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THE KINGDOM OF THAILAND

PRELIMINARY SURVEY REPORT TO THE MASTER PLAN STUDY FOR IRRIGATED AGRICULTURAL DEVELOPMENT PROJECT IN THE GREATER MAE KLONG RIVER BASIN

DECEMBER 1977

JAPAN INTERNATIONAL COOPERATION AGENCY

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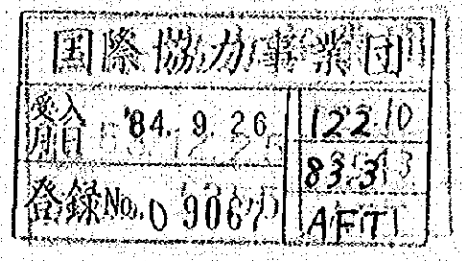


JAPAN INTERNATIONAL COOPERATION AGENCY

PREFACE

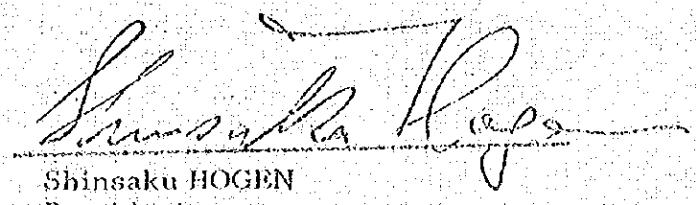
The Government of Thailand requested the Government of Japan for cooperation in agricultural development aiming at paddy production increase per unit acreage and extension of double cropping so as to take countermeasures against reluctant expansion of paddy cropping fields.

As part of the technical cooperations with the Kingdom of Thailand, the Japan International Cooperation Agency (JICA) dispatched an 11-member survey team headed by Mr. Jiro Sakurai, Technical Chief Adviser, Agricultural Structure Improvement Bureau of the Ministry of Agriculture and Forestry, for carrying out a 47-day preliminary survey (July 18 - September 2, 1977) in connection with the Master Plan Study on the Greater Mae Klong River Basin Irrigated Agriculture Development Project.

The Report submitted herewith covers the findings of the said preliminary survey. I hope the Report will prove to be useful for the coming full-scale survey.

I wish to express my heartfelt appreciation to the Thai Authorities concerned, the Embassy of Japan, and the Japanese Ministries of Foreign Affairs, and Agriculture & Forestry for their cooperation extended to the team.

December 1977



Shinsaku HOGEN
President,
Japan International Cooperation Agency

December, 1977

Mr. Shinsaku Hogen
President
Japan International Cooperation Agency
Tokyo, Japan

LETTER OF TRANSMITTAL

Dear Sir,

I, the undersigned, wish to submit herewith the Final Report on the Preliminary Survey of the Master Plan Study for the Greater Mae Klong River Basin Irrigated Agriculture Development Project, Thailand. The Field survey in the Project Area had been carried out for 47 days (July 18 through September 2, 1977). In the course of the survey, various discussions and study meetings were held between Thai Government organizations concerned and the Mission.

The Mission has made the preliminary survey of the Master Plan Study for irrigated agriculture development including land consolidation for the objective area of 420,000 hectares involved in the Greater Mae Klong River Basin about 60 km west of Bangkok.

On top of the above survey, the Mission has conducted the field investigation for the on-going land consolidation projects, Sapphaya and Chanasutr in the Chao Phya River Basin.

On the basis of findings in the survey, the Mission has obtained a clear picture on the present agriculture in the Project Area so as to look into necessity of the proposed Master Plan Study that will be a keystone for plan formulation of the development by agricultural production increase.

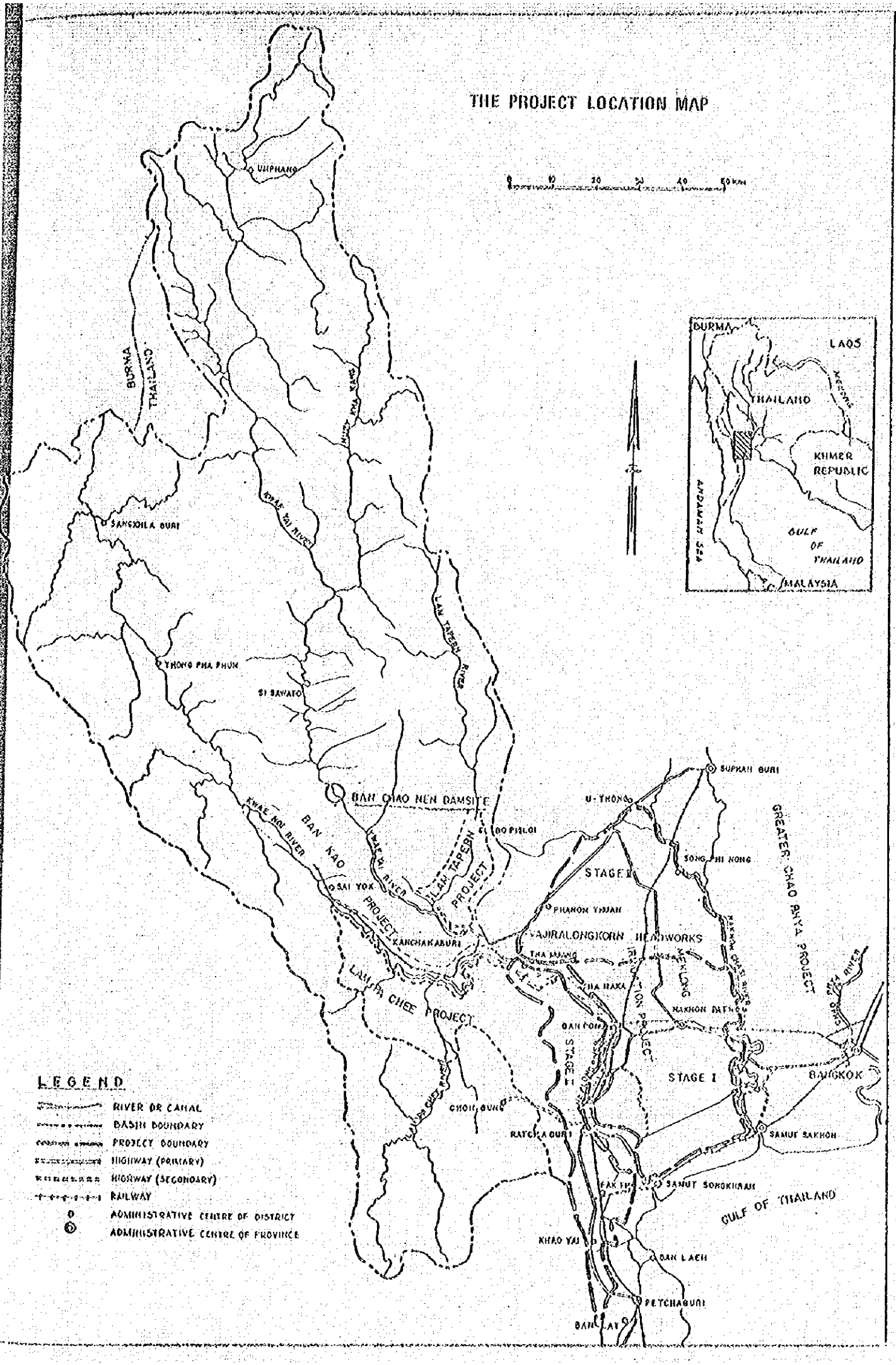
As mentioned in Chapter IV of this Report, the Preliminary Survey revealed that the Master Plan Study was essentially required for the irrigated agriculture development in the Mae Klong River Basin.

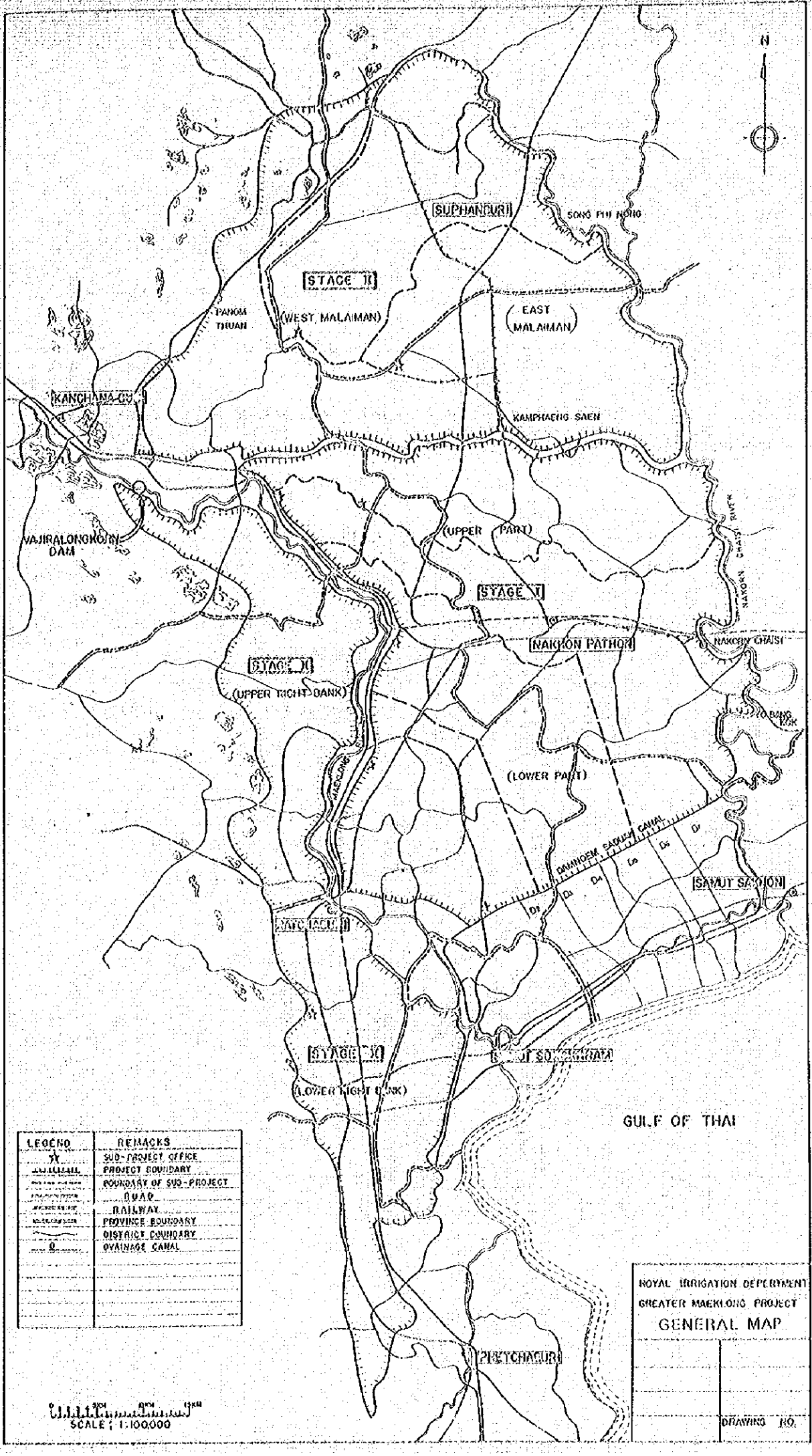
We are confident that the successful result of development made along with the direction in the Report will give a great impact to future social and economical development in Thailand, which will provide a good example to the neighboring countries.

I wish to express my sincere thanks for the closest cooperation and proper timely advices given by staff concerned in the Royal Irrigation Department, Ministry of Agriculture and Cooperatives, Central Land Consolidation Office, Technical and Economical Assistance Department and other Thai Government agencies concerned, and Ministry of Foreign Affairs, Japan, Embassy of Japan (Bangkok), Ministry of Agriculture and Forestry, and Japan International Cooperation Agency (JICA).

Respectfully yours,

Jiro Sakurai
Leader of the Preliminary Survey
Mission of the Master Plan Study for
the Greater Mae Klong River Basin
Development Project, Thailand


THE PROJECT LOCATION MAP
0 10 20 30 40 50 KM
BURMA
LAOS
THAILAND
KHMER REPUBLIC
ANDAMAN SEA
GULF OF THAILAND
MALAYSIA
UMPHANG
BURMA
THAILAND
KHEK KHA KANG
KWAE NOI RIVER
SANGKHLA BURI
THONG PHA PHUM
SI SAWAT
LAM TAPHRA KHAN
BAN CHAO NEN DAMSITE
KWAE NOI RIVER
BAN NAO
KWAE YAI RIVER
SAI YOK
LAM TAPHRA PROJECT
KANCHANABURI
LAM CHEE PROJECT
CHOK GUNG
SUPHAN BURI
U-THONG
SONG PHI NONG
STAGE II
PHANOM THUAN
VAJIRALONGKORN HEADWORKS
THA MUANG
THA RAKA
MEKLONG IRRIGATION PROJECT
NAKHON NAYOK
NAKHON CHAI SRI
GREATER CHAO PHYA PROJECT
BANGKOK
STAGE I
RATCHA BURI
SAMUT SAKHON
SAMUT SONGKHRAM
KHAO YAI
BAN LAEM
PETCHABURI
BAN LAY
LEGEND
RIVER OR CANAL
BASIN BOUNDARY
PROJECT BOUNDARY
HIGHWAY (PRIMARY)
HIGHWAY (SECONDARY)
RAILWAY
ADMINISTRATIVE CENTRE OF DISTRICT
ADMINISTRATIVE CENTRE OF PROVINCE


N
SUPHANBURI
SONG PHI NONG
STAGE II
(WEST MALAIMAN)
PANOM THUAN
EAST MALAIMAN
KANCHANABURI
KAMPHAENG SAEN
VAJIRALONGKORN DAM
(UPPER PART)
NAKON CHAISI RIVER
STAGE I
NAKON PATHOM
NAKON CHAISI
STAGE III
(UPPER RIGHT BANK)
TO BANGKOK
(LOWER PART)
MAE KLONG
DAMNOEM SADUAK CANAL
SAMUT SAKHON
STAGE IV
STAGE V
(LOWER RIGHT BANK)
GULF OF THAI
PHETCHABURI
LEGEND
REMARKS
SUB-PROJECT OFFICE
PROJECT BOUNDARY
BOUNDARY OF SUB-PROJECT
ROAD
RAILWAY
PROVINCE BOUNDARY
DISTRICT BOUNDARY
DRAINAGE CANAL
SCALE : 1:100,000
ROYAL IRRIGATION DEPERTMENT
GREATER MAEKLONG PROJECT
GENERAL MAP
DRAWING NO.

Preliminary Survey Team of the Master Plan Study
on the Greater Mae Klong River Basin in Thailand

Assignment	Name	Present Position
Leader	Mr. Jiro SAKURAI	Technical Chief Adviser, Agricultural Structure Improvement Bureau Ministry of Agriculture & Forestry (MAF)
Irrigation (Sub-Leader)	Mr. Kazuya NAKAMURA	Assistant Chief, Design Division Construction Department Agricultural Structure Improvement Bureau, MAF
Agronomy	Mr. Chuji MIYASAKA	Executive Director, Tochigi Agriculture & Forestry Statistics Association
Soil	Dr. Masanori MITSUCHI	Chief Researcher, Third Division of Soil Department of Chemistry National Institute of Agricultural Sciences, MAF
Irrigation & Drainage Structure	Mr. Mitsuru ISHIKAWA	Irrigation & Drainage Planning Official Engineering Division, Planning Department Tohoku Regional Agricultural Administration Office, MAF
Land Consolidation	Mr. Tadashi KIMURA	Assistant Chief, Irrigation & Drainage Division Construction Department Chugoku-Shikoku Regional Agricultural Administration Office, MAF
Drainage & Cooperation Plan	Mr. Masaki SHIMIZU	Assistant Chief, Land Improvement Division Department of Agriculture, Forestry & Fishery Okinawa General Bureau Okinawa Development Agency
Agricultural Economy	Mr. Kohki NAKAMURA	Adviser for Tokyo Technical Division, Sanyu Consultants Inc. (SCI)
Meteorology & Hydrology	Mr. Ikuzo IWAMOTO	Director of the Third Technical Department, SCI
Rural Development	Mr. Yoshitomo MIYANISHI	Economist of Overseas Department, SCI
Coordination	Mr. Yoshiaki OTSUBO	Senior Technical Official Technical Affairs Division for Agriculture & Forestry Japan International Cooperation Agency (JICA)

Personnel Contacted during the Survey

Name	Status
Mr. Charin Atthayodhin	Deputy Director General, RID
Mr. John Boonlu	Director, Central Land Consolidation Office (CLCO)
Mr. Paitoon Palayasoot	Deputy Director, CLCO
Mr. Phayun Chanthasiro	Director, Topo-survey Div., RID
Mr. Damrong Jaraswathana	Director, Hydrology Div., RID
Mr. Chari Tulyamond	Project Manager, Mae Klong Project
Mr. Chalermthep Ratanaprayook	Agronomist, RID
Mr. Savang Jumpa	Director, Ban Chao Nen Dam Project
Mr. Wichai Sriwarapong	Chief Construction Engineer, Mae Klong Project
Mr. Ananda Karunyakorn	Chief, Land Consolidation Branch, RID
Miss Supha Sing-Intra	Economist, Project Planning Div., RID
Mr. Sa-ngad On-num	Economist, Project Planning Div., RID
Mr. O-Sot Charnvej	Economist, O & M Div., RID
Mrs. Chujit	Chief, O & M Div., RID
Mr. Pira Vathakanon	Construction Div., RID
Mr. Sonkitie	Western Region Design Section, Design Div., RID
Mr. Chachawal	Chief, O & M Div., RID
Mr. Paisal Teanglum	Chief Engineer, 10th Regional Office, RID
Mr. Prachak Soothdhibong	Project Engineer, Right Bank Project
Mr. Thavatchai Satrwsajang	First Grade Engineer, CLCO
Mr. Manoch Nilniyon	Agronomist, the 10th Regional Office
Mr. Supat Yuvachitti	Procurement Officer, the 10th Regional Office
Mr. Dannai	Chief, Land Classification Section, RID
Mr. Chao	Land Classification Section, RID
Mr. Siri	Land Classification Section, RID
Mr. Pongpit	Soil and Water Research Section, Technical Division, Department of Agriculture

ABBREVIATION

mm	:	millimeter
cm	:	centimeter
m	:	meter
km	:	kilometer
sq.m, m^2	:	square meter
sq.km, km^2	:	square kilometer
rai	:	Thai unit of area, 1 rai = 0.16 ha.
ha	:	hectare
l, lit.	:	liter
cu.m, m^3	:	cubic meter
lit/sec	:	liter per second
cu.m/sec (CMS)	:	cubic meter per second
lit/sec/ha	:	liter per second per hectare
PPM	:	part per million
ton, m.t	:	metric ton
EL.	:	elevation above mean sea level
MSL	:	mean sea level
NWL	:	normal water level
FWL	:	full water level
HWL	:	high water level
WL	:	water level
sec.	:	second
min.	:	minute
hr.	:	hour
min.	:	minimum
max.	:	maximum
%	:	percent
No.	:	number
^{o}C	:	degree centigrade
HP	:	horse power
ET	:	evapotranspiration
HYV	:	high yield rice variety
O & M	:	operation and maintenance
FY	:	fiscal year
MOAC	:	Ministry of Agriculture and Cooperatives
ALRO	:	Agricultural Land Reform Office
RID	:	Royal Irrigation Department
CLCO	:	Central Land Consolidation Office
BAAC	:	Bank for Agriculture and Agricultural Cooperatives
Cahangwat	:	province
Amphoe	:	district
Tambon	:	sub-district
Muban	:	village
Khlong	:	canal

TABLE OF CONTENTS

CHAPTER I. INTRODUCTION

1. Dispatch of Preliminary Survey Team

In compliance with the request by the Government of Thailand for the technical cooperation for the Master Plan Study on the Greater Mae Klong River Basin, the Government of Japan dispatched a Preliminary Survey Team aiming at exchanging views with the Thai authorities concerned and conducting necessary field survey for establishing the general approach to the said study.

2. Members of the Team and Survey Period

The Survey Team, consisting of eleven (11) members as listed separately with the respective speciality, stayed in Thailand for the period of forty-seven (47) days from July 18 to September 2, 1977. During the period, the Team made field survey not only on the Mae Klong River Basin including the upperstream catchment areas of the Quae Yai and Quae Noi Rivers, but also on the Sappaya and Chanasutr areas in the Greater Chao Phya River Basin.

The Team's itinerary and Personnel contacted during the Team's stay in Thailand are as shown in separate sheets, respectively.

3. Findings

The findings obtained by the Team are outlined in the following chapters. In Chapter II, the Team's understandings on the general background of the Mae Klong River Basin are summarized. The Team's findings in the survey and comments are described in Chapter III. The purpose and necessity of the Master Plan Study of the Mae Klong River Basin, which are considered inevitable for the agricultural development of the relevant area, are explained in Chapter IV. Chapter V describes about the approach to the Master Plan Study together with the results of consultation with Thai authorities concerned.

CHAPTER II. PURPOSE OF MASTER PLAN AND ITS APPROACHES

1. Summary of Findings in Field Survey

The preliminary survey mission for master plan formulation of the Mae Klong River Basin Development Project has carried out the field survey to collect the related data. The findings obtained from the said survey are summarized as follows:

1) Possibility of agricultural development

The Project Area is blessed with more fertile soils as compared with other areas in Thailand, and also advantageous in producing considerably high yield per unit acreage and its location close to Bangkok. Thus, it seems significant to preferentially develop the agriculture in the Project Area.

2) Land consolidation

The main water utilization facilities which the RID constructed have effectively functioned with their excellent structures. The water supply to the terminal facilities has not always been satisfactoriry, and also the drainage facilities have not been provided completely.

In consideration of the above facts, the Project Area will be converted into the superior farming lands with well-functioning agricultural infrastructures, if the main irrigation and drainage facilities shall be provided on the basis of RID's plans and the land consolidation shall be promoted by constructing related terminal canal and ditch systems, road networks, farm plot arrangement including land levelling and land exchange.

3) Study on water requirements

Implementation of land consolidation and introduction of paddy double cropping will result in unavoidable increase in the water requirements. The Ban Chao Nen Dam, now under construction on the Quae Yai River, and the proposed Ban Tha Thung regulating reservoir on its downstream will function to increase the water available for irrigation

in the present plan.

Since the expected water supply increase, however, is not considered to fulfill the requirements in its entirely, the further study should be made on the following points:

a) Review on availability of irrigation water from Ban Chao Nen Dam and Ban Tha Thung Na regulating reservoir,

b) Study on dam construction on the upperstream of the Quae Noi River,

c) Study on planning to construct several small dams on the river basins of the Quae Noi and the Quae Yai,

d) Study on planning to provide water intake facilities so as to effectively utilize the released water from the Vajiralong Korn Dam,

e) Study on recycling use of irrigation water in the Project Area,

f) Investigation and study on field water requirements in depth,

g) Study on upland irrigation, and,

h) Investigation on operation losses in canal systems and study on countermeasures to reduce the losses.

It is recommended to carry out the continuous long-range investigation and study after Master Plan Study.

4) Study on drainage

a) Floodings from the Mae Klong River

The floodings into the Project Area will be eased to some extent by Ban Chao Nen Dam.

Study on flood discharges from the Quae Noi and the Quae Yai Rivers revealed that the floodings from Quae Noi River basin always reached the Project Area more quickly with much more discharges than those from the Quae Yai River. Thus, the water level of the Mae Klong depends upon the discharges from the Quae Noi River.

As fundamental countermeasures, it should be studied to provide a dam on the Quae Noi River so as to control its floodings.

b) Drainage in the Project Area

The following are the major subject to be taken up for drainage improvement in the Project Area:

i) Determination of unit area drainage discharge to meet the conditions of paddy double cropping, introducing of new varieties and farm mechanization, and,

ii) Study on direct discharge to the Bay of Thailand for drainage control in the area of left bank in the downstream of Stage 1.

For the lowlying flat lands, the existing drainage facilities should be improved so as to increase their regulating capacity as the irrigation water sources.

5) Road networks

Recently, automobiles as a means of transportation have been increased in numbers in the highlying lands and also in the lowlying lands in addition to navigation. In future, further increase of automobiles and farm

mechanization will require to consolidate the road networks in the Project Area. Being the case as such, it is essential to conduct a survey on existing road networks so that a comprehensive development plan should be established for consolidation of trunk roads in the Area.

6) Crops

In due consideration of the cropping pattern prevailing in the Project Area, the crop classification should be made to meet the locally characteristic conditions.

The future paddy growing aims to diffuse and stabilize the double cropping, which necessitate for detailed study on introduction of new high yielding varieties and farm mechanization together with agricultural extension services. In this study, it is required to pay due considerations to balancing the cropping acreages of paddy and sugar cane that is grown rather widely in the Project Area.

It is desirable to provide a training center in the Area for practical and effective extension of farming techniques to farmers.

7) Agricultural development in the Project Area

The agricultural development in the Area depends upon how to develop the potentiality as quickly as possible. In this connection, the master plan that aims at the well-balanced development of the total Project Area, should be formulated soonest possible to proceed to the feasibility study stage.

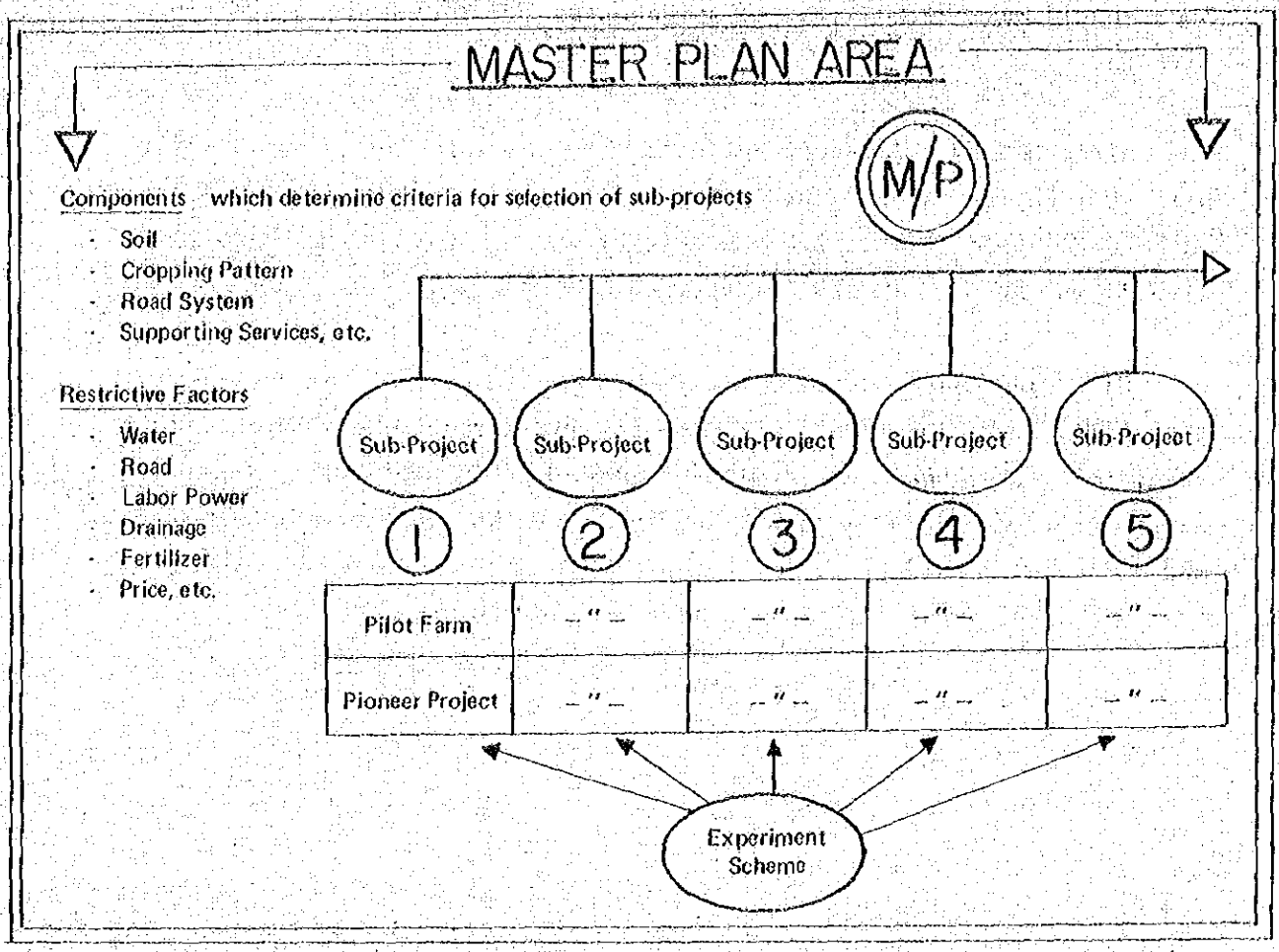
The study on field water requirements in depth, which is the base of germination of definite water requirements, should be carried out in the coming dry season as the important matter in the Master Plan study. Preparatory works to carry it out smoothly should be completed possibly soon, including delivery of survey materials and giving a proper guidance to the local staff. Also, the procedures for drought discharge survey should be followed quickly as well.

The Master Plan Study aiming at a comprehensive development of the Area should make it possible to advance the social welfare of the inhabitants.

Since having a large extension of the objective area, the Project will be technically and financially difficult to be developed in one package deal with full-scale implementation. On top of the large extension of the Area, there exist many regional differentials therein.

With clear understanding on these local characteristic features, therefore, the Master Plan Study for the Mae Klong Project with on-farm development as a nucleus should be promoted in the following procedures. For references, the flow charts of Project Works are shown in Figures 1 and 2.

FIG. 1 SYSTEMATIC APPROACH TO THE MASTER PLAN STUDY

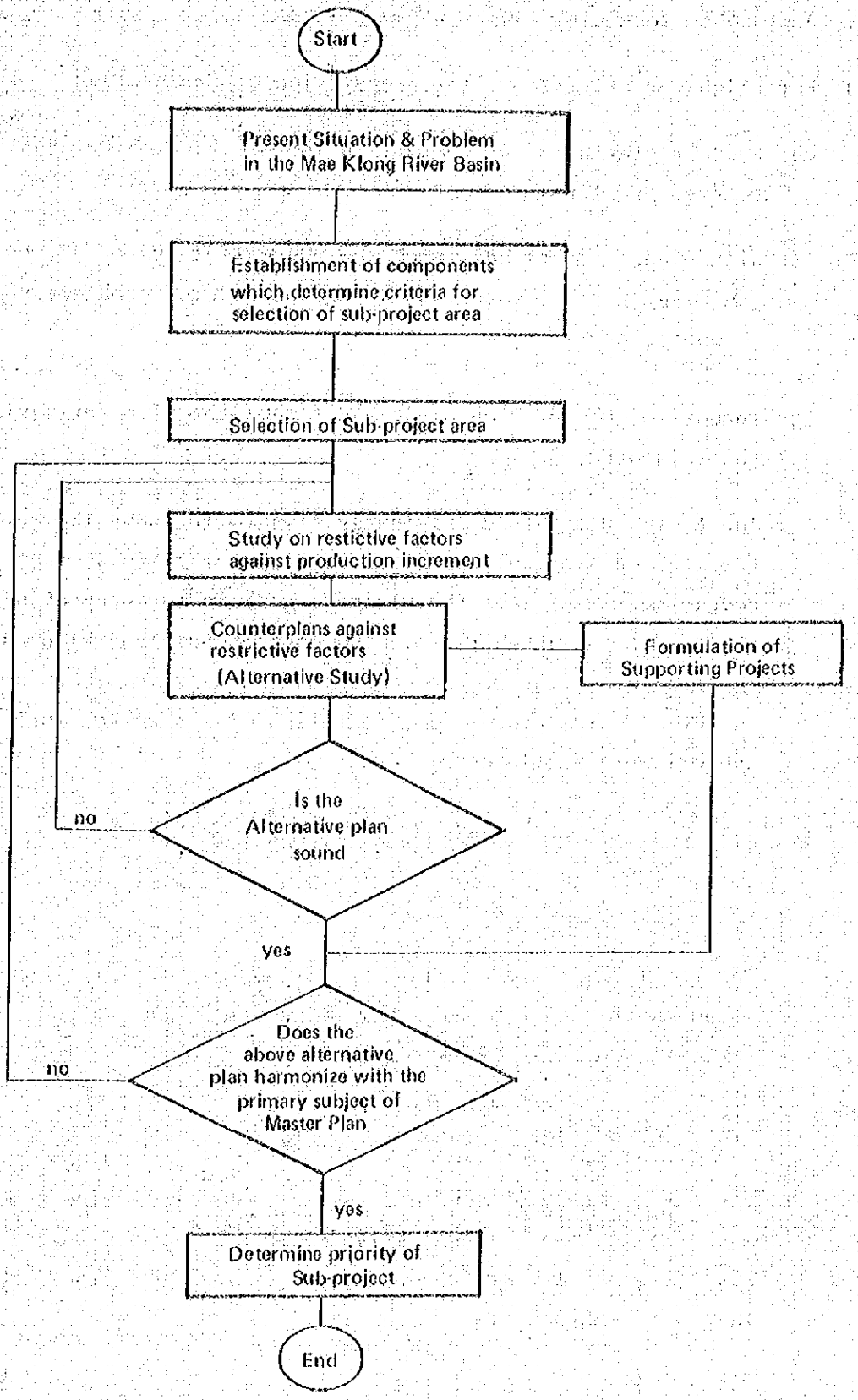


Supporting Project

- Dam
- Canal System
- Road Net-works
- Agri. Supporting Services etc.

FIG. 2 PROCEDURES OF MASTER PLAN STUDY

Objective: Increment of Crop Production through On-farm Development



2. Approaches to Master Plan Study

1) Establishment of criteria for preparation of Master Plan

a) Present status of agriculture in the Mae Klong River Basin and related problems.

With clear understandings on the present status of agriculture and other general situations, various related problems shall be squeezed out.

b) Purpose of Master Plan Study and establishment of criteria for the said study.

The Master Plan Study originally aims to increase the agricultural production on the onfarm development basis so taht the development can reach the ultimate goal in advancement of social welfare of the inhabitants. The comprehensive development of the Area will require the establishment of several sub-projects in the area for easier implementation of the works, for which the criteria should be prepared.

2) Establishment of sub-projects and alternative studies

a) Establishment of sub-projects

The total Project Area shall be devided into several sub-project areas on the basis of the above components and regional characteristic features.

b) Study on negative factors for production increase

Various alternative studies shall be made to provide the countermeasures for the above negative factors. These studies will clarify necessity of supporting projects such as those for securing water sources, farm mechanization, etc.

c) Study on alternative plans and priority among sub-projects

The alternative plans for respective sub-projects shall be further studied on whether or not each alternative can meet the total project requirements, and the priority shall be given to respective sub-projects.

3) Study Items

The Master Plan Study should be carried out in two stages as follows:

a) Field Survey (both in dry and wet seasons)
b) Home Office works

These works should be performed according to the following items, the details of which are summarized in Annex 1.

a) Field Survey

i) Field investigation
ii) Supplemental data collection
iii) Topographical survey
iv) Rectification of topo-maps
v) Soil survey
vi) Geological survey
vii) Hydrological survey
viii) Plan formulation for irrigation scheme
ix) Plan formulation for drainage scheme
x) Plan formulation for land consolidation
xi) Agricultural survey
xii) Agro-economical survey
xiii) Plan formulation for water management scheme
xiv) Establishment of sub-projects
xv) Other various surveys related to the Project

b) Home Office works

i) Macro-study on development of the Greater Mae Klong River Basin

ii) Assessment of water resources and land resources in the said River Basin

iii) Determination of irrigable area

iv) Determination of cropping pattern and irrigation water requirements

v) Establishment of land consolidation program

vi) Establishment of drainage and flood control program

vii) Establishment of water management program

viii) Establishment of dam construction program

ix) Plan formulation of agriculture and agro-economic study

x) Estimate of Project cost

xi) Study on priority and feasibility of sub-project in their stage development

xii) Plan formulation of implementation schedule and operation and management scheme of the Project

xiii) Computation of benefits accrued from Project

xiv) Economic and financial evaluations of the Project.

c) Reports

The following reports shall be submitted to the Government of Thailand:

i) Interim Reports (for both dry and wet seasons)

The Interim Reports (English version) in twenty (20) copies should be submitted when the field survey is completed.

ii) Draft Final Reports

The Draft Final Reports (English version) in twenty (20) copies shall be submitted within fifteen (15) months from commencement of the Study. The commends on the said Draft Final Reports should be issued by the Government of Thailand within twenty (20) days after receipt of the Report and delivered to the Embassy of Japan, Bangkok.

iii) Final Reports

The Final Main Reports and their appendices (both in English

version) in thirty (30) copies each shall be submitted with necessary revision made according to the comments within one month after receipt of the comments.

d) Services and Facilities to be Provided by the Government of Thailand

i) The Government of Thailand should provide the data and information necessary for the Study.

ii) The Government of Thailand should arrange for the quick and smooth customs clearance of the survey equipment and materials which the Mission members will bring into the field so as to exempt from any taxes and duties imposed by the Government for the goods brought by the Mission members in Thailand. In this respect, the Government of Japan should submit to the Government of Thailand a list of those goods to be brought-in before the Mission arrives in the field.

iii) The Government of Thailand should make arrangement of exemption of taxes, duties and levies incurred during the survey by the Mission.

iv) The Government of Thailand should request the ministries and other governmental organizations concerned to cooperate with the Mission in smooth execution of the survey.

v) The Government of Thailand should provide the necessary computer machines and other equipment so that the Mission can conduct the hydrological analysis and soil tests free-of-charge.

vi) The counterparts personnel in the following fields should be designated to cooperate with the Mission in conducting the Study effectively.

1) Irrigation
2) Drainage
3) Land Consolidation
4) Soil Survey
5) Geology
6) Hydrology
7) Structure (dam, canal & road)
8) Surveying
9) Fishery (freshwater)
10) Estimate (construction cost)
11) Agronomy
12) Agro-economy

The number of counterparts personnel and their respective assignment periods should be decided by prior consultation of the Mission with the Thai authorities concerned to commencement of the Study.

vii) The Government of Thailand should provide the office space for the Mission.

viii) The necessary arrangement should be made to obtain the permission of the authorities concerned for the mission to conduct the survey in the objective areas.

ix) During the surveying period, the security of the Mission members should be guaranteed by the authorities concerned.

x) Besides the above, the Government of Thailand should extend close cooperation to the Mission in every respect for smooth execution of the Study.

xi) In the course of the home office works of the Mission, the Government of Japan is in a position to train the Thai counterparts personnel in Japan, and these counterpart personnel should cooperate with the Mission members in preparing the reports.

ANNEX 1

DETAILED CONTENTS OF SURVEY

1. Field Survey

1.1. Study on the existing data and the results of field survey should be made to grasp the present status of the Project Area.

1) Review should be made on the reports prepared by the Preliminary Survey Mission, existing data, information and reference materials available.

2) Field survey should be carried out in the Project Area and its immediate vicinity.

1.2. Additional Data Collection

The additional data should be collected to supplement the following data collected already by the Preliminary Survey Mission:

a) Topo-maps (1/50,000) for the Quae-Yai and the Quae-Noi river basins, data on levelling points in their related areas, and topo-maps (1/10,000 & 1/4,000) of Stage I II Areas (There is no topo-map of 1/4,000 for the Stage I area.)
b) Aerial photos of the proposed dam site
c) Hourly Rainfall distribution data in the Greater Mae Klong River Basin
d) Photomatic records of water level and discharges
e) Sediment and tide records at the estuary of the Greater Mae Klong River
f) Records on earthquakes
g) Plans of land use and land reform in the Project Area
h) Sugar production program and various data on sugar tests in the Project Area, the data obtained in Rice Experimental Station, cropping pattern, yields and farm management
i) Population, results of agriculture census, land ownership, farmers' organization extension services, agricul-

tural crediting, statistics of market prices of farm products, water right, land acquisition law, land price, price index of commodities, agro-economic and socio-economic data including Marketting system of farm products

10) Other data and information related to the Project works.

1-3. Topographical Survey

Topographical survey (1/500-1/1000) should be carried out for the dam site, if necessary (cross-sectional survey of rivers, plane survey by Stadia method).

1-4. Rectification of Topo-Maps

Existing topo-maps (1/10,000) covering the Stage I & II areas should be rectified on roads and other major structures.

1-5. Soil Survey

Soil maps, land use maps and land classification maps should be prepared according to the data obtained in the Preliminary Survey and the Master Plan Study.

1-6. Geological Survey

1) In the proposed dam sites (two or three sites), the field surface survey should be conducted and test borings about 50 m deep, if necessary.
2) Survey should be made to identify the dam construction materials, and physical test of those materials should be made, if necessary.
3) The survey method shall be determined in depending on the results of the field survey, trial drilling and physical tests mentioned above.

1-7. Hydrological Survey

1) The conditions and special features of the rivers should be looked into based on the existing meteorological and hydrological data and the field survey in the related river basins.
2) Study on river discharges in the Greater Mae Kong River Basin shall be conducted for about 20 years period.
3) Study on water balance - demand and supply of water, should be conducted.
4) Study on flood control in the Project Area should be conducted.
5) Detailed study should be made on operation rule of the Ban Chao Nen Dam and the regulating reservoir to be provided in the downstream of the said dam, and on the water utilization right of power generation and irrigation.

1-8. Irrigation

1) The water requirements should be determined based on the existing data and supplemented data (including actual survey values).
2) The proposed Project Area should be decided based on the water balance, existing topo-maps (1/10,000) and soil maps. In this case, the proposed project area means the total objective area of the development.

1-9. Drainage

1) The drainage networks in the Project Area should be decided on the basis of the existing topo-maps (1/10,000)
2) The countermeausres to control floodings from the Greater Mae Klong River should be established.
3) According to the existing data and the results of field survey, the study should be made on the time when the flooding damages occur, the duration of floodings,

flooding depth, acreages submerged by floodings, and scale and extent of floodings

4) The study should be made on suitability of existing design unit discharge, and the new unit discharge should be determined if the existing one is found unsuitable.

1-10. Land Consolidation

1) In the light of the existing topo-maps (1/10,000) and the results of field survey, the study should be made on the precise acreage commanded by major structures the RID (Royal Irrigation Department) is now constructing or planning to construct in the Project Area.
2) The Project Area should be adequately divided into several blocks to select the model district representing respective blocks taking into account such various conditions as soil, cropping pattern, road networks, topography, etc.
3) The design criteria should be established for the size of farming block, road width, type of canals (both irrigation and drainage) and so forth.

1-11. Agriculture

1) The survey should be carried out on the following subjects: present land use, land ownership, cropping pattern, labor forces, input materials, yields, productivity, farming method of the respective crops, etc.
2) Based on the above survey, the proposed cropping pattern should be established.

1-12. Agro-economic survey

1) The agro-economic survey should be made on processing plants of farm products, pricing mechanism, marketing system, farm income and expenditure, farmers' conventional way of life and farming, etc.

2) The present status of farmers' organization, crediting, extension services, and activities of research institutes should be studied.

1-13. Water Management

1) The clear picture should be functions of existing irrigation and drainage facilities in the Project Area.
2) In view of proposed cropping pattern, form of farm management, effective water resources utilization, etc., the plans should be formulated on the appropriate facilities, organization, operation of the water management in the Project Area.

1-14. Provision of Sub-Projects

1) On the basis of such essential conditions for development, as topography, soil, proposed cropping pattern, major facilities of irrigation and drainage, road networks, etc., the Project Area should be divided into several sub-projects under the cooperation of the respective experts, who should determine the development priority of these sub-projects.

1-15. Other Surveys

1) The survey for fresh water fishery in the Project Area should be made on kinds of fish, amount of catches, relation of fishery to the farmers life so as to make a plan for fishery development in future.
2) Socio-environmental survey should be carried out on health and medical facilities and education facilities, etc.
3) The data collection and survey should be made on the submerged area by dam construction.
4) The data collection and study on plan formulation should be made on electrification program to be developed by dam construction.

II. Home Office Works

2-1. The macro-study should be made on socio-economic aspect in development of the Greater Mae Klong River Basin.

2-2. According to the results of field survey, evaluation should be carried out on water resources and land resources of the Project Area.

1) The review should be made on the results of field survey for water resources development in the whole Project Area on the basis of hydrological analysis of rainfall, discharges, etc.
2) The review shall be made on the result of field survey for land resources development in the whole Project Area on the basis of the collected data of topography, soil and land use.
3) The study should be made on the possibility of agricultural development of the Project Area, according to the development possibility of water and land resources.

2-3. Determination of Irrigable Area

1) Based on the proposed cropping attern, land use plan, water utilization plans that will be prepared in the field, the review should be made on irrigable area in the Project Area.

2-4. Determination of Cropping Pattern and Irrigation Water Requirements

1) From the technical and economical viewpoints, the review should be made on various cropping pattern prepared in the field to determine the best suited plan to the Project Area.
2) On the basis of the best available cropping pattern, the irrigation water requirements should be determined in taking into account the following factors: the water requirements in the field, irrigation loss,

diversion loss, conveyance loss, and effective rainfall, etc.

3) The water amount to be stored in the reservoir should be computed on the basis of the relationship between water requirements in the Project Area and water resources in the relevant river basins.

2-5. Plan Formulation of Land Consolidation

1) The further technical and economical study should be made on the model districts selected in the field survey so that the best available plan of land consolidation can be formulated.

2) The rough estimate should be made on the construction cost for land consolidation of the whole Project area as well as the model districts.

2-6. Plan Formulation of Drainage and Flood Control

1) The detailed technical and economical study should be made on the drainage plan, unit drain discharge, flood control and their related physical planning which will be designed in the field, so that the best suited plans can be formulated.

2-7. Determination of Water Management Plan

The further technical and economical study should be made on the water management program prepared in the field so as to establish the most suitable and practical water management system.

2-8. Plan Formulation of Dam Construction

1) The best available plan for dam construction should be formulated with detailed technical and economical study on the basis of the water storage amount obtained from irrigation and flood control plans, and the results of soil survey and physical tests for construction materials.

3) The power generation plan should be established, if the dam construction plan includes the power generation program.

2-9. Agriculture and Agro-economic Plan Formulation

1) The optimum scale, proper operation method of farm management, and adequate amount of farm inputs that can meet the proposed cropping pattern should be sought for.
2) The output of farm products in "With Project Condition" should be computed to study the farmers' economy.
3) The study should be made on the various agri-supporting services such as farmers' organization, crediting system, water management organization, extension activities, distribution systems, etc.

2-10. Estimate of Project Cost

The cost estimates should be made by sectors (Irrigation/Drainage, Land Consolidation, Flood Control, Power Generation, etc.) and by respective sub-projects (cited in 1-14) to compute the rough amount of the total Project construction cost.

2-11. Study on Priority and Feasibility of Sub-Projects in their Staged Development

1) The feasibility and need of the staged development should be studied by respective sectors - agricultural development, flood control and power generation.
2) The feasibility in staged development shall be comparatively studied among sectors as well as in the sector itself.

2-12. Plan Formulation of Project Implementation and Operation & Management of the Project

1) The study should be made on the organization of operation and management of the Project after its completion, and also its operation plan should be formulated.

2-13. Estimate of Benefit

1) The benefit estimate should be made roughly by the sectors and sub-projects.
2) The study should be carried out on secondary effects and social effects.

2-14. Economic Evaluation and Financial Evaluation

1) Regarding irrigation, flood control and power generation, the annual operation funds should be estimated on the basis of cost by sectors and respective sub-projects.
2) The Economic Internal Rate of Return (EIRR) should be computed based on the Project cost, operation cost and expected benefit.
3) The financial evaluation of the Project should be made.

CHAPTER III. GENERAL BACKGROUND OF THE PROJECT

1. Present Situation of the Greater Mae Klong River Basin (Comparative Study with other Regions in Thailand)

In the regional divisions of Thailand, the Greater Mae Klong River Basin belongs to the Western Region among six (6) regions of the country, the Northeast, North, Central Plain, East, West and South. The Western Region, being occupied mainly with the mountains along the Thai-Burma boundary and adjoining hilly lands, has the plain lands only in the eastern tip of the Region, and the Project Area is located in the east end of the Region.

The natural and socio-economic conditions of the Area are similar to those of the Central Plain. (Refer to Note 1.)

1) Transportation

The Project Area, extending 50 km to 150 km west from Bangkok, Metropolis of the country, is linked therewith by the Asian Highway and the National Railway. The express bus service provides ten (10) round-trips a day between the center of Bangkok and Kanchanaburi at the north-west end of the Region, taking about two (2) hours for a single trip.

The Asian Highway is connected with each Changwat capital city in the Area by asphalt paved roads, and the branch road networks are insufficiently provided yet, although those linking the municipalities in the Area with each other are well arranged.

The Area is blessed with economical conditions because of being closely located to Bangkok.

Note 1. Agricultural statistics of Thailand divides the country into six (6) regions or four (4) regions. In the former divisions, the Project Area belongs to the Western Region, and in the latter belongs to the Central Region. Fig. 1 shows locations of the Western Region and the Central Plain in the six-division.

Fig 1

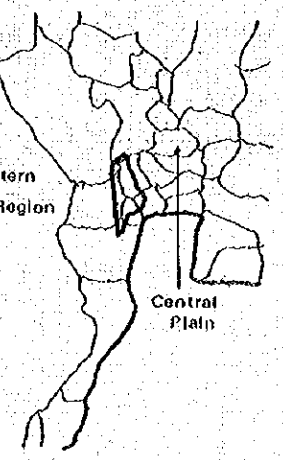


Fig 2

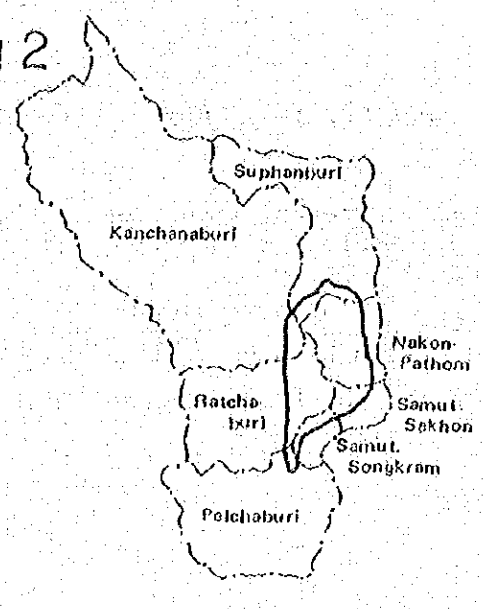


Figure 2 shows the relationship of the location among the Project Area and its related seven Changwat, each of which includes a part of the Area. Three (3) Changwat (Kanchanaburi, Ratchaburi and Petchaburi) west of the Area are mostly occupied with mountains and hilly lands in their western parts and the plain lands develop unevenly in only their eastern parts, where a part of the Project Area extends.

Such being the case, it should be noted not to be directly employed the existing statistic figures of agriculture for the averages of Western Region and those of seven Changwat.

2. Density and Growth of Population

Population density of the nation, the Metropolitan area, and the related seven (7) Changwat is shown hereunder. The average density of seven (7) Changwat is 76 heads/km^2, which is almost the same as that of the national average 75 heads/km^2. (The national average excludes Bangkok and Thomburi areas). The Changwat-wise figures, however, range from minimum 23 heads/km^2 of Kantchanaburi to maximum 483 heads/km^2 of Sam Song Kram. In the land classification, however, some Changwat include statistically unclassified areas, e.g., 89 percent of Kanchanaburi and 76 percent of Petchaburi are unclassified yet, chiefly consisting of mountains.

In view of the above, the population density of the Project Area, most of which is a plain land, is estimated at about 200 heads/km^2 on the assumption that it is classified between Na Khon Pathom (238 heads/km^2 with 21 percent of unclassified area) and Suphanburi (117 heads/km^2 with 24 percent of unclassified area). In other words, the population density of the Project Area is estimated at about three times as many as the national average excluding the metropolitan areas.

Population Density - 1976

	Population	Total Area (1000 rai)	Total Area (km^2)	Population Density (Persons/km^2)
1) Kingdom	43,213,711	321,250	514,000	84
2) Bangkok-Thonburi	4,545,608	968	1,549	2,935
3) (1)-(2)	38,668,103	320,282	512,451	75
Related Provinces	3,022,422	24,824	39,718	76
Kanchanaburi	447,679	12,179	19,486	23
Nakhon Pathom	518,474	1,361	2,178	238
Ratchaburi	596,756	3,200	5,120	117
Suphanburi	677,372	3,387	5,339	127
Petchaburi	345,218	3,973	6,357	54
Samut Songkram	192,335	249	398	483
Samut Saknon	244,588	525	840	291

The annual average growth rate of population in a period 1967 through 1976 is shown in the following table, which reveals that the national average (excluding the metropolitan areas with 4.26 percent per annum) is about 3.11 percent per annum and the Project related seven Changwat is about 2.24 percent on an average. The Changwat-wise growth rate ranges from 4.44 percent of Kanchanaburi at maximum to 0.9 percent of Samut Songkram at minimum. The growth rate of the Project area is estimated at nearly 1.96 percent per annum on the average of three Changwat, Nakhon Pathom, Ratchaburi and Suphanburi. The figure is considerably lower than the national average excluding the metropolitan areas.

Growth Rate of Population (%)

Kingdom	3.22	Nakhon Pathom	1.86
Bangkok Metropolitan	4.26	Ratchaburi	2.49
		Suphanburi	1.54
Kingdom exclusive of Metropolitan	3.11	Petchaburi	1.95
		Samut Songkram	0.90
Related Provinces	2.24	Samut Sakhon	2.36
Kanchanaburi	4.44		

3. Land Tenancy and Farming Scale

The regional comparison between the owned land and tenant land in 1976 is shown as follows: The rate of the owned land in the Project Area is presumed to be between 62 percent of the Central Plain and 74 percent of the Western Region, and lower than that of national average.

Land Tenancy

	Owned	Tenant	Others
North	76	19	5
North East	91	4	5
Central Plain	62	35	3
West	74	24	2
East	70	27	3
South	92	4	4
Whole Kingdom	83	13	4

The Fourth Five-Year Development Plan (FFP p. 166) describes that the farming size per household is 14.7 rai (2.35 ha.) on a national average. In the Project Area, the rate of farming households which cultivate larger farm lands than the above average occupy about 40 percent in Changwat Samut Sakhon and Samut Songkram, and more than 60 percent in other five project related Changwat.

4. Land Productivity

In view of paddy yield per rai, the land productivity in the Project Area is estimated at about 300 in the wet season and 533 in the dry season, which are classified into the comparatively high yielding group on the national basis.

5. Farmer's Income

Taking the national average farmer's income in 1974 as 100, the Western Region produces about 245 of agricultural income and 126 of non-agricultural income, both of which are higher than the national average.

Average Cash Income Per Household by Regions

Region	Agriculture	Non-Agriculture	Total
Whole Kingdom	100	100	100
Central Plain	188	117	166
West	245	126	208
East	193	128	168
North	106	75	97
Northeast	55	82	62
South	78	141	98

NOTE: The cash income of the farm household in 1974 is ฿9,493 of agricultural income and ฿4,315 of non-agricultural income (Total ฿13,808) on a national average.

6. Position of the Mae Klong Project in the Fourth Five-Year National Economic and Social Development Plan

1) Large-Scale Irrigation Projects

The data furnished in August 1977 by the Financial Division, RID, reveal that in a period of the Fourth Five-Year Development Plan (1977-1981) there will be 15 large-scale irrigation projects implemented and the related budget amount to about ฿6,946.5 million, including ฿1,420 million for the Mae Klong Project which the second largest budget from the Phisanulok Project, ฿2,189.5 million, and on top of the above, 11 new projects are under contemplation with budgetary support of total ฿4,150 million.

CHAPTER IV. PRESENT STATUS OF THE MAE KLONG PROJECT AREA

1. Agricultural Economy

In consideration of time factor, the preliminary survey was conducted to concentrate energy to the qualitative study and so the quantitative study will be made in the Master Plan Study stage.

The analysis in this study was made on the following basins:

i) Farm economy study made by RID in 1976 for 850 farm households in the Project area.
ii) Data collected at Irrigation Office No. 10.
iii) Findings obtained by interview in the project related Changwat offices.

1) Project Area

The Project Area extends administratively over seven (7) Changwat, Kanchanaburi, Ratchaburi, Nakhon Pathom, Suphanburi, Petchaburi, Samut Sakhon and Samut Songkram, including 27 Amphoe, 267 Tambon and 744 Muban.

The gross area is about 2,912,900 rai (466,000 ha.), and the RID divides the Project Area into nine (9) sub-projects, the details of which are illustrated in Tables E-1 and E-2.

2) Population Density

The population density in 1976 and growth rate in recent 10 years are summarized in the succeeding page on the basis of the related seven (7) Changwat, Bangkok and the Nation.

	Total	Male	Female	Growth Rate
Kanchanaburi	447,679	225,873	221,806	4.4
Nakhon Pathom	518,474	256,576	261,898	1.9
Ratchaburi	596,756	299,430	297,326	2.5
Suphanburi	677,372	336,364	341,008	1.5
Phetchaburi	345,218	169,810	175,408	1.9
Samut Sakhon	244,588	121,064	123,524	2.4
Samut Songkhran	192,335	93,953	98,382	0.9
Bangkok Metropolitan	4,545,608	2,325,472	2,220,136	4.3
Kingdom of Thailand	43,213,711	21,790,510	21,423,201	3.2

3) Number of Farm Households

Heads of the related Tambon reported that the number of farm households in the Project Area, 1977 was as follows:

	Stage I	Stage II	Whole Area
Total number of households	73,176	66,087	139,263
Farm households	43,225	45,502	88,727
Non-farm households	29,951	20,585	50,536
Rate (%)	59	69	64

4) Economic Survey on Farm Households

The farm size, number of family, land use, land tenancy, etc., are summarized as follows:

	Stage I	Stage II	Whole Area
Number of sample family	411	439	850
Number of family members	6.5	6.4	6.4
Working population	3.7	4.0	3.9
Farm size (rai)	24.11	31.35	27.85
Rate of owned land (%)	73.0	79.6	76.8
Cropping Acreage (rai)	22.34	28.74	25.65
Paddy Fields	14.00	21.26	17.65
Upland fields	5.19	6.19	5.71
Vegetables & fruit trees	3.15	1.29	2.19

5) Agricultural Production

In general, the agricultural production, which is performed in rather extensive manner, can be said to stay in low level in view of potentiality of soils and others. This is because poor provision of on-farm infrastructures, shortage of labor force, insufficient extension services and low profitability act negative factors to restrain the farmers' incentive.

6) Farm Products Processing Plant

There are 19 sugar factories in the Project Area, most of which are located along the national way running from Ban Pong to Kanchanaburi. Currently, they operate about 100 days in a year on an average, and from the viewpoint of optimum operation program, it is required to increase in sugarcane yield per unit acreage and to extend the harvesting period.

Besides the sugar factories, there are several rice mills, Tapioka processing plants, and lumber mills in the Area. The detailed survey, however, has not been conducted yet on these factories.

2. Topography

The Project Area is divided into four topographical units as illustrated in Map T-1.

i) Diluvial terrace.
ii) Old alluvial fan with its apex near the Vajiralong Korn Dam site.
iii) Riverine alluvium developed in strip along the Mae Klong River.
iv) Marine alluvium.

The diluvial terrace distributes at about EL 20 m along the western edge of the Project Area. The parent materials of the diluvial terrace is the siliceous sandstone which had been deposited since more than several ten thousand years before and weathered to a considerable extent. The diluvial terraces occupy only small part of the Project Area.

The old alluvial fan is considered to be developed by floodings from the old Mae Klong River about 2,000-3,000 years ago when the coast line located around Suphanburi. The relevant fan at EL 5-20 m extends toward east or northeast with slope at 1/5,000 on an average. The old alluvial fan is topographically characterized by considerable undulations, including old river courses, natural levees and back swamps that had been formed by shiftings.

The riverine alluvium develops in strip extending from Kanchanaburi to Ratchaburi. The elevation ranges from 5 m around Ratchaburi to 20 m around Kanchanaburi.

The marine alluviums distribute in the east of the Project Area, closely to the Nakhon Chaisi River. Besides the above, the marine alluvium also develops in the southern part from Ratchaburi along the downstream of the Mae Klong River. The deposits are mainly of heavy clay, and those of the southern part of Bang Len characteristically contain sea shells and gypsum.

These marine alluviums lie at elevation below 5 m without natural levees and quite flat with little slope.

3. Soils

Moormann prepared a hypothetical report and soil map (1962) showing the soil types and their distribution in the Project Area. This survey prepared the more detailed soil map than that of Moormann's in adding the results of analysis recently made by about 100 survey points. (Map S-1).

The said results will be explained by topographies. In Thailand, the soils are classified by great soil group for high categories and by soil series for low categories on the U.S.A. standard.

1) Present Soil Condition

a) Diluvial terrace

i) Gray Podsolic Soil (Korat Series): Sandy (sandy loam to loamy sand), excessively drained soil that occurs in the upper part of the diluvial terrace. This soil has gray to grayish brown colored surface soil and yellow brown subsoil. Having been highly weathered, this soil is extremely poor in nutrient status. Recently, the sugar cane fields has been developed in the said soil, although some are left intact as shrubbery.

ii) Low Humic Gley Soil (Roi Et Series): Light-gray colored, highly weathered soil that occurs in the lower part of the diluvial terrace. This soil has loamy to sandy surface soils and clayey subsoils, providing rather high water holding capacity. The rainfed paddy fields are developed over the said soil, from which only low yielding is available due to the low soil capacity of nutrient supply (1,000-1,2000 kg/ha).

b) Semi-recent terrace

i) Noncalcic Brown Soils (Kampaen Saen Series): Brown-colored, well-drained soil of medium texture that occurs in highlying parts of the fan (old natural levee). The surface layer shows weak acidic reaction, whereas subsoil is neutral with high capacity of nutrient supply. Chiefly the lands consisting of this soil is utilized as sugar cane fields or residential area.

ii) Low Humic Gley Soil (Nakhon Pathom Series): Somewhat poorly drained, fine loamy to clayey soil that is found in the lowlying parts of the fan. The soil has grayish brown color commonly with ferruginous mottles. The soil, showing the neutral or weak alkaline reaction, has high capacity of nutrient supply and is utilized as the paddy fields.

iii) Kampaen Saen Series and Nakhon Pathom Series are distributed complicatedly. Since it is impossible to show their distribution separately on the map in the given preciseness; their distributions are shown on the soil map.

iv) Slightly Hydromorphic Alluvial Soil (Saraburi Series): Impermeable, heavy clay soil that occurs in lowlying part of the fan. The soil shows brownish gray color with ferruginous mottles. This soil shares the character of Grumusol to a certain extent that cracks run deep in the dry season with slickenside developing on the crack-faces. This soil has high capacity of nutrient supply and retention with neutral or weak alkaline reaction. The soil is best suited to paddy cultivation.

v) Hydromorphic Alluvail Soil (Yang Pong and Karasin Series): Impermeable to highly impermeable, heavy clay soils that occur in basin-shaped back swamps in the fan. These soils are submerged permanently or most of all the year round. They have bluish gray color due to strongly reducing condition. Surface layers are commonly dark-colored, but sometimes mucky or peaty.

c) Riverine Alluvium

i) Aeric Alluvial Soil (Muang Series): Brown to yellow-brown colored, moderately to highly permeable, loamy soils that are found in the natural levee of the Mae Klong River. These soils have a neutral reaction with high nutrient reserves. The areas with the soil are utilized primarily as sugar cane fields, or the residential lots.

ii) Somewhat Hydromorphic Alluvial Soil (Ratchaburi Series): Grayish brown-colored, slightly impermeable to impermeable, clayey soils that widespread in the Mae Klong River alluvium. The soils have a neutral reaction with high nutrient supply and nutrient holding capacity. The paddy cropping is is largely carried on the soil.

d) Marine Alluvium

i) Saline Alluvial Soil (Tha Chin Series): Unripened, strongly reduced and bluish gray colored soils that occur along the coastline to the south of Damnoen Saduak Canal. Since the soil is affected by sea water at high tide, the salt concentration is considerably high. The soil shows the neutral or weak alkaline reaction and the electric conductivity is in the range between 4,000 and 10,000μmho. (Refer to Tables S-1, S-2 and S-3.) Generally, the soil has extremely low permeability due to fine texture and high groundwater level. Natural vegetation is nipa palms and mangroves. Some areas in this series have been developed for shrimp breeding or salt farms.

NOTE: Fresh marine sediments are generally muddy with no cracks nor cleavage blocks. This state is referred to as "unripened."

ii) Ripened Alluvial Soil (Bang Phae and Bang Leng Series): Clayey, impermeable soils that widespread in lowland to the north of Damnoen Saduak canal (Lower part of Stage 1). These soils have dark gray surface soil and gray to olive gray subsoil. Shell fragments and segregates of gypsum are normally present. Though sulphide content is high, there is no fear of acidification due to the formation of free sulphuric acid because it is readily neutralized by plenty of lime presently both in soil and flood water. Then, the soil shows neutral or weak alkaline reaction, with high capacity of nutrient supply. The Bang Phae Series is different from the Bang Leng Series in that the former has low groundwater table and are relatively ripened. Most of the areas with this series are

utilized as the paddy fields cropped with broadcasted rice, and some are intensively cropped with vegetables around Damnoen Saduak canal.

iii) Thionic Alluvial Soil (Rangsit Series): Impermeable, gray colored, heavy clay soils that have characteristic red and ochre yellow mottles. It is reported that these soils develop in ripened marine alluvium with low lime contents. Reactions of subsoil are strong acid with pH order of 4 (partly 3), Table 2. Different from the Bang Phae and Bang Len soils, these soils have no segregates of gypsum. In the Project Area, this soil occurs in the East Malaiman in Stage II area and the lowlying part of the lower right bank. The areas with this soil are utilized as paddy fields for broadcasting rice or floating rice.

2) Land Use Capability

The Mae Klong area has been considered as less developed area in agriculture due to water shortage, although the soil conditions are favorable in chemical and physical properties. The areas, therefore, have a promising potentiality for agricultural development, although soils unfavorable to the development are partly included.

The Land Classification Division prepared the general land classification maps at the scale of 1:1,250,000 (1972) which reveal that the Project Area can be roughly divided into four districts (Map Unit; 1, 2, 4 and 9) - (Refer to Map S-2). The Map Unit 1 covers the alluvium along the Mae Klong and the Marine Alluvium except for those along the coast line. Soils of the unit are clayey and impermeable, and rated as best suited to rice cropping (P-I). The Map Unit 2 falls onto the area of Roi Et Series of diluvial terrace, and are regarded as suited to rice cultivation (P-II). The Map Unit 4 covers the old alluvial fan in topography, which is the association of the land suited to rice and to upland

crops (P-II, U-II); impermeable soils are suited to paddy cropping, and permeable soils to upland crop cultivation. The Map Unit 9 covering most of the alluvium around the littoral area with high salinity are rated as unsuited to farming (P-V, U-V).

Further study was made on the series-wise land use capability on the basis of soil maps (Map S-1). For references, the signs as P-I, IIa...Vt, U-I, IId, ...VIIIx, etc. indicate the land capability classification adopted by Soil Survey Division (Land Development Department). P and U mean the paddy field and upland field, respectively and I, II, III, etc. indicate the grade of land. Furthermore, a, b, c...x specify the factors of limitation of the land for agricultural development. Taking examples, (P-I, U-IIId) means that the relevant land is classified into the first grade as paddy field and into the third grade as upland field chiefly due to poor drainage. Main limiting factors are expressed as follows:

a = acidity, f = flood damage, x = salinity,
s = soil, m = moisture deficiency, d = poor drainage
e = erosion, etc.

a) The following soils seem most suitable to paddy cropping:

i) The slightly humic alluvial soil occurring along the Mae Klong River. (Rachaburi Series, P-I, U-IIIf).

ii) Low humic gley soil occurring in lowlying part of the old alluvial fan (Nakhon Pathom Series P-I, U-IIId).

iii) The slightly humic alluvial soil occurring in the lowlying lands of the old alluvial fan. (Saraburi Series, P-I, U-IVd).

b) The ripened alluvial soil occurring in the marine alluvium (Bang Phae Series: P-I, U-IVd, and Bang Leng Series, P-I, U-IVf) will prove to be highly productive, if proper measures are taken for flood protection. However, some of the Bang Leng

soils which are less ripened relatively to Bang Phae soils, have high electric conductivity above 4,000μmho and it is required to check if it is harmful to rice growing (survey hindrance by salinity concentration).

c) Thionic alluvial soil (Rangsit Series, P-IIa-IIIa, U-IVf) is said to be less productive than other ripened marine alluvial soils (Bang Phae and Bang Leng Series). These show weaker acidic reaction than the typical ones found in the eastern part of the Central Plain (Rangsit Series, Strong Acid Phase) and there does not seem to exist so much hindrance to the paddy cropping.

d) The non-calcic brown soil distributing in the highlying lands in semi-recent terrace (Kampaen Saen Series, P-IVm, U-IIm) and the arid alluvial soil distributing in the natural levees along the Mae Klong River (Tha Muang Series, P-IVm, U-IIf) are generally loamy and naturally fertile with high permeability and suited rather to upland crop cultivation in considering the topographical conditions as well.

e) The areas where the following soils distribute have some limitations to giving the low priority of development.

i) Soil zones with very low nutrient reserves: The gray podsolic soil (Korat Series, P-Vm, U-IIIs-IVe) and the Low Humic Gley Soil (Roi Et Series, P-IIIs, U-IIId) in the diluvial terrace.

ii) Soil zones with high salt concentrations: The unripened alluvial soils occurring south of the Damnoen Saduak canal (Tha Chin Series, P-Vx, U-Vx).

iii) Almost year-round submerged swamps: The humic alluvial soil in the back swamps which sporadically distribute in the semi-recent alluvial terrace (Yang Pong and Karasin Series). The Roi Et and

Korat Series, occurring in the marginal part of the Project Area, are given less weight in the Project Area. However, the No. 1 Mae Klong Pilot Project Area is located in the Roi Et Series area; the experimental results obtained therein shall be applied to the actual farming with care in taking into account the special properties of the soil. It is worthwhile studying whether to reclaim the year-round submerged swamps into farming lands or to turn into regulating ponds in their positive utilization.

3) Items to be Surveyed in the coming Study Stage

a) Preparation of medium-scale soil maps

The soil maps at the scale of 1:100,000 are now being prepared by the Soil Survey Division (Land Development Department). Although soil maps so far published can cover only the eastern portion of the Project Area, the soil maps for the western part of Thailand will be published next year. With both maps, the soil maps at the scale of 1:100,000 will be able to cover the whole Project Area. Even in the case, single sheet of soil map covering the whole project area must be developed from several sheets of soil map.

Prior to publication of the soil maps of western Thailand, if the copy sheet of the original soil maps is available, the soil maps of the whole Project Area (1:100,000) will be readily prepared. The soil maps at the scale of 1:100,000 are of great use as the basis for not only the Master Plan Study but further studies.

b) Continual field study of the soil profiles

It is necessary to grasp the characteristic features of the representative soil profile of each soil series by excavating pits. In the current survey, however, the soils of the

lowlying part of the old alluvial fan (Nakon Pathom, Yang Pong and Saraburi series) and of the marine alluvium (Bang Phae, Bang Len and Rangsit series) have been left unsurveyed due to submerged conditions and the restriction of time. It is recommended that field investigation of these soils should be carried out after harvesting of rice. Although there is a plan to introduce the Quae Noi river water to the area lying to the west of right bank of Stage II, the said area seems to be dominated by such infertile soils as Korat series (P-Vm, U-IIIs-IVe) or Khao Yoi/Pak Tho asssociation (P-IVm/III, U-IVa); consequently it is desirable to conduct field investigation on soils of the area to provide the various reference materials for study, in considering the area belonging to the same river system as the Project Area.

c) Topography and land use classification of the old alluvial fan

Even if the medium scale soil maps are prepared as proposed in (a), the scale is still too small to show the detailed distributions of old river courses, natural levees, back swamps and their corresponding complicated soil distribution in the semi-recent terrace. Since topographical conditions and soil condition are closely related to the land use not only at present but in future, it is desirable in the near future to prepare topographical classification and land use map by use of large-scaled topo-maps, stereoscopic aerial photos and, if possible, data supplied by Land Sat (Satellite for land survey).

d) Collection of analytical data of soils

In addition to the data shown in Table 2, the RID Chemistry and Physics Laboratory provides the data[/1] on chemical and physical properties of soils in the Stage II West Malainan district. Furthermore, analytical data are also available

/1 Laboratory File 25/2511 on Land Drainage Investigation, Soil Chemistry and Physics Laboratory, RID, 1970.

from the works of Kawaguchi and Kyuma[1], and the staff of Tropical Agriculture Research Center. By collecting these data, the physical and chemical properties of soils in the project area will be clarified to a considerable extent.

e) Related soil problems to the artificial irrigation

It is primarily important to secure the irrigation water by providing dams and canals. Such measures, however, will cause the sedimentation in dams and canals of larger portion of floating matters, which have been the source of the maintenance of soil fertility. These phenomena combined with introduction of double cropping will strengthen the plundering of nutrients from the soils. Under the conditions that relatively high costs of fertilizers restrict the amount of fertilizers to be dosed, the problem of how to maintain the soil fertility will become important in the future.

Under the climate with low rainfall and distinct dry season, there is the possibility that an upland irrigation might cause salt accumulation in surface soil, and further study is required in this respect.

f) Effective utilization of precipitation

Most part of precipitation in the latter half of the wet season, the peak of which occurs in September, is evapotranspirated as surplus waters in the dry season. The Soil and Water Research Branch (Technical Division, Department of Agriculture) experimented the mulch on the fields after harvesting maize to reveal that considerable amount of effective water was retained in the soil until the following sowing season, thus giving favorable effect to growth of plants. In this view, it seems worthwhile taking up

/1 Kawaguchi, K and Kyuma, K. (1969) Lowland Rice Soils in Thailand. (The Southeast Asia Research Center, the Kyoto University, Japan).

experimentarily the subject of effective water utilization in the upland crop cultivation in the Project Area.

4. Meteorology and Hydrology

1) Meteorology

The Project Area climatically belong to the tropical savanna zone, having two seasons, the dry and the wet. Generally, the dry season lasts from November to April following year, and the wet season from May to October, but the months of April and November, according to data, have yearly variation in rainfall, being considered as transition period.

The meteorology in the Project Area can be only presumed from the data observed at Kanchanaburi, since few meteorological data are available, except rainfall records. However, locating in the northern part of the Project Area, Kanchanaburi appears unreasonable to represent the meteorology of the Project Area.

a) Temperature

The annual mean temperature is 28°C, and the mean maximum temperature is 38°C in April. The mean minimum temperature is 17.5°C in January.

b) Humidity

The annual mean humidity is 68.8 percent, and the mean maximum humidity is 93.3 percent in October while the mean minimum humidity is 36.1 in March.

c) Wind Direction and Wind Velocity

The west wind blows in March through October at the average velocity of three to five knots (m/s), while the northeasterly wind blows from November through January at the velocity of three to five knots. The mean maximum velocity at Kanchanaburi

is recorded by 55 knots (SW) in July and the next by 50 knots (SE) in April.

d) Rainfall

The annual average rainfall is 1,117.0 mm, and the monthly average maximum is 236.0 mm in October, followed by 235.0 mm in September. The monthly minimum rainfall is 2.9 mm in January, followed by 8.6 mm in December. (Refer to Tables M-1 and M-2).

2) Hydrology

a) Rainfall and Rainfall Observation

In the Mae Klong River Basin, about 30 rainfall stations are established. These stations are classified into two (2); the ones operated by RID and the others by MET (Meteorological Department). The locations of these stations and operation-wise division are indicated in the Map No. . Since most of the stations are provided along the Mae Klong River, their locations are considered unfavorable to conducting the appropriate observation of the rainfall distribution in the Project Area.

Table M-1 shows the annual mean rainfall obtained from the observation data which have been recorded in seven (7) stations representing mountainous area and plain area, respectively. The following matters can be assumed from the table; there are much rainfall in the mountainous area and the littoral area, whereas a little in the plain area, and in the mountainous area, there is a large difference in rainfall between the Quai Noi River Basin and the Quae Yai River Basin, the former indicate 1500 mm and the latter 960 mm per annum.

The annual rainfall in the Project Area is roughly divided into two (2), the wet season (May to October) and the dry season (November to April). The transition period of the two seasons sometimes staggers about one month. The annual ratio of discharge of the two seasons is in general 80 percent in the wet season and 20 percent in the dry season. The above ratio is variable by years with transition period staggering.

b) Runoff

The Project Area has provided with about twenty gauging stations for discharges and water level of the river, taking records at the respective gauging points. The location of the gauging stations, which are operated by RID, is indicated in the Map No. II-1.

The survey team has arranged the discharge data observed at three gauging stations that are representative in the Project Area. They represent the Quai Noi River Basin, Quae Yai River Basin, and Mae Klong River Basin, respectively. (The one at the Mae Klong River Basin represents the river basin downstream from the confluence of the above two rivers, Quai Noi and Quae Yai rivers). These stations are indicated as K10, K20 and K11 on the Map. The station K11 is located at about five-kilometer downstream of the Vajiralong Koru Dam and considered best suited for surveying the water resources of the Project Area. Table II-2 shows the observed values of runoff for nine years (1967-1975) at the station K11. From the said table, the annual mean runoff in the Mae Klong River was estimated at about 11,300 million tons, which includes 9,100 million tons in the wet season and 2,100 million tons in the dry season, respectively. With transition period of season stagger, the above figures may fluctuate seasonally, and this is considered as a common phenomenon in discharge and runoff.

The annual ratio of runoff is 80 percent in the wet season and 20 percent in the dry season, the same ratio as the discharge.

The basin-wise classification of total runoff is made to be shown in Table H-3. The following matters are studied presumably on the basis of the said table; the acreages of the Quai Noi River Basin and the Quai Yai River Basin are 7,000 km^2 and 11,184 km^2, respectively and the comparison rate of the two is 1:1.596. The annual mean runoff is about 6,500 million tons for the former and about 4,400 million tons for the latter, and the comparison rate is 1:0.678. This is because the difference in distribution of rainfall results in more total runoff (about 30 percent) in the Quae Yai with smaller basin, than that in the Quai Noi. The relationship between the total rainfall and the total runoff, shown in Table H-3, is 0.62 in the Quai Noi River, 0.41 in the Quae Yai, respectively, and 0.38 around the Vajiralong Koru Dam.

Table H-4 shows the monthly total maximum runoff by years observed at three gauging stations.

c) Flooding

Floodings in the Project Area have taken place concentrically in July and August in a year. Table H-5 shows the time of occurrence highest discharge and flood discharge observed at three gauging stations, from which the close relationship can be found between floodings at K11 (Vajiralong Korn Dam) and those at Quai Noi River. The highest discharge has occurred at K11 one to two days after flooding at K10, and it appears that the floodings in the Mae Klong River are affected by the Quai Noi River discharge. The recent large-scale floodings

took place in 1972 and 1974. The highest discharge was observed by 3,561 m^3/sec in August, 1972 at the dam site.

The data provided in the local RID office reveal that the river capacity for flood discharge is estimated at 1,500 m^3 sec-2,000 m^3/sec. in the downstream of the Vajiralong Koru Dam, and the larger flooding to exceed the above capacity overflows the both banks to cause the inundation over the farm lands and residential area in lowlying lands. The damages by the floodings are described in details in paragraph on "Drainage."

d) Water Quality

Table B-7 shows the results of water quality survey made on main rivers in Thailand. The river water of the Mae Klong contains considerably high concentration of Ca^{++} and Mg^{++} as compared with that of other rivers due to the related catchment area located in the limestone zone. The reactions of neutral and high alkali saturation in the Mae Klong alluvial soil largely depend on the flood water quality.

e) Present problems

The present hydrological problems in the Area are summarized as follows:

i) The discharge of the Mae Klong River is reduced abruptly at Dam site during the period of December to May, the following year. Such reduction reaches below 100m^3/sec. as shown in Fig. H-1. Therefore, it will become difficult to irrigate in the dry season taking into account the responsible release amount of water by 50m^3/sec.

ii) The Bau Chao Nen Dam, which started to store water from September, 1977, will change the discharge of the Quae Yai River to a large extent. In connection, various effects by dam operation to the river discharges should be studied.

iii) The annual mean runoff is about 11,300 million ton as shown in Table H-2, and the yearly water amount available is estimated at about 9,500 million ton due to difficulty in utilization in the dry season in relation to the compensational discharge to the downstream. On the assumption that the runoff is fully utilized, the water available per year is estimated at about 2,300 mm/year to the total objective acreage, 420,000 ha. Even if the effective rainfall added to the above discharge, the total suppliable amount of water will be short to introduce paddy double cropping in the Project Area, in considering farm losses, conveyance losses, etc.

5. Irrigation

The water balance study is one of the basic subjects on master plan formulation of the Mae Klong Area.

In the irrigation sector of the current study works, the water balance for existing plans (Feasibility Study of Stages I and II) was

reviewed, and also the field survey was carried out to select the major items to be studied in the coming Master Plan Study.

The study made on both demand and supply of water was focused on understanding about relationship between the elemental conditions presented in the existing plans and present situation of the Project Area. And forecasted problems in the coming Master Plan Study are studied on their approaches, treatment method and possibility of solution, based on the on-farm development program.

1) Present water utilization

In the Project Area, the irrigation facilities planned in the Stage I were constructed in 1974, except on-farm development and drainage facilities, to supply the irrigation water to the related area. Table 0-1 shows the results of interview on the irrigation services. (The above table covers only the results of water supply to the left bank area from the Vajiralong Korn Dam, excluding those in the wet season from the water intake facilities in the downstream of the Dam.)

The table also clarifies that the commanded area by Dam is about 48 percent to the designed objective area in the wet season and 15-18 percent in the dry season.

The Project Stage I aims to solve the water shortage problem in the wet season, and the irrigation in the dry season is out of consideration. Actually, some areas, which are considerably small in acreage, are irrigated in the dry season by water taken from the Dam. These areas to be irrigated in the dry season have gradually increased in acreage by the rate of 1.06 in 1975 and 1.22 in 1976 on the basis of the figures in 1974.

2) Water Requirements

The Feasibility Study Report by RID (The Greater Mae Klong Multi-Purpose Project/Second Stage Development/Appendix B) reveals that the water demand in the Mae Klong River Basin was roughly divided into three (3); the irrigation, salinity control, and river maintenance including navigation, and the water amount required for the respective purposes were estimated as follows:

a) Irrigation water

Taking evapotranspiration (U), effective rainfall (Re), percolation (P), conveyance losses (Ec) and farm efficiency (Fe) as the factors, the unit rough water requirement (Ig) was estimated. The irrigation water requirements are determined by multiplying cropping acreages assumed on monthly demands and cropping pattern by the unit rough water requirements. The example is shown below.

The value of Igij is computed by the following equation:

$$Igij = \frac{Uij - Reij}{Ec.Ef} + Pij \quad \text{----- (1)}$$

Each factor mentioned above can be estimated as follows:

- o Evaporation (U) — U = k.E (by Penman's formula)
  Where: k = crop factor
  E = Evaporation measured by evaporation pan
- o Percolation (P) — Irrigation season = 0 mm
  Non-irrigation season = 1.0 mm
- o Conveyance loses (Ec) — 80%
- o Farm officiency — 75%

Any of U, Re, P, Ec and Ef is an important factor that determines the water requirements in the regional agricultural development, especially, the following points should be studied in the Master Plan Study.

i) Percolation

The Project Area, chiefly consisting of soils with much clayey contents, has varieties in its structure. Since the soil survey conducted found that there develop some soils with high percolation in a part of the area for the Stage II, a considerable number of survey points should be established in the whole Project Area so as to study the percolation and recycling utilization of water in the extension manner.

ii) Conveyance losses

The contemplated canal systems, including ready-completed ones, are rather long and no discharge control devices are provided in the course. When water demand varies frequently in considerably short intervals, the following problems may take place:

(a) Response taking long time, the water demand is expected to be followed by slow response in water supply.

(b) The conveyance losses will occur unavoidably as shown below. In particularly, the frequent fluctuation of water demand in short intervals will bring about bigger conveyance losses to reduce the conveyance efficiency.

This problem will be more clearly revealed with progress of on-farm development; the diversification of cropping items will complicate the water management and the water demand will be determined under the initiative of beneficiaries, the farmers. One of the solutions of the problems is to provide the regulating ponds in the courses of the canal systems.

In this case, the capacity and location of respective regulating ponds should be studied, and the computer simulation analysis will be applicable. Generally, the large capacity ponds should be provided for large-scale canals and the small capacity ponds for the small-scale canals. The location of the ponds will be limited to a certain extent in consideration of the flat topography of the project area because sufficient difference in elevation is required to provide such regulating ponds for securing the head. The topographical restriction will be more severely imposed to select the suited site for large capacity regulating ponds in the Project Area.

Even if, however, the topographically suited sites to the ponds cannot be selected in the Area, the regulating ponds plan should be studied in consideration of the employment of pumping system for lifting up the water. The qualitative analysis of the canal system improvement shall be made by computer simulation to evaluate the regulating pond plan from economic viewpoint.

The small-scale pond plan shall be studied in best utilization of the borrow pit located along the canal routes.

iii) Water utilization for other purposes than irrigation

The Mae Klong River discharge should be maintained not only for the irrigation but for others such as navigation and salinity control. The RID estimated the designed minimum discharge at 50 m^3/sec. in the dry season to meet the above demands. The total water requirements, however, should be estimated including purposes for water quality control and domestic use.

3) Water supply and its improvement

When the water requirements estimated, the water supply system and its improvement should be established. Therefore, the present mission has collected the basic hydrological data for the study as many as possible. For a consideration on the collected data, the available water in the whole Mae Klong River Basin cannot be said to sufficiently cover the demands; i) the annual mean runoff reaches only 2,300 mm to the total beneficial area of 420,000 ha. and yearly fluctuates to a considerable extent, ii) a large difference of discharge exists between the dry season and the wet season, and the seasonal transition period, from the dry to the wet and vice-versa, sometimes staggers (particularly around May).

Under the conditions, the water resources development in the Project Area will chiefly require to possibly minimize difference of the discharges between the dry season and the wet season.

The following figure illustrates the result of the analysis made on the basis of the Feasibility Study of RID and the Quae Yai River Regulating Pond Plan Feasibility Study of JICA (1976).

In the figures, the A curve and B curve show discharges observed at Tha Muang (K3) on the Mae Klong River on condition of before and after construction of the Ban Chao Men Dam, and the encircled port by A curve and B curve, showing the difference of discharge, means that the surplus water of the Quae Yai River will be stored in the dam from July through November (wet season) and the stored water will be released from November through June (dry season).

In this connection, the water amount stored in the wet season and released in the dry season is mathematically estimated at about 2,300 million cubic meter. The figure, however, clarifies that such improvement in the discharge cannot secure the required water sufficiently in the dry season.

For further improvement of discharge, a countermeasure should be taken along with the direction to bring the B curve near the average line or further to the C curve.

On the assumption that the B curve is brought near the average line, the water volume shown in the figure as storage potentiality should be stored in the wet season, and the roughly estimated volume is about 2,700 million cubic meters.

For discharge improvement, construction of a new dam is considered as a measure. The further study of water release program from the Ban Chao Nen Dam will make an improvement of the discharge to a large extent, in considering that the said dam will have larger capacity than the designed storage and release in the wet season.

Therefore, the discharge improvement to be studied in the coming Master Plan Study should aim to clarify the total water requirements in the area, including agricultural use and other uses, so that actual water utilization for agriculture can be increased in amount under the closest coordination with the power generation. In this approach the problem is the crush of interest against the power generation, although considered most economical. The coordination with the power generation will reveal the limit of development by this method.

In the case of maximum utilization of the Ban Chao Nen Dam, discharge improvement of the Mae Klong River will have limitation unless otherwise discharge improvement made in the Quai Noi River. It is presumed that a new dam shall be constructed for promotion of agricultural development in the Area, judging from the collected hydrological data. And the new dam will be provided across the Quai Noi River.

6. Drainage

1) Topography in view of drainage

The Project Area is composed of the alluvial fan and the low-lying flat lands; the former has its apex at the Vajiralong Korn Dam (EL about 20 m), from which the fan extends at opening angle of about 135° North-North East towards South-South East, slightly undulating with 1/2,000 slope to the area with about five-meter contour line, from which the latter extends continuously with slope below 1/20,000.

There exist gentle slopes bulging from outside terraces around the boundary of the Project Area on both banks, the left and the right, and the semi-main irrigation canals, R-1, and L-1, bound the area.

The Song-Phi-Nong River bounds the north of the Area, and joins the Nakhon Chaisi River, one of the tributary of the Chao Phya River. This Nakhon Chaisi River bounds the east of the Area.

2) Present conditions of drainage

a) Stage I block

The RID divides this block into five sub-projects/1 and execute operation and maintenance of ready-constructed irrigation canals as well as construction of new canals and improvement of existing drainage canals according to feasibility study of Stage I.

The construction works of Stage I, as shown in Table D-1, progressed by 38.4 percent in total length at the end of fiscal 1977 (September).

The canals, Klong Tha Sarn, Klong Tha Rua, Klong Tha Pa, link with the Mae Klong River and the Nakhon Chaisi,

/1 Kampaen Saen, Nakhom Phatom, Nakhom Chum, Ratchaburi Left Bank, Damnoen Saduak.

and five canals - the above three and Klong Ta Kot, Klong Ban Bang - are originally natural waterways branched from the Mae Klong River. These canals were provided in 1927-1933 with the regulating gates at both ends to function as irrigation/drainage canals[/1], so that the water could be taken from the Mae Klong River when the water level of the River exceeded a certain level. In the present Project, however, they have been turned to the exclusive drainage canals because total necessary amount of water is supposed to be diverted from the Vajiralong Korn Dam. And also lateral drainage canals connected with these main canals have been under construction.

The design dimensions of these canals are shown in Table D-2.

When the Mae Klong River discharge exceeds 3,000 CMS[/2] (Probability: approximately 1/5 year), the river water flows into the Stage I block over the low embankments, roads, bridges, etc.

A part of flooding in the block flows into the Nakhon Chaisi River through Tha Sarn, Tha Rua, and Tha Pa, all of which have the maximum discharge capacity by only 177 CMS (Design Discharge: 105 CMS - interview survey at Project Office), and most of floodings flow down southward. The surplus water by irrigation and rainfall in highlying area as well as in the block flows down southward flooding in the area.

The surplus water in the west side of the lower part of the Stage I block flows into Klong Lam Phya and Klong Ta Khot and is intercepted by Dammoen Saduak after utilized as irrigation water. In the east side, the surplus water is intercepted

/1 Actual result in 1975 is shown in Table D-2. 454 x 106 m^3 of water was diverted for irrigation.

/2 The Project Manager explained that floodings occur on the right bank when the discharge reaches 2,500 CMS and on the left bank when it reaches 3,000 CMS. The report by ILACO describes that the discharge exceeding the design flood of 3,100 CMS will cause floodings from breaching dikes to the right bank.

by Klong Chinda, from which the water flows into Nakhon Chaisi River. In relation to the water level between the above two waterways, however, the water flows adversely in Klong Chinda to irrigate the areas around the river and the further southern areas, and the surplus water is received by the Damnoen Saduak canal after utilized.

Originally, seven waterways were planned to be constructed from Damnoen Saduak Canal to the sea. But four of them have been so far completed to discharge the surplus water up to Klong Sunak Hon outside the sea-defense-dike and through the Klong. The water is conveyed to the Mae Klong River and Nakhon Chaisi River as shown in Tables D-1 and D-2.

The total capacity of four waterways is about 200 CMS (50 CMS each). Since the Klong Sunak Hon, which receives the water from the above four, has only 100-120 CMS in its capacity even by total of the eastern and the western directions (50-60 CMS each), the terminal gates of these four canals cannot be opened all simultaneously.

The canal system in the downstream from Damnoen Saduak canal is called "Water Conservation System" which aims to conserve the water for not only irrigation but navigation and domestic use, rather than to drain.

RID gives a specific meaning to this area.

This Project aims at:

i) Water conservation
ii) Drainage
iii) Sea Dike Protection (Sea-defense-dike). (Refer to Fig. D-1.)

The respective commanded area:

i)	Irrigated area	153,000 rai (24,500 ha)
ii)	Objective area	257,800 rai (Surveyed by Economist) (41,200 ha)

b) Stage 2 right bank

In the upper right bank, there extends a slightly elevated land-like natural levees, along the Mae Klong River. On the other hand, there develops a gentle slope from the western outside area to the Area. Therefore, the middle part of the area forms a natural drainage channel in lowlying lands in parallel with the Mae Klong River.

A part of flooding from highlying lands western outside of the Project Area is caught by the R-1 canal running along the boundary and the other runoff flows into the drainage canal in the central part of the area through crossing constructions over or under the R-1 canal.

The Report by JICA describes that at the upstream end of the Area, the surplus water (2) caused by exceeding the designed flood discharge of the Vajiralong Korn Dam, 3,100 CMS (1), will flow into the area from breaching dike.

The total discharge of (1) and (2) is estimated at about 6,100 CMS (a little over the value in 50-year probability). (The Project Manager explains that the surplus water flows into the Area when the discharge exceeds 2,500 CMS.)

The floodings from the Mae Klong, surplus waters of irrigation water and rainfall in the area flow down southward through the above natural drain channel in the middle of the area. Although some drained to Mae Klong River through several small outlets existing in the course of discharging, most of the water flowing southward is stored in the area north of

Ratchaburi to function as regulating pond, and naturally drained to the Mae Klong River through No. 7 right Mae Klong canal (Klong Lum Din), when the water level of the Mae Klong River lowers later.

The RID has a plan to improve outlets to the Mae Klong River and rearrange the drainage system by dividing it reasonably.

In the lower right bank south of Ratchaburi, drainage is made chiefly by two canal system, Klong U. Rua and Klong Bang Tabun directly pouring into the sea, and Klong networks developed in the area between the above two Klongs. In the Project, however, the floodings from highlying lands outside of the area and the surplus water of irrigation and rainfall shall be caught by the Klong Norm Sai and Yai Pra Du (the existing Klong Pra Du shall be improved), both running from north to south in the area.

The survey team has not carried out thorough investigation of the area due to time factor.

c) Stage 2 Left Bank (Malaiman)

The flooding from the western highlying lands partly flows into the area and partly into the Song Phi Nong running along the northern boundary of the area.

The West Malaiman, with considerable undulation, provides several streams that run down toward east and form many natural regulating ponds around Malaiman Highway. Then, these streams further flow down through the lowlying flat East Malaiman up to the Nakhon Chaisi River after being separated into many klongs like Klong Ban Len, Klong Bang Luang, etc.

These klongs, in relation to their water levels and that of the Nakhon Chaisi, sometimes flow adversely; the area is irrigated by the water supplied from the Nakhon Chaisi River, too.

For this area, the RID is making the detailed design on the basis of the existing general plan of the Mae Klong River Development Project.

3) Findings of the drainage study in the Project Area

a) Drainage

i) No springing of confined aquifer on a large scope.

ii) Poor terminal treatment of urban wastewater occurs only locally.

iii) In the upstream, some poor treatment of the irrigation water takes place at the terminal facilities of the canal.

iv) The operation of tale regulators of the irrigation canal sometimes causes over-irrigation, which is considered as not so serious by RID.

v) There is no customary rule to give priority for drainage. On flooding, however, the Mae Klong River water may be drained to the above-mentioned five drainage canals under the responsibility of RID.

vi) The domestic animals are bred in the borrow pit for canal construction, drainage canals and natural streams, but the RID pays no special consideration to this planning.

b) Navigation

Navigation is performed through Damnoen Saduak and other small klongs such as Klong Chinda, Klong Chedle Bucha (from Nakhon Phatom). In other waterways, navigation is performed only locally.

e) Water quality

i) The urban waste water has seriously polluted the Chadipaucha River and Klong Chedie Bucha (Nakhon Phatom), the water of which can not be used as irrigation water as in what it is.

The countermeasures now under contemplation are to discharge the water from Mae Klong river through irrigation canals; then, these river waters will be used as the irrigation water. (Source: O & M Office).

ii) Weeds grow extremely thick in the drainage canals around the swine-breeding area of Nakhon Phatom and herbicide dosing has been practised once every two years. The maintenance of drainage canals is the duty of inhabitants, who have not properly carried it out. (Source: O & M Office).

iii) Water side slope gradient of the canal is 1 to 2, although some sandy soil slopes are eroded. (Source: O & M Office).

Considerable erosion on the sandy soil waterside slope of canals is seen along the Mae Klong River, too.

d) Pumping

Through the field investigation, many pumps were seen operated to a considerable extent in the Project Area and its immediate vicinity.

In the Stage 2 Right Bank of the Project and the Ban Bang Project in Ayudhaya, the RID has installed the pumping stations for irrigation purpose, which are now under smooth operation. The Chao Phya Project involves a plan to install dual purpose pumping units (irrigation & drainage use) in its project area. Furthermore, the investigation found some farmers

to operate small-size pumps for the use of irrigation or drainage.

4) Problems (Causes of flood in the Project Area)

As mentioned above, the causes of flood are summarized as follows:

i) Floods from the Mae Klong River

The Report by ILACO details that the probable flood discharge at the Vajiralong Korn Dam is estimated as shown in the following table, whereas the designed flood discharge of the Dam is determined at 3,100 CMS, the capacity of the Mae Klong River is about 2,250 CMS at the point 15 km downstream from the Dam, and only 1,500 CMS at Ratchaburi.

Flood Discharge at Vajiralong Korn Dam (By ILACO)

Probable Year (1/year)	5	10	50	100
Discharge (CMS)	3,200	4,050	5,900	6,900

The Japanese survey team, however, made field investigation between the water intake at Tha Pa canal and Ratchaburi to conduct simple water depth measurement at several points, which found the river cross-section to have less capacity than that quoted by ILACO. Also, there were so many sand dredging vessels operated in the river that the cross-section might be quite irregular.

The RID has been carrying out the survey of the cross-sections so as to rearrange them in the future.

The tidal effect appears to reach considerable upperstream of farther than Ratchaburi.

In the Master Plan Study Stage, it is required to carry out the total study in taking into account various factors as above.

ii) Floods from the Nakhon Chaisi and Song Phi Nong Rivers

As quoted in the report by ILACO, the floods from the Nakhon Chaisi river have ceased since completion of two dams of Bumiphol and Sirikit provided on the Chao Phya River Basin. This fact was confirmed through interviews with staff of Klong Chedle Bucha O & M Office at Nakhon Chaisi, RID, and inhabitants around the conjunction of Klong Chinda. (They say there have been no overflowings since these 10 years.)

It is reported, however, some small-scale floodings have taken place along the Song Phi Nong River (Report by ILACO and Design Division of RID). The RID plans to improve drainage in the Stage 2 Malaiman. And although the RID plans to construct the dikes along the Song Phi Mong River as well, insufficient river cross-section at downstream will make it difficult.

iii) Floods from the hilly lands west of the Project

Floodings in the Right Bank were already mentioned in paragraph on Drainage system, and for the Left Bank, ILACO reported that the study was needed to provide the intercepting canals.

The Project Office explained there would be no problems about drainage in the area, but such comments are considered indefinite due to the fact that the sub-project has not started yet.

The detailed study in the Master Plan study is required to supplement the result of the current study.

iv) High tide from the Bay of Thailand

In the Stage 1, the sea-defense-dike has been completed. The RID considers the countermeasures for the high tide to have been established, although some enforcement works are needed against ground settlement. However, a little fear exists that the dike may not be able to stand against expected high tide. (Refer to Map D-2 and Fig. D-1).

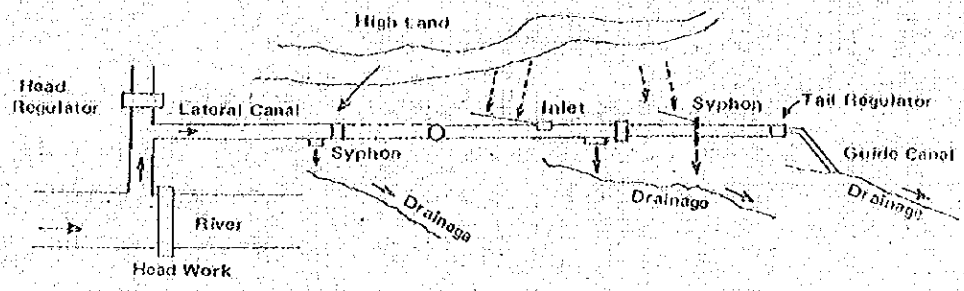
For the stage 2 Lower Right Bank, the field investigations and study have not been made in this survey.

v) Surplus water due to rainfall in the area and operation losses in the upstream, etc.

The RID determined the basic values for designing of the drainage canal construction in the Stage 1 on the empirical basis in the lowlying land development works, like the Chao Phya Project, in the past.

Design Rainfall:	150 mm (1/10 year probability)
Drainage duration:	5 days
Losses:	25%
Unit area drainage discharge:	0.00042 CMS/rai (0.00262 CMS/ha)

In general, the drainage and floodway systems are shown as follows:



The Project Area having a considerably sloped topography in the upstream, the rainfall is expected to make runoff more quickly than designed drainage duration, five days.

Since the irrigation canals provide a large system, it is impossible to properly operate the related facilities to meet various conditions such as small fluctuation of demands, local rainfall, etc., and the surplus water therefor flows down through the drainage system illustrated above.

In the lowlying lands, the drainaged water from upstream and the rainfall in that area are ponded due to poor drainage capacity of the area.

5) Countermeasures of flood protection and drainage improvement

The floods from the Mae Klong River attack the Project Area almost every year, but the flood velocity is relatively slow due to topographical flatness and high water level in the downstream. The example shown in Table A reveals that the flood velocity is about 104 m/hr. (The flood takes eight (8) days to proceed 20 km). Consequently, few severe damages like breaks or total wash-out have taken place, and damages of paddy crops due to inundation are given in relatively small acreage.

On the other hand, such flooded water, rainfall and irrigation surplus water are retained in the downstream area to be utilized for navigation, domestic use, etc.

The inundation to a certain extent is recognized as a matter of nature, and then, the present situation is said to be stabilized in that sense.

However, further study is essentially required to develop the agriculture and increase in land and labor productivity.

a) Basic design values

In view of double cropping of high yielding varieties by transplanting method, combination cropping with upland crops and employment of mechanized farming, the basic design values presently employed (shown in (4)-v) should be studied furthermore. According to the results of the said study, the original plan may have to be modified to the large extent about drainage systems, and the related facilities.

In changing the present condition, consideration for the whole project area may be required because modification for one part will give effect to the remaining whole area. Therefore, it will be essential to plan for the whole Project Area at first, then the sub-project for the modification of the plan shall be established to meet the whole Project conditions, and such sub-project shall be implemented in the proper procedures.

b) Countermeasures to be taken in each block

At present, the following are considered as the respective countermeasures to be taken by blocks:

i) Water conservation project block

In the block, insufficiency of the water discharge capacities of the Mae Klong River and Nakhon Chaisi River bounding the east and west of the Project Area, and Klong Sunak Hon flowing into the above two rivers is the problem for smooth drainage. Although the RID originally planned to construct seven drainage canals to the sea, the difficulty in land acquisition has made the construction works interrupted as mentioned before.

It is necessary to restudy at an early stage the construction of direct waterway to the sea, at least for four existing drainage canals.

ii) Lowlying lands of Stage 1, Upper and Lower Right Bank of Stage 2, and East Malaiman

In the above four districts, it is proposed that many existing natural streams and artificial canals shall be rearranged to systematize multi-functioning canal networks for irrigation, drainage, supply source of domestic water, and navigation.

In the field, it is recommended to provide the farm road networks in addition to conventional ditch and dike method, or dike method. The following paragraph on Land Consolidation details in this connection.

When planning the land consolidation, relation between the width of converted land to canals and the acreage of farm lands, and between the water level to be controlled and the elevation of fields should be studied in taking into account introducing the pumping method for drainage.

Although there have come up some comments that the time is not yet ready for introducing the pumps into the Project Area, it is considered reasonable to introduce pumps due to the fact that actually some farmers have employed pumps already in the country; particularly in the Project Area, small-size pump units are operated in the lowlying lands.

As another sources to supply water to the lowlying lands, it should be studied to utilize positively the Klong Tha Pa and other canals. The details are described in the paragraph on Hydraulic Structures.

iii) West Malaiman and highlying lands in East Malaiman

The drainage facilities in the block are now under planning. There are several hollows functioning as natural flood storage basins, which should be positively utilized as the regulating ponds.

It is desirable, therefore, to well arrange and coordinate the study made by RID and the coming Master Plan Study.

The facilities mentioned in the above ii) and iii) can be provided in either project; irrigation and land consolidation in which the project is suitable to do so. And it should be carefully studied from various viewpoints such as farmers' share of burden, promotion of projects, the national economy of the country, etc.

c) Countermeasures against floodings in the Basin

The main cause of the floodings in the Project Area is the Mae Klong River, the hydrological studies on which are

detailed in the paragraph on Hydrology of this Report, covering the status of the upstream area. Both arrival time of flood and peak flood discharge at Vajiralong Korn dam are mainly affected by Quae Noi River.

The flooding in August 1974 clearly shows the above effects as a result; consequently, it is considered most important for the countermeasures against floodings of the Area, to control the discharge of the Quae Noi River.

6) Proposals for Master Plan Study

The following are proposed to be carried out in the coming Master Plan Study in view of the approach, work items, procedures, etc.

a) Field Survey (desirable to be carried out in the highest inundation period) on discharge observation and availability study for regulating ponds in the project area.

b) Establishment of target for sub-project-wise implementation in coordination of land consolidation total of all project area.

c) Determination of unit area drainage discharge on the basis of the above item b).

d) Determination of flood discharge into the Area in consideration of Dam construction.

e) General planning of the drainage system in the whole area - including water way to the sea - on the basis of items b) and d).

f) Establishment of the drainage method for every sub-project to meet the characteristic features of the respective sub-projects, according to item b) above.

Example: 1) irrigation canals and drainage canals separately.

2) combination of dual purpose canals and pumping station.

3) item 2) as above and regulating ponds.

4) combination of dikes, dual purpose canals with regulating capacity and pumping station.

g) Determination of drainage discharge of each drainage system.

h) Preliminary design of drainage facilities and related cost estimates.

i) Check of the restricting social factors.

j) Feedback.

k) Determination of the total project.

The approaches to these studies are illustrated in Figs. D-2 & D-3.

7. Land Consolidation

1) Present status of land consolidation and its related problems

At present, the land consolidation works have been most progressed in the right bank tract of the Chao Phya River in the Central Plain. The land consolidation works had been initiated with the technical cooperation extended by the Republic of China (Taiwan) and the Netherlands for the Upper Chao Phya, where the Chao Phya Dam (financed by the World Bank) and the main irrigation facilities were completed in 1957 and 1964, respectively. Thus, the on-farm development in the area has been progressed rapidly since then.

Thailand, in 1950 through 1975, had provided many dams and main canals, which have been serving not only irrigation use but also flood control; however, the effective utilization of water in the on-farm level has not been sufficiently realized yet. The land consolidation has been essentially required for improvement of the situation, and in 1974, the Thai Government issued the Land Consolidation Act so that the firm organization can be established for consolidation of the on-farm level infrastructures including land reform.

The on-farm development so far made in Thailand together with provision of irrigation facilities has been progressed in the staged development manner and roughly classified into five (5) types.

a) Ditch and Dike (400m interval between ditches) (Extensive)
b) a) + Farm Road
c) b) + Additional Ditch on the Bund
d) Reparcelling without Land Levelling (Intensive)
e) Reparcelling with Land Levelling

The on-farm development has no obvious classifications on whether intensive development or extensive, but only relative classification, though many arguments has been made. Referring to the above five types, the intensive development may be applied to both cases of "With Reparcelling" and "With Land Levelling" and the extensive development may be applied to the other cases.

Most of the development projects, which have been currently executed, will be classified into type with Land Levelling, and some project like the Phitsanulok Project, aim at the development involving the type b) above (Ditch, Dike and Farm Road).

The ultimate goal of the on-farm development is to consolidate the farm lands intensively to meet the local farming conditions. At present, however, it is required to study further about feasibility of the total development of a certain area in one package from the viewpoints of local conditions and economical effects.

The Royal Decree is prerequisite in a procedure for implementing the land consolidation project for a certain area, and the selection of objective area should be made on the basis of the following factors:

a) The objective area should have availability of irrigation water in the dry season.

b) The objective area should have a number of landed farmers.

c) The farm size in the objective area should be of equal size on an average.

d) The farmers in the objective area should have earnest desire to carry out the paddy double cropping.

After selecting a project area which is qualified in meeting the above conditions, there will be a preliminary plan established, based upon which the authorities concerned will hold meetings with land owners. When more than 50 percent of farmers consent to the plan, the project will reach the stage of implementation.

"General Guide" was prepared as a guideline of planning and designing, when the Chanasutr Project was carried out under the technical cooperation of the Netherlands.

Presently, the planning and designing are made along with the guideline of "Planning and Implementation of Land Consolidation" which was prepared by the Royal Irrigation Department (RID) in 1976 as the revision of the "General Guide".

The RID has been carrying out the construction works of most of the project. The annual work volume undertaken by RID has been increased as shown in Table1-1. Upbringing of the contractors, however, will be indispensably required with the rapid increase in number of the similar natured projects. The authorities concerned has a plan to entrust contractors with some project works from 1978.

The actual results of implementation of on-going projects are shown as follows:

Table L-1. Land Consolidation Projects Under Construction

(unit: rai)

Project/Year	1969	1970	1971	1972	1973	1974	1975	1976	Total	1977	1978
Chapasutr	(160)		(490)	(659)		(1,427)	(768)	(1,168)	(4,672)	(2,832)	(20,608)
	1,000	—	3,062	4,118	—	8,920	4,800	7,300	29,200	17,700	128,800
Sapphaya			(124)	(162)	(352)	(213)	(544)	(390)	(1,785)	(829)	
	—	—	773	1,010	2,200	1,333	3,400	2,440	11,156	5,174	—
Boromdhart							(1,136)	(1,552)	(2,688)	(3,680)	(11,833)
	—	—	—	—	—	—	2,100	9,700	16,800	23,000	73,958
Nong Wai								(160)	(160)	(480)	(11,360)
	—	—	—	—	—	—	—	1,000	1,000	3,000	71,000
Total	(160)		(618)	(821)	(352)	(1,640)	(2,448)	(3,270)	(9,305)	(7,821)	(43,801)
	1,000	—	3,835	5,128	2,200	10,253	15,300	20,440	58,156	48,874	273,758

Note: Figures in parentheses show hectares

The Government organizations concerned have been responsible technically and financially to execute construction and operation and maintenance of the main irrigation facilities, whereas the farmers concerned must bear a part of the construction costs in the on-farm development; particularly 100 percent of land levelling cost must be borne by farmers. Consequently, it is decided by farmers' will whether or not the land levelling is carried out. For references, the land levelling cost occupies about 30 to 45 percent in the unit cost of the total project works.

The unit project cost of the respective projects is shown in Table L-2.

The Taiwan Method was applied to the Sapphaya Project, the Dutch Method to Chanasutr and Boromdhart Projects and the compromised method of the above two to Nong Wai Pioneer Agriculture Project.

Differences between the Taiwan method and the Dutch are that the former takes the length of run of the plot by 120-150 meters and the latter by about 200 meters, a little longer than that of the former. Both methods take the width of plot by 40-60 meters in equally dividing the related farm lands.

It will depend upon the local conditions to employ which method of the two, the Taiwan or the Dutch. Generally speaking, the larger unit plot will be advantageous in view of the land deduction rate by seven (7) percent which is regulated by the Land Consolidated Act, and also the longer length of run will be efficient in application of mechanized farming.

However, from viewpoints of water management and land levelling works, the effective water management will take longer time and the adequate land levelling works will be difficult and sometimes costly in its implementation in the plot with the longer length of run.

Under consideration of farming machines now employed in the area, about 150 meters length of run will be suitable and practicable. Naturally, it is necessary to decide the best suited plot size to the local conditions in taking account the land deduction rate, unit acreage of Rai, soil properties and so forth.

2) Land Consolidation in the Mae Klong Area

The Mae Klong Area has been developed in staged manner. No on-farm facilities are provided in the area, though the main irrigation facilities have been constructed in some districts.

In comparison with the Chao Phya Area, the Area, located in the western part of the country, has variety in topographical conditions with lowlying lands, terraces and detrital fans, and there are some differences in cropping pattern. (Sugar cane, fruits trees plantation), social conditions (road networks linking with Bangkok) and so forth. Under the situation, the

land consolidation should be planned to involve the cultivation of upland crops in co-existing with paddy.

The field survey revealed that the Project Area might be roughly classified into four patterns: paddy growing area, sugar cane growing area, paddy/sugarcane growing area and fruits tree growing area. The sugarcane is grown in comparatively large acreage. The land consolidation for paddy/sugar growing area should be made in consideration of the well balanced expansion of paddy field and the sugarcane growing area, and also the consolidation as upland cropping fields should be planned for such area when the cropping pattern of the total area is examined.

a) Land consolidation of paddy fields

On planning of land consolidation of paddy fields, the type and plot size should be determined in taking into account the mutual relationship among topographical conditions, soil properties, water utilization, scale of farm mechanization, land ownership, etc. The topographical conditions will affect to a large extent the construction cost of the land consolidation.

It was surveyed that there exist in the Mae Klong Area the diluvial terraces and alluvial fans developing with considerable undulation. Under the situation, the uniformal on-farm development should be avoided in the area, but the characterized development should be planned to meet the local conditions such as topography, soil properties, etc.

There may be some areas unsuited to direct, total application of land consolidation method that has been carried out at present with large farm size and land levelling involved.

The ultimate goal of land consolidation is to develop the large farm plot land consolidation, however, since such development requires a heavy burden of farmers for land levelling, it may be necessary that the farmers themselves carry out the land levelling works little by little.

Furthermore, no farm roads can be seem in the paddy cropping areas, which hinders the farmers from farming works. It is required to review the road construction plan in the current land consolidation program and to establish the effective plan for farm road networks in the area.

b) Land consolidation in the lowlying flat lands

The lowlying part in the Mae Klong area (Stage 1) has no plan for main irrigation facilities construction due to chronological inundation caused from flooding in the wet season, surplus irrigation water, and water conservation in the Dommere Saduk canal. At present, the paddy cropping by broadcasting method (Direct Sewing) in utilization of the most fertile soil in the area and flat topography. It is deemed readily available to introduce the land reform in the area for a consideration of existing large scale of farm blocks.

On top of the above, the effective and systematic utilization of the surplus water and drained water will enable farmers to secure the irrigation water even in the dry season. Introduction of dike method with drainage development, which is now employed in many places as countermeasures for inundation, will make it possible to have paddy double cropping in the lowlying part.

In the lowlying part, navigation is a means of transportation in the wet season, whereas the no road networks available

in the dry season, and the farming in the dry season cannot but be carried out in the extensive manner.

It is essentially required to study an approach to development of the lowlying lands for an effective land use.

c) Development in sugarcane growing area

Sugarcane is a representative upland crop in the Mae Klong area. Sugarcane is grown in the considerable large area, particularly in the area where the development is planned in the Stage 1, the sugarcane cropping covers up to the extent that the main irrigation facilities are provided.

Sugarcane cropping as well as other croppings requires irrigation facilities for stabilization of yielding, and farm mechanization for saving labor in the harvesting season and well-balanced distribution of labor to paddy cropping. The land consolidation for upland fields will be inevitably required in future.

The growing acreage of sugarcane relates to the paddy cropping acreage and further to the water management. Then, the study should be made on irrigation method and land consolidation for sugarcane fields.

d) Fruit tree plantation area and vegetable cropping area

The right bank tract of the Nakhon Chaisit river, extending in the east of Mae Klong Area, and the area along the Damnern Saduk canal are those where the fruit tree plantation and vegetable cropping are extended because of their comparatively high population density and location near to Bangkok.

The lowlying lands provide with the comparatively small-scale polder dikes and the furrow irrigation is carried out.

The highlands are cropped with paddy, fruit trees and vegetables from which some farmers produce considerably high benefit.

The irrigation water sources in these areas are the irrigation surplus water and drained water, which are taken into consideration when planning the land consolidation.

3) Problems

The field survey including the interviews with farmers in the Project Area, revealed that there would be various problems (see below), which in the coming Master Plan Study should be studied further not only as problems in this Project but as those in general in Thailand.

a) Land levelling is poorly carried out.
b) Too long on-farm irrigation ditches prevent effective water management.
c) Farmers hold no positive attitude toward land reparcelling, sticking to their original landholding.
d) Farmers do not understand completely about the Land Deduction Rate of seven percent.
e) Farmers are not familiar with rotation irrigation.
f) The farming practices by Taiwan Method have not rooted, though introduced in Sapphaya Project.

These problems can be classified into three: engineering, institutional, and farming problems.

In the engineering aspect, land levelling problem as a)should be studied further in considering that the earth moving volume is rather small as compared with considerably large plot size

which causes technical difficulty in making the levelling more precise, and that the total land levelling cost, occupying a greater part of the construction cost, should be borne by farmers.

The problem in b) will be solved by studying to make the appropriate size reparcelling of the plot available; as a matter of fact, long irrigation ditches extending about two kilometers will not function adequately in such extremely gently sloped lands as the Project Area, and also will hinder the officers in large from keeping the proper operation and maintenance.

The reasonable plot size is in the range of three to nine hectares. In Thailand where the considerably large plot size is applied, the reasonable length of ditches will be 800 m in taking into account the acreage unit of Rai. The provision of irrigation ditches (the ditch embankment concurrently utilized as roads) at such intervals should be studied in details in the Master Plan Study stage in considering the land deduction rate.

For references, the Project-wise length of canals per unit acreage is shown in Table 3 and the earth moving volumes in Table 4.

Table 3. Length of Canals Per Unit Acreage

Project	Length of Road	Length of Farm Ditch	Length of Drain	Remarks
Boromdhart	(39.4) 6.30 M	(37.5) 6.00 M	(32.5) 5.20 M	Dutch method
Nong Wai	(51.1) 8.17 M	(57.7) 9.23 M	(37.9) 6.06 M	
Supphaya	(60.9) 9.75 M	(56.3) 9.00 M	(46.10) 7.38 M	Taiwan method

Note: Figures in parenthesis show volumes per 10 a.

Table 4. Earth Moving Volumes

Project	Sample Area	Average Quantity	Average Moving Distance
Chanasutr	88A-1	(27.95) 44.73 m^3	52.06 m
	88A-2	(20.57) 32.92 m^3	35.77 m
	88A-3	(22.95) 36.72 m^3	50.90 m
	88A-4	(28.08) 44.93 m^3	50.11 m
	Average	(24.38) 39.82 m^3	47.37 m
Boromdhart	722-1	(14.35) 22.97 m^3	35.47 m
	722-2	(13.51) 21.62 m^3	33.50 m
	722-3	(33.69) 53.91 m^3	30.10 m
	Average	(20.52) 32.83 m^3	33.02 m

The problems in c) and d) will be obstacles to make a plan of exchanging the lands for land consolidation. In Thailand, there have been no land consolidation projects implemented, including land reform and land exchange.

The regular farming plot should be provided, after new farming practices established, so as to carry out effective farm maintenance and efficient mechanized farming, although presently the farming plot size is planned to be adjusted to the acreage of respective farmers' owned lands.

The Government of Thailand has issued the Land Reform Law to solve the related problems. The Chao Phya Pilot Project involves those problems concerning the restriction of land

holding (up to 20 rai by non-cultivating landowners and up to 50 rai by landed farmers) and land exchange. The Chao Phya Pilot Project draw special attention as the model project of the land consolidation.

The conversion of Thai agriculture to intensive farming will require to introduce mechanized farming in view of the labor forces, since the paddy cropping has been originally carried out in the extensive manner. On top of the aobve, the deep knowledge and advanced techniques will be necessitated for effective water management and farm maintenance.

At present, the RID conducts the operation and maintenance of the main irrigation facilities, and the farmers' organization will have to engage itself in the operation and maintenance of on-farm level facilities that will be provided with the land consolidation progressed. Therefore, it is inevitably required to firmly establish the farmers' organization aiming to give guidance of farm management including water management. Particularly, the guidance of farm management shall be made in the long run, and best suited way to the local conditions, in due consideration of the results obtained from the Taiwan method.

8. Hydraulic Structures

The hydraulic structures in the Mae Klong River Basin have been provided in various irrigation and drainage projects that were formulated in the Mae Klong River Basin comprehensive development program in 1963. In the progress of development, the construction of on-farm facilities and drainage facilities delays slightly to schedule, whereas that of headworks and main and lateral irrigation canals has been smoothly progressed. Such being the case, some existing facilities seem to function ineffectively. In future, therefore, the on-farm facilities should be provided as soon as possible on top of completion of irrigation and drainage facilities.

1) Irrigation and drainage facilities

The Mae Klong River, the main water sources in the Project Area joins two tributaries, the Quae Yai and the Quae Noi Rivers at Kanchanaburi approximately 100 km upstream from the estuary.

a) Dam

Although there has been no large-scale reservoir provided in the Mae Klong River basin, the EGAT (Electricity Generating Authority of Thailand) has been constructing Ban Chao Nen Dam across the Quae Yai River to complete in 1980 (started in 1974). Fig. St-1 shows the dimensions of the Dam, which aims electric power generation, including flood control and irrigation water supply. The part of 50 percent to the total construction works would have been completed in August 1977 to start storing water within 1977. The Dam is expected to function for flood control in the Quae Yai River in the latter part of 1977, since storing water starts in 1977 in considering that it takes about 4 years to reach the full storage level due to relation between the inflow water and the dam capacity. Besides the Dam, at Ban Tha Thaung Na, about 28 km downstream from the Ban Chao Nen, an adverse-regulating reservoir is planned to be provided so as to execute the effective operation and control of water.

On the other hand, a dam on the Quae Noi River is in the survey stage; the RID has been conducting the large scale basic survey at Khao Kwang since 1960's. The RID has made geological survey on the expected dam site; bore drilling at dam center - 27 points, 33 holes, total depth 1,780 m, and bore drilling at upstream and downstream of dam center - 8 holes, total depth 380 m, grand total 41 holes and 2,160 m in depth. Furthermore, tunnelling survey (3 holes, 282 m long) found many sink holes. The geological features of the dam foundation is composed of limestones, doromitic lime stones, silicious limestones, shaly limestones, etc. belonging

to the periods ranging from carboniferous period to Permian period, the permeability of which range in general between 1×10^{-4} and 1×10^{-3}, and some parts have been found to provide a considerably high permeability therein. Another surveys have been carried out for borrow pit of construction materials on the river terrace in upstream and downstream of the dam center and bore drilling survey for the saddle part around the reservoir area. Those boring cores are stocked in the warehouse in the local project office and will be useful in the future study.

b) Water intake facilities

The existing main facilities for water intake from the Mae Klong River are the Vajiralong Korn Dam and several gravity intake gates, which are provided by RID, the construction period: 1967-1969 for the former and 1920's-1930's for the latter.

The Vajiralong Korn Dam is located near Kanchanaburi, having total length of about 120 m in full movable weirs and functioning excellently. The said dam is the only one water intake facilities in artificially controlling water level of the Mae Klong River. Backing up the water up to EL 22.0 m allows to supply water to the whole Mae Klong River Basin which the RID planned to take in the feasibility study.

The gravity water intake gates have structures to make it available to take water with water level heightened by increasing in river discharge, and play an important role to take water about 453 MCM in 1975 so that the water can be supplied to cover the whole Project Area; these facilities, however, will be laid aside when the present Mae Klong Project is realized in the future.

c) Irrigation Canals

The Project has a plan to provide a large scale irrigation

networks having total length of about 1,620 km, which includes only the main and lateral canals to be constructed in the irrigation and drainage project. For introducing water into each farm plot, a great number of irrigation ditches should be provided. Presently, the canals designed for Stage 1 have been already completed and those for Stage 2 are now under construction. The construction progress is expected to reach 56.8 percent to the total length at the end of 1977. Table St-1 shows the related costs and work progress for canal construction, and Map St-1 shows the Stage-wise work progress.

In general, the ready-constructed canal systems are satisfactorily provided, although there are several minor problems involved such that the diversion structures are provided with insufficient consideration paid to the terminal water use plan, the under-drains or weep-holes should have been provided as countermeasures for groundwater and wasteways are poorly provided.

The RID has executed successfully the operation and maintenance of the main canals in the manner that the supply amount of water is decided on the basis of the seasonal demand obtained by accumulated water requirements for 1,000 rai as minimum unit.

In view of the actual water utilization, however, incompleted consolidation of on-farm facilities and increase in sugarcane growing acreages seem to reduce the water utilization ratio.

All the irrigation canals are of open-type with mostly concrete lining (partly earth canal). The concrete lining is implemented with so-called "thin living" for erosion and percolation protection. Erosion on slope has already taken place on some parts of the earth canal, which is adopted after careful study on conveyance losses from geological and topographical surveying on canals.

d) Drainage canals

The RID has planned to construct drainage canals with total extension of 1,850 km, the construction progress of which is comparatively sluggish to that of irrigation canals and 20 percent to the total length is expected to be completed by the end of 1977.

Table St-2 shows the related costs and work progress for canal construction, and Map St-2 shows the Stage-wise progress.

The drainage canals in the Project, particularly those along the Damnoen Saduak canal in downstream of Stage 1 area, function not only for drainage purpose but for navigation, domestic water supply and irrigation purposes.

Most of the existing drainage canals, including some to be improved, are laid with such gentle slope that the extremely small flow velocity and thickly growing aquatic weed appears to hinder smooth discharge of water.

In the Project, the irrigation canals are designed to be linked with the drainage canals at their terminals. The delay in construction of the drainage canals prevent the surplus water from discharging to the drainage canals through tail regulators and a part of water is discharged to the farm lands in the downstream.

e) Road networks (including navigation)

The means of transportation in the Project Area is automobiles and ships. In highlying lands the automobiles are employed and in lowlying lands combination of automobiles and ships is employed.

Recently, automobiles and farming machines have increased in number, and so popularization of these facilities is expected with road networks consolidated in the lowlying lands as well as in the highlying lands.

In the Project Area, the road networks have been provided steadily, and construction works and maintenance of these roads are made by RID, Highway Department, etc.

The Survey Mission has not been able to complete the survey on present transportation in the Project Area, and the main road networks are shown in Map St-1 and St-2.

2) Related problems and approaches to their solution

a) Dam

It was mentioned in the above paragraphs on "Irrigation" "Hydrology" that river discharge control requires to provide a dam.

The Ban Chao Nen Dam, now under construction on the Quae Yai River, has a capacity to store the total annual discharge of the said river, and it is meaningless to construct a new dam in the upperstream of the Ban Chao Nen Dam in respect to water utilization. In other words, the proper dam operation will allow the inflow discharge to be controlled to meet the irrigation requirements.

Under the circumstances, it will be an important subject to study how to increase the water available for irrigation in coordinating with the water demands for power generation. As a result of the above study, review will be required on the scale of the adversely regulating reservoir to be provided at Ban Tha Thaung Na.

On the other hand, the geological survey has been made since 1960 at Khao Kwan, the proposed dam site for river discharge improvement required by irrigation and drainage program.

The said survey revealed that the foundation rocks developing in the proposed reservoir area consisted of the limestones. Such lime stone areas in general have sufficient bearability, whereas some countermeasures should be taken for high permeability.

In the case of Khao Kwang, there have been many sink holes found in the tunnelling surveys, and further detailed technical studies should be made for construction of a large dam in the site with such geological conditions.

However, the proposed dam site at Khao Kwang has various advantages to secure the sufficient water for agricultural development; the site is favorable in its topography, the water management can be conveniently carried out for large beneficial areas extending close to the dam although a little difficult to control flood waters during construction works due to its location at downstream of the Quae Noi River, and the dam is expected to control a great deal of discharge in the big river basin (flood protection).

For the limestone areas, a careful study about all reservoir areas is required to establish proper countermeasures for water leaks. Only the detailed studies for reservoir area as well as embankment sites will be able to clarify the possibility of dam construction in this proposed site.

For references, the data obtained in construction of Ban Chao Nen dam will be of great use for plan formulation of dam construction at Khao Kwang, although sufficient data could not be collected in this survey.

The summary of study items on dam problem is as follows:

i) Coordination of discharge amounts from the Ban Chao Nen reservoir and the Ban Tha Thaung Na reservoir; the coordination between irrigation use and power generation use.

ii) Study on possibility of large dam construction on the Quae Noi River (When resulting in being negative technically and economically, the study should be furthered on possibility of small dam construction on the Quae Nai River and Quae Yai River.)

The above studies should be made from the viewpoints not only engineering but social aspects relating to other projects and rescue measures of inhabitants in the submerged area in the dam site.

b) Water intake facilities

The Vajiralong Korn Dam, completed in 1969, was designed on the basis of the result of feasibility study by RID so as to meet most of the irrigation water requirements in the areas of Stage I and II, and actually the dam provided in the adequate location to irrigate the Project Area, will function successfully with excellent structures after completion of the related several projects.

In future, however, the increase in water demands is expected due to introduction of new paddy varieties, change of cropping pattern involved in the on-farm development, and also, the concentrated paddling works by farm mechanization may increase the intake water amount.

To synchronize water supply and to meet the increasing demands, there should be two plans considered: the expansion of water-intake facilities of Vajiralong Korn Dam and construction of a new headwork.

On studying these plans, the following matters should be taken into consideration:

i) The existing irrigation canals in the Stage I area should be increased in their capacity by widening or heightening of embankments, when the expansion of the water intake facilities of Vajiralong Korn Dam is implemented.

ii) The provision of new headworks at the downstream will save operation losses of irrigation water and produce good effect in regulating the discharges; proper operation of a new headworks and dam reservoir will increase the water utilization ratio.

iii) A new headworks will be able to respond quickly to the demands at the terminal fields of the irrigation system, although the Vajiralong Korn Dam cannot readily respond due to the long distance between dam and terminal fields.

iv) Since navigation in the Mae Klong River is busier in its downstream, a new headworks should be designed providing the shipway.

There are merits and demerits in the respective plans and it is recommended to study preferentially the new water intake facilities in the downstream, particularly positive utilization of the existing natural water intake available should be considered. Furthermore, the pumping irrigation should be comparatively studied with the headworks, if the navigation problem hinders construction of adequate water intake facilities.

c) Irrigation canals

More than half of the proposed main and lateral irrigation canals in the Project Area have been completed; especially the scheduled construction works in the Stage I have been

finished at all, and the data and information in these works shall be fully utilized in Master Plan Study.

The study on design of total canal systems, therefore, should be made in taking into the account the fact that the Project requires a considerably long extending canal system, the upperstream portion undulates to some extent but the downstream portion develops quite flat, and the careful attention should be paid to the following points:

i) Since the longer canal system bring about operation losses, it is required to reduce such losses by providing regulating reservoirs, farm ponds, etc., in the course of the system. All regulating facilities should be provided by fully utilizing the mashes and natural ponds dotting in the Area.

ii) Judging from the topographical features, the gravity irrigation seems unavailable for the total Project Area. Therefore, the area classification on availability for gravity irrigation should be made based on the detailed topo-maps, so as to study the need of pump irrigation from the technical and economical viewpoints.

iii) Furthermore, the study should be made on availability of repeated water use as much as possible.

iv) Review should be made on provision of diversion facilities to meet the requirements in on-farm development.

v) The construction costs of canals involved in the irrigation project are fully borne by the Government, whereas those involved in the land consolidation project are partly borne by farmers. Since these two kinds of construction works cannot be clearly defined in their ranges, it is recommended to classify the works on the basis of the terminal commanded acreage.

The above major items should be studied to cope with the on-farm level development program.

d) Drainge canal

The drainage improvement in the Project aims to protect the floodings from the Mae Klong River and to drain the rainfall in the Area and surplus water discharge from the upstream areas.

e) Road networks (including navigation)

In the Project Area, the road networks as well as irrigation and drainage facilities should be consolidated for activating the agricultural production, as the popularization of automobiles and farming machines is promoted. The navigation will play an important role as a means of transportation for the time being.

Under the situation, a comprehensive transportation facilities improvement program should be established on the basis of existing road networks, road improvement programs prepared by respective organization concerned present popularization of automobiles and farming machines and navigation.

Particularly, the O and M roads provided along the canals will be more functionally utilized by linking with other roads in crossing in the right angle. This plan is worthwhile studying for effective use of the existing facilities.

f) Others

i) Maintenance of canals

For effective utilization of limited water resources, the adversely regulating reservoir of Ban Chao Men Dam, the proposed dam on Quae Noi River and water intake facilities in the downstream shall not be operated and maintained independently but organically according to close and quick exchange of information among each other. Practical measures should be studied to meet the requirements.

ii) Utilization of borrow pits

Borrow pits for construction of irrigation and drainage canals will form hollow lands along the canals, and some of these pits are used as the ponds for domestic animals. The further study may allow them to be utilized positively for farm ponds, or the materials shall not be dug but collected widely lest the hollows should be formed. Such a manner should be comparatively studied to save construction cost and compensation cost of land acquisition and to utilize the flat lands.

The canals should be designed in due consideration that the water has the closest relationship with the life of inhabitants in respect to domestic water supply, navigation, and other daily conveniences.

iii) Protection of shadow trees

The existing paddy fields provide many shadow trees planted around the farm plots, which give a good resting place to farmers and animals; consequently, a careful attention should be paid to protection of existing trees and plantation of new trees, when construction works are implemented for canals and land consolidation.

9. Agriculture

At present, Thailand is one of the biggest rice exporting countries like the United States of America. Recently, rice mono-culture has turned into crop diversification. Production of maize, tapioca and sugar cane has increased rapidly. More than one million metric tons of rice is exported every year and rice export still comes first in foreign currency earning. In 1976, cultivated paddy fields of 8.9 million hectare surpass the total cultivated area of four (4) million hectares by other major agriculture products such as rubber, maize, kenaf, coconut and tapioca.

In the Mae Klong River Basin Development Project Area located southwest of the Central Plain, 1976 the paddy cropped acreage was about 627,000 hectares (507,000 ha. in the wet season and 120,000 ha. in the dry season), sugar cane field about 201,000 hectates, in seven Changwat. These acreages occupy 67 percent and 21 percent in the total cultivated lands 938,000 ha, respectively. Total acreages planted by vegetables, orchards and others excluding paddy rice and sugar cane account to 12 percnet to total cultivated lands. (Refer to Table A-1).

a) Present situation of paddy double cropping

In the dry season of 1976, total paddy cropped acreage in seven project-related Changwat was about 120,000 hectares, which occupy about 13 percent in the total arable lands, and about 19 percent in the total paddy fields (630,000 ha). The nation-wise paddy cropped acreage in the dry season of 1976 was 377,000 hectares, which is approximately four (4) percent to the total paddy cropping acreage of the country (8,896,000 ha.). Therefore, 19 percent of the ratio of double cropping in the Project Area is considerably higher than that of national average.

In particular, the double cropping ratio in Changwat Nakon Pathom including most part of the Stage I area where the main canals have been already provided, reaches approximately 43

percent and the total paddy production in the dry season has been larger than that in the wet season.

The dry season paddy cropped acreage in the past three years in the Stage I area was 4,510 hectares in 1974, 5,000 hectares in 1975 and 8,196 hectares in 1976, respectively, and these figures show the fact that the dry season paddy cropping was increased by 82 percent only for two years, and also the provision of irrigation facilities will allow the dry season cropping acreage to be much more increased because the yield of dry season paddy is larger than that of wet season paddy.

b) Outline of paddy cropping

i) Varieties and cropping pattern

The Thai Government has succeeded to develop high yielding varieties, RD strains (RD/1-RD/11) by steady study and research in high yielding varieties breeding programs. Also, the excellent conventional varieties have been developed by pure line selection.

However, it is reported by farmers or Changwat officers in charge that farmers have still now employed the local varieties by 70 percent in their paddy growing in the wet season cropping, while most of the dry season cropping is made with new varieties.

Table A-4 shows the varieties that the Government recommends to the farmers in the Central Plain.

The RD strains with non-photosensitivity has stabilized growing period - ranging 125-135 days between sowing and maturing.

On the other hand, the conventional local varieties is photosensitive with longer growing period such that they are sown in June through September and mature only in November through January. And seedlings of 60 days old from sowing are transplanted with leaves halved by cutting off.

Farmers tend to grow the conventional variety instead of high yielding varieties due to the fact that the former variety (conventional variety) has a greater number of consumers. The conventional variety has also characteristics of growing without fertilizer which can reduce the production costs although it has a low yield.

Figure A-1 illustrates the present cropping pattern and the proposed cropping pattern.

ii) Fertilization

Table A-5 shows the standard of fertilizer application to the paddy plants. The effective diffusion of fertilizing techniques require easiness of purchasing, reasonable price in paddy production cost, proper water management for fertilizer dosing.

In the wet season paddy cropping, almost no fertilizers are dosed both in nursery stage and after-transplanting, while some fertilizers are dosed in the dry season cropping for the high yielding varieties are planted.

Most of the fertilizers used in the Area are formula 16-20-0, the chemical fertilizers of granular ammophose. The Government recommends to use them by 95 kg per hectare. The Thai-produced fertilizers are used by about 45 percent to total consumption and the rest are imported. (Refer to Table A-2 and A-6 on import of fertilizers).

c) Pest control

Some varieties of RD strains are susceptive to yellow-orange leaf, which is infected by leaf hoppers, the carriers of virus; then, the control should be made for driving them away. Recently, the bactorial leaf blight has thickly taken place, and besides the above, brown spot, bokanae disease, etc. are found in the Area as well.

As most injurious insects, there are many rice stem-borer, gall midge (not so serious as in the North), leaf hopper, and green rice hopper found in the Project Area. The insect control, however, has been scarcely carried in the Area.

d) Farm mechanization

Small-type power tillers (10 HP cultivator) has been increasingly employed to paddy cropping farming works in Thailand, while large-type tractors are operated in sugar cane fields.

A considerable number of irrigation/drainage pump have been used in the Project Area. Other machines like threshers, processors, planters will become more popular not only in Project Area but in whole Thailand.

e) Sugarcane and other crops

Sugarcanes are widely grown in the north and the west parts of the Project Area (chiefly Kanchanaburi, Suphan Buri, Ratch Buri).

The yield per rai is estimated at about 8-10 tons (50-63 tons/ha), and the price at factory yard is about 280-300 Baht/ton. Although the recent sugar market shows the declining tendency, the farmers are increasingly growing sugarcane because considerably little labor can produce larger income as compared with paddy cropping.

Main uplnad crops are maize, cotton, kenaf, tobacco, beans (chiefly Mung beans), cassava, etc.

There are so many vegetables produced in the Area, such as Chilli, onion, Chinese cabbage, cabbage, potato, cucumber, tomato, eggplant, etc.

The upland crops are grown mainly in the northwest of the Area, and the vegetables are produced in the south of Changwat Nakhon Pathom.

Statistically, fruits are divided into two: fruits and tree fruits. A great many fruits such as banana, papaya, mandarin orange, lemon, pomelo, mango, letchi, pomagranata and other tropical fruits are found in the Area. Coconut is named as tree fruits.

Vegetables and fruits are intensively grown by the high ridge method under well managed farm maintenance because those fields for vegetable and fruits growing exist in the ponded lands or marsh lands.

Vegetable growing periods are largely divided into three in a year; end of October to early February, middle of February to early June, and end of June to early September.

Fruits like banana, coconut and papaya are perennially produced, and others are generally in a period between May and July, though slightly staggers by kinds of fruits.

In previous paragraph, it is mentioned already that many small-type plowing machiens have been introduced into the Area. The survey revealed those machines are priced in the market.

f) Related problems

i) Problems in paddy cropping

(a) Introduction of high yielding varieties

The Government recommending high yielding varieties of RD strains are non-photosensitive, having more advantages in early maturing than conventional local varieties which are photosensitive.

The cultivation of new high yielding varieties requires well-managed water control, much dosing of fertilizers, effective pest control that result in higher production cost. And yet consumers do not appreciate their taste. Such being the case, farmers tend to grow the conventional local varieties without any special care, despite taking a rather long time for maturing.

Well-functioning irrigation facilities, however, will make it more advantageous to grow new varieties than conventional local varieties.

(b) Paddy and sugar cane growings

As mentioned previously, the cropping acreage of sugar cane will be increased in future as well and the keener competition to secure labor forces will take place due to coincidence of harvesting for sugar cane and wet season paddy.

The respective production costs of paddy and sugar cane should be studied in details in the coming stages. The following will give a general idea of the advantage on the basis of their roughly estimated benefit per hectare.

	Yield/Ha (ton)	Unit Price/Ton (Baht)	Estimated Benefit/Ha. (Baht)
Paddy			
Wet Season	2.4/1	2,200	5,280
Dry Season	3.8/1	2,200	8,360
Total	6.2	2,200	13,640
Sugar Cane	50/2	252/3	12,600

NOTE: /1 Yield in Nakhon Pathom, 1975/76 Cropping Year (Table A-3).
/2 Converted into values per hectare (50 tons) from per rai (8.08 ton in national average during cropping year 1972/73-1975/76). (Refer to Table A-6).
/3 Farm gate price in 1975/76 (Table A-6).

As learned from the above table, one paddy cropping in a year produces lower benefit than sugar cane growing, whereas double paddy cropping produces more benefit than sugar cane growing. Definite comparison of their advantage requires to study in detail of their production costs and market prices.

ii) Paddy losses after harvesting

It is reported that the paddy losses after harvesting is extremely large in the Southeast Asian countries in reaching 15 to 35 percent. (In Japan, such losses count only five (5) percent.)

If five (5) percent of the said losses can be reduced, the actual harvest will give the same effect as production increase in the equivalent amount to 20,000 ha. production for 400,000 ha. of the paddy fields. As such, the reduction of these losses is one of the important factors for production increase.

g) Countermeasures to be taken

i) Solution for competition between paddy cropping and sugar cane growing

The Project Area provides a number of sugar factories as a center of the sugar cane growing in Thailand.

It is essentially required, therefore, for formulating the comprehensive development of the Area that the targets of sugar cane yield and layout of cane field should be decisively established.

In considering above factors, the Master Plan Study should be carried out so as to clarify the relations between paddy and sugar cane from the viewpoint of national-level aspects (earning of foreign currency and employment opportunities increase), farmers level aspect (income increase), and local industries aspects (protection of sugar industry).

ii) Rotational cropping of paddy and other crops

As Table A-1 shows in the lower column, in the areas where the water utilization facilities are readily constructed, the varieties in RD strains shall be cropped by sowing in mid-July and harvesting in end-October, then, pulses shall be cropped after paddy cropping to be harvested before sowing the second paddy cropping and leaves and stalks of pulses shall be plowed into the soil so that nitrogen can be reduced to the soil.

Comparison of Gross Income by Paddy and Pulses

	Paddy	Groundnut	Soybean	Mungbean
Yield/ha (ton)	2.0/1	1.2	0.9	0.8
Farmers Income/kg (Baht)	2.1	3.4	3.9	3.3
Gross Income/ha. (Baht)	4,200	4,800	3,510	2,640

NOTE: The above table is prepared with mathematical averages for 3 years (1974-76) obtained from the Agricultural Statistics (1975/76).

/1 3-year average in the Central Plain.

iii) Countermeasures for processing losses after paddy harvesting

As mentioned already, a considerably large processing losses after paddy harvesting are in a sense losses to the nation. Middle-men's beating down of the paddy price gives losses to the farmers.

The countermeasures to be taken fro above losses are as follows:

(a) To strengthen the cooperatives.

(b) To provide paddy storage facilities and milling plant under control of cooperatives or similar organizations.

(c) To facilitiate agricultural crediting, and so forth.

10. Agriculture Supporting Services

1) Encouragement of extension services

As a general rule, it is considered reasonable to place one extension agent for 500 farm households in order to render proper services, but in the Project Area only one agent is serving for about 3,000 farm households. In this regard, the current extension staff should be strengthened.

2) Farmers' training

The farmers' training tends to degenerate into mere thing of forms; easy-going technical meeting, distribution of pamphlets, all of which farmer cannot follow willingly. It is desirable, therefore, to make a suitable and substantial training plan to the local conditions to respond to farmers' requirements.

On top of demonstration farm of cropping superior varieties, a training center should be provided in an area with 50 km diameter so as to give collective training about 15 days during slack seasons.

c) Farmers' organization and crediting

There exist several farmers organizations such as Sugar Cane Growers Associations, Agricultural Cooperatives, Farmers Groups, 4-H Clubs, etc., and the detailed survey on their actual status has not been carried out in this study.

Also, there are several agricultural credit available in the Project Area, and the lenders of these credits are mostly merchants, large landed proprietors. The interests imposed on the credits are in considerably high range from 20-36 percent per annum. In the light of the Bank for Agriculture and Agricultural Cooperatives, the interest is 12 percent per annum.

In another aspect, a new farmers' organization should be formed for carrying out the proper water management by farmers themselves.

CHAPTER V. COLLECTED DATA AND RECORDS OF SURVEY

LIST OF COLLECTED DATA

I. ECONOMICS

1.	Agricultural Statistics of Thailand	Source: DAE (Division of Agricultural Economics), MOAC
2.	Bulletin of the Bank of Thailand	Bank of Thailand
3.	The Fourth National Economic and Social Development Plan 1977-1981	National Economic and Social Development Board, Office of Prime Minister
4.	Interim Country Report on Thailand Joint Research Project on Regional Development in the Southeast Asian countries	Institute of Developing Economies
5.	Inventory of Sugar Mill Factory	Irrigation Office No. 10, RID
6.	Inventory of Sugarcane Cultivated Area	Irrigation Office No. 10, RID
7.	Population and Housing Census 1970	National Statistics Office

II. SOIL

1. Detailed reconnaissance soil map of southern central plain area, Soil Survey Division, 1972.

2. Report on the preliminary soil survey of the Mae Klong Irrigation Project area, by Moormann F.R., Miscellaneous Soil Report (MSC) No. 1. RID, Agri. Dept. and Rice Dept. 1962.

3. The soils of the Kingdom of Thailand, by Moorman, F.R. and Rojanasoowthon S., Soil Survey Report (SSR)-72A, 1972.

4. General land Capability Map of Thailand, Soil survey interpretation series-2, Land Classification Div., 1972.

5. Climate and Crops in Thailand, by A.L.J. van den Eslaart, Soil Survey Div., SSR-96, 1973.

6. Kinds and Intensities of Soil Surveys, by G.H. Robinson and C. Suraphol, Soil Survey Div., SSR-91, 1972.

7. Report of soil analysis, Mae Klong project, Lab. No. 25/2511, 11/2512, Soil Chemistry and Physics Laboratory, RID, 1970.

8. Method and Procedure by Photo-interpretation for Survey of Rubber Plantations In Thailand, by D.C. Schwaar, Soil Survey Div., SSR-85, 1971.

III. METEOROLOGY AND HYDROLOGY

1. Climatological Data of Thailand 20-Year period (1951-1970)
   Source: Meteorological Department, Ministry of Communication Bangkok, Thailand.

2. Daily Rainfall

	Name of Station	Observation Period	Remarks
1)	Tha Maka Kanchanaburi	1952-1974	
2)	Tha Muang	1952-1974	
3)	Muang Ratchaburi	1952-1974	
4)	Thong Pha Phum Kanchanaburi	1952-1974	Quae Noi R.
5)	Si Sawant Kanchanaburi	1952-1968	
6)	Bang Phae Ratchaburi	1952-1974	
7)	Si Sawat Kanchanaburi	1954-1974	Quae Yai R.
8)	Muang Samut Songkhram	1952-1974	Maeklong R.
9)	Sai Yok Kanchanaburi	1954-1973	Quae Noi R.
10)	Sangkhla Buri Kanchanaburi	1952-1974	Quae Noi R.
11)	Pak Tho, Ratchaburi	1952-1974	
12)	Sanut Songkhram	1952-1974	

3. Daily discharge data on Maeklong River Basin

1)	K 10 (K9)	1962-1976	Quae Noi
2)	K 20 (K6)	1957-1975	Quae Yai River
3)	K 11 (K8)	1957-1975	Maeklong River

Above-mentioned stations are representative on the Maekong River Basin.

Source: Hydrology Division of RID.

4. Basic Map on the Greater Maeklong Project

1)	Topo-map	1:50,000 (Project area only)
2)	Topo-map	1:250,000 Including River Basin
3)	Contour Map	1:100,000 One meter contour
4)	Irrigation & Drainage Planning Map on the Greater Maeklong Project	1:100,000

Source: RID, Office of Bangkok

IV. LAND CONSOLIDATION

1. Design and Implementation Land Consolidation Project
2. Planning and Implementation of Land Consolidation
3. Land Consolidation in Thailand
4. Land Consolidation Cost
   Nong Wai, Chanasutr, Boromdhart, Supphaya
5. Detail Data of Land Consolidation
6. Land Levelling Average Moving Distance
7. The Implementation of Land Consolidation
8. Standard Cross-Section of Farm Road (Chanasutr)

Source: (1) Central Land Consolidation Office
(2) Land Consolidation Section of RID

V. DRAINAGE

1. Water Inflow to Flood Area (Thai Language)
2. Flood Condition in Nakhon Chun Sub-Project (Thai Language)
3. Damage by Flood
4. Drainage System in the Project Area (under construction and constructed canal)
5. Annual Progress Report on the Land and Water Utilization on Paddy Field in Thailand for 1974 and 1975.
6. Planning Map of Drainage Canal in the Project Area
7. Map of Flood Damage in the Project Area (Kampain Saen, Nakhon Chum, Tha Maka, and Rachaburi Left Bank)
8. General Planning Map of Damnoen Saduak Sub-Project

VI. STRUCTURE

1. Summary Report on Ban Chao Nen Dam
2. Report of Geographical Survey on Khao Kwang Dam
3. The Progress Map of Irrigation and Drainage Facilities on the Maeklong Project Area
4. Recommended Practices for the Design of Canal System
   Volume III
   Volume IV
5. Typical Cross-Section of the Irrigation Canal
6. Road Map of O & M, Feeder and Village Road
   Scale: 1/10,000 (Existing and Proposed)
7. Classified Type on Existing Road
   Scale: 1:200,000 (Asphalt and Laterite)
   Source:RID of Bangkok Office

VII. AGRICULTURE

1. Suphan Buri Rice Experimental Station, Department of Agriculture

Source: Suphan Buri RES

VIII. Others

1. Total Assistance to Thailand by Source and Type January-December 1976
2. Economic and Technical Assistance under the Third National Economic and Social Development Plan
3. Presentation of Thailand's Technical Cooperation Program to Japan

Source: DTEC, Thailand

Working Itinerary of Preliminary Survey Team in Thailand

Date	Description
July 18 (Mon.)	Arrived at Bangkok (JAL 471)
19 (Tues.) to 22 (Fri.)	Courtesy call to Japanese Embassy, JICA Office and Thai Authorities concerned having several discussions with personnel concerned
23 (Sat.)	Team member meeting
24 (Sun.)	Off
25 (Mon.)	Left Bangkok for Kanchanaburi for field survey in the Mae Klong River Basin
26 (Tues.)	Inspected the Ban Chao Nen Dam Mr. Y. Miyanishi arrived at Bangkok
27 (Wed.)	Survey on the Stage I area and returned to Bangkok
28 (Thurs.)	Had discussion with various personnel concerned of the government authorities
29 (Fri.)	Meeting with the Central Land Consolidation Office (Mr. John Boonlu and Mr. Paitoon Palayasoot)
	Meeting with the Land Consolidation Section, RID and the Chief of Computer Center
	Visited Bankhen for collection of basic data
	Team Leader and Coordinator left for Japan
30 (Sat.)	Off
31 (Sun.)	Off (Preparation for second field trip)
Aug. 1 (Mon.)	Made trip to Ayuthaya, on the way, inspected Rangsitnua Project, Land Reform Office at Ayuthaya and the Bang-Ban Pump Irrigation Project
2 (Tues.)	Made trip from Ayuthaya to the Chao Phya Dam and inspected the Chanasutr area on the way also, investigated the Boromdhart land consolidation project, the Soromodhart land consolidation project and so-called Ditch & Dike project
3 (Wed.)	Left the Chao Phya Dam for Kanchanaburi and visited the rice experiment station at Suphanburi having various discussions with the personnel concerned.
4 (Thurs.)	At nearby Sai Yok, investigated the dam site as proposed by RID Agri-group visited Kanchanaburi provincial Office
5 (Fri.)	Investigated the location and structure of natural drainage channel connnected with the Mae Klong River using speed boat

Aug. 6 (Sat.)	Investigated the Petchaburi area
7 (Sun.)	Off
8 (Mon.)	Meeting with the Project Manager, Mr. Chari and his staff in the project office and collected basic data
	Agri-group visited Suphanburi provincial office and rice experimental office
9 (Tues.)	Investigated canal system at Nakhon Pathom area
	Agri-group visited Petchaburi and Samut Songkhran provincial office
10 (Wed.)	Survey on field situation on the East Malaiman area
	Team member meeting
11 (Thurs.)	Returned to Bangkok, investigated the Damnoen Saduak canal on the way
12 (Fri.)	National Holiday
	Discussion among the team member
13 (Sat.)	Off
14 (Sun.)	Off
	Team Leader and Coordinator arrived at Bangkok (JL461)
15 (Mon.)	Discussion among the team member and preparation of minutes of meeting
16 (Tues.)	Meeting with Mr. Charin Atthayodhin, Deputy Director General, RID on the team's findings in the field survey
17 (Wed.)	Preparation of Interim Report
18 (Thurs.)	-do-
	Deputy team leader left for Japan
19 (Fri.)	Preparation of Interim Report
20 (Sat.)	Team member meeting on Interim Report
21 (Sun.)	Team member meeting on Interim Report
22 (Mon.)	-do-
23 (Tues.)	-do-
24 (Wed.)	Preparation of Interim Report
25 (Thurs.)	-do-
26 (Fri.)	-do-
27 (Sat.)	Off
28 (Sun.)	Off
29 (Mon.)	Submission of Interim Report to RID

Aug.30 (Tues.)	Meeting with RID Officials concerned on the Interim Report submitted
31 (Wed.)	Meeting among team member
Sept.1 (Thurs.)	Meeting with personnel concerned of the Japanese Embassy and JICA Office
	Preparation for trip
2 (Fri.)	Left Bangkok for Japan (LH 640)