2.1.3 Livestock

Livestock production in the UCR steadily increased during 1982-1987 except buffaloes and swine (see Table 2.6). Especially the number of cattles and chickens increased rapidly during 1982-1987 at a rate of more than 8.0% per annum. Lop Buri and Sara Buri are main provinces of livestock production, contributing about 55% of livestock GRP of the UCR. Especially, 63.4% of cattle, 52.3% of swine and 46% of chicken and buffalo of the UCR are raised in these two provinces in 1987.

2.1.4 Fresh Water Fishery

Fish production volume in tonage in the UCR rapidly increased during 1983-1986 (see Table 2.7). Fish is raised mainly in ponds in the UCR. Main character of fish production is that value per ton is much higher than that of the Whole Kingdom. It is about 2 times as much as the national average. Ang Thong records the highest value per ton being 24,473 Baht or 3.5 times as much as the national average.

Main provinces of fish production are Ang Thong and Ayutthaya, together contributing 67% of fish production tonnage of the UCR.

2.2 Agro-Economic Condition

2.2.1 Farm Income

Average per capita income of agriculture sector in the UCR is 5,342 Baht, which is about one-ninth of the income in non-agriculture sector (47,238 B). The per capita income decrease by - 3.0% per annum during the 1982-86, in contrast with the non-income agricultural sector which increased by 5.5% per annum during the same period. The income disparity between these sectors has been expanding.

In the central region average per capita income of agricultural sector recorded 7,557 Baht in 1986, which was much higher than that of the national average. However, the income decreased at a rate of - 6.2%.

Table 2.6 Livestock Production

(Unit:1,000Head)

		1982	1983	1984	1985	1986	1987	Growth Rate
CHAI NAT	Buffaloes	40.8	49.7	16.9	19.9	22.4	20.6	-12.8%
	Cattle	24.5	32.8	46.5	49.7	50.2	51.0	15.8%
	Swine	25.7	37.9	47.7	42.1	38.4	39.0	8.7%
	Duck				78.5	75.4	120.2	23.7%
	Chicken				501.3	494.1	474.5	-2.7%
SING BURI	Buffaloes	7.7	11.3	6.5	6.9	6.9	5.0	-8.4%
	Cattle	15.1	17.9	20.4	16.9	17.0	17.3	2.9%
	Swine	40.1	43.1	45.2	39.5	40.5	32.3	-4.2%
	Duck				90.5	86.8	75.4	-8.8%
	Chicken				219.0	270.0	223.0	0.9%
ANG THON	Buffaloes	10.4	11.7	13.0	12.9	12.4	9.2	-2.5%
	Cattle	28.6	35.6	31.9	32.5	32.7	33.3	3.1%
	Swine	54.4	31.7	31.3	30.0	28.9	29.1	-11.7%
	Duck				388.4	424.0	437.7	6.2%
	Chicken				485.7	430.6	414.5	-7.6%
AYUTTHAYA	Buffaloes	26.8	34.4	30.4	28.4	31.9	34.3	5.1%
	Cattle	16.8	19.5	20.2	33.0	33.0	33.6	14.9%
	Swine	24.5	27.9	25.5	25.7	25.8	26.0	1.2%
	Duck				474.8	487.5	476.4	0.2%
	Chicken				569.4	577.3	959.3	29.8%
LOP BURI	Buffaloes	45.8	49.9	29.7	36.0	40.3	25.6	-11.0%
	Cattle	117.7	145.2	144.2	162.9	156.9	159.8	6.3%
	Swine	89.2	86.4	88.9	80.6	82.0	84.2	-1.2%
	Duck				106.6	104.6	127.3	9.3%
	Chicken				860.4	869.1	987.7	7.1%
SARABURI	Buffaloes	36.4	38.1	40.5	41.8	41.7	33.9	-1.4%
	Cattle	37.3	38.9	50.9	64.5	63.4	64.6	11.6%
	Swine	35.8	34.8	52.7	53.7	53.6	54.7	8.8%
	Duck				54.6	45.6	48.9	-5.4%
	Chicken				657.5	661.6	781.5	9.0%
UCR	Buffaloes	167.8	195.0	137.0	145.9	155.6	128.5	-5.2%
	Cattle	240.0	289.9	314.2	359.4	353.2	359.6	8.4%
	Swine	269.7	261.9	291.3	271.6	269.1	265.3	-0.3%
	Duck				1,193.4	1,223.9	1,285.9	3.8%
	Chicken				3,293.2	3,302.6	3,840.6	8.0%
CENTRAL	Buffaloes	555.0	574.2	500.8	513.7	520.5	463.2	-3.5%
	Cattle	914.5	992.8	1,100.5	1,159.7	1,158.3	1,179.7	5.2%
	Swine	1,268.6	1,410.1	1,387.1	1,350.7	1,346.5	1,404.9	2.1%
	Duck				7,430.1	7,207.1	7,826.9	2.6%
	Chicken				23,179.6	23,254.7	25,733.2	5.4%
WHOLE KINGDOM	Buffaloes	6,417.4	6,354.4	6,300.9	6,249.9	6,256.9	5,998.4	-1.3%
	Cattle	4,578.7	4,832.6	4,789.0	4,829.0	4,878.7	4,968.8	1.6%
	Swine	4,022.1	4,192.7	4,263.2	4,224.1	4,201.1	4,209.1	0.9%
	Duck				14,779.4	15,092.1	15,619.9	2.8%
	Chicken				78,716.8	79,264.9	84,494.7	3.6%

Source: Agricultural Statistics of Thailand

Table 2.7 Fresh Water Fish Production **Unit : Baht/House Hold**

		1983	1984	1985	1986	Growth Rate
CHAI NAT	Production(ton)	107.3	170.0	266.9	350.1	48.3%
	Production(1,000 B)	2,378.1	4,320.5	6,788.4	11,681.4	70.0%
	Area(rai)	175.9	691.8	786.2	910.5	73.0%
	B/T	22,169.4	25,410.3	25,435.1	33,368.8	14.6%
	B/R	13,516.6	6,245.5	8,634.2	12,830.1	-1.7%
SING BURI	Production(ton)	103.4	142.7	145.3	350.6	50.2%
	Production(1,000 B)	2,652.3	3,702.9	3,797.0	6,708.8	36.3%
	Area(rai)	208.2	522.5	487.8	492.0	33.2%
	B/T	25,651.3	25,952.3	26,124.7	19,137.2	-9.3%
	B/R	12,742.4	7,087.1	7,784.0	13,635.1	2.3%
ANG THON	Production(ton)	180.0	416.0	1,103.5	1,456.0	100.8%
	Production(1,000 B)	3,569.4	12,070.4	20,882.8	43,111.2	129.4%
	Area(rai)	213.3	1,106.4	1,257.6	1,761.5	102.1%
	B/T	19,834.3	29,015.4	18,924.7	29,608.9	14.3%
	B/R	16,735.7	10,910.0	16,604.9	24,473.8	13.5%
AYUTTHAYA	Production(ton)	907.1	1,576.7	1,424.1	1,843.2	26.7%
	Production(1,000 B)	31,162.0	57,704.3	48,962.5	65,965.6	28.4%
	Area(rai)	1,105.4	4,379.9	5,115.3	6,848.0	83.7%
	B/T	34,353.4	36,599.1	34,382.6	35,789.0	1.4%
	B/R	28,190.2	13,174.8	9,571.9	9,632.8	-30.1%
LOP BURI	Production(ton)	288.4	387.9	933.7	581.5	26.3%
	Production(1,000 B)	6,529.5	16,054.5	26,683.2	10,756.8	18.1%
	Area(rai)	302.8	485.4	527.3	636.9	28.1%
	B/T	22,641.1	41,392.5	28,577.9	18,498.0	-6.5%
	B/R	21,563.6	33,078.2	50,602.5	16,888.4	-7.8%
SARABURI	Production(ton)	80.4	90.5	160.8	350.5	63.3%
	Production(1,000 B)	1,756.4	1,778.8	2,827.7	6,708.8	56.3%
	Area(rai)	221.8	237.4	285.6	469.4	28.4%
	B/T	21,835.2	19,657.6	17,587.6	19,142.7	-4.3%
	B/R	7,917.9	7,492.3	9,901.7	14,292.8	21.8%
UCR	Production(ton)	1,666.6	2,783.7	4,034.2	4,931.8	43.6%
	Production(1,000 B)	48,047.7	95,631.5	109,941.6	144,932.4	44.5%
	Area(rai)	2,227.4	7,423.3	8,459.8	11,118.4	70.9%
	B/T	28,830.5	34,353.8	27,252.2	29,387.3	0.6%
	B/R	21,571.0	12,882.6	12,995.8	13,035.4	-15.5%
CENTRAL	Production(ton)	9,476.0	11,068.7	16,009.9	20,016.1	28.3%
	Production(1,000 B)	178,585.3	203,775.2	248,464.2	337,146.2	23.6%
	Area(rai)	12,281.0	23,247.8	25,004.3	28,181.5	31.9%
	B/T	18,846.0	18,410.0	15,519.4	16,843.8	-3.7%
	B/R	14,541.6	8,765.4	9,936.9	11,963.4	-6.3%
WHOLE KINGDOM	Production(ton)	46,966.4	50,410.9	75,254.1	89,325.1	23.9%
	Production(1,000 B)	1,005,579.1	1,226,358.1	1,565,170.4	1,935,049.6	24.4%
	Area(rai)	233,732.8	232,649.1	253,903.9	279,129.9	6.1%
	B/T	21,410.6	24,327.2	20,798.5	21,663.0	0.4%
	B/R	4,302.3	5,271.3	6,164.4	6,932.4	17.2%

B/T:Production(Bhat)/Production (ton)
B/R:Production(Bhat)/Area(Rai)
Source: Department of Fisheries

Net farmer's household income in 1986/87 is 30,471 baht, which is about 40% higher than that of the national average. Of the total from household income, net farm income accounts for 40 % in the UCR. The share in Sara Buri and Ang Thaong are very low being 4 % and 18 % respectively, because investment expenditures for livestock are high in Sara Buri. Lop Buri and Sing Buri recorded highest net farm income in the UCR, where the share of land owners operating their farm is high.

As for the net income from crop per rai, the UCR shows a higher value than those of the central region and the whole Kingdom despite that value of the expenditure for crop per rai is lower than that of the central region (see Table 2.9). Sing Buri, which records the highest rice yield and the highest rate of land owner operate farm in the UCR, shows the highest net income from crop per rai with the highest expenditure in the UCR. On the contrary, Ayutthaya, recording the lowest rate of land owner operate farm in the UCR, shows the average net income in the UCR in spite of a high expenditure.

Table 2.8 Structure of Farmer's Income and Expenditure (1986/87)

	Farm-income	Farm-Expenditure	Net Farm-income	Non Farm-income	Net H.H. income	H.H. Expenditure	Cash Saving
Chai Nat	21963	9509	12454	11431	23885	26606	-2721
Sing Buri	46592	29475	17117	14550	31666	29813	1853
Ang Thong	21507	15404	6103	18262	24364	34206	-9842
Ayutthaya	37434	25603	11832	15182	27014	27577	-562
Lop Buri	37586	18821	18765	22716	41481	29906	11575
Sara Buri	37616	36744	871	23328	24199	29589	-5390
UCR	34089	21997	12092	18379	30471	29313	1158
Central	36063	22670	13393	17605	30998	30628	370
Whole Kingdom	18166	9156	9010	13296	22306	19043	3263

Source : Office of Agriculture Economics

Table 2.9 Income and Expenditure of Crop

Unit : Baht/Rai

	Expenditure	Income	Net-income
Chai Nat	247	704	457
Sing Buri	613	1678	1064
Ang Thong	293	722	429
Ayutthaya	585	1020	435
Lop Buri	353	776	423
Sara Buri	348	782	433
UCR	389	858	470
Central	454	881	427
Whole Kingdom	221	540	319

Source : Office of Agricultural Economics

Table 2.10 Income and Expenditure of Livestock

Unit : Baht/H.H.

	Expenditure	Income	Net-income
Chai Nat	2212	3256	1044
Sing Buri	11644	13372	1728
Ang Thong	4183	6377	2194
Ayutthaya	4526	4016	-510
Lop Buri	3755	6102	2347
Sara Buri	22896	8517	-14379
UCR	7585	6365	-1220
Central	5428	7079	1651
Whole Kingdom	1841	3709	1868

Source : Office of Agricultural Economics

2.2.2 Agricultural Input

1) Fertilizer

In 1987, fertilizer consumption in the central region accounts for 44% of the total fertilizer consumption in the Whole Kingdom. About 50% of fertilizer consumption in the Central Region was used for paddy. However, the use for paddy decreased by - 1.5 per cent per annum during the 1984-1988. In contrast, the fertilizer use for fruits and tree crop and vegetables

in the Central Region increased rapidly at an annual rate of 24.7% and 14.6% respectively. The fertilizer use in Thailand 1986 is 23.4 Kg/Ha of cultivated land. This level is one of the lowest levels of fertilizer use in the world.

Average crop yields in Thailand except cassava are one of the lowest in the world also. According to Chai Nat Field Crop Research Center the yield is not at a level to be attained by fertilizer application.

Table 2.11 Chemical Fertilizer Consumption

	Fertilizer Consumption			
	Central		Whole Kingdom	
	Ton	(%)	Ton	(%)
Rice	339,710	(-1.5)	640,000	(-1.1)
First Rice	189,364	(-0.4)	459,240	(-0.4)
Second Rice	150,346	(-2.8)	180,760	(-2.8)
Field Crop	178,520	(4.2)	318,067	(3.7)
Fruit and Tree Crop	72,311	(24.7)	318,068	(17.0)
Vegetables	85,966	(14.6)	272,630	(14.6)
Total	676,509	(3.4)	1,548,765	(5.0)

( ) : Annual Growth Rate During the 1983/84-1987-88
Source : Office of Agricultural Economics

Table 2.12 Fertilizer Consumption Per Hectar

	1986(Kg/Ha)	Growth Rate * (%)
Thailand	23.4	5.3
Asia-Pacific	89.4	8.3
Developing Coutnrie	92.6	10.0
World	90.4	3.1

* : Annual Growth Rate 19876-86
Source : Selected Indicators of Food and Agriculture Development in Asian-Pacific Region 1977-87

1) Agricultural Chemicals

Supply of agricultural chemicals in the Whole Kingdom increased rapidly except insecticide during the 1979-84. In 1984, agricultural chemicals consist of insecticides and fungicides 12%, herbicides 42% and other chemicals 4%. About 50% of insecticides and fungicides are used for paddy. Herbicides are used mainly for fruits which consume 69% of the total herbicides. More than 50% of the total agricultural chemicals is used in the central region.

Table 2.13 Supply of Agricultural Chemicals in 1983/84

	Central	Whole Kingdom	Growth Rate (1979-84)
Insecticides	60	14,309	-5.8
Fungicides	40	3,931	7.1
Herbicides	60	14,114	21.7
Others	40	1,405	16.7

Source ; Office of Agriculture Economics

2) Agricultural Equipment

Use of agricultural equipment spreaded rapidly in Thailand during 1984-87. This trend is the same in the central region. The share of the Central Region in the use of agricultural equipment is much larger than its share in agricultural land, 22%.

Table 2.14 Number of Equipment Used in Agriculture in 1987

	Central (%)	Whole Kingdom Unit
Two Wheel Walking Tractors	38.5(6.7)	515,075(12.7)
Big Tractors	51.8(12.8)	40,450(12.6)
Water Pump	52.9(10.3)	768,328(10.8)
Sprayers with Machine Operated	76.9(17.9)	142,607(15.8)
Sprayers with Hand Operated	31.8(19.9)	1,704,696(23.7)
Treshing Equipment	60.9(4.1)	34,884(7.3)

( ) : Annual Growth Rate 1984-87
Source : Agricultural Statistics of Thailand

2.2.3 Food Consumption

Expenditure for food consumption during the 1977-87 increases at a rate of 2.9%, which is higher than population growth rate of 2.1%. Of these food consumption, coffee, tea and edible oil increased remarkably and only fish decreased during the same period. During the 1982-87 consumption of dairy products such as milk and cheese increased rapidly. The total calorific consumption in kilocalories per capita per day slightly increased in Thailand during the 1975-85. The availability of dietary calories per average requirement is over 100. According to FAO, however, the average rate of the availability per requirement should be more than 110 to satisfy the whole people. In Thailand, more than 20% of children suffer under malnutrition.

Composition of the source of calories has changed sharply. Calorie intake from cereals changed little. However, rice consumption decreased and wheat consumption increased sharply. Consumption of alcoholic beverages, edible oil, animal products, fruit and vegetables increased rapidly. This is the same tendency as in the case of private food consumption expenditure.

Food import during the 1982-87 increased by 20% per annum, which is much larger than the increase of agricultural export (7.1%). Of the import, fishery products, dairy products and wheat show high growth rates.

Table 2.15 Private Food Consumption Expenditure at 1987 Prices

	Consumption Component(%)				Aannual Growth Rate(%)		
	1977	1982	1987		1977-82	1982-87	1977-87
Rice and Cereals	26.1	25.2	24.6		1.9	2.7	2.9
Meat	19.7	22.2	24.4		5.1	5.1	5.1
Fish	12.7	10.4	5.4		1.4	9.7	5.6
Milk, Cheese and Egg	5.6	5.3	6.1		1.4	6.3	3.8
Oil and Fat	2.1	2.5	3.4		6.2	9.6	7.9
Fruit and Vegetables	17.5	18.0	19.4		3.3	4.7	4.0
Sugar, Preserves and Confectionary	4.9	4.7	5.6		1.7	6.8	4.2
Coffee,Tea,Cocoa,etc.	0.6	0.7	1.2		5.6	15.2	10.3
Other Food	10.6	11.0	9.8		3.2	0.9	2.1
Total(Million Baht)	61,153	69,661	81,378	Average	2.6	3.2	2.9

Source : NESDB

Table 2.16 Availability of Dietary Calories

	1974-76	1983-85	Growth Rate(%)
Total Calories/Requirement (Unit : K Cal)			
Total Calories	2269	2303	0.3
Average Requirement	2220	2220	
Calogires % Requirement	102	104	0.3
Composition (Unit : %)			
Total Cereals	71.1	70.1	0
Rice	69.4	63.0	-1.6
Wheat	0.7	1.0	7.1
Roots & Tubers	2.6	2.7	1.3
Pluses & Beans	0.5	0.9	10.8
Nuts & Oilseed	3.0	4.6	9.5
Fruit & Oilseed	5.0	6.5	5.7
Sugar & Honey	9.1	9.1	0.4
Fats & Oils	2.0	2.6	5.9
Alcoholic Beverages	0.5	3.0	42.3
Total Animal Products	5.6	6.9	4.6
Meat & Offals	3.0	4.0	6.8
Milk & Milk Products	0.3	0.5	11.4
Eggs	0.6	0.8	6.3
Fish and Sea Food	1.8	1.6	-2.1
Others	0.5	0.6	1.6

Source : FAO

Table 2.17 Nutritive Condition of Child (0-60 month) in 1988

Unit : %

Province / Condition	Chai Nat	Sing Buri	Ang Thong	Ayut thaya	Lop Buri	Sara Buri	UCR	Cen tral	North- East	North	East	South	Whole Kingdom
Normal	91.7	88.7	90.4	95.0	81.0	86.3	88.2	89.9	72.4	79.0	89.6	83.8	78.9
Malnutrition	8.3	11.3	9.6	5.0	19.0	13.7	11.8	10.1	27.6	21.0	10.4	16.2	21.1

Source : Ministry of Health

Table 2.18 The Import of Food

Good	Share (%) 1982	1987	Growth Rate (%)
Food Crop and Products	25.9	14.7	7.2
Vegetable Oil and Oil Seed	7.2	0.9	-20.5
Livestock Products	48.4	41.7	16.6
Fishery Products	8.3	35.9	61
Others	10.2	6.8	10.7
Total (Million Baht)	7800	19510	20.1

Source : Agricultural Statistics

2.3 Natural Condition

2.3.1 Chao Phraya River Basin

The UCR is located at the upper part of the lower Chao Phraya River basin, which include Chao Phraya Old Delta. The Chao Phraya River basin covers an area of 162,600 sq.km., equivalent to 32% of the national territory. Run off from Chao Phraya River basin is 30,300 million cubic meter (MCM) on annual average, but fluctuates between 14,500 MCM in dry year to 47,500 MCM in wet year, due to the rainfall characteristics of the basin. Natural environment of the UCR is very much influenced by the environmental condition of the River basin. At the same time the environmental condition, especially water, affects the downstream area, the Bangkok Metropolitan Region (BMR), where the most of nation's economic activities are concentrated.

Chao Phraya River basin is broadly divided into three parts: upper basin, middle basin and lower basin. Total length of Chao Phraya River system in the basin is 980 km., and its length from Nakhon Sawan to the Gulf is 250 km.

The Chao Phraya River basin and location of the UCR is shown on Fig. 2.1. The climate of the basin is tropical monsoon with relatively dry condition compared to the Southern and Eastern region of Thailand. Annual rainfall is 1000 to 1300 mm and 60 to 90 percent of rainfall occurs in rainy season. Annual average temperature is 26 to 28 degree, and relative humidity is 70 to 75 percent.

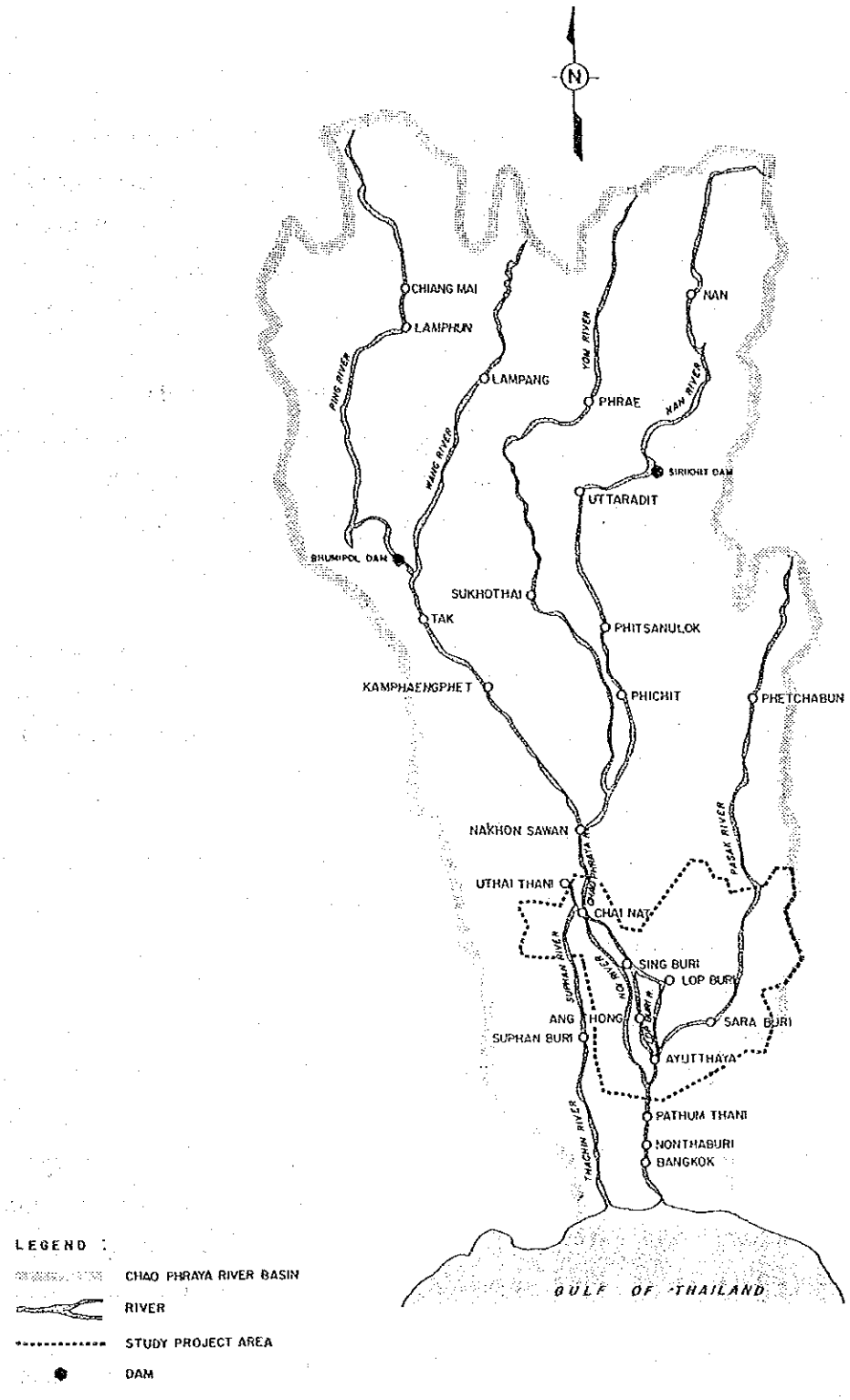


Fig. 2.1 The Chao Phraya River Basin Map

2.3.2 Upper Central Region

1) Geographical and Meteorological Condition

The UCR is located in the Chao Phraya River basin. Land in the UCR is divided into mainly three major categories: (1) The Chao Phraya delta which is generally very low lying and flat land with little difference in elevation, (2) the fan terraces which are located at the foot of mountainous areas with gentle sloop and undulation, and (3) the mountainous areas.

Most areas of Ayutthaya, Ang Thong and Sing Buri are in the deltaic area. Western part of Chai Nat, and eastern parts of Lop Buri and Sara Buri are the terrace area. Eastern part of Lop Buri and Sara Buri are the mountainous areas. A small part of western Chai Nat also includes mountainous areas.

The basin has a similar rainfall pattern with annual rainfall of less than 1,500 mm. It is noted that annual fluctuation of rainfall in both the amount and distribution is conspicuously large, and it affects the hydrological environment of the area.

Flooding in wet season and drought in dry season are one of the significant factors characterizing the land use pattern of the UCR. This affects the agricultural production pattern especially in dry season.

Due to very flat terrain and river bed slope, flood plane of Chao Phraya River especially Ayutthaya and western part of Lop Buri easily suffer from a deep flood during the wet season. These areas are called as "Conservation Area" which is mainly used for floating rice cultivation. In accordance with the basic design concept of the Chao Phraya Project, "Conservation Area" in Chao Phraya River delta is designated as a deterring basin for flood mitigation to the down stream area of Bangkok Metropolitan area.

Fig. 2.2 shows the thematic map to indicate the flooding area. This map is produced by analyzing the LANDSAT image taken in November 1987. Total area is 897 thousand rai.

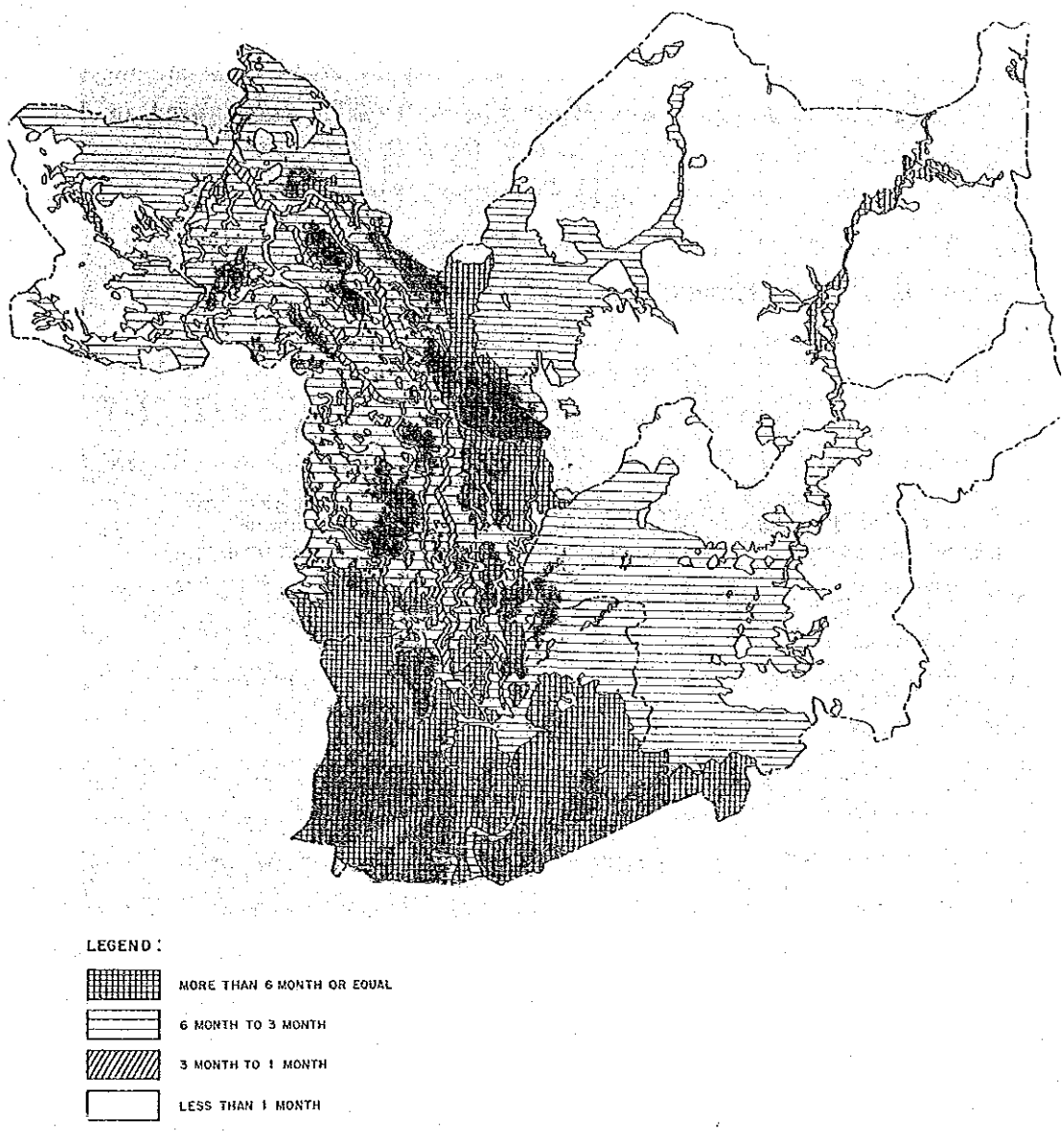


Fig. 2.2 Flooded Area

2) Soil Condition

Soil in the UCR is affected by characteristics of meteorological and geographical conditions. Soil distribution in UCR is summarized in Table 2.19.

Table 2.19 Soil Distribution in UCR

Soil	Share (%)	Distribution
Alluvial Soils	29.9	Chao Phraya Delta
Grumusols	16.7	Paddy Area in Lop Buri, Western Part of Sing Buri and Ang Thong
Low Humic Gley Soils	9.3	Old Alluvial Sediment
Brown Forest Soils	8.3	Hilly and Mountainous Area
Rendzinas	5.4	Hilly and Mountainous Area
Hydromorphic Non-Calcalic Brown Soils	4.9	Semi-recent Alluvium Terrace
Hydromorphic Alluvial Soil	4.1	The area along the Psak River
Slope Comples	10.1	Mountainous Area
Others	11.3	

Source : DLD

(1) Alluvial soils

Alluvial soils are the most widespread in the UCR. The majority of the soils is composed of heavy clay and clay with impeded drainage; a few percent have a loamy texture. By far a large part of the alluvial soils in the UCR is used for growing rice. Upland crops are grown, either exclusively or in rotation with rice. Better drained soils along the rivers are found commonly with the human settlements; fruit and garden crops are grown here. Of the alluvial soil area, about 40% is covered by the acid sulphate soils which is predominant in Ayutthaya. Most of the acid sulphate soils are moderately suited only to rice-growing and offer very poor prospects for upland crop.

(2) Grumusols

Most Grumusols are found in the flatter, depressed areas, but those on basalt may occur in a distinctly undulating landscape. Grumusols are composed of heavy clay and generally fertile. When it is dry, these soils crack deeply and when it is under paddy, land surface is usually smooth. The lower grumusols are mostly in use for paddy cultivation while the higher ones are in use for upland crops, especially corn and sorghum.

(3) Low-humic gley soils

Low-humic gley soils are predominantly formed on older alluvial sediments. These soils are characterized by signs of gleying throughout the profile or starting immediately below the surface horizon. Texture of these soils ranges considerably from clay throughout to loamy sand or even sand to a considerable depth. There is a considerable difference in these soils according to the age of the alluvial sediments on which they were formed. Those on semi recent sediments are not strongly leached and weathered. Frequently, they are highly saturated with bases in the subsoil and are moderately fertile. Low-humic gley soils on older terrace sediments are more strongly weathered. These soils are of lower fertility, especially when the texture is sandy. Most Low-humic gley soils are continuously cropped to paddy, depending, as a rule, on rain water only. The groundwater level drops sharply during the dry season, so that only a single crop can be grown.

(4) Brown forest soils

Brown forest soils are found in Lop Buri and Saraburi; their main occurrence is in the hilly and mountainous areas, where they are found on steep slopes and on slope colluvium. These soils are composed of sandy. Therefore, these soils are easy to induce erosion. When situated on slopes which are not steep, these soils have a fair agricultural potential, but most of the brown forest soils are too steep, too shallow, or both, for cultivation.

3. DEVELOPMENT POLICY AND ZONE-SPECIFIC STRATEGIES

3.1 Zoning System for Agricultural Development

The UCR is divided into 4 zones based mainly on natural conditions. Existing conditions and characteristics by zone are as follows:

Zone 1 Intensive Rice Cultivation Area

The area consists of alluvial soils and grumusols composing of clay. Most of the soils are best suited for paddy. Irrigation facilities are well equipped in the area. Therefore, paddy yield in the area is one of the highest in the Kingdom.

The better drained soils composing of sandy loam or loamy sand etc. also spread along the rivers in the area. The soils are suited for upland crop. Existing land use is commonly found along the human settlements: fruits and garden crops are grown here. This zone is also endowed with groundwater resource.

Zone 2 Floating Rice Cultivation Area

This zone consists mainly of acid sulphate soils and hydromorphic alluvial soils composing of heavy clay. Flooding problems occur regularly, and the depth of flood is the greatest in the area. Floating rice cultivation, therefore, is dominant agricultural activity in the rainy season.

Zone 3 Upland Crop Cultivation Area

This zone consists of various types of soil. Agricultural potential of this zone is comparatively high for both upland and paddy crops. However, rainfed cultivation is dominant in the zone. Therefore, the agricultural production fluctuates by year. Productivity per rai, especially of upland crop, decreases yearly because of decreasing soil fertility.

Zone 4 Soil Conservation Area

This area consists mainly of brown forest soils composing of sandy soils. These soils are found in the hilly area and at the foot of mountainous area and have a fair agricultural potential. Main constraint of this zone is erosion. Existing land use is rainfed upland crop area and idle land.

Zone 5 Forest Reservation Area

The area consists of slope complex soils and existing land use is forest or national park. The area, therefore, is unsuitable for any agricultural activity.

3.2 Development Policy and Strategy

Main problems in the agriculture sector of the UCR are identified as follows:

- Income disparity,
- Seasonal unemployment, and
- Unstable production.

In order to solve the problems, the following development strategies are recommended.

3.2.1 Agricultural Intensification

The UCR is endowed with fertile soil and enjoys high productivity of paddy among other regions in the whole Kingdom. Land resources for agricultural activity, however, have been fully utilized in the UCR. There is no room for increasing production by expanding agricultural land. To achieve the agricultural intensification, the following actions should be accelerated:

- Increasing productivity with appropriated technology and landuse,
- Expanding high productivity crops, and
- Using water resource effectively.

Improvement of post harvest facilities, such as those for storing and packaging, is necessary to control products quality, to cope with fluctuating market and thus to enhance value added.

Expanding newly released high yielding varieties and cheaper fertilizer will successfully achieve the agricultural intensification.

Development and better management of water resource will accelerate agricultural activities during dry season and increase yields.

3.2.2 Agricultural Diversification

Major crops of the UCR, which are rice and maize, have greatly contributed to export. Farmer's income has, however, been affected by the world market situation. In the upland crop cultivation area, production has been fluctuating by rainfall, and the water shortage during dry season has made farmers seasonal unemployment. However, the main crops will continue to play an important role in sustaining export and feed factories. In this context, agricultural diversification to create farm opportunities during the dry season and to compensate unstable income should be accelerated.

- Expanding livestock and fishery production
- Expanding fruits and vegetable production

To achieve this diversification, development of water resources should be accelerated; and the increase of livestock and fishery production, nitrogen riched crop and forage production should be expanded. The nitrogen rich resources will make existing hydrocarbon resources production of the UCR more effective.

These diversification, especially increasing dairy products, will contribute to foreign exchange savings.

3.2.3 Conservation of Agricultural Environment

Inappropriate farming system has induced land deterioration such as soil erosion and deterioration of soil fertility. The forest area is very small in the UCR. However, reforestation of deteriorated farm land and idle land is not feasible. Fertile soil is the most important natural resource to sustain future agricultural

development in the UCR. In this context following farming systems should be expanded in these areas:

- Agro-forestry
- Raised bed cultivation

These farming systems will contribute to not only the alleviation of land deterioration but the agricultural diversification and intensification.

3.3 Development Potentials and Strategies by Zone

3.3.1 Zone 1: Intensive Rice Cultivation

This zone will continue to play a role of rice bowl area.

Most of soils in the area are best suited for paddy and irrigation facilities are well equipped in the zone. Rice productivity is one of the highest area in Thailand. Therefore, the zone should continue to play the role.

1) Agricultural Intensification

(1) Increasing Rice Production

- Improvement of Water Management

According to agricultural statistics, only 18% of paddy cultivation area is growing second rice because of water limitation. Recent study on Chao Phraya river projects suggested the potential for expanding second rice cultivation area from 5 to 10% of existing second rice cultivation area, by improving water management. Expanding second rice cultivation area will much contribute to rice production increase.

- Expanding High Yield Variety

Recently, Thai government has released high yield varieties of rice such as Supan Buri 60. According to Rice Research Center, the

variety is suited for the natural conditions in the UCR and has almost same potential of productivity for both rainy and dry seasons, and the potential yield is about 40% higher than that of existing average yield in the UCR. Therefore, the high yield variety should be expanded in the zone.

2) Agricultural Diversification

(1) Effective Use of Residual Water

Only about 25% of rice cultivation area has potential to grow second rice and 75% of the land is idle after first rice cultivation. However, there are residual water in the soil after rice harvesting. Short cropping period varieties such as vegetable, soybean and mung bean are possible to grow with this water resource.

Royal Irrigation Department (RID) changed the policy for irrigation water supply so that crops other than rice can also use the irrigation water at present. This policy will accelerate crop diversification and expand planted area during the dry season. Therefore, not only vegetable but also soybean is possible to grow by supplying only supplemental irrigation water.

(2) Conversion of paddy field to upland crop

The crop suitability map shows that soils suited for both upland crop and paddy spread along the river in this zone. The area has potential for crop diversification through paddy to upland crop. To convert the field, raised bed cultivation is feasible because the area is necessary to drain during the rainy season. Promising crops in the area are pomelo, banana and mango etc. Under these tree crops, cultivation of vegetables, medical crops, pasture and fresh water fish (in the pond between ridge) should be accelerated.

(3) Fishery

There is a fishery station in Chai Nat. Main roles of the station are research, breeding, extension and fish fry production. There are other two fishery stations to be established in Ang Thong and Sing Buri in 1990. Fish fry production will then increase by two times of the existing production. Pond area will expand by land consolidation project. In this context, fresh water fish production should be expanded.

(4) Livestock

There is no room for expansion of agricultural land. However, the following land resources can be utilized for the expansion of forage production.

- Road side and dike
- Backyard
- Paddy field with residual water in soil after harvesting rice

A large volume of unused farm by-products such as straw and rice bran, is also available in the zone. These unused feed and land resource should be utilized effectively to expand livestock production.

3.3.2 Zone 2 : Floating Rice Cultivation

This zone will primarily play a role of water retention.

The zone consists of acid sulphate soil characterized by low productivity. Flooding problems occur perennially and the depth of flood is greater than any other areas. The role of water retention is important for downstream area, Bangkok in particular. Floating rice cultivation, therefore, should be continued during the rainy season.

1) Agricultural Intensification

Because of natural conditions, rice yield during the rainy season is comparatively low. Increase of floating rice productivity is important. To this end, Rice Research Center has released high yield floating rice varieties, such as Hantra 60 of which potential yield is about 25% higher than that of average yield during rainy season in the zone. This variety should be expanded more into this zone.

2) Diversification

Degree of diversification during the dry season is mostly similar to that in the Zone 1. Flooding period is longer than that of Zone 1. Therefore, this zone has advantage of raising high value fresh water fish.

3.3.3 Zone 3 : Upland Crop Cultivation

In this zone, effort should be made to accelerate the development of environmentally sound agriculture.

Productivity of maize in this zone has been decreasing as the results of soil deterioration, rainfall pattern changes caused by deforestation, inappropriate land use and nonfertilizer cultivation. Production is fluctuating by rainfall because rainfed cultivation is predominant in the zone.

Unused water resources are available in this zone. They are Pasak River and its tributary streams. However, the volume of these water resources is not enough to irrigate the major crops.

Generally, the ecosystem of upland crop cultivation area in tropics is very sensitive. In particular soil conditions are easy to deteriorate. Fertile soil is the most important natural resource in Thailand. In this context, the following environmentally sound farming system should be expanded coupled with water resource development. Development concept for this zone is summarized in Fig. 3.1.

1) Conservation of Agricultural Environment

Model of a proposed Integrated Farming System (IFS) is shown in Fig. 3.2 and effect of existing farming system and IFS are shown in Fig. 3.3 and 3.4.

The area for the IFS comprises the three types of area: house lot, raised bed cultivation and main crop cultivation.

Main purposes of the IFS are as follows:

- Effective use of limited water resource
- Improvement of agricultural environment by increasing trees and tree crops and
- Promotion of agricultural productivity increase and diversification.

Effects of the IFS on environment and agriculture are as follows:

Effects on environment

- Maintenance and increase in the soil fertility as well as prevention of soil erosion, through expanding tree crop area to cover soil surface.
- Increase in the water holding capacity of soil by improvement of micro climate and shading of soil surface.

Effects on agriculture

The improvement of environment by expanding tree and tree crop makes significant direct and indirect contributions to the agriculture diversification and intensification as follows:

- Stable production ensured by substantial water retention in soil
- Agricultural diversification through expanding tree crop
- Further diversification in the area under tree crop shade
- Recycle use of products and stable farm income through diversification
- Reduction of seasonal unemployment through the diversification at farm level

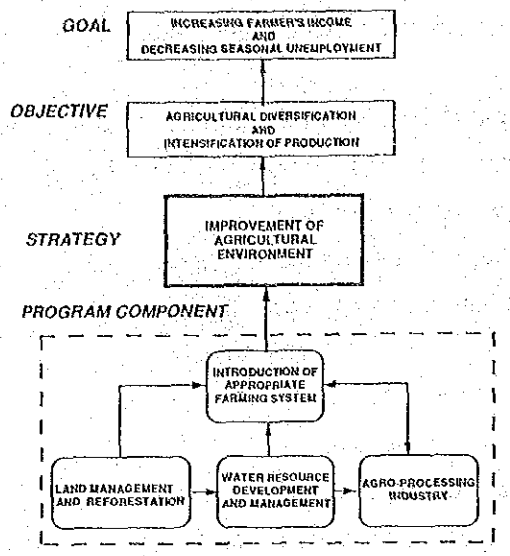


Fig. 3.1 Pasak River Basin Agriculture Development Concept

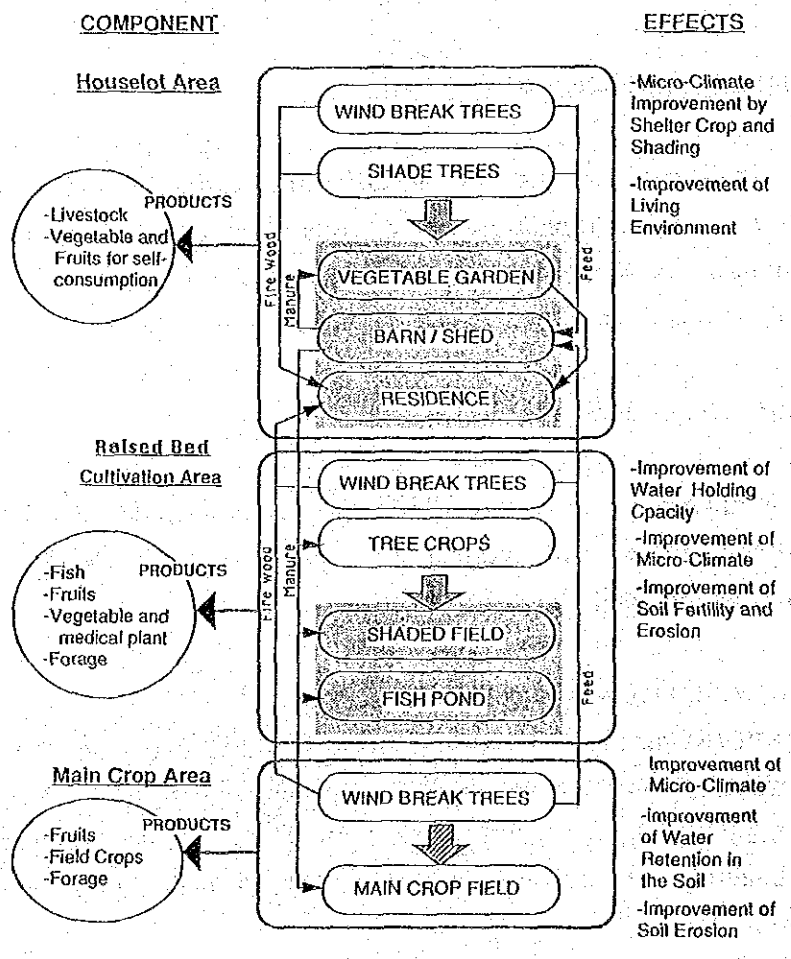


Fig. 3.2 Component of Integrated Farming System

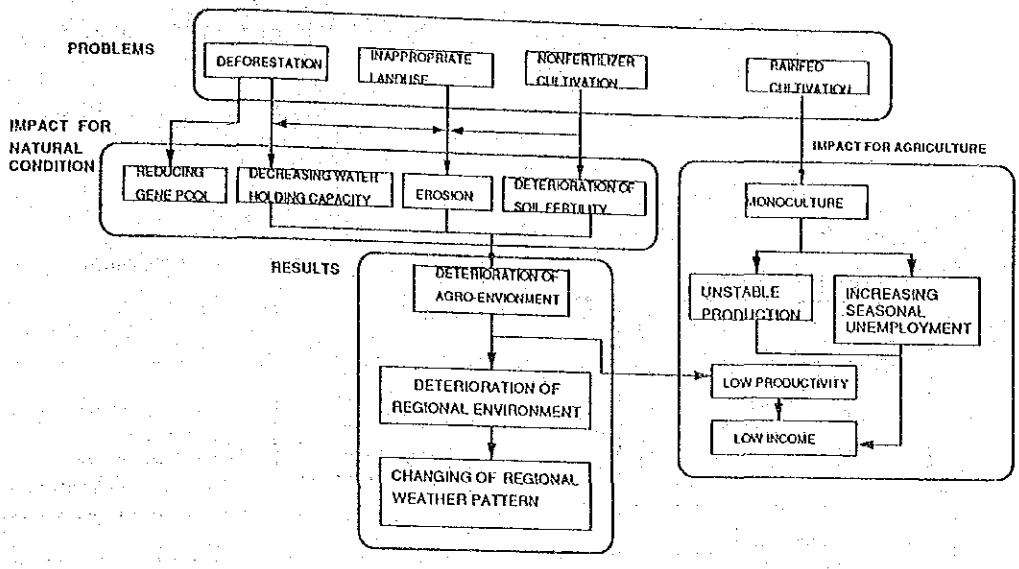


Fig. 3.3 Existing Farming

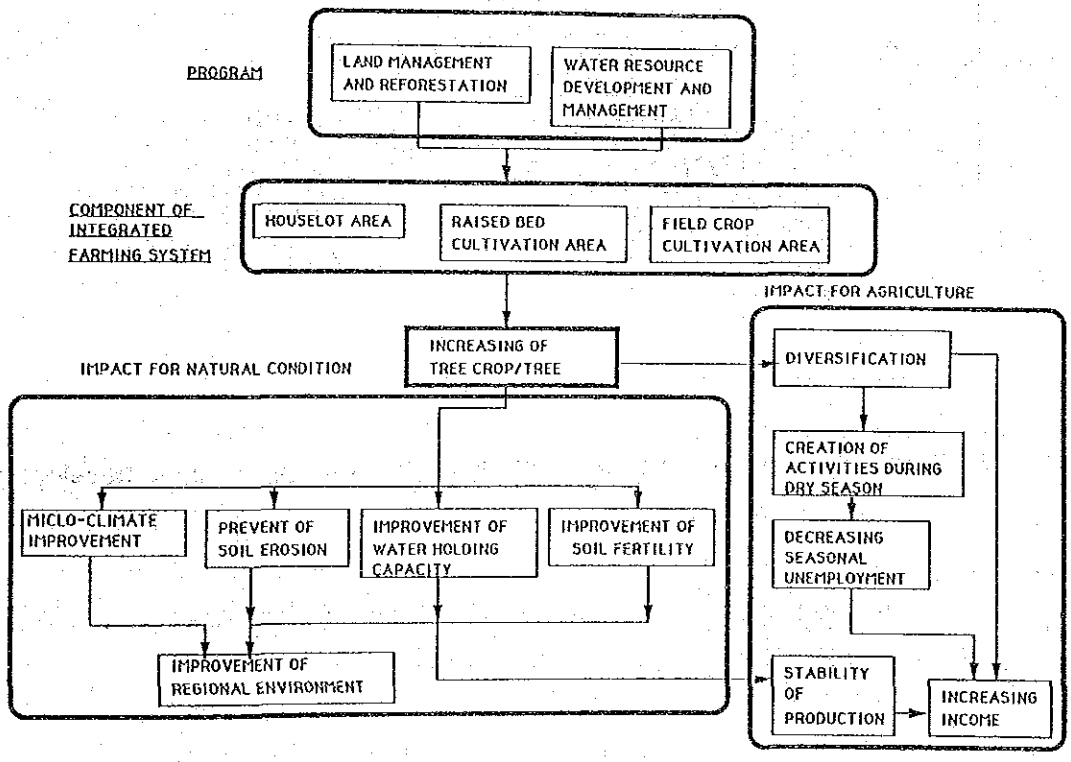


Fig. 3.4 Effects of Integrated Farming System

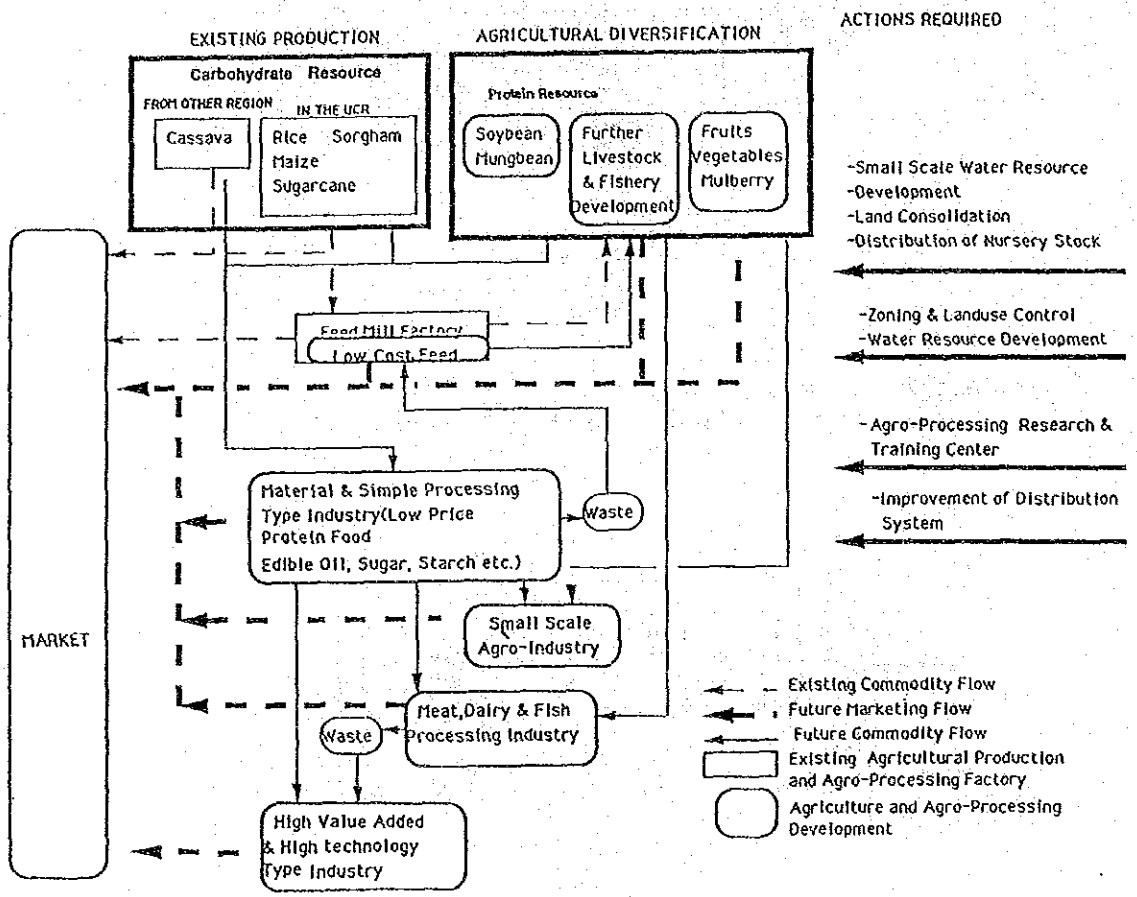


Fig. 3.5 Transformation of Agricultural Output with Agro-processing Development

2) Crop Diversification

(1) Main crop diversification

Maize will continue to be the main crop for sustaining both domestic feed industries and agricultural export. However, composition of main field crop should be changed from a maize dependent pattern to a more diversified pattern with the emphasis as follows :

Sugarcane

Sugarcane factory is under construction in Lop Buri. To sustain this factory and encourage further location of sugarcane factories, sugarcane production should be expanded.

Soybean

Soybean is a very important protein resource for both man and livestock. Agro-processing enables a much more diversified use of existing hydrocarbone resources such as cassava and maize. Therefore, this protein resource will gain an increasing importance in the agro-processing particularly for import substitution.

(2) Tree crop

In view of the potential role of tree crops in improving environment and supporting crop diversification, promissing tree crops under the proposed IFS are as follows:

- In house lot area : Mango, Jack Fruits, Coconut, Klue namua, Bamboo, Sugar Apple, Pomelo, Java Apple, Guava, and Sapadillia
- In raised bed cultivation area : Mango, Coconut, Lime, Pomelo, Tangerine, and Guava
- Main crop cultivation area : Tamarind, Lucune, Cashew Nut, Malbery, and other trees as wind breaker

(3) Livestock and Fishery

Livestock and fishery are the important component to sustain the IFS as shown Fig. 3.2. Especially, livestock development is closely linked with further agro-based industrial development. This linkage is summarized Fig. 3.5.

Establishment of two fishery stations is planed in Lop Buri and Sara Buri. In this connection, not only livestock but fishery should be developed under the IFS.

3.3.4 Zone 4 : Soil Conservation

1) Conservation of Agricultural Environment

Agro-forestry should be a main thrust for this zone.

This zone has been severely affected by erosion because of soil characteristics and topographic conditions. Predominant land use is idle land or low productivity field. The area should be covered with vegetation throughout the year to prevent the land from further erosion and to improve regional environment. Therefore, agro-forestry should be expanded in this zone.

2) Diversification

(1) Perennial Crop

Perennial crops should be expand as the main crop of agro forestry. However, species of tree should be selected in accordance with the purpose of diversification. Promising perennial crop is as follows.

(2) Fruits production

Fruit tree such as tamarind and cashew nut crops will contribute to reducing seasonal unemployment because dry season is the harvesting period of these crops.

(3) Forage Tree

Leucaena, which is a legumminous forage tree, is important for both prevention of soil erosion and development of livestock.
The nitrogen-rich feed from this tree contributes to increasing livestock productivity.

(4) Sericulture

Sericulture is a promising agro-industry in Thailand. According to Sericulture Research Center, murbery is possible to grow in the eroded area.

4. PRODUCTION TARGETS

4.1 Measurements and Method for Target Setting

The method of target verification for agriculture is based on the analyses of productivity, land availability through land consolidation, and the change of value added for agricultural crops (includes vegetable and fruits). For other products, prospects for domestic market demand, the relative shares of those sub-sectors to the total agricultural GRP, and the relative position of those sub-sectors in terms of regional comparative advantage to the national agricultural GDP are examined.

The results are shown on Table 4.1 and 4.2. Table 4.1 illustrates the estimated agricultural harvesting land area based on the outcomes of land suitability analysis, land consolidation and water management projects. Table 4.2 delineates the possible and effective production pattern for the above agricultural products along with the recommended land use with production (yields) enhancing measures and projects.

4.2 Future Production Scenario

4.2.1 Rice

The harvesting area decreases from the current level of 4.99 million rai to 3.95 million rai in 2010. This reduction of land area is compensated by the yield upraise of 1.44% per year reaching to 592 kg/rai from current 423 kg/rai in 2010. The targeted yields would be surpassing the current Asian average yield figure for paddy. It is believed that intensified land use along with efficient water management as well as intensification of farming system with dissemination of new varieties and technologies as describe in the agricultural sector plan, will bring these results.

Table 4.1 Price Forecasts for Agricultural Commodities

(1985 US$/metric ton)

Commodity	Actual 1970	Actual 1980	1987	Forecast 1995	Forecast 2000	Increase or Decrease 1987-1995	Increase or Decrease 1987-2000
Rice	396	416	177	173	166	-0.3	-0.5
Haize	161	120	58	68	73	2.0	1.8
Sugar	223	606	115	224	254	8.7	6.3
Sorghum	143	124	56	62	68	1.3	1.5
Soybean	322	284	166	198	148	2.2	-0.9
Soybean Oil	845	572	257	470	371	7.8	2.9
Rubber	1270	1560	860	1150	1060	3.7	1.6
Palm Oil	716	559	264	327	296	2.7	0.9
Copra	619	434	238	305	266	3.1	0.9
Cotton	1740	1960	1270	1230	1160	-0.4	-0.7
Jute	754	295	248	243	236	-0.3	-0.4
Tobacco	2717	2205	1471	1492	1439	0.2	-0.2

Source : World Bank 1989

Table 4.2 Comparative Advantage in Agricultural Production, 1986

Product	Domestic Resource Cost
Livestock/1	
Chicken	16.15-17.01
Eggs	13.26-15.57
Pork	24.22
Beef	19.03-45.85
Dairy	32.87-36.91
Fishery/2	
Shrimp	7.86-9.95
Shrimp farming/a	6.55-10.48
Squid	11.79-24.10
Fish	11.26-16.24

Source : TDRI

Assuming the implementation of these measures, the results are shown in Table 4.3-4.5. GRP for paddy in Table 4.5 should read that average annual growth rate of 0.2% for paddy consists of annual average of 0.99% of decrease in land availability,annual rate of 1.44% for productivity increase, and annual rate of 0.28% decrease in projected rice price.

4.2.2 Field Crops

Prospects for field crops in the international markets are envisaged as bright as seen in Table 4.1 according to the World Bank. Maize, sugarcane, soybean, and sorghum are the main crops to answer this prospective growing demand. In addition, the readily procurementable condition of such crops in the UCR, opens a new avenue for the UCR industrialization namely agro-processing industry. These crops are directly utilized as ingredients and in further residuals and wastes are again utilized as feedstocks to nurse livestock and fisheries. By completing with this cycling nature of agricultural production and product utilization, the UCR is said to foster new comparative advantage and to stock the capability to seize new economic opportunities represented by new types of agro-industry in the latter part of the year 2000s, where current high technologies for agro-industries seem readily available. For restoration of agricultural environment on one hand, and diversification of agricultural production on the other hand, aiming the achievement of food production cycle or extensive utilization of resource advantage, these field crops plays an important role.

Harvesting area for field crops are estimated as shown on Table 4.3. According to the land utilization analysis the land area of about 3 million rai is available for field crops.

In addition to the above by planting twice a year, this land area could expand 1.3 times and also it is estimated that 30% of wet season paddy field could be in use for field crop during dry season. With this estimation, harvesting area for field crop is calculates.

Value added per rai for these crops in average has been assumed to increase at a speed of 1.4% per annum reflecting upraise trend of world prices for these crops toward the year 2010 with 1.8% per annum increase in average.

Table 4.3 Land Utilization and Productivity for the year 2010

Type of Land	Harvesting Area * 1000 Rai	Yields Total KG/Rai	Production Ton
1. Paddy			
Floating	631	425	268.2
Wet	2473	600	1483.8
Dry	770	700	539
	3874	592	2291
Actual for 1987	4990	423	2112.3
2. Field Crop *		1987 Bahts/Rai	Million Bahts
Wet	742		
Upland crops	4155		
	4897	811	3972.2
3. Fruits *	689	3074	2117.8
4. Vegetables *	223	2695	602

* For these products Yields and Production Figures are in terms of value added

Table 4.4 Value Added Per Rai

	1987 National AV. VD Bahts/Rai	1987 UCR AV. VD Bahts/Rai	2010 Projection VD Bahts/Rai
Paddy	776.8	1050.7	1458.4
Field Crops	737.4	336.8	811.1
Vegetables	1539.7	2246.2	2695.4
Fruits	2474.2	878.2	3073.7

Table 4.5 Agricultural GRP Target

	1987 Total V.Added MMB	1987 AG GRP Share (%)	2010 Total V. Added MMB	2010 AG GRP Share (%)	1987/2010 Growth Rate UCR/UCR (%)	Growth Rate (1987/2010) World Mkt Price (%)	Value Added Per Rai (%)	Productivity Per Rai (%)	Land Availability (%)
Paddy	5,433.3	53.7	5,649.7	28.3	0.17	-0.28	-0.28	1.44	-0.99
Field Crops	1,943.1	19.2	3,972.2	19.9	3.16	1.80	0.88	0.42	1.86
Vegetables	49.6	0.5	602.0	3.0	11.46		0.30	0.80	10.37
Fruits	584.8	5.8	2,117.8	10.6	5.75		0.40	0.95	4.41
Ag. Forestry	13.5	0.1	207.2	1.0	12.60				
Others	606.5	6.0	1,559.1	7.8	4.19				
Livestock	1,293.2	12.8	4,877.4	24.4	5.94				
Fisheries	200.3	2.0	1,007.7	5.0	7.28				
Grand Total	10,124.3	100.0	19,993.1	100.0	3.00				
Employments *100	718.0		564.0		-1.04				
Per Farmer Aggrp	14,100.2		35,448.8		3.99				

Based on these, GRP for field crop in Table 4.4 should read that average annual growth rate of 3.16% is the interaction of average annual growth rates of 1.34% for land availability, 0.42% for productivity per rai, and of 1.4% for value added. By achieving these, this sub-sector still remains as one of major components of diversified agricultural production structure in the year 2010.

4.2.3 Fruits

In the same manner as the above, two sub-sectors of agriculture, annual average growth rates for fruits and vegetables are obtained. For fruits, current value added per rai in UCR is 3 times lower than that of national average as shown in Table 4.4. With introduction of market oriented variety of fruits in their quality, seasonality and logistical aspects as suggested in agricultural report, this sub-sector should be able to increase productivity in terms of value added per rai toward the year 2010. Then this sub-sector is expected to contribute 10.6% share in the 2010 agricultural GRP.

This sub-sector is envisaged to show 5.8% annual average growth rate for its value added toward the year 2010. This growth is achieved by land availability with annual average growth rate of 4.4%, productivity growth rate (yields) of 1.0%, and annual value added increase of 0.4%. Should the new farming system as suggested in the agricultural section be applied in view of betterment for agricultural environment, these growth rate are easily achievable. For this sub-sector, upland area is the main focus.

4.2.4 Vegetables

Vegetable products hold currently high value added per rai productivity as 2,246 Baht against the national average of 1,540 Baht. This sub-sector with effective use of residual water in the soil after paddy harvesting especially in the central plain area of the UCR and proximity to the BMR, will contribute as an additional income source for the UCR agriculture. Although the share of vegetable over the UCR agricultural GRP is limited as 3% in the year 2010, the average growth rate of sub-sector GRP is fast with 11.5% per annum with rate of growth for land availability 10.4%, productivity 0.8% and value added per rai 0.3%.

4.2.5 Livestock and Fisheries

As mentioned precedently livestock and fisheries have been growing rapidly in recent years. The market prospects for these products are bright. In addition in the UCR, diversified field crop production, possible utilization of land for forage production, utilization of farming by-products such as straw and rice bran, and the readily available low cost feed staff in terms of wastes from agro-processing industry together, restrengthen the comparative advantage of the said sub-sectors. In these instance, the Team estimated the growth of these sub-sectors as 5.9% per annum for livestock and 7.3% per annum for fisheries. As for livestock speed of growth, this implies three times as big as current level value added for the next 20 years, and this growth is well within the possible range. With these speed of growth, the UCR is expected to be one of the animal protein supply base for the future Thailand food market structure. Then the livestock sub-sector is expected to share 24.4% of the agricultural GRP in 2010 and fisheries 5%.

In turn, these sub-sector growths are necessary pre-requisites for fostering further food processing industries such as meat and dairy products in the UCR, which is strategically emphasized as one of industrialization opportunities for the UCR. Although the Table 4.2 reveals that feed cattling in Thailand is less competitive to the outside economies, the plan formulated in the agricultural sector enables to change the less favorable comparative advantage to strong one, in view of a total production chain of food production with the efficient utilization scheme of resources endowed in the UCR.

4.2.6 Agro-forest and Other Subsectors

In view of conserving the agricultural environment in the UCR, especially in upland area, agro-forestry projects are recommended. Sericulture, forage tree, perennial crops are the main products from these agro-forestry projects. With these, it is projected that the 1% of the agricultural GRP in 2010 could be obtained from agro-forestry. For the basis of such estimation, the value added of 700 Baht per rai in forest area for 296 thousands rai were assumed.

Others include simple agricultural processing products. As diversified agricultural production structure enlarges, these activities should increase. At the national level this sub-sector occupies 12% of agricultural GDP in 1987. For the estimation of this sub-sector GRP, the extrapolation of the past trend of the UCR was applied. The result is 4.2% annual growth with 8% sub-sector share in 2010. This way of projection might yield under-estimation of this sub-sector's contribution to the agricultural GDP in view of agro-processing industry growth and increasing production of fruits and vegetable. However, considering the relative share of this sub-sector to the total agricultural GDP at national level in conjunction with difficulty associated with demarcation of this sector's activity between agriculture and industry, the lower part of estimation was adopted here for the purpose of verifying the attainability of targeted GRP.

4.2.7 Overall (Agricultural GRP per Capita)

Having analyzed the each agricultural sub-sector prospects in considering the proposed projects and program, it is concluded that agricultural sector growth of 3% per annum average toward the year 2010 is attainable. Thus to achieve this target, importance lies in implementation of recommended measures.

At this moment, the overall agricultural productivity and employment in the sector should be mentioned in answering the current problems of agriculture, namely unstable and less sufficient farm income and seasonability of farm employment. The strategies adopted in agriculture are intensification, diversification and restoration of agricultural environment. The result is the annual 3% growth in agricultural GRP with total average productivity (per agricultural employment) growth rate of 4% toward the year 2010.

5. PROGRAMS AND PROJECTS

To implement the agricultural development strategies, the following projects and programs are proposed. Accelerated development of upland area in conjunction with crop diversification, intensification and linkage to agro-based industries should be induced in the UCR. Proposed projects and programs are described by zone as follows :

5.1 Zone 1 : Intensive Rice Cultivation

This zone is within the Chao Phraya Irrigation Project and the area without flood is 2.81 million rai. Potentially paddy area is 1.27 million rai in this area. 1.54 million rai of the potential land for upland crop or both upland crop and paddy is included in this zone.

5.1.1 Improvement of Irrigation System in Chao Phraya River Basin

According to a recent study on Chao Phraya River Irrigation by the RID - JICA, second rice planted area can be increased by 10% by improving irrigation systems. Second rice is important for export due to its high quality. The improvement of the system will contribute to increasing rice production and earning of foreign exchange. Actual area of paddy cultivation in this zone is targetted to be 1.01 million rai in the future.

5.1.2 Development of Groundwater

The Chao Phraya River Basin is endowed with a plenty of groundwater resources, although the volume of the groundwater resource would not be sufficient for paddy irrigation.

The area of 1.54 million rai with better drained soil, being suited for upland crop, is along the Chao Phraya River. This area has large potential for crop diversification with the use of groundwater resource. Although actual planting

area will be less than half of potential area because of intensive land requirement for housing and other urban use 0.7 million rai of agricultural land is potentially irrigable.

Type of crops to be grown in the groundwater irrigation area should be vegetables and fruits of high value added type.

5.2 Zone 2 : Floating Rice Cultivation

Total area of this zone is 1.92 million rai. This area is subject to flooding and type of the soil is suitable only for paddy. There is 0.74 million rai of floating rice field in this area. Expansion of high yield variety of both ordinary and floating rice, and the diversification based on fresh water fisheries should be implemented. Research and development with appropriate extension activity is proposed. Actual planting area for paddy is estimated at 1.63 million rai.

5.3 Zone 3 : Upland Crop Cultivation

A part of Changwat Chainats and most part of Lop Buri and Sara Buri are included in this area. This area is most promising for crop diversification and further intensification in the UCR. Environmentally sound agriculture is the main goal in this area. There is a total of 4 million rai of potential area for agriculture. In order to fully utilize this potential area, the following programs and projects are proposed. Coordination among water resource development, land consolidation program, and agro-industry development is indispensable.

5.3.1 Water Use Development of Tributary Stream of Pasak River

Pasak River Basin in Lop Buri and Sara Buri is endowed with fertile soils and there is the largest potential for agricultural diversification in the UCR. However, the production has been subject to fluctuating rainfall, therefore, farmer's income has been unstable. Creation of stable income sources for small and medium farmers should be urged to sustain their maize production. Extension of IFS with water resource project is essential.

Expanding raised bed cultivation system combined with water resource development of tributary stream of Pasak river is practical because the volume of water is not sufficient to irrigate for main crops.

This project will greatly contribute to agricultural diversification, intensification and alleviation of seasonal unemployment. Small and medium scale water resource development, land consolidation program and tree crops introduction are the supplemental components.

5.3.2 Establishment of Breeding and Distribution Center of Dairy Cow and Forage Seed

Consumption of dairy products in the country has increased in the recent years. The UCR has potential for dairy products because of a plenty of feed materials. To meet domestic consumption and to save foreign exchange through import substitution of dairy products, distribution of dairy cow should be urged. Proposed location of the center is Phra Phutthabat which is the center city to provide various urban services for the upland crop cultivation area.

5.3.3 Establishment of Milk Collecting Stations

In accordance with the increase in daily cow and promotion of daily products, an efficient system of milk collection stations are necessary.

5.3.4 Improvement and Extension of Agricultural Input

Generally, upland crop yield in Thailand is lower than other Asian countries. Yield of maize in the UCR has decreased due to a small volume of fertilizer application and low quality seed. Therefore, increasing the yield should be stressed for agricultural intensification.

To achieve this goal, improvement and extension of agricultural input, particularly low price fertilizer and high quality seed, should be extended for small and medium farmers.

5.4 Zone 4 : Soil Conservation

This area is in Changwat Lop Buri and Sara Buri. It is suitable for field crop if a soil erosion problem is fully solved. Total area is 370 thousand rai. Agro-forestry is proposed in this area. Perennial crops, fruit trees, forage trees and mulberry are suitable crops to be introduced. Tree crop seedling supply program by Royal Forest Department is necessary. Actual project area is estimated as 296 thousand rai.

6. Farming-Processing Linkages

The UCR is one of the most important granary of Thailand. Main agricultural products in the area are rice, maize, sorgham, sugarcane, mung bean and soybean, which contribute about 12%, 15%, 45%, 4%, 10% and 6% respectively of total production of the whole Kingdom.

The UCR also plays a role of collecting the agricultural products to be exported.

According to our survey of distribution activities, a large volume of cassava and maize, which account for 40% and 35% of total production in Thailand, are collected from the northern and northeastern regions to the UCR for export. However, most of the agro-products collected and produced in the UCR are exported without any processing or only with simple processing such as pellet.

Rice, cassava and maize have contributed to foreign exchange earnings in Thailand. In parallel with economic development, however, domestic consumption of these main crop has been increasing as shown in Table 6.1.

Pattern of domestic food consumption has been changing especially in favour of protein food. The animal protein food such as livestock products requires major crops for feeding products and their waste. This trend is expected to continue with further economic development of Thailand, and livestock production will be more important for export as well. From the view point of stabilizing formers income, livestock development provides an important source of income of the farmers who support for agricultural diversification and environmentally sound agriculture in the UCR.

According to FAO, supply of low cost feed is the most important factor to develop livestock in a tropical area. To provide the low cost feed, development of agro-based industry should be necessary for effective use of industrial by-products and waste.

Table 6.1 Growth of Production and Domestic Consumption(1982-1987)

	Production Growth Rate(%)	Domestic Consumption Growth Rate(%)	Domestic Consumption Share(%)
Rice	1.3	1.3	73
Maize	5.6	14.5	42
Sorgham*	-19.9	42.2	85
Cassava**			
Fresh	2.8	7.5	--
Products		4.7	
Sugarcane	4.1	5.4	69
Mungbean	-1.0	0	43
Soybean	24.4	8.4	206

* : 1985-87
** : 1984-87
Source : Office of Agricultural Economics

The linkages to be developed between agro-based industry and agriculture in the UCR are shown in Fig. 6.1. At the first stage of agro-based industry development, industries for simple processing should be encouraged to grow as a basis for further processing activities and to maintain an advantage of the UCR as the collecting center and main production area of agricultural raw materials.

- Large volume of industrial by-products and waste will be generated by simple processing industry. These by-products and wastes will induce further development of feed industries. The linkage will realize the recyclic use of agricultural materials for production of low cost feed.

- Most of raw materials containing mineral nutrition can be utilized in the UCR through livestock activities. Waste from livestock industries will again contribute to the prevention of soil deterioration.

- As shown in Table 6.1, Thailand is scant of soybean and has imported soybean cake as protein feed. Leguminous crops such as soybean and mungbean are not only important agro-industrial materials but effective to making the soil more fertile through their cultivation. The UCR has great potential to expand these crops.

- There are a large volume of unused industrial materials such as rice bran, straw, husk and sugarcane bagas. These materials are possible to be used effectively. At the first stage, most of production are the processing of basic materials such as starch and edible oil. Downstream processing industries such as snack and noodle etc., are expected to be developed by using these materials at the second stage. Fruits, vegetables, livestock, fishery and sericulture production will increase at this second stage as a result of agricultural diversification. Small or medium scale agro-based industries using these products are expected to grow. These products and wastes are potentially important for bio-technology and the bio-tech industries in the long-run.

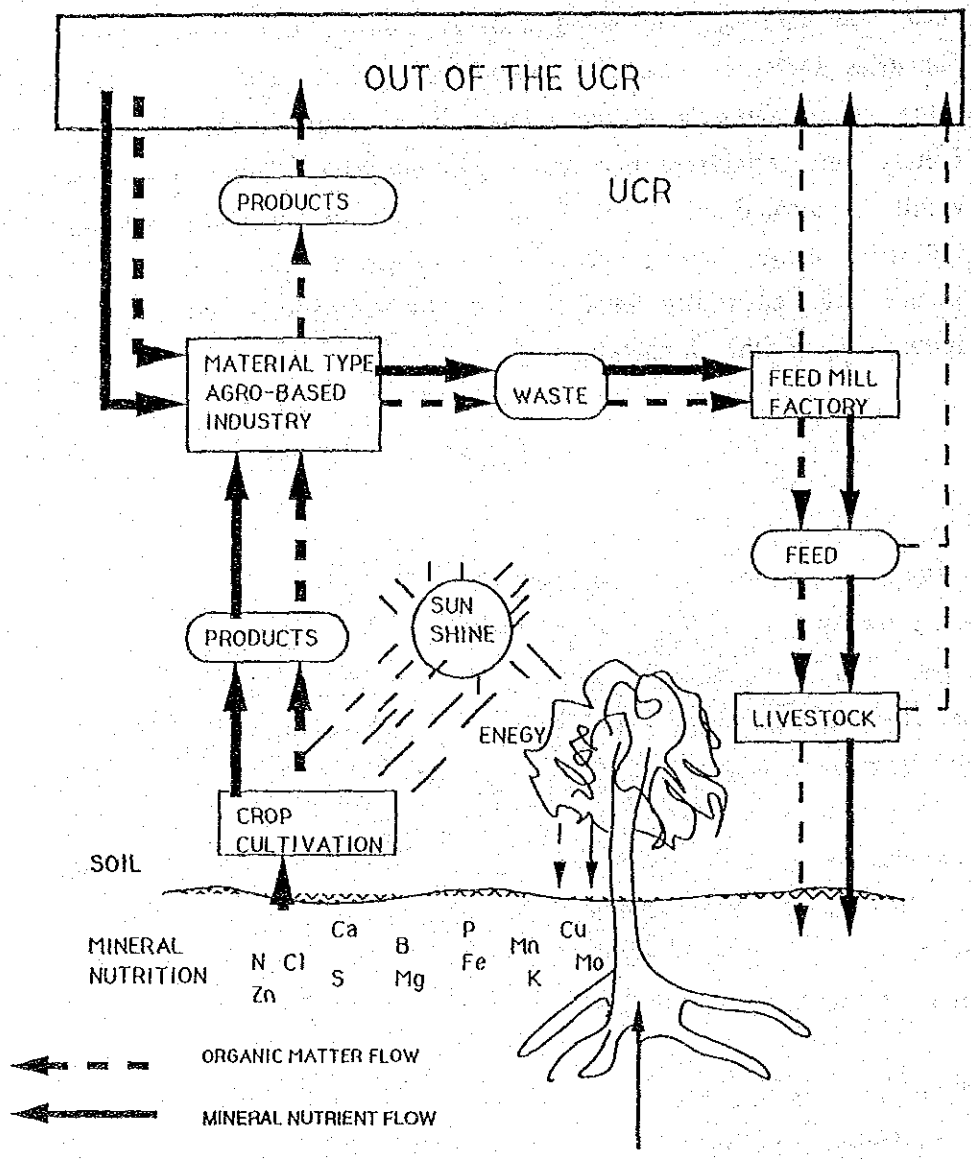


Fig.6.1 Nutrient Cycle in the UCR

PART V

INTEGRATED PASAK RIVER BASIN DEVELOPMENT

1 INTRODUCTION

1.1 Objective

It is important for river basin development planning to look at activities in the whole basin. It has not been a common practice in Thailand to plan for basin-wide development activities. By a basin-wide development planning, we can avoid duplication of development effort among concerned agencies and a basin-wide planning can facilitate coordination among projects.

This preliminary study of Pasak Basin Development is aimed at proposing a large scale project, i.e., Pasak dam project, and identification of medium and small scale projects. Regarding the Pasak dam development, this study proposes a new scheme of land consolidation and resettlement which will facilitate the implementation of Pasak dam. This scheme is innovative one asking not only sacrifice to people at inundating areas but also giving benefits to those people.

In order to improve degrading agricultural resources in the basin, new and environmentally sound agricultural farming systems is proposed in this study. Such a farming system is sustainable-type of development which should be promoted to other regions of Thailand as well. The agriculture promoted in the area will be linked to agro-industry development and presented in this basin development program.

The Pasak basin development program involves various development activities. This will necessitate coordinated efforts among various agencies concerning water resources development, land use management, extension activities of a new farming system. For this purpose, an institutional set-up to implement the basin development activities is proposed.

1.2 Present Status of Pasak Dam Project

Pasak dam development is a King's initiation project, and present status of the Pasak dam development should be first explained. The Pasak dam was proposed long time ago and there has been no action to implement the project. However, approximately two years ago, His Majesty the King suggested the investigation of Pasak dam. Since then a few preliminary studies have been conducted by the Royal Irrigation Department and development alternatives, in terms of scale, were listed in reports.

Pasak dam has been proposed for the purpose of: BMR's water resources and flood protection, water resources for Bang Pa Kong basin, salt water prevention in Chao Phraya River, etc..

The RTG cabinet approved conducting a feasibility study at the beginning of 1990. A committee for the Pasak dam is scheduled to be set up and the role of the Committee is to prepare a T/R for the up-coming feasibility study. The NESDB Economic Preparedness Planning Division has been working to set up the Committee by organizing concerned agencies.

Meanwhile, working group of Pasak basin was established in the National Water Resources Committee; the role of group is to oversee and coordinate water resources development activities in the Pasak basin conducted by various agencies. This is a very timely movement of the government considering the needs of Pasak basin development and Pasak dam project.

1.3 Approach of This Study

In the following, an approach employed for the Pasak dam development preliminary study is presented, which requires special attention considering that a feasibility study is up-coming for the Pasak dam. The objectives and approach of this Pasak dam preliminary study is:

1) To propose a model for water resources and related agricultural development; and this model may be adopted for any size of dam which will be recommended by the up-coming feasibility study. We do not wish to claim the scale of dam employed in this study is the optimal one among many alternative scales;

2) To propose a model in order to input the UCR study results for the up-coming feasibility study;

3) To propose a model involving a set of development schemes. Without such schemes, implementation of Pasak dam will be very difficult. The schemes consist of water resources development, a new type of land consolidation, and agricultural farming system as well as an institutional set-up to implement the schemes.

4) To propose Pasak dam in order to benefit the UCR agriculture and industrial development, particularly GSIC, i.e., Greater Saraburi Industrial Core.

2. PRESENT CONDITIONS

2.1 Water Resources and Development

Water resources potentiality in the Pasak River basin is explained in the Part I of this report. As observed from Table 2.4 of the Part I, flow volume varies very high between wet season and dry season. This is due to a seasonal rainfall pattern as well as deforestation in the basin. Particularly deforestation affects on the flow fluctuations in wet season and causes floods at the upstream areas and also it causes very low base flow in dry season.

Water resources development activities in the Pasak River basin were rather slow in the past. Fig. 2.1 shows the whole Pasak River Basin with some medium scale projects identified by the Pre-feasibility Study on the Upper Pasak Medium Scale Irrigation Projects (1982) and Feasibility Study on the Upper Pasak Medium Scale Irrigation Projects (1983). Small and medium scale irrigation projects implemented in the past within UCR area, i.e., lower Pasak basin, are shown in the Fig. 2.4 of Part I of this report. There is no large scale project implemented in the whole basin. The list of existing small and medium scale projects can be found in a publication such as "Water Resources Development in Thailand for Large-Medium Scale Projects and Small Scale Project" by the Royal Irrigation Department.

There are many small scale projects implemented in the past. No water has been available in dry season in case wiers were constructed without storages. Water can be utilized only in wet season in such cases. This indicates the necessity of more storage facilities to be used for dry season as well as for wet season, which is recommended in Chapter 5 of Part I of this report.

2.2 Land Resources

The total Pasak basin area is 14,520 km^2. The land use of the basin may be classified into 11,620 km^2 (80 %) as agricultural area and the rest of 2,900 km^2

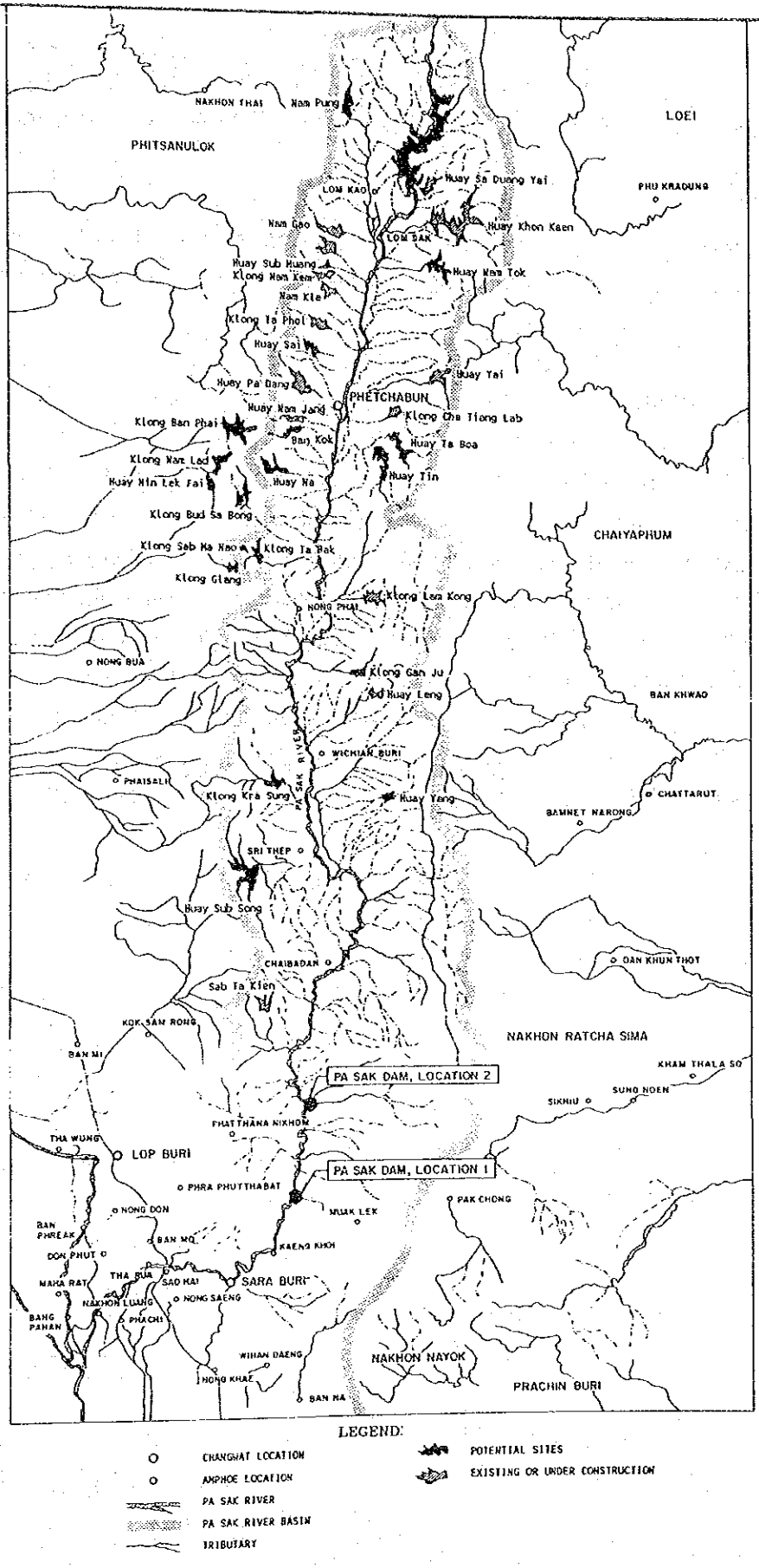


Fig. 2.1 The Pasak River Basin Map

(20 %) as preserved forest and others. The agricultural area may be further classified into 6,530 km^2 as paddy area and 5,090 km^2 as upland area and others.

The Pasak basin area within the boundary of UCR is 4,960 km^2. The soil and land resources of the upland UCR, including Pasak basin, is presented in the Part III of Land Use.

2.3 Present Agriculture

Agricultural potential of Pasak River basin is comparatively high for both upland and paddy areas. However, rainfed cultivation is dominant in the basin and yearly fluctuations of agricultural production is rather high. Productivity in terms of yield per rai has been decreasing year by year due to deteriorating soil fertility, changes in rainfall pattern caused by deforestation, and inappropriate land use and cultivation using no fertilizer. The data of such productivity fluctuation is shown in Part IV of this report. This situation can be improved by introducing irrigation water and environmentally sound farming system, which is explained in Section 3.5.

3. DEVELOPMENT PROGRAM AND PROJECTS

3.1 Pasak Dam Project

3.1.1 Alternative Development Schemes

There are two sites proposed for the location of Pasak dam: Amphoe Pattana Nikom in Chanwat Lopburi for the upstream site and Amphoe Kan Koy in Chanwat Saraburi for the downstream site. In each site, various scales of dam are technically possible. The selection of site and scale depend on the purpose and concept of planning the dam. According to a preliminary study conducted by the RID, the characteristics of dam and associated data are presented in Table 3.1 and Table 3.2.

This preliminary study selected the upstream site for Pasak dam location with the following reasons (i) Foundation problem seems to be less for the upstream site since the Kang Koy site is limestone area. (ii) More villages, temples, and public facilities will be under the water if dam is built at the downstream Kang Koy site. (iii) More benefits will be brought to upland area of UCR if dam is built at the upstream of Pattana Nikom site.

Among various alternatives of dam at Pattana Nikom site, the following planning concepts and objectives were applied for the selection of dam scale in this preliminary study.

1) Minimize social conflicts arising from inundation of human settlement and public facilities.

2) Enhance agriculture in the basin by developing many small and medium scale water resources. Medium scale reservoirs in upstream tributaries will also help reduce floods in the BMR.

Table 3.1 Pasak Dam Alternative Schemes at Pattana Nikom

Location	Amphoe: Pattana Nikom			Province: Lopburi	
Alternatives	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Storage level	35 m	36 m	37 m	40 m	42 m
Catchment area	12,420 km2	12,420 km2	12,420 km2	12,420 km2	12,420 km2
Av. rainfall/yr.	1,199 mm	1,199 mm	1,199 mm	1,199 mm	1,199 mm
Potential evap./yr.	1,716 mm	1,716 mm	1,716 mm	1,716 mm	1,716 mm
Av. inflow into resersoir/yr.	2,268 MCM	2,268 MCM	2,268 MCM	2,268 MCM	2,268 MCM
Length of dam	1,000 m	1,060 m	1,120 m	1,300 m	1,600 m
Height of dam	26 m	27 m	28.0 m	31 m	33 m
Width of dam	9.0 m	9.0 m	9.0 m	10 m	10 m
River bed level (MSL)	12 m	12 m	12 m	12 m	12 m
Lowest water level:LWL (MSL)	28 m	28 m	28m	28 m	28 m
Storage level:SL (MSL)	35 m	36 m	37 m	40 m	42 m
Highest water level:HWL (MSL)	36 m	37 m	38 m	41 m	43 m
Dam crest level (MSL)	38 m	39 m	40 m	43 m	45 m
Dead storage (MCM)	52 MCM	52 MCM	52 MCM	52 MCM	52 MCM
Storage at SL (MCM)	155 MCM	185 MCM	225 MCM	365 MCM	464 MCM
Maximun storage at HWL (MCM)	185 MCM	225 MCM	265 MCM	415MCM	510 MCM
Water surface area at LWL	9.5 km2	9.5 km2	9.5 km2	9.5 km2	9.5 km2
	5,938 rai	5,938 rai	5,938 rai	5,938 rai	5,938 rai
Water surface area at SL	23 km2	37 km2	50 km2	93 km2	132 km2
	14,375 rai	23,125 rai	31,250 rai	58,125 rai	82,500 rai
Water surface area at HWL	37 km2	50 km2	64 km2	110 km2	161 km2
	23,125 rai	31,250 rai	40,000 rai	68,750 rai	100,625 rai
Irrigable area in rainy season	100,000 rai	129,000 rai	167,000 rai	300,000 rai	400,000 rai
Irrigable area in dry season	33,000 rai	43,000 rai	56,000 rai	100,000 rai	130,000 rai
Railway length flooded	2.5 km	4.0 km	5.0 km	16.2 km	17 km
Number of villages flooded	5	6	6	25	28
Number of schools	0	2	3	8	11
Number of temples	0	1	2	8	11
Number of health stations	0	1	1	2	3
Number of bridges	0	1	1	3	4
Number of police stations	0	1	1	2	3
Number of railway stations	0	0	2	2	2

Table 3.2 Pasak Dam Alternative Schemes at Kang Koy

Location	Amphoe:Kang Koy	Province: Saraburi	
Alternatives	Alternative 1	Alternative 2	Alternative 3
Storage level	34 m	40 m	42 m
Catchment area	14,260 km2	14,260 km2	14,260 km2
Av. rainfall/yr.	1,199 mm	1,199 mm	1,199 mm
Potential evap./yr.	1,716 mm	1,716 mm	1,716 mm
Av. inflow into resersoir/yr.	2,604 MCM	2,604 MCM	2,604 MCM
Length of dam	390 m	410 m	430 m
Height of dam	29 m	35 m	37 m
Width of dam	9 m	10 m	11 m
River bed level (MSL)	8 m	8 m	8 m
Lowest water level:LWL (MSL)	28 m	28 m	28 m
Storage level:SL (MSL)	34 m	40 m	42 m
Highest water level:HWL (MSL)	35 m	41 m	43 m
Dam crest level (MSL)	37 m	43 m	45 m
Dead storage (MCM)	60 MCM	60 MCM	60 MCM
Storage at SL (MCM)	438 MCM	1,300 MCM	1,924 MCM
Maximun storage at HWL (MCM)	530 MCM	1,600 MCM	2,270 MCM
Water surface area at LWL	25 km2	25 km2	25 km2
	15,625 rai	15,625 rai	15,625 rai
Water surface area at SL	76 km2	210 km2	270 km2
	47,500 rai	131,250 rai	168,750 rai
Water surface area at HWL	89 km2	237 km2	303 km2
	55625 rai	148,125 rai	189,375 rai
Irrigable area in rainy season	500,000 rai	1,200,000 rai	1,200,000 rai
Irrigable area in dry season	250,000 rai	400,000 rai	1,000,000 rai
Railway length flooded	19 km	36 km	46 km
Number of villages flooded	35	65	72
Number of schools	8	19	20
Number of temples	8	17	17
Number of health stations	1	3	3
Number of bridges	1	4	5
Number of police stations	1	3	3
Number of railway stations	3	6	6

3) Prepare water resource with the framework of UCR development plan such that the storage is able to provide urban and industrial water to Greater Saraburi Industrial Core (GSIC).

4) Although a large size reservoir will be beneficial for flood protection in BMR, flood protection should not be coped only by a large reservoir but it should be done also by watershed management, such as reforestation. Flood protection should be looked at from a basin-wide macroscopic view point. Watershed management augments low flow in a dry season and it has the same benefit as a large storage reservoir. Without such a measure, a large reservoir will be filled with sediment and the life of the reservoir becomes short.

3.1.2 Selected Alternative of Pasak Dam

Based on these planning concepts, this preliminary study did not employ a large size alternative to formulate a model, but employed a smaller scale dam: the storage level of 35 meter. Features of the dam with selected scale are shown in the Table 3.2. The active storage is 103 million cubic meter with storage level of 35 meter and highest water level of 36 meter above the mean sea level. This will inundate the area of 37 km^2 at the highest water level causing minimal damages to existing settlement and public facilities as shown in the table.

3.1.3 Needs of Low Flow Augmentation and Water Demands

Due to deforestation of Pasak River basin in the past few decades, base flow in the dry season period became low: below 10 m^3/sec for 3 to 5 months most of years; and as low as 2 - 3 m^3/sec for less than one month was observed for three dry seasons in the past 15 years record from 1973 to 1987. If daily flow is examined, occurrence of below 2 m^3/sec is observed in three years and below 3 m^3/sec in 9 years, both during the past 15 years.

1) Water demand for Lopburi upland

In order to implement the Pasak dam project, resettlement scheme will be essential. The best location to resettle villagers would be around the reservoir areas where water can be supplied by pumping from the

reservoir. Considering the resettlement scheme explained later, 78 km^2 must be developed as a well irrigated land to accommodate people coming from inundating areas. To develop 78 km^2 water supply of 3 m^3/sec will be necessary for the upland of Lopburi province. The total volume for 4 months becomes 23 MCM.

During of wet season, water should be pumped to the upland areas for irrigation water. The water may be used as supplementary irrigation water and it will make farming activities more stable than before. This amount of wet season water was not included in water requirement since water in wet season is abundant in Pasak River.

2) Water demand for Ban Moh-Kang Koy project

A feasibility study of Ban Moh-Kang Koy project was made in 1981, however, its implementation was postponed due to insufficiency of irrigation water. When Pasak dam project is implemented there will be water available in Pasak river even for dry season. The Ban Moh-Kang Koy project has planned area of 17,500 rai for dry season paddy irrigation. This will require approximately 3 m^3/sec for high demand season and 50 MCM for the whole growing season.

3) Water demand for GSIC urban center

Major cities in the GSIC area are Nong Khae, Saraburi, Kaeng Koy, Ban Mo, and Tha Rua. These urban centers currently intake water from Pasak River and irrigation canals: Saraburi, Kaeng Koy from Pasak River and Nong Khae, Ban Mo, and Tha Rua from irrigation canals.

Provincial Waterworks Authority's forecast for these municipalities for urban water supply in 2012 are 1,997 m^3/hour equivalent to 0.55 m^3/sec, where total population is estimated as 150,000 people. As major industrialization is going to take place in the area, the total population of the GSIC area is assumed approximately 350,000 people (see Vol. 2 of Spatial Framework for Development and Urban Management). This will require 1.3 m^3/sec for urban water supply. Part of this amount may be withdrawn from irrigation canal, however, most of this will be obtained from Pasak River since the core city of Saraburi intake water from the

river. The total volume for the four months of low flow period amounts to 13 MCM.

4) Water demand for GSIC industries

Industrial water requirement was estimated for the UCR industrial sector. The estimate assumes high-tech industry will use groundwater as a source of industrial water. According to the estimation, industrial water demand in year 2010 will be 1.1 m^3/sec; however, highest demand will be 1.2 m^3/sec in year 2001, where the demand decrease from 2010 to 2001 is due to improved water use efficiency. The total volume for the four months of low flow period amounts to 12 MCM.

3.1.4 Water Allocation

In order to supply water and to augment the low flow for the UCR upland areas in Lopburi province as well as paddy area and GSIC in Saraburi province, low flow should be more than 10 m^3/sec. Assuming 103 MCM of storage is available at the beginning of low flow season, January,10 m^3/sec can be released from the reservoir up to April. This discharge and flow volume should satisfy the water demands for the economic activities of Lopburi and Saraburi provinces which will be taking place in the framework of UCR development.

Water allocation for the demands is as following:

Water demand	flow rate	4-month volume
Lopburi upland	3.0 m^3/sec	23 MCM
Ban Moh-Kang Koy project	3.0 m^3/sec*	50 MCM
GSIC urban water	1.3 m^3/sec	13 MCM
GSIC industrial water	1.2 m^3/sec	12 MCM
Total	8.5 m^3/sec	98 MCM

Note* : this is a maximum flow rate for high demand period.

Other than water supply to various economic activities, Pasak dam reservoir will facilitate waterway navigation along Pasak River by the narrow but long water surface near to Phetchabun Province.

1) Conjunctive use of various sources of water

There may be a dry year when Pasak dam reservoir is not filled up with water at the beginning of low flow season. In this case water supply from the reservoir may not be sufficient to support the economic activities at the downstream of the dam. Considering such situation, conjunctive use of various water sources such as Chainat-Pasak Canal, Pasak dam, and groundwater becomes important. Therefore, it should be encouraged not to be dependent upon only one source of water to avoid such a risk; in this respect, groundwater development by individual industry should not be discouraged as long as safe yield is observed. When surface water is abundant groundwater recharge is a good measure to reserve water; and groundwater recharge would not be difficult in Saraburi area since some groundwater comes from sinholes in a limestone formation.

3.1.5 Irrigable Area and Beneficiaries

Location of Pasak dam development is indicated in the Fig. 3.1 showing inundating and beneficiary areas. Irrigation beneficiary area includes Ban Mo-Kaeng Koy project which is listed as medium scale project in the section 3.2. The upland beneficiary areas around the Pasak dam reservoir is provided with irrigation water by pumping from the reservoir. As explained in the section of Land Use Management, the upland benefically areas are delineated by the contour lines of below 43 meter and above 36 meter. The highest water level of reservoir with the selected scale is 36 meter and water can be pumped to 43 meter contour lines of the east and west sides of river bank. The pumped water will be conveyed to the southward by a main canals along the contour lines at the both sides of river bank.

If topography is in such a way that a main canal meanders and a short-cut of the meandered canal is possible, the enclosed area between the meandered canal and the short-cut canal may be reserved as a large storage. The storage will function as a intermediate storage. By pumping water from the reservoir, water will be available all year round in the upland beneficiary area.

In order to benefit farmers in the upland, main canals and laterals should be constructed by the RID; and even ditches may be constructed by the agency.

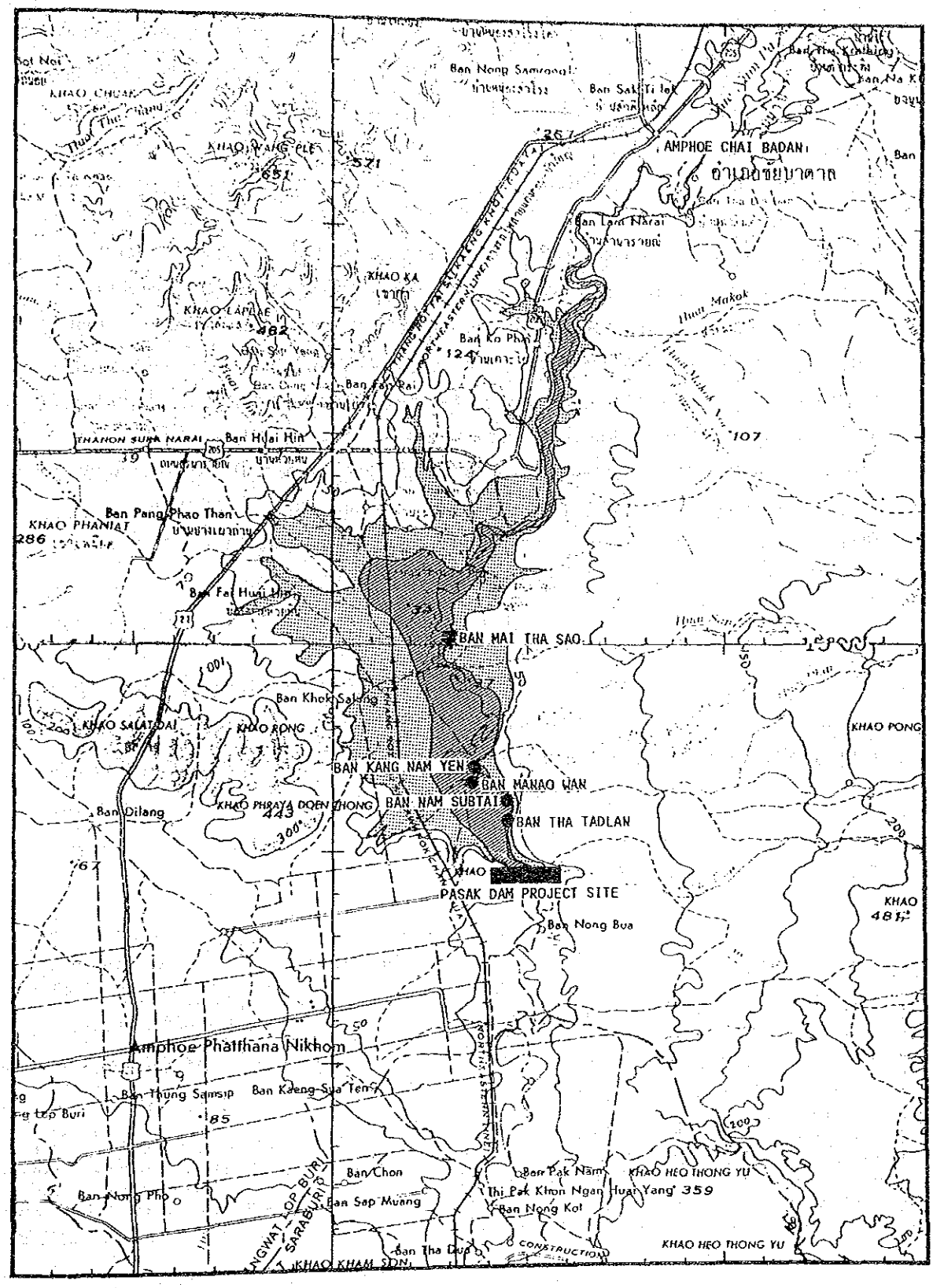


Fig. 3.1 Inundating and Beneficiary Area by Pasak Dam

This scheme is proposed as a special land reform and a land consolidation program as explained later in this chapter. Such ditches should be connected with farm ponds and raised-bed cultivation farms.

3.1.6 Environmental Consideration

No deforestation is expected by the Pasak dam inundation. Some data at the inundation area is listed in Table 3.1 and 3.2. By the up-coming feasibility study, environmental assessment will be made. It should be mentioned that basin-wide environmental base line study may be carried out as a part of the environmental assessment, particularly for the natural resources of forest, soil and water. This is important because one of reasons that the UCR study proposes Pasak basin development program is to improve the environment for human activities in the basin. For example, sediment yield is 46 tons /km^2/year according to a RID report; and this amount should be greatly reduced by implementing Pasak basin development program.

3.2 Medium Scale Projects

Medium scale projects are implemented by RID and similar schemes to large scale project, such as Pasak dam project, are applied to medium scale projects.

Table 3.3 Pasak River Basin Medium Scale Project

Project	Location		Type of work	Capacity of storage (MCM)	Irrigable area (rai)	Period of construction	Const. cost (million B.)
	Amphoe	Province					
Existing							
1 Klong Priow	Nong Sang	Saraburi	weir	-	91,900	1955-1973	
2 Huey Som	Pattananikom	Lopburi	reservoir	12.5	9,000	1956-1958	
3 Sao Hai	Sao Hai	Saraburi	pumping st.	-	434,000	1970-1981	
4 Sub Takien	Chaibadan	Lopburi	reservoir	8.6	9,000	1985-1990	128
Under construction							
5 Lam Sonthi	Chaibadan	Lopburi	weir	-	45,000	1990-1992	280
Potential sites							
6 Ban Moh-Kang Koy	Kang Koy	Saraburi	pumping st.		88,500	unscheduled	1000
7 Hua Hin		Lopburi	reservoir	3.4	2,400	unscheduled	unknown
8 Wang Kan Luang		Lopburi	reservoir			unscheduled	unknown
9 Khao Pang Hei		Lopburi	reservoir	40	16,000	unscheduled	unknown
10 Kud Ta Pet	Chaibadan	Lopburi	reservoir	32	40,000	unscheduled	unknown

Table 3.3 shows potential medium scale projects in Pasak River basin and locations of the projects are shown in Fig. 3.2. For implementation of medium scale project, priority may be necessary to be attached to each project. High priority should attached to projects which include beneficiary areas where paddy and a weir exist without storage facilities, resulting no water available in a dry season. In such a area, project implementation will stabilize water supply and enhance wet and dry season cultivation.

In upland areas, farm ponds should be constructed by farmers themselves as proposed in the Part I. Such farm ponds should be connected with irrigation canals implemented under the medium scale projects.

Coordination among large scale, medium scale, and small scale projects have to made. This is particularly important not to cause duplication of development efforts as well as to enhance complementary relations or effects among projects. It was found that medium scale projects listed in Table 3.3 are not located inside of the upland beneficiary areas of Pasak dam.

3.3 Small Scale Projects

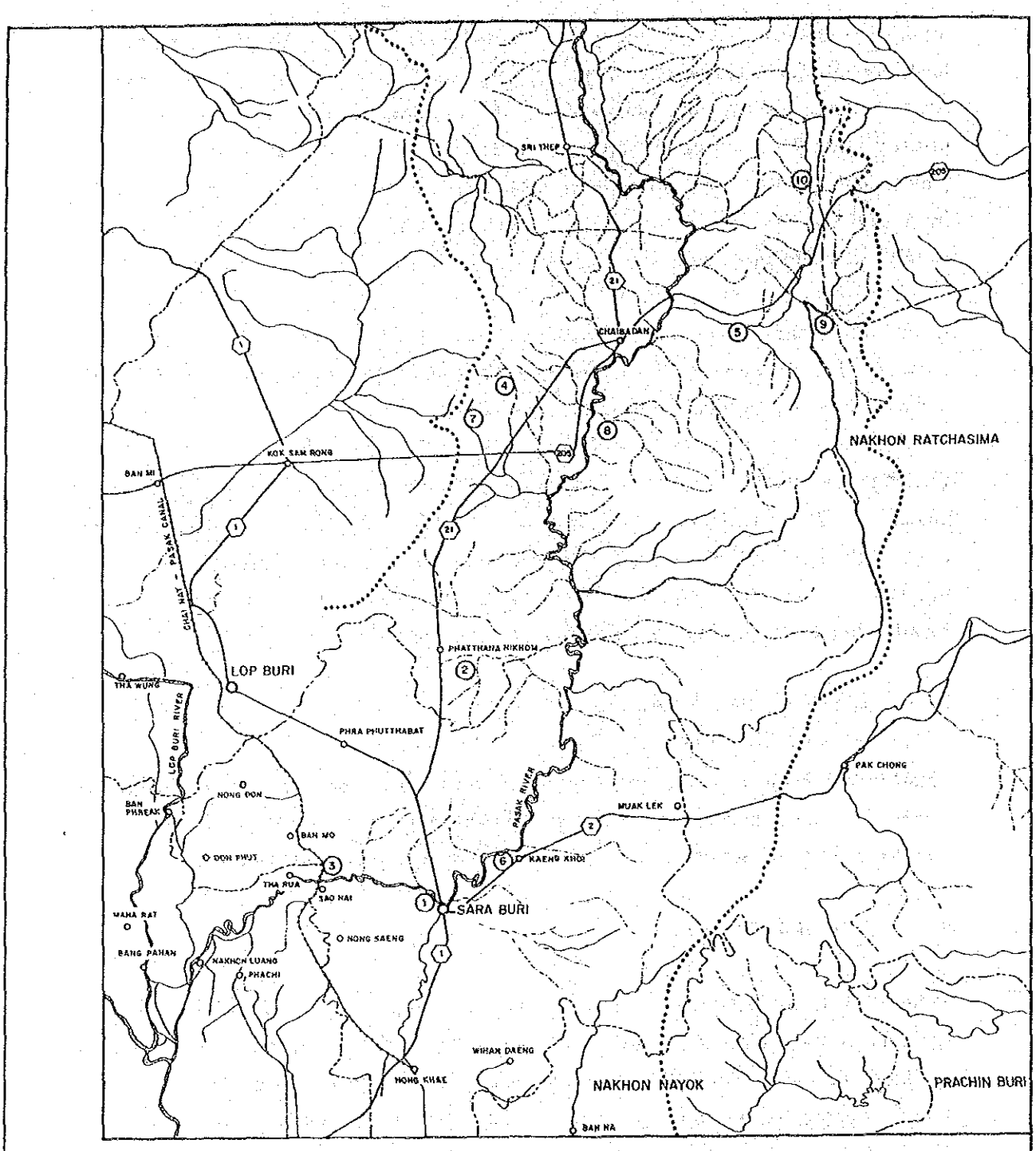
Small scale projects serve for domestic water needs and wet season irrigation. There are many small scale projects without any water available in dry season due to a lack of water storage with sufficient size of catchment area.

3.3.1 Potential Projects

Table 3.4 shows potential small scale projects with the names of villages and districts. The projects in the table were among those requested, in principle, by local people. The RID Region 8 Office has examined requested projects and listed technically feasible projects. There are many implementing agencies involved in small scale projects. There would be many more potential sites for small scale projects, which farmers have made requests and will make requests in the future.

3.3.2 Satisfying On-farm Needs

Small scale projects should incorporate individual farmer's farm pond or storage in order to satisfy individual farmer's need. Such a farm storage



LEGEND :

- CHANGWAT LOCATION
- AMPHOE LOCATION
- CHANGWAT BOUNDARY
- ROAD
- RIVER
- CANAL
- PASAK BASIN AREA
- ① ~ ⑩ MEDIUM SCALE PROJECTS

Fig. 3.2 Location of Medium Scale Projects

should be as deep as at least 6 to 7 meters and a farm storage may occupy approximately 1 rai in 17 rai of cultivated land. Storage may be such a type of raised bed cultivation with water surface.

3.3.3 Coordination among Projects

Coordination among large scale, medium scale, and small scale projects have to made, particularly for beneficiary areas, in implementation. It was found that six potential small scale projects were found inside of the upland beneficiary areas of Pasak dam; and they are indicated in Table 3.4. It will be necessary to look into details of these small scale projects whether the projects could be duplication of development efforts or complementary with Pasak dam project.

Table 3.4 Small Scale Water Resources Projects in Pasak Basin

Project Name	Location			Project Type	Location
	Mu Village	Sub-District	District		
Ban Subtakien Noi Reservoir	2 Subtakien Noi	Subsomboon	Lumsonthi	Small	
Kao Noi Reservoir	6 Kao Noi	Subtakien	Chaibadan	Small	
Klong Tago Weir	6,7 Klong Tago	Nikomnarai	Chaibadan	Small	
Dredge Ban Subyang Reservoir	3 Subyang	Silatip	Chaibadan	Improve exsisting	
Dredge Kratum Swamp	4 Ta Madue	Nong Yai To	Chaibadan	Movil Service Center	
Dredge Hangtalad Swamp	9 Subpasuk	Silatip	Chaibadan	Movil Service Center	
Puek-o Dredging	2 Tasam	Ta Dindum	Chaibadan	Movil Service Center	
Dredge Huoy Takro Canal	2 Koh Rung	Koh Rung	Chaibadan	Movil Service Center	
Dredge Sublungka Canal	- -	Koh Rung	Chaibadan	Movil Service Center	
Dredge Kung Canal	1 Buachoom	Buachoom	Chaibadan	Movil Service Center	
Dredge Nongrakum Swamp	1 Buachoom	Buschoom	Chaibadan	Movil Service Center	
Ban Kaotambol Reservoir	2 Kaotambol	Nasom	Chaibadan	Movil Service Center	
Dredge Hinrap Canal	4 Subkaomaew	Buachoom	Chaibadan	Movil Service Center	
Dredge Lumnarai Canal	7 Sapankao	Lumnarai	Chaibadan	Movil Service Center	
Dredge Sungbadal Swamp	7 -	Chaibadal	Chaibadan	Movil Service Center	
Dredge Klongtakien Weir	4 Subkaomaew	Buachoom	Chaibadan	Movil Service Center	
Construct a pond	7 Raipattana	Nikomnarai	Chaibadan	Movil Service Center	
Construct a supply canal	2 -	Ta Dindum	Chaibadan	Movil Service Center	
Ban Kaewsamduang Reservoir	2 Kaewsamduang	Chainarai	Chaibadan	Movil Service Center	
Dredge Puk Chado			Chaibadan		in beneficiary area
Dredge Huay na Canal	2 Makokwan	Makokwan	Chaibadan	Movil Service Center	in beneficiary area
Huay Ploo Weir	Manaowan		Pattananikom	Existing	in beneficiary area
Ban Manao Wan weir	Manao Wan		Pattananikom	Existing	in beneficiary area
Lam Goad Thong Weir			Chaibadan	Existing	in beneficiary area
Huay Phai Weir	Chaibadan		Chaibadan	Existing	in beneficiary area
Dredge Puk Yai	Chaibadan		Chaibadan	Existing	in inundating area
Dredge Nong Bua Swamp	Makok Wan		Chaibadan	Existing	in inundating area
Huay Yai Reservoir	7 Coke Sa-ad	Muangkom	Chaibadan	Movil Service Center	
Dredge Pukvan Swamp	1 Nong Pukvan	Nong Pukvan	Ta Luang	Movil Service Center	
Dredge Songton Swamp	2 Nong Pradu	Nong Pukvan	Ta Luang	Movil Service Center	
Dredge Sang Swamp	4 Hua Lum	Hua Lum	Ta Luang	Movil Service Center	
Dredge Jan Swamp	5 Nong Jan	Hua Lum	Ta Luang	Movil Service Center	
Dredge Po Ku Swamp	2 Bo Ku	Ta Luang	Ta Luang	Movil Service Center	
Kao Saladdai Reservoir		Silatip	Chaibadan	Small	
A reservoir	4 -	Huoy Hin	Chaibadan	Small	
Lumphrayamai Project	4 Sub Kaomaew	Buachoom	Chaibadan	Tend to be a medium size project	
Kao Lakkal Reservoir	13 Coke Samaesan	Mahapote	Srabos	Tend to be a medium size project	

Considering the nature of small scale projects, it is expected that most of the projects would be complementary with Pasak dam project. This is because small scale projects do not have storages with sufficient catchment yielding reliable amount of water all year round and water supply from Pasak dam reservoir can provide the small scale projects with reliable water.

Small scale projects should not be implemented in inundating area of large and medium scale projects since development efforts will be wasted in the future. In this table,two of the small scale projects were found in the inundating area of Pasak dam.

3.4 Land Use Management

3.4.1 Land Suitability in the Basin

Pasak River basin, in the UCR, includes two provinces of Lopburi and Saraburi. Land use suitability in the provinces is shown in the Table 3.5. This indicates agricultural development taken place by the large, medium and small scale water resources development can be directed more toward upland crop rather than paddy. Land use management of upland area including Pasak basin is explained in Part III of this report. The rest of this section is devoted in a resettlement scheme for the Pasak dam project.

3.4.2 Land Suitability in the Pasak Dam Project Area

Pasak dam project area is defined as 161 km^2 and it is shown in the Fig. 3.1. The area is delineated by the contours below 43 meter. Land suitability of the project area is shown below:

Land use suitability	Percentile	
Paddy	22 km^2	14 %
Upland crop	114 km^2	71 %
Paddy and upland crop	2 km^2	1 %
other	23 km^2	14 %
	161 km^2	100 %

In the project area, 37 km^2, which is below 36 meter contour, will be inundated by the reservoir; and 124 km^2, which is above 36 meter and below 43 meter,

Table 3.5 Land Use Suitability of the District in Pasak Basin

Unit : 1000 rai

Name of Provinces and Districts	Area Total (1,000rai)	Paddy	Upland Crop	Paddy & Upland Crop	Not Suitable
LOP BURI					
Chai Badan	1,069.2	113.5	745.8	16.9	193.0
Phattahana Nikhom	325.2	78.7	210.9	5.1	30.5
Tha Luang	314.5	41.0	251.2	1.9	20.3
SARA BURI					
Muang Sara Buri	314.9	189.1	32.4	14.8	78.6
Kaeng Khoi	544.4	47.2	191.0	50.1	256.1
Ban Mo	174.4	159.3	15.1	0.0	0.0
Muak Lek	470.3	8.8	241.9	12.2	207.5
Sao hai	78.2	73.1	1.5	3.6	0.0
TOTAL	3,291	711	1,690	105	786
	(100%)	(22%)	(51%)	(3%)	(24%)

Source : LDD soil map

Table 3.6 Population Density of District in Pasak Dam Project Area

Name of Provinces and Districts	Area (1000rai)	Population,1980 (Persons)	Pop. Density Persons/Sq.km)
LOP BURI	0.00		
Chai Badan	1,069.20	98,081	57
Phattahana Nikhom	325.16	50,404	97
TOTAL	1,394	148,485	67

Table 3.7 Land Tenure of Districts in Pasak Dam Project Area

Kind of tenancy / District	Most villagers have title deed	Most villagers have Nor Sor3 or Nor Sor3 Kor	Most villagers have Sor Kor1, Sor Tor Kor or no evidence of tenancy
Chai Badan	1%	40%	59%
Phattahana Nikhom	42%	35%	23%

Source: Rural Data Base for Accelerated Rural Development Program, 1987.

will be the upland beneficiary areas. It is intended to provide water to the beneficiary area by pumping from the reservoir. Most of the inundating area is suitable for paddy and beneficiary area is suitable for upland crops. In the area of 124 km^2, there are some areas, such as mountains, which are not suitable for cultivation; this amounts to 23 km^2. Therefore, beneficiary area suitable for cultivation is 124 km^2 minus 23 km^2: 111 km^2.

3.4.3 Land Reform and Consolidation Program

1) Resettlement area

In order to implement Pasak dam project it is necessary to resettle people living in the inundating area. The best place for such resettlement would be near the places where they used to live, such as east and west banks of the river. Therefore, the resettlement may take place from the inundating area to the beneficiary area. There are already settlement and farm land in the beneficiary area; and the resettlement to such area should involve land reform and land consolidation. Assuming resettlement will be conducted in this way, the project area for land reform and consolidation program is 111 km^2.

2) Resettlement scheme

Land tenure of the Pasak dam project area of 161 km^2 has to be estimated for resettlement planning. It is assumed that land tenure is homogeneous in the districts of Lopburi province: percentage of different land title holders in the project area is the same as that of the districts. Similar assumption was made for population density. Population density of three districts is shown in Table 3.6 and the land tenure of the project area is shown in Table 3.7. From the table the population involved in the resettlement in 161 km^2 is calculated as approximately 11,000 people (161 km^2 x 67 people/km^2). Assuming the families engaged in farming activities are 80 percent of total families, the number of people becomes 8,800 people. Number of people in the inundating area is approximately 2,500 people (37 km^2 x 67 people/km^2).

The beneficiary area of 111 km^2 is reduced to 77.8 km^2 assuming the net

area under cultivation is 70 percent, which is approximately 50,000 rai. Per capita cultivation area is, therefore, 5 to 6.25 rai (50,000 rai/10,000 to 8,000 people). One farm family can own a net cultivated area of 25 to 31.25 rai if one family has five persons. Under the implementation of land reform and land consolidation applied to the 161 km^2 of project area, all the farm family are to own, on an average, 25 to 30 rai equipped with irrigation water all year round, which will be a sustainable farm scale.

Since inundated area of 37 km^2 is approximately 23 percent of total project area of 161 km^2, the people already settled in the beneficiary area will lose approximately one forth of cultivated area. According to the Agriculture Land Consolidation Act, the size of reduction due to land consolidation will not be more than 7 percent where 25 percent is much more than the regulation; and the government has to compensate the rest of 18 percent. The land reform and land consolidation program for the Pasak dam project may be carried out totally by governmental finance although current practice of land consolidation is financed partly (50 % of construction cost) by farmers themselves. If this scheme is carried out, government can implement the Pasak dam project and farmers settled in inundating area and both banks without irrigation water can obtain land with full land tenure and equipped with irrigation water. Productivity of farm land will be increase and stabilized, and the increased benefit should worth more than the reduction due to land consolidation.

3) Special considerations required for resettlement

In the past land consolidation has been conducted for paddy land, and the proposed scheme for Pasak dam project is mainly for upland crop field. Implementation of such land consolidation may require special legislations, more detail explanation and proposals are found in Land Use Management of Part III.

Several points should be mentioned as important considerations to implement the proposed land reform and consolidation program.

- Destruction of consolidation in rural communities.

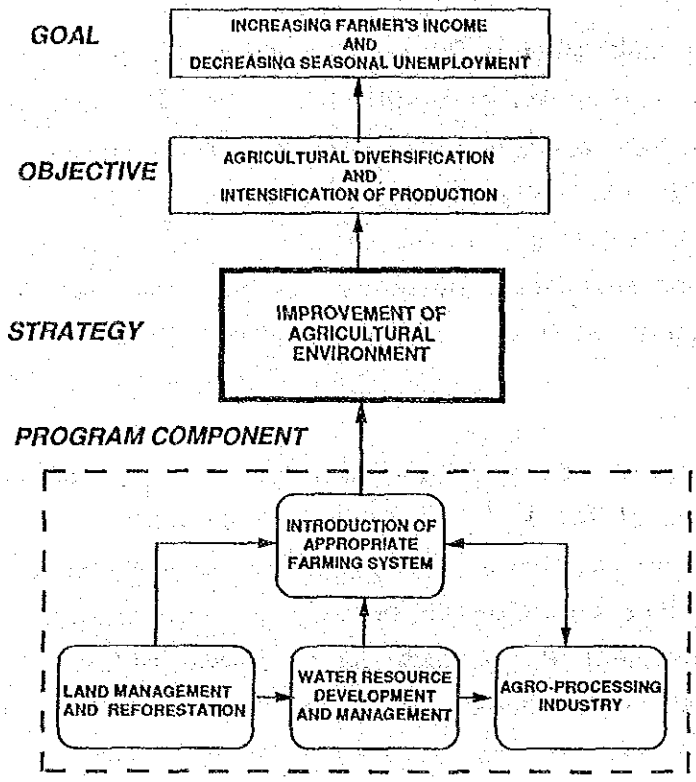


Fig. 3.3 Pasak River Basin Agriculture Development Concept

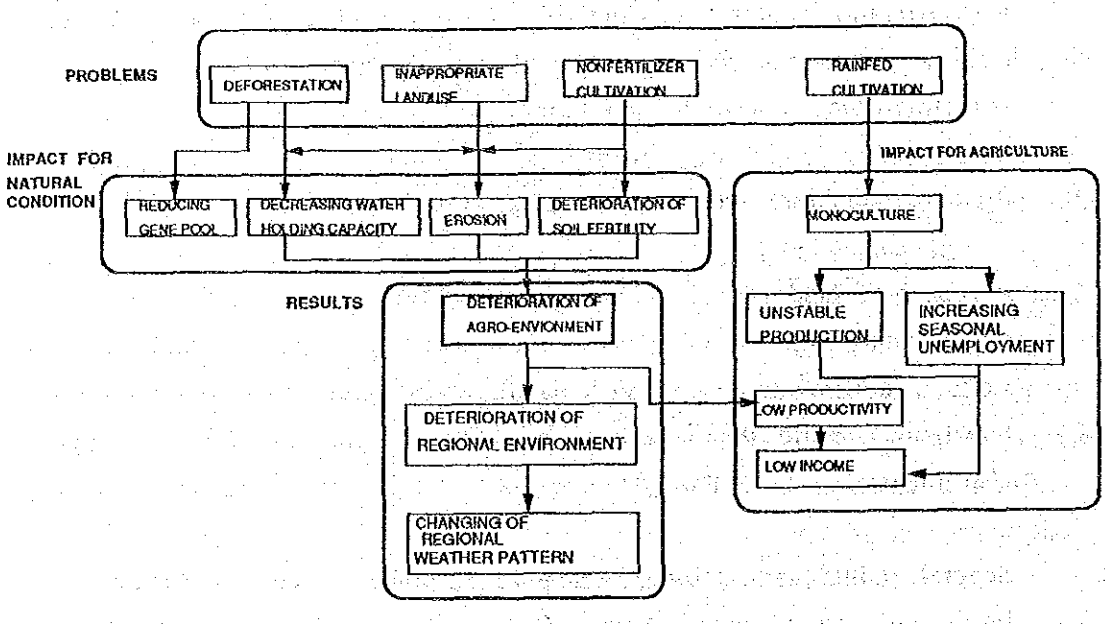


Fig. 3.4 Existing Farming

- Equity consideration in case a land holding size varies among farmers.
- Equity consideration in case land productivity varies among farm lands.
- Evaluation of land titles for farmers with no evidence of tenure.
- Amount of compensation necessary for resettlement.

3.5 Proposed Farming System

Environmentally sound agricultural farming system will be realized by implementing various water resources projects proposed in this chapter. First, Improvement of agricultural environment will be realized by water related projects and agro-forestry for erosion area rehabilitation.

The concept of Pasak River basin agricultural development is shown in Fig. 3.3. Existing farming practice and its effects is shown in Fig. 3.4. Farming system to be employed and its effects in the basin is shown in Fig. 3.5. Crop diversification should be introduced in the basin with tree crops, livestock and fishery. In the field crop area subject to soil erosion at present, agro-forestry should be introduced. More details of such farming system is found in Part IV of this report.

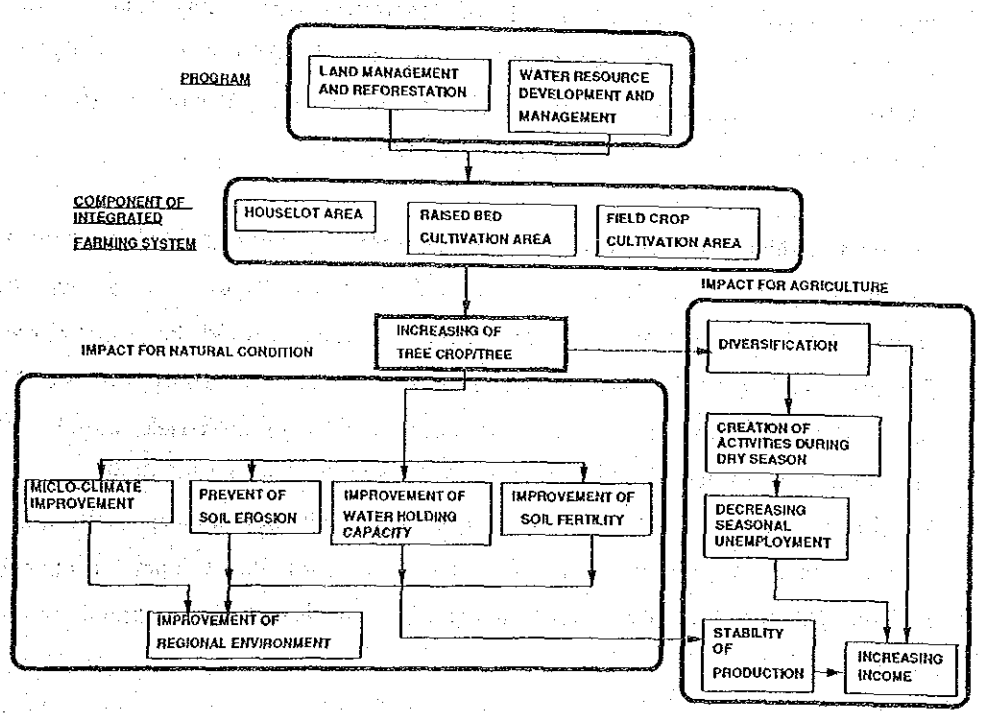


Fig. 3.5 Effects of Integrated Farming System

3.6 Cost Estimate

Pasak dam project cost may be nearly one billion baht including compensation cost for public facilities and resettlement. In this amount, dam itself is about 500 million bahts to construct and implementation of land reform and land consolidation costs approximately 200 million bahts (4,000 bahts/rai x 50,000 rai). The rest may be invested for pumping stations on the Pasak dam reservoir as well as main and lateral canals along the contour of 43 meters.

A medium scale water resources project cost approximately 100 to 300 million baht per project. A small scale project cost is likely to be less than 10 million baht.

3.7 Development Schedule

1) Large scale project

As regard to water resources development of Pasak dam, a schedule may proceed as follow: (i) a committee is due to set up soon; (ii) Cabinet approval of T/R may take some time; (iii) feasibility study will take at least 12 months; Cabinet approval of feasibility study may take some time; 1 years for resettlement survey and detail design; 2 years for resettlement negotiation; 5 years for construction; altogether 10 years may be necessary until water will be available.

Water demands for the GSIC area is growing; in year 2001 for example, industrial water demand will be 1.2 m^3/sec; GSIC Urban water demand could be 0.7 m^3/sec; and the total GSIC demands would be approximately 2.0 m^3/sec. Reliable flow of Pasak River would not satisfy this demand rate; and therefore, an alternative source of Chainat-Pasak canal should be looked at to supply this amount until Pasak dam is available. Pipelines between Chainat-Pasak canal and demand centers will not be wasted since the pipeline can be used even after Pasak dam is completed and conjunctive use of alternative sources is desirable as stated in the section 3.1.

2) Medium scale projects

Implementation of a medium scale project will take around 3 years to complete. Those medium scale projects listed in this chapter should be implemented as soon as possible since reliable sources of water can be secured by large and medium scale projects and also the large scale project will take rather long time to start benefit upland people.

3) Small scale projects

As regard to small scale projects, a project is completed within 1 year and such projects should be implemented according to requests by local people. While a large scale project of Pasak dam is being prepared, many small scale projects should be implemented in the upland areas. This will create demands for provision of more stable water storages, which can be realized by medium and large scale water resources projects. This will results in a desirable condition where tertiary systems exist when major facilities area completed.

4 INSTITUTIONAL ARRANGEMENT AND SET-UP FOR PASAK BASIN DEVELOPMENT

At present, there are several agencies those responsibilities are fully or partly concerned water resources development in the Pasak Basin area. A master plan for water resources utilization and development has not yet made. In order to set a policy and draw up master plan, a committee should be appointed and comprised of representatives from agencies concerned. Furthermore, in order that the water management of the basin is made efficiently, an institutional set-up needs to be formulated. This institutional set-up will take care the management of water resources for the whole basin area. It should be noted that the proposed organization is not a new agency.

4.1 Proposed Institutional Organization

Fig. 4.1 shows the proposed institutional organization for Pasak River Basin Development. The responsibility of the organization is proposed as following.

1) National Water Resource Committee has responsibility according to the Prime Minister Office Appointment dated January 10, 1990. The committee will report to the Cabinet for approval of policy concerning development of large, medium and small scale water resources projects. In summary, the committee is responsible for :

- giving guidelines to implementing agencies for planning a development program of assigned projects
- check and approve an implementation plan submitted by agencies concerned
- solve urgent problems related to a water resources development plan for implementing agencies
- set priority for water allocation from water sources in order to cope with the requirement for domestic supply, hydropower, industry, agriculture and others.

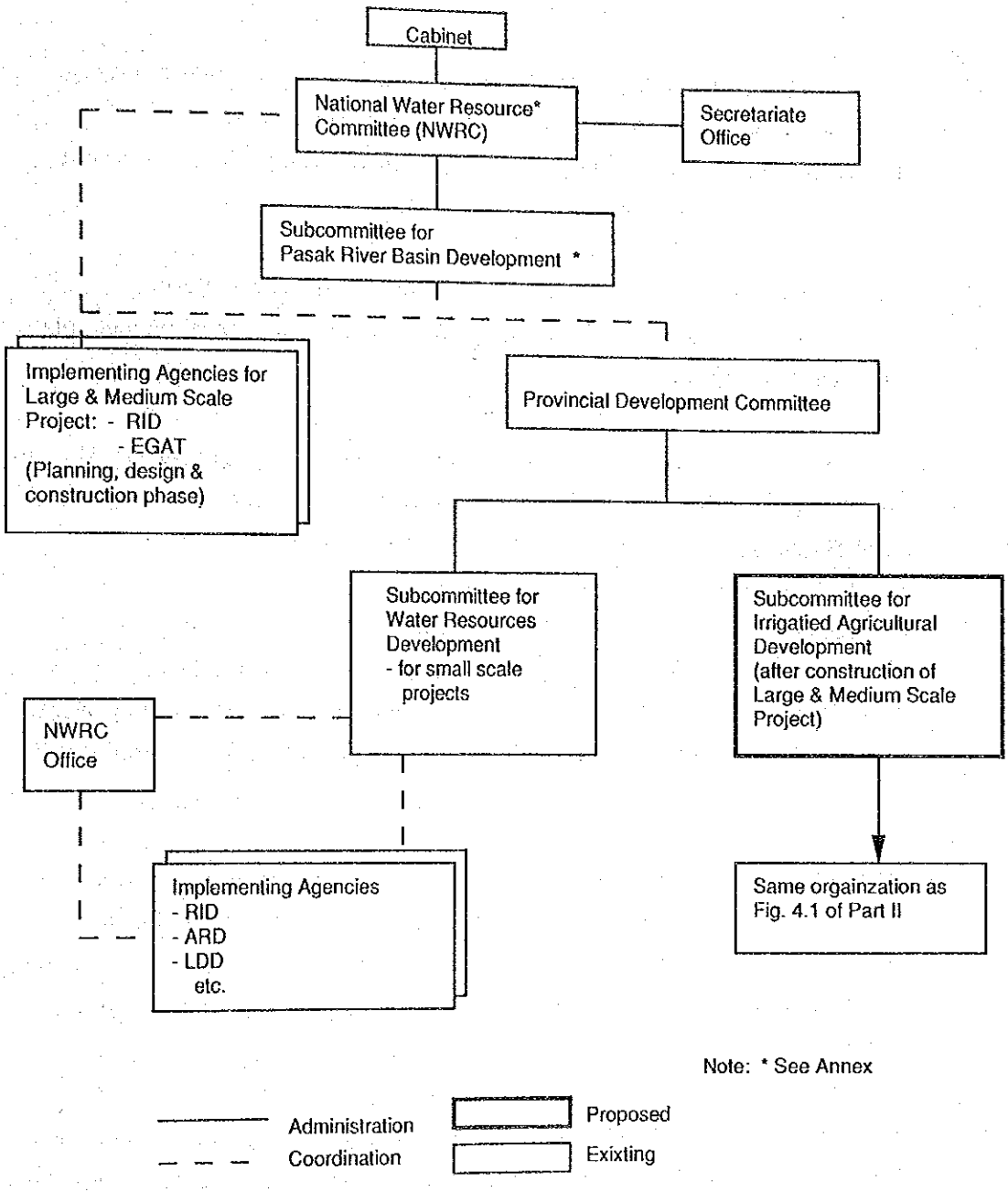


Fig. 4.1 Proposed Institutional Set-up for Pasak River Basin Development

- supervision of water quality control
- appoint subcommittee or working group for special assignment deems necessary.

2) The Pasak River Working Group was set up in 1990 as shown in annex. This working group should be upgraded to a sub-committee. Sub-committee for Pasak River Basin Development should be responsible, according to the appointment of NWRC, for :

- set up guidelines to systematically develop Pasak River Basin
- coordinate with agencies concerned for making the development plan and report to NWRC

It is proposed that the secretary of the sub-committee should be Director of Secretariat Office of NWRC or representatives in stead of Director of RID Regional 8 as appointed now as shown in Annex.

Furthermore, it is proposed that working groups under the sub-committee should be set up to work cooperatively with other components relevant to the Basin Development, i.e. land management, industrial development, agricultural development and environmental conservation.

3) After policy and guidelines are set by the Committee, it is proposed that the existing organizations and agencies such as RID should do the implementation work, i.e. planning and construction. For management, the institutional set-up as proposed in Chapter 4 of Part II will do the work.

4) For implementation of small scale projects and NEA projects, steps and process of projects request should follow the existing procedure set by National Rural Development Committee (Kor Chor Chor).

4.2 Proposed Guidelines for Solving Problems in Water Shortage and High Demand

Water shortage in dry season in the area of Pasak River Basin is not avoidable since the demand of water become greater and greater year by year. Among

those demands from several sectors, the demand for agriculture is the biggest and difficult to control. The reason is it involves many people and very large area. Therefore, the main target to solve this kind of problem is to increase the efficiency of water utilization for agricultural sector. The approach is not only saving the amount of water used in the paddy field, but also the proper diversification of agriculture to be introduced. This will result in using less water in the same size of area.

Guidelines for solving problem of water shortage and high demand are proposed as following.

1) Development of Water Storage Sites

After the policy and guidelines for development of Pasak River Basin are made, the implementation (construction) of reservoirs or storages should be carried out as soon as possible in order to cope with the demand estimated. It should be noted that the justification on whether or not to build a new project(s) should not be based on economical feasible only. Basic needs of people and social needs are also the very important factor to be accounted.

2) Improvement of Water Management for Agriculture

It is apparent that water utilization for agriculture is currently used improperly. Another words, the use of water for this sector is not optimum. Long tradition of rice cultivation with the belief of abandant water availability may be the reason of the phenomenon. Means for water management improvement are proposed as following :

(1) Establish an efficient water allocation and monitoring program for irrigation scheduling.

(2) Improve water delivery and distribution system. Existing irrigation canals, lateral, tertiaries and related structures should be maintained or upgraded into a good and operable conditions. These structures are essential tools for proper allocation and distribution of water. For new projects, careful criteria for system design should be made. The system should be capable to handle the amount of water required for all purposes.

(3) Upgrade the capability of government officials working in this field. This can be done by training, both classroom and on-the-job.

(4) Improve the operation and maintenance equipment and communication equipment/system. These equipment will help facilitate the performance of operation staff and system.

(5) Encourage field officials to work at full capacity. The agencies concerned should have a policy in such a way that their staff are alert and work efficiently.

3) Establishment and Strengthening of Water User Organization

In new project areas or existing project areas where water user organization has not been established, an attempt to establish water user organization should be made. For an existing water user organization, effort should be provided for strengthening it. Water user organization has proved in many areas that its functions will minimize water shortage satisfactorily.

4) Set Up Water Right and Emphasize on Law Enforcement

Water right should be established based on all purposes of water utilization in Thailand. There are many types of water users. Therefore, priority and allocation method should be made and formulate a regulation or law. The regulation/law will be a ground information for further planning of development and be a measure to minimize the conflict of beneficiaries. However, the law must be enforced.

5) Regional Campaign for Efficient Utilization of Water

People should be informed to be aware of water shortage problem that may occur and have negative effect to everyone, water is not properly utilized. Campaign on this matter can be done by several ways such as :

(1) Provision of informations through mass media, i.e. newspaper, radio, TV and village speaker.

(2) Establishment of Dialogue/Training Program for key people concerned such as politicians, policy makers, developers, government officers, etc.

(3) Promotion of low water consumption crops in irrigation project and to promote fruit trees for cultivated land in the catchment area.