

**THE KINGDOM OF THAILAND
ROYAL IRRIGATION DEPARTMENT
MINISTRY OF AGRICULTURE AND COOPERATIVES**

**THE FEASIBILITY STUDY
ON THE INTEGRATED AGRICULTURE
AND WATER RESOURCES DEVELOPMENT PROJECT
OF THE MENAM CHUMPHON BASIN**

MAIN REPORT



JANUARY 1993

JAPAN INTERNATIONAL COOPERATION AGENCY

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ROYAL IRRIGATION DEPARTMENT

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JAPAN INTERNATIONAL COOPERATION AGENCY

国際協力事業団

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PREFACE

In response to a request from the Government of the Kingdom of Thailand, the Government of Japan decided to conduct a feasibility study on the Integrated Agriculture and Water Resources Development Project of the Menam Chumphon Basin and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Thailand a study team headed by Mr. Kunio Ota, Sanyu Consultants Inc., three times between October, 1991 and November, 1992.

The Team held discussions with the officials concerned of the Government of Thailand, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

In wish to express my sincere appreciation to the officials concerned of the Government of the Kingdom of Thailand for their close cooperation extended to the team.

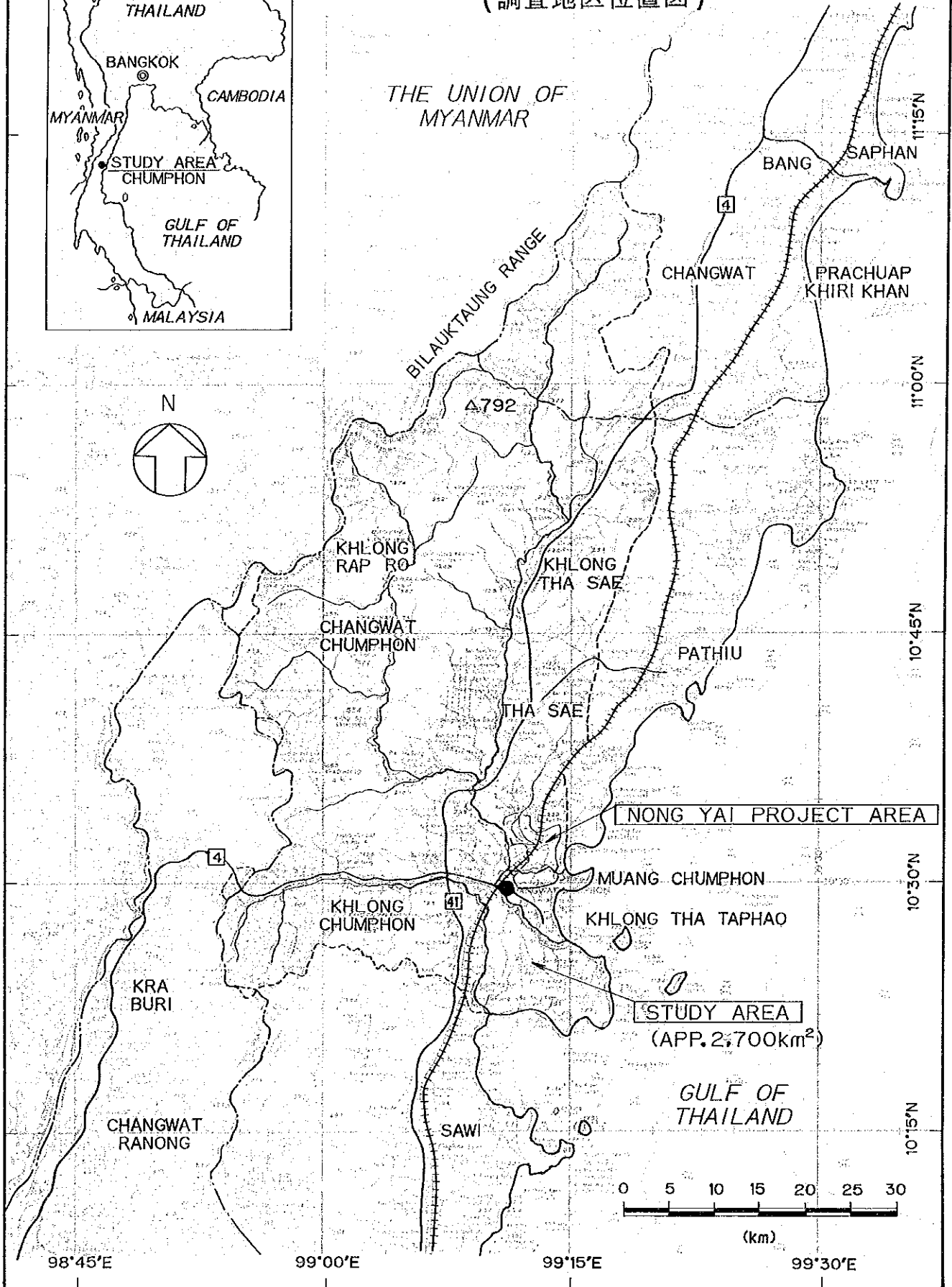
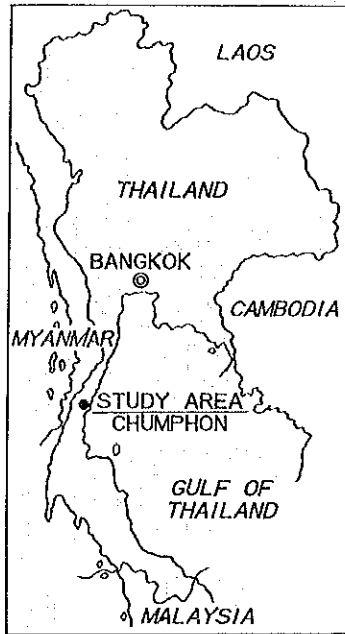
January, 1993



Kensuke Yanagiya
President
Japan International Cooperation Agency

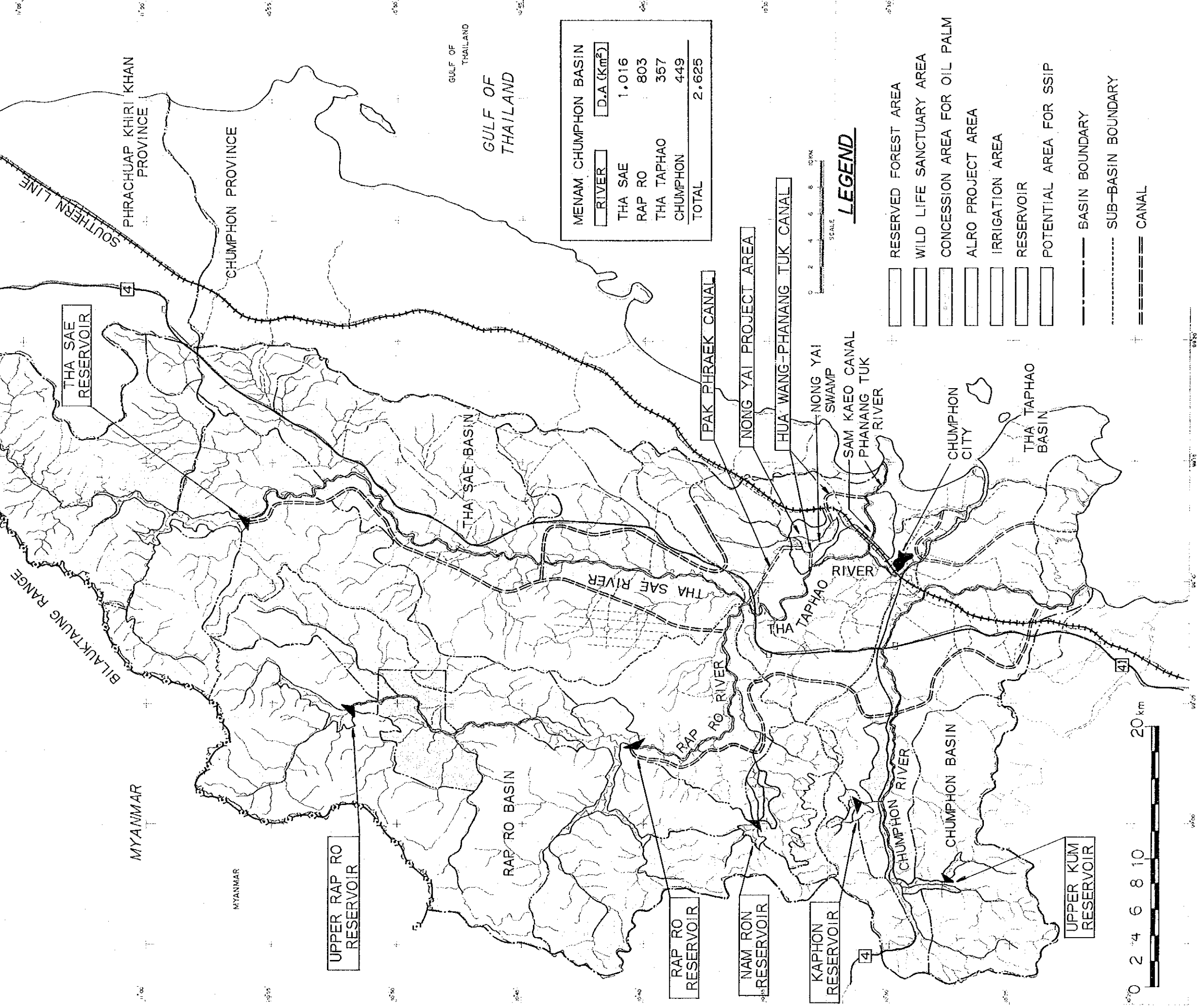
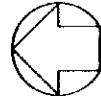
LOCATION MAP

(調査地区位置図)



WATER RESOURCES DEVELOPMENT PLAN OF THE MENAM CHUMPHON BASIN

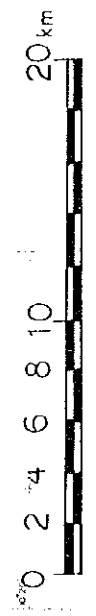
(流域水資源開發計畫一般圖)



RIVER	D.A. (Km ²)
THA SAE	1,016
RAP RO	803
THA TAPHAO	357
CHUMPHON	449
TOTAL	2,625

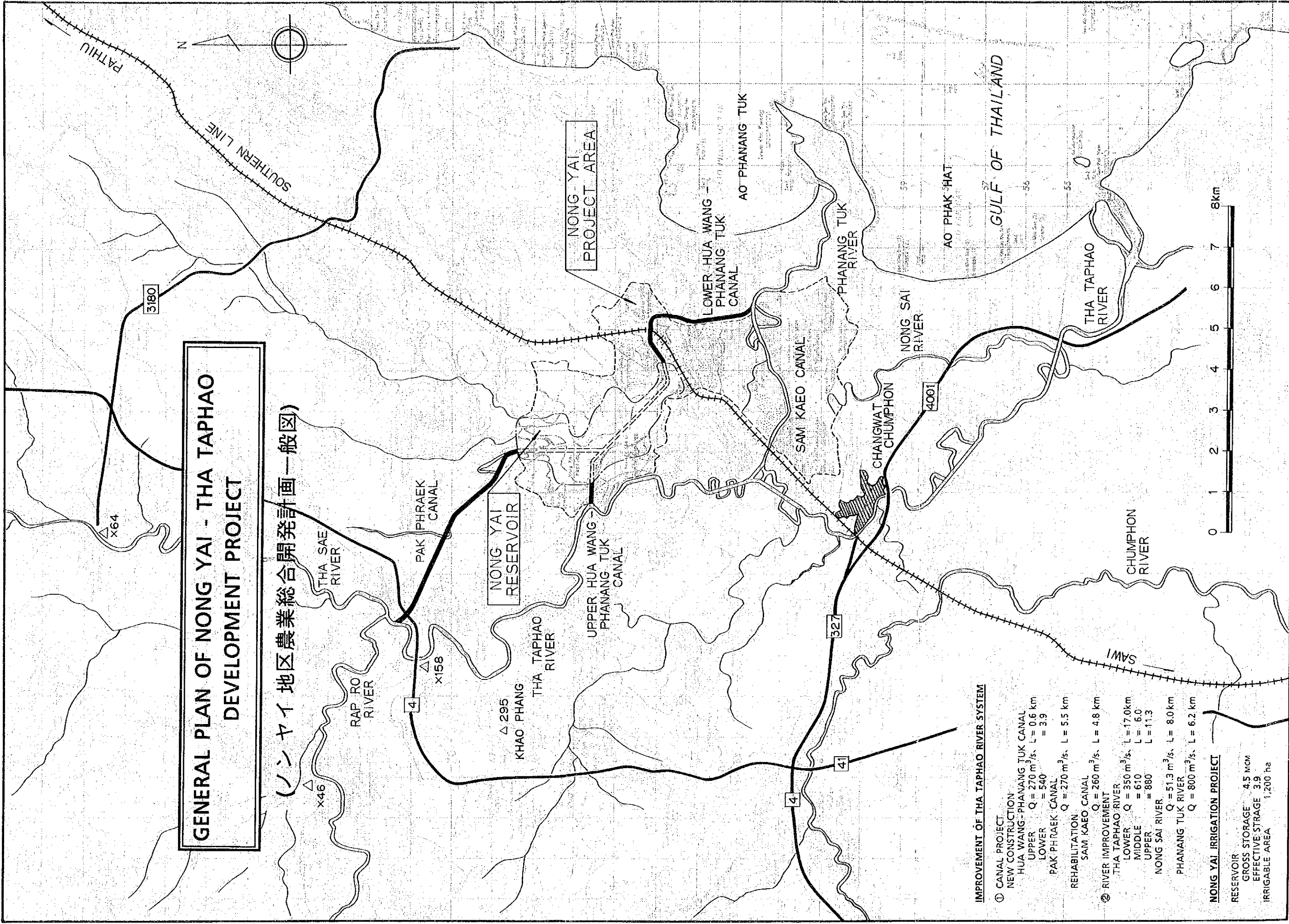
LEGEND

- RESERVED FOREST AREA
- WILD LIFE SANCTUARY AREA
- CONCESSION AREA FOR OIL PALM
- ALRO PROJECT AREA
- IRRIGATION AREA
- RESERVOIR
- POTENTIAL AREA FOR SSIP
- BASIN BOUNDARY
- SUB-BASIN BOUNDARY
- CANAL



GENERAL PLAN OF NONG YAI - THA TAPHAO DEVELOPMENT PROJECT

(ノンヤイ地区農業総合開発計画一般図)



IMPROVEMENT OF THA TAPHAO RIVER SYSTEM

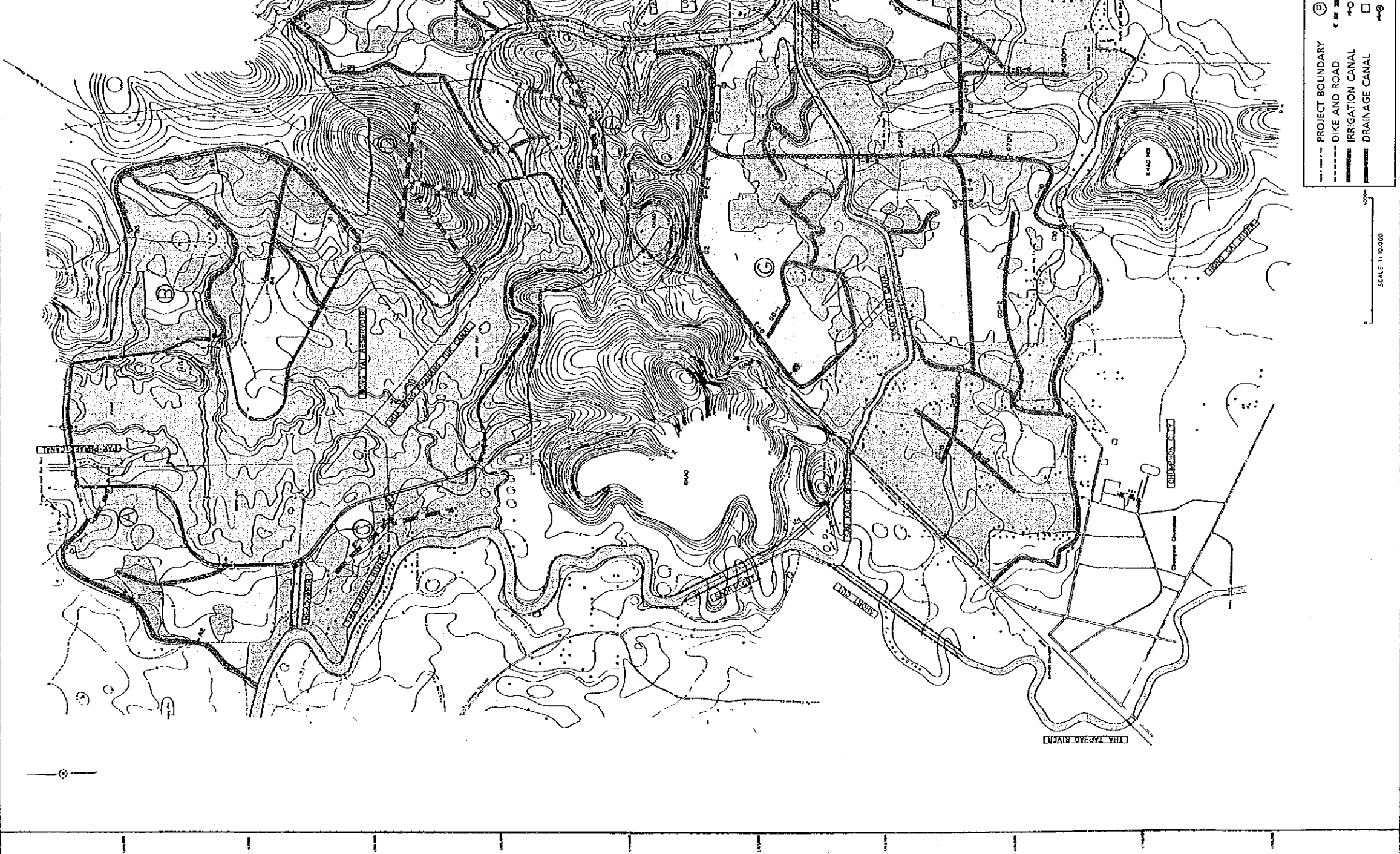
- ① CANAL PROJECT
NEW CONSTRUCTION
HUA WANG-PHANANG TUK CANAL
UPPER Q = 270 m³/s, L = 0.6 km
LOWER Q = 540 = 3.9
PAK-PHRAEK CANAL
Q = 270 m³/s, L = 5.5 km
- REHABILITATION
SAM KAEO CANAL
Q = 260 m³/s, L = 4.8 km
- ② RIVER IMPROVEMENT
THA TAPHAO RIVER
LOWER Q = 350 m³/s, L = 17.0 km
MIDDLE Q = 610 L = 6.0
UPPER Q = 880 L = 11.3
NONG SAI RIVER
Q = 51.3 m³/s, L = 8.0 km
PHANANG TUK RIVER
Q = 800 m³/s, L = 6.2 km

NONG YAI IRRIGATION PROJECT

- RESERVOIR
GROSS STORAGE 4.5 MCM
EFFECTIVE STRAGE 3.9
IRRIGABLE AREA 1,200 ha

MAJOR FEATURES OF NONG YAI IRRIGATION PROJECT

ITEM	DESCRIPTION
1) LOCATION	T. MA. CHANG, T. NATING, T. BANG LUK, A. MUANG, CHUMPHON PROVINCE
2) AREA	2,200 ha (54,100 mu)
3) RESERVOIR	102 ha, 1m
4) IRRIGATION & DRAINAGE FACILITIES	IRRIGATION CANAL : PEAK 2,405 m ³ /s DESIGN DISCHARGE : OPEN 20.1 km, PIPE 4.2 km CANAL LENGTH : PEAK 27.6 km DESIGN DISCHARGE : PEAK 27.6 c.m.s. CANAL LENGTH : 17.2 km
5) GROSS AREA	13,000 mu
6) PADDY LAND	11,000 mu
7) IRRIGABLE AREA	7,500 mu
8) WATERBURY	4.8 KM
9) RESERVOIR CAPACITY	62 m ³ M.S.L.
10) H.W.S.	4.5 m M.S.L.
11) L.V.S.	2.0 m M.S.L.
12) RESERVOIR AREA	543 ha (8,400 mu)



LEGEND

---	PROJECT BOUNDARY	⊙	PUMP STATION
---	DIKE AND ROAD	—	PIPE LINE
---	IRRIGATION CANAL	⊙	INTAKE FACILITY
---	DRAINAGE CANAL	⊙	DISCHARGE CHAMBER
---		⊙	IRRIGATION BLOCK
---		⊙	SLUICeway
---		---	PADDY
---		---	MIXED ORCHARD
---		---	OTHER

SCALE 1:10,000

GENERAL PLAN OF NONG YAI IRRIGATION PROJECT

(ノンヤイ灌漑事業計画一般図)

- LOCATION MAP
- WATER RESOURCES DEVELOPMENT PLAN
OF THE MENAM CHUMPHON BASIN
- GENERAL PLAN OF NONG YAI-
THA TAPHAO DEVELOPMENT PROJECT
- GENERAL PLAN OF NONG YAI IRRIGATION PROJECT
- LIST OF TABLES
- LIST OF FIGURES
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ABBREVIATIONS, GLOSSARY AND UNIT

AGENCIES

ALRO	Agricultural Land Reform Office, MOAC
ARD	Office of Accelerated Rural Development, MOI
BAAC	Bank for Agriculture and Agricultural Cooperatives
DA	Department of Agriculture, MOAC
DLD	Department of Land Development, MOAC
DMR	Department of Mineral Resources, MI
DOAE	Department of Agricultural Extension, MOAC
EGAT	Electricity Generating Authority of Thailand
FAO	Food and Agriculture Organization of the United Nations
JICA	Japan International Cooperation Agency
MD	Meteorology Department
MOAC	Ministry of Agriculture and Cooperatives
MOI	Ministry of Interior
NESDB	Office of National Economic and Social Development Board, Prime Minister's Office
RFD	Royal Forestry Department, MOAC
RID	Royal Irrigation Department, MOAC

OTHER ABBREVIATIONS

FS	Feasibility Study
GDP	Gross Domestic Product
GRP	Gross Regional Product
GPP	Gross Provincial Product
HYV	High Yield Varieties
LV	Local Varieties
EIRR	Economic Internal Rate of Return
NPV	Net Present Value / Net Production Value
B/C	Benefit Cost Ratio
GPV	Gross Production Value
F.C	Foreign Currency
L.C	Local Currency

C.I.F	Cost, Insurance and Freight
F.O.B	Free on Board
O & M	Operation and Maintenance
H.W.S	High Water Surface
N.W.S	Normal Water Surface
L.W.S	Low Water Surface
M.S.L	Mean Sea Level
SSIP	Small Scale Irrigation Project

GLOSSARY

Changwat	Province
Muang	Capital of Province
Amphoe	District
Tambon	Sub-district
Muban	Village
Mae Nam	Large river
Nam	A medium-size river
Lam	A small river
Kwae	A tributary of a river
Huai	A rivulet

UNIT

Rai	Unit of land measurement, 0.16ha
Baht	Unit of Thai currency
mm	Millimeter
cm	Centimeter
m	Meter
km	Kilometer
cu.m	Cubic meter
cu.m/sec	Cubic meter per second
sq.km	Square kilometer
ha	Hectare
°C	Degree centigrade
MCM	Million cubic meter

SUMMARY AND RECOMMENDATIONS

SUMMARY AND RECOMMENDATIONS

INTRODUCTION

- 01 With the objectives of firstly formulating an integrated agriculture and water resources development plan of the Menam Chumphon basin, and secondly conducting a feasibility study on a selected priority project(s), this study was implemented over 2 years from 1991 to 1992 in 2 phases. The phase I study included formulation of preliminary water resources development plans of the Menam Chumphon basin, and selection of priority projects. In the phase II study, additional field investigation was carried out for the selected priority projects, and the feasibility report has been prepared containing the results of the phase I and II study.

GENERAL DESCRIPTION OF THE STUDY AREA

- 02 The Study Area is located in the northernmost corner of Southern Thailand, about 500 km from Bangkok. The Study Area stretches over 2 provinces of Chumphon and Prachuap Khiri Khan with a total area of 2,625 sq.km. The Study Area is divided into 4 river basins of Tha Sae (1,016 sq.km), Rap Ro (803 sq.km), Chumphon (449 sq.km) and Tha Taphao (357 sq.km).
- 03 The climate of the Study Area may be classified as tropical monsoon with heavy annual rainfall and a short dry season. Annual rainfall generally decreases towards the north; the southern part of the Study Area has a rainfall of 1,900 to 2,100 mm a year; the average annual rainfall of the northern part is around 1,500 mm.

Tropical depressions and occasionally tropical storms from the Pacific approach the Study Area between September and November and bring heavy rainfall.

Two storms and 8 tropical depressions reached the Study Area during the 39-year period from 1951 to 1989. Typhoon Gay hit the Study Area on 4, November 1989 with a maximum windspeed of 120 km per hour near its center. In the Study Area, the hardest hit areas were Amphoe Muang Chumphon and Amphoe Pathiu. The peak flood discharge of the Tha Taphao river is estimated at 1,200 cu.m/sec by the Royal Irrigation Department (RID).

- 04 The present land use of the Study Area is summarized below:

PRESENT LAND USE

Category	Area	
	sq.km	%
Forest Land	960.9	36.6
Farm Land		
- Paddy field	151.1	5.8
- Upland field	76.1	2.9
- Tree crops	634.5	24.2
- Fruit trees	243.4	9.3
- Mixed orchard & vegetables	74.7	2.8
Sub - total	1,179.8	45.0
Roads, rivers and others	484.3	18.4
Total	2,625.0	100.0

- 05 The Study Area is administratively composed of 4 Amphoe, 30 Tambon and 277 Muban. The population of 4 Amphoe was 241,500 in 1990 with an average population density of 67 and 185 persons per sq.km for the whole area and for Amphoe Muang Chumphon respectively.

The trunkroad network is considered rather good. The national highways of route 4 and 41 run across the Study Area, and a seaside road has recently been constructed to connect Amphoe Muang Chumphon and Amphoe Pathiu. The Office of Accelerated Rural Development is promoting the construction of rural trunkroads; however, rural roads to connect villages with the rural trunkroads are defective.

Rural electrification is also quite good. The rate of rural electrification in 3 Amphoe of Chumphon province reaches 92 percent on a village basis. The municipality of Chumphon is supplied with running water. In the rural areas, people rely on rainwater for drinking to be stored in jars. In Amphoe Pathiu there is a serious lack of water for domestic use.

- 06 The gross provincial product (GPP) of Chumphon province has continued to expand from Baht 4,250 million in 1981 to Baht 9,286 million in 1989 at an average annual growth rate of 10.3 percent. The average annual growth rates of the agricultural sector and the non-agricultural sector are 10.1 percent and 10.4 percent respectively for the same period. 46 percent of the GPP was shared by agricultural products (Baht 4,247 million).

- 07 The frequent occurrence of floods from the Tha Tapaho river cause substantial damage to crops, farmland, public facilities and others in the low-lying areas along the river including the municipality of Chumphon. Recent serious floods occurred in 1970, 1971, 1988 and 1989, especially the flood caused by Typhoon Gay on 5, November 1989 which inundated 24,000 ha of farmland for 3 days, and damaged crops covering 17,800 ha amounting to 841 million Baht.

While there are a few small scale irrigation projects in the Study Area, agriculture of 85 percent of farmland relies on rainfall. Even during the rainy season, supplemental irrigation is needed due to seasonal and annual fluctuations of rainfall.

For increasing agricultural productivity and stabilizing agriculture farming in the area, the lack of water for irrigation use is a serious problem.

BASIN DEVELOPMENT PLAN

(Objectives of Development)

- 08 Paying attention to income distribution, economic stability and the people's quality of life, the Seventh National Economic and Social Development Plan (1992 to 1996) has set the 3 major objectives: Firstly to continuously sustain the country's economic growth at an appropriate level with stability, secondly to distribute income and development prosperity to regions, and thirdly to develop human resources, quality of life, environment and natural resources.

In line with the National Plan, the objective of the integrated agriculture and water resources development project of the Menam Chumphon basin has been set to increase the income level of the farmers through water resources development for agriculture with flood control and water distribution to farm lands, and intensive backup from agricultural extension services. To accomplish the development objectives, this project has proposed to implement, firstly, the agricultural development plan, secondly, the water resources development plan, and thirdly, the irrigation development plan.

(Agricultural Development)

- 09 The basic approach to agricultural development includes 1) increase of crop yields, 2) crop diversification, and 3) strengthening of agricultural extension services. Cropping area of traditional crops such as maize, rubber, coffee, coconut, and oil palm would not be increased as the market demand seems to be stagnant; therefore, efforts will be made to improve the productivity of these crops. With the implementation of irrigation projects, crop diversification will be encouraged.

(Water Resources Development)

- 10 Six reservoir sites have been identified in the Study Area. Of 6 reservoirs, 3 reservoirs of Tha Sae, Rap Ro and Upper Rap Ro are classified as large-scale projects, and the 3 other reservoirs, medium-scale projects. The large-scale projects will be operated for multipurpose uses of irrigation, flood control, and domestic water supply, while the medium-scale projects will provide water storage for irrigation uses including domestic water supply in irrigation areas.

There is a potentiality of developing 45 small-scale irrigation projects (SSIP) in the hilly areas apart from the catchment areas of the above 6 reservoirs, areas of land reform projects and wildlife sanctuary areas.

In addition, the Nong Yai swamp located about 4 kilometers northeast of the municipality of Chumphon will be rehabilitated for irrigation and domestic water supply.

(Irrigation Area)

11 There are about 54,500 ha of farmland that need irrigation water, water demands of which are greater than the potential water resources of 303 million cubic meters. In order to determine the irrigation area, reservoir operation of the 3 multipurpose reservoirs was run on a monthly basis under the hydrological conditions of 1985, a drought year with a return period of 10 years. By implementing of the proposed 52 projects, 41,520 ha of farmland will be irrigated as follows:

STORAGE SCHEME AND IRRIGABLE AREA

Reservoir	Catchment Area (sq.km)	Effective Storage (MCM)	Irrigable Area (ha)
Tha Sae	338	80.3	9,860
Rap Ro	503	92.7	12,520
Upper Rap Ro	106	32.4	3,510
Nam Ron	21	6.9	1,060
Upper Khum	16	7.1	1,100
Kaphon	15	5.0	770
45 SSIP	452	74.6	11,500
Nong Yai	102	3.9	1,200
Total	1,553	302.9	41,520

(Disaster Prevention of Farmland)

12 Flooding in and around the municipality of Chumphon is caused by the flood water of the Tha Taphao river. The practicable measures of reducing flood are 1) reduction of peak flow by reservoirs, 2) increase of discharge capacity by river improvement, and 3) diversion of flood water by means of floodways.

The flood control plan of multipurpose reservoir conflicts with other plans. The larger the flood control storage is, the smaller the regulated peak flood flow, resulting in lower costs for river improvement works; however, the irrigable area will be decreased. In order to determine reasonable flood control storages of the multipurpose reservoirs, preliminary economic evaluation of alternative cases with different flood control storages and flood magnitudes was carried out by the benefit and cost ratio method. As a result, this project proposes to provide a flood control storage equivalent to 50 percent of the total volume of flood inflow to the reservoir with the return period of 30 years as shown below.

FLOOD CONTROL STORAGE

Reservoir	Total Storage (MCM)	Flood Control Storage (MCM)	Sediment Storage (MCM)	Effective Storage (MCM)
- Tha Sae	133.0	47.6	5.1	80.3
- Rap Ro (W/O Upper)	192.0	120.1	9.1	62.8
- Rap Ro (W/Upper)	192.0	90.2	9.1	92.7
- Upper Rap Ro	63.9	29.9	1.6	32.4

Note: W/o Upper: Without Upper Rap Ro, W/Upper: With Upper Rap Ro.

- 13 The effect of food control by reservoirs is shown below:

FLOOD CONTROL BY RESERVOIR

Item	Rap Ro Reservoir	Tha Sae Reservoir
Reservoir		
- Catchment area (sq.km)	(609)	(338)
- Flood surcharge level (m MSL)	65	100
- Peak inflow discharge (cu.m/sec)	1,120	530
- Peak outflow discharge (cu.m/sec)	410	210
Outlet of River		
- Catchment area (sq.km)	(803)	(1,016)
- Present peak flood (cu.m/sec)	880	630
- Design peak flood (cu.m/sec)	530	610
X158 Station of Tha Taphao River		
- Catchment area (sq.km)	(1,819)	
- Present peak flood (cu.m/sec)	1,510	
- Design peak flood (cu.m/sec)	1,150	

- 14 The safe channel capacities of the Tha Taphao river are 430 and 350 cubic meter/second for the upper-middle reaches and the lower reaches respectively, while the magnitude of the design flood of the river is 1,150 cubic meter/second. In 1990, immediately after Typhoon Gay, RID has prepared the flood mitigation program of the Tha Taphao river including improvement of the Sam Kaeo canal, construction of the Hua Wang-Phanang Tuk canal and improvement of the Tha Taphao river. In addition to the above canal project, this drainage improvement plan includes the proposal to construct a new Pak Phraek canal that branches off from the Tha Taphao river, at the upstream of the X158 station. Outlines of the drainage improvement plan of the Tha Taphao river system are as follows:

IMPROVEMENT OF THA TAPHAO RIVER SYSTEM

River and Canal	Flow Capacity (cu.m/sec)	
	Present	Design
Improvement of Tha Taphao River		
- Upper reaches	430	880
- Middle reaches	430	610
- Lower reaches	350	350
Rehabilitation of Sam Kaeo Canal	140	260
New Construction of Canal		
- Pak Phraek	-	270
- Hua Wang-Phanang Tuk	-	270

On the other hand, farmland on low-lying areas along the Klong Chumphon is also subject to frequent flooding. As there is no potential for constructing a large-scale reservoir, flood control must be based on river improvement. The river needs the construction of about 40 km of levees from the river mouth to release a design discharge of 345 cubic meter/second with a return period of 10 years. It is recommended to carry

out a feasibility study on the water resources development of the Khlong Chumphon basin.

- 15 The improvement of Tha Taphao river system together with the construction of the Rap Ro and Tha Sae multipurpose reservoirs will be able to prevent the floods within the return period 30 years, which will eradicate the damages of around 19,000 ha of farmland, 17,300 houses inclusive of the municipality of Chumphon, 760 ha of shrimp farm, livestock, roads, bridges, etc., amounting to annual average 390 million Baht.

(Selection of Priority Project)

- 16 Among the proposed projects for the water resources development of the Menam Chumphon basin, the Rap Ro and Tha Sae multipurpose projects and the Nong Yai-Tha Taphao development project, which consists of the Nong Yai irrigation project and the drainage improvement project of the Tha Taphao river system, were chosen taking into account of the followings; 1) flood mitigation effect to the municipality of Chumphon and the surrounding farm lands, 2) irrigation effect to the farm lands around the municipality of Chumphon, predominant farm land in the Study Area, 3) high B/C ratio.

Since immediate treatment of the flood mitigation in and around the municipality of Chumphon is required, the latter project which expected to bring about immediate effect without serious environmental problems was selected for a feasibility study. Furthermore, the Nong Yai irrigation project which is a part of the selected project will effectively demonstrate the irrigated agriculture system in the Menam Chumphon basin.

NONG YAI PROJECT AREA

(Location and Area)

- 17 The Nong Yai area is located on the alluvial plain of the Tha Taphao river, about 4 km northeastward of the municipality of Chumphon. In the north of the project area, the Nong Yai swamp extends the area of about 700 ha with the maximum water surface during the rainy season. Of the total land area of 2,260 ha, farmland occupies 2,019 ha as shown below.

PRESENT FARM LAND USE

Farm Land	Area(ha)
Paddy Field	716
Mixed Orchard	1,090
Tree Crop	149
Upland Field	40
Mixed Farm	24
Total	2,019

(Major Crops and Yields)

18 The agriculture farming is the typical Thai southern practice with tree crops, fruit and paddy. The present cropping area and yields are given as follows:

PRESENT CROPPING AREA AND YIELD

Crop	Cropping Area		Yield (ton/ha)
	(ha)	(%)	
Paddy			
- Rainy season paddy	565	28.0	1.63
- Double cropping paddy	30	1.5	1.94
- Fallow	121	6.0	
Sub-total	716	35.5	
Tree Crop			
- Coconut	749	37.0	3,600 (1/)
- Young coconut	100	5.0	
Sub-total	849	42.0	
Fruit			
- Mangosteen	54	2.7	2.19
- Cashewnut	32	1.6	1.13
- Durian	30	1.5	4.38
- Pomelo	20	1.0	5,000 (1/)
- Pineapple	16	0.8	
- Fallow	262	13.0	
Sub-total	414	20.5	
Vegetable (Pepper, Soybean, Cucumber)	40	2.0	
Total	2,019	100.0	

Note: (1) = fruits/ha

(Land Tenure)

19 The farm size of paddy fields for 50 percent of paddy farmers is less than 0.8 ha. For other crops, the average farm sizes are 1.06 ha for coconut, 0.84 ha for orchard, and 0.43 ha for field crops. About 75 percent of farmers are owner-farmers. Tenant farmers represent only 2 percent of farmers. However 36 percent of farmers at Tambon Na Thung which is one of the village in the project area are found to be land less (NRD-2C).

(Livestock Raising and Inland Fisheries)

20 Ninety six farmers raise 307 heads of beef cattle in 3 Tambon. Farmers show a willingness to raise beef cattle for sale. Problems to be solved for the development of livestock-raising are lack of pasture in the dry season, floods in the rainy season and shortage of investment capital.

In addition, shrimp culture, catfish and other freshwater fish are raised by 38 farmers around the Nong Yai swamp and along the Tha Taphao river. The problems in the area are floods in the rainy season, disease, lack of knowledge on fish culture and the high cost of fish feeding.

(Irrigation and Drainage)

21 There is no irrigation system in the project area. Apart from some farm land irrigated by small portable pumps owned by farmers, the agriculture of most farms depends on

unsteady rainfall. In the southern part of the project area, the Sam Kaeo canal functions as the main canal with the dual purpose of irrigation and drainage, however, water in the canal cannot be used for irrigation during the dry season due to the fact that sea water intrudes into the canal.

In the northern part of the area, the Nong Yai swamp provides the surrounding farmland with irrigation water during the dry season. However in the rainy season, the water level of Nong Yai swamp is raised by 5 ~ 6 meters MSL, and the swamp causes drainage problem in the surrounding area due to the poor drainage capacities of natural river channels.

(Population and Farm Household)

22 The population and households in the project area are summarized as follows:

POPULATION AND HOUSEHOLDS

Tambon	Population	Total Household	Farm Household	Average Families
Na Thung	5,580	1,088	477	5.1
Bang Luk	1,728	357	344	4.8
Na Cha Ang	3,495	649	413	5.4
Total	10,803	2,094	1,234	5.2

(Infrastructure and Social Services)

23 National road No.3180 passes through the middle of the project area. Of 15 villages (Muban) related to the project area, 14 are connected to the rural electrification network. The ratio of electrification is 80 percent on a household basis.

Except for a part of Tambon Na Thung linked to the municipality of Chumphon, rural people rely on rainwater and 4 wells for drinking and daily use. Shortage of water in the dry season is a serious problem in the project area. There is only a small market near the railway station of Na Cha Ang for distribution of agricultural products and some daily goods.

NONG YAI -THA TAPHAO DEVELOPMENT PROJECT

(Project Components)

24 The Nong Yai-Tha Taphao Development Project proposes the implementation of the following development plans:

Nong Yai Agriculture Development

- 1) **Agriculture Development**
 - Increase in yields and crop intensities
 - Irrigated agriculture
 - Improvement of rainfed agriculture

- Promotion of cattle-raising
- Promotion of swamp fisheries
- Strengthening of agricultural extension services
- 2) Water Resources Development
 - Rehabilitation of Nong Yai swamp
- 3) Irrigation Development
 - Construction of irrigation systems
 - Development of on-farm facilities for irrigation
 - Water management by water users' groups
- 4) Drainage Improvement
 - Construction of main drainage canals
 - Development of on-farm facilities for drainage

Drainage Improvement of Tha Taphao River System

- 1) Improvement of Rivers
 - Tha Taphao river
 - Phanang Tuk river
 - Nong Sai river
- 2) Rehabilitation of Sam Kaeo Canal
- 3) Construction of Canals
 - Pak Phraek canal
 - Hua Wang-Phanang Tuk canal

NONG YAI AGRICULTURE DEVELOPMENT

(Land Use Plan)

25 According to soil suitability analysis for irrigated agriculture, paddy fields and upland fields are well developed adapting to soil characteristics. An area of 116 ha of land under natural vegetation will be converted into farmland. The proposed land use is summarized as follows:

PROPOSED LAND USE

Land Use Type	Area (ha)	Percentage
Paddy Field	630	30.3
Orchard	1,370	65.9
Upland Field	40	1.9
Pasture Land	38	1.8
Total	2,078	100.0

(Main Crops and Yields)

26 The proposed crops are selected in consideration of 1) soil suitability, 2) marketability, 3) farmers' experience and technology, 4) farmers' intention, and 5) guidelines of the government agencies concerned. According to farm investigations by the Department of

Agriculture, 12 villages (Muban) wish to increase paddy cropping. The proposed cropping and yields are as follows:

PROPOSED CROPPING AREA AND YIELD

Crops		Area (ha)	Yield (ton/ha)
Paddy	: Rainy season paddy	630	3.13
	: Dry season paddy	60	4.06
Tree Crops	: Coconut	728	7,500 ^{1/}
	: Young coconut	170	13,400 ^{1/}
Fruit	: Mangosteen	135	7.80
	: Cashew nut	60	1.75
	: Durian	135	7.50
	: Pomelo	110	9,400 ^{1/}
	: Pineapple	32	40.60
Vegetable		40	25
Pasture		38	
Total		2,138	

Note : ^{1/} : fruits/ha

(Livestock Pilot Project and Swamp Fisheries)

- 27 According to the farm survey, livestock-raising is an important income source next to crop production. This Nong Yai agriculture development has proposed to promote beef cattle-raising at Tambon Bang Luk, as a pilot project, where farmers are willing to expand beef cattle-raising.

Regarding the use of the water bodies of the Nong Yai swamp (maximum water surface area of 543 ha), the development of inland fisheries has been proposed in order to meet fish demand for home consumption.

(Irrigation Development)

- 28 From the results of the reservoir operation study on a 10-day basis for the period of 10 years from 1981 to 1990, the Nong Yai reservoir is available for irrigation of 1,200 ha of farmland under the condition of two times of water shortages during the 10 year-period. Irrigation water will be supplied for cultivation of 630 ha of paddy, 530 ha of fruit trees, and 40 ha of field crops.

(Nong Yai Reservoir)

- 29 The Nong Yai swamp will be rehabilitated to provide 4.5 million cubic meters of water storage by the construction of dikes. In addition to irrigation water supply, the indirect benefits of the Nong Yai reservoir are 1) flood mitigation, 2) fisheries in the reservoir, 3) use of dikes for transportation of farm input and output, and 4) provision of recreation areas.

DISASTER PREVENTION OF FARMLAND

- 30 The Tha Taphao river system shall be improved to enable the release of design flood discharge of 1,150 cubic meter/second, which is almost equivalent to the probable peak

discharge with the return period of 10 years, or treatable for flood discharge with a return period of 30 years after completion of the proposed multipurpose reservoirs.

Flood water of the Tha Taphao river is currently released into the sea through the river as well as the Sam Kaeo canal. The urgent drainage improvement plan of the RID has proposed to rehabilitate the Sam Kaeo canal and to construct the Hua Wang-Phanang Tuk canal.

In this study, the construction plan of the Pak Phraek canal has been newly proposed in order to divert floods of the Tha Taphao river into the Nong Yai reservoir. Outlines of the drainage improvement plan of the Tha Taphao river system are as follows:

OUTLINES OF DRAINAGE IMPROVEMENT PLAN

River and Canal	Discharge (cu.m/sec)		Remarks
	Present	Proposed	
Design Discharge of Tha Tapaho		1,150	
① Upper Reaches of Tha Taphao	430	880	1,150 - ②
② Pak Phraek Canal	-	270	new construction
③ Hua Wang-Phanang Tuk Canal	-	270	new construction
④ Middle Reaches of Tha Taphao	430	610	① - ③
⑤ Sam Kaeo Canal	140	260	rehabilitation
⑥ Lower Reaches of Tha Tapaho	350	350	rehabilitation

After completion of these drainage improvement works of the Tha Taphao river system, such damage as 17,600 ha of farmland, 16,600 houses in both urban and village area, 760 ha of shrimp farm, livestock, roads, bridges, etc. will be saved totaling approximately 300 million Baht per year.

CONSTRUCTION WORKS

(Nong Yai Agriculture Development)

31 The major structures for the Nong Yai agriculture development are summarized as follows:

- 1) Nong Yai Reservoir
 - Catchment area : 102 km²
 - Total water storage : 4.5 MCM
 - Effective water storage : 3.9 MCM
 - Dikes : Length of 11.4 km with crest width of 8.0 m
 - Ring roads : Length of 2.5 km with crest width of 8.0 m

2) Irrigation Canal

The proposed irrigation area of 1,200 ha is divided into 7 blocks, of which 6 blocks of 600 ha in total will be supplied with pumped water.

The irrigation canals convey water to a terminal irrigation area of 48 ha (300 rai).

IRRIGATION CANAL

Irrigation Block	Irrigable Area (ha)	Pipe Line		Open Channel		Total Length (km)
		Discharge (cu.m/sec)	Length (km)	Discharge (cu.m/sec)	Length (km)	
A	103	-	-	0.40	1.81	1.81
B	152	-	-	0.61	4.10	4.10
C	62	0.16	1.10	-	-	1.10
D	76	0.19	1.55	-	-	1.55
E	99	-	-	0.43	2.59	2.59
F	108	0.28	1.55	-	-	1.50
G	600	-	-	1.34	11.59	11.59
Total	1,200		4.15		20.09	24.24

(Drainage Improvement of the Tha Taphao River System)

32 For discharge of the design flood (1,150 cubic meter/second) of the Tha Taphao river, the proposed drainage improvement project will provide the following canal works and river improvement works:

CANAL PROJECT

Canal	Discharge (cu.m/sec)	Work Length (km)
Pak Phraek Canal	270	5.5
Hua Wang-Phanang Tuk Canal		
- Upper section	270	0.6
- Lower section	540	3.9
Sub-total		4.5
Sam Kaeo Canal	260	4.8
Total		14.8

RIVER IMPROVEMENT PROJECT

River	Discharge (cu.m/sec)	Work Length (km)
Tha Taphao River		
- Upper reaches	880	11.3
- Middle reaches	610	6.0
- Lower reaches	350	17.0
Sub-total		34.3
Phanang Tuk River	800	6.2
Nong Sai River	50	8.0
Total		48.5

IMPLEMENTATION PROGRAM OF PROJECT

- 33 The Royal Irrigation Department (RID) will be the executing agency responsible for implementation of the Nong Yai-Tha Taphao Development Project composed of the Nong Yai agriculture development plan and the drainage improvement plan for the Tha Taphao river system.

The implementation of the project is scheduled to be completed in the five years between 1992 and 1996 as shown in Table 1.

PROJECT COST

- 34 The estimated project costs amount to 1,976.6 million Baht at 1992 prices, of which 759.2 million Baht are constituted the foreign currency component. The project costs include 10 percent of physical contingencies. Price escalation contingencies are calculated at a rate of 1 percent per year for the foreign currency component, and for the local currency component, 5 percent for 3 years from 1992 to 1995 and 4 percent after that. In the calculation, a foreign exchange rate of US\$1.00 = Baht 25.0 = Yen 125 is applied. The project costs are summarized as follows:

PROJECT COSTS

(Unit: Million Baht)

Project	Local Currency	Foreign Currency	Total
① Nong Yai Agriculture Development	205.6	130.8	336.4
② Drainage Improvement of the Tha Taphao River System			
- River improvement	353.0	188.8	541.8
- Canal construction	658.8	439.6	1,098.4
Sub-total	1,011.8	628.4	1,640.2
Total	1,217.4	759.2	1,976.6

PROJECT EVALUATION

(Economic Evaluation)

- 35 The economic feasibility of the project has been evaluated by the economic internal rate of return (EIRR). Quantitative benefits in monetary terms from the project will be generated from crop production and livestock raising for the Nong Yai agriculture development plan and prevention of flood damage by the drainage improvement of the Tha Taphao river system. The economic internal rate of return is calculated based on the analysis period of 30 years and the gestation period of 10 years attaining full benefits in the component of irrigated agriculture. The results of the economic evaluation of the project are summarized in the following:

ECONOMIC INTERNAL RATE OF RETURN

	Project	EIRR (%)
①	Nong Yai Agriculture Development	9.5
②	Drainage Improvement of the Tha Taphao River System	18.7
③	Overall	17.1

(Farm Budget Analysis)

36 In order to evaluate the financial impact on beneficiary farmers through the implementation of the proposed agriculture development plan, farm budget analyses have been made for 2 types of representative farm households with a farm size of 1.44 ha (9 rai); the type 1 farm household is mainly engaged in paddy cultivation, and type 2 farm household in fruit cultivation. The representative farm households may have workable capacities for off-farm labor, as the farm size is only 1.44 ha. In the farm budget analysis, therefore, off-farm income of 19,500 Baht per year, which is equivalent to the half of the present off-farm income, is considered. With the implementation of the project, the representative farm households will enjoy the incremental surplus of 11,000 to 29,200 Baht a year.

(Evaluation on Environmental Impact)

37 The project area is currently situated under such adverse conditions as flood damage and poor drainage conditions in the rainy season; a lack of irrigation and domestic water; a salt water problem caused by sea water intrusion in the dry season; low agricultural productivity and destruction of land resources by extensive and rainfed farming; poor transportation conditions and inadequate marketing network.

The project is expected to lead to flood mitigation by the Tha Taphao river improvement and canal projects, water resources development by the reservoir construction, increase of agricultural product and conservation of land resources and soil by supplying the irrigation water, raising the human use values by the domestic water supply, improvement of transportation means by the dike and road construction surrounding the reservoir, and improvement of the marketing network by the installation of Tambon Na Cha Ang market, resulting in improvement of the natural and social environment conditions in the area.

During the 1980's, archaeological artifacts, (3 metal drums, bead strings and bracelets) were found in and around the project area. Due attention should be paid to save the cultural items especially during excavation activities. Furthermore, demarcation of the construction site as well as acquisition of land should be undertaken with careful consultation with the presently occupying farmers.

(Overall Evaluation of Project)

- 38 The economic internal rate of return of the Nong Yai-Tha Taphao Development Project composed of the Nong Yai agriculture development plan and drainage improvement plan of the Tha Taphao river system has been estimated at 17.1 percent, thus clarifying the economic feasibility of the implementation of the project from the viewpoint of the national economy. The individual economic internal rate of return of the agriculture development might be not so attractive as the economic indicator. Agriculture, however, is still the most important sector in the Thai economy despite its low productivity. In this situation, implementation of the project will play an important role in accomplishing the development objectives of the 7th National Plan. Apart from the profitability of the project from the standpoint of the national economy, the project will have a significant financial impact on the farmers as shown in the farm budget analysis. The implementation of the project has no significant negative impacts on the environment of the area, when the following countermeasures are taken to the construction work of the canals, reservoir and river improvement: 1) protection of cultural and historical heritage, and 2) proper compensation and rehabilitation for affected inhabitants.

RECOMMENDATION

- 1) The Study Team recommends the prompt implementation of the Nong Yai-Tha Taphao Development Project close to the proposed implementation schedule. The proposed project will significantly contribute to the primary objectives of the Seventh National Plan since the agricultural sector is still important to the Thai economy.

The project is formulated with the aim of solving two main problems confronted by the rural people: irrigation water shortage in the dry season and floods in the rainy season. The drainage improvement of the Tha Taphao river system will contribute to the intensive use of farmlands in the Tha Taphao river basin which includes the Nong Yai area.

The economic internal rate of return of 17.1 percent for the Nong Yai-Tha Taphao Development Project shows that the implementation of the proposed project is feasible from the viewpoint of the national economy. The economic internal rate of return for the part of the Nong Yai Agriculture Development Project is estimated at 9.5 percent, considering primary benefits.

- 2) It is recommended that prior to initiation of the detail design and construction of the project, additional surveys regarding topography, geology and hydrology of the Nong Yai swamp should be carried out.

The Nong Yai irrigation plan was prepared based on topographic maps with the scale of 1 : 10,000. In order to upgrade the design level of irrigation and drainage facilities, it is necessary to prepare topographic maps with a scale of 1 : 4,000 covering the proposed irrigation area. Hydrological observations such as rainfall and river inflow should be done at the proposed Nong Yai reservoir site. Additional geological investigation such as drilling and soil tests should be done at the construction sites of important structure such as bridges, regulators and weirs.

- 3) The reservoir plan in this study was drawn up paying attention to improvement of the poor drainage conditions in the farm land adjacent to the reservoir. The detailed design of the reservoir should pay further attention to this point. In addition, it is recommended that the project facilities should be constructed with great care to the preservation of the cultural heritages as well as the consultation with the local people for the acquisition of land.

**Table 1: IMPLEMENTATION SCHEDULE OF
NONG YAI-THA TAPHAO DEVELOPMENT PROJECT**

Description	Quantities	1992 Y	1993 Y	1994 Y	1995 Y	1996 Y
(I) THA TAPHAO RIVER SYSTEM IMPROVEMENT PROJECT						
1. RIVER IMPROVEMENT PROJECT		F/S	D/D		Construction	
1.1 Tha Taphao river	34.3 km	-----	-----			
1.2 Nong Sai river	8.0 km	-----	-----			
1.3 Phanang Tuk river	6.2 km	-----	-----			
2. CANAL PROJECT						
2.1 Sam Kao canal (rehabilitation)	4.8 km	-----	-----	Construction		
2.2 Hua Wang Phanang Tuk canal	4.5 km	-----	-----			
2.3 Pak Phraek canal	5.5 km	-----	-----			
(II) NONG YAI IRRIGATION PROJECT						
1. Nong Yai reservoir (Dike and Road)	13.9 km	F/S	D/D	Construction		
2. Irrigation and Drainage system	1,200 ha	-----	-----			
3. Agricultural Development Facilities	L.S	-----	-----			

CHAPTER 1. INTRODUCTION

CHAPTER 1. INTRODUCTION

1.1 BACKGROUND OF THE STUDY

In the Chumphon river basin located at the northernmost of the South Thailand, the productivity of agriculture, the main industry in the basin, is low due to lack of irrigation facilities, unsteady rainfall that fluctuates yearly and seasonally, and floodings occurred frequently during the late rainy season.

A strong tropical storm and a Typhoon attacked the Chumphon river basin in 1988 and 1989 respectively, resulting in very great flood damage to crops, farm lands, public facilities, and houses. In 1990, the Government of Thailand set forth a policy for priority implementation of the integrated agriculture development of the basin through irrigation development, drainage improvement and flood control, for which the government agencies concerned are requested to formulate development plans.

In the above situation, the Government of Thailand requested the Government of Japan to extend technical cooperation for the implementation of the feasibility study on the integrated agriculture and water resources development project of the Menam Chumphon basin. In response to the request of the Government of Thailand, the Government of Japan sent the preliminary study team through the Japan International Cooperation Agency (hereinafter referred to as "JICA"), the official agency responsible for the implementation of technical cooperation programmes of the Government of Japan, to Thailand in March, 1991. The scope of work was agreed on March 22, 1991 between JICA and the Royal Irrigation Department, Ministry of Agriculture and Cooperatives (hereinafter referred to as "RID").

In accordance with the scope of the work, JICA commenced the feasibility study on the integrated agriculture and water resources development project of the Menam Chumphon basin (hereinafter referred to as the "Study"), and the feasibility study team (hereinafter referred to as the "Team") was dispatched to Thailand to conduct the Study on October 23, 1991. The report was prepared in January 1993 to present the results of the Study.

1.2 OBJECTIVES AND SCOPE OF THE STUDY

1.2.1 Objectives of the Study

The objectives of the Study are 1) to formulate an integrated agriculture and water resources development plan of the Menam Chumphon basin, and 2) to conduct a feasibility study on selected priority project(s).

1.2.2 Scope of the Study

The Study Area covers approximately 2,700 sq.km of the Menam Chumphon basin. The Study was conducted over a 2 Japanese fiscal year period from 1991 to 1992 in 2 phases as described below:

Phase I Study

- 1) Collection and analysis of the relevant existing data and information, and field surveys including:
 - Natural conditions
 - Agriculture
 - Agricultural infrastructure
 - Socio-economic situation, and
 - Other information related to the project
- 2) Review of existing agricultural plan, water resources development plan and flood control plan,
- 3) Formulation of a preliminary integrated agriculture and water resources development plan for the Menam Chumphon basin, and
- 4) Selection of priority project(s)

Phase II Study

The feasibility study on the priority projects was carried out based on the results of the phase I study, covering the following items:

- 1) Additional work in Thailand, data collection and analysis, and

- 2) Preparation of feasibility reports including the results of Phase I and Phase II studies.

1.2.3 Procedure of Project Formulation

Procedure of the project formulation is shown in Figure 1-1.

1.3 NATIONAL POLICY ON AGRICULTURE DEVELOPMENT

The Government of Thailand has set forth the Seventh National Development Plan (1992 - 1996) with the three development objectives to 1) maintain economic growth rates at appropriate levels to ensure sustainability and stability, together with 2) redistribution of income and development benefits to the regions and rural areas, and 3) development of human resources, environment and natural resources and raising of the quality of life.

Agricultural production during the Sixth Plan period grew at an average rate of 3.4 percent per year. The relatively low growth was attributable to the weakening prices of major world commodities after 1989 and the climatic conditions characterized by continual droughts towards the end of the Sixth Plan. The share of the agricultural sector in GDP gradually declined to about 11.5 percent in 1991. Nevertheless, the sector is still important to the Thai economy as the share of agricultural employment remains as high as 64 percent of total employment.

In the Seventh National Development Plan, the target of average overall economic growth rate of 8.2 percent per year assumes that the agricultural sector will be able to attain an average growth rate of 3.4 percent. Agricultural development to support the economic growth objective will emphasize enhancement of productivity and higher value added products as follows.

- 1) Efficient use of natural resources to serve as an agricultural production base,

- 2) Research, development and transfer of technology in agriculture, together with provision of necessary inputs to production,
- 3) Restructure of agricultural production in line with the local conditions and market demand,
- 4) Development of agro-processing industry, and
- 5) Improvement of agricultural and cooperative development system.

In order to promote the efficient use of natural resources, protection of fertile agriculture will be undertaken, particularly in areas where the government has already invested heavily in the provision of irrigation and other basic services, to enable these farm lands to be used for agricultural purposes. Land encroachment and speculation to convert agricultural land to other uses will be prevented, and land-use plans as well as demarcation of clear zoning of land will be formulate to serve as guideline for basic infrastructure development in line with types of land utilization.

More efficient use of water will be encouraged as supply of irrigation water is limited and increasingly falls short of demand. Collection of water fees will be considered in irrigated agriculture areas based on the amount of use to ensure fairness to all farmers. Irrigation water fee schedules will be appropriately revised distinguishing between water for agriculture and non-agricultural uses. Within the agricultural sector, calculation of water fee should only cover the maintenance costs of the water distribution system. Water utilization and delivery systems will be set up to distribute water from the principal waterways down to the farm level.

The government will play the leading role in research and development of training programs, to enable farmers to apply new technical knowhow to reduce production costs, and increase their competitiveness. It is equally important to ensure adequate provision of production inputs and to enhance efficient use of agricultural machinery.

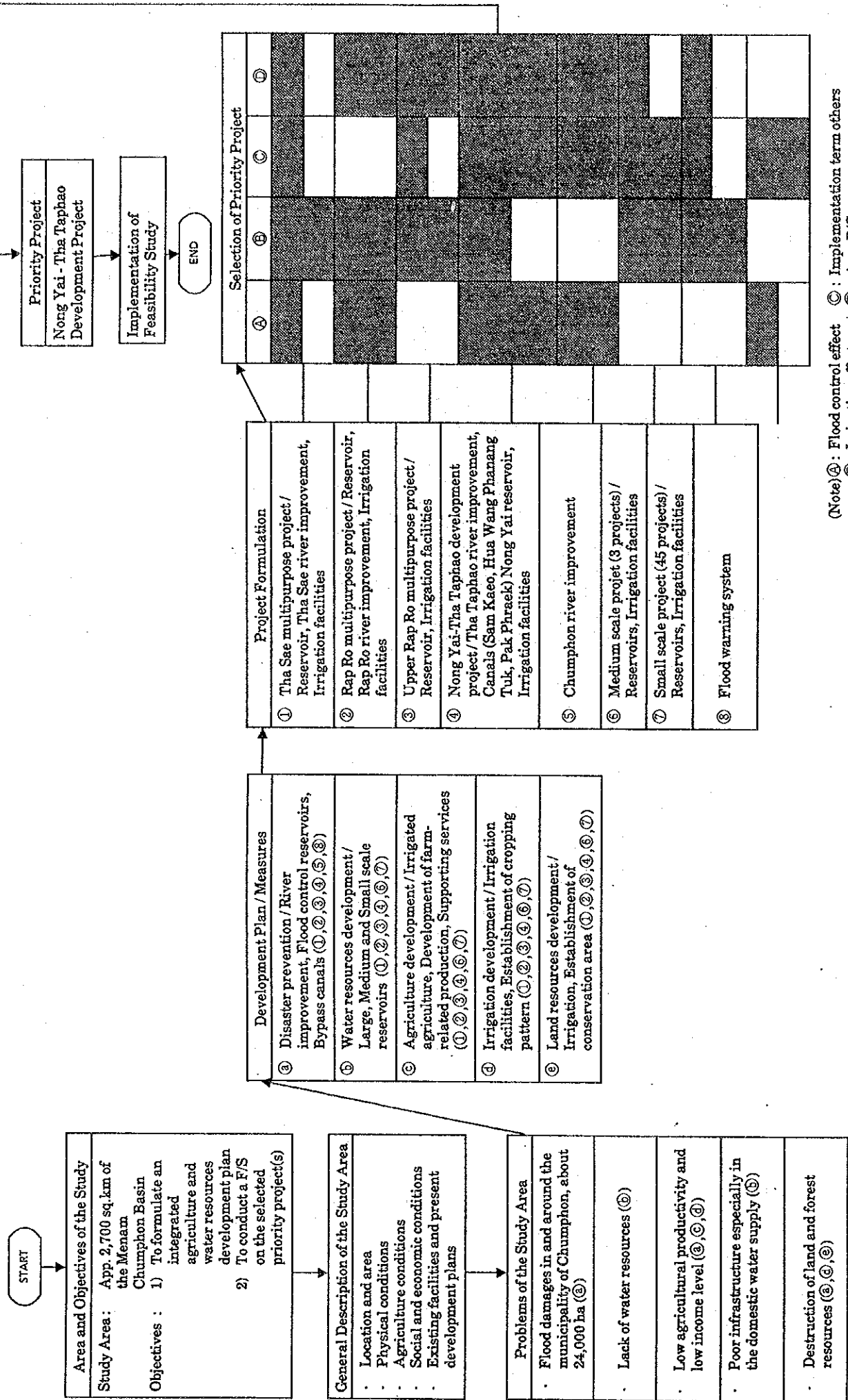
The agricultural promotion and extension services provided by the government will be changed from the primarily product-specific type of promotion to provision of knowhow to enable farmers to formulate production plans at the farm level by themselves. The government will provide the necessary extension services as normally required by farmers.

The private sector will be encouraged to cultivate commercial forests where there is a related industry in an integrated manner, as well as cultivation of community forests or for commercial purposes by agricultural institutions.

Productivity in the agro-processing industry will be enhanced by encouraging public and private sector cooperation in acquisition and transfer of knowhow on high-yielding seedling varieties, high quality animal stocks, quality improvement of raw materials and products, standard development of products and packaging technology.

Agricultural production restructural plans will be formulated at the provincial level to include both work programs and projects to solve agricultural problems and to respond to the needs of farmers. Operation of local public agencies should be fully integrated so as to be readily able to serve government policy to devolve central power and budgetary authority to the regions.

FIGURE 1-1 FLOW CHART FOR PLANNING THE WATER RESOURCES DEVELOPMENT PROJECTS OF THE MENAM CHUMPHON BASIN



CHAPTER 2. GENERAL DESCRIPTION OF THE STUDY AREA

CHAPTER 2. GENERAL DESCRIPTION OF THE STUDY AREA

2.1 LOCATION AND AREA

The Study Area is located in the northernmost part of Southern Thailand, about 500 km from Bangkok. The Study Area is situated across 2 provinces of Chumphon and Prachuap Khiri Khan with a total land area of 2,625 sq.km. 90 percent of the Study Area administratively belongs to Chumphon province and 10 percent to Prachuap Khiri Khan province. The famous Isthmus of Kra, the narrowest part of the Malay Peninsula, is located just south of the Study Area.

2.2 PHYSICAL CONDITIONS

2.2.1 Topography and Geology

(1) Topography

The Study Area has a long and narrow shape, about 100 km from north to south and about 30 km wide from east to west direction. The north of the Study Area, about 11°N, is the beginning of the Phuket range, one of the 2 main mountain systems running through the peninsula.

The Study Area may be divided into 4 different river basins: Tha Sae, Rap Ro, Tha Taphao and Chumphon. In the Tha Sae river basin, the alluvial plain, which is surrounded in the north, east and west by hills and mountains, extends to the south toward the Tha Taphao river basin. The Tha Sae river originates in the northern mountains, about 500 m above sea level, and flows southward to join in the Tha Taphao river. The Rap Ro river basin is mainly composed of hills except for some narrow flat lands spreading along the river. The Rap Ro river originates in the northwestern mountains about 500 m above sea level and flows southward parallel to the Tha Sae river to join in Tha Taphao river.

After the Tha Sae and Rap Ro rivers join, the river is named Tha Taphao. The Tha Taphao river basin is composed of the alluvial plain extending toward the Gulf of Thailand. The Chumphon river basin is composed of the mountains and the alluvial plan in the upstream section and the downstream section respectively. The river, which springs from the southwestern mountains at an elevation of around 500 m, flows eastward in the mountainous areas and then turns to the northward along the national highway route 4; the river turns again, the south, after crossing the national railway, to drain into the Gulf of Thailand.

The mountains in the Study Area are generally situated more or less in a direction parallel to NE-SW and the rivers flow in a direction parallel to NE-SW or NW-SE in the mountainous areas, which may suggest that there are 2 major fault systems, the faults with the direction of NE-SW and NW-SE.

(2) Geology

As far as the geological structure is concerned, Thailand can be divided into 3 major tectonic units; they are the Shan-Thai, the South Chins and the Indochina. The Study Area is situated on the Shan-Thai Craton of which the basement is composed of the Precambrian high-grade metamorphic crystalline rocks. In southern Thailand, the basement is exposed in comparatively small isolated occurrence at Hua Hin, Prachuap Khiri Khan and Surat Thani. The basement does not crop out in the Study Area.

The cover rocks of the basement in the Study Area are composed of 4 sedimentary formations: Kraburi, Matsi, Chumphon and Fangdang. The Silurian - Devonian Kraburi formation is formed of graywacke, pebbly sandstone, pebbly shale and mudstone, which is extensively distributed in the western part of the Study Area. The Carboniferous Matsi formation, being made up of siltstone and shale, is widely distributed in the eastern part of the Study Area. Furthermore, this formation sporadically appears in the folded and faulted structures in the western part of the Study Area; however, the boundary between the Matsi formation and Kraburi formation is not clear.

The Permian Chumphon formation, consisting of bedded fossiliferous limestone, brecciated limestone and partly dolomitic, is scattered in various sized bodies in the eastern part of the Study Area. The Jurassic Fangdang

formation is scattered in small bodies in the southeastern part of the Study Area. The formation is composed of red to reddish-brown, cross-bedded sandstone, quartzitic sandstone and conglomerate.

In addition, the Igneous rocks are locally exposed in the northwestern part of the Study Area. The Quaternary deposits accumulated along the major valleys and rivers comprise unconsolidated sediments; they are sandy silt and silty sand interbedded with gravel and clay.

The Study Area had been affected by many orogenic movements and igneous activities. The main folding phases probably took place during the Post-Triassic and Late Cretaceous or Early-Tertiary period, resulting in tight and isoclinal folds of the Permo-Carboniferous rocks with slaty axial-plane cleavage. 2 major fault systems can be recognized; the NE-SW and NW-SE fault. The former, namely Ranong Fault Zone, is strikeslip showing right lateral movements, whereas the latter is usually minor and offset the previous fault.

2. 2. 2 Climate and Hydrology

(1) Climate

a) General Climate

Globally, Thailand belongs to 3 climate types: the savanna climate, the tropical monsoon climate and the tropical rainforest climate. Most of Thailand, i.e. the North-East, the North and the Central Region, show the savanna climate. The Study Area may be classified as the tropical monsoon climate with heavy annual rainfall and a short dry season. Figure 2-1 shows the average monthly rainfall and temperature at Amphoe Muang Chumphon. The annual average rainfall is 1,941 mm and there are 2 months with less than about 60 mm of rainfall.

The climate of the Study Area is under the influence of 2 monsoon with a dry and wet season, covering the months of December to April and from May to November respectively. In the dry season, the north-east tradewinds, also called the winter monsoon, reach the Study Area, but they are dry and do not

bring much rainfall; when, however, these winds have been moistured over the Pacific Ocean, they cause winter rains which are most pronounced along the east coast of the peninsula where the Study Area is located. In spring, air movements from sea to land become so strong that the winter monsoon is replaced by the summer monsoon blowing from the south-west from May to November.

b) Rainfall

In the Study Area, there are 7 rainfall gauging stations (Figure 2-2). Rainfall records at 2 stations (Amphoe Muang Chumphon and Amphoe Phathiu) have been available since 1952. A list of rainfall gauging stations is given below:

RAINFALL STATIONS IN THE STUDY AREA

Code No.	Location	Length of Record	Annual Rainfall (mm)
10013	A. Muang Chumphon	1952 to 1992	1,941
10022	A. Phathiu	1952 to 1992	1,482
10033	A. Tha Sae	1953, 1956 to 1992	1,831
10092	Sam Kaeo Regulator	1953 to '70, '72, '92	2,145
10112	Ban Rap Ro, X46A	1979 to 1992	1,716
-	Kaeng Phra Chao	1965 to 1986	2,242
-	Ban Ta Ngo	1963 to 1988	1,559

Annual rainfall generally decreases towards the north; the southern part of the Study Area, around Amphoe Muang Chumphon, has a rainfall of 1,900 to 2,100 mm per year (Figure 2-3), whereas the average annual rainfall at the northernmost part is around 1,500 mm, except for around 2,200 mm of annual rainfall at Kaeng Phra Chao which is located in the mountainous areas. As can be seen from Figure 2-1 showing the average monthly rainfall at Amphoe Muang Chumphon for 30 years from 1961 to 1990, there is usually a dry season in February and March. Then, from April on, the south-west monsoon appears, and the rainfall remains moderate at around 200 mm per month until September; Rainfall increases 350 mm in November.

c) Other Climatic Information

The mean monthly temperature varies from 28.5°C in April to 25.0°C in December, a range of only 3.5°C. Being related to rainfall, the mean monthly evaporation is lowest as 96.1 mm in November, whereas the highest evaporation of 151.8 mm has been recorded in March, totaling 1,399 mm per year. The monthly mean relative humidity has an average of 82 percent with the lowest in March and April of 78 percent while the highest takes place in October and November, 85 percent.

(2) Hydrology

a) River Runoff

The Study Area is composed of 2 major river systems, the Tha Taphao and the Chumphon. The 2 rivers of Rap Ro and Tha Sae meet at Ban Kaho Kaeo, Amphoe Muang Chumphon about 20 km north of the municipality of Chumphon, after which the river is named Tha Taphao. For study purposes, the Study Area with a total area of 2,625 sq.km is divided into 4 river basins: Tha Sae (1,016 sq.km), Rap Ro (803 sq.km), Tha Taphao (357 sq.km) and Chumphon (449 sq.km).

There are 7 riverflow gauging stations in the Study Area; river discharge data are available at 6 stations; 1 station has recorded only water stage so far. The average monthly runoff for 17 years from 1973 to 1990 of the Tha Sae river at the X64 station is illustrated on Figure 2-4, showing that the river runoff pattern reflects the rainfall characteristics; river runoff gradually increases from April to August, decreases in September as rainfall in September decreases; and sharply increases to reach its culminating point in November. Outlines of the streamflow gauging stations are as follows:

STREAM FLOW GAUGING STATION

Code No.	Location	River	Catchment Area (sq.km)	Length of Record	Annual Runoff (mm)
-	Kaeng Phra Chao	Rap Ro	330	1965 ~ 1986	791
-	Hat Som Paen	Rap Ro	188	1983 ~ 1987	660
X46	Ban Ta Kham	Rap Ro	751	1978 ~ 1992	844
-	Ban Ta Ngo	Tha Sae	352	1963 ~ 1967	502
X64	Ban Tha Sae	Tha Sae	957	1973 ~ 1992	546
X158	Tha Taphao	Tha Taphao	1,819	1965 ~ 1992	*
X53	Ban Siep Yuan	Chumphon	223	1978 ~ 1992	1,209

Note: *: discharge data are not available.

b) Flood

Thailand lies between 2 areas of typhoon activity; one is in the Bay of Bengal and the second is in the North Pacific. Typhoons from the Pacific occasionally approach northern Thailand between mid-August and mid-November. For Peninsular Thailand, no storm of full typhoon intensity have reached Peninsular Thailand as typhoon frequencies decrease toward the Equator, and tropical depressions and occasionally tropical storms do cross the Peninsula. These storms generally occur between October and December with heavy rainfall.

Available records indicate that 2 storms and 8 tropical depressions have hit the Study Area during the 30-year period from 1951 to 1980. Typhoon Gay, described by the Weather Bureau as the most violent storm reported in Thailand in 39 years, hit the Study Area with destructive winds on November 4, 1989. The maximum wind speed was 120 km per hour near its center. In the Study Area, the areas hardest hit were Amphoe Muang Chumphon and Amphoe Phathiu. Records of flood flows caused by Typhoon Gay are available only at the X46 station with a catchment area of 751 sq.km on the Rap Ro river. The peak discharge of 649.4 cu.m/sec was recorded at 1 : 00 am. on November 5, 1989. At Amphoe Muang Chumphon, the highest flood water level reached 5.16 m MSL, while the left bank elevation was 4.00 m MSL.

As previously mentioned, no river flow discharge record is available for the Tha Taphao river which causes annual floods around the municipality of

Chumphon due to limited river capacities of about 430 cu.m/sec. The highest 5 annual peak flood discharges at the 2 stations are given below:

ANNUAL PEAK FLOOD DISCHARGE

Order	X64 Station 1/ Tha Sae River		X46 Station 2/ Rap Ro River	
	cu.m/sec	Date	cu.m/sec	Date
1	698.8	Nov. 1988	726.8	Jul. 1979
2	554.0	May 1976	649.4	Nov.1989
3	549.0	Nov. 1987	589.1	May 1978
4	431.1	Nov. 1975	562.1	Aug. 1980
5	401.0	Aug. 1986	541.0	Nov. 1988

Note: 1/: 1973 - 88', 1990 2/: 1978 - '90

2.2.3 Landforms and Soils

(1) Landforms

Landforms in the Study Area are divided into the following 6 types:

LANDFORMS AND AREA

Landforms	Area (sq.km)	(%)
(a) Old and recent beach ridges	36	1.4
(b) Active and former tidal flats and depressions	109	4.1
(c) Plains	274	10.4
(d) Undulating and rolling terrain	301	11.5
(e) Hillslope and low hills	567	21.6
(f) Mountains	1,338	51.0
Total	2,625	100.0

a) Old and Recent Beach Ridges

Beach ridges are formed by the accumulation of sand and shells due to strong waves. The slope of the beach ridge is about 2 to 4 percent.

b) Active and Former Tidal Flats and Depression (swamp)

Tidal flats are regularly flooded by sea water. The depression behind the beach ridge is low land (swamp) which is flooded throughout the year. This land is formed from sea water and rare brackish water sediments. The former tidal flat is the plain behind the beach ridge or swamp. It is accumulatively formed from fresh water sediments or brackish water sediments and sea water sediments. The land in this area is flat or fairly flat with a slope of not more than 2 percent.

c) Plains (lower terrace and flood plain)

Levees were formed from flooding sediments. This area is usually flooded, but only for a short time in the flooding season. Low terraces are next to the levees and are rather plain and flooded in the rainy season. They are rather poorly drained. This topography is formed by fluvial deposits and is paralleled along both sides of the river. The land in this area is flat or rather flat with a slope of not more than 4 percent.

d) Undulating and Rolling Terrain (middle and high terrace, coalescing fans)

This topography is originally formed from old river sediments. It is located next to the low terraces and an upland with a slope ranging from 2~8 percent.

e) Hillslopes and Low Hills

This topography is found next to the slope complex near the hill with a slope of 16~30 percent.

f) Mountains

This topography consists of a succession of mountain ranges north to south which are the biggest and longest in the west part of Thailand. These ranges are on the border between Thailand and Myanmar and also between Chumphon province and Ranong province.

(2) Soils

The parent materials of the soils in the Study Area are classified into 4. The soils in old and new beaches, tidal flats, depressions and areas which were formerly tidal flats are formed from marine water sediments. While soils in low terraces and flood plains are formed from riverine sediments. The soils in middle and high terraces are formed from old alluviums. While soils in the hillslopes and low hills are formed from residuum and colluviums. The soils in mountainous areas are generally very shallow.

The soils in the Study Area are classified into 7 types (USDA Soil Taxonomy) ; Ultisols (919 sq.km, 35.1 percent), Entisols (302 sq.km, 11.4 percent), Inceptisols (12.9 sq.km, 0.5 percent), Alfisols (31.8 sq.km, 1.2 percent), Spodosols (12.7 sq.km, 0.5 percent), Mollisols (6.8 sq.km, 0.3 percent) and Histosols (1.5 sq.km, 0.05 percent). These are classified into 49 soil series, including 9 variants and 6 associations. The distribution of these 7 soils orders based on the land form is shown as follows:

SOIL DISTRIBUTION

Landforms	Order	Area (sq.km)	(%)
(a) Old and recent beach ridges	Entisols	23.2	0.9
	Spodosols	12.7	0.5
(b) Active and former flats and depressions	Entisols	108.7	4.1
(c) Plains	Entisols	143.0	5.3
	Ultisols	88.0	3.4
	Alfisols	31.8	1.2
	Inceptisols	9.9	0.4
(d) Undulating and rolling terrains	Histosols	1.5	0.1
	Ultisols	271.5	10.4
	Entisols	26.6	1.0
(e) Hillslope and low hills	Inceptisols	3.1	0.1
	Ultisols	559.8	21.3
(f) Mountains	Mollisols	6.8	0.3
		1,338.4	51.0

There are 2 main soils in the Study Area, that is, Ultisols (35 percent) and Entisols (11 percent). Ultisols is mainly distributed in the upland area, i.e. hills and footslopes. Entisols are distributed in the lowland areas, i.e. beach ridges, tidal flats, depressions, and planes.

There are 2 problem soils in the Study Area. One is saline soil and the other is potential acid sulfate soil. Saline soil covers 86.6 sq.km which is 3.3

percent of the Study Area, and is distributed in swamps and tidal flats. Potential acid sulfate soil covers 17.8 sq.km which is 0.7 percent of the Study Area, and is distributed in former tidal flat areas.

(3) Land Suitability Classification

The land suitability classification for crops is the only primary classification based on soil information from the detailed reconnaissance survey. Chemical and physical quality of soil, topography, flooding conditions and soil drainage at present are considered. The area of each suitable land class according to crops is shown as follows:

AREA OF LAND SUITABILITY CLASSIFICATION

(Unit: sq.km)

Class	Paddy	Upland Crops	Coconut	Rubber	Fruit Tree	Pasture
I	31	-	-	668	-	997
II	86	78	1,218	353	190	221
III	109	618	1,407	1,604	28	1,407
IV	1	324	-	-	324	-
V	2,398	1,605	-	-	2,083	-

Note : There are 5 classes of soil suited for paddy, upland crops and fruit tree.

I : Extremely suitable soil, II : Well suited soil,
 III : Moderate suitable soil, IV : Less suitable soil.
 V : Unsuitable soil.

There are 3 classes of soil for coconut, rubber, pasture.

I : Extremely suitable soil, II : Less suitable soil,
 III : Unsuitable soil

2.3 AGRICULTURE

2.3.1 Land Use

The total area of the Study Area is 2,625 sq.km, or equivalent to about 44 percent of the land of Chumphon province, of which forest land occupies about 37 percent of the total land of the Study Area. In 1961, the forest area of Chumphon province was 414.4 thousand ha, corresponding to 69 percent of the total land area of the province (600.9 thousand ha). According to data prepared by the Royal Forestry Department, forest land has decreased year by year. In 1989, the forest land shares only 24 percent of the total land area of the

province. This circumstances is attributed to illegal cultivation, concessions to private companies and ALRO (Agricultural Land Reform Office.). In the Study Area, forests are officially classified into reserved forests and wild life sanctuaries.

Undulating and rolling terrain (middle and high terrain, coalescing fans) are widely used to grow rubber trees, coconut palms and some fruits. Some infertile areas are left idle and are covered with weed. Rubber trees, coconut palm, coffee, oil palms and some upland crops are mostly grown in the hills and on the footslopes.

Mountainous areas were mostly covered with forest before, but due to deforestation, the forest area has been decreasing rapidly. After deforestation, rubber trees, coconut palm, coffee, oil palms and some upland crops are being grown in some of the areas by private companies and in-migrants.

The present land use of the Study Area is classified as follows:

PRESENT LAND USE

Category	Area	
	sq.km	%
Forest	960.9	36.6
Farm Land		
- Paddy field	151.1	5.8
- Upland field	76.1	2.9
- Tree crops	634.5	24.2
- Fruits	243.4	9.3
- Mixed orchard & vegetables	74.7	2.8
Sub - total	1,179.8	45.0
Others	484.3	18.4
Total	2,625.0	100.0

The land use in the Study Area based on the landform is as follows; Most of the old and recent beach ridges and dunes are covered with coconut trees and some parts area deserted and covered with bushes and grasses. The depressions (swamp) and active tidal flats have been covered with mangroves. But now some areas are being converted into shrimp ponds. Paddy were grown in areas which were formerly tidal flats.

Fruits, rubber trees, vegetables and paddy are grown in planes (lower terrace and flood plain). The lower plain is used to grow paddy, while the upper plains are used to grow fruit trees, coconut palm ,oil palm and other tree crops.

2.3.2 Crops and Yields

According to the data prepared by the provincial offices of agriculture in 2 provinces, a total area of 107,680 ha was under crops in 1990 including 1,207 ha of dry season paddy cropping. In 3 Amphoe of Chumphon province, dry season paddy cropping was practiced for 1,207 ha of paddy fields (or a cropping intensity of paddy of about 14 percent). Most farm lands are utilized for tree crops and fruit plantation and followed by upland crops as given below:

TOTAL CROPPED AREA IN 1990

(Unit: ha)

Crops	Chumphon	Prachuap Khiri Khan	Total
Paddy			
- Rainy season	7,593	-	7,593
- Dry season	1,207	-	1,207
Upland Crops	20,831	436	21,267
Tree Crops	52,536	1,089	53,625
Fruits	18,785	11	18,796
Vegetables	4,807	385	5,192
Total	105,759	1,921	107,680

Most paddy cropping is practiced on low-lying land along the main rivers. Average yields of rainy season paddy in 1990 range from 2.0 ton/ha in Amphoe Muang Chumphon to 2.3 ton/ha in Amphoe Tha Sae. In 1990 rainy season paddy was planted to 7,593 ha; however, the harvested area was 6,758 ha with an average yield of 2.1 ton/ha. Average yields of dry season paddy in 1990 were 3.1 ton/ha for Amphoe Tha Sae and 4.0 ton/ha for Amphoe Muang Chumphon.

The harvested area of coffee in Chumphon province increased from 15,200 ha in 1987 to 25,500 ha in 1990, corresponding to 52.2 percent of the national total in 1990. The same holds true for the Study Area; the harvested area of coffee amounted to 11,904 ha, or 47 percent of the provincial total. Average yields of coffee are 500 kg/ha for Amphoe of Tha Sae and Pathiu, and 1,030 kg/ha for Amphoe Muag Chumphon, whereas the national average yield in 1990 is 1,220 kg/ha.

Most soils used for coconut plantations are sand or sandy loam spreading along the east coast of the Study Area. Most farmers in these areas grow coconut. Since 1985 the planted area of coconut had a tendency to decrease. The planted area of coconut in the Study Area was 16,164 ha in 1990. Detailed information on yields of coconut is not available so far except for Amphoe Muang Chumphon that has an average yield of 450 fruit/rai in 1990, lower than the provincial average yield of 637 fruit/rai.

The planted area of oil palm in Chumphon province increased from 12,800 ha in 1987 to 19,200 ha in 1990, the harvested area from 9,300 ha to 12,800 ha for the same period. The production of oil palm in 1990 of Chumphon province (144,600 ton) shared about 13 percent of the total national production. The expansion of oil palm plantations in Chumphon province is mainly due to soils suitable for oil palm growing. The oil palm planted area in the Study Area was 7,678 ha, of which 6,645 ha was in Amphoe Tha Sae. Most oil palm cultivation is practiced in settlement areas. There are 2 settlement projects operated by settlement cooperatives in Amphoe Tha Sae and Amphoe Pathiu. Besides, there are large scale oil palm plantations that have their own processing factories. Average yields of oil palm in 1990 are 6,900 kg/ha (1,100 kg/rai) for Amphoe of Pathiu and Tha Sae, 7,500 kg/ha (1,200 kg/rai) for Amphoe Bang Sapan Noi and 9,100 kg/ha (1,450 kg/rai) for Amphoe Muang Chumphon, whereas the national average yield of oil palm in 1990 is 12,300 kg/ha.

The rubber plantations in the Study Area amount to 12,448 ha. Rubber plantations within the Study Area are mainly concentrated in undulating to moderately steep areas in Amphoe Tha Sae and Amphoe Muang Chumphon. Many of rubber producers are of small scale holdings, and farmers are in need of seeking the off-farm employment. Most of the farmers tap daily and suspend during periods of rainfall. Detailed information on rubber yields is not available except for Amphoe Muang Chumphon with an average yield of 100 kg/rai in 1990, same to the national average yield in 1990, where as the provincial average yield is reported to be 247 kg/rai.

According to the statistics obtained from the provincial office of agriculture, the area under fruit trees is 18,796 ha; 6,623 ha in Amphoe Muang Chumphon, 12,063 ha in Amphoe Tha Sae. Papaya and durian are important fruits in the Study Area followed by mangosteen, rambutan and banana.

Average yields of durian, rambutan, mangosteen, banana and papaya are 12.2 ton/ha, 3.4 ton/ha, 11.0 ton/ha 6,100 fruits/ha and 28.1 ton/ha respectively.

The total acreage under vegetables in the Study Area fluctuates every year and occupies only a relatively small part of the total cultivated land. Most vegetables are grown as mixed farming with fruit trees. Main vegetables harvested in 1990 were pepper, cucumber, ginger, white gourd and so on.

Average yield of selected crops in the Study Area are summarized below, along with potential yields recommended by the provincial offices of agriculture concerned as below:

PRESENT YIELD OF SELECTED CROPS

(Unit: ton/ha)

Crops	Chumphon	Prachuap Khiri Khan	Potential Yields
Paddy			
- Rainy season	2.0~2.3	2.2	2.8
- Dry season	3.1~4.0	-	4.0
Coffee	0.5~1.0	0.5	1.6
Oil Palm	6.9~9.1	7.5	17.5
Rubber	0.6	0.9	1.6
Papaya	2.8	2.8	6.3
Maize	2.7~3.8	2.2	3.8

2.3.3 Livestock and Shrimp Culture

Livestock raising in the Study Area has expanded during the last decade as the secondary sources of income for smallholders. About 18,400 heads of cattle were raised in 1990 in the Study Area by about 2,200 farm households with about 3,100 ha pasture; 11,600 heads in Amphoe Tha Sae, 2,900 heads in Amphoe Muang Chumphon, 3,200 heads in Amphoe Phathiu, and 700 heads in Amphoe Bang Sapan Noi respectively.

The shrimp culture of Thailand has been remarkably developed; total shrimp production has increased from 15,800 tons in 1986 to 55,600 tons in 1990, of which 40,800 tons of production is shared by jumbo tiger shrimp. In the Study Area, there are 1,509 ponds for jumbo tiger shrimp culture in 1990 with a

total pond area of 2,700 ha (16,893 rai) being managed by 1,059 operators. Of 2,700 ha of pond area, an area of 1,970 ha is operated by 8 private enterprises.

2.3.4 Farming Practice

In the Study Area, most land is devoted to the cultivation of tree crops and fruits. Land preparation for growing these crops are done by 4-wheel tractors. Orchardists apply chemicals for weed control and some orchardists have installed watering systems of sprinklers as introduced for fruit irrigation in Chanthaburi province. Orchard growers tend to manage their farms on a commercial basis by applying improved farming technology.

Usually farmers transplant for rainy season paddy cropping and broadcast for dry season paddy cropping. Most farmers use the recommended new varieties for rainy season paddy. High yielding varieties are used by 52 percent of the farmers in the Study Area; the highest rate is in Amphoe Phathiu (94 percent); the lowest rate is in Muang Chumphon (37 percent). Fertilizers and chemicals are used by 80 percent of the farmers and 74 percent respectively.

2.3.5 Farm Size and Land Tenure

Of 42,343 farm households in the Study Area, 12,926 farm households (or 30 percent of the total) are engaging in paddy cultivation. The National Rural Development Database (NRD-2C) of the NESDB reveals that farm sizes of 78 percent of the paddy farmers falls within the 0.16 to 1.6 ha range, as shown below:

FARM SIZE OF PADDY FARMERS

(Unit : Nos. of paddy farmers)

Farm Size	Chumphon	Prachuap Khiri Khan	Total (%)
less than 0.16 ha	144	2	146 (1)
0.16 ~ 0.80 ha	5,287	17	5,304 (41)
0.81 ~ 1.60 ha	4,804	22	4,826 (37)
1.61 ~ 3.20 ha	2,063	9	2,072 (16)
3.21 ~ 8.00 ha	503	-	503 (4)
more than 8.00 ha	75	-	75 (1)
Total	12,876	50	12,926 (100)

In the Study Area, there seems to be no serious problem concerning land ownership ; only 3 percent of farm households are tenant farmers. Part owners and tenant farmers rent farm lands from people in the same villages (65 percent) and from their parents/relatives (21 percent).

LAND TENURE

(Unit : Nos. of farm household)

Tenure	Chumphon	Prachuap Khiri Khan	Total (%)
Owner	35,271	2,157	37,428 (89)
Part Owner	3,121	397	3,518 (8)
Tenant	1,340	57	1,397 (3)
Total	39,732	2,611	42,343 (100)

2. 3. 6 Farmer's Groups and Agricultural Credit

In the Study Area, about 3,000 farmers and 7,900 farmers are members of agricultural cooperatives and farmer's groups respectively mainly for the purpose of borrowing institutional agricultural credit. There are several kinds of agricultural credit for farmers, including the Bank for Agriculture and Agricultural Cooperatives (BAAC), agricultural cooperatives, commercial banks, merchants and others. Among these sources, BAAC plays an important role in agricultural credit in the Study Area. 244 villages, or 38 percent of the total number of villages that borrowed agricultural credit, had the loan from BAAC; however, 65 villages, or 10 percent of villages, still borrowed funds for farming from merchants.

Agricultural credit supplied by BAAC Chumphon branch during the period from April 1990 to March 1991 amounted to about Baht 457 million for 7,654 client farmers. Of the amount of total credit, Baht 135 million (or, 30 percent) are for fisheries production purpose, and Baht 81 million (or 18 percent) are for oil palm production purposes.

2.4 SOCIO - ECONOMY

2.4.1 Administrative Units

The Study Area is administratively composed of 4 Amphoe in 2 provinces; the 3 Amphoe of Muang, Tha Sae and Pathiu are in Chumphon province and the Amphoe of Bang Saphan Noi is in Prachuap Khiri Khan province. The Amphoe of Tha Sae is fully covered by the Study Area; meanwhile the 3 Amphoe of Muang Chumphon, Pathiu and Bang Sapan Noi are partly covered. There are 30 Tambon and 277 villages related to the Study Area as summarized below:

<u>ADMINISTRATIVE UNIT</u>			
<u>Province</u>	<u>Amphoe</u>	<u>Tambon</u>	<u>Villages</u>
Chumphon	Muang	16	140
	Tha Sae	7	82
	Pathiu	5	43
Prachuap Khiri Khan	Bang Sapan Noi	2	12
Total	4	30	277

2.4.2 Population

The population of 4 Amphoe related to the Study Area was 241,531 in 1990 with an average population density of 67.1 persons per sq.km, ranging between 32.4 persons per sq.km in Amphoe Tha Sae and 184.5 persons per sq.km in Amphoe Muang Chumphon. The ratio of rural population versus municipal population is approximately 95:5; thereby, indicating that the Study Area is composed of an agrarian society.

POPULATION OF FOUR AMPHOE

Amphoe	Population	Area (sq.km)	Population Density (Persons/sq.km)
Muang Chumphon	124,533	675.1	184.5
Tha Sae	49,620	1,531.2	32.4
Phathiu	37,249	672.4	55.4
Bang Saphan Noi	30,129	720.0	41.8
Total	241,531	3,598.7	67.1

2. 4. 3 Infrastructure and Social Services

Infrastructure and social services in the Study Area are considered in rather good condition except for some aspects of communications (roads, bridges, telecommunications etc.) in some remote areas i.e. hilly and mountainous areas of 3 Amphoe : Ban Sapan Noi, Tha Sae and Pathiu.

(1) Road and Transportation

The trunkroad network in the Study Area is considered rather good. The national highway route 4, which forms a part of the Asian Highway, runs across the Study Area from north to south, and a seaside road has recently been constructed to connect Amphoe Muang Chumphon and Amphoe Phathiu. The Office of Accelerated Rural Development of the Ministry of Interior is promoting the construction of rural trunkroads to connect Amphoe to the network of primary highways; however, rural roads to connect villages to rural trunkroads are defective; in Amphoe Tha Sae, especially in north-south portions near streams, many rural roads are impassible during the rainy season because of annual floods and poor maintenance work.

The national railway runs through the Study Area parallel to the national highway route 4. There are 2 railway stations in the Study Area: Chumphon and Na Cha Ang. In the Study area there is no commercial airport at present. A study on the construction of a medium-sized airport in Tambon Bang Son of Amphoe Pathiu has been completed, and the Provincial Government Office is promoting the construction of the airport.

(2) Rural Electrification

The electrification in the Study Area is quite good. The rate of electrification in 3 Amphoe of Chumphon province reaches 92 percent on a village basis and is summarized as follows:

RURAL ELECTRIFICATION

<u>Amphoe</u>	<u>Nos. of Village Electrified</u>	<u>Percent</u>
Muang Chumphon	136	97
Tha Sae	70	85
Phathiu	42	88
Total	248	92

(3) Water Supply

In the Study Area only the municipality of Chumphon is supplied with running water from the Tha Taphao river. The intake facilities are installed in the municipality, middle reaches of the river. Water intake from the Tha Taphao river is confronted with problems of water quality and water quantity in dry season. The waterworks authority has a plan to shift the intake facilities further upstream. In 1990, the waterworks authority supplied 3.6 MCM of water to 6,800 households. In rural areas, people rely on rainfall for drinking water to be stocked in jars or concrete tanks. In Amphoe Pathiu the lack of water for domestic use is considered very serious.

(4) Public Health

In Chumphon province, there are 1 provincial hospital, 6 community hospitals and 77 health stations; however, on an average, 1 physician covers 11,547 persons, 1 nurse for 1,683 persons and 1 public health officer for 28,122 persons, respectively. These figures may indicate that public health services in Chumphon province need improving. The same is found in the Study Area.

(5) Education

The educational structures in Chumphon province are relatively in good condition. There are 331 elementary and secondary schools with the enrollment of 73,846 students in 1990, and 3 vocational schools. The Study Area has schooling problems in remote areas, especially in Amphoe Tha Sae.

(6) Marketing Facilities

In Amphoe Muang Chumphon, there are 2 central markets whose structures are considered improper for this municipality distribution system. In the other 3 Amphoe the markets are in similar conditions, except for the market of Amphoe Pathiu recently rebuilt after typhoon Gay.

2.5 REGIONAL ECONOMY

The gross provincial product (GPP) of Chumphon province has continued to expand from Baht 4,250 million in 1981 to Baht 9,286 million in 1989 at an average annual growth rate of 10.3 percent. Agricultural production increased from Baht 1,971 million in 1981 to Baht 4,247 million in 1989 at an average annual growth rate of 10.1 percent, whereas the average annual growth rate for non-agricultural production was 10.4 percent for the same period. The GPD in 1989 is equivalent to 0.5 percent of the national domestic product.

46 percent of the GPP in 1989 was taken up by agricultural products (Baht 4,247 million), of which major products were crops (Baht 3,021 million), fisheries (Baht 709 million), livestock (Baht 241 million) and simple agricultural processing productions (Baht 230 million), and the average annual growth rates since 1981 were 10.5 percent, 9.5 percent, 10.8 percent and 15.3 percent respectively.

With a total population of approximately 410 thousand in Chumphon province, the GPP per capita was Baht 22,630, being less than the Baht 31,608 national average; however, it is higher than the average value of Baht 21,955 of the South Thailand in the same year.

2.6 PRESENT WATER RESOURCES DEVELOPMENT PROJECTS

2.6.1 Surface Water

The average annual rainfall in the Study Area with a catchment area of 2,625 sq.km is 1,900 mm, of which 650 mm of rainfall, or 1,700 MCM, is assumed to be surface runoff through stream channels. As the South Thailand including the Study Area has relatively high rainfall when compared with other regions of Northeast, North and Central, irrigation development projects are not so much implemented in the South Thailand. In the Study Area there are 1 medium scale canal project (Sam Kaeo canal), 16 small scale irrigation projects and 9 Kor Sor Chor projects. No large scale project has been implemented in the Study Area. In addition to irrigation projects, the provincial waterworks authority has a water intake on the Tha Taphao river for water supply to the municipality of Chumphon.

Under the above irrigation projects, 19 weirs, 3 ponds and 3 pumping stations are operated; however, no distribution canal system has been constructed except irrigation ditches provided by farmers. Irrigation area amounts to about 17,000 ha, or equivalent to 15 percent of the total farm land of the Study Area, and agriculture of 85 percent of the total farm land relies on rainfall. With the existing irrigation projects, it is assumed that about 120 MCM of runoff is utilized for irrigation. Accordingly more than 90 percent of potential water resources is released into the sea.

2.6.2 Groundwater

There are 2 kinds of aquifer in the Study Area: the Chao Phraya aquifer in the low lying area around the municipality of Chumphon and the Mata sediment aquifer in areas of mountain and hill. Water quality of groundwater is generally good except some places where groundwater contains salt; however, yields of groundwater are 5 - 30 m³/hr for the Chao Phraya aquifer and 5 - 10 m³/hr for the Mata aquifer, which is not sufficient to exploit groundwater for domestic use. In the Study Area there are 300 wells constructed by the Department of Mineral Resources and 140 wells by the Office of Accelerated Rural Development.

**FIGURE 2-1 MAJOR CLIMATIC FACTORS OBSERVED AT CHUMPHON
(1961-1990)**

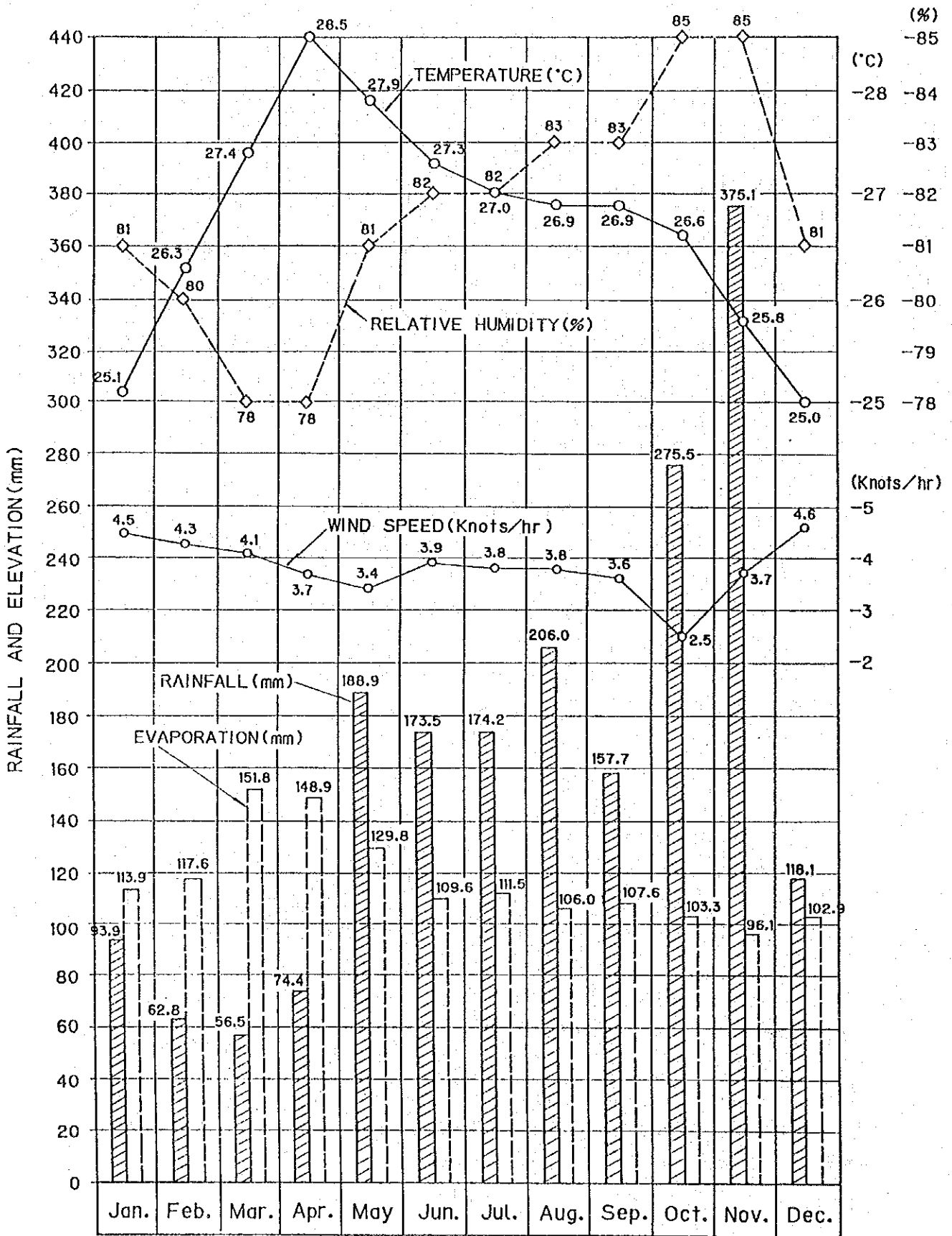


FIGURE 2-3 ISOHYET MAP (ANNUAL RAINFALL)

ANNUAL RAINFALL (mm) 1952-1985

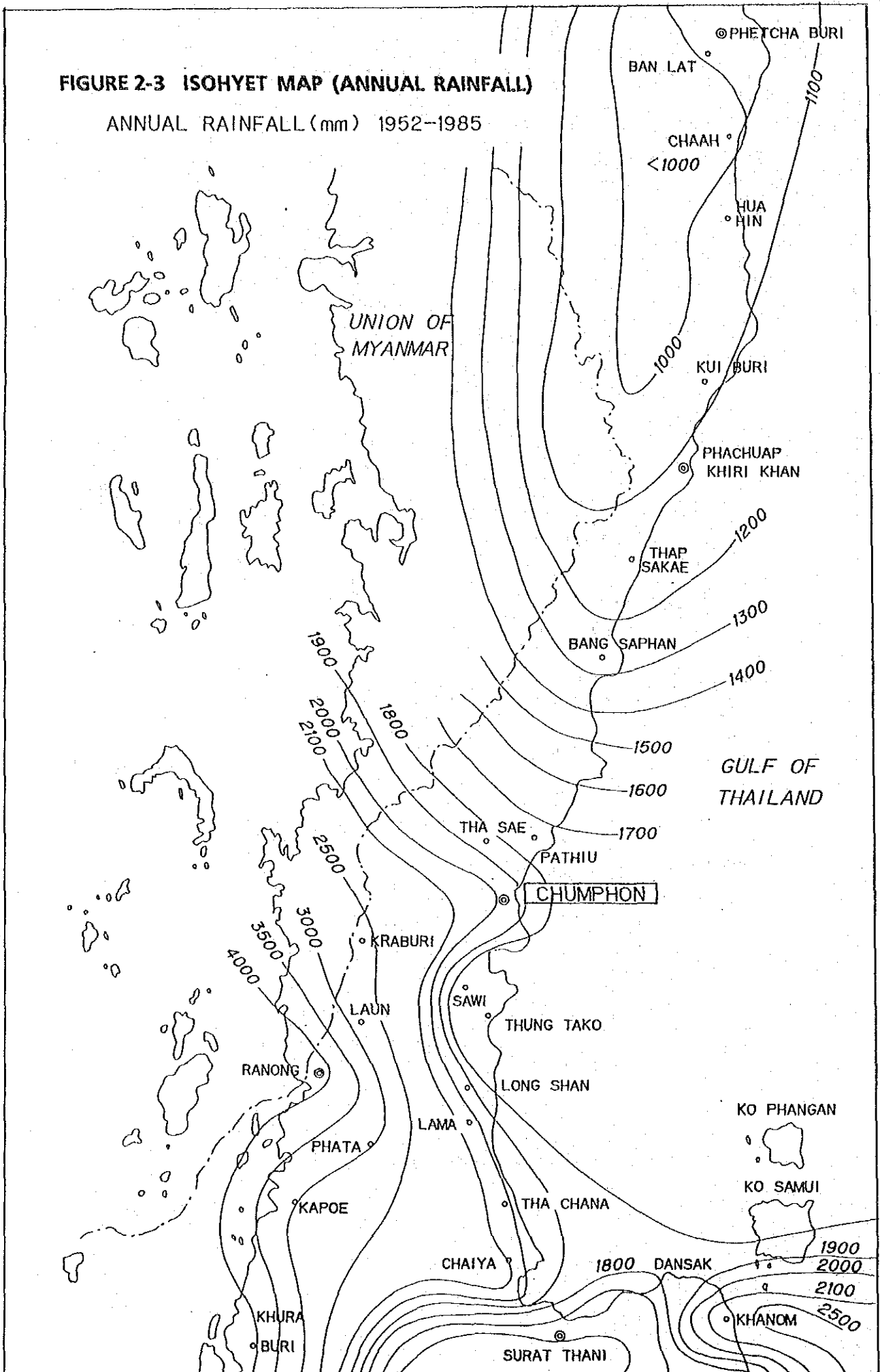
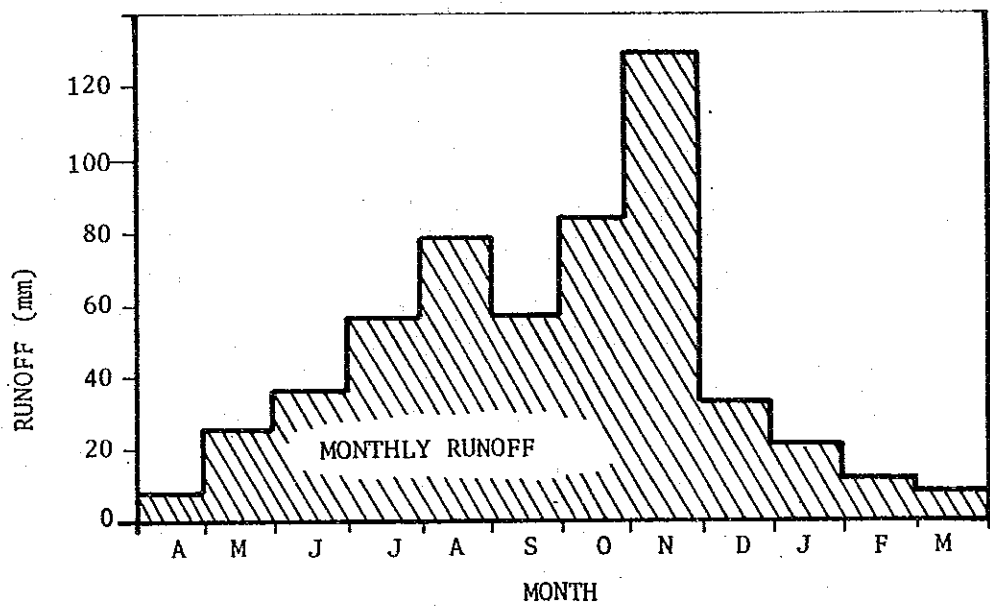


FIGURE 2-4 MONTHLY RUNOFF AT STATION X64, THA SAE RIVER

- CATCHMENT AREA : 957 SQ.KM.
- AVERAGE FOR 17 YEARS



CHAPTER 3. BASIN DEVELOPMENT PLAN

CHAPTER 3. BASIN DEVELOPMENT PLAN

3.1 PROBLEMS AND NEEDS OF THE STUDY AREA

3.1.1 Land Resources

As far as land resources are concerned, the Study Area is faced with 2 problems; actual and potential problems. Actual problems on land are mangrove forest destruction, deforestation and soil erosion, while potential problems are caused by soil chemical properties, i.e. saline soil and potential acid sulfate soil.

Several reserved mangrove forests under the RFD in Amphoe Muang Chumphon extend along the coastal area of the Gulf of Thailand. Rural people and private enterprises have developed mangrove forests for shrimp culture in spite of the conservation plan by the Thai government. Mangrove forests play an important role in maintaining livelihoods including fish. Accordingly, there is a conflict between fishery development projects and forest conservation plan.

Deforestation causes destruction of the ecosystem in surrounding forests as well as decreases in water-holding capacities. Furthermore, soil erosion problems are also caused by forest destruction in steep slope areas. The major causes are due to poor management of land such as the tilling of soils on the slopes, no materials or crops to cover soils, no terracing for crop cultivation, etc.

Saline soils are distributed in tidal flat areas which used to be filled with mangroves and nipa palms. These areas are not important agricultural lands, and are being converted into shrimp ponds which produce more benefit compared to agricultural crop production. Potential acid sulfate soils are distributed on former tidal flats. Paddy is grown in these areas of acid sulfate soils. Soils contain a high content of pyrite (FeS_2) under submerged and reduced conditions. But once pyrite is oxidized by drainage or exposure to air, sulfuric acid is produced decreasing the pH of the soil by 3.0. To prevent oxidization, groundwater level should be controlled and kept above the pyrite

rich layer (about 15-20cm). Groundwater table at present is enough to maintain the soil in a reduced condition.

Land as a factor in agricultural activities should be considered a key resource in rural development. A master plan for land use should be prepared by classifying land for appropriate land use. A land use plan should properly demarcate conserved forest areas including mangrove forests.

3.1.2 Agriculture and Irrigation

(1) Agriculture

Farm lands in the Study Area are not fully developed for crop production. According to NRD-2C data in 1990, only 40 villages (or, 14 percent of total villages) fully utilized their farm lands; 191 villages (69 percent) utilized 3/4 of their farm lands; 46 villages (17percent) utilized not more than half of their farm lands. Among many reasons why villagers did not fully utilize their farm lands, the most serious reason reported by villagers is water shortage (52 percent), followed by low yields (13 percent). In Amphoe Tha Sae, 44 percent of villages experience shortages of water.

The recent increase in crop production of the Study Area is attributable to expansion of the cultivated area. Average yields of the major crops are lower than the national average. Harvested areas of coffee of the Study Area shared about 24 percent of the national total harvested area in 1990, whereas product of the Study Area shared about 14 percent. Emphasis should be placed on increasing the yields and cropping intensities. Besides infrastructure improvement, this requires more effective agricultural support services, such as extension, credit and marketing.

(2) Irrigation

The existing irrigation projects supply water for about 17,000 ha, which is 15 percent of the total farm land of the Study Area. Agriculture of 85 percent of the farm land relies on rainfall that fluctuates seasonally and yearly. There is no diversion work or reservoir on the stream of the main rivers. The

present irrigation projects seem not to function as originally designed because no water distribution system has been provided.

About 80 percent of annual rainfall concentrates in 7 months from May to November, or 40 percent in 3 months from September to November under the influence of tropical storms or depressions. Even during the rainy season, supplemental irrigation is needed due to seasonal and annual fluctuations of rainfall. The annual river runoff of the basin is estimated at about 1,700 MCM, of which about 10 percent runoff is used for irrigation, thus, the development of water resources is the key to agricultural development of the Study Area. For effective water use, irrigation canal systems should be provided down to the on-farm level.

3.1.3 Flood

Historic flooding of the Study Area has been caused mainly by floodwaters of the Tha Taphao river. Almost every year floods inflict substantial damage, especially in the flat areas around the Municipality of Chumphon. Recent high floods in 1970, 1971, 1988 and 1989 caused heavy losses to public facilities, road systems, business and personal property. They also destroyed approximately 18,000 ha of farm land. The frequent occurrence of floods is an obstacle to the socio-economic development of the Study Area.

To reduce the severity of the flood problems, reservoirs are needed to store floodwaters of the rivers of Tha Sae and Rap Ro together with the improvement of the Tha Taphao river. The construction of a floodway may be the alternative to the enlargement of flow capacities of the Tha Taphao river along which many houses are built.

3.1.4 Socio-Economic Aspect

Despite annual flushing floods into the lowland portion of Amphoe Muang Chumphon resulting from concentrated heavy rains and frequent storms, causing damage to the agriculture production and the stability in daily life of local inhabitants through the year, the population in the Study Area, however, has shown steady growth over the past 10 years. This is due to the

number of in-migrants, especially from the Central Region, being higher than the number of out-migrants from this province. This has gradually caused population pressure in this province, especially in the lowland areas which are appropriate for residency. In 1989 Amphoe Muang Chumphon had a population density of more than 180 persons per sq.km. The land prices in this Amphoe are soaring 2-5 times in the past 5 years, especially for areas in the municipality and/or nearby main roads.

With this growth in population, the cultivated land area of Chumphon province increased from 145.7 thousand ha in 1986 to 210.5 thousand ha in 1990. This implies a significant increase of approximately 44 percent in agricultural land, especially for fruit tree & tree crops, vegetables & flowers and livestock farms but a decrease for paddy fields and upland crop fields. This would be caused by various factors such as low market prices, irrigation-shortages, higher costs of inputs, but the expansion of the residential area in lowland plains is also an important reason. Recently, in order to solve this constraint, various programmes such as the ALRO (Agricultural Land Reform Office) Programme has been started in the last 2 years to implement settlements for landless farmers in the forest areas of this province.

Agriculture continues to be the predominant sector, accounting for 46 percent of the gross product of the province, whereas the agricultural production of the whole country shared 15 percent of the gross domestic product (GDP) in 1989.

3.2 DEVELOPMENT OBJECTIVE AND PROJECT COMPONENT

Paying attention to income distribution, economic stability and the people's quality of life , the Seventh National Economic and Social Development Plan (1992 to 1996) has set the 3 major objectives : (1) to continuously sustain the country's economic growth at an appropriate level through stability, (2) to distribute income and development prosperity to the regions, and (3) to develop human resources, enhance the quality of life, and improve the environment and natural resources.

Low agricultural productivity of the Study Area is mainly due to shortages of irrigation water, floods and lack of knowledge of advanced farm

technology. The average annual income per capita of the agricultural sector increased from about 5,900 Baht in 1987 to about 7,100 Baht in 1990 ; however, it is still about 1/5 of the non-agricultural sector. The economic depression may be the basic cause of the poor quality of life of the rural people.

In line with the Seventh National Plan, the objective of the integrated agriculture and water resources development project of the Menam Chumphon Basin has been set up to increase the income level of the farmers through water resources development for agriculture with control of flood and water distribution to farm land, and intensive backup from agricultural extension services.

To accomplish the development objective, this project has been proposed to implement the following basic development plans:

1) Water Resources Development Plan

- Construction of multipurpose reservoir for irrigation, flood control and domestic/municipal water supply
- Construction of medium and small scale reservoirs for irrigation and domestic water supply
- Rehabilitation of swamp for irrigation and inland fisheries purposes
- Construction of floodway
- Improvement of river and canal for the dual purposes of irrigation and flood protection

2) Agricultural Development Plan

- Increase in yields and crop intensities
- Irrigated agricultural development
- Improvement of rainfed agriculture
- Livestock development
- Improvement of access to extension services

3) Irrigation Development Plan

- Construction of irrigation and drainage system
- Development of on-farm facilities of irrigation and drainage
- Organization of water users' groups for improvement of water management

3.3 LAND RESOURCES DEVELOPMENT

Many forest lands have been converted into cultivated lands. Under the circumstances, the target of land resources development of the Study Area is to improve the productivity of the existing farm lands. There are 2 problem soil areas, saline soil and acid sulfate soil areas in a part of the Study Area. Saline soil areas, which are mostly used for growing nipa palms and mangroves, are excluded from the project. Actual acid sulfate soil areas, currently being used for paddy cultivation, need careful soil management; groundwater table should be controlled to be above the layers rich in pyrites to prevent pyrites from excessive oxidation, unless improvement is carried out throughly.

During the phase I study, preliminary land suitability classification for irrigated agriculture is made for plain areas (271 sq.km) by means of interpretation of results of soil surveys, on condition that irrigation is supplied, drainage is improved, and an adequate amount of fertilizer is applied. Soils are classified into 4 levels: well suited (S₁), moderately suited (S₂), poorly suited (S₃), and not suited(N). Results of land suitability classification are summarized below:

Class	Paddy	Upland Crops	Coconut	Coffee	Fruit	Oil Palm
S ₁	89	57	140	-	-	111
S ₂	5	170	12	229	141	59
S ₃	175	31	106	29	117	88
N	2	13	13	13	13	13
Total	271	271	271	271	271	271

With the implementation of proposed irrigation projects as mentioned in Chapter 3. 5: irrigation development, 41,520 ha of farm lands will be irrigated. Most of the irrigable lands are best suited for production of paddy, upland crops, coconut and coffee with irrigation. However, with proper soil and water management, other crops may be grown. The major land-related problems that must be solved are : (1) soil fertility, (2) land development, (3) surface drainage and water control, and (4) soil erosion control.

3. 4 AGRICULTURAL DEVELOPMENT

3. 4. 1 Basic Approach

Areal expansion of farm land has been the main measure to increase the crop production of the Study Area. New land coming under cultivation has a low yield and is apt to suffer from drought damage and eventually the soil fertility deteriorates. The main source of increased production must come from higher yields and cropping intensities. Agricultural development involves irrigation and drainage improvement and production support such as extension services and supply of input. Irrigation development will be promoted as much as possible where physical conditions allow the development of water resources. The basic approach to agricultural development includes;

- 1) Increase of crop yields
- 2) Crop diversification, and
- 3) Strengthening of agricultural extension services

There is a need to improve rainfed agriculture that presents the most acute problems of poverty, low yields and natural resources degradation. This requires programs of applied research and extension for developing suitable technology, including conservation of water, water-saving cultivation, and soil conservation.

3. 4. 2 Crop Production

Cropping area of traditional crops such as maize, rubber, coffee, coconut, oil palm would not be increased as the market demand seems to be stagnant; thereby, efforts will be made to improve productivity. Production of paddy, the staple food of the rural people, will be proposed through introduction of dry season cropping in the low-lying areas along the Tha Taphao river in order to meet the demand for local consumption. The project proposes to crop dry season paddy amounting to 20 percent area of proposed irrigable paddy fields.

With the implementation of irrigation projects, crop diversification will be encouraged. Attractive price and marketing opportunities will

determine the selection of crop diversification. Soybean, fruits and vegetables such as baby corn, tomato, asparagus, etc. are recommendable in consideration of recent market demands. The proposed cropping calendar of irrigated agriculture is presented in Figure 3-1.

3.4.3 Development of Farm-related Production

Cattle in the Study Area are raised generally on natural grasslands with extensive pasturing farming, resulting in low capacities of carrying and breeding. Cattle raising is mostly based on wild grass during the rainy season and standing hay after reaping paddy or new shoots germinated from paddy stumps during the dry season. As cattle slightly increase weight annually, repeating their weight increase during the rainy season and decrease during the dry season every year, it takes 5 to 7 years to sell them to animal markets.

According to the land plan proposed by DLD, a large part of upland areas in the Study Area are suited for livestock pasture development. At the moment, since most of these areas are under replantation of para rubber, oil palm, fruit trees and tree crops, the development of livestock is not yet applied. In order to meet the increasing demands for meat, a livestock development project will be proposed. With the improvement of pasture lands and bathing places, as well as provision of supplemental feed during the dry season, the carrying capacity of grass land is estimated to be 2.0 heads per ha (or 0.5 ha per head).

There is a need to strengthen inland fisheries in the Study Area due to the available potentials of many large water bodies in the Study Area. The Department of Fisheries is promoting inland fisheries projects to raise the annual fish protein consumption level of the rural people to 20 kg per capita. For the promotion of inland fisheries, the Department of Fisheries conducts extension services for rural people including rehabilitation of swamps, fish seed supplies, fish catch, and so on.