10,600	406	14,704
A2 Normal Growth	2,766	10,918	406	14,090
A3 Low Growth	1,938	11,200	406	13,544
2. Plan B without New Irrigation Project				
B1 High Growth	3,698	9,484	406	13,858
B2 Normal Growth	2,766	9,870	406	13,042
B3 Low Growth	1,938	10,213	406	12,557

(2) Economic Evaluation

EIRR for six alternative Plans is estimated as shown in the following table.

	A1	A2	A3	B1	B2	B3
EIRR (%)	14.4	14.1	13.8	15.0	14.7	14.5

Every alternative plan shows the relatively high EIRR of more than 14.0%. The most desirable plan will be A1 or A2 which will use the diversion water for the new irrigation area in the lower Nan together with the existing area in the lower Nan and Delta because the depressed area at present in the lower Nan will be newly developed and the income disparity of the peoples between the existing and new area will be reduced.

(3) Evaluation of Net Farm Income

Average net farm income for each beneficial area of the Project is estimated as shown in

Table 13.2. The farm income at all beneficial areas will be remarkably increased by the diversified agriculture under the stabilized irrigation water supply of the Project.

Table 13.2 Net Farm Income

(Unit, Baht/family)

Beneficial Area		Without Project	With Project	Net Increment
1. Chao Phraya Delta (31.6 rai),	Owner	42,000	103,000	61,000
	Owner/Tenant	21,200	75,700	54,500
2. Existing Phitsanulok (31.9 rai),	Owner	43,500	118,700	75,200
	Owner/Tenant	24,700	90,900	66,200
3. New Phitsanulok (31.9 rai),	Owner	5,000	71,800	66,800
	Owner/Tenant	2,000	57,400	55,400
4. Associate Project (15.5rai),	Owner	10,600	107,900	97,300
	Owner/Tenant	7,600	89,800	82,200

13.3 Other Advantages and Benefits of the Project

The Project has a large economic benefit as shown in the raw water rate of 1.3 Baht/cu.m for the developed diversion water of 2,000 MCM and 0.9 Baht/cu.m for the increased outflow of 2,800 MCM at the Sirikit dam in the dry season, while EIRR of 15 to 16% for all alternative plans. In addition to the above, the Project will produce the following benefits and advantages.

(1) At the Kok, Ing and Upper Nan Basin

- The existing flood damage at the area along the lower Ing river could be mitigated by the water diversion of 175 cu.m/sec during the flood season.
- Diversified agriculture in the basins is accelerated by the stable irrigation water supply in the dry season and farmer's income will largely increase accordingly.
- Preservation of aquatic ecology and expansion of fish culture at the river and wetland in the Ing basin could be materialized easily and sustainably by the dry season water supplied by the Project.
- Agro and eco truism at the area along the water diversion route will be developed in parallel with the Project and under participation of the peoples in the area and will contribute to the job creation and income generation for the rural peoples in the basin.
- Agricultural products including processed foods in the basin could be exported to the large market of China, Myanmar and Laos through the Mekong river.

(2) Sirikit Dam

- The Sirikit dam will increase the flood control capacity in the reservoir substantially by reducing the existing carrying over capacity for the next dry year. The flood outflow at the Sirikit dam to the lower Nan river will be minimized in future and the existing flood at the Chainat barrage and the lower Chao Phraya river will be largely mitigated.

(3) Nan River Basin

- The water resources development for irrigated agriculture in the tributaries of the Nan river has been suspended long time due to a large influence to reduce the water resources at the

Chainat barrage and to occur chronic water shortage problem in the Delta. Such as water resources development could be accelerated without inducing water shortage problem in the Delta after the Project. The water resources development by the large and medium scale dams will mitigate the peak flood discharge by the reservoir storage and contribute to the flood control at the lower Nan river and the lower Chao Phraya.

- The aquatic ecology at the dry season in the lower Nan river will also be improved by the bulk water supply in the dry season.
- The water management in the dry season for the river flow, reservoir operation, irrigation system, etc will be improved and carried out smoothly.

(4) Chao Phraya Delta

- Diversified agriculture being progressed at the Delta will be promoted successfully by the stable irrigation water supply in the dry season.
- The export of diversified agricultural products including processed foods will be increased, while job creation and income generation in the rural area will be promoted by diversified agriculture and agro-industry.
- Urban and industrial development in the Delta will be sustained by the dry season water supply.
- The existing groundwater conditions facing problems of decreased quantity, water level lowering, poluted quality, land settlement, etc. could be improved by supplying surface water in the dry season instead of over pumping of the groundwater.

14. Conclusion and Recommendation

(1) The irrigated agriculture in the upper Chao Phraya basin tends to expand, reducing the flow of the Chao Phraya river at Chainat from where water is diverted and distributed to the existing large-scale irrigation projects in the delta. Water demand in the delta also tends to increase because of agricultural, urban and industrial development. If these tendencies continue as they are, water resources especially in dry season will become short seriously in future. (Under the current water resources development policy as well as agricultural development policy including crop diversification program, about 4,000 MCM of water will be deficient in dry season in future.) Probable shortage of water in future would be far beyond of saving by means of effective operation and management of water, however, it is an urgent necessity to consider the comprehensive measures of water resources management aiming at sustainable development of limited water resources.

(2) In case that decision is made to take actions to mitigate the chronic shortage of water prevailing over the Chao Phraya basin during dry season, water diversion as studied by the F/S can be considered as one of feasible measures from engineering point of view. Possible actions inclusive of improvement of operation rules of the existing storages, such as some 640 MCM of additional dry season release from the Sirikit reservoir proposed by the F/S, should however be taken to cope with the immediate needs of dry season water. A series of water balance scenarios within a possible range are shown in this report for further consideration of appropriate actions by the Thai side. About 8,000 MCM of the water resources in the Kok and Ing basins are very valuable for the peoples living in the basin,

however most of them are released unused to the Mekong river at present. On the basis of the maximum development of the potential water resources in eventual future, the JICA Study estimated the volume of water to be reserved in the basins and in turn available water for diversion. However, to lead the implementation of the proposed project into success, it is necessary to continue the public relation activities with full information regarding the EIA and other studies including participatory rural appraisal etc, aiming to arrive at the common consent and understanding among the residents in the donor basins.

(3) In view of the magnitude of influence that might be caused by the water diversion, public relation activities should be executed not only in the Kok, Ing and upper Nan basins but also in the direct beneficiary areas in the lower Nan and Chao Phraya delta, and further at the national level. Water allocation and operation in the Chao Phraya seem to be done well making the use of its scale merit, however, the risk of water shortage even in wet season in future should be fully recognized by all concerned.

(4) In view of a critical condition of balance between demand and supply of water, "Water Resources Management" in the Chao Phraya basin is of quite importance. It is therefore necessary to establish a responsible organization to take charge of this (Strengthening of National Water Resources Committee, Establishment of Basin Authority, etc.).

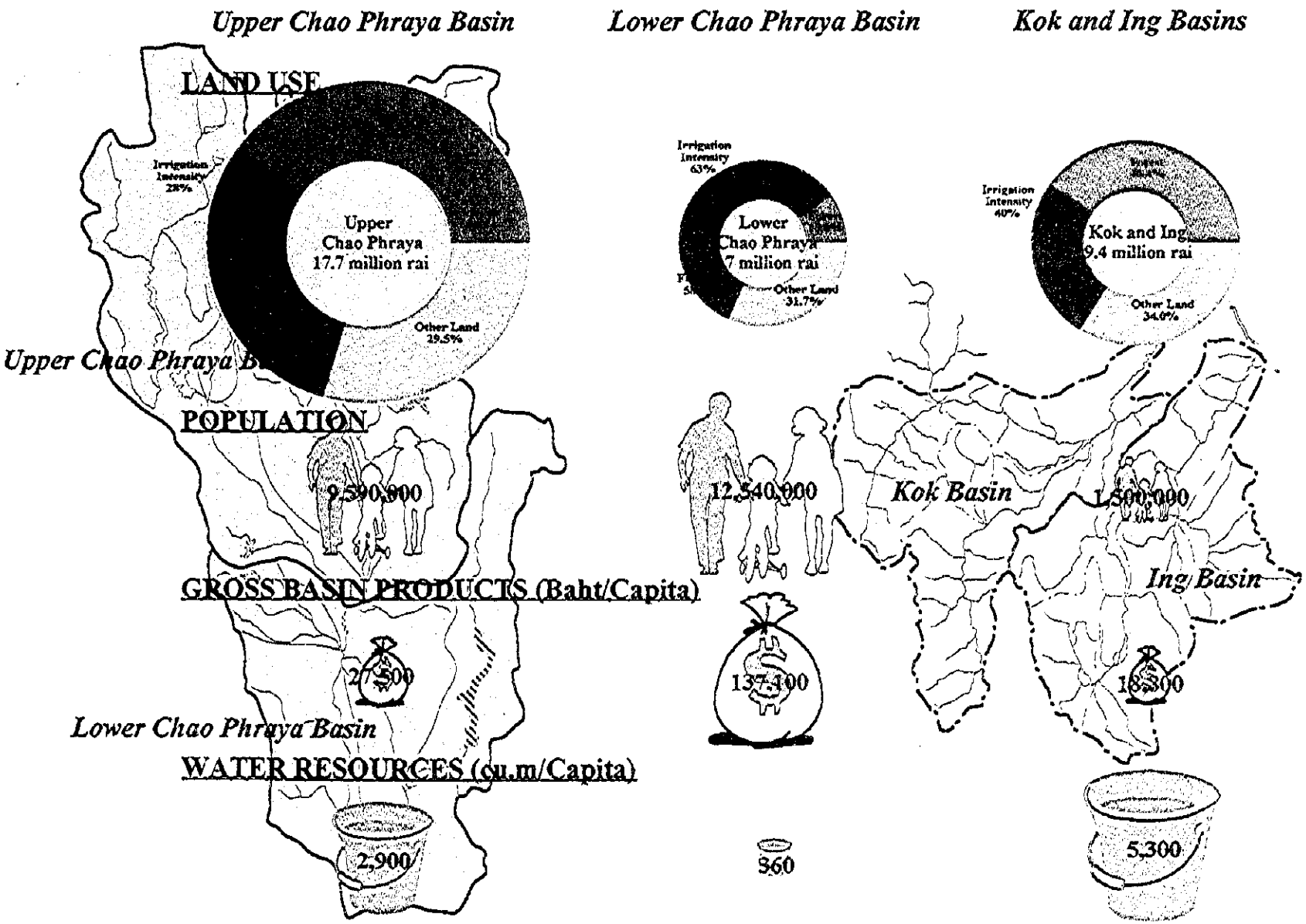
(5) For the sustainable development of water resources and rationalization of water use, it is recommended to collect water charge from water users. In the case of the water diversion, it is desirable to allocate a part of the collected charge for development of the Kok and Ing basins.

(6) The JICA environmental technical assistance study was carried out focusing on review of RID's EIA study and supplemental study in due consideration of watershed conservation and sustainable rural development. Regarding EIA as it ought to be, RID is recommended to refer the conclusion and recommendation of the JICA environmental technical assistance study for future consultation with OEPP.

List of Figure

Figure 2.1	Socio-Economic Indicator in the Chao Phraya, Kok and Ing Basin
Figure 3.1	Socio-Economic Indicators of the Chao Phraya Basin
Figure 3.2	Increasing Area for Diversified Crops in the Chao Phraya Delta
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 Basin
Figure 4.4	Irrigated Agriculture Development
Figure 4.5	Schematic Diagram of Wet and Dry Season
Figure 4.6	Large Empty Space of Storage in the Bhumibol and Sirikit Reservoir
Figure 4.7	Function Involved in Water Management
Figure 5.1	Dry Season Cropping Intensity in 25 Irrigation Projects in the Delta
Figure 5.2	Current Situation of Salinity Intrusion into Groundwater Aquifer
Figure 5.3	Structure of Water Demand and Supply (1)
Figure 5.4	Structure of Water Demand and Supply (2)
Figure 6.1	Location of Alternative Water Diversion Plan
Figure 7.1	Present Operation and Improved Operation of Sirikit Reservoir
Figure 8.1	Irrigation Development and River Runoff in Kok, Ing and Upper Nan Basin
Figure 8.2	Kok and Ing River Flow before/after Potential Development
Figure 10.1	Existing, Proposed and Potential Water Resources Development
Figure 10.2	Associate Irrigation Projects in the Ing Basin
Figure 11.1	Kok-Ing Diversion Canal
Figure 11.2	Ing-Yot Diversion Tunnel
Figure 11.3	Yao Dam and River Training
Figure 13	Project Benefit Estimation

Figure 2.1 Socio-Economic Indicator in the Chao Phraya, Kok and Ing Basins



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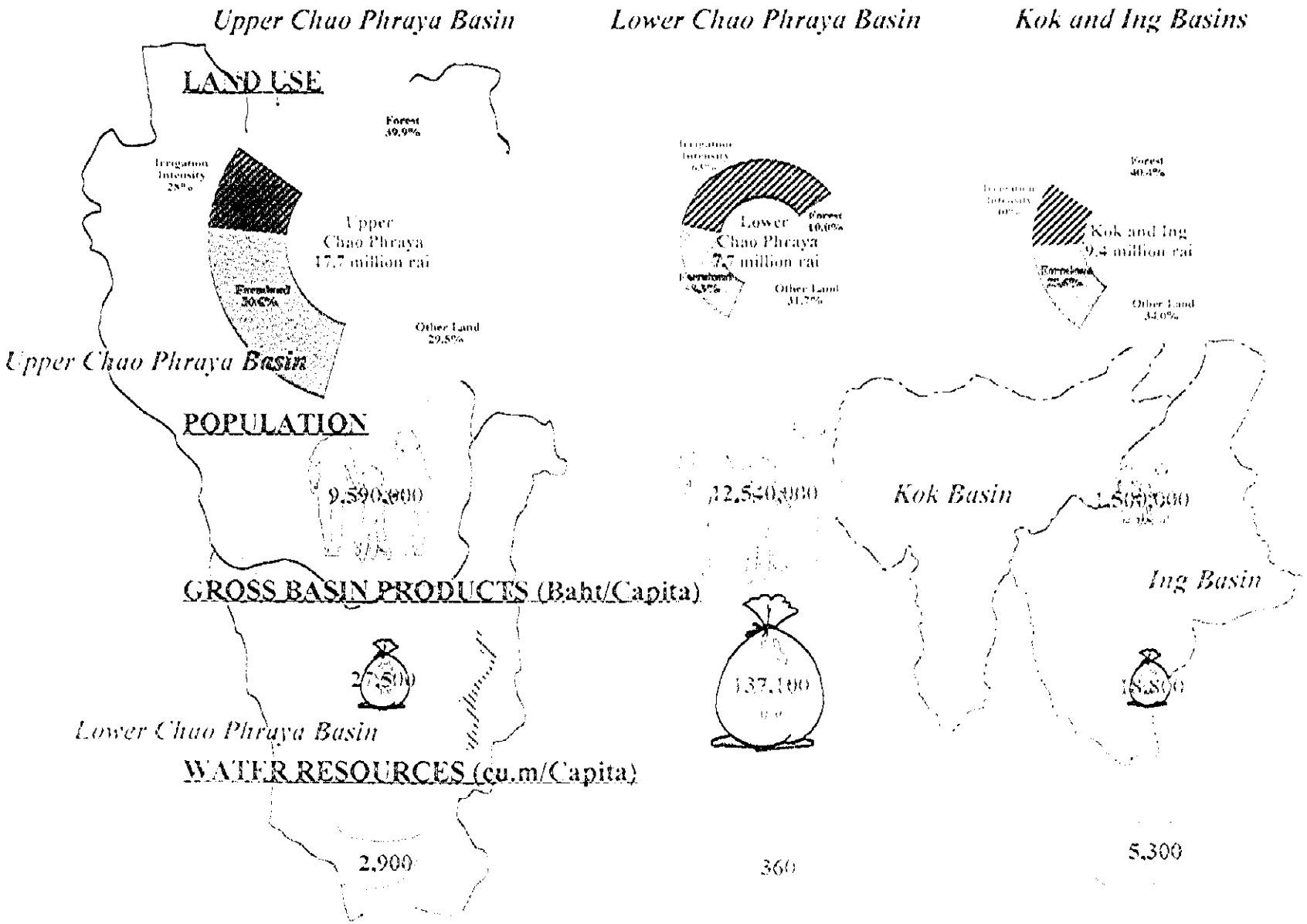

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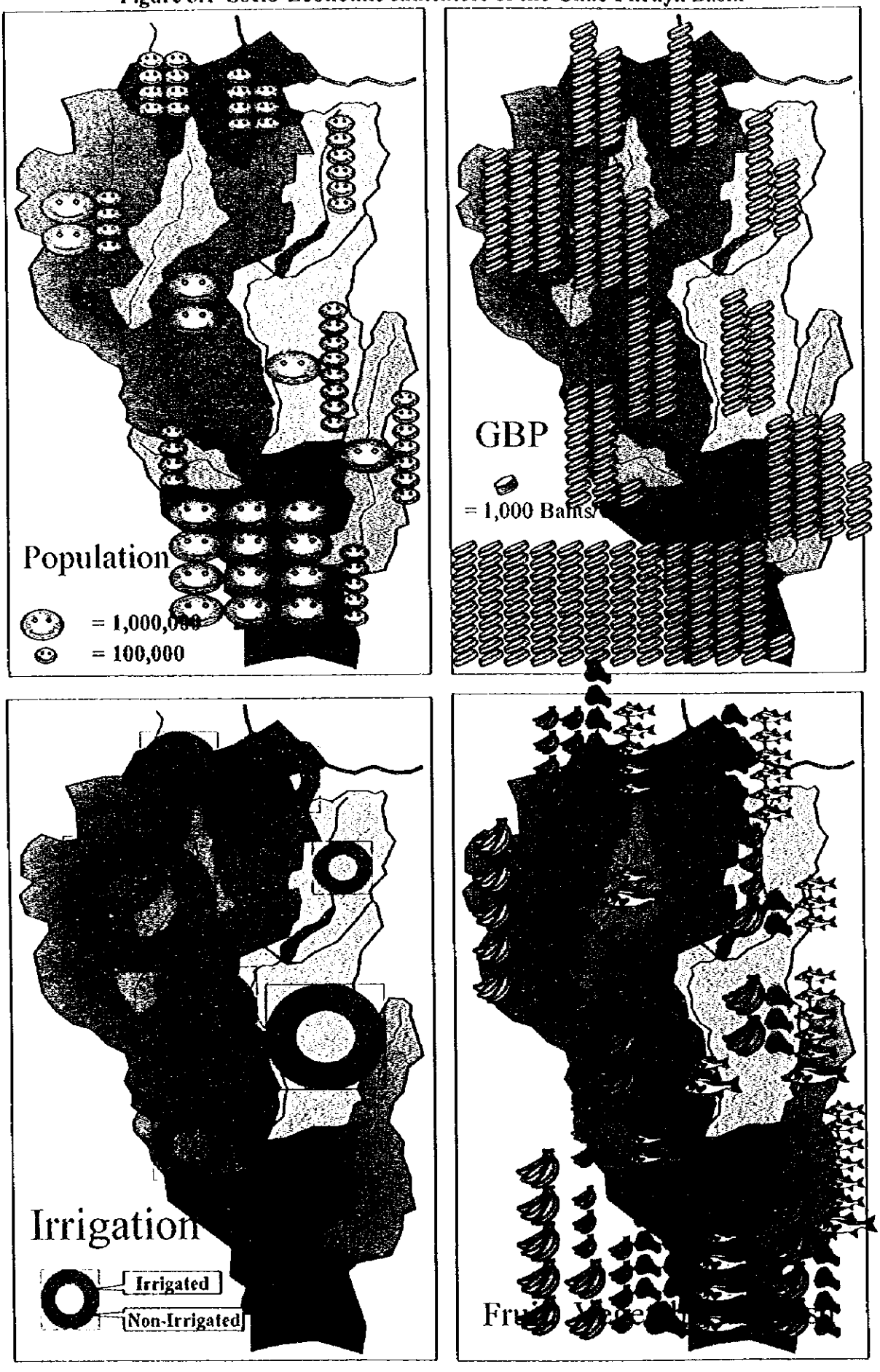

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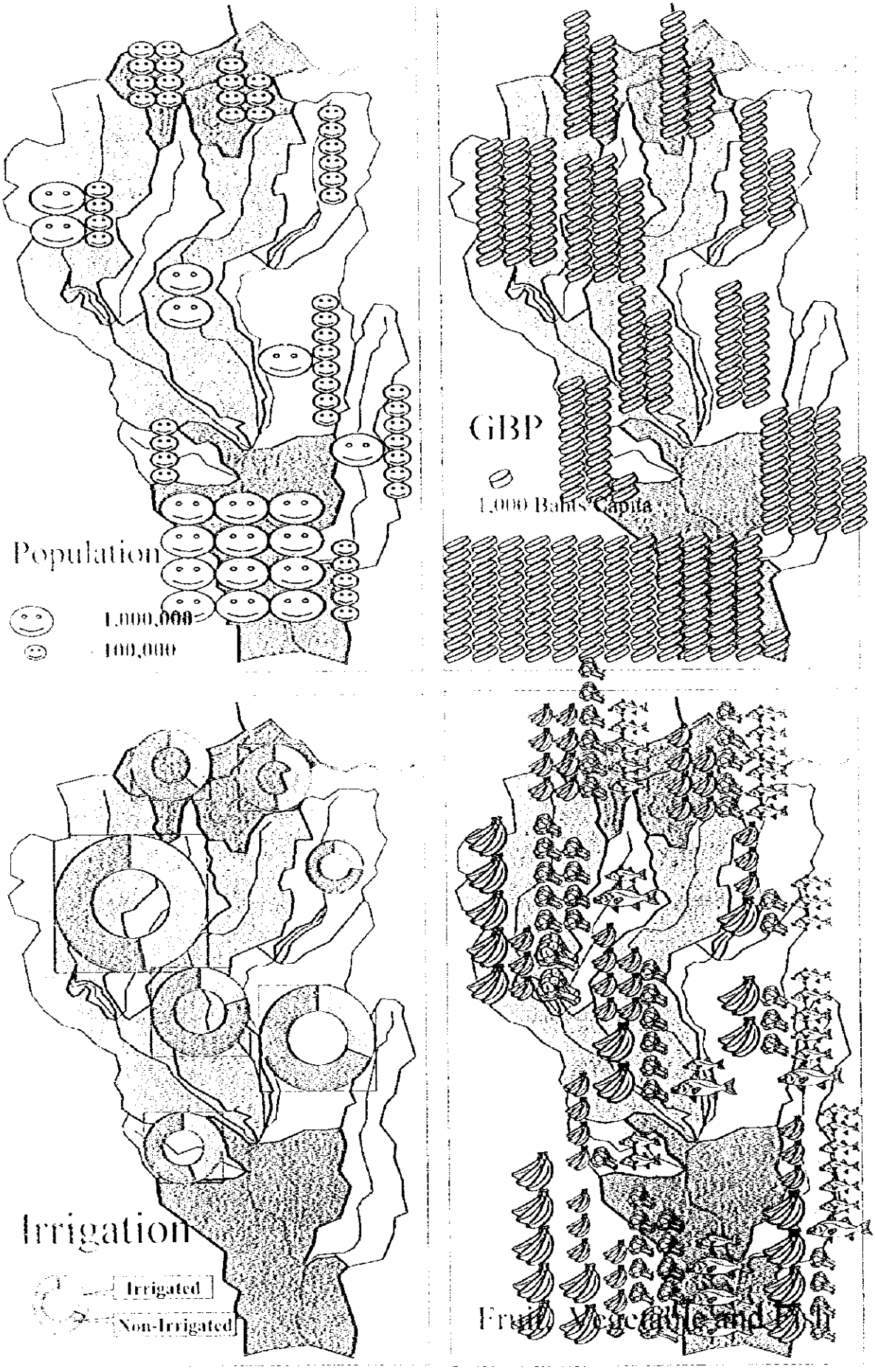


Figure 3.2 Increasing Areas for Diversified Crops in the Chao Phraya Delta

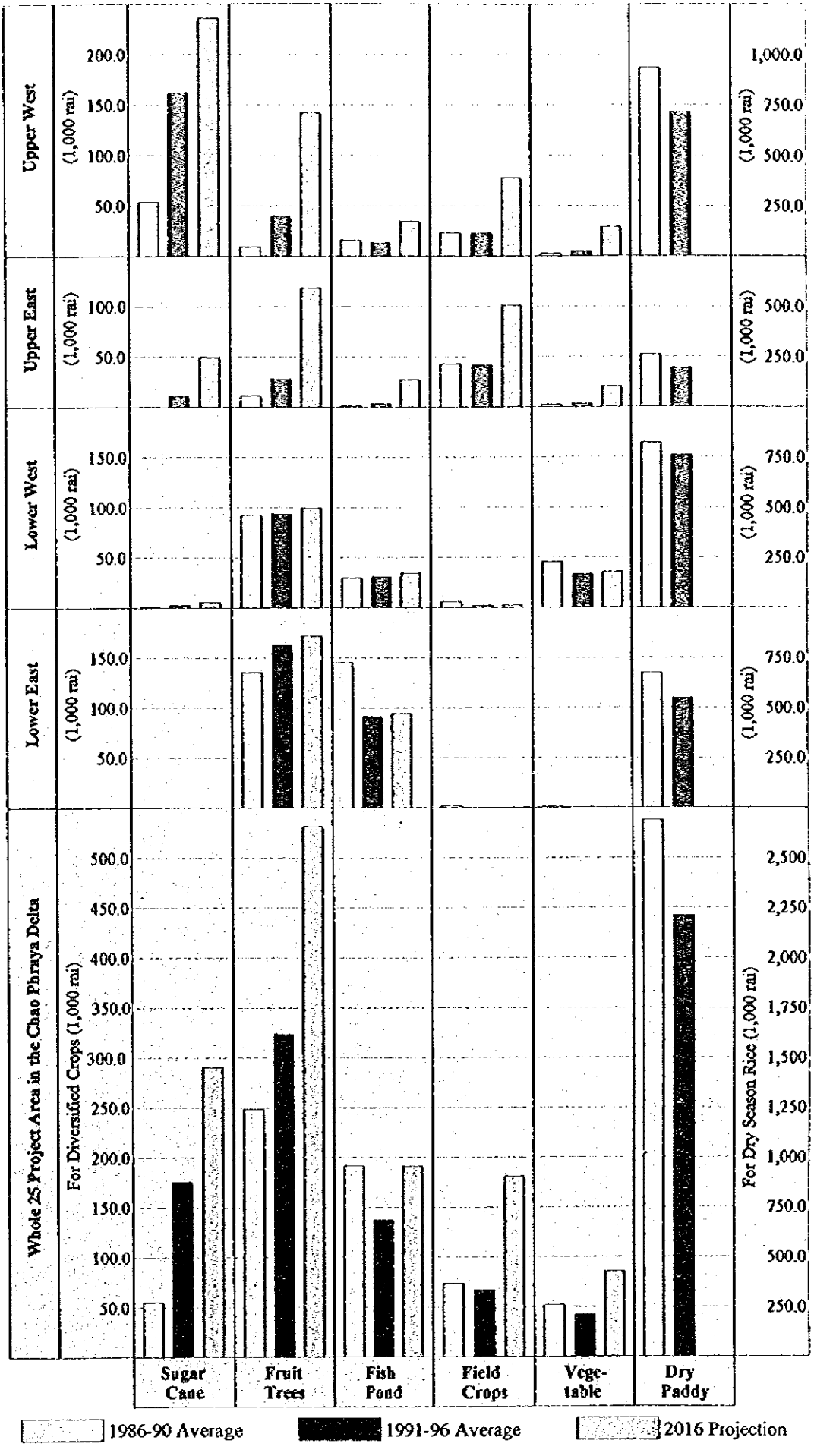


Figure 4.1 Land and Water Resources in Southeastern Asian Countries

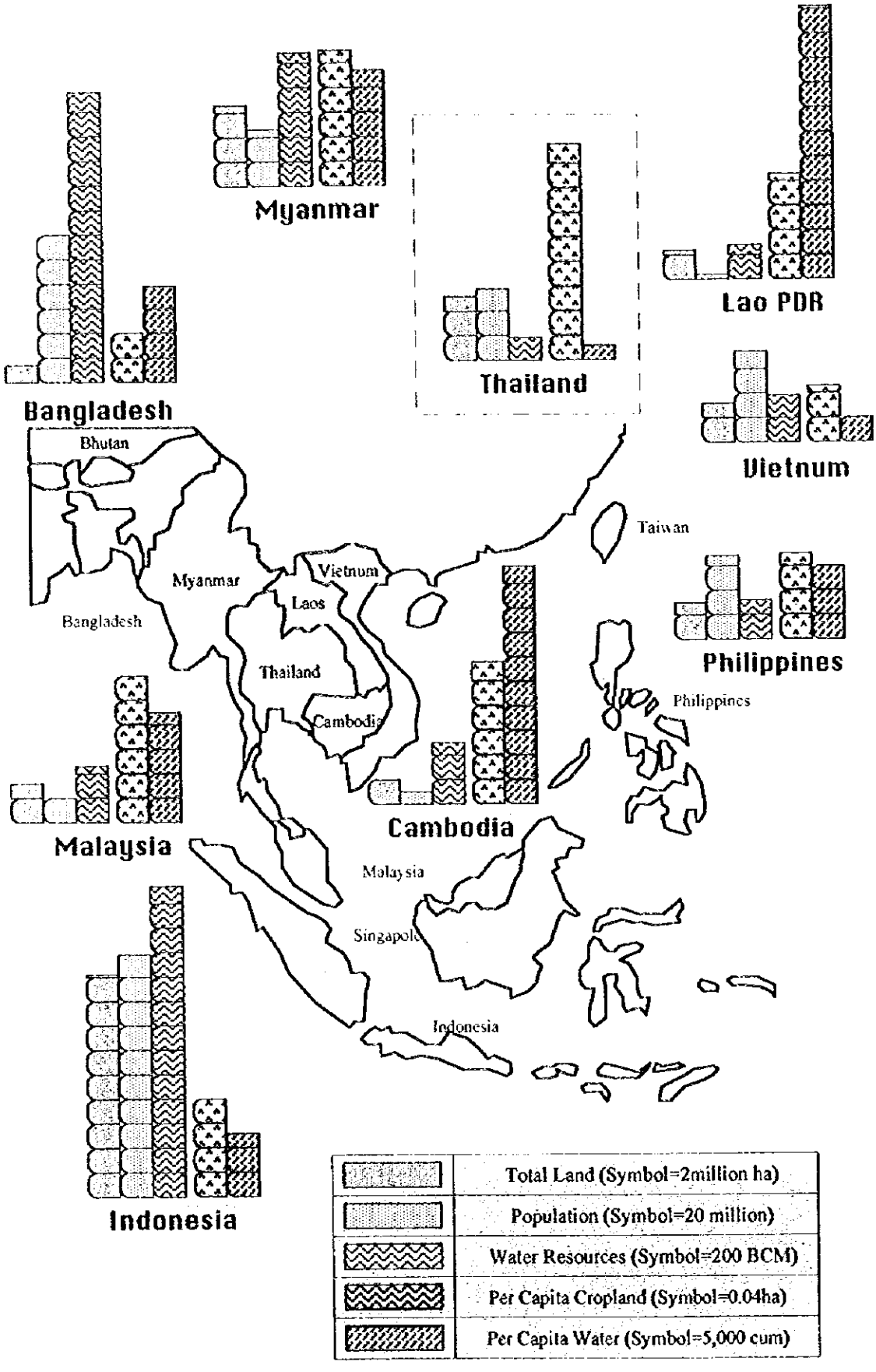


Figure 4.2 Land and Water Resources in Thailand

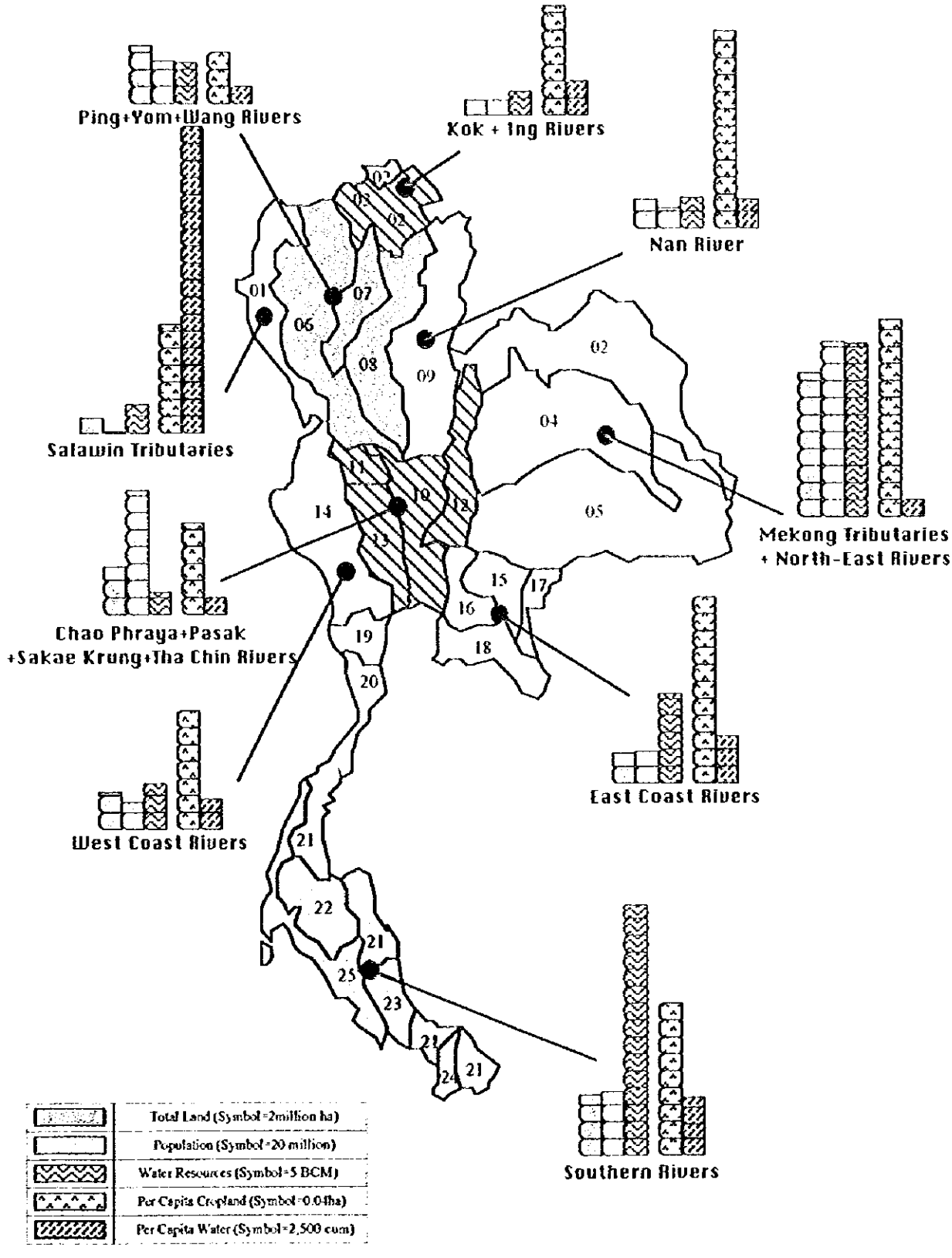
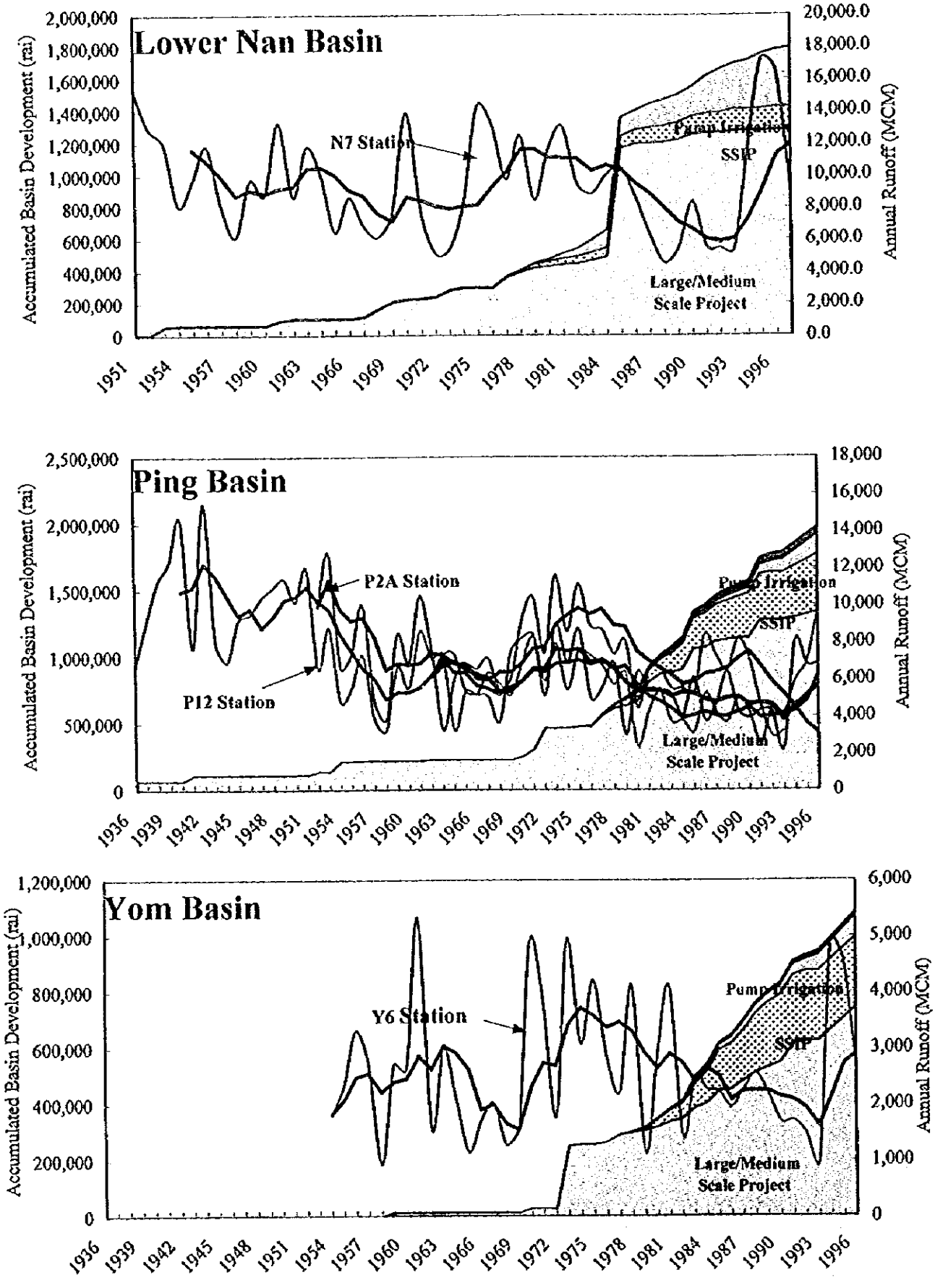


Figure 4.3 Basin Development and River Runoff in Three Basins



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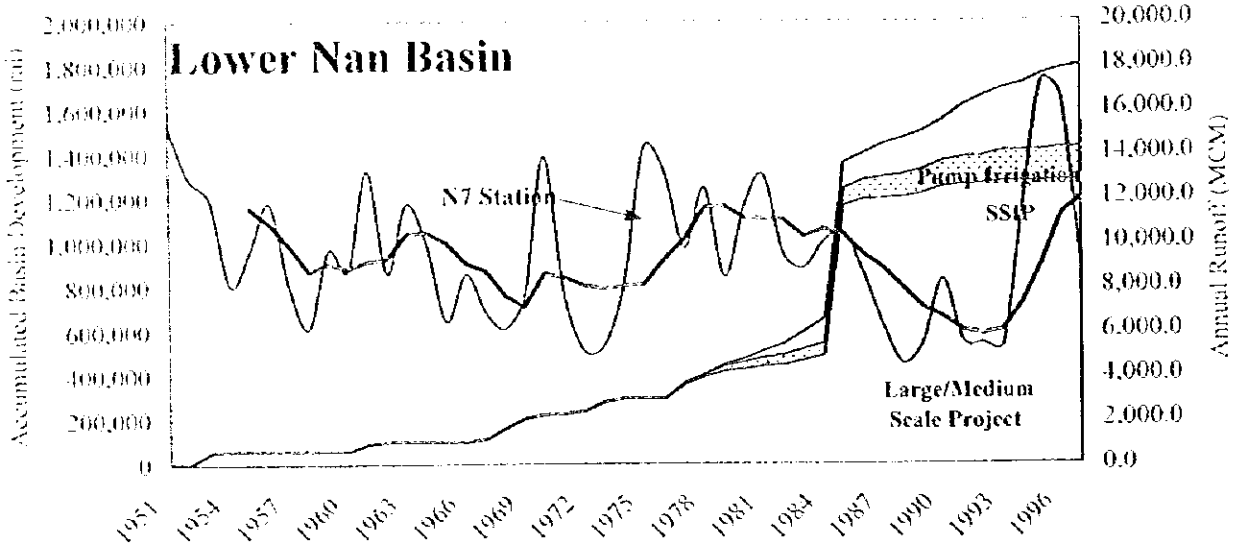
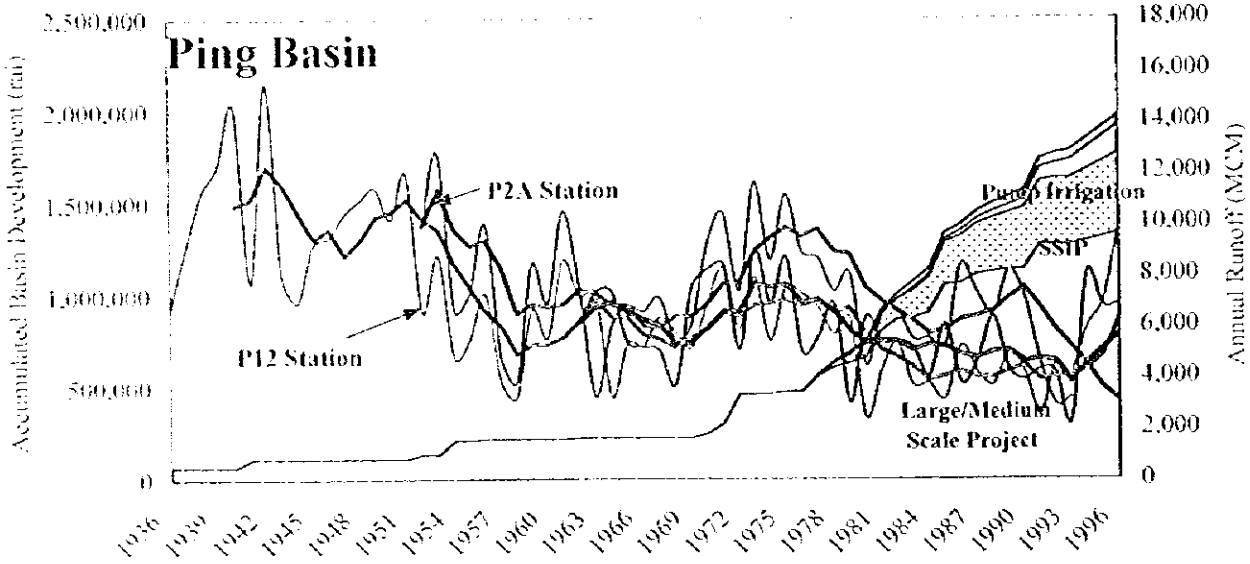




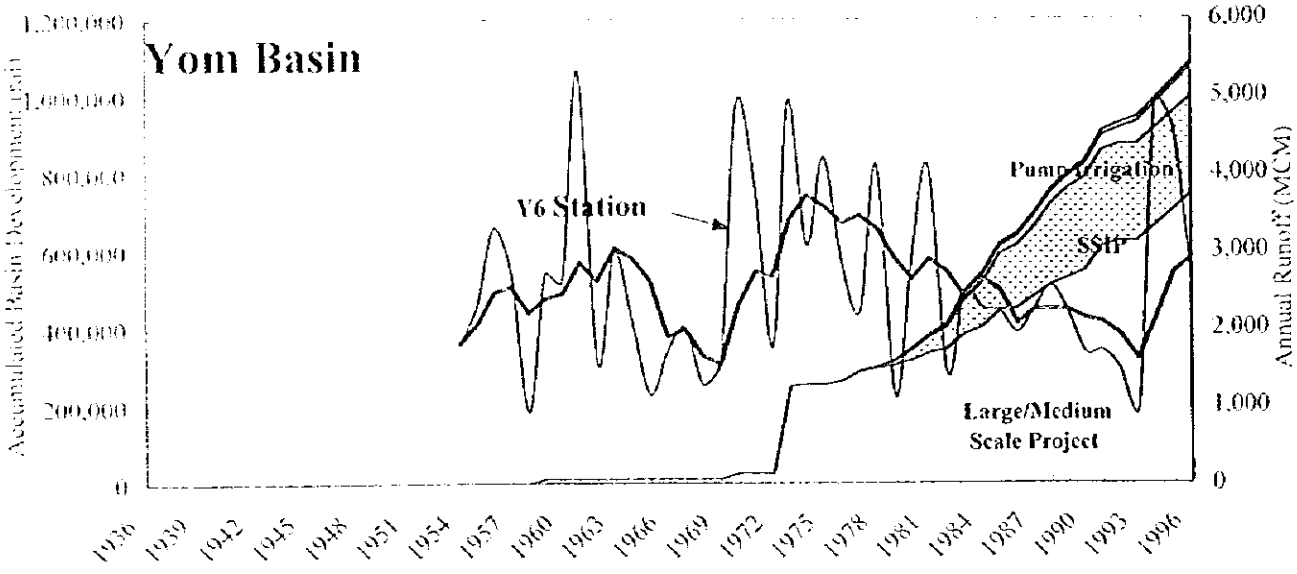
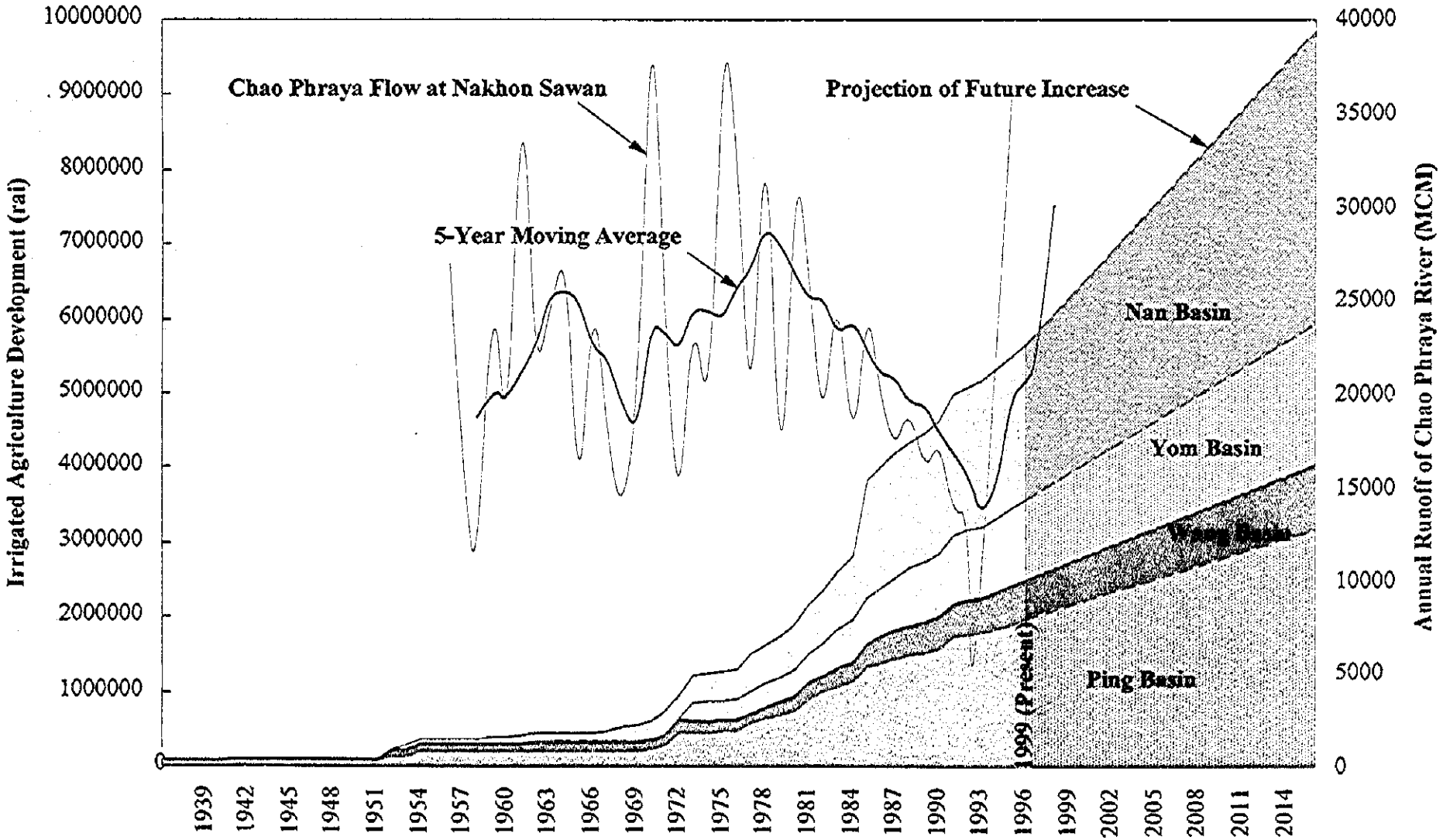


Figure 4.4 Development of Upper Chao Phraya Basin and Flow of Chao Phraya River at Nakhon Sawan



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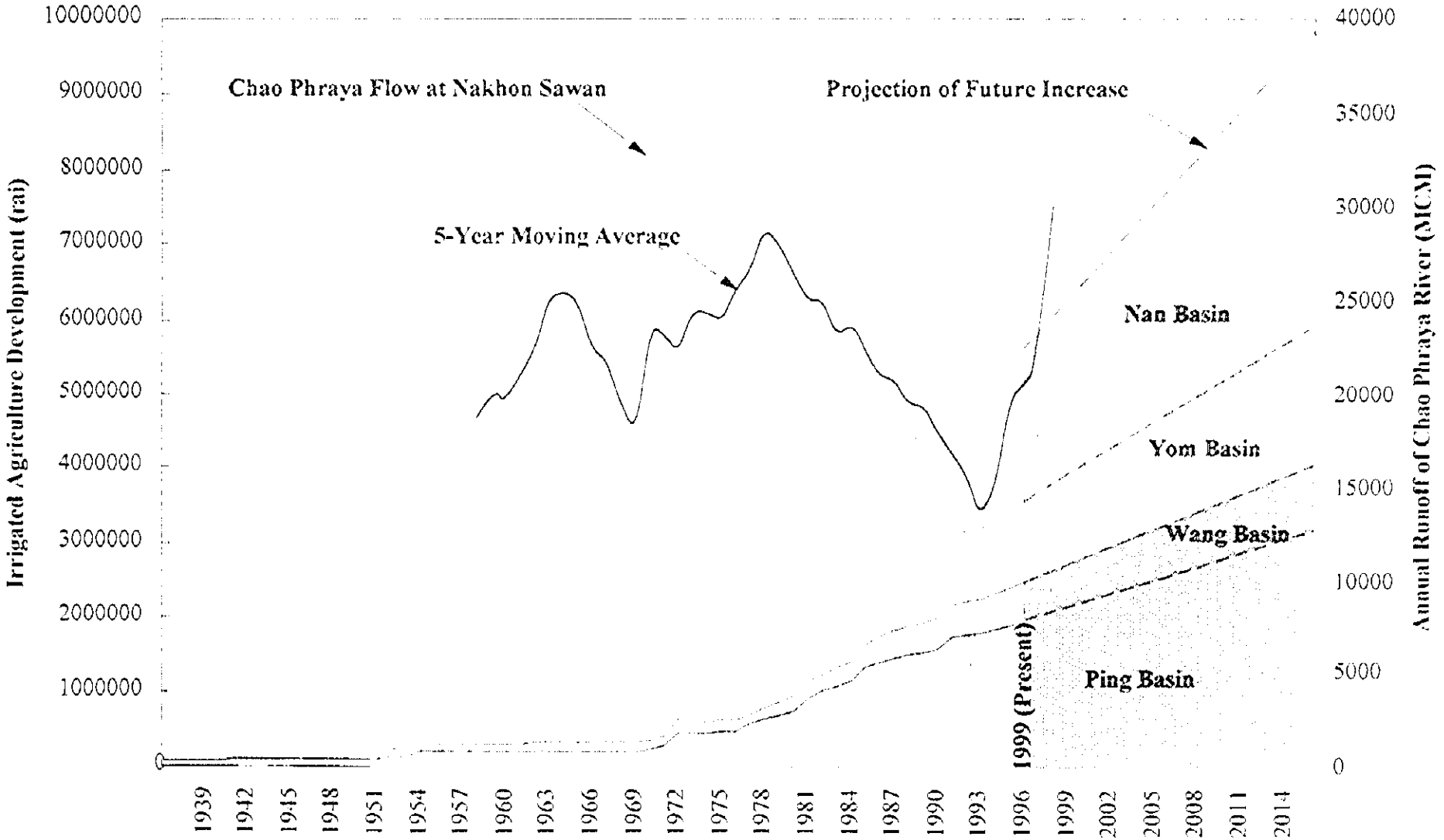


Figure 4.5 Schematic Diagram of Wet and Dry Season Flow in the Chao Phraya River

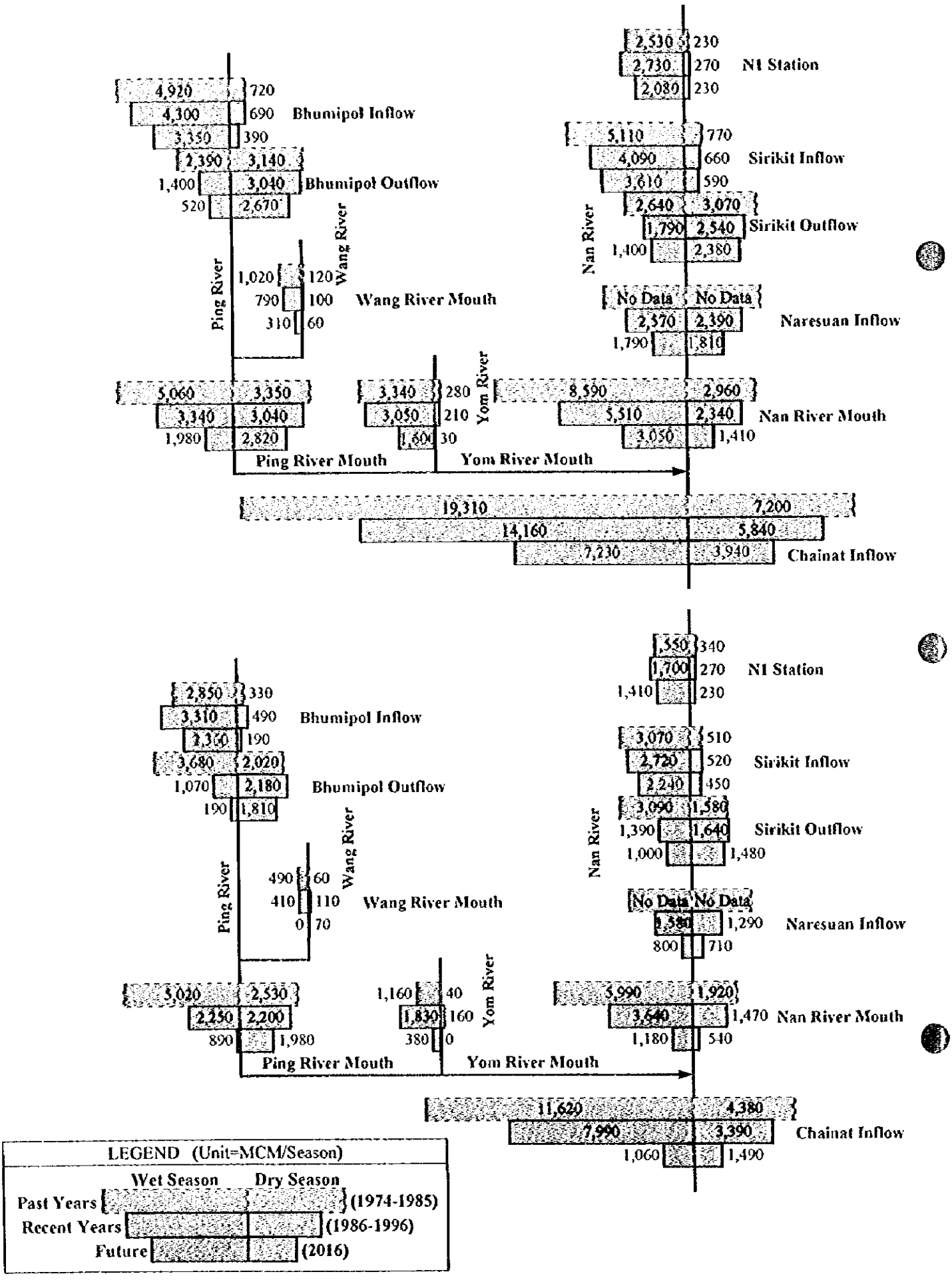
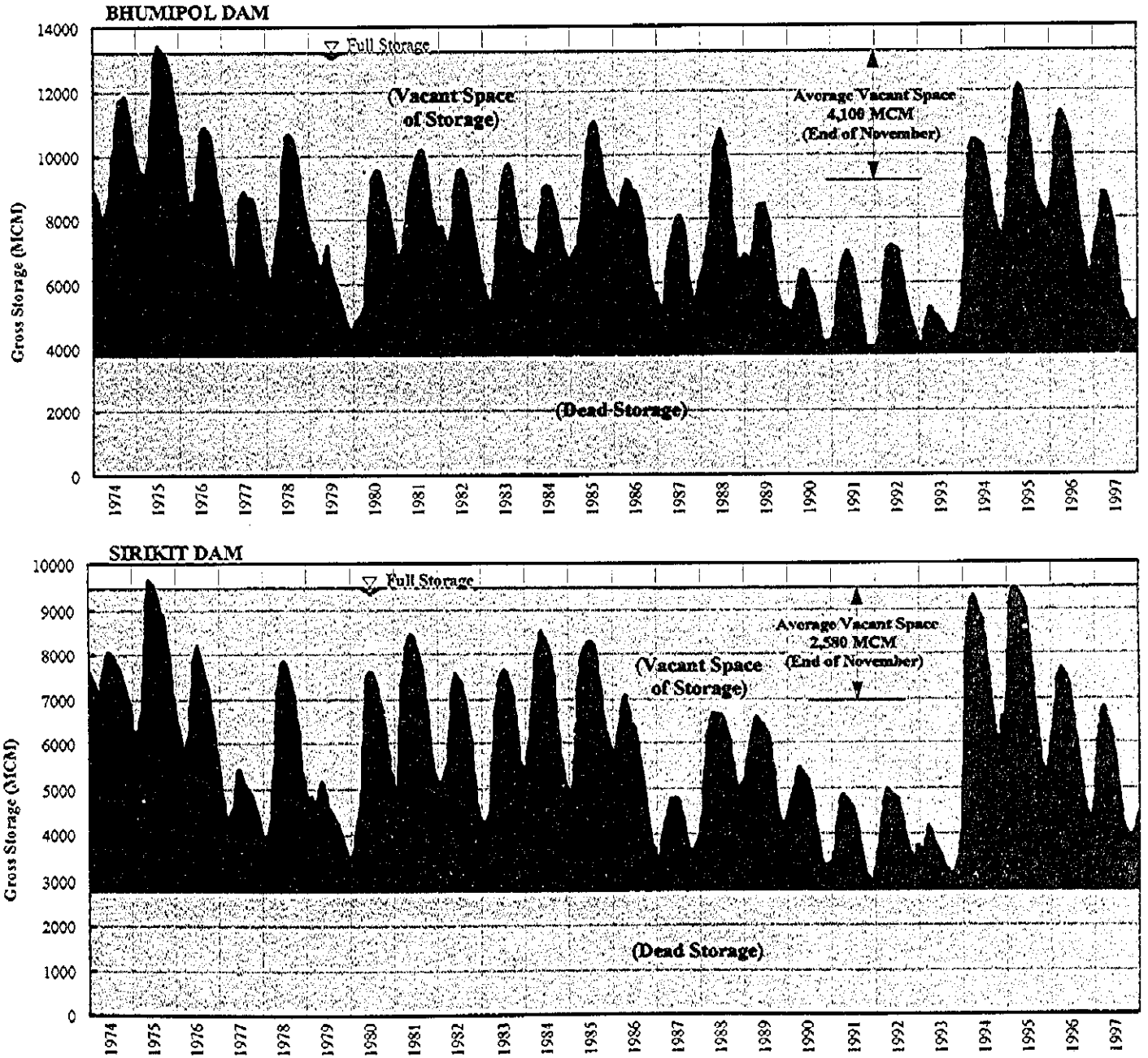


Figure 4.6 Large Empty Space of Storage in the Bhumipol and Sirikit Reservoir



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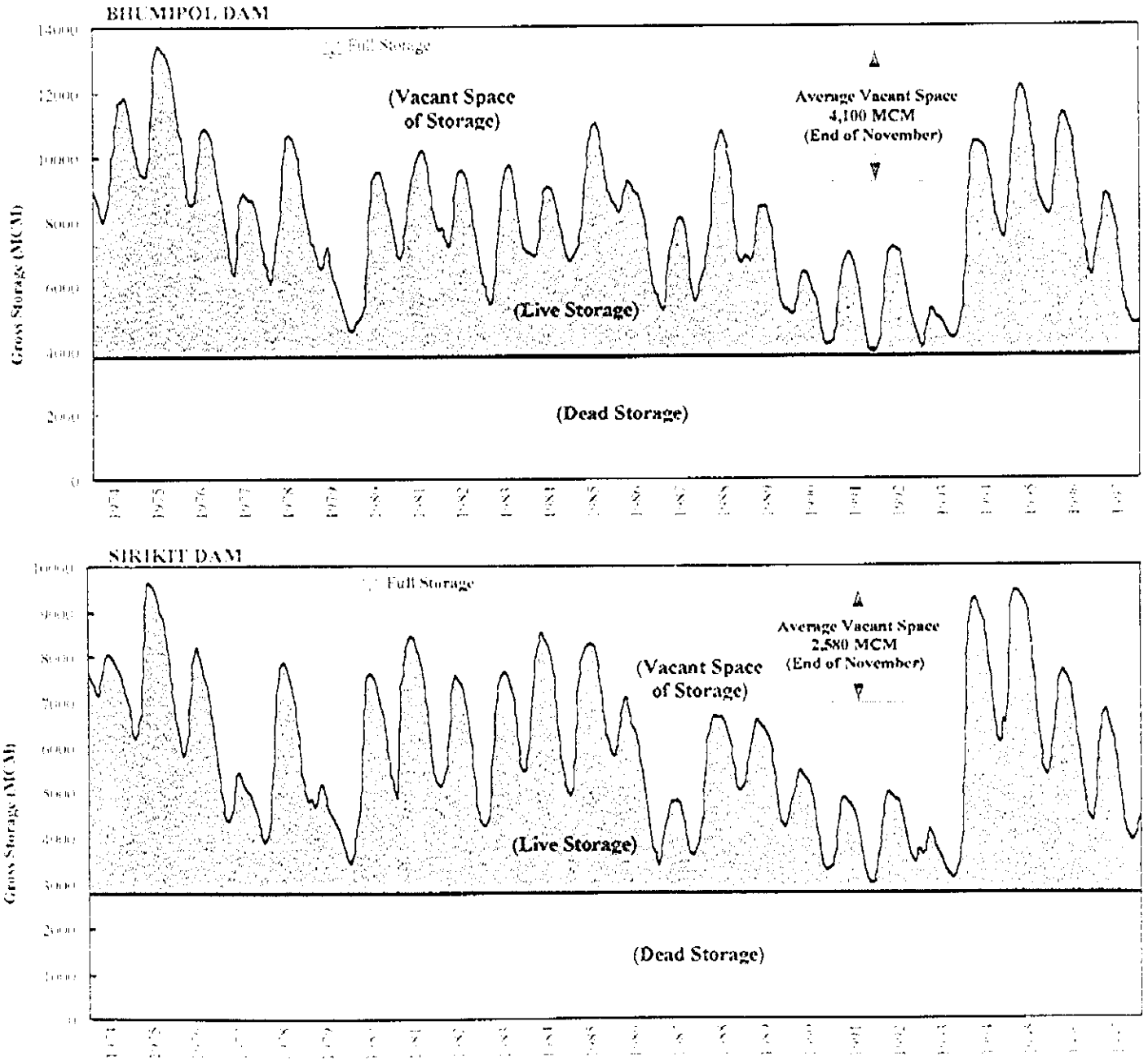
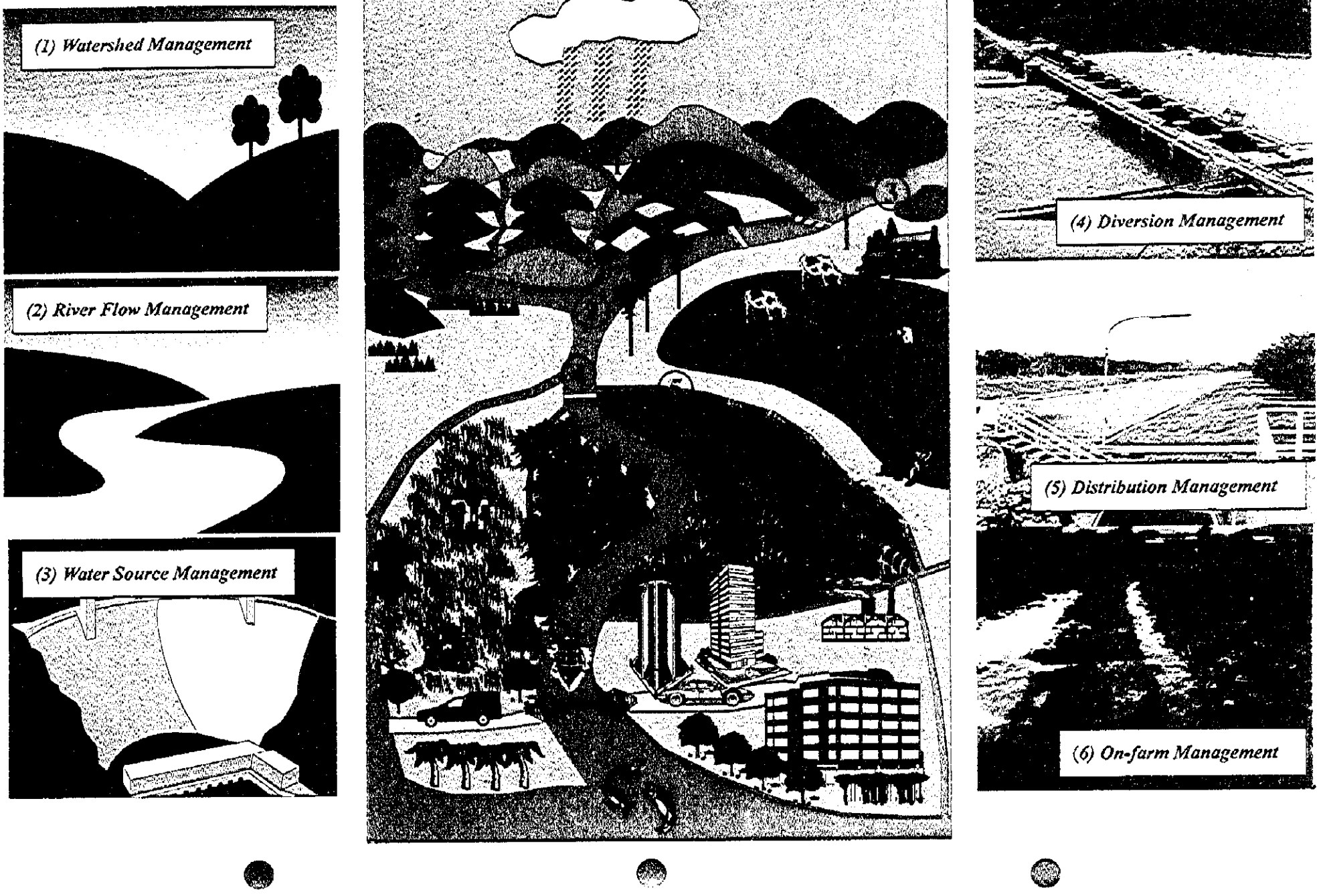
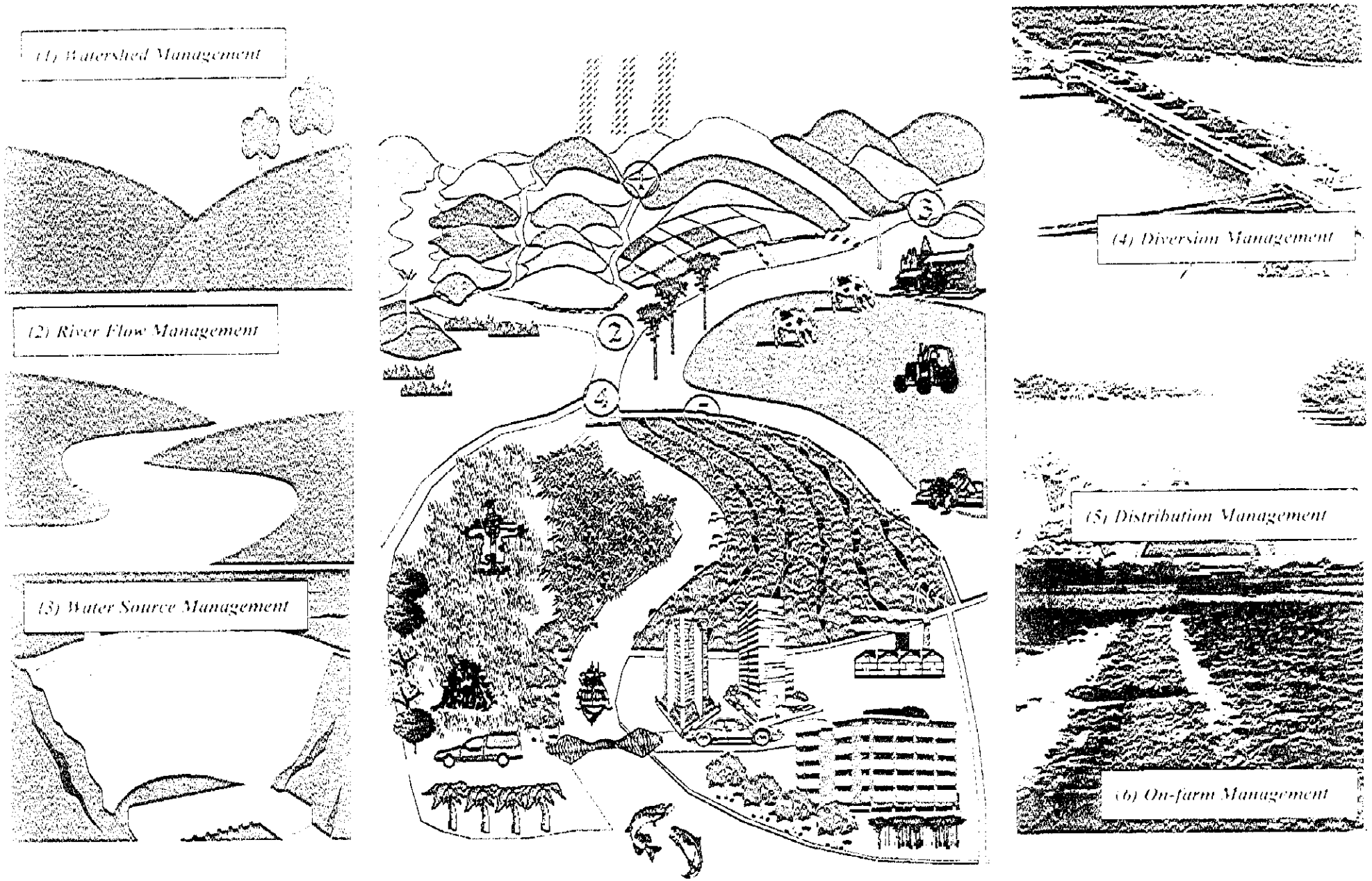


Figure 4.7 Functions Involved in Water Management




(1) Watershed Management
(2) River Flow Management
(3) Water Source Management
(4) Diversion Management
(5) Distribution Management
(6) On-farm Management