3.2 Agricultural Condition

Agriculture in the upper and lower Chao Phraya basins is the most important sector in Thailand to support the national food security, create the rural employment and stabilize the regional economy. Many irrigated agricultural developments to produce paddy have been implemented in the upper and lower Chao Phraya basins in parallel with the water resources development for irrigation. However the existing irrigation intensity in the upper Chao Phraya basin holding a large farm area of 23.8 million rai is still low as 28% in wet season and only 6% in dry season. The irrigation water has been used mainly for paddy cultivation in the wet and dry seasons.

Thai government has emphasized the agricultural development for crop diversification, livestock bleeding and fish culture since the year of 1986 (6th National Development Plan) taking into account the increasing domestic and export demand of those products in future. The developments for those products have been accelerated and succeeded in the lower Chao Phraya basin and some northern provinces in the upper Chao Phraya basin, where the sufficient and secure irrigation water is available and farmers are familiar with irrigated agriculture. This development will be expanded in 21 century because of the increasing domestic and export market demand, the expanding agro-industry enterprises, the guarantee of high income for farmers, etc. Accordingly, more irrigation water will be required in the upper and lower Chao Phraya basins to succeed the sustainable development for those products in future.

On the other hand, the Kok-Ing basin, the donor basin of the Project holds a large suitable farm land not only for paddy but also for diversified crops and fish culture as well as a rich water resources to be used for agricultural development. However the agriculture in the basin has still been placed at the primitive conditions due to lack of water resources development for irrigated agriculture and poor farming technology of farmers.

In order to grasp the water use for the existing and future irrigated agriculture development, the agricultural conditions in the three basins of upper and lower Chao Phraya and Kok-Ing are studied based on the data of Agricultural Statistics of Thailand and Statistics Report of Changwat and summarized as follows;

3.2.1 Farm Land Use

Farm land use for paddy, field crops, fruits, vegetables etc. in 1986 and 1993 is studied as shown in the Supporting Report and summarized in the following Table 3.2.1.

Table 3.2.1 Farm Land Use in Three Basin (1986 & 1993)

Unit: 10^3rai

Crops Area		Upper Chao Phraya							Lower Chao Phraya	Kok-Ing
		Nan	Ping	Wang	Yom	Sakae Krang	Pasak	Total		
1. Paddy	1986	4,140	2,255	443	3,285	1,003	2,426	13,552	9,023	1,701
	1993	3,752	1,947	459	2,777	886	2085	11,906	9,663	1,581
Variation Rate (%)		(91)	(86)	(104)	(85)	(88)	(86)	(88)	(85)	(93)
2. Field Crops	1986	2,178	1,285	351	1,496	578	2,598	8,486	3,400	558
	1993	2,320	1,408	298	1,521	614	2,670	8,831	3,179	329
Variation Rate (%)		(107)	(110)	(85)	(102)	(106)	(104)	(104)	(93)	(59)
3. Fruits	1986	229	239	42	198	50	129	887	678	119
	1993	399	481	69	233	58	355	1,595	813	177
Variation Rate (%)		(174)	(201)	(163)	(118)	(115)	(277)	(180)	(120)	(149)
4. Vegetables	1986	12.9	34.9	4.1	10.3	7.3	15.3	84.8	118.0	20.1
	1993	35.9	102.2	10.7	25.1	11.6	19.6	205.1	127.0	39.4
Variation Rate (%)		(279)	(293)	(259)	(244)	(159)	(128)	(242)	(107)	(196)
5. Total	1986	6,560	3,814	840	4,989	1,638	5,168	23,009	13,219	2,398
	1993	6,507	3,938	837	4,556	1,570	5,130	22,538	11,782	2,126
Variation Rate (%)		99	103	100	91	96	99	98	89	89

(1) Land Use Rate of Paddy and Diversified Crop Area

Land use rate of paddy and diversified crop area in 1993 is estimated based on the above Table 3.2.1 and shown in the following table;

Land Use Rate of Paddy and Diversified Crops in 1993

Unit: %

Crops Area	Upper Chao Phraya							Lower Chao Phraya	Kok-Ing
	Nan	Ping	Wang	Yom	Sakae Krang	Pasak	Total		
Paddy	58	49	55	61	56	41	53	65	75
Field Crops	36	36	36	33	39	52	39	27	15
Fruits	6	12	8	5	4	7	7	7	8
Vegetables	-	3	1	1	1	-	1	1	2
Total	100	100	100	100	100	100	100	100	100

- The upper Chao Phraya basin, especially the Pasak sub-basin is formed with hilly topographical area and holds a large suitable land for the field crops.
- The lower Chao Phraya and Kok-Ing basins hold a large flat wet land, where paddy cultivation is dominant.
- Fruits cultivation has been accelerated in recent years and its cultivation area reaches 7 to 8% of the total area. The Ping basin holding the provinces of Chiang Mai and Lamphun shows the highest rate of 12% in the fruit cultivation.

(2) Upper Chao Phraya

- The farm area in the upper Chao Phraya basin is 24.2 million rai in 1986 which has increased since 1980's by converting the forest area to the farm land. This type of farm land expansion was prohibited in 1980's by the government in order to conserve the forest area. The farm area in 1993 is 23.8 million rai, which has decreased slightly as compared with that in 1986 due to expansion of the urban area in the basin. The farm area in the

basin is not likely to decrease any more taking into account the increase in population which requires more food and jobs as well as the government policy for expanding agriculture rather than urban industrial development after experienced 1997 economic crisis in the country.

- Paddy area in 1986 is 13.7 million rai, which has also decreased to 11.9 million rai in 1993 due to conversion of the paddy area to the diversified crop areas. Paddy area in 1993 however still occupies as large as 50% of the total farm area and uses many rain and river waters in the basin. A large paddy area of more than 70% has been cultivated under rainfed condition and shows low yield of 300 to 350 kg per rai. The paddy area, especially the area under rainfed condition will decrease in future due to low productivity and conversion of the area to the diversified crop area and urban area, etc.
- Field crop area in the basin increases slightly during 1986 to 1983. The field crops such as sugar cane, maize, soybean were not profitable in the past years due to rainfed cultivation, low yield and low farm gate price. The field crop area in future however will increase because of agricultural policy of the government after the economic crisis in 1997 to expand those crop areas in order to decrease the foreign currency spending for the import of those crops. In addition, the large market demand and the raising farm gate price of those crops after the economic crisis will cause also increase of future cultivation of those crops.
- Fruits and vegetables have also increased remarkably during 1986 to 1993 because of increasing domestic and export market demand. The increasing tendency of those crops will continue in future because many processing manufactures for those crops have been established and operated in recent years which require a large quantity of new materials for their products.

The upper Ping basin holding the province of Chiang Mai are the most famous area to produce those crops. The upper Nan and lower Nan basin related to the Project will have also a large potential to expand those crop area in future because the upper Nan has a suitable climatic condition and hilly area for those crops and high rainfall, while the lower Nan holds suitable land having sandy loam soils, and can receive sufficient irrigation water from the Sirikit reservoir.

(3) Lower Chao Phraya

Total farm area is 13.5 million rai in 1986, which has decreased fairly to 12.3 million rai in 1993 because many farm areas have been converted to the urban and industrial areas in recent years. The provinces near Bangkok metropolitan area decrease the farm area and increase the other area more seriously as shown in Table 3.2.2.

Table 3.2.2 Variation of Farm and Other Land Area at Provinces near Bangkok

Unit: 10^3rai

Provinces	Decrease in Farm Area (10^3 rai)			Increase in Other Area (10^3 rai)		
	1986	1993	Rate (%)	1986	1993	Rate (%)
Saraburi	340	263	77	161	243	150
Suphanburi	2,347	2,065	88	300	585	195
Ayuthaya	1,244	1,092	88	242	394	163
Pathum Thani	765	631	82	189	323	171
Nakhon Pathom	874	744	85	373	502	135
Nonthaburi	206	162	79	183	227	124
Bangkok	388	243	63	590	735	123

- The paddy area in the lower Chao Phraya basin which is mostly consisting of the irrigated area has decreased largely from 9.0 million rai in 1986 to 7.7 million rai in 1993 due to expansion of urban and industrial areas. The irrigated paddy area in the provinces near Bangkok metropolitan area mentioned in Table 3.2.2, will decrease further in future due to continuos urban and industrial development.
- The field crop area in the basin decreases slightly during 1986 to 1993 due to the low market price but the areas of fruits and vegetables have increased due to increase in market demand and high farm gate price. In future, those crop areas in the lower districts of the basin being called as the conservation zone will not increase due to limitation of the suitable land area caused by expansion of the urban and industrial areas and inundation problem in the wet season but will increase remarkably in the upper districts consisting of the provinces of Nakhon Sawan, Uthai Thani, Chai Nat, Lopburi, Saraburi, Suphanburi because of availability of the suitable land and increasing market demand in the lower Chao Phraya basin.

(4) Kok-Ing Basin

Although the farm land in the Kok-Ing basin has not changed so much during 1986 to 1993, the paddy area has slightly decreased from 1.7 million rai in 1986 to 1.6 million rai in 1993, while the field crop area decreased considerably from 560,000 rai in 1986 to 330,000 rai in 1993 due to low profitable crops. On the contrary, the fruit and vegetable areas increased remarkably because of suitable climatic and soil conditions and high market price of those crops.

The fruit and vegetable areas will expand remarkably in future taking into account the particular climatic condition, rich irrigation water and market demand by tourism development in the basin.

3.2.2 Paddy Cultivation

(1) Existing Harvested Area and Production

The harvested area and production of paddy in recent years from 1991 to 1996 in the whole country as well as in the upper and lower Chao Phraya and the Kok-Ing basins are summarized in Table 3.2.3.

Table 3.2.3 Existing Harvested Area and Production of Paddy (Average 1991～1996)

Item	Whole Country	Upper Chao Phraya							Lower Chao Phraya	Kok-Ing
		Nan	Ping	Wang	Yom	Sakae Krang	Pasak	Total		
Harvested Paddy Area (10^3ton)										
Wet Season	55,960	2,570	1,550	330	2,040	710	1,490	8,690	5,930	1,030
Dry season	4,320	440	140	-	220	60	70	930	2,070	20
Production (10^3ton)										
Wet season	20,380	1,060	730	140	830	250	600	3,610	2,810	470
Dry season	2,940	310	100		160	40	40	650	1,530	10

- The paddy is the most important crop in the country to support the national food security and to gain foreign currency by export. The harvested area and production of paddy in the

country in recent years are about 60 million rai and 23 million ton respectively throughout the wet and dry seasons.

- The wet season paddy area and production in the whole Chao Phraya basin mark an average of 14.6 million rai (26% of the country area) and 6.4 million ton (31% of the country production) respectively. Especially the lower Chao Phraya basin has a large irrigation area for paddy and shows a large harvested area of 5.9 million rai (40% of the area in the whole Chao Phraya basin) and production of 2.8 million ton (44% of the whole Chao Phraya basin). Namely the Chao Phraya basin has fulfilled the important role in the country to supply the sufficient rice for national demand.
- However the rainfed paddy area in the wet season still occupies 70% in the upper Chao Phraya basin and its yield is as low as 300 kg/rai. The rainfed paddy area with low productivity will be decreased in future and converted to the urban and village areas and filed crops.
- The dry season paddy areas in the country and in the Chao Phraya basin are very small as shown as less than 10% of the wet season paddy area due to scarce rainfall, lack of irrigation system and shortage of irrigation water in the system during the dry season.
- The dry season paddy has been cultivated mainly in the lower Chao Phraya basin showing the area of 2.1 million rai and the production of 1.5 million ton which occupies about 50% of the countrie's cultivation area and production respectively. However the dry season area and production in the upper Chao Phraya basin has been fluctuating by the availability of irrigation water as shown the high value of 1.7 million rai and 1.2 million ton in the wet year of 1996 but the low value of only 0.46 million rai and 0.3 million ton in the dry year of 1994.

Table 3.2.4 Variation of Dry Season Paddy Area and Production in Lower Chao Phraya

Item	1992	1993	1994	1995	1996	Average
Upper Chao Phraya						
Area (10^3 rai)	930	700	460	900	1,980	930
Production (10^3 ton)	670	480	310	630	1,220	660
Lower Chao Phraya						
Area (10^3 rai)	1,810	1,900	1,580	2,200	2,860	2,070
Production (10^3 ton)	1,270	1,400	1,100	1,650	2,230	1,530

- The Kok-Ing basin has been cultivated mainly for the wet season paddy by using rich rainfall and river water in the basin but not for the dry season paddy except small irrigation area.

(2) Paddy Balance in Thailand in Recent Years

The balance of the paddy supply and demand in Thailand for recent years can be obtained from the statistical book of production and marketing of agricultural commodities published by the Office of Agricultural Economics. The balance is presented in Table 3.2.5.

Table 3.2.5 Paddy Balance in Thailand in Recent Years

Unit: 10^3ton

Item	1993/94	1994/95	1995/96	1996/97	1997/98 expected
1. Supply (Production)	22,050	23,490	22,970	24,200	25,050
Wet season paddy	16,480	18,160	17,730	17,780	17,840
Dry season paddy	1,970	2,950	4,290	4,550	3,590
Stock at the beginning year	3,600	2,380	950	1,870	3,620
2. Demand	12,310	12,960	12,580	12,700	12,780
Domestic consumption	10,250	10,360	10,000	10,110	10,220
Seed quantity	710	1,000	980	990	960
Other uses	1,350	1,600	1,600	1,600	1,600
3. Export	7,360	9,580	8,520	7,880	8,770
4. Balance (1-2-3)	2,380	950	1,870	3,620	3,500

- The annual paddy production is 23.4 to 24.0 million ton in the normal year except 22.0 million ton in the dry year of 1993/94. The total domestic paddy demand is about 12.6 million ton, of which the food consumption is about 10.0 million ton and the remaining 2.6 million ton for seed and other uses.
- The average paddy consumption per capita is estimated at 180 kg (120 kg in rice) in the recent years. In accordance with the study results of the Kasetsart University and the Office of Agriculture Economics 1997, the rice consumption per capita in Thailand has decreased as shown in the following table.

	1963~67	1968~72	1973~77	1978~82	1983~87	1988~92	1993~96
Milled rice (kg/Capita)	171.7	192.2	184.7	165.4	154.5	129.4	119.1
Paddy (kg/Capita)	260.2	291.2	279.9	250.6	234.1	196.1	180.5

Note: Milled rice = 66% of paddy

- The export quantity of paddy is 8.5 million ton in the average year but 7.4 million ton in the dry year and 9.6 million ton in the wet year.

(3) Future Paddy Demand in the Country

There is no data for paddy demand at the year of 2016 which is the target year of the Project completion. The paddy demand for the year 2016 is therefore predicted based on the following assumptions;

- Population in Thailand would increase to 75.6 million in 2016 from 59.1 million in 1994 taking into account the population growth rate.
- Paddy consumption per capita at present is 180 kg (120 kg in rice), which will be decreased to 150 kg (100 kg in rice) in 2016. Total paddy consumption will reach to 11.3 million ton (150 kg×75.6 million).
- Paddy demand for seed, for other uses and for export will not change and would remain at the present level of 11.1 million ton consisting of 2.6 million ton for seed and other uses, 8.5 million ton for the export and 1.5 million ton for stock.
- Accordingly the total paddy demand in 2016 is predicated at 23.7 million ton which is mostly same as the present 23.4 million ton.

(4) Future Paddy Area and Production in Chao Phraya Basin

The wet season paddy area in future at the national level and in the Chao Phraya basin will be slightly decreased due to the paddy area conversion to the diversified crop area and urban and industrial areas, and low productivity and income in the rainfed paddy area, etc.

In order to achieve the paddy production of 22.4 million ton in the year of 2016, the irrigated paddy area in the wet season will be expanded instead of the rainfed paddy to recover the paddy production lost due to ducts decreasing area. The existing dry season paddy area in the Chao Phraya basin however will not be changed because the existing dry season paddy area is mainly located at the land suitable only for paddy in the Delta and the low-lying land along the river and provided with a complete on farm system, high productivity and profit-ability together with the existing water right. Of course, the dry season paddy area will not be increased in future due to limited water resources and water use for diversified crops in the dry season.

The future paddy area and production in the Chao Phraya basin and other regions as well as the whole national are estimated as shown in Table 3.2.6.

Table 3.2.6 Estimated Paddy Area and Production in future

Item	Present			Future			
	Area 10^3rai	Production 10^3ton	Yield ton/rai	Area Decreasing Rate %	Area 10^3rai	Yield ton/rai	Production 10^3ton
1. Upper Chao Phraya							
Wet Season Paddy	8,960	3,610	0.40	90	8,060	0.44	3,550
Dry Season Paddy	930	650	0.70	100	930	0.70	650
Sub-total	9,890	4,260	-	-	8,990	-	4,200
2. Lower Chao Phraya							
Wet Season Paddy	5,930	2,810	0.47	85	5,040	0.50	2,520
Dry Season Paddy	2,070	1,530	0.74	100	2,070	0.74	1,530
Sub-total	8,000	4,340	-	-	7,110	-	4,050
3. Other Regions							
Wet Season Paddy	41,070	13,960	0.34	90	36,960	0.37	13,670
Dry Season Paddy	1,320	760	0.58	100	1,320	0.58	760
Sub-total	42,390	14,720	-	-	38,280	-	14,430
4. National Total							
Wet Season Paddy	55,960	20,380	0.36	89	50,060	0.39	19,740
Dry Season Paddy	4,320	2,940	0.68	100	4,320	0.68	2,940
Total	60,280	23,320	-	-	54,380	-	22,680
							>22,400

- The wet season paddy area in future will decrease to 90% of the present area in the upper Chao Phraya and the other regions while in the lower Chao Phraya, the area will be largely decreased to 85% due to the urban and industrial development and acceleration of crop diversification.
- The yield of the wet season paddy in future will increase about 10% from the present yield level because of expanding irrigation area of the Chao Phraya basin in future.
- Area and production in the dry season paddy however, will mostly be kept same as the present ones.

In accordance with the study result of O.A.E in 1996, it is expected that the paddy harvested area at the end of the five-year plan, or in the year of 2001 will decrease to 55 million rai in the wet

season and 3 million rai in dry season due to limitation of the irrigation water, decrease of rainfed paddy area, increase of diversified crop areas, etc. It is said also that paddy production shall reach to at least 22.5 million ton in total by increase of yield based on expansion of irrigated paddy area. The above assumption for paddy area however, will be slightly changed in the year of 2016 as mentioned in Table 3.2.6. The wet and dry season paddy areas will be 50 million rai and 4.3 million rai respectively at the national level and 5 million rai and 2.1 million rai in the lower Chao Phraya basin.

3.2.3 Diversified Crop Cultivation

(1) Field Crop Cultivation

The main field crops are maize, sugar cane, mung and soy beans, cassava, groundnut and cotton which are cultivated at the hilly area in the upper and lower Chao Phraya basins and the Kok-Ing basin. The harvested area of the field crops in 1993 reaches 8.7 million rai in the upper Chao Phraya and 3.0 million rai in the lower Chao Phraya.

The average harvested area and production of the field crops are summarized in Table 3.2.7.

Table 3.2.7 Existing Harvested Area and Production of Field Crops (Average 1991～1996)

Item	Whole Country	Upper Chao Phraya							Lower Chao Phraya	Kok-Ing
		Nan	Ping	Wang	Yom	Sakae Krang	Pasak	Total		
1. Harvested Area (10^3rai)										
Maize	8,080	810	450	40	350	240	1,410	3,300	930	300
Sugar cane	5,770	220	360	50	280	150	180	1,240	1,180	-
Mung & Soy beans	4,840	770	480	40	830	140	710	2,970	440	50
Cassava	8,500	260	250	-	90	110	80	790	360	10
Groundnut	620	60	50	40	60	10	20	240	30	30
Cotton	410	50	20	-	80	10	40	200	30	20
Total	28,220	2,170	1,610	170	1,690	660	2,440	8,740	2,970	410
2. Production (10^3rai)										
Maize	3,780	360	200	20	140	100	750	1,570	440	140
Sugar cane	46,740	1,590	3,150	270	2,270	1,260	1,390	9,930	9,990	-
Mung & Soy beans	830	120	90	10	140	20	100	480	70	10
Cassava	19,040	530	570	-	200	260	190	1,750	800	40
Groundnut	150	10	10	10	10	-	10	50	10	10
Cotton	90	10	-	-	20	-	10	40	10	-

- The upper Chao Phraya basin is formed with hilly area suitable for field crops and has been cultivated to a large area of maize, sugar cane, bean and cassava. Cultivation of these crops will be expanding in future because of the high market demand, if stable supply of irrigation water could be secured.
- The lower district of Chao Phraya basin is mostly formed with a flat delta area being suffered from inundation in the wet season so that the field crop area is scarce. Maize, sugar cane and bean are being cultivated at the high land area in the upper district of the basin. Cultivation of these crops will not be expanding in future in the lower district of the basin due to limited suitable land for field crops but will remarkably increase in the upper district where in a large suitable land area exists.

(a) Maize Cultivation

- The harvest area, production and production value of maize at the national level have been increasing in recent years as shown in Table 3.2.8

Table 3.2.8 Maize Cultivation Status in the Country

Item	1992/93	1993/94	1994/95	1995/96
Harvested Area (10^3 rai)	7,725	7,610	8,446	7,896
Production (10^3 ton)	3,672	3,328	3,965	4,155
Farm gate price (Baht/ton)	2,720	2,810	2,920	4,050
Farm Value (10^6 Baht)	9,988	9,352	11,578	16,828

- Although maize production has increased in recent years, it is still not sufficient to meet the livestock feed demand, as in 1995, about 280,000 ton was imported. On the other hand, the import price of maize has increased because of Baht devaluation after 1997 economic crisis, accordingly, the farm gate price is raising and the growing area is going to expand.
- The maize is mainly cultivated at the upland area in the upper Chao Phraya and the Kok-Ing basins and not prevailing in the lower Chao Phraya basin.

(b) Sugar Cane

- The sugar cane is one of the most important crops in the country to gain the foreign currency through its export. In accordance with the increasing world market demand for sugar, the harvest area, production and export value in the country have been largely increasing in recent years as indicated in Table 3.2.9 and 3.2.10.

Table 3.2.9 Sugar Cane Cultivation Status in the Country

Item	1992/93	1994/95	1994/95	1995/96
Harvested Area (10^3 rai)	6,198	4,997	5,767	6,156
Production (10^3 ton)	39,827	37,823	50,597	57,974
Farm Value (10^6 Bath)	14,298	17,701	22,010	22,378

Note: In 1993/94 the production is low due to scarce rain and irrigation water in the dry season

Table 3.2.10 Sugar Export Status

Item	Quantity 10^3 ton			Unit Price Bath/ton			Export Amount 10^6 Baht		
	1993	1994/	1995	1993	1994/	1995	1993	1994/	1995
Raw Sugar	1,681	1,902	2,798	5,370	6,450	7,410	9,032	12,265	20,724
Refined Sugar	538	709	959	5,860	6,960	8,370	3,153	4,938	8,028
Molasses	569	838	1,194	1,140	1,060	1,070	647	890	1,115
Others	17	25	24	32,760	44,320	71,380	557	1,108	1,713
Total	2,805	3,474	4,975	4,770	5,530	6,350	13,389	19,201	31,580

- Sugar cane is grown all over the Chao Phraya basin and its cultivation area and production are 2.4 million rai and 19.9 million ton respectively. These values represent about 40% of the country's cultivation area and production figures. The provinces of Nakhon Sawan, Kampaeng Phet, Lopburi, Nakhon Pathom, Suphan Buri and Kanchanaburi at upper district of lower Chao Phraya basin are well known for sugar cane cultivation. Four large sugar refineries are operating in Suphan Buri and Sing Buri provinces and have high demand for sugar cane.

- The sugar cane cultivation will be expanding further in the upper district of the lower Chao Phraya basin taking into account the increasing market demand and sugar price as mentioned above.

(c) Mungbean and Soybean

The harvest area and production of mungbean and soybean in the upper Chao Phraya basin is 3.0 million rai and 480,000 ton respectively, which occupies as large portion as 60% of those in the country. However those crop cultivation has not been expanding in recent years as shown in Table 3.2.11.

Table 3.2.11 Cultivation Status of Mungbean and Soybean

Item	Mungbean				Soybean			
	1993	1994	1995	1996	1993	1994	1995	1996
1. Whole Country								
Harvest Area 10^3 rai	2,189	1,966	2,094	2,080	2,145	2,374	2,471	1,719
Production 10^3 ton	261	231	256	234	480	513	528	386
2. Upper Chao Phraya								
Harvest Area 10^3 rai	1,593	1,408	1,491	1,473	1,400	1,615	1,611	965
Production 10^3 ton	195	167	185	166	309	337	345	217

- Mungbean cultivation will not be expanded in future because the mungbean supply is only depending on the domestic market demand, which will not increase largely in future.
- Soybean cultivation will increase slightly in future because soybean is oil seed crop which is not sufficient for domestic consumption at present and in future. 203,000 ton soybean and 13,900 ton soybean oil are presently imported and the foreign currency of US$60 million is spent, therefore, soybean cultivation will be promoted in future by the government.

(d) Other Field Crops

- Cassava is not a recommendable crop by the government because the farm land shall be occupied a long period of one and half years, the soil becomes infertile and the income from the production is low. Cassava is mainly cultivated in the northeast region, but a few in the upper Chao Phraya basin.
- Groundnut and cotton are cultivated at the overall area in the upper Chao Phraya and the Kok-Ing basins but its area is limited and will not be expanded in future due to low income from the production.

(2) Fruit Cultivation

(a) Cultivation Area

The domestic and export market demand for fruit has increased remarkably in recent years and as a result, fruit cultivation area has been expanding in the Chao Phraya and the Kok-Ing basins.

The potential land area in 1993, total plantation area in 1996-97 including yield and unyield areas in the three basins are shown in Table 3.2.12.

Table 3.2.12 Area of Fruit Cultivation

Unit: 10^3 rai

	Upper Chao Phraya							Lower Chao Phraya	Kok-Ing
	Nan	Ping	Wang	Yom	Sakae Krang	Pasak	Total		
1. Potential Area in 1993	399	481	69	233	58	355	1,595	813	177
2. Plantation Area in 1996/97									
(1) Yield Area	182	360	34	189	21	163	958	460	98
(2) Unyield Area	115	161	20	80	14	86	467	172	61
Total (1) + (2)	297	521	54	269	35	249	1,425	632	159

- Fruit plantation area including unyield fruits has increased largely in recent years and reaches 1,425,000 rai in the upper Chao Phraya basin and 632,000 rai in the lower Chao Phraya basin. In the upper Chao Phraya, the Ping basin holding provinces of Chiang Mai and Lamphun has the large plantation area of 521,000 rai.
- Fruit trees are planted generally at the commercial farm area to meet the market demand and at the small area surrounding the villages to be consumed by the village inhabitant. Many commercial farms are existing in the provinces of Nan, Uttaradit, Petchabun, Sukhothai, Tak, Chiang Mai and Lamphun in the upper Chao Phraya and Suphan Buri, Pathum Thai and Nakhon Pathom in the lower Chao Phraya. The provinces of Chiang Rai and Phayao in the Kok-Ing basin have also many commercial orchards.
- Since the commercial orchards require to secure irrigation water in the dry season, the areas in the provinces of Chiang Mai, Lamphun, Nan, Uttaradit and Petchabun with many irrigation projects in the upper Chao Phraya will further expand in future.
- Although the provinces of Nakhon Pathom and Pathum Thani located in the lower Chao Phraya basin hold the existing large commercial orchards, these provinces will not be able to expand their areas in future, because the land suitable for fruit plantation is limited in these provinces.
- In the lower Chao Phraya basin, the provinces of Lop Buri and Saraburi which are located at the east upper district will increase the commercial orchards in future because of suitability of soil for fruit plantation and large market of Bangkok metropolitan area.
- The Kok-Ing basin has a suitable climatic, condition, land and rainfall for fruit plantation and has developed many commercial orchards of mango, tamarind, longan, lichee and pineapple.
- The plantation area of fruits in the three basins will be further increased in future taking into account the large suitable land area in the basins, the high market demand, many manufactures to process fruits and the high profitability, etc.

(b) Major Fruits

Major plantation fruits in the three basins are summarized in Table 3.2.13.

Table 3.2.13 Harvested Area and Production of Major Fruits in 1995

Area & Production	Upper Chao Phraya							Lower Chao Phraya	Kok-Ing
	Nan	Ping	Wang	Yom	Sakae Krang	Pasak	Total		
1. Harvested Area (10^3rai)									
Mango	43.8	78.5	13.3	52.5	8.0	45.4	241.5	122.2	18.3
Pomelo	2.7	2.4	0.8	9.3	0.7	1.6	17.5	16.4	0.2
Lime & Orange	2.2	2.6	1.0	1.4	0.9	1.6	9.7	116.9	0.3
Coconut	6.5	12.6	2.7	8.0	3.5	12.0	45.3	71.2	0.6
Tangerine	10.6	2.3	2.0	27.4	-	13.6	55.9	6.2	1.0
Sugar Apple	3.0	3.4	0.9	3.6	0.7	9.5	21.1	16.6	-
Banana	7.5	25.0	1.9	21.3	2.6	9.2	67.5	31.6	1.0
Lichee	0.1	27.0	-	2.1	-	0.6	29.8	-	17.5
Tamarind	31.2	6.7	5.2	21.0	0.1	42.2	106.4	3.4	6.5
Longan	1.0	151.7	4.1	12.3	-	0.7	169.8	0.6	22.6
Others	83.1	47.8	2.5	29.7	4.0	26.6	193.7	74.7	30.4
Total	191.7	360.0	34.4	188.6	20.5	163.0	958.2	459.6	98.4
2. Production (10^3rai)									
Mango	32.9	68.4	10.0	24.8	9.1	29.1	174.3	186.0	10.6
Pomelo	4.1	1.6	0.7	4.1	0.7	1.5	12.7	19.8	2.4
Lime & Orange	0.7	0.7	1.8	0.9	0.4	0.2	4.7	429.5	0.1
Coconut	9.9	13.1	2.8	8.5	4.9	10.0	49.2	187.7	0.8
Tangerine	6.5	1.8	0.9	81.1	-	35.2	125.5	15.2	1.3
Sugar Apple	3.9	2.0	0.5	4.2	0.6	13.5	24.7	24.4	-
Banana	9.6	52.7	3.4	50.4	5.5	14.9	136.5	59.1	3.4
Lichee	0.1	25.3	-	1.7	-	0.3	27.4	-	11.8
Tamarind	9.6	3.7	2.2	9.4	0.1	11.3	36.3	1.7	1.9
Longan	5.3	133.8	4.4	10.8	-	0.5	154.8	0.9	22.6
Others	50.2	97.5	6.1	52.0	7.6	38.4	251.8	254.3	29.8
Total	132.8	400.6	32.8	247.9	28.9	154.9	997.9	1,162.9	83.4

- Mango, banana, Tangerine, Tamarind and Longan are prevailing fruits in the upper Chao Phraya, while mango, orange and coconut are those in the lower Chao Phraya and mango lichee and longan are those in the Kok-Ing basin.
- Provinces of Chiang Mai and Lamphun, Uttaradit, Petchabun in the upper Chao Phraya, Pathum Thani and Kanchanaburi in the lower Chao Phraya and Chiang Rai in the Kok-Ing basin are famous of large area cultivation with many kinds of fruits.
- Mango is the most popular fruit all over the basin and has been cultivated in large scale at the provinces of Phetchabun, Sukhothai, Chiang Mai, Tak, etc. in the upper Chao Phraya and Uthai Thani, Ang Tong, Nakhon Pathom, Samut Prakan, etc. in the lower Chao Phraya.
- Lime and orange, coconut, banana, etc have also been planted all over the basin.
- Lichee and Longan plantation however is limited at the Chiang Rai and Lamphun provinces in the upper basin and the Kok-Ing basin which are being located at the northern mountainous area in the country.

(3) Vegetable Cultivation

Vegetables are being grown all over the provinces in the Chao Phraya and Kok-Ing basins. Although many kinds of vegetables are cultivated, the economically important vegetables are garlic, ginger, shallot, cucumber, chilli, baby corn and sweet corn, chinese kale, chinese cabbage, and cabbage etc. All of these are people's common daily foods and their harvested area and production in the Chao Phraya and Kok-Ing basins are summarized in Table 3.2.14.

Table 3.2.14 Harvested Area and Production, 1996/97

Crops	Upper Chao Phraya							Lower Chao Phraya	Kok-Ing
	Nan	Ping	Wang	Yom	Sakae Krang	Pasak	Total		
1. Area (10^3 rai)									
Garlic/Ginger	2.1	105.0	7.2	8.1	-	2.6	125.0	0.4	35.9
Shallot	19.1	56.9	0.9	5.2	-	1.0	83.1	1.1	9.1
Cucumber	9.0	3.0	-	3.9	0.6	3.2	19.7	15.7	1.2
Chilli	3.7	6.0	-	3.2	0.2	7.2	20.3	11.8	4.3
Baby Corn/Sweet Corn	0.5	6.8	-	1.1	1.1	1.2	10.7	20.7	6.9
Bean	4.9	3.6	0.9	2.2	0.4	5.3	17.3	20.3	2.0
Chinese Kale	6.9	5.8	-	1.8	0.9	0.9	16.3	28.5	1.4
Chinese Cabbage/Cabbage	5.6	40.6	0.3	2.4	0.2	5.8	54.9	6.6	12.6
Others	13.4	150.6	5.9	29.5	3.1	35.0	237.5	85.6	20.5
Total	65.2	378.3	15.2	57.4	6.5	62.2	584.8	190.7	93.9
2. Production (10^3 ton)									
Garlic/Ginger	2.8	267.4	6.9	10.7	-	3.9	291.7	0.5	76.8
Shallot	31.9	142.7	1.3	9.0	-	2.5	187.4	3.2	21.5
Cucumber	14.7	6.4	-	7.5	0.8	5.2	34.6	24.1	2.4
Chilli	4.0	8.6	-	2.5	0.2	10.3	25.6	8.9	9.1
Baby Corn/Sweet Corn	0.7	5.6	-	1.3	1.7	2.6	8.9	25.6	19.3
Bean	5.4	5.6	0.9	2.5	0.4	12.0	26.8	28.8	2.7
Chinese Kale	12.9	10.2	-	3.1	2.0	1.3	29.5	58.1	1.9
Chinese Cabbage/Cabbage	17.8	108.6	1.5	4.5	0.4	17.3	150.1	10.3	33.9
Others	14.2	416.5	20.7	164.5	11.8	52.5	680.2	113.5	44.4
Total	104.4	971.6	31.3	205.6	17.3	107.6	1,437.8	273.0	212.0

- The Pin basin including the provinces of Chiang Mai and Lamphun is the largest vegetable production area in the upper Chao Phraya. The vegetables produced in the basin are exported to the market in the Bangkok metropolitan area. Vegetables of garlic, ginger onion, shallot, potato, cabbage, etc are being planted on large scale and agro-business basis in the basin.
- Vegetable plantation at the other sub-basins in the upper Chao Phraya has been carried out mainly for own consumption in the sub-basins and on small scale basis.
- In the lower Chao Phraya basin, many kinds of vegetables are being cultivated for supply to the large consumers in the Bangkok metropolitan area and the other urban and industrial areas. Since the farm land in the basin is often suffered from inundation in the wet season, the vegetable is cultivated generally by providing the high ridges.
- In the Kok-Ing basin, many kinds of vegetables are also planted mainly for export to the market in the Bangkok metropolitan area.
- Plantation of water melon, potato, onion, tomato, etc in addition to the vegetables

mentioned in the above Table 3.2.14 will be further promoted in future in all basins and provinces in accordance with increase of population and consumption demand.

3.2.4 Livestock Breeding

Livestock breeding for cattle, swine and chicken in Thailand in recent years has been expanding due to increasing domestic and export demands.

Comparison on the number of livestock breeding between 1986 and 1995 is shown in Table 3.2.15.

Table 3.2.15 Number of Livestock Breeding in 1986 and 1995

Unit: 10^3 head

Livestock		Whole country	Upper Chao Phraya						Lower Chao Phraya	Kok-Ing
			Nan	Ping	Wang	Yom	Sakae Krang	Pasak	Total		
Buffalo	1986	6,257	225	170	88	188	33	112	816	213	159
	1995	4,182	106	90	51	89	23	58	417	107	80
Cattle	1986	4,879	208	198	94	187	45	223	955	498	116
	1995	6,822	339	308	128	320	72	295	1,462	660	151
Swine	1986	4,201	228	217	70	214	30	146	905	600	166
	1995	5,369	239	307	62	211	35	170	1,024	881	160
Chicken	1986	79,265	3,852	5,016	887	3,422	584	2,191	15,952	7,840	2,748
	1995	148,784	6,590	6,412	1,160	3,740	1,171	5,621	24,694	20,336	4,426

(1) Buffalo

Buffalo played a vital role in paddy cultivation in the past, but the number of breeding has been decreasing year by year since agricultural machinery such as tractor and combine have been prevailing in cultivation and harvesting. Only poor farmers who can not afford to own or hire tractor for cultivation still keep buffalo for farming purpose. The number of buffaloes in the Chao Phraya and the Kok-Ing basins in 1986 has decreased about half in 1995 and will decrease more in future.

(2) Cattle

The number of cattle breeding has increased year by year due to increasing demand for meat, milk and dairy products. The provinces breeding the cattle are Petchabun, Nakhon Sawan, Lampang, Chiang Mai, Tak and Lopburi in the upper Chao Phraya and Suphan Buri in the lower Chao Phraya. These provinces have bred about 150,000 to 200,000 head of cattle in each province.

Number of cattle breeding in the Kok-Ing basin is still small as shown 100,000 in Chiang Rai and 92,000 in Phayao.

Cattle breeding for meat and milk production will be expanding in future because Thailand has imported many meat and milk products to meet the domestic market demand. Government intends to promote the cattle breeding to enable the country to produce the meat and milk sufficient for own consumption..

(3) Swine

Swine has been bred all over the provinces in the Chao Phraya and Kok-Ing basins, but the number of breeding during 1986 and 1995 does not increase remarkably as compared with that of cattle.

The provinces breeding large number of swine are Chiang Mai with 246,000 and Saraburi with 91,000 in the upper Chao Phraya and the provinces of Suphan Buri with 157,000 and Nakhon Pathom with 457,000 in the lower Chao Phraya. Number of swine in the Kok-Ing basin is as small as 160,000 heads.

Swine breeding in future will increase gradually in accordance with increasing market demand due to increasing population.

(4) Chicken

Chicken is the most important livestock for domestic and export demands and the number of breeding in 1995 reached 149 million in the country, of which 24.7 million was in the upper Chao Phraya and 20.3 million in the lower Chao Phraya. The breeding number in 1995 was 1.5 times of that in 1986 in the upper and 2.6 times in the lower Chao Phraya.

The provinces breeding large number of chicken are Chiang Mai, with 5.5 million, Lopburi with 3.3 million and Saraburi with 3.0 million in the upper Chao Phraya, and Nakhon Sawan with 3.1 million, Suphan Buri with 3.1 million, Ayuttaya with 4.1 million and Nakhon Pathom with 3.3 million in the lower Chao Phraya.

Chicken breeding, especially for meat production will increase remarkably in future due to expanding market demand in Japan, Hong Kong and Singapore.

(5) Export Value of Animal Products and Import Value of Animal Feed

The export value of animal products has increased and the import value of animal feed has also increased as indicated in the Table below:

Unit: 10^6 Baht

Item	1991	1992	1993	1994	1995
Export Value of Animal Product	15,170	17,020	16,830	20,313	23,391
Import Value of Animal Feed	6,220	8,524	10,459	12,158	12,359

The export value of animal products of 23.4 billion Baht reaches about 50% of that of rice, therefore the government intends to promote the livestock breeding and expand the processing industry of the annual products. The main import materials for animal feed are soybean cake with 4.1 billion Baht and sweetened forage with 1.4 billion Baht. As a matter of fact, these materials could be produced in Thailand under the crop diversification program in order to save the foreign currency for import.

3.2.5 Freshwater Fish Culture

The freshwater fishes being cultured in the Chao Phraya basin are tilapia, sepat, siam, catfish and snake-head fish.

In the upper Chao Phraya basin, tilapia is the most popular species, while in the lower Chao Phraya basin, many cultured fishes have been developed at the fish ponds, irrigation canals, paddy field, etc. The freshwater fish culture conditions in the Chao Phraya and the Kok-Ing basins in 1995 are summarized as shown in Table 3.2.16.

Table 3.2.16 Freshwater Fish Culture Condition in 1996/97

Item		Upper Chao Phraya							Lower Chao Phraya	Kok-Ing
		Nan	Ping	Wang	Yom	Sakae Krang	Pasak	Total		
No. of Household	(10^3)	15.6	7.3	1.6	10.0	1.8	10.3	46.6	37.5	10.7
No of Pond	(10^3)	20.5	8.8	1.8	13.1	3.0	12.7	59.9	41.4	15.0
Cultured Area	(10^3 rai)	18.8	10.5	0.9	10.3	2.3	16.0	58.8	309.7	11.0
Production	(10^3 ton)	16.8	4.9	0.8	8.0	1.5	6.4	38.4	158.0	3.1
Yield	kg/rai	890	470	850	780	670	400	650	510	280

- In the upper Chao Phraya basin, the fish culture is most prevailing in the Nan basin showing the culture area of 18,800 rai and production of 16,800 ton. The yield in the Nan basin shows also the high value of 890 kg/rai because the sufficient water in wet and dry seasons is available for fish culture at the area along the Nan main stream, especially at the Phitsanulok large irrigation area. The Yom basin presents also a large activity for fish culture at the area along the main river in the provinces of Phitsanulok and Phichit.
- In the lower Chao Phraya basin, the fish culture is one of the most important industry. There are many swamps, ponds, creek systems in the basin which could receive the fish culture water throughout the year and many skillful farmers for the fish culture. Accordingly, the large fish cultural area of 310,000 rai which is about 5 times of the total area in the upper Chao Phraya basin are existing and its production reaches the large quantity of 158,000 ton. The famous provinces for the fish culture in the basin are Suphan Buri. Nakhon Pathom, Bangkok, Samut Prakan, etc., which produce the large quantity of 20,000 to 50,000 ton/year.
- The Kok-Ing basin has also a high potential for the fish culture at many swamps, ponds, wetlands etc. However the yield for the fish culture is as low as 280 kg/rai which is about 50% of the yield in the Chao Phraya basin, because of scarce water in the dry season and poor culture technology of farmers.
- The fish culture will be promoted in future and in all basins in order to supply the protain sources and to provide the high income sources to the rural peoples.

3.2.6 Agricultural Development Policy in the Revised 8th Plan

(1) Agricultural Development Policy in the Revised 8th National Plan

Thailand has been experiencing an acute economic crisis since July 1997. In order to minimize the economic impact to the society and to recover the country economy, the government decided to review and revise the 8th National Development Plan aiming at a sound economic structure for future development under such circumstances. Agricultural sector will become a vital sector to recover the ailing economy in the revised 8th Plan and the key elements of the measures for stable agricultural production foundation are as follows;

(a) Restructuring Agricultural Production

- To improve an agricultural production structure by changing from traditional production process to quality agricultural products with different variety in line with market demand.
- To improve the foundation of sustainable agriculture development to cope with domestic

and export markets.

- To improve the plan for efficient utilization of chemical fertilizer and chemical compound through the combined use of organic and chemical fertilizer as well as the natural pest control method.
- To expand agricultural technology under the Royal Initiated New Theory.

(b) Agro-Processing Development

- To establish forward agricultural market in order to reduce risk due to price fluctuation as well as to provide an appropriate planning.
- To establish cooperation center between government and private sector to support private sector in securing production base expansion for raw materials and technology transfer in agro-industry activities.
- To review tax structure in order to provide the incentive for agro-industry and agro-processing.
- To establish the institute for special agricultural products.

(c) Development Production and Processing Technology for Systematic Export

- To conduct research and develop the new agro-industrial products as well as new plant and animal breeds to be competitive in the world market.
- To develop processing of herbs for medicine and health food at industrial scale.

(d) Natural resource and Environmental Management

- To mark out the clear demarcation of environmental protection zone on the map and at the site.
- To accelerate conducting of the rehabilitation of Thailand's marine environments.
- To accelerate the water resources management with emphasis on water demand in line with increase of utilization efficiency and restructuring pricing structure of water fees to properly reflect the actual capital cost and operation and maintenance cost.

(2) Agricultural Policy and Measures of MOAC

In order to achieve the above agricultural development policy revised in 8th plan, MOAC has set up the economic policy and measures as shown in Table 3.2.17.

Table 3.2.17 Economic Policy and Measures of MOAC under the Revision of the 8th Plan

	Item
1.	Policy on agriculture restructure (a) Measures of stipulating large specific agricultural areas with emphasis on production that connect to complete circuit of marketing and processing for agro-industry of important agricultural commodities. (b) Measures of risk reduction of small scale farmers.
2.	Policy on increasing production efficiency and reducing production cost (a) Measures of research and appropriate technology development including biotechnology of crops, livestock and fishery (b) Measures of implementing Champion Product Pilot Project in part of MOAC. (c) Measures of production base expansion for procurement of raw materials to feed a continuous agro-industry by negotiating with neighboring countries. (d) Measures of purchasing technical know how or increasing proportion of a budget for technology research and development to 10% of MOAC budget.
3.	Policy on quality improvement and processing (a) Measures of stipulation of exporting agricultural commodities emphasizing on one stop service. (b) Measures of encouraging and supporting farmers who are members of various organization to play a vital role in controlling and promoting production and marketing activities. (c) Measures of research and development for quality control (d) Measures of promotion of safe and natural condition production for domestic consumption and for export to specific markets.
4.	Policy on restructuring of MOAC (a) Measures of restructuring administrative works of MOAC to facilitate an integrated service, efficient natural resources conservation and restoration. (b) Measures of reducing official parts in service at Tambon level by decentralizing authority to local organizations.
5.	Policy on saving in the rural areas (a) Measures of mobilizing saving of agricultural cooperatives, farmer's groups and other rural saving groups
6.	Policy on fertilizer and chemical compound (a) Measures of management for efficient utilization of chemical fertilizer and other chemical compound. (b) Measures of using trash and agricultural by-products by private sector to produce organic fertilizer and biofertilizer and other agricultural inputs.
7.	Policy on management of forest, land, water and coastal resources as well as biodiversity (a) Measures of land provision and land distribution as well as solving problem of cultivated land. (b) Measures of management on conservation and protecting preservation areas. (c) Measures of conserving and restoring ecological system of deteriorated coastal areas. (d) Measures of developing natural resources to be suitable for conserved tourism and promoting agro-tourism. (e) Measures of developing potential of irrigated land for an efficient production including solving problem of environmental pollution.
8.	Policy on preparation in response to global climate change (a) Measures of prevention effects of natural disasters and provide appropriate assistance to farmers. (b) Measures of internal food security to avoid natural disaster effects. (c) Measures of restoring occupation and livelihood after natural disaster.
9.	Policy towards the 21st century (a) Measures of accelerating survey and making a list of living affairs in Thailand including database system to manage natural resources. (b) Measures of follow up, solving, and negotiating on trade barrier problems not relevant to taxation.

(3) Importance of Irrigation Development

Agriculture sector is once again given an important task with a higher expectation to lessen the economic impact and fuel a rapid recovery of the ailing economy. It is, therefore, essential to map out a long-term agricultural development plan not only to cope with the current economic crisis but also to lay a sound foundation for future development. The current economic crisis also provides an opportunity to present the government with a comprehensive long-term agricultural development plan similar to the attention given to industrial development during the past 3 National Plans i.e. 5th, 6th and 7th Plans.

The Central Plain, the rice bowl of Thailand, used to be and still is a major paddy producing area as well as the key area in agriculture and economy of the country. About 25% of the total rice production in the wet season and 70% in the dry season come from the Central Plain. In the past, large investments have been spent for the development of irrigation and drainage systems with on-farm development works and related infrastructures. Under the irrigated agriculture condition, the Chao Phraya Delta also acts as a pilot area for agricultural reform such as change in rice cropping techniques, farm mechanization, new agricultural activities and new crops. Furthermore, This area is undergoing a process of crop diversification and intensification under the irrigation systems.

In accordance with expansion of economy of the country in the past, use of water resources in Thailand has been more diversified in many other uses. Following increase of water demand for agriculture and non agriculture users, especially in the upper Chao Phraya basin, shortage of irrigation water for dry season cultivation in the lower Chao Phraya basin frequently occurs.

In general, demand of water in the agricultural sector dominates among others and use of water for irrigation shares the most essential part of the total water demand of the country. However, the government and concerned agencies are working on water management to have better overall irrigation efficiency in each irrigation project. Obviously, the Chao Phraya basin is facing water shortage, and no matter how efficiently water is being utilized, there is still not enough water to meet current demand from various users.

The issue of water utilization efficiency is getting much attention and is generally believed to be able to solve the water shortage problem. This is true to a certain extent, but not a solution to water shortage problem. Irrigation is being blamed as the inefficient user of water which again is partially correct. However, the fact remains that with surface gravity irrigation which is the case for Chao Phraya basin, the high possible efficiency cannot exceed 60 percent. So if consider only one individual project, the efficiency is usually low, but the nature of the basin development is that there are many more projects downstream. Therefore, the runoff water (or wastage) is used again by the project downstream, and possibly the same water is used again and again until it reaches the sea. Irrigation efficiency needs to be improved which in turn can increase the project cultivable area, but the improvement alone is certainly not sufficient to offset the overall increasing demand. One possible solution is to construct major strategic storage or transbasin water resources development

The Kok and the Ing are two subbasins of the Mekong River situated in the northern part of the country. Geographically and climatically, the areas within the two subbasins are ideal for agricultural development. In addition, the areas are close to the southern part of the People Republic of China with some 200 million people, hence it is a huge potential market for export. Water resources development of the two subbasins is still low, and has high potential for further development. Through the hydrological analysis and the socio-economic development trend study of the two subbasins, it is believed that the water resources, potential exceeds the socio-economic

development potential. However, it should be stated clearly that any transfer of the water resources should be those surplus of the subbasin own socio-economic development requirement, and at the same time, should satisfy the low flow condition.

In conclusion, water has become one of the major national concerns, and it is the limiting factor in the expansion of an irrigated agriculture. In order to cope with restructuring the agricultural production for competitiveness of produce in the world market and minimizing the economic impact on the rural people, there is an urgent need for water resources and irrigation development in the Chao Phraya basin.

(4) Promotion of Agro-Industry

Thailand has been exporting agricultural products as raw materials. Even though industry as regards to food processing is progressing, quantity and value of export of those processed agricultural products are uncomparable to the quantity and value of the products exported as raw materials. Moreover, the agro-industry that has been developed recently is of a large scale and beneficial to the firms of big investors; the farmers still play a role of raw materials suppliers without any value-added income.

A term of 'value added' farm products at regional and village levels has been thought of since the 6th and 7th Plans, however, not much progress has been achieved since then. In the 8th Plan, the idea has been brought about and introduced into the national policy of agro-industry promotion. And this time, a link-age between small scale agro-industry at the regional and farm levels and large scale agro-industry will be formulated. Farmers will be encouraged to seek higher value of their products through diversified household or community agro-industries. Networks between small-scale industries in the rural areas, and a system of widely distributed financial and other industry-related services will be established.

In the 8th Plan, the policy on industry promotion which includes agro-industry has been clearly stated about its direction that the activities should be thrusted and incentives and/or supporting services should be provided by public sector. There are two policies directly related to the promotion, each of which contains various measures.

(a) Development of Household, Rural and Community Industries

- To encourage private sector to assist farmers and communities by providing capital, technology, information services and investment opportunities in small scale agro-processing operations.
- To encourage local people jointly establish and retain ownership of the community industries, through tax incentives, investment promotion privileges and providing necessary marketing information and technology in order to upgrade their operational efficiency.
- To establish contracting networks that link large scale industries within and outside the region with the rural community industries.

(b) Decentralization of Industries and Related Activities to the Regions

- To increase the number of local entrepreneurs and upgrade their capabilities by providing continuous training that are related to modern management and technology.

- To facilitate relocation of industries from Bangkok metropolitan area to the provincial and rural areas.
- To develop regional industrial centers in nine provinces: Lamphun, Phitsanulok, Nakhon Sawan, Nakhon Ratchasima, Khon Kaen, Ratchaburi, Surat Thani, and Songkla. Industrial zones should be established in these provinces, and industrial link should be developed within the same region and with neighboring provinces.
- To promote and establish a single industrial center in the form of an industrial estate for medium and small scale industries, for each group of provinces. Similar industrial networks with neighboring provinces should be promoted.
- To enlarge the private sector's role in collaborating with the public sector for the establishment of industrial estates, industrial zones and industrial parks.
- To generate opportunities for industrial development at sub-regional level by establishing special economic zones and tax free zones along the borders to hasten the expansion of trade and investment both inside Thailand and with neighboring countries.

(5) Export-Oriented Agricultural Products

Today an atmosphere of international trade has greatly changed, especially for agricultural goods with high competition among countries of origin. This is because there are more new potential suppliers with appropriate technology who are capable of producing goods with lower production costs. Market orientation of agricultural produces has become more complicated due to specific characteristic and requirement of each market stemmed from taste and preference of the consumers. Furthermore, developed countries have specifically given importance to standard and quality of goods, and sanitary and phytosanitary measures, including environmental concerns that many of them were used to boycott trade from various countries.

With respect to the above factors, the government, through its relevant bodies and organizations as MOAC and Ministry of Commence, is trying to set up different measures to increase competitive ability in international market, and at the same time search for new market to absorb exporting agricultural goods. In general those measures can be concluded as follows:

(a) Dividing agricultural goods into three groups for better production management to comply with specific policy, which are export accelerated goods, goods produced to substitute importation, and stabilized production goods. For export accelerated goods, they are now rice, rubber, fruits, flowers, chilled or frozen poultry cut and shrimp.

(b) Studying on agricultural commodity export promotion and development. MOAC by OAE in 1997 conducted a study in U.S.A., Europe, Japan and China on taste and behavior of the consumers and requirement for each agricultural goods and processed products. Information obtained from the study was used in a seminar organized for public and private sectors to cooperatively plan for production development to meet the market requirements.

(c) Ministry of Commerce, through its Department of Export Promotion, publishes essential information relevant to international trading, and processes of exporting agricultural goods and their processed products to facilitate the exporters. It also coordinates with MOAC and concerning organizations to plan production management, exporting as well as controlling standard and quality of agricultural goods and their processed products.

(d) MOAC has established offices of Agricultural Consulate in the important countries of exporting and importing of agricultural goods which are U.S.A., China, Japan, Australia, Indonesia, and Belgium. The main purposes of establishing these offices are gathering agricultural information in those countries, cooperating with public and private sectors so as to facilitate agricultural goods exporting and importing business, and to help solve problems and difficulties in the channels.

(e) The government stipulates necessary measures and incentives to support exporting business. This is to stimulate and activate agricultural goods exporting business in order to build up competitive ability in the world market. Important measures are providing necessary information efficiently, providing credits or capital sources with appropriately low interest rates, providing public services to lower the cost of production of the agricultural exporting goods, and setting up promotion campaign for agricultural goods exporting.

3.2.7 Future Agricultural Development in the Beneficial Area of the Project

(1) Proposed Beneficial Area

Agricultural beneficial area to be developed by the diversion of water in the Project can be expected as follows;

- Existing irrigation area of 1.15 million rai in the lower Nan basin consisting of the Phitsanulok stage 1 of 667,000 rai and the pump irrigation of 485,000 rai. These areas have been suffered from irrigation water shortage, which will be recovered by the Project.
- Proposed irrigation area of 495,000 rai in the lower Nan basin consisting of the Phitsanulok, stage 2 of 295,000 rai and the expansion of pumping irrigation of 200,000 rai. These areas could receive the outflow of Sirikit dam after control of the diversion water of the Project. Therefore it will be the potential beneficial area of the Project.
- Existing 25 large scale irrigation project areas of 7.2 million rai which are lying on the Delta area and under the irrigation by the Chainat barrage. The irrigation areas, especially the upper irrigation areas of about 4 million rai, have always been suffered from water shortage in the dry season and will require the diversion water of the Project in order to promote and succeed in the diversified agriculture in future.

(2) Proposed Diversified Agriculture

In the wet season, the irrigated paddy will be mainly planted in the beneficial areas of the Project, except the perennial crop areas such as orchard, sugar cane, etc. In the dry season, the diversified crop areas for field crops, orchard, and vegetable and fresh water fishery area to be expanded under the full irrigation.

(a) Beneficial Area in Lower Nan

- The people living in the lower Nan basin are consuming non-glutinous rice as main food, so that production of such rice will be expanded in the wet and dry seasons in future for local consumption and export.
- As for diversified crops, mungbean and soybean in field crops, mango, coconut, banana

and tamarind in fruits and shallot, chinese kale and cabbage in vegetables will be mainly planted in the beneficial area in future.

(b) Beneficial Area in Delta

In the Delta, the upper west and east district will be main beneficial areas, because the areas in the upper district hold a large suitable land for diversified crop plantation and look forward to the irrigation water in the dry season to accelerate promotion of the crop diversification program in the district. The lower district being called as the conservation area will not be developed so much by the Project because it consists of many suitable land for paddy cultivation but no large potential for diversified agriculture area except the fresh water fish culture.

- Non-glutinous rice has been cultivated in the wet and dry seasons for consumption at the Delta area including Bangkok metropolitan area as well as for exportation.
- As for field crops, sugar cane cultivation is prevailing in the upper west district and will be expanded further in future. Sugar cane plantation will be increased also at the upper east district, if the irrigation water is supplied by the Project.
- Field crops such as mungbean and soybean will be expanded in the upper district as the second crops of the wet season paddy.
- Fruits of mango, coconut, lime, banana, pomelo, etc and vegetables of cucumber, chilli, baby corn, bean, chinese kale, etc., will be expanded in future.
- Fish culture will be largely promoted in every province in the Delta area in order to obtain the local protein sources and the high income of farmers.

(c) Beneficial Area in Kok-Ing

The beneficial area in the Kok-Ing basin has very suitable climate and soil for the particular fruits such as lichee and longan and vegetables of garlic, ginger, sweet corn, potato, cabbage, etc. These fruits and vegetables will be largely expanded in future because of the high market demand in the country.

3.2.8 Crop and Fish Culture Budget

Budget of crops for paddy field, fruit and vegetable as well as for fish culture in the proposed beneficial area of the Project is studied classifying into yield per rai, unit price of product and input cost for production as well as gross and net value. The study result is summarized as shown in Table 3.2.18.

- The net value in the future with project is rather high as compared with the present value, because of the high yield and quality under the full and secure irrigation water supply and the increasing farm gate prices of agricultural products in future.
- Paddy production in future will not be profitable as shown in the financial net value of 585 Baht/rai in wet season and 1,329 Baht/rai in dry season. Farm gate prices of fruits and fish culture shows the high value of more than 15,000 Baht/rai. Although, the net value of vegetable is 2,700 to 3,000 Baht/rai/time, three times cultivation could be possible in a year so that the net value of 8,100 to 9,000 Baht/rai is expected in a year.
- Crop budget for the field crops and fruits is estimated based on the representative crops such as

mungbean and soybean for the field crops and mango for the fruit.

- Detailed crop and fish culture budget is estimated in the Supporting Report.

Table 3.2.18 Crop and Fish Culture Budget

Crops	Present					Future with Project									
	Financial					Financial					Economic				
	Yield kg/Rai	Unit Price B/kg	Gross Value B	Input Cost B/Rai	Net Value B/Rai	Yield kg/Rai	Unit Price B/kg	Gross Value B	Input Cost B/Rai	Net Value B/Rai	Yield kg/Rai	Unit Price B/kg	Gross Value B	Input Cost B/Rai	Net Value B/Rai
1. Lower Chao Phraya															
(1) Upper District															
Wet Paddy	584	4.2	2,453	1,925	528	584	4.2	2,453	1,925	528	584	4.6	2,686	1,501	1,185
Dry Paddy	777	4.5	3,497	2,052	1,445	850	4.2	3,570	2,241	1,329	850	4.6	3,910	1,793	2,117
Sugar Cane	9,745	0.475	4,629	4,276	353	10,580	0.835	8,834	4,432	4,402	10,580	1.051	11,088	2,957	8,131
Field Crops	-	-	6,860	2,627	4,233	-	-	9,731	2,821	6,910	-	-	10,318	2,359	7,959
Fruits	1,084	10.0	10,840	5,406	5,434	884	19.4	17,150	5,311	11,839	884	22.0	19,448	4,448	15,000
Vegetable	1,300	4.0	5,200	4,409	791	1,490	5.1	7,599	4,724	2,875	1,490	5.4	8,046	3,634	4,412
Fish Culture	370	12.5	4,626	4,041	585	1,330	15.15	20,150	6,614	13,536	1,330	16.33	21,715	5,944	15,771
(2) Lower District															
Wet Paddy	584	4.2	2,453	1,925	528	584	4.2	2,453	1,925	528	584	4.6	2,686	1,501	1,185
Dry Paddy	777	4.5	3,497	2,052	1,417	850	4.2	3,570	2,241	1,329	850	4.6	3,910	1,793	2,117
Sugar Cane	9,745	0.475	4,629	4,276	353	10,580	0.838	8,866	4,432	4,434	10,580	1.051	11,120	2,957	8,163
Field Crops	-	-	6,860	2,627	4,233	-	-	9,801	2,821	6,980	-	-	10,318	2,359	7,959
Fruits	1,084	10.0	10,840	5,406	5,434	884	19.4	17,150	5,311	11,839	884	22.0	19,448	4,448	15,000
Vegetable	1,300	4.0	5,200	4,409	791	1,490	5.2	7,748	4,724	3,024	1,490	5.4	8,046	3,629	4,417
Fish Culture	370	12.5	4,626	4,041	585	1,330	15.15	20,150	6,614	13,536	1,330	16.33	21,715	5,944	15,771
2. Lower Nan															
Wet Paddy	584	4.2	2,453	1,925	528	584	4.2	2,453	1,925	528	584	4.6	2,686	1,501	1,185
Dry Paddy	765	4.5	3,443	2,142	1,301	850	4.2	3,570	2,242	1,328	850	4.6	3,910	1,798	2,112
Sugar Cane	9,608	0.475	4,564	4,275	289	10,580	0.828	8,760	4,436	4,324	10,580	1.048	11,014	2,962	8,052
Field Crops	-	-	6,876	2,642	4,234	-	-	9,656	2,823	6,833	-	-	10,179	2,369	7,810
Fruits	1,084	10.0	10,840	5,406	5,434	884	19.4	17,150	5,311	11,839	884	22.0	19,448	4,448	15,000
Vegetable	1,300	4.0	5,200	4,409	791	1,490	5.0	7,450	4,728	2,722	1,490	5.3	7,897	3,648	4,249
Fish Culture	370	12.5	4,626	4,041	585	1,330	15.15	20,150	6,614	13,536	1,330	16.33	21,715	5,944	15,771

Figure 3.1 Socio-Economic Indicator in the Chao Phraya, Kok and Ing Basins

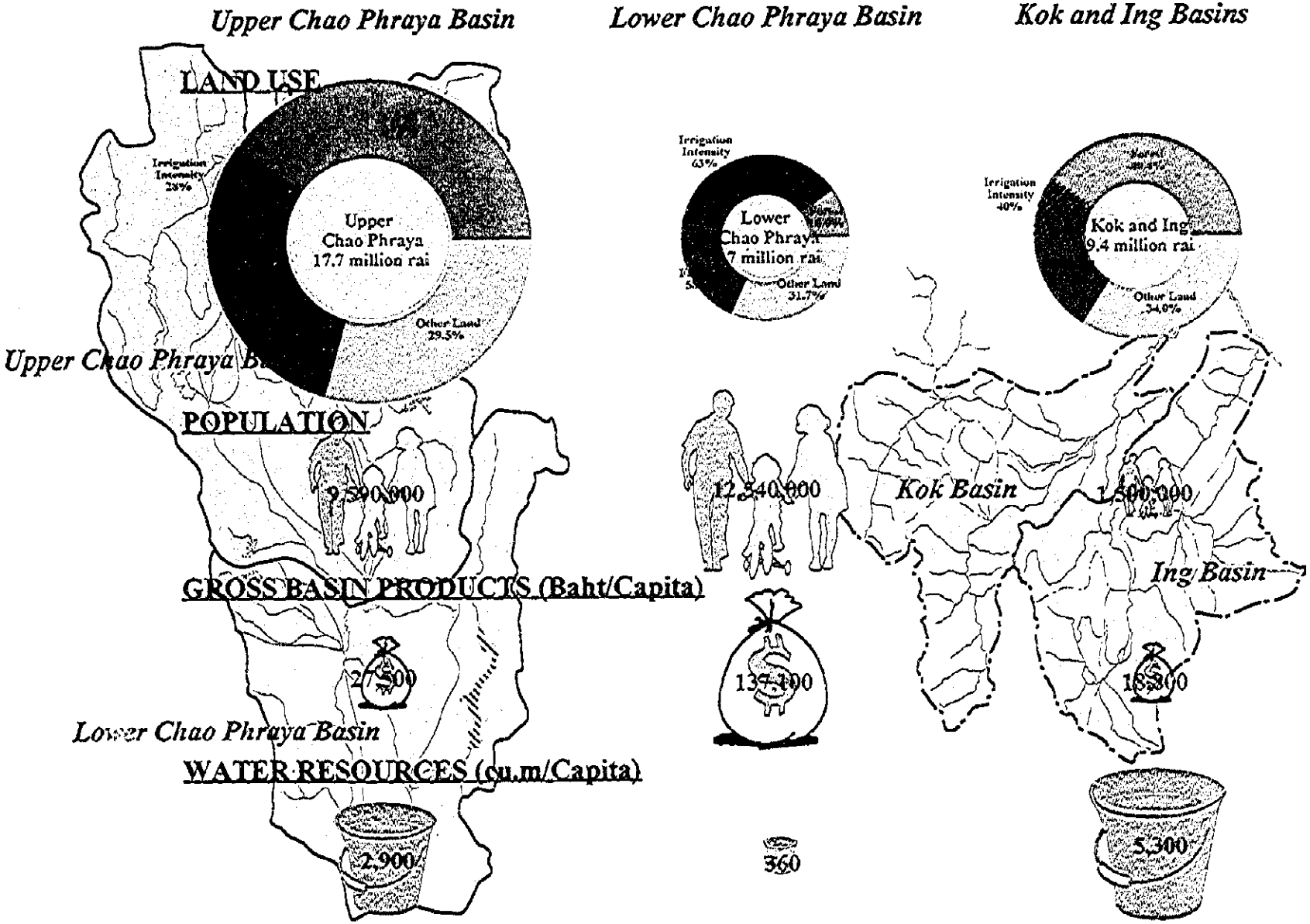


Figure 3.1 Socio-Economic Indicator in the Chao Phraya, Kok and Ing Basins

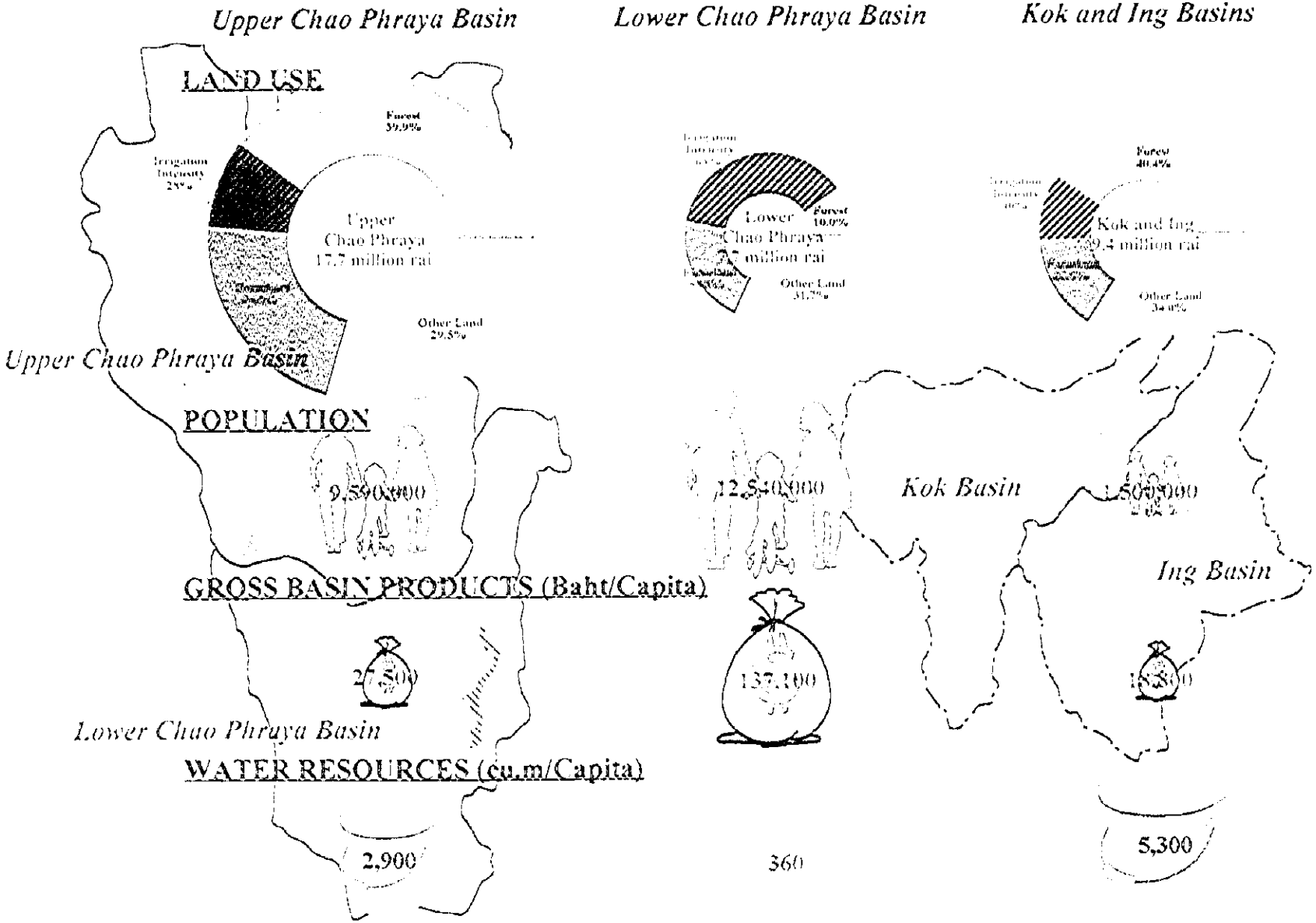
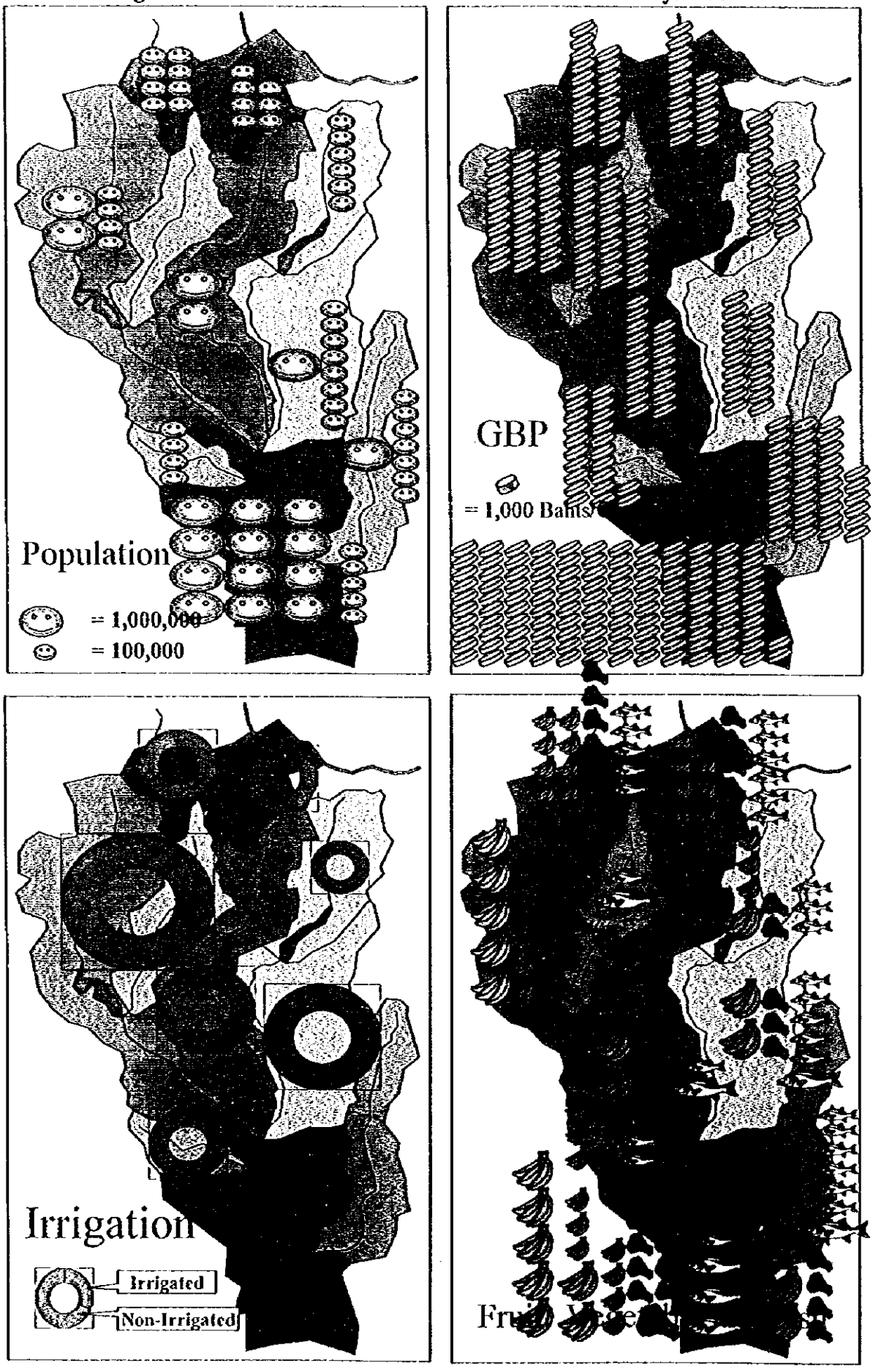


Figure 3.2 Socio-Economic Indicators of the Chao Phraya Basin



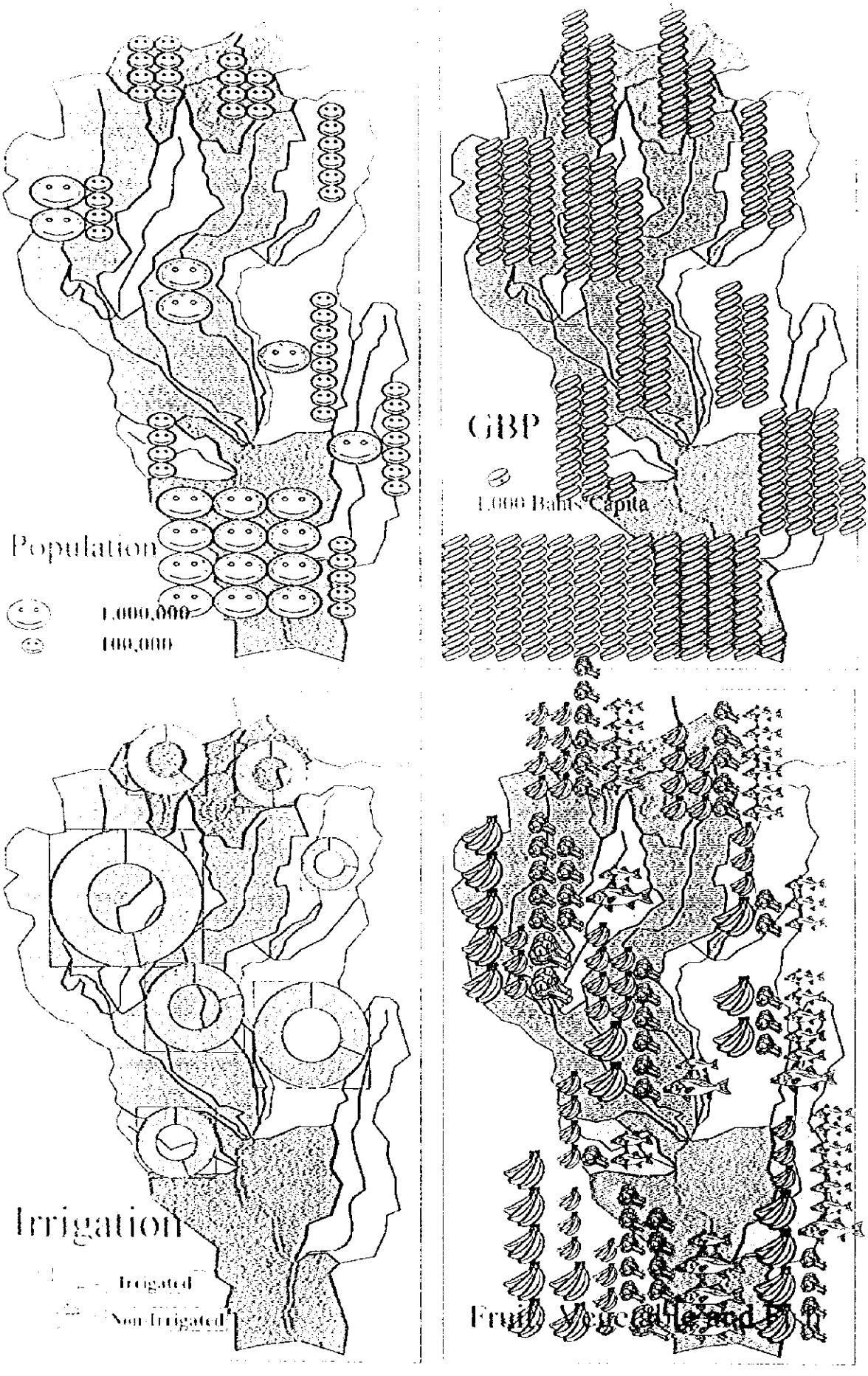
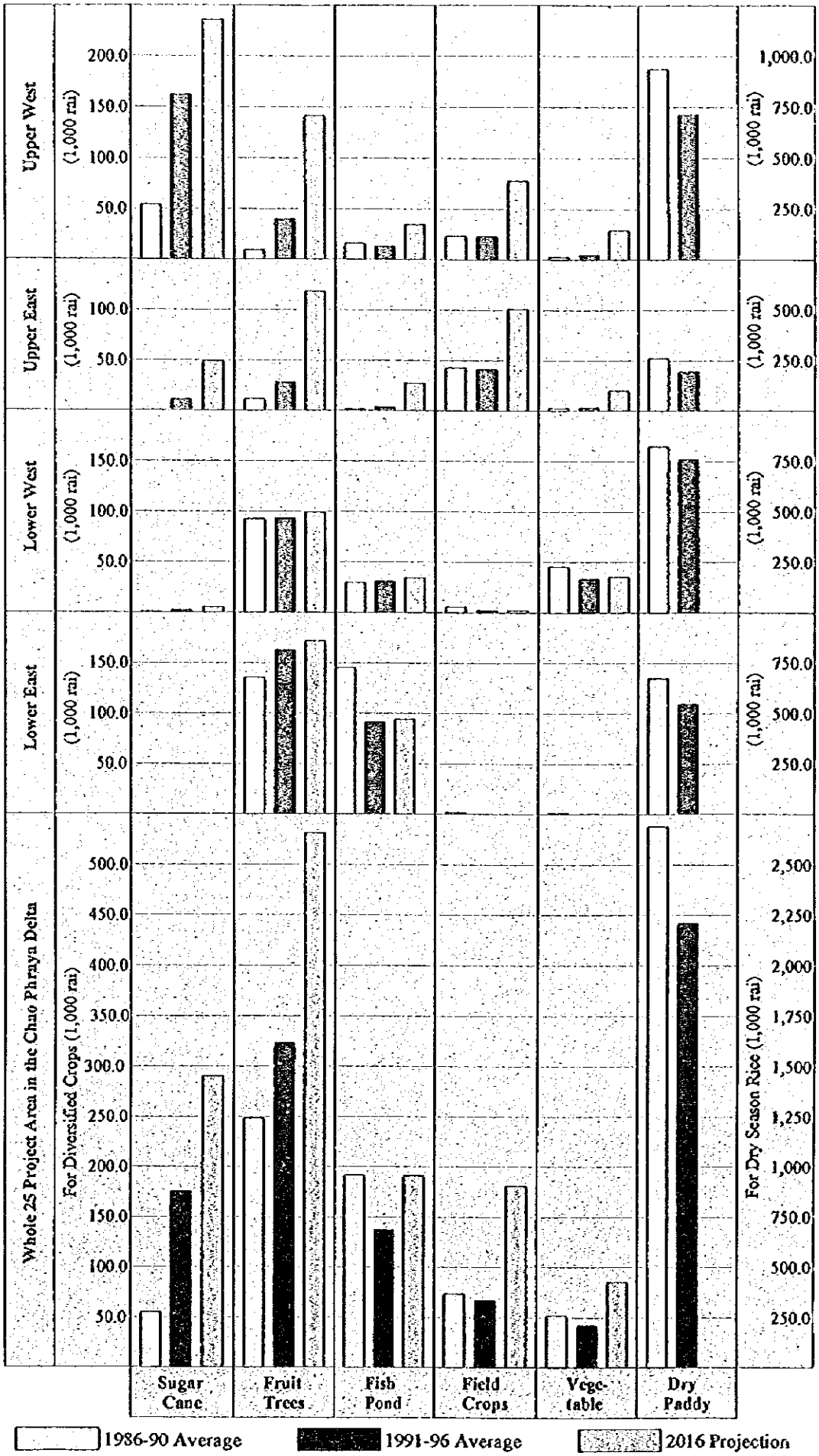

Population
1,000,000
100,000
GBP
1,000 Baht/Capita
Irrigation
Irrigated
Non-Irrigated
Fruit, Vegetable and F

Figure 3.3 Increasing Areas for Diversified Crops in the Chao Phraya Delta



CHAPTER 4.

WATER RESOURCES DEVELOPMENT AND MANAGEMENT IN THE UPPER CHAO PHRAYA BASIN

CHAPTER 4 WATER RESOURCES DEVELOPMENT AND MANAGEMENT IN UPPER CHAO PHRAYA BASIN

4.1 Water Resources Development

4.1.1 Limited Water Resources in Chao Phraya Basin

(1) Scarce Water Resources in Thailand

The surface water resources in Thailand are scarce as compared with those in the other countries of Southeastern Asia. The comparison of the potential surface water resources in Thailand and those in the other countries is shown in table 4.1.1.

Table 4.1.1 Potential Surface Water and Farm Land Resources in South Asian Countries

Country	Total Land Area 10^3 km^2 2wz	Population 10^6 (2)	Potential Water Resources			Potential Farm Land Area		
			Amount 10^9 m^3 (3)	Runoff Yield mm (4)=(3)/(1)	Per Capita Amount 10^3 m^3 (5)=(3)/(2)	Area 10^6 ha (6)	Per Capita ha (7)=(6)/(2)	Water Per ha 10^3 m^3 (8)=(3)/(6)
(1) Thailand	512	60.5	212	414	3.5	21.0	0.35	10.1
(2) Cambodia	177	10.3	498	2,814	48.3	2.4	0.23	207.5
(3) Lao P.D.R	231	5.0	270	1,169	54.0	0.8	0.16	337.5
(4) Vietnam	325	74.5	376	1,157	5.0	6.6	0.09	57.0
(5) Myanmar	658	46.5	1,082	1,644	23.3	10.1	0.22	107.1
(6) Malaysia	329	20.0	456	1,386	22.8	4.9	0.25	93.1
(7) Indonesia	1,812	193.8	2,530	1,396	13.1	31.0	0.16	81.6
(8) Philippines	298	70.3	323	1,084	4.6	9.2	0.13	35.1

- The potential surface water resources in Thailand are 212 billion cu.m which are very scarce when compared with those in the other Southeastern Asian countries showing the runoff yield of 414 mm (30% of the other countries) and the per capita water of 3,500 cu.m (10 to 15%).
- Although Thailand is known as the agricultural country in Asia holding the large farm area of 21 million ha which shows the large per capita area of 0.35 ha (1.5 to 2.0 times of the other countries), the water resources per ha are quite limited to be only 10,100 cu.m (5 to 10% of the other countries). Accordingly, many farm areas in Thailand have been suffered from chronic water shortage.
- It is therefore very important and necessary that Thailand shall emphasize the water resources development and management in the country to sustain the national food security and the prosperity in the national socio-economy.

(2) Surface Water Resources in River Basins of Thailand

The potential surface water and farm land resources in the river basins of Thailand are studied in accordance with the data in "Water Resources Development for 25 Basins in Thailand" prepared by NESD, runoff data provided by RID and farm land data in "Agricultural Statistics of Thailand". The study result is shown in the Supporting Report and summarized Table 4.1.2.

Table 4.1.2 Potential Surface Water and Farm Land Resources in Thailand

River Basin	Total Land Area km^2 (1)	Population Number 1996 10^3 (2)	Potential Water Resources			Potential Farm Land Area		
			Amount (MCM) (3)	Runoff Yield mm (4)=(3)/(1)	Per Capita Water $10^3 m^3$ (5)=(3)/(2)	Total Area 10^3 ha (6)	Per Capita ha (7)=(6)/(2)	Per ha Water m^3/ha (8)=(3)/(6)
1. Chao Phraya Basin								
Nan	34,330	2,370	11,550	336	4.9	1,090	0.46	10,600
Yom	23,620	2,000	3,610	153	1.8	770	0.39	4,700
Ping & Wang	44,690	3,100	8,400	188	2.7	810	0.26	10,400
Sakae Krang	5,190	440	1,300	250	3.0	260	0.59	5,000
Pasak	16,290	1,680	2,980	183	1.8	870	0.52	3,400
Delta & Tha Chin	33,810	12,540	4,500	133	0.4	1,970	0.16	2,300
Sub-total	157,930	22,130	32,340	205	1.5	5,770	0.26	5,600
2. Kok & Ing Basin								
Sub-total	15,000	1,500	8,200	547	5.5	380	0.25	21,600
3. Other Basins								
Northeast	119,180	20,500	32,280	271	1.6	9,220	0.45	3,500
Mae Kong & Salaween	68,220	1,390	25,010	367	18.0	310	0.22	80,700
West Coast	43,190	3,500	13,730	318	3.9	860	0.25	16,000
East Coast	36,440	3,900	26,360	723	6.8	1,710	0.44	15,400
South	72,110	7,600	73,830	1,024	9.7	2,750	0.36	26,800
Sub-total	339,140	36,890	171,210	505	4.6	14,850	0.40	11,500
Total	512,070	60,520	211,750	414	3.5	21,000	0.35	10,100

Remark; Potential water resources are estimated by average value of 1974 to 1984

- Although the potential water resources at the country level reach the slightly high amount of 212 billion cu.m p.a, those in the Chao Phraya basin and the Northeast region show very small value of 32.3 billion cu.m for each of them. Namely the Chao Phraya and Northeast have a large land area and population (more than 70% of the country area) but their water resources are only 64.6 billion cu.m (30% of the whole water resources in the country).
- The water resources in the Chao Phraya whole basin are the lowest in the country as shown in the runoff yield of 205 mm, the per capita water of 1,500 cu.m and the per ha water of 5,600 cu.m because the basin is formed with large plateau areas with gentle slope, alluvial plains along the major rivers and delta areas lying on the lower Chao Phraya, where in the rain water is easily lost through evaporation from ground surface and used for large rainfed paddy areas.
- The Nan river basin in the Chao Phraya has a slightly high potential water resources as shown in the yield of 336 mm, the per capita water of 4,900 cu.m and the per ha water of 10,600 cu.m.
- Although the Delta and Tha Chin basin has a large farm area of about 2.0 million ha, the potential water resources are very scarce as shown in the per capita water of only 400 cu.m and the par ha water of 2,300 cu.m. The main water resources in the Delta and Tha Chin basin are depending on those in the upper Chao Phraya basin, especially the water supply by the Nan and Ping.
- The Kok and Ing basin related to the Project has the rich water resources of 8.2 billion

cu.m as compared with population of 1.5 million and farm land area of 380,000 ha.

- The other river basins in the country such as the west coast, east coast, south region, etc have sufficient water resources to support agricultural and socio-economical development in each respective basin.

(3) Decreasing Water Resources in Upper Chao Phraya Basin in Recent Years

As mentioned in 2.3.2 "Seasonal and Annual Runoff Variation", the runoff in the upper Chao Phraya basin has decreased in the recent years due to a little decrease of rainfall and large increase of irrigation water use in the upper Chao Phraya basin. Accordingly the potential water resources at the Nakhon Sawan station and the Chai Nat barrage site have decreased remarkably. The decreasing water resources conditions are summarized in Table 4.1.3 and shown in Figure 4.1.2.

Table 4.1.3 Decreasing Water Resources at Major Stations in Upper Chao Phraya Basin

Unit MCM

Major Station	Catchment Area km²	Past Years 1974-84			Recent Years 1985-96			Decreasing Rate (%)		
		Wet	Dry	Total	Wet	Dry	Total	Wet	Dry	Total
N1 at Nan	4,609	2,530	230	2,760	2,370	280	2,650	94	122	96
Sirikit Inflow	13,130	5,110	770	5,880	4,090	660	4,750	80	86	81
Sirikit Outflow	13,130	2,640	3,070	5,710	1,790	2,540	4,330	68	83	76
N7 at Phicit in Nan	29,153	7,230	3,600	10,830	5,240	2,820	8,060	72	78	74
Whole Nan Basin	34,289	8,590	2,960	11,550	5,510	2,340	7,850	64	79	68
Y17 at Yom	9,284	3,170	260	3,430	2,870	200	3,070	91	77	90
Whole Yom Basin	23,600	3,340	270	3,610	3,050	200	3,250	91	74	90
Bhumibol Inflow	26,100	4,920	720	5,640	4,300	690	4,990	87	97	88
Bhumibol Outflow	26,100	2,390	3,140	5,530	1,400	3,040	4,440	59	97	80
Wang W4A	10,507	1,020	120	1,140	790	100	890	77	83	78
P7A in Ping	42,700	4,660	3,320	7,980	3,060	3,060	6,120	66	92	77
Whole Ping Basin	44,650	5,050	3,350	8,400	3,340	3,040	6,380	66	91	76
C2 at Nakhon Sawan	110,569	18,020	7,380	25,400	12,930	6,240	19,170	72	85	75
Chai Nat Inflow	119,000	19,310	7,200	26,510	14,160	5,840	20,000	73	81	75
Chai Nat Diversion	119,000	8,260	4,580	12,840	6,450	4,000	10,450	78	87	81
Chai Nat Release	119,000	11,050	2,620	13,670	7,700	1,850	9,550	70	71	70

- In the Sirikit and Bhumibol dams, the reservoir inflow has decreased caused by decrease of rainfall and increase of irrigation water uses in the upper Nan and upper Ping in the recent years and as a result, the outflows from these dams have also decreased. Both dams have tried to store the wet season inflow as much as possible so as to release more dry season outflows in their reservoir operation.
- In accordance with the water resources development in the upper Chao Phraya basin which emphasizes to store the wet season runoff in the reservoirs and to use it in the dry season, the wet season runoff in the upper basin has decreased in the recent years while the dry season runoff also decreased at major stations due to increasing irrigation area in the dry season.
- At the Chai Nat barrage site which is the most important water control point in the Chao

Phraya basin to allocate and supply the water to the large irrigation area of 7.3 million rai and the Bangkok metropolitan area, the annual inflow decreases to 20,000 MCM in the recent years from 26,500 MCM in the past years. The decreased water consists of 5,200 MCM in the wet season and 1,300 MCM in the dry season. This decreasing water condition has brought about the large constraints for the sustainable agricultural, industrial and urban development in the Delta.

4.1.2 Existing and Future Water Resources Development in Upper Chao Phraya Basin

It is rather difficult to use effectively the surface water resources in the upper Chao Phraya basin to meet the domestic and irrigation demand throughout a year because of large seasonal and annual runoff fluctuation, no or scarce dry season discharge in the tributaries and rivers, big flood used to occur in the period of August to September, etc.

The water resources development is used to be classified into the large, medium and small scale in accordance with the project dimension and the pumping project. The large and medium scale projects are in principle, planned, implemented and operated to store a rich wet season runoff in the reservoirs for use in the dry season. The small scale projects are generally implemented at small tributaries mainly for supplemental irrigation for wet season paddy and usually not for the irrigation of the dry season crops due to lack of dry season discharge in the tributaries. The pumping irrigation projects which are mainly constructed along the lower Nan and Ping have the large irrigation area for paddy and diversified crops because such area can easily receive the dry season water which is released from the Sirikit and Bhumibol dams.

The inventory survey for the existing and future water resources development projects (mainly irrigation projects) in the upper Chao Phraya basin was carried out by JICA Team in collaboration with Thai local consultants and governmental agencies including RID and DEDP. The survey result is summarized in the Supporting Report, classifying the basin into sub-basins of the Nan, Ping, Yom, etc and the projects into the large, medium and small scale as well as the pumping irrigation.

Most of the existing and proposed water resources development projects in the upper basin are planned, implemented and managed for the purpose of irrigated agriculture. The projects for domestic water supply and/or hydropower alone are very few.

(1) Outline of the Existing Projects

The existing largest and most important dams in Thailand are the Bhumibol dam with the gross storage capacity of 13,500 MCM constructed on the Ping river and the Sirikit dam with the capacity of 10,500 MCM on the Nan river. They were constructed in 1964 and 1974 respectively with multipurpose of irrigation mainly for the Delta area of about 7.3 million rai, municipal water supply in Bangkok Metropolitan area and hydropower generation of 535 MW at the Bhumibol and 500 MW at the Sirikit. The outline of both dams is given in the Supporting Report.

In addition to the above two largest dams, there are existing large, medium and small scale dams with a total capacity of 2,000 MCM. The notable large dams and weirs are as follows;

Table 4.1.4 Existing Large Scale Projects

Project Name	River Basin	Catchment Area (km^2)	Annual Runoff (MCM)	Reservoir Capacity (MCM)	Gross Effective (MCM)	Irrigable Area (10^3 rai)
1. Large Dam						
Mae Ngat	Ping	1,281	290	265	243	30
Mae Kuang	Ping	569	210	263	249	175
Kiu Lom	Wang	2,700	590	112	108	160
Tap Salao	Sakae Krung	534	158	160	152	144
Krasico	Chao Phraya	1,200	170	201	190	130
2. Weir						
Naresuan	Nan	19,500	4,900	-	-	650
Lower Ping	Ping	40,000	6,000	-	-	600
Nae Yom	Yom	12,000	2,300	-	-	220

Most of these large and medium scale dams and weirs have suffered from water shortage problems in the recent years due to decreasing runoff in the upstream basin caused by irrigation development and increasing irrigation and other water demands at the beneficial area in the downstream basin.

The Bhumibol and Sirikit dams are planned to serve for irrigation of about 600,000 rai in the Lower Ping and 1.5 million rai in the Uttaradit and Phitsanulok respectively in addition to 7.3 million rai in the Chao Phraya Delta. However the inflows of both reservoirs are not sufficient to fill up the large storage capacity and as a result, the large empty volumes of 3,000 to 4,000 MCM at the Bhumibol and 2,000 to 3,000 MCM at the Sirikit have always appeared at the end of wet season. Accordingly some irrigation projects which are proposed in connection with the function of both dams have to be suspended, while the cropping intensity in the dry season in the existing project area in Delta is placed at the low level of 30 to 40%. Other large and medium scale dams have supplied the reservoir water mainly for supplemental irrigation of wet season paddy within their tributary areas. The reservoir water use for dry season crops is quite limited due to scarce reservoir inflow.

(2) Outline of Future Project

A large storage dam like the existing Bhumibol and Sirikit dams will not be built any more in future in the upper Chao Phraya basin because there is no suitable damsite with provide the large reservoir capacity where sufficient inflow is available.

The future large dams are mostly proposed with the reservoir capacity of less than 1,000 MCM as shown in the following table;

Table 4.1.5 Proposed Large Scale Projects in Future

Name	River Basin	Catchment Area (km^2)	Annual Runoff (MCM)	Storage Capacity (MCM)	Irrigation Area (10^3 rai)
Khwae Noi	Lower Nan	4,254	1,620	770	343
Nam Khek	Lower Nan	854	490	345	68
Khlong Wang Chao	Lower Ping	-	-	295	26
Kiew Kho Ma	Wang	1,280	265	140	27
Kaeng Sua Ten	Yom	3,580	930	1,175	305
Mae Wong	Sakae Hrung	615	270	250	61
Pasak	Pasak	12,930	2,110	785	230
Total				3,760	1,060

Most of the above large dams except the Pasak dam which is under construction at present have encountered the environmental issues including resettlement problem in the reservoir area. Therefore it is difficult to expect early implementation. Implementation of the Kaeng Sua Ten dam has been suspended for a long time due to the environmental impact to be induced by the reservoir. The Mae Wong dam proposed in the Sakae Krang sub-basin and the Khwae Noi dam in the lower Nan sub-basin are under detailed design but have faced a large environmental problem and delayed the commencement of the dam construction. Accordingly, the water resources development in future shall rely more on the medium and small scale projects and pumping projects.

In addition, the unit raw water charge to be derived from those future water resources development projects will be much higher due to high land acquisition cost. Average investment cost per cubic meter of developed water resources from future large/medium scale storage dam project will cost about 21.7 Baht as shown in the Supporting Report.

(3) Increasing Reservoir Capacity in Future

The existing and future reservoir capacity of each project in each sub-basin are shown in the Supporting Report 4.1 and Summarized in Table 4.1.6.

Table 4.1.6 Existing and Future Reservoir Capacity at Each Sub-Basin

(Unit MCM)

Item	Nan			Ping			Yom	Wang	Sakae Krang	Pasak	Total
	Upper	Lower	Sub-total	Upper	Lower	Sub-total					
(1) Existing	28	57	85	640	4	644	73	196	163	879	2,040
(2) Future	1,206	1,287	2,493	901	450	1,351	1,724	634	481	1,093	7,776
(3) Increase(2)-(1)	1,178	1,230	2,408	261	446	707	1,651	438	318	214	5,736

Remark; The reservoir capacity of 24,000 MCM in the Sirikit and Bhumibol dams is not included in the above table.

- The total reservoir capacity by the large, medium and small scale projects is about 2,000 MCM at present and will largely increase to about 7,800 MCM (3.9 times) in future.
- The existing reservoir capacity in the upper and lower Nan basin is very small as shown in the above table, because of delay of water resources development which will give a large impact to the inflow of Sirikit dam and Chai Nat barrage. A number of medium and small scale projects with reservoirs in addition to the large dam of Khwai Noi are proposed in the upper and lower Nan basin and their total reservoir capacity will reach

the large volume of 2,500 MCM in future which is the biggest capacity in the upper Chao Phraya basin and at the same time, will bring about a large water shortage problem to the Delta area.

- The existing reservoir capacity in the upper Ping basin shows the largest value of 640 MCM in the upper Chao Phraya because the water resources in the basin have been developed with high priority for irrigated agriculture. A number of medium and small scale reservoirs will be further developed in the upper and lower Ping basin and their capacity will reach the large volume of 1,350 MCM in future.
- Since the water resources in the Yom basin have not been developed yet but will be largely developed by the Kaeng Sua Ten dam and a number of medium and small scale reservoirs and as a result, the future total reservoir capacity in the basin will reach 1,700 MCM.
- Although the water resources in the other basins will be developed also in future, their increased capacity by the development is not so large as compared with that in the Nan, Ping and Yom.

4.1.3 Existing and Future Water Use

The water resources developed by the large, medium and small scale projects except the largest dams of Sirikit and Bhumibol have been used mainly for irrigated agriculture in the beneficial area of each sub-basin in the upper Chao Phraya. Since the Upper Chao Phraya basin holds the large farm area of 23.8 million rai of which the existing irrigation area is 6.6 million rai and the large population of 9.6 million of which 6 million has been engaged in agriculture, the Thai government including RID and DEDP, has emphasized to develop the water resources in this basin mainly for the irrigated agriculture since 1970's.

In accordance with the government effort, the irrigation area in the upper basin has increased remarkably from 1980's to 1990's as shown in Figure 4.1.3. The existing total irrigation area in the basin reaches 6.6 million rai in the wet season and 1.6 million rai in the dry season. However the irrigation intensity is still low as 28% in the wet season and only 7% in the dry season. Accordingly, Thai government intends to expand the irrigation area in future together with the water resources development.

In accordance with the decreasing water resources caused by irrigation water use in the upper Chao Phraya basin, the Delta area in the lower Chao Phraya which is supporting the national food security and economy has faced the chronic water shortage problem. In order to set up the balanced water use in the upper and lower Chao Phraya basin, it is very important to grasp the existing and future water use for irrigation in the upper basin and to develop and manage the limited water resources properly for its water use.

The existing and future irrigation area developed by the large, medium and small scale projects as well as pumping system is compiled in the Supporting Report 4.1 based on the inventory survey result. The outline of the irrigation area and water demand is as shown in Table 4.1.7 (1).

Table 4.1.7 (1) Irrigation Area and Water Demand of Existing and Future Project in Upper Chao Phraya

(Unit: Area 10^3rai Water MCM)

Item / Rever Basin & Project Type	Unit Demand cu.m/rai		Existing Irrigation Project				Future Irrigation Project				Increase			
			Area		Water Demand		Area		Water Demand		Area		Water Demand	
	Wet ①	Dry ②	Wet ③	Dry ④	Wet ⑤=①×③	Dry ⑥=②×④	Wet ⑦	Dry ⑧	Wet ⑨=①×⑦	Dry ⑩=②×⑧	Wet ⑦-③	Dry ⑧-④	Wet ⑨-⑤	Dry ⑩-⑥
1. Upper Nan Basin														
(1) At N1 Station														
L/M/S	1,200	1,800	181.8	32.2	218.2	58.0	332.0	91.4	398.4	164.5	150.2	59.2	180.2	106.6
Pump	1,000	1,600	45.7	3.0	45.7	4.8	67.1	13.3	67.1	21.3	21.4	10.3	21.4	16.5
Total	-	-	227.5	35.2	263.9	62.8	399.1	104.7	465.5	185.8	171.6	69.5	201.6	123.0
(2) At Sirikit Site (End of Upper Nan)														
L/M/S	1,200	1,800	239.1	40.5	286.9	72.9	485.4	122.5	582.5	220.5	246.3	82.0	295.6	147.6
Pump	1,000	1,600	66.0	7.1	66.0	11.4	131.6	26.2	131.6	41.9	65.6	19.1	65.6	30.6
Total, Upper Nan	-	-	305.1	47.6	352.9	84.3	617.0	148.7	714.1	262.4	311.9	101.1	361.2	178.2
2. Lower Nan Basin														
(1) At Naresuan Barrage														
Phitsanulok (1), L/M/S	1,200	1,800	667.1	400.2	800.5	720.4	667.1	400.2	800.5	720.4	0.0	0.0	0.0	0.0
Phitsanulok (2), L/M/S	1,200	1,800	0.0	0.0	0.0	0.0	500.0	250.0	600.0	450.0	500.0	250.0	600.0	450.0
L/M/S	1,200	1,800	233.4	48.6	280.1	87.5	324.6	60.4	389.5	108.7	91.2	11.8	109.4	21.2
Existing Pump	1,000	1,600	253.4	76.7	253.4	122.7	305.3	152.6	305.3	244.2	51.9	75.9	51.9	121.5
DEDP New Pump	1,000	1,600	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	-	-	1,153.9	525.5	1,334.0	930.6	1,797.0	863.2	2,095.3	1,523.3	643.1	337.7	761.3	592.7
(2) Total Lower Nan														
Phitsanulok (1), L/M/S	1,200	1,800	667.1	400.2	800.5	720.4	667.1	400.2	800.5	720.4	0.0	0.0	0.0	0.0
Phitsanulok (2), L/M/S	1,200	1,800	0.0	0.0	0.0	0.0	500.0	250.0	600.0	450.0	500.0	250.0	600.0	450.0
L/M/S	1,200	1,800	738.3	140.4	886.0	252.7	1,674.0	438.1	2,008.8	788.6	935.7	297.7	1,122.8	535.9
Existing Pump	1,000	1,600	391.6	122.4	391.6	195.8	485.6	242.8	485.6	388.5	94.0	120.4	94.0	192.6
DEDP New Pump	1,000	1,600	0.0	0.0	0.0	0.0	200.0	100.0	200.0	160.0	200.0	100.0	200.0	160.0
Total	-	-	1,797.0	663.0	2,078.1	1,168.9	3,526.7	1,431.1	4,091.9	2,507.4	1,729.7	768.1	2,016.8	1,338.5
3. Ping Basin														
(1) Upper Ping at Bhumibol dam														
L/M/S	1,200	1,800	1,104.1	257.4	1,324.9	463.3	1,868.1	409.0	2,241.7	736.2	764.0	151.6	916.8	272.9
Pump	1,000	1,600	46.0	4.6	46.0	7.4	58.8	11.7	58.8	18.7	12.8	7.1	12.8	11.4
Total	-	-	1,150.1	262.0	1,370.9	470.7	1,926.9	420.7	2,300.5	754.9	776.8	158.7	929.6	284.2
(2) Total Lower Ping														
L/M/S	1,200	1,800	623.8	148.5	748.6	267.3	1,109.0	299.4	1,330.8	538.9	485.2	150.9	582.2	271.6
Pump	1,000	1,600	104.5	10.4	104.5	16.6	154.3	77.2	154.3	123.5	49.8	66.8	49.8	106.9
Total	-	-	728.3	158.9	853.1	283.9	1,263.3	376.6	1,485.1	662.4	535.0	217.7	632.0	378.5
4. Yom Basin														
L/M/S	1,200	1,800	893.1	181.0	1,071.7	325.8	1,757.0	426.7	2,108.4	768.1	863.9	245.7	1,036.7	442.3
Pump	1,000	1,600	76.3	7.7	76.3	12.3	110.8	51.9	110.8	83.0	34.5	44.2	34.5	70.7
Total	-	-	969.4	188.7	1,148.0	338.1	1,867.8	478.6	2,219.2	851.1	898.4	289.9	1,071.2	513.0
5. Wang Basin														
L/M/S	1,200	1,800	479.5	78.5	575.4	141.3	802.2	127.8	962.6	230.0	322.7	49.3	387.2	88.7
Pump	1,000	1,600	54.3	5.5	54.3	8.8	77.7	15.6	77.7	25.0	23.4	10.1	23.4	16.2
Total	-	-	533.8	84.0	629.7	150.1	879.9	143.4	1,040.3	255.0	346.1	59.4	410.6	104.9
6. Sakae Krang Basin														
L/M/S	1,200	1,800	571.0	83.4	685.2	150.1	822.1	143.4	986.5	258.1	251.1	60.0	301.3	108.0
Pump	1,000	1,600	7.0	1.4	7.0	2.2	33.5	2.8	33.5	4.5	6.5	1.4	6.5	2.2
Total	-	-	578.0	84.8	692.2	152.4	855.6	146.2	1,020.0	262.6	257.6	61.4	307.8	110.2
L/M/S	-	-	5,316.0	1,329.9	6,379.2	2,393.8	9,684.9	2,617.1	11,621.9	4,710.8	4,368.9	1,287.2	5,242.7	2,317.0
Pump	-	-	745.7	159.1	745.7	254.6	1,232.3	528.2	1,232.3	845.1	486.6	369.1	486.6	590.6
Grand Total	-	-	6,061.7	1,489.0	7,124.9	2,648.4	10,917.2	3,145.3	12,854.2	5,555.9	4,855.5	1,656.3	5,729.3	2,907.5
7. Pasak Basin														
L/M/S	1,200	1,800	516.0	56.5	619.2	101.7	1,119.9	153.9	1,343.9	277.0	603.9	97.4	724.7	175.3
Pump	1,000	1,600	40.4	4.0	40.4	6.4	64.4	12.8	64.4	20.5	24.0	8.8	24.0	14.1
Total	-	-	556.4	60.5	659.6	108.1	1,184.3	166.7	1,408.3	297.5	627.9	106.2	748.7	189.4

Remarks, L/M/S; Large, Medium and Small scale Projects.

(1) Existing and Future Irrigation Area

The existing and future irrigation area is summarized in Table 4.1.7 (2) based on the data in Table 4.1.7 (1).

Table 4.1.7 (2) Summary of Existing and Future Irrigation Area

(Unit Area 10^3 rai, Intensity %)

Item	Nan			Ping			Yom	Wang	Sakae Krang	Total	Pasak	Grand Total
	Upper	Lower	Sub-total	Upper	Lower	Sub-total						
(1) Farm Area	1,120	5,720	6,840	2,000	2,100	4,100	4,800	950	1,630	18,360	5,450	23,810
(2) Existing Irrigation												
Area in Wet	305	1,797	2,102	1,150	728	1,878	969	534	578	6,062	556	6,618
Area in Dry	48	663	711	262	159	421	189	84	85	1,489	61	1,550
Intensity in Wet	27	31	31	58	35	46	20	56	35	33	10	28
Intensity in Dry	4	12	10	13	8	10	4	9	5	8	1	7
(3) Future Irrigation												
Area in Wet	617	3,527	4,144	1,927	1,263	3,190	1,868	880	836	10,918	1,184	12,102
Area in Dry	149	1,431	1,580	421	377	798	479	143	146	3,145	167	3,312
Intensity in Wet	55	62	61	96	60	78	39	93	51	59	22	51
Intensity in Dry	13	25	23	21	18	19	10	15	9	17	3	14

(a) Whole Upper Chao Phraya Basin

- The existing irrigation area is 6.6 million rai in the wet season and 1.6 million rai in the dry season which will be increased 12.1 million and 3.3 million respectively, about two times of the existing irrigation area. Accordingly the existing irrigation intensity of 28% and 7% in the wet and dry seasons respectively will be improved largely to 51% and 14%.
- The large/medium scale irrigation projects serve for the large existing area of 4.3 million rai in the wet season equivalent to 65% of the total existing area. The future irrigation area will be increased to 7.3 million rai which is about 1.7 times of the existing area. Since the large/medium projects will have the storage reservoir, the dry season irrigation area reaches 1.2 million rai at the present and 2.4 million rai in future which is about 30% of the wet season area (30% intensity).
- The existing small scale irrigation projects serve for 1.6 million rai in the wet season or equivalent to 24% of the total existing area. However, the small scale project area in future will be largely increased to 3.6 million rai which is about 2.4 times of the present service area. Many small farm land areas being scattered in the small tributary basins and under rainfed condition will be developed in future by the small scale projects. However, the dry season irrigation area of the small scale project is limited to be about 10% of the wet season area due to small scale reservoir and scarce runoff in the tributaries.
- The pumping irrigation area in the wet season is 0.8 million rai in the existing project and 1.3 million rai in the future project. The pumping irrigation area is not large as compared with those of the large/medium and small scale projects, because the

pumping area is mostly located at the area along the lower Nan and Ping rivers, where the water released from the Sirikit and Bhumibol dams can be easily pumped up. However the pumping projects can develop the large dry season irrigation area occupying 30 to 50% of the wet season area depending on the availability of water from the Sirikit and Bhumibol in the dry season. The existing and future irrigation areas in the dry season by pumping projects are 160,000 rai and 530,000 rai respectively.

(b) Upper Nan Basin

The upper Nan basin is generally formed with a number of tributaries with steep topography so that the large scale irrigation project is not existing. The irrigation projects are consisting of the medium and small scale as well as pumping system..

- The existing irrigation area in the upper Nan is 305,000 rai in the wet season and 48,000 rai in the dry season, of which 65% area was completed by 1985 and 35% was during 1985 to 1995. The future irrigation area is proposed to be 617,000 rai in the wet season which is two times of the existing area and 149,000 rai in the dry season, three times of the existing area. The increased irrigation area in future will cause the problem to reduce the reservoir inflow and outflow of the Sirikit dam.
- Although the large irrigation area is not existing at present and in future in the upper Nan, a number of medium and small scale project areas are existing and proposed in future. The medium scale area in future will reach to 256,000 rai in the wet season or equivalent to 3.7 times of the existing area and 93,000 rai in the dry season, 5.4 times of the existing one.
- The existing small scale irrigation area of 170,000 rai in the wet season and 23,000 rai in the dry season will be increased to 229,000 rai and 29,000 rai respectively in future.
- The pumping irrigation area in future will increase also from the existing 66,000 rai in the wet season to 132,000 rai in future. The existing dry season area of 7,000 rai will also increase to 26,000 rai in future. The Yao dam which is to be constructed under the Project for the flood control purpose could supply the dry season water to the downstream area along the upper Nan river.
- The existing irrigation intensity of 27% in the wet season and 4% in the dry season will be largely improved to 55% and 13% respectively.

(c) Lower Nan Basin

- The lower Nan basin hold the largest farm area of 5.72 million rai in the upper Chao Phraya basin and its irrigation water use will bring about the large water shortage problem in the Delta area.
- The irrigation area in the lower Nan basin has increased largely since 1984 when the Naresuan barrage was completed for the Phitsanulok irrigation project and the pumping irrigation project by DEDP was commenced. Namely the irrigation area of about 600,000 rai in 1984 has been increased to 1.8 million rai in the wet season and

0.7 million rai in the dry season at present.

- The existing large/medium scale projects including the large Phitsanulok right bank irrigation area hold the large areas of 1.26 million rai in the wet season and 0.53 million rai in the dry season, which occupy as large as 70% in the wet season and 80% in the dry season of the existing total irrigation area. The large/medium scale area in future will be further expanded to about 2.5 million in the wet season and 1.0 million rai in the dry season by the large projects of Khwai Noi, Phitsanulok left bank, Nam Khek, etc. Although the Khwai Noi, Nam Khek and other medium scale projects will have the own reservoir at the tributaries and irrigate the own beneficial area, the Phitsanulok left bank project will use the Sirikit water and cause the large problem to reduce the inflow of Chai Nat barrage which has responsibility for water supply to the agricultural, municipal and industrial areas in the Delta area.
- The existing small scale irrigation area is small as 148,000 rai in the wet season and 15,000 rai in the dry season because the farm land area in the lower Nan basin is mostly extending on the flat alluvial plain along the main stream and very scarce in the small tributary basins. The small scale project area in future will be small also as 386,000 rai in the wet season (11% for the total area) and 39,000 rai (3%) in the dry season.
- The existing pump irrigation project covers slightly large area of 392,000 rai, which has been developed by DEDP and used the Sirikit water. The future pumping irrigation area will increase to 686,000 rai in the wet season and 343,000 rai in the dry season. This large increase of area will use the Sirikit water and bring about large problem of reducing the inflow at the Chai Nat barrage site.
- The existing irrigation intensity of 31% in the wet season and 10% in the dry season will be largely increased to 61% and 23% respectively.

(d) Upper Ping Basin

The upper Ping basin includes the provinces of Chiang Mai and Lamphun which are the famous agricultural districts to produce many kinds of diversified crops.

- The upper Ping basin has the existing area of 1.15 million rai in the wet season and 0.26 million rai in the dry season. The future irrigation area will be further expanding and reaches 1.9 million rai in the wet season and 0.42 million rai in the dry season. Namely the future farm land in the upper basin will be fully irrigated during the wet season, although the dry season irrigation is still limited at the intensity of 21%.
- In the upper basin, the large scale irrigation projects such as Mae Ngat dam, Mae Kuang dam, Mae Tang weir, Ping Kao weir, etc and a number of medium scale projects have been developed and their existing irrigation areas reach to 0.76 million rai in the wet season which is equivalent to 66% of the existing total irrigation area. Although the large irrigation projects like the Mae Ngat and Mae Kuang will not be proposed in future, a number of medium scale projects seem to be developed and as a result, the future irrigation area by the large/medium scale will reach 0.9 million rai in

the wet season which is slightly larger than the existing 0.76 million rai. The existing dry season area of 0.26 million rai will also increase to 0.42 million rai in future.

- Although the existing small scale project area is 350,000 rai in the wet season and 35,000 rai in the dry season, the small scale projects will be largely developed in the upper basin in future and the area will reach to as large as 980,000 rai in the wet season and 98,000 rai in the dry season (about 2.8 times of the existing area).
- The pumping irrigation is not prevailing in the upper Ping and its irrigation area in the wet season is only 46,000 rai at present and 59,000 rai in future.

(e) Lower Ping Basin

- The lower Ping basin locates at the downstream of Bhumibol dam and covers mainly the provinces of Tak and Kamphaeng Phet and holds a large farm area of 2.1 million rai.
- Although the existing total irrigation area in the lower Ping is 728,000 rai in the wet season and 159,000 rai in the dry season, the area will increase remarkably in future to 1.26 million rai and 0.38 million rai respectively. The existing irrigation intensity of 35% in the wet season and 8% in the dry season will also be increased remarkably in future to 60% and 18% respectively.
- The existing large/medium scale project area of 0.54 million rai in the wet season will be expanded to 0.94 million rai in future by development of a number of medium scale dams at the tributaries in the lower basin.
- The existing small scale area of 79,000 rai in the wet season will be increased to 168,000 rai, or about 2 times of the existing area.
- The existing pumping irrigation area of 105,000 rai in the wet season and 10,000 rai in the dry season will be increased to 154,000 rai and 77,000 rai respectively in future. The increased pumping irrigation area will use the water released from the Bhumibol dam, hence it will bring about the water shortage problem at the Chai Nat barrage site.

(f) Yom Basin

The Yom basin has also a large farm area of 4.8 million rai, which is larger than that in the whole Ping basin. However, the irrigation area has not yet been expanded so much as compared with that in the Nan and Ping basins because of scarce water resources and less suitable damsite to store the wet season runoff.

The irrigation project has been mainly developed after 1972 in the Yom basin. The existing irrigation area is 970,000 rai in the wet season and 189,000 rai in the dry season, which will be expanded to 1.87 million rai and 479,000 rai respectively in future.

- The existing irrigation area is small as shown by the irrigation intensity of 20% in the wet season and 4% in the dry season as compared with that in the Nan and Ping because the large dam such as the Sirikit and the Bhumibol is not existing in the Yom basin. The future irrigation area however, will increase to 1.87 million rai (39% intensity) in the wet season and 480,000 rai (10%) in the dry season after construction

of the large dam of Kaeng Sua Ten.

- The small scale projects will also increase in future to 729,000 rai in the wet season from the existing 201,000 rai and 73,000 rai in the dry season from the existing 20,000 rai. The small scale project area in future will become more than 3 times of the existing one because a number of small scale project sites are scattered in the Yom tributary basins.
- Pumping irrigation areas of the existing and in future are small as compared with the large/medium and small scale because the dry season runoff in the basin is scarce and mostly used for irrigation in the tributary basins and as a result, no available dry season water in the mainstream.

(g) Other Basins

Other basins of the Wang, Sakae Krang and Pasak have no large irrigation area like the Nan, Ping and Yom and their existing irrigation areas are about 530,000 to 580,000 rai in the wet season and 65,000 to 88,000 rai in the dry season.

- The existing irrigation area in the Wang basin is 534,000 rai in the wet season which shows the high irrigation intensity of 56%. Since there are existing many suitable medium and small scale damsites in tributaries, the future irrigation area will be further developed and reach 880,000 rai in the wet season and 143,000 rai in the dry season. The irrigation intensities in the wet and dry seasons show the high rate of 93% and 15% respectively in future. Accordingly the water in the Wang basin will be mostly used in the own basin in future without surplus water to release to the Ping river.
- The existing irrigation area in the Sakae Krang is 580,000 rai in the wet season (35% intensity), of which 277,000 rai is developed by the Tab Salao large scale dam and the other by some medium scale projects. The existing small scale projects have also been expanded to the large area of 294,000 rai in the wet season occupying 50% of the total existing area. The future irrigation area will be further expanded and increased to 836,000 rai in the wet season and 150,000 rai in the dry season. The existing irrigation intensities of 35% and 5% in the wet and dry seasons will be increased to 51% and 9% respectively.
- The Pasak basin has a large farm area of 5.45 million rai but the existing irrigation area is only 556,000 rai (10% intensity) in the wet season. The future irrigation area will increase largely to 1.18 million rai (22% intensity) by development of the large, medium and small scale projects. The pumping irrigation in the basin is limited to 40,000 rai at present and 64,000 rai in future due to no or scarce runoff in the dry season in the main stream of the Pasak. If the Kaen Koi Ban Mo Pumping project which is under defailed design and will use the Pasak reservoir water will be implemented, the future irrigation demand by pumping system will increase largely.

(2) Irrigation Water Demand

The irrigation water demand in the upper Chao Phraya basin has been estimated based on the irrigation area mentioned in the above (1) and the following unit irrigation demand.

(a) Unit Irrigation Demand

- Unit irrigation demand in the large, medium and small scale projects is estimated at 1,200 cu.m/rai in the wet season and 1,800 cu.m/rai in the dry season which is slightly larger than that of the pumping projects because the large, medium and small scale projects require larger water losses at the reservoir and main/secondary canals compared with the losses in the pumping project whose beneficial area locates nearly the rivers. Pumping unit irrigation demand is estimated at 1,000 cu.m/rai in the wet season and 1,600 cu.m/rai in the dry season.

(b) Irrigation Water Demand

Irrigation water demand in the existing and future projects is estimated as shown in Table 4.1.7 (1). Classifying into the large/medium and small projects, pumping projects and each basin and summarized in Table 4.1.8.

Table 4.1.8 Summary of Irrigation Water Demand

(Unit MCM)

	Nan			Ping			Wang	Yom	Sakae Krang	Total	Pasak	Grand Total
	Upper	Lower	Sub-total	Upper	Lower	Sub-total						
(1) Existing Project												
Wet Season	353	2,078	2,431	1,371	853	2,224	630	1,148	692	7,125	660	7,785
Dry Season	84	1,169	1,253	471	284	755	150	338	152	2,648	108	2,756
Total	437	3,247	3,684	1,842	1,137	2,979	780	1,486	844	9,773	768	10,541
(2) Future Project												
Wet Season	714	4,095	4,809	2,301	1,485	3,786	1,040	2,219	1,000	12,854	1,408	14,262
Dry Season	262	2,507	2,769	755	662	1,417	255	851	263	5,555	297	5,852
Total	976	6,602	7,578	3,056	2,147	5,203	1,295	3,070	1,263	18,409	1,705	20,114
(3) Increased Demand in Future, (2) - (1)												
Wet Season	361	2,017	2,378	930	632	1,562	410	1,071	308	5,729	748	6,477
Dry Season	178	1,338	1,516	284	378	662	105	513	111	2,907	189	3,096
Total	539	3,355	3,894	1,214	1,010	2,224	515	1,584	419	8,636	937	9,573

- The irrigation water demand of the existing projects in the upper Chao Phraya basin excluding that in the Pasak basin are 7,130 MCM in the wet season, 2,650 MCM in the dry season and 9,770 MCM in total. Namely the irrigation water of about 10 billion cu.m has been used in the recent years in the upper Chao Phraya basin. This existing water demand will increase largely to 18,400 MCM in total in future, and as a result the additional irrigation water of 8,600 MCM will be used from the existing potential water resources in the upper Chao Phraya basin.
- The Nan basin will expand the irrigation area largely from 2.1 million rai at present to

4.1 million rai in future and require the additional irrigation water of 350 MCM in future which is equivalent to 39% of the total additional water of 8,600 MCM in the upper Chao Phraya.

- The Ping and Yom basins also require the large additional water demands of 2,220 MCM and 1,580 MCM respectively in total. However the additional demands in the Wang and Sakae Krang are rather small as 520 MCM and 420 MCM respectively.

(3) Other Water Demand

The other water demands of the municipal, domestic and industrial uses in the upper Chao Phraya basin are estimated based on the data in "Water Resources Development for 25 Basins in Thailand" prepared by NESDB 1993. The result is shown in the Supporting Report and sumarized in Table 4.1.9.

Table 4.1.9 Summary of Other Water Demand

(Unit MCM)

	Nan	Ping	Wang	Yom	Sakae Krang	Total	Pasak	Grand Total
(1) Existing Demand, 1996	118	148	22	74	9	371	115	486
(2) Future Water Demand, 2006	139	190	26	92	16	463	148	611
(3) Future Water Demand, 2016	160	233	29	111	22	555	181	736
(4) Increased Demand, (3) – (1)	42	85	7	37	13	184	66	250

- The other water demand in the upper Chao Phraya basin excluding the Pasak basin is 370 MCM at present and 555 MCM in the year of 2016. These water demands are small value at only 3 to 4% of the irrigation water demand.
- All provincial capitals in the upper Chao Phraya basin are located nearby the main stream of the Nan, Ping, Yom, etc. and using the municipal water by pumping system.
- Domestic water for towns and centers in the rural area is generally supplied by groundwater and its amount by the surface water is small.
- Share of the other water use in the wet and dry seasons will be about half or 50% of the annual total.

(4) Total Water Demand

Total water Demand for irrigation and others is summarized as follows;

Table 4.1.10 Summary of Total Water Demand

(Unit MCM)

	Nan	Ping	Wang	Yom	Sakae Krang	Total	Pasak	Grand Total
(1) Existing Project								
Wet Season	2,490	2,298	641	1,185	697	7,311	717	8,028
Dry Season	1,312	829	161	375	157	2,834	165	2,999
Total	3,802	3,127	802	1,560	854	10,145	882	11,027
(2) Future Project								
Wet Season	4,889	3,903	1,055	2,275	1,011	13,133	1,499	14,632
Dry Season	2,849	1,534	270	907	274	5,834	388	6,222
Total	7,738	5,437	1,325	3,182	1,285	18,967	1,887	20,854
(3) Increased Demand in Future, (2) - (1)								
Wet Season	2,399	1,605	414	1,090	314	5,822	782	6,604
Dry Season	1,537	705	109	532	117	3,000	223	3,223
Total	3,936	2,310	523	1,622	431	8,822	1,005	9,827

4.1.4 Decreasing Future Potential Water Resources

(1) Runoff to be Lost by Water Demand in Future

Due to increasing irrigation and other water demand in future, a part of the existing runoff at major stations in the basin will be lost. The runoff to be lost by increase of water demand in future in the wet and dry seasons is studied taking into acount the following conditions and shown in Table 4.1.11.

- The increased irrigation and other water demand shown in Table 4.1.8 and 4.1.9 is to be replenished by the existing potential runoff at the major stations.
- Increase of water demand in the wet season will be balanced by the wet season runoff at the station.
- 20% of the dry season water demand will be supplied directly by the side flow of the tributary basins in the dry season but the remaining 80% of the demand will be supplied by the reservoir which stores the wet season water for use in the dry season. Namely 20% of the water demand is reducted from the dry season runoff and 80% of the demand from the wet season runoff.
- The decreasing rate of the reservoir outflow in the Sirikit and Bhumibol dams is assumed at 30% in the dry season and 70% in the wet season for the total inflow taking into account the existing outflow rates in the wet and dry seasons, water release for irrigation in the wet season and river maintenance water in the wet season.
- The water demands in the wet and dry seasons by pumping system will be supplied directly from the wet and dry seasons runoff respectively, because the pumping water is mostly taken directly from the mainstream of the lower Nan and Ping.

(2) Recreating Future Potential Water Resources

The future potential water resources at major station in the basin will be largely decreased due to increasing future water demand. The decreased future potential water resources are

estimated as shown in Table 4.1.12 and summarized as follows;

- The existing Sirikit outflow of 1,790 MCM and 2,540 MCM in the wet and dry seasons will decrease to 1,400 MCM and 2,380 MCM respectively in future due to increased water use in the upper Nan basin.
- The existing water resources of 5,510 MCM and 2,340 MCM in the wet and dry seasons in the whole Nan basin will largely decrease to 3,050 MCM and 1,410 MCM respectively in future, because of the large water use for irrigation in the lower Nan basin. Namely the future potential water resources in the Nan basin will become about 50% of the existing one which will bring about a large water shortage problem in the Delta area.
- The existing Bhumibol outflow of 1,400 MCM and 3,040 MCM in the wet and dry seasons will decrease considerably to 520 MCM and 2,670 MCM respectively due to large water use for irrigation in the upper Ping basin.
- The existing water resources in the whole Ping basin consisting of Bhumibol outflow and water resources of the Wang and lower Ping basins are 3,340 MCM and 3,040 MCM in the wet and dry seasons, which will decrease to 1,980 MCM and 2,820 MCM respectively in future. The future water resources of the whole Ping basin in the wet season will decrease to 1,980 MCM which is small as compared with 3,050 MCM in the Nan basin. Accordingly, some constraints may occur in the river maintenance and pumping irrigation at mainstream in the lower Ping.
- The future water resources in the Wang and Yom especially for the dry season water resources will be mostly lost by the future water use in both basins.
- The existing inflow at the Chai Nat barrage which is collecting all surplus water in the upper Chao Phraya basin and supplying to the Delta area with the large volume of 14,160 MCM and 5,840 MCM in the wet and dry seasons will largely decrease in future to 7,230 MCM and 3,940 MCM respectively. The future water use in the Delta area will face the critical water shortage problem.

When the above mentioned water demand will take place in the dry year such as 1991 to 1993, the future potential water resources at major stations in the basin will be largely decreased and the critical water shortage problem will occur in all sub-basins in the upper Chao Phraya. The inflow at the Chai Nat barrage will be only 1,060 MCM and 1,490 MCM in the wet and dry seasons, respectively which will give a large damage to the irrigated agriculture and socio-economy in the Delta.

The decreasing potential Water Resources from the past years (1974-85) to the recent years (1986-96) and the future (2016) are also summarized and shown in table 4.1.13 and in Figure 4.1.

Table 4.1.11 Runoff to be lost by Water Demand in Future

(Unit MCM)

River Basin & Project Type	Increased Water Demand		Decreasing Runoff			
	Wet	Dry	Wet		Dry	
1. Nan Basin						
(1) At N1 Station						
Irrigation Demand, I/M/S	180	106	180+(106×0.8)=	265	106×0.2=	21
- do - , Pump	21	17		21		17
Total	201	123		286		38
(2) At Sirikit Dam						
Irrigation, I/M/S	296	148	296+(148×0.8)=	414	148×0.2=	30
Other Demand, Pump	66	31		66		31
- do - , Pump	5	5		5		5
Total (Sirikit Inflow)	367	184		484		66
Sirikit Outflow	-	-	551×0.7=	386	551×0.3=	165
(3) Upstream of Naresuan						
Phitsanulok Irrigation (2) I/M/S	600	450		600		450
Irrigation, I/M/S	109	21	109+(21×0.8)=	126	21×0.2=	4
- do - , Existing Pump	52	122		52		122
Other Demand, Pump	6	6		6		6
Total	767	599		784		582
(4) Lower Nan Total						
Phitsanulok, Irrigation (2) I/M/S	600	450		600		450
Irrigation, I/M/S	1,123	536	1,123+(536×0.8)=	1,552	536×0.2=	107
- do - , Existing Pump	94	193		94		193
- do - , DEDP New Pump	200	160		200		160
Other Demand, Pump	16	16		16		16
Total	2,033	1,355		2,462		926
2. Ping Basin						
(1) At Bhumibol Dam						
Irrigation, I/M/S	917	273	917+(273×0.8)=	1,135	273×0.2=	54
- do - , Pump	13	11		13		11
Other Demand, Pump	20	20		20		20
Total (Bhumibol Inflow)	950	304		1,168		86
Bhumibol Outflow	-	-	1,254×0.7=	878	1,254×6.3=	376
(2) Lower Ping, Total						
Irrigation, I/M/S	582	272	582+(272×0.8)=	800	272×0.2=	54
- do - , Pump	50	107		50		107
Other Demand, Pump	23	23		23		23
Total	655	402		873		184
3. Wang Basin Total						
Irrigation, I/M/S	387	89	387+(89×0.8)=	458	89×0.2=	18
- do - , Pump	23	16		23		16
Other Demand, Pump	4	4		4		4
Total	414	109		485		38
4. Yom Basin, Total						
Irrigation, I/M/S	1,037	442	1,037+(442×0.8)=	1,391	442×0.2=	88
- do - , Pump	35	71		35		71
Other demand, Pump	19	19		19		19
Total	1,091	532		1,445		178
5. Sakae Krang, Total						
Irrigation, I/M/S	301	108	301+(108×0.8)=	387	108×0.2=	22
- do - , Pump	7	2		7		2
Other demand, Pump	7	7		7		7
Total	315	117		401		31
6. Chai Nat Barrge Site						
Sirikit Outflow	331	220		386		165
Lower Nan Total	2,033	1,355		2,462		926
Bhumibol Outflow	878	376		878		376
Lower Ping	655	402		873		184
Wang	414	109		485		38
Yom	1,091	532		1,445		178
Sakae Krang	315	117		401		31
Total (1~6)	5,717	3,111		6,930		1,898
7. Pasak						
Irrigation, I/M/S	725	175	725+(175×0.8)=	865	175×0.2=	35
- do - , Pump	24	14		24		14
Other demand, Pump	33	33		33		33
Total	782	222		922		82
Grand Total (6+7)	6,499	3,333		7,852		1,980

Table 4.1.12 Future Potential Water Resources at Major Station in Upper Chao Phraya Basin

(Unit MCM)

Basin and Major Station	Existing Potential Water Resources						Decreasing Future Runoff ③			Future Potential Water Resources					
	Average Year ①			Dry Year ②						Average Year ④ = ① - ③			Dry Year ⑤ = ② - ③		
	Wet	Dry	Total	Wet	Dry	Total	Wet	Dry	Total	Wet	Dry	Total	Wet	Dry	Total
N1 Station in upper Nan	2,370	270	2,640	1,700	270	1,970	290	40	330	2,080	230	2,310	1,410	230	1,640
Inflow of Sirikit Dam	4,090	660	4,750	2,720	520	3,240	480	70	550	3,610	590	4,200	2,240	450	2,690
Outflow of Sirikit Dam	1,790	2,540	4,330	1,390	1,640	3,030	390	160	550	1,400	2,380	3,780	1,000	1,480	2,480
Inflow of Naresuan Barrage	2,570	2,390	4,960	1,580	1,290	2,870	780	580	1,360	1,790	1,810	3,600	800	710	1,510
Whole Nan Basin	5,510	2,340	7,850	3,640	1,470	5,110	2,460	930	3,390	3,050	1,410	4,460	1,180	540	1,720
Inflow of Bhumibol Dam	4,300	690	4,990	3,310	490	3,800	950	300	1,250	3,350	390	3,740	2,360	190	2,550
Outflow of Bhumibol Dam	1,400	3,040	4,440	1,070	2,180	3,250	880	370	1,250	520	2,670	3,190	190	1,810	2,000
Whole Wang Basin	790	100	890	410	110	520	480	40	520	310	60	370	-70	70	0
Whole Wang & Ping Basin	3,340	3,040	6,380	2,250	2,200	4,450	1,360	220	1,580	1,980	2,820	4,800	890	1,980	2,870
Whole Yom Basin	3,050	210	3,260	1,830	160	1,990	1,450	180	1,630	1,600	30	1,630	380	-20	360
Whole Sakae Krang Basin	-	-	-	-	-	-	400	30	430	-	-	-	-	-	-
Inflow of Chai Nat Barrage	14,160	5,840	20,000	7,990	3,390	11,380	6,930	1,900	8,830	7,230	3,940	11,170	1,060	1,490	2,550
Whole Pasak Basin	2,350	190	2,540	1,620	110	1,730	920	80	1,000	1,430	110	1,540	700	30	730

Remark: (1) The average value of 1991 to 1993 is adopted for the dry year.

Table 4.1.13 Summary of Decreasing Potential Water Resources

(Unit MCM)

Basin and Major Station	Average Year									Dry Year								
	Past Year (1974 - 85)			Recent Year (1986 - 96)			Future (2016)			Past Year (1979 - 80 Average)			Recent Year (1997 - 93)			Future (2016)		
	Wet	Dry	Total	Wet	Dry	Total	Wet	Dry	Total	Wet	Dry	Total	Wet	Dry	Total	Wet	Dry	Total
N1 Station in upper Nan	2,530	230	2,760	2,730	270	3,000	2,080	230	2,310	1,550	340	1,890	1,700	270	1,970	1,410	230	1,640
Inflow of Sirikit Dam	5,110	770	5,880	4,090	660	4,750	3,610	590	4,200	3,070	510	3,580	2,720	520	3,240	2,240	450	2,690
Outflow of Sirikit Dam	2,640	3,070	5,710	1,790	2,540	4,330	1,400	2,380	3,780	3,090	1,580	4,670	1,390	1,640	3,030	1,000	1,480	2,480
Inflow of Naresuan Barrage	-	-	-	2,570	2,390	4,960	1,790	1,810	3,600	-	-	-	1,580	1,290	2,870	800	710	1,510
Whole Nan Basin	8,590	2,960	11,550	5,510	2,340	7,850	3,050	1,410	4,460	5,990	1,920	7,910	3,640	1,470	5,110	1,180	540	1,720
Inflow of Bhumibol Dam	4,920	720	5,640	4,300	690	4,990	3,350	390	3,740	2,850	330	3,180	3,310	490	3,800	2,360	190	2,550
Outflow of Bhumibol Dam	2,390	3,140	5,530	1,400	3,040	4,440	520	2,670	3,190	3,680	2,020	5,700	1,070	2,180	3,250	190	1,810	2,000
Whole Wang Basin	1,020	120	1,140	790	100	890	310	60	370	490	60	550	410	110	520	-70	70	0
Whole Wang & Ping Basin	5,060	3,350	8,410	3,340	3,040	6,380	1,980	2,820	4,800	5,020	2,530	7,550	2,250	2,200	4,450	890	1,980	2,870
Whole Yom Basin	3,340	280	3,620	3,050	210	3,260	1,600	30	1,630	1,160	40	1,200	1,830	160	1,990	380	-20	360
Whole Sakae Krang Basin	-	-	1,300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Inflow of Chai Nat Barrage	19,310	7,200	26,510	14,160	5,840	20,000	7,230	3,940	11,170	11,620	4,380	16,000	7,990	3,390	11,380	1,060	1,490	2,550
Whole Pasak Basin	-	-	-	2,350	190	2,540	1,420	110	1,530	-	-	-	1,620	110	1,730	700	30	730