FEASIBILITY REPORT

ON

THE KAMPHAENG SAEN IRRIGATED AGRICULTURE DEVELOPMENT PROJECT

IN

THE MAE KLONG RIVER BAISN

IN

THE KINGDOM OF THAILAND

MAIN REPORT

OCTOBER 1979

JAPAN INTERNATIONAL COOPERATION AGENCY

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P R E F A C E

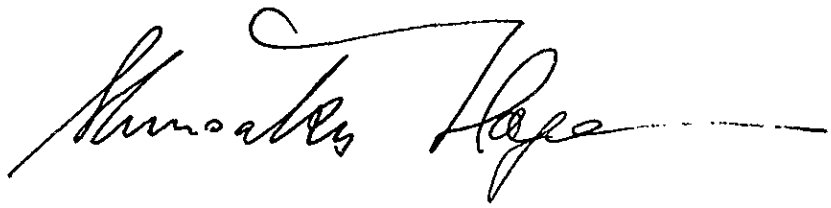
The Government of the Kingdom of Thailand requested the Government of Japan to render a technical cooperation for the irrigated agriculture development project covering about 28,000 ha in the Kamphaeng Saen Area which was accorded the highest priority in development in the Greater Mae Klong River Basin by increasing cropped area and yield of paddy as a major crop.

In compliance with the request, the Japan International Cooperation Agency (JICA), the executing agency of overseas cooperation by the Government of Japan, has dispatched the survey team headed by Mr. O. Ishiyama (Sanyu Consultants Inc., Nagoya, Japan) twice from January 22, 1979 through March 17, 1979, and June 18, 1979 through July 21, 1979, so as to carry out the field surveys on the Kamphaeng Saen Irrigated Agriculture Development Project.

Holding many discussion meetings about development strategy with Thai authorities concerned, the Team made technical and economical studies on the Project. Further studies and analyses made in home office based on the data and information collected in the field surveys have been concluded into this Feasibility Study Report of the Project.

I hope this Report will serve in promoting the Kamphaeng Saen Irrigated Agriculture Development Project as well as deepening the friendly relationship between the two countries.

Finally, I sincerely wish to express my heartfelt thanks for the closest cooperation and assistance rendered to the Survey Teams by Thai authorities concerned, Japanese governmental agencies in Thailand and the Ministry of Foreign Affairs and the Ministry of Agriculture, Forestry and Fishery, Japan, and furthermore, I deeply appreciate every possible effort made by the staff of the Teams for carrying out the Project studies.



SHINSAKU HOGEN
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

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

Dear Sir:

We have the honor to submit herewith our Feasibility Report for the Kamphaeng Saen Irrigated Agriculture Development Project in the Kingdom of Thailand. The report has been prepared on the basis of our findings of the survey team, which visited Thailand twice, in January-March and June-July, 1979, and various discussions held between the Thailand Government agencies concerned and the Team.

The Project, covering a gross area of about 28,000 ha, would have a low cost investment and bring quick yield and would give benefits to a small unit of farmer. We wish to state that this development scheme would be one of the best plans for Irrigated Agriculture Development in Thailand.

This Report comprises the following volumes:

Volume 1 - Main Report
Volume 2 - Appendix

We hope that this development project would serve as a good example and could contribute to the socio-economic development in the rural area as well as in the entire Thailand.

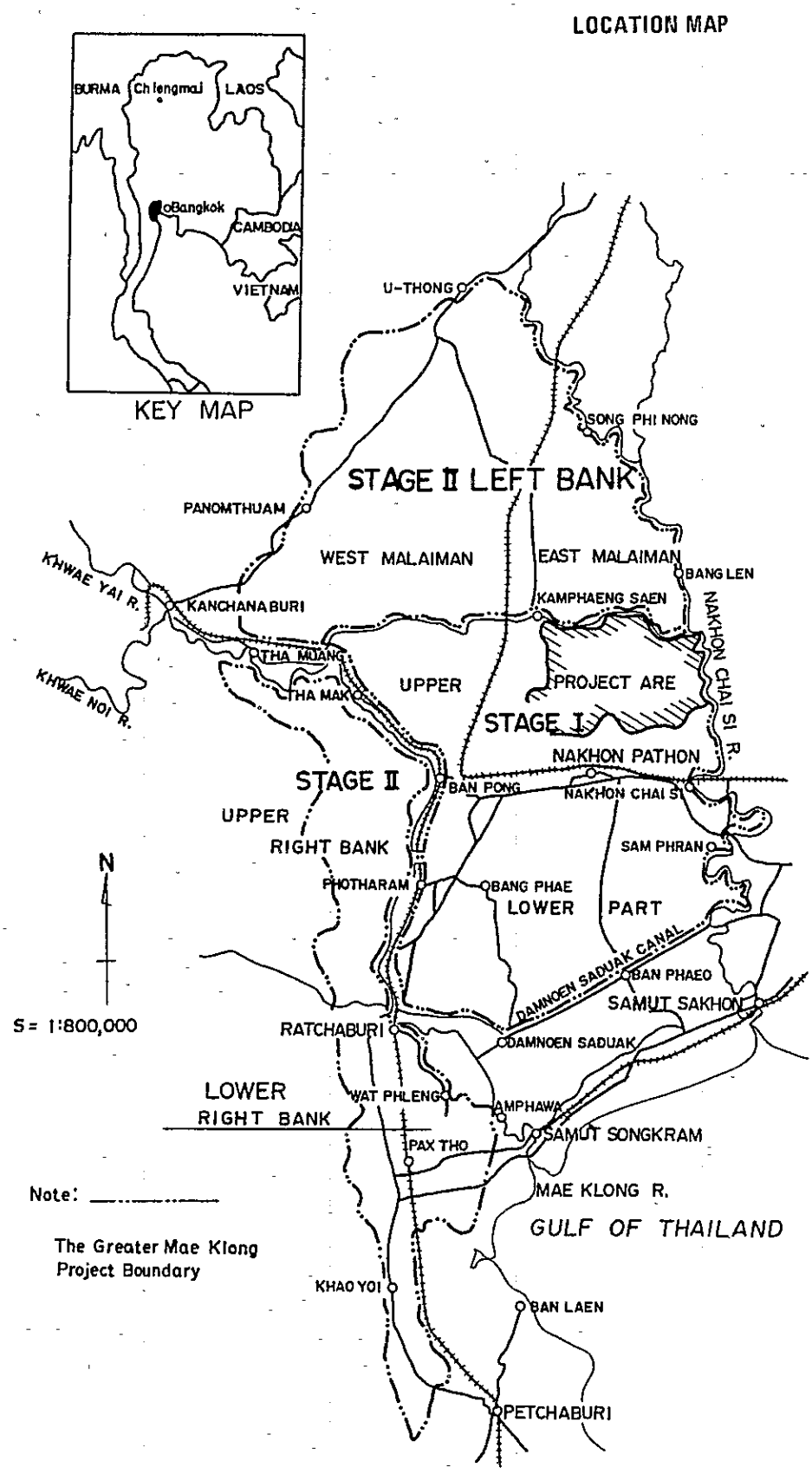
Finally, we take this opportunity to express our deep gratitude to the Royal Irrigation Department, Central Office for Land Consolidation, Land Department, Department of Agricultural Extension, other department and offices related to the study in Thailand, Ministry of Foreign Affairs (Japan), Embassy of Japan in Thailand, Ministry of Agriculture, Forestry and Fishery, Japan International Cooperation Agency, Supervisory Group of the Project and Japanese experts for Thai Irrigated Agriculture Development Project for their valuable assistance and cooperation extended to us throughout the study-period and for the compilation of this Report.

Respectfully yours,

O. Ishiyama

Osamu Ishiyama
Team Leader for the
Feasibility Study on
Kamphaeng Saen Irrigated
Agriculture Development
Project

October 1979


LOCATION MAP
BURMA
Chiengmai
LAOS
Bangkok
CAMBODIA
VIETNAM
KEY MAP
U-THONG
SONG PHI NONG
STAGE II LEFT BANK
PANOMTHUAM
WEST MALAIMAN
EAST MALAIMAN
BANG LEN
KHWAE YAI R.
KANCHANABURI
KAMPHAENG SAEN
NAKHON CHAI SI R.
THA MUANG
UPPER
PROJECT ARE
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STAGE I
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BAN PONG
NAKHON CHAI SI
UPPER
RIGHT BANK
SAM PHRAN
PHOTHARAM
BANG PHAE
LOWER
PART
DAMNOEN SADUAK CANAL
BAN PHAEO
SAMUT SAKHON
N
S= 1:800,000
RATCHABURI
DAMNOEN SADUAK
LOWER
RIGHT BANK
WAT PHLENG
AMPHAWA
SAMUT SONGKRAM
PAK THO
MAE KLONG R.
GULF OF THAILAND
Note:
The Greater Mae Klong
Project Boundary
KHAO YOI
BAN LAEN
PETCHABURI

LEGEND

- Project Boundary
- Existing Irrigation Canal (untouched)
- Improved Irrigation Canal (existing)
- Existing Drainage Canal (untouched)
- Improved Drainage Canal (existing)
- Proposed Drainage Canal (sub-lateral)
- Proposed Feeder Road (new and improved) (along irrigation & drainage canals)
- Ⓖ Proposed Drainage Regulator
- Type A On-farm Development
- Type B On-farm Development
- Type B&C On-farm Development
- Sugarcane Area Development

PROJECT MAP

THE KAMPHAENG SAEN
IRRIGATED AGRICULTURE DEVELOPMENT PROJECT

MAIN PROJECT FEATURES

Project Area:	Gross area	: 28,000 ha
	Irrigable area (present)	: 17,200 ha
	Irrigable area with project	: 16,380 ha
Irrigation:	Total canal capacity	: 20.9 m^3/sec.
	Total canal length	: 119,072 m (12 lateral & sub-lateral)
	Canal improved with project	: 47,774 m (6 lateral & sub-lateral)
	Irrigated area with project	: 14,870 ha for wet season paddy
		: 14,080 ha for dry season paddy
		: 1,200 ha for sugarcane
	Total	: 30,150 ha (Crop Intensity=184%)
Drainage:	Total canal length	: 201,457 m
	Improved with project	: 68,270 m
	Constructed with project	: 108,326 m
	Service road	: 176,596 m
On-farm:	Type A development	: 2,655 ha (2,560 ha)/a
	Type B development	: 11,675 ha (11,070 ha)/a
	Type C development	: 1,650 ha (1,550 ha)/a
	Sugarcane area development	: 1,220 ha (1,200 ha)/a
	Total	17,200 ha (16,380 ha)

/a --- area with project.

Project Costs:	Total excluded price increase	= B501.50 (B220.31)/b million
	Anticipated price increase	= B152.60 (B 59.59)/b million
	Total project cost	= B654.10 (B279.90)/b million

/b --- these amount represent foreign currency component.

Project Benefits: Incremental net value of production = B248.85

Project Evaluation:
- Economic internal rate of return 27%
- Farm rent recovery index 38%
- Project cost recovery index 19%

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CURRENCY, WEIGHTS AND MEASURES, ABBREVIATIONS AND GLOSSARIES

CURRENCY EQUIVALENTS, WEIGHTS AND MEASURES, ABBREVIATIONS AND GLOSSARIES

Currency Equivalents

Japanese Yen	¥ 1.00 = US$ 0.005	(=฿ 0.10)
US Dollar	US$ 1.00 = ฿ 20.00	(=¥200.00)
Thai Baht	฿ 1.00 = ¥10.00	(=US$0.05)

Weights and Measures

1.0 rai	=	0.16 hectare
1.0 hectare	=	6.25 rai

Abbreviations

MOAC	Ministry of Agriculture and Cooperatives
RID	Royal Irrigation Department
COCL	Central Office of Land Consolidation
ALRO	Agricultural Land Reform Office
DAE	Department of Agricultural Extension
BAAC	Bank for Agriculture and Agricultural Cooperatives
JICA	Japan International Cooperation Agency
HYV	High Yielding Varieties
EL	Elevation above mean sea level
O & M	Operation and Maintenance

Glossaries

Changwat	province
Amphoe	district
Tambon	sub-district
Muban	villages
Muang	capital of province

SUMMARY, CONCLUSION AND RECOMMENDATION

SUMMARY, CONCLUSION AND RECOMMENDATION

Introduction

1. The study of Kamphaeng Saen Agriculture Development Project, under the framework of the Master Plan Study for the Greater Mae Klong River Basin Development Project/JICA, was principally aimed at on-farm development. This report is based on the findings of the survey team which visited Thailand two times in January-July, 1979.

Background

2. The Thai economy in GNP has an average annual growth rate of about 7% since 1975. GNP per capita was estimated at about ฿8,400 (US$420) in 1977. Despite of its increase in GNP, unequal income distribution and under-employment still exist as major economic problems. In order to overcome these problems, the Government has taken new national development targets and strategies in the Fourth National Economic and Social Development Plan (1977-1981). The major targets and strategies, among others, are to increase agricultural production and farmers' income, and to provide employment opportunity by promotion of irrigated agriculture development project.

3. The Project Area, although main irrigation canals and facilities were completed under the Mae Klong Irrigation Project in 1972, has inadequate terminal facilities and is irrigated only in the limited areas of the originally planned irrigable area. Taking into account these ineffective conditions, first step-measure would be to make best use of the facilities provided. Thus, upgrading irrigation systems, improvement of drainage conditions and on-farm development are primarily desired. Such project, which is low cost and quick yielding, is urgently requested by the farmers as well as the government.

Project Area

4. The Project Area which lies north of Muang Nakhon Pathom, is about 50 km west of metropolitan Bangkok, and covers the east part of present Kamphaeng Saen sub-project area in the Greater Mae Klong Project, which is divided by the Malaiman highway. The area covers a gross area of about 28,000 ha and extends over five (5) Amphoes in Changwat Nakhon Pathom. The climate in the Project Area is tropical and monsoonal. The wet season period is from May to October and the dry season period is from November to April. The average annual rainfall is about 1,100 mm.

5. Topography in the Project Area is roughly classified into two; namely, hilly land on the west and plain land extending from the center to the east. The Project Area is situated on the eastern end of the typical fan-shaped land developed by a deposit of the Mae Klong in its lower basin. Soils are predominantly clayey, of high cation exchange capacity, high base saturation percentage and highly fertile, and suitable for diversified crops.

6. There are two highways connected to Bangkok in the north and south of the area. Several roads passing through the Project Area connect with the said two highways. It can be said that the area is conveniently situated for marketing. In the Project Area, the western part is rather dense in road network but the eastern part is sparse. The road density is around 17 m/ha including O & M road along the canals.

7. About 82% of the area or 22,830 ha is cultivable, of which 14,640 ha (52%) is cultivated for paddy, 4,680 ha (17%) for sugarcane, 1,490 ha (5%) for other crops and 680 ha (3%) for orchard. While the irrigable area with the project is about 17,200 ha which has been estimated based on the water available for the Project Area, consisting of about 14,640 ha for paddy field, 1,220 ha for sugarcane and 1,340 ha for fallow land. Out of the total paddy field, 7,080 ha or

48% is for the wet season paddy and 11,900 ha or 81% for the dry season paddy, while an area of 4,340 ha or 30% of paddy field is managed by double cropping of paddy. Crop intensity in the arable land including fallow land is currently about 120%. About 22% of arable land is possessed by landlord.

8. The present irrigation system in the Project Area could be grouped into three based on the course of water available passing across the Malaiman highway, the boundary of the Project Area. It was estimated that originally planned irrigable area was about 27,860 ha based on the design canal capacity of 20.9 m^3/sec. Nevertheless, potential area to be irrigated under the design water level of existing laterals is about 13,550 ha or 59% of total arable land. Furthermore, only 30% of paddy land can obtain water directly from the canals and ditches. About 4,300 ha of irrigable area obtain water from the Nakhon Chaisi due to insufficient water distribution of water head in the lateral/sub-laterals and insufficient provision of on-farm facilities.

9. The area could be subdivided into three drainage systems - Tha Sarn, Tha Rua and Nakhon Chaisi. The Tha Sarn river is used for the irrigation purpose. Several check structures in the river block its flow and divert the water into both sides of the river. The high water level in Nakhon Chaisi river occurs during the period from October to December (maximum in November). The flood which flows over the bank occurs once in several years' frequency. The Tha Rua drain the excess water to the Nakhon Chaisi but has drainage problems in its low land. The poor drainage is due not only to flood from the rivers but also due to the absence of checkgate operation, uncontrolled structures and narrow passage. Those floods usually continue and occur during the months of August to December.

10. Although the Project Area is provided with ditches under the Dikes and Ditches Project, these ditches have not been functioning well

and inefficient in water distribution due to low density of on-farm facilities, ineffective canal location and absence of maintenance. The existing farm ditches has a density of about 10.9 m/ha (2m/rai) and commanded area of about 117 ha varied from 20 ha to 250 ha for each turnout.

11. Total farm household 6,620 families accounts about 67% of the total household in the Project Area. On an average, a farm family consists of 6.6 members, of which 2 to 4 members per farm family are expected as farm labor force. The average farm size is 4.0 ha (25 rai). The size of farm plot is mostly 2-3 ha, which generally compose of several sub-plots, varying between an area of 0.06 ha and 1.6 ha. The farmer owns 2 or 3 farm plots for their farming. Rate of mechanization is about 80% for land preparation and about 5% for threshing but nil for transplanting and harvesting. Fertilizer application is low and area treated by chemicals is small. Average yield for transplanted wet and dry season paddy in the irrigated land is 2.6 tons/ha and 2.8 tons/ha, respectively. In rainfed field during the wet season, the average yield for broadcasting paddy is 1.6 ton/ha and 2.0 ton/ha for transplanting paddy. The west part of Project Area is mainly planted with sugarcane which has an average yield of 45 tons/ha. Vegetables and some other crops are cultivated on the elevated land through the year and on the land along the Nakhon Chaisi river during the dry season.

12. In and around the Project Area, there are five institutes and one agricultural college. These would contribute and play a critical role on agricultural extension and training to farmers. The present extension services mostly are rendered to the farmers' group by district extension officers. However, it is expected that the National Agricultural Extension Project, which covers the Kamphaeng Saen area, would improve the present conditions and widely extend its services to a large number of farmers. Farmers' groups are organized for the purpose of obtaining a loan. The membership rate for agricultural cooperatives is 15% at present.

The Project

13. The Project would undertake, (i) upgrading of irrigation and drainage systems, (ii) on-farm development, and (iii) strengthening O & M capability for field office.

14. In order to extend the irrigable area as wide as possible, improvement of existing canals and facilities would be required. However, increasing canal capacity should be second step of the project, when water is available to irrigate more land. This would be proposed in the master plan study. The project would then upgrade the function of existing system, to bring into full operation within the quantity of water available through the existing canals at Malaiman highway (20.9 m^3/sec in maximum), without widening the existing canal and heightening water level at Malaiman highway. Under this basic approach, the project would supply water to an area of 14,870 ha and 14,080 ha for paddy in the wet and dry seasons and 1,200 ha for sugarcane, respectively, with provision of heightening the water elevation at a turnout on the laterals as well as increasing the height of embankment and improvement and/or reconstruction of check structures.

15. The drainage problems in Tha Sarn drainage area would be solved after the completion of the irrigation system in the Stage II area (left bank side area). However, these expectation might not be realized immediately. Therefore, the project would provide with small flood protection dike as a feeder road along the river, outlet with gate connected to two or three creeks and channels to discharge below the existing check gates. The project would also provide with ditches to extend lateral of 8L-1R-1L-51 for irrigation/flood protection purposes and gates at each point crossing the drains or channels, to prevent the area from intrusion of flooded water coming from the Nakhon Chaisi. The Kamphaeng Saen drainage system would then be surrounded with existing laterals, farm ditches and feeder roads. Other areas, which are located along the three rivers and outside Kamphaeng Saen drainage system, would be provided with only farm ditches and drains, so flood problems will still remain in these areas.

16. For the purpose of increasing agricultural productivity, vast area for double cropping and reducing production costs, agricultural land improvement at on-farm level is vitally important. In the formulation of development, the project would give priority to (i) provision of adequate farm ditches, (ii) improvement of drainage conditions, (iii) provision of farm road, and (iv) rearrangement of farm plot. Therefore, the project would develop on-farm facilities with 3 types of level. In Type A, farm ditches would be provided in order to deliver directly the water to more than 70% of farmers in its service area, farm drain would be extended covering four farm plots at the terminal point and farm road would be located along the farm ditches, but no land levelling and rearrangement of farm plot would be provided. In Type B, the farm ditches, drains and roads would be connected with all farm plots but land levelling and rearrangement would be made locally. In Type C, the farm plot would be rearranged into standard size. These farm plots could obtain water from an inlet and drained into an outlet and would be shaped in rectangular and levelled the land.

Type A would be applied to an area of 2,655 ha where drainage problems will be left. Type B would be applied to about 11,675 ha. Type C for 1,650 ha would be applied to better land taking into account topography, drainage condition, farmers' willingness on the development plan and so forth. In the sugarcane area of about 1,220 ha, Type A development level would be adopted.

17. Upon completion of the project, the irrigable area would be about 16,380 ha, of which about 15,180 ha are for paddyland, and about 1,200 ha for sugarcane. The area irrigated during both the wet and dry seasons paddy would increase from 7,080 ha to 14,870 ha and from 11,900 to 14,080 ha, respectively. Annual cropping intensity would increase from 120% to about 169% in the entire Kamphaeng Saen area. Better water control, improved extension services and expanded credit facilities would encourage increased planting of high yielding rice varieties, heavier fertilizer applications and

greater use of crop protection chemicals. The use of machinery for land preparation and threshing would be further increased.

At full development, transplanting paddy yields are expected to be 4.2 tons/ha in the wet season and 4.6 tons/ha in the dry season, and sugarcane yield will be 80 tons/ha. The total annual paddy production from the Project Area at full project development in 1990 would be about 124,400 tons as compared to 47,200 tons at present. The production of sugarcane would increase from 210,600 tons at present to 303,600 tons at full development. More grain storage would be required at full development. For increased amount of rice, the private millers are expected to meet all project requirements.

18. The project was estimated at US$32.7 million (฿654.1 million) consisting of US$13,995,000 for foreign currency and US$18,710,000 (฿374.2 million) for local currency. The project cost per hectare excluding price increase was estimated at US$1,531.00 (฿30,620). Implementation of the project would be completed not less than 6 years including one year for preparation of construction.

Project Management and Coordination

19. The RID would be the Executing Agency for the project implementation. The project manager would be directly responsible for the project execution at the project site, with the assistance of Mae Klong Project Director. Each division related to the project would carry out its specific performance and assist the project manager. Design for irrigation and drainage works would be undertaken by the staff of the Mae Klong Project and design for on-farm facilities would be made in the project office. COLC would prepare the issue of Royal Decree on the implementation of Land Consolidation based on the Act. The Project Coordinating Committee should be organized for the smooth execution of the project.

20. RID would also undertake the operation and maintenance of the completed projects. Project engineer for O & M of Kamphaeng Saen area would be responsible for all aspects in water operation and

system maintenance. The O & M office would be reorganized with adequate number of staff and common irrigators for effective water distribution at field level.

Under the project, some construction equipment, vehicles and communication facilities and building for O & M would be provided. This provision would be made principally to cover the Project Area.

21. DAE would strengthen its organization and expand extension services by the National Agricultural Extension Project. Therefore, the complete services would be expected in the Project Area. Good coordination between RID and DAE should, however, be maintained through Agricultural Development Coordinating Committee in Bangkok and at field level.

22. Upon completion of the project, requirement of certified seed for HYV and fertilizer would be increased. It would then be necessary to produce and store more certified seeds of HYV and promote use of chemicals, rat control and application of fertilizer. In order to promote the use of appropriate seeds, effective fertilizers and timely application of chemicals for achieving full target yield, training and educating farmers of new techniques as well as displaying and selling these input materials at village level are of primary importance.

23. Farmers' group under the administrative assistance of DAE is a legal association with the right to undertake all business enterprise and its transactions. Aside from this association, RID has a program to organize farmers' group for the irrigation water management called "Irrigation Water Users' Association". This should be a core of the farmers' association for efficient use of irrigation water as well as promotion of new techniques in agricultural practices in cooperation with extension officer at village level.

Project Benefit and Evaluation

24. At the full project development, net incremental benefit for the project would amount to ฿248.85 million. The economic rate of return of the project over a 50-year evaluation period is about 27%. The rate of return is only moderately sensitive in reduction or delay of benefits. However, even under adverse conditions, the rate of return would not fall below 22%. Farm rent and project cost recovery indices are 38% and 19%, respectively.

Conclusion and Recommendation

25. The Project is economically feasible and financially justifiable, taking into account low cost per hectare, incremental project benefits, increase in farm labor employment opportunities, and in farm income, and furthermore favorable results of rate of return and sensitivity test.

26. It is expected that this type of development project, which is low cost and quick-yielding, and its effect will reach large number of small farmers, should be extended to all over the Mae Klong Irrigation Project Stage I area together with the improvement of existing canals and facilities to use water effectively.

27. Under the project, the area to be irrigated through three existing laterals was estimated based on the design discharge of 20.9 m^3/sec in total. This quantity of water should be ensured and strictly controlled at the crossing point of Malaiman highway with provision of measurement devices by the government.

28. Further study for water operation and flood control project on Chao Phya river basin including Nakhon Chaisi river is principally important, in order to solve drainage problems in the area along the Nakhon Chaisi river untouched by the project and to get more irrigation effects in the project area.

29. Under the project, an area of about 4,000 ha along the Nakhon Chaisi, where rats are damaging the crops in the wet season, was proposed to plant double cropping paddy. Thus, it is recommended that rat control program should be actively carried out in this area prior to the completion of the project.

CHAPTER I. INTRODUCTION

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In response to the request of the Government of the Kingdom of Thailand (Thai Government), the Government of Japan has conducted the feasibility study on Kamphaeng Saen Irrigated Agriculture Development Project under the framework of the Master Plan Study for the Greater Mae Klong River Basin Development Project through the Japan International Cooperation Agency (JICA), which is the official agency responsible to execute the Japanese Government's technical cooperation programme for the overseas projects.

In accordance with the scope of works for the study of the project agreed by both Governments, the study was carried out by the survey team through JICA with the purpose of formulating the irrigated agriculture development project and verify the feasibility of the project covering a gross area of about 28,000 hectares which is located at the northeast of Nakhon Pathom in the Mae Klong Irrigation Project Area. The survey works consist of field works and home works. Field works consist of collecting and evaluating data and information, carrying out the field survey in the Project area and to hold discussions and exchange of views on the matters related with the project formulation, while home works consist of formulating the project and preparation of the feasibility study report in the home office (Japan).

This Report is based on the findings of the study team and supervisory group asssigned to the project (Table 1-1 refers) during the period from January 22 to March 18 and from June 18 to July 21, 1979, with the assistance and cooperation of the personnel concerned to the Study (Table 1-2 refers). This report also incorporates all the provisions which were discussed in the meeting between the Thai authority and the Team members.

Table 1-1. Supervisory Committee and Study Team Members Assigned to the Study

Supervisory Committee Members

	Name	Position
1.	Mr. Humiya SEKO (Chairman)	Chief Technical Advisor Agricultural Structure Improvement Bureau (ASIB) Ministry of Agriculture, Forestry & Fishery (MAFF)
2.	Mr. Kazuya NAKAMURA (Member)	Deputy Director, Project Planning Division, Planning Dept., ASIB, MAFF
3.	Mr. Masaki SHIMIZU (Member)	Deputy Director, Project Planning Division, Construction Dept., ASIB, MAFF
4.	Mr. Tadashi SAKAMOTO (Member)	Deputy Director, Design Division, Construction Dept., ASIB, MAFF
5.	Mr. Toshio YAMAMOTO (Member)	Deputy Director, Resources Division, Planning Dept., ASIB, MAFF
6.	Mr. Takashi TAUCHI (Member)	Deputy Director, Water Use Division, Construction Dept., ASIB, MAFF
7.	Mr. Masahiro SASAKI (Member)	Deputy Director, Area Planning Division, Planning Department, ASIB, MAFF
8.	Mr. Kuniyasu KADOWAKI (Member)	Deputy Manager, 2nd Technical Appraisal Division, Economic Research and Technical Appraisal Department, Overseas Economic Cooperation Fund

Study Team Member

Name (Position)	Period
Mr. Osamu ISHIYAMA (Team Leader)	Jan. 22 - Mar. 17, 1979 Jun. 6 - Aug. 31, 1979
Mr. Kunio OHTA (Irrigation)	Jan. 22 - Mar. 17, 1979 Jun. 25 - Aug. 4, 1979
Mr. Kosaku CHICHIBU (Drainage)	Jan. 22 - Mar. 10, 1979 Jun. 25 - Aug. 31, 1979
Mr. Yoichiro KURODA (Hydrological Analysis)	Jun. 6 - Aug. 8, 1979
Mr. Hideo HIRATSUKA (Land Consolidation)	Jan. 22 - Mar. 10, 1979 Jun. 6 - Aug. 31, 1979
Mr. Mamoru FUJITA (Design & Estimation)	Jun. 6 - Aug. 31, 1979
Mr. Tatsuo HAMAJIMA (Cultural Plan)	Feb. 5 - Mar. 17, 1979 Jun. 6 - Aug. 4, 1979
Mr. Tetsuo DOKIYA (Agri-Extension & Farmers' Organization)	Jan. 22 - Mar. 17, 1979 Jun. 6 - Aug. 4, 1979
Mr. Hiroki NAKAMURA (Agro-Economy)	Feb. 5 - Mar. 17, 1979 Jun. 25 - Aug. 31, 1979
Mr. Norio KOIWA (Soil)	Jan. 22 - Mar. 17, 1979 Jun. 6 - Aug. 4, 1979

Table 1-2. Personnel Contacted During the Survey

Name	Position
Mr. Charin Atthayodhin	Deputy Director General, RID
Mr. Paitoon Palayasoot	Secretary General, COLC
Mr. Damrong Jaraswathana	Director, Hydrology Div., RID
Mr. Chari Tulyanond	Project Manager, Mae Klong Irrigation Improvement Project
Mr. Chaleimthep Ratanaprayook	Office of the Deputy Director General for O & M
Miss Supha Sing-Intra	Chief, Economic Branch, Planning Div., RID
Mr. Sa-ngad On-num	Economic Branch, Planning Div., RID
Mr. Osot Chanvej	Agronomist, O & M Div., RID
Mr. Boonlu Poolsanock	Land Consolidation and Ditch and Dike Branch, O & M Div., RID
Mr. Danai Triyadhen	Chief, Land Classification Branch, Soil & Geology Div., RID
Mr. Paisal Teanglum	Region X, RID
Mr. Chamras Chindasanguan	Region X, RID
Mr. Sompote Sukhumpanich	Region X, RID
Mr. Wichai Sriwarapongse	Office Engineer, Construction Div., Mae Klong Irrigation Project) (MKIP)
Mr. Praseot Milintangul	Hydrologist, Hydrology Div., RID
Mr. Nit Dhanunajavn	Survey Division, RID
Mr. Precha Jotisangasa	Survey Division, RID
Mr. Vilas Promchotchai	O & M Division, RID
Mr. Prasarn Leelasorn	Chief of Soil & Geology Division, RID
Mr. Udom Rakchanya	O & M Division, RID
Mr. Boonthai Otagaventa	Design Division, RID
Mr. Soonthon Monthapun	Project Engineer, Kamphaeng Saen Sub-project

CHAPTER II. BACKGROUND

CHAPTER II. BACKGROUND

2.1. General

Thailand covers some 514,000 km^2 of land being situated in the central part of the Indo-China peninsular. The population is around 43 millions (1976) with a growth rate declining from 3.0% in 1970 to about 2.8% since 1973 annually. The Thai economy in GNP, which had an average annual growth rate of about 6% between 1972 and 1975, grew by about 7% since 1975. GNP per capita was estimated at about ฿8,400 (US$420) in 1977. Nevertheless, unequal income distribution and under-employment still remain as major economic problems.

In order to solve these problems, the country has taken up a new development targets and strategies in the Fourth Five-Year Plan formulation (1977-1981). The national objectives for the Fourth Five-Year Plan are to accelerate economic recovery, reduce income disparities, reduce population rate, improve manpower quality, increase the level of employment, improve the management of basic resources, rehabilitate environmental conditions, and strengthen national security management.

2.2. Agricultural Sector

Out of total land area of some 51.4 million ha, more than half is forest and about 36% or some 18.6 million ha was used for agricultural purpose in 1975/76. Some 11.7 million ha or about 63% of the land for agricultural purpose are cultivated for paddy. This paddy land area, however, planted rice in only 76% of the land due to deep water remained in the field, shortage of irrigation water and little provision of water distribution system. As the amount of irrigated area is limited, most of the cultivated area can be used only during the rainy season.

Agriculture accounts for about 27% of net domestic products, about 78% of total employment and about 60% of export earnings in 1977. The production of rice was estimated at about 14.2 million tons annually

on average for last five years (1973-1977), of which exported rice was marked as the annual average value of about 1.5 million tons, although it was unstable every year.

The crop production grew at a growth rate of about 13.3% against the rate of Gross Domestic Product of 30% in the last five years (1973-1977). This may indicate a widening of the income disparity between rural and urban areas. About 80% of the country population lives in rural area and their economic livelihood relies on agriculture. Therefore, in order to support the government effort to "raise the income and living standard of the rural peoples in various regions", increase of agricultural production through yield improvement and increased cropping intensity where water is available is indispensable due to little possibility to expand agricultural land.

2.3. Irrigated Agriculture Development

The irrigation in Thailand has much developed to the vast land as a supplementary irrigation for wet season rice in order to increase rice production as well as stabilized export earning from the rice, since Royal Irrigation Department was established in 1904. Afterward, many irrigation projects were implemented to control the water in wet season and to provide an irrigation water to the dry season crops through construction of reservoir dam with hydropower generation and flood control purposes, and provision of diversion structures and distribution canals.

At present, about three-fourths of total cultivated land area is dependent on rainfall for water supplies. Irrigated areas total 3.2 million ha, or about 17.2 percent of total farm areas. However, it has been estimated that only about 1.6 million ha is effectively irrigated. This figure actually refers to wet season irrigation. Dry season irrigation only covers an area of 0.77 million ha, of which only 0.32 million ha or about 2 percent of total farm area has water

control adequate for double cropping. The Central region has the highest share of irrigable area, accounting for approximately 1.87 million ha as compared with 0.38 million ha in the Northeast. By the end of 1976, on-farm facilities were completed in the area of about 1.22 million ha or 38% of irrigable area.

Although provision has been made of on-farm facilities effectively to distribute water to farms under the Dikes and Ditches Act (1962), those efforts were rewarded with success to some extent. Many lands, which have been already provided with main and lateral canals, are still left without enough irrigation water at the on-farm level.

Under such circumstances, the Government has formulated the plan of on-farm development, particularly the land consolidation program (so-called Irrigated Agriculture Development), and took necessary legal and institutional measures in enactment of Land Consolidation Act (1974) and Agricultural Land Reform Act (1975) for smooth execution of the development program. The Government carried out the administrative reorganization that has transferred the Royal Irrigation Department which belonged to the Ministry of Interior into the Ministry of Agriculture and Cooperatives, and newly established the Central Office of Land Consolidation, in-charge of planning and execution of land consolidation projects, and the Agricultural Land Reform Office for promotion of the land reform.

The Japanese Government has dispatched the Japanese experts to give necessary technical advice for planning and implementation of Irrigated Agricultural Development plan in the Lower Greater Chao Phya Basin and the Greater Mae Klong Basin. The Japanese Government has been implementing the Chao Phya Pilot Project, the Mae Klong Pilot Project and the experiment/training program in the Suphan Buri Rice Experiment Station and Training Center as its cores under the Japanese Government's technical cooperation programme since 1977.

These actions are expecting to play a role of accelerating on-farm development program, expanding irrigated agricultural land, upgrading agricultural productivity and increasing farm income not only in the said two basins but throughout the country.

2-4. The Greater Mae Klong River Basin Development Project

The Greater Mae Klong River Basin Development Project is aiming at providing water to irrigable land, covering an irrigable area of some 466,000 ha located in the west of Thailnad, flood control and hydropower generation through construction of a few reservoir dams and diversion and distribution facilities. The area was divided into three according to the development stages. The Greater Mae Klong Irrigation Project Stage I, assisted by World Bank, was commenced in 1964 and completed in 1972, which have provided with the Vajiralong Korn Diversion Dam, intakes on both sides of the river, flood protection dike feeder roads and irrigation and drainage canals in the left bank side of the Mae Klong covering an irrigable area of some 191,000 ha. However, some of the additional works are still under construction. The Kamphaeng Saen area is located in the said project area. The area has been provided with irrigation and drainage system by the project as aforementioned but with insufficient provision of on-farm facilities.

While implementing main facilities for the irrigated agriculture in the Mae Klong area, RID has further studied to clarify the multi-purpose development in the Greater Mae Klong River Basin, including development of Stage II and Stage III areas. The Japanese Government has also dispatched the study team for formulating master plan for the Greater Mae Klong River Basin Development Project under the framework of technical cooperation program for the Irrigated Agriculture Development since 1977. This study will be completed in March 1980.

During the course of the master plan study, the entire area was grouped into proper size for project execution in making implementation schedule of on-farm development, which covered an area of about 50,000 ha. Besides this study, in the light of concrete water operation plan of Sri Nagarind Dam which would start in 1981 and effective use of this water, the Thai government requested to carry out the on-farm development project in the Mae Klong Basin in the early stage. Under these circumstances, the Japanese government has decided to take up the Kamhaeng Saen Project as first priority in the Mae Klong area for feasibility study taking into account the completed main irrigation system, land planted paddy as the main crops, land mostly irrigated by pump and/or gravity system, the majority of farmers who are willing to improve their on-farm facilities, fertile land and available topographical map, etc.

2-5. Project Formulation

Development of new and improved irrigation facilities would play a major role in overcoming the aforementioned problems and stabilizing the agricultural production, specially in rice. Consequently, it would raise farm income and solve disparity of living standard between the rural and urban areas.

However, some of the areas still remained suffering from inadequate quantity of irrigation water for farm land, even though a main irrigation canal and facilities were already provided. In the project area, only about 30% of cultivable land could obtain water directly from farm ditches. This means that abundant water is used ineffectively due to insufficient provision of terminal facilities. For using those waters efficiently for the irrigation purpose, adequate provision of on-farm facilities is primarily important.

On-farm development may be defined, from an engineering point of view, as the provision of farm ditches, drains and roads in the service area of existing turn-out on a lateral canal. Legal model of

"extensive" scheme exists under the Dikes and Ditches Act (1962). This Act requires farmers to construct bounds around their paddy fields for transplanted rice cultivation and to dig ditches to irrigate and drain blocks of 8 ha. If the farmers fail to do so, RID is empowered to construct the works at the expense of the owners. This Act has been used to permit the construction of tertiary ditches and the irrigated areas in Thailand. However, the repayment provisions have never been enforced. The Act does not provide for the construction of farm roads. "Intensive" model has been undertaken in further development of on-farm facilities, under the "Land Consolidation for Agriculture Act" issued in 1974. In this Act, "land consolidation" means conducting of land development activities on every single plot of cultivated land so as to increase productivity and to reduce cost of production by way of consolidating a number of fragmented pieces of land in the same areas and rearranging land shapes and boundaries; constructing irrigation and drainage systems and farm roads; undertaking activities of land levelling, soil improvement planning on production and marketing of agricultural products including exchanging, transferring and accepting transfer of right in land; giving land for hire-purchase and others relating to land consolidation and alignment of land boundaries for habitation. Under the Act, the Government established a Central Land Consolidation Committee, Provincial Land Consolidation Committees and a Central Office of Land Consolidation under the Ministry of Agriculture and Cooperatives. Intensive on-farm development (by Land Consolidation Act) is compulsory if more than half of the affected land owners approve it. The Government has the power to acquire the land of any farmer who is unwilling to participate in the scheme. Compensation is paid for land taken for ditches, drains and roads only in cases where more than 7% of the area of the farm is taken. The Act gives the Central Committee power to determine the principles and procedures of cost recovery from project beneficiaries, with the specification that the cost of common facilities shall be repaid in annual installments of not less than 10% of the capital cost and full levelling works' expenditures, beginning the third year after completion of the work,

with a government subsidy of not less than 10% of the cost. The farmers are responsible for payment of operation and maintenance cost of all common on-farm facilities.

In planning and designing on-farm facilities, a great deal of study and discussion have been made in what is applicable to the project under the land consolidation programme. However, the development of on-farm facilities could not clearly distinguish "intensive" or "extensive" model. The images of land consolidation may be varied in each farmer and in each region, wherever the land is currently irrigated with enough water or not. Immediate target for the project should be set in the lower cost and quick yielding so as to step up present farm income to advanced one. The stage development is one of recommendable ways to conduct the comprehensive improvement of land to the farmers and to achieve full target of on-farm development in the future. In fact, farmers in the project area strongly require the improve of present conditions in on-farm facilities, farm ditches, drains and roads. Most of them claim the shortage of water and excess water in the farm plot, even though main irrigation and drainage systems are completed. Lack of farm road as well as O & M road for farm ditches are a major problem for the farmer. However, their immediate needs are to receive adequate water at the necessary time and drain an excess water rapidly from the farm plot and provide to farm road for hauling their product. Only some farmers would improve their land in levelling and filling up their farm plots by their own fund, when water is available. These farmers' needs on on-farm facilities must be incorporated in the plan and and design, specially for charging the construction cost of on-farm facilities to the farmers in the project and to collect this cost in high rate.

Increasing in the existing canal capacity for possible expansion of the area to be irrigated may be taken as second step of the project when water is available under the master plan of Greater Mae Klong River Basin Development Project.

This would be clarified in the master plan study. Under this approach upgrading the function of existing system to bring into full operation within the quantity of water available to obtain through the existing canals at Malaiman highway (20.9 m^3/sec in maximum), without widening the existing canal and heightening water level at Malaiman highway would be worked out. However, some of laterals in the downstream, some of sub-laterals and all of farm ditches are required to provide enough capacity for full development stage in future.

Upgrading the existing drainage canals with enough capacity and improve the drainage system and protect the currently inundated farm land against the flood from Tha Sarn and Nakhon Chaisi rivers through provision of feeder road, farm ditches and farm road together with installation of sluice gates for the purpose of flood protection are primarily required.

For the purpose of increasing agricultural productivity, vast area for double cropping and reducing production costs, agricultural land improvement at on-farm level is vitally important. The design criteria for on-farm development works have not been so far clearly stipulated. However, the plan and design of on-farm facilities should be made from teh technical, economical, social and political viewpoints. When farm land of more than 70% of the projected area can directly obtain irrigation water from ditches, the on-farm development project is applied to Land Consolidation Act. Allowing for these conditions, a few types of development strategy at on-farm level would be worked out. These should, however, be economically feasible.

For the purpose of strengthening of O & M capability for the project office, some construction equipment, vehicles and communication facilities and building for O & M are required under the Project. These provisions would be made principally to cover the project area.

CHAPTER III. THE PROJECT AREA

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3.1. General

(1) Location

The Kamphaeng Saen project area is located about 50 km west from metropolitan Bangkok and lies between latitude 13°50' - 14°N., and longitude 100° - 100°15' E., having a gross area of 28,000 ha. The area is nearly in the shape of rectangle, and is bounded on the west by the Malaiman highway and on the east by the Nakhon Chaisi river.

The Kamphaeng Saen area, which covers the northeastern part of the 1st stage area in the Greater Mae Klong Irrigation Project, administratively belongs to Changwat Nakhon Pathom, comprising 5 Amphoes, Kamphaeng Saen, Nakhon Pathom, Don Tum, Bang Len and Nakhon Chaisi.

(2) Climate

The project area is located at the western end of the tropical savanna climate zone in Thailand. The climate can be divided into two climate seasons, dry season and wet season. The climate with two seasons is characterized by the two major wind systems of south-west monsoon and the northeast monsoon. The wet season is for a period from May to October and the dry season from November to April. From May to September, the southeast monsoon prevails and rain is abundant. The mean annual rainfall in the area is around 1,100 mm, with the range of annual rainfall between 650 mm and 1,360 mm. Mean annual temperature is about 27°C. The hottest season extends from April to May, recorded about 29°C in mean monthly temperature (See Table 3-1).

(3) Topography and Soil

As far as topography is concerned, the project area can be classified into two: fan deposits and alluvial plains. The western part of the area belongs to the fan deposits of the Mae Klong river which extends from Kanchanaburi to downward to east. The land slope

is gentle, being 1:5,000, and the ground elevation ranges from EL 5 m to 8 m.

The topography of eastern part is flat and low-lying alluvial plain. There is some depression and swamps studded in the lowest land. The ground elevation ranges from EL 1 m to 4 m.

Approximately 63 percent of the Project Area is covered with hydromorphic alluvial soils and the remaining 37 percent is covered with non-calcic brown soils. Approximately 54 percent of the hydromorphic alluvial soils belongs to the marine alluvial soils.

Most of the soils are clayey except for non-calcic brown soils distributed in the natural levees, and the soils with relatively high clay contents are widely distributed in the Project Area.

The soils with acidity ranging from weak to strong are found at many points, while the soils with neutral to alkaline reaction are widely spread in the Area.

The soils in the Project Area have moderately high natural fertility with higher cation exchange capacity and base saturation percentage. The test pit surveys of the representative soils, however, reveal that the soils are generally medium to slightly low in cation exchange capacity, and the natural fertility is evaluated by moderate to moderately low. In general, the effective surface soil layers are thick so that top soil treatment in land consolidation with land levelling is required in civil works.

In the Project Area, about 4,000 ha of acidic sulfate soils are distributed. However, these soils also suffer from phosphate deficiency. The field experiments have proven that an increasing application of phosphate fertilizers can successfully accomplish the paddy production increase. Consequently, the phosphate fertilizers application will be essential to the paddy field, while neutralization by liming is necessary for upland fields.

One of the important problems for execution of the development plan is improvement of poor drainage soil caused by topography and soil properties and improvement of poor drainage conditions in the paddy fields. The low-lying lands along the Nakhon Chaisi River and other major rivers are chronically inundated in the wet season, used only for the single cropping of the dry season paddy. The paddy land extending from Tha Sarn river (northern boundary of the Project Area) to the south of Don Toom, has a poor drainage or slightly poor drainage condition. Furthermore, many poor drainage lands are found sporadically in the whole Project Area, and the land along borrow pits are kept as swampy area. These poor drainage lands have difficulty in natural drainage due to unfavorable topographical conditions, and its soils are left saturated for a long time in a year.

The single cropping of the dry season paddy is a major cropping pattern in this paddy field. As a result of exposing the soils in the paddy field to dry condition during several months after wet season, big cracks exist in the single cropped land at the land preparation season. Such yearly swelling and shrinking of the soils will affect favorably the development of soil structure and increasing permeability of soil.

The Project Area is composed mainly of clay soils with high water holding capacity. The soils of low-lying lands having excess water, which is located along the road from Don Toom to Ban Suan Thura in the southern boundary, and swampy area adjacent to borrow pit and depression area scattered throughout the project area are strongly gley soil rich in undecomposed organic matters. These soils are formed under the strongly reductive condition in the waterlogged paddy field. Therefore, sound rice production can hardly be achieved on the strongly gley soil owing to its strongly reductive condition.

(4) Transportation

Through the Malaiman highway (Route No. 321) which is the eastern boundary of the area, the project area connects indirectly with two national highways to terminate in Bangkok. Besides the highway, there are district roads totalling some 330 km in length. Most of district roads are provided with laterite surfacing. Most of irrigation canals have been equipped with operation and maintenance roads along the one side of the constructed embankments, which has been used by the people for transportation purposes as well. The western part of the area has a rather dense network, while in the eastern part the road is scarce due to current flood. The average density of roads in the area is around 17 m/ha including the operation and maintenance roads.

3.2. Present Land Utilization

(1) Land Classification

As the result of land classification made for the project area, lands unsuitable for the production of crops (including residential lot, roads and canals, etc.) were figured out at 5,080 ha (18.1%). Lands suitable for crop production is 22,920 ha (81.9%) with the following details:

Group	U_1	2,730 ha	
	U_2	120 ha	
	U_3	110 ha	
	Sub-total		2,960 ha
Group	R_1	13,760 ha	
	R_2	4,120 ha	
	Sub-total		17,880 ha
Group	U_2/R_2		2,080 ha
	Total		22,920 ha

According to the existing data available for present land use, the paddy lands are 14,640 ha, occupying 63.9 percent of the total arable lands (22,920 ha) and the sugarcane lands are 4,680 ha, occupying 20.4 percent. The present paddy fields of 14,640 ha account for 81.9 percent of the lands suitable for paddy lands of 17,880 ha, while the existing sugarcane fields are 1.6 time as large as the lands suitable for upland fields of 2,960 ha. Consequently, the above figures might suggest that most of the U_2/R_2 group lands and some unirrigable lands of the suitable lands for paddy fields might be converted to the sugarcane fields, and furthermore, some of the suitable lands for paddy fields might be used as the sugarcane fields or remained fallowed.

(2) Land Use

The topographical feature of the project area, in general, is gently slopes from the land along the Malaiman highway to the Nakhon Chaisi river. Roads and villages are located on the relatively elevated land. The villages, consisting of 20 to 560 houses, are situated along the roads and rivers. There is no urban area in the project area.

The farm land is cultivated with comparatively high crop intensity at present. The land along the Malaiman highway is predominantly planted sugarcane and rice land is gradually developed in the land going toward the downstream. The upstream area is predominantly planted with transplanting and/or broadcasting wet season rice and the downstream area with transplanting dry season rice. Double cropping of rice is practised in the land with adequate water supply system and occupies about 30% of paddy land.

Vegetables are planted by making high ridge in the farm land. These areas are distributed mostly among the land along the Nakhon Chaisi river and partially along the irrigation and drainage canals, where water is available even during the dry season. Coconut and other fruit trees are planted on the land nearby homesteads scatteringly but not so large. Fallow lands and swamps are mostly

distributed on the lowest land. The homestead land has an average of 1.0 rai more or less per household.

The present land use in the Project Area is as follows:

	Area (ha)	(%)	
Paddy Field	14,640	(52.3)	(64.1)
Sugarcane	4,680	(16.7)	(20.5)
Vegetable, Orchard & Others	2,170	(7.7)	(9.5)
Fallow Land	1,340	(4.8)	(5.9)
Sub-total	22,830	(81.5)	(100.0)
Non-arable Land	5,170	(18.5)	
TOTAL	28,000	(100.0)	

Cultivated land in the Project Area occupies about 21,490 ha land which is accounted for some 77% of the gross Project Area. Paddy fields, in general, are situated in flat lowland area and such depressed areas in between hilly lands. Wet season rice is cultivated for about 7,080 ha or 48% of land classified as paddy field and dry season rice is for about 11,900 ha (81%), respectively.

About 1,340 ha of arable land, which is accounted for about 5% of the gross area, is identified as fallow lands due mainly to the prevailing poor drainage condition. The said fallow lands could be fully developed through implementing possible drainage improvement under the project.

The present cropping intensity is 120%, which is estimated based on the cropped area of about 27,320 ha included area planted wet and dry season paddy, sugarcane, vegetables and others and cultivable area of about 22,830 ha.

(3) Land Tenure and Size

In 1975, Thai Government issued "Agricultural Land Reform Act (B.E. 2518) aimed at better allocation of land resources and redeeming land for farmer. In this Act, the government would purchase or expropriate the land for agriculture, which is state-owned land or private land which is not cultivated by land owner himself and/or owned in excess of his right in accordance with this Act; and allocate these land to purchase, rent or cultivate by farmers who do not own land or own very little land, and farmers' group. This means an improvement of landholding size in connection with title and other certificates in land for agriculture. The excess land of the right in this Act means the land exceeding 50 rais (8 ha) of land owned by farmer who operate his land by himself and 20 rais (3.2 ha) owned by landlord who does not operate by himself.

In the Five-Year Plan (1977-1981), the government intends to redeem land for farmers on a nationwide basis. During the first stage, the redemption of land will be carried out in areas where

land deeds or land title-certificates are already available. The Land Department will have to carry out surveys within the shortest possible time to determine the number of landholdings that should be redeemed. As for areas where land title-certificates are to be issued, the Land Department will carry out a survey on land ownership make cadastre concurrently with the issuance of land title-certificates to facilitate subsequent formulation of a land redemption plan. While in the Project Area, Land Department has carried out cadastral mapping survey and land registration services since 1978.

According to DLD surveyed data (1975/76), about 22% of farm land in the Project Area is owned by landlord, of which some 77% live in Nakhon Pathom Province. The land owned by farm operators and partial tenants are about 74% and 4% of arable land in the Project Area, respectively. Ninety-six percent of land owners have title-deeds in land, and only four percent has "Certificate of use" and "Other land certificates". Land ownership and tenure in the Project Area are as follows:

	No. of Household	Land Ownership		Land Tenure	
		Area (ha)	%	Owned (ha)	Rented (ha)
Landlord	(867)	5,090	22	-	
Owner/Operator	4,448	16,734	74	16,734	
Partial tenants	341	1,006	4	1,006	1,363
Tenants	886	-	-		3,727
Total	5,656	22,830	100	17,740	5,090
	(5,675)/1	(100%)		(78%)	(22%)

/1 --- No. of farmers operating in their own land and/or rented land.

The average size of farm land by owner is about 5.9 ha (36.7 rai) in the Project Area, while land owner who possesses farm land of less than 8.0 ha (50 rai) shares about 92% in numbers and 71% in area. Whereas, the average size of farm land by owners operated and partial

tenants are about 3.8 ha (23.5 rai) and 3.0 (18.4 rai), respectively. Most of them possess the land of less than 8.0 ha. These average values show less area than the ones operated by themselves.

The land ownership distribution in the area in 1979 is estimated as follows:

Land Size (ha)	No. of Landowner (No.)	(%)	Area of Landowner (ha)	(%)
Less than 8.0	5,177	91.5	16,111	70.6
8.0 - 16.0	387	6.8	4,554	19.9
16.0 - 24.0	73	1.3	1,370	6.0
24.0 - 32.0	9	0.2	260	1.1
More than 32.0	10	0.2	535	2.4
Total	5,656	100.0	22,830	100.0

In general, the average size of farm land owned by farmers tends to decrease, while the number of landless farmers tends to increase.

3.3. Present Irrigation and Drainage

(1) Irrigation System

The Kamphaeng Saen area is supplied with irrigation water through the 12 canals branched off from the left main canal constructed under the Greater Mae Klong Irrigation Project. The area has been subdivided into three sub-irrigation systems; 2L-5L, 1R-1L-5L and 2R-1R-1L-5L. Actual area currently irrigated directly from the canals and farm ditches is assumed to be about 30% of paddy field; while total designed irrigable area has been estimated at about 27,860 ha by the RID data applied in the design stages, which were 0.75 l/s/ha of unit irrigation requirement and 20.9 m^3/s of total design water capacities available to three sub-irrigation systems in the Project Area.

The canals for irrigation use consist of two systems, the major irrigation canal system constructed under the Greater Mae Klong Irrigation Project and the farm ditch system under the "Ditches and Dikes" program. The farm ditch branches off at the farm turnout installed on the irrigation canal in order to distribute irrigation water to farm land. The total length of 12 irrigation canals and farm ditches are approximately 119 km and 304 km, respectively. The density of farm ditches, as an index of water distribution efficiency at farm level, is estimated to be 10.9 m/ha on an average. In the Project Area, 239 farm turnouts have been constructed, and average commandable area and length of farm ditch per farm turnout are 117 ha and 1,270 m, respectively.

Sub-system	Designed Area (ha)	Length of Canals (m)	Farm Ditches		No. of Turnout	Per Turnout	
			Length (m)	Density (m/ha)		Commanded Area	Farm Ditch Length
2L-5L	9,820	36,550	104,400	10.6	70	140	1,490
1R-1L-5L	12,500	46,912	128,400	10.3	104	120	1,230
2R-1R-1L-5L	5,540	35,610	71,300	12.9	65	85	1,100
Total or Average	27,860	119,072	304,100	10.9	239	117	1,270

Of the total canal length of 119,072 m, 96,730 m of canals, except 8L-1R-1L-5L and parts of 2L-5L and 1R-1L-5L, are lined with concrete, corresponding to 81% of the total length. The thickness of lining varies between 5 to 10 cm depending on the canal discharge capacity. In general, the canal lining is in good condition. The slope of canal bed is mostly designed at 1:10,000 but 1:5,000 for 5L-1R-1L-5L. The number of check facilities is 40 with average spacing of 3.0 km, including tail regulators. Most of road crossing

structures are of roadway culvert consisting of single or double barrels of reinforced concrete pipes, totalling at 24 culverts. A loss of water head at the roadway culvert varies from 0.1 m to 0.3 m with the size and discharge capacity.

As FSL (design water level in canal at full water supply period) of canals are designed as steady uniform flow based on peak water requirements, water levels in the canals shall be controlled by operating check facilities when the discharges is less than the designed one. Installation of additional check facilities would be needed at suitable locations in order to extend commandable area both at full and partial supply.

The irrigation systems in the Kamphaeng Saen area was contructed with the purpose of supplying irrigation water for the area of 27,860 ha. However, many farm plots are not irrigated with the existing systems as originally designed. There are uncommandable farm plots which are located higher than the elevation of FSL or have lake of on-farm facilities, like farm ditches. In the latter case, the situation would be improved by provision of adequate on-farm facilities.

While in the farm plots which ground elevation is higher than the FSL, only farm plots situated along an irrigation canal/farm ditch can receive water by pumping up.

Based on the detailed topo-map (1:4,000 with 0.25 m contour interval) and canal profiles as prepared by RID, commandable area as served by the existing gravity system has been estimated. Criteria for this estimation are (i) 0.10 m of diversion water headloss at farm turn-out, (ii) 0.25 m/km of conveyance loss head in farm ditches, and (iii) 0.10 m of distribution loss head at the

terminal point of farm ditches. The commandable area was estimated to be about 17,970 ha in gross area, of which an arable land accounted for about 13,440 ha or 59% of total arable land and 48% of original irrigable area in the design stage. This commandable area means that it would be irrigated by the provision of on-farm facilities without any improvement of existing laterals and sub-laterals.

As stated above, the existing canal capacities are designed for supplementary irrigation for wet season rice and could irrigate dry season rice field to limited areas. The Sri Nagarind dam is under construction on the Quae Yai, which is expected to supply storage water for large-scale dry season irrigation starting from 1981.

(2) Drainage System

Drainage System

The Kamphaeng Saen area can be subdivided into three drainage systems for the discussion of present drainage conditions; namely, Tha Sarn, Tha Rua and Nakhon Chaisi, as follows:

Tha Sarn drainage system - The Tha Sarn river, which run along the north boundary of the area to the east, was ordinarily one of the natural channel which branches off the Mae Klong river and meets the Nakhon Chaisi river. The river has been used for dual-purpose of irrigation and drainage in its basin including a part of Project Area before the completion of Mae Klong irrigation project-Stage I. Afterwards, the river has been reconstructed as a main drainage canal by the RID.

However, the area lying on the left bank side of the river which is the Stage II-area of said project, has no irrigation canal and facilities to obtain water from the Mae Klong river and puts dependence upon this river as an irrigation water source. Therefore, four control structures in the river are sill in use for checking up the water level and cause a poor drainage condition in the area. The total length of the river is about 65.7 km, of which about 27.6 km is for an area of about 7,100 ha in the Project Area along the river. The discharge capacity of the river is 53.96 m^3/s, consisting of diversion water (51.92 m^3/s), as a part of the Mae Klong river floods, and drainage water (2.04 $m^3/$) from its basin.

Tha Rua Drainage System - The system is subdivided into two sub-drainage systems: Kamphaeng Saen and Tha Rua sub-systems. The Tha Rua river, which has a function of spillway for the flood of Mae Klong river in case of emergency, passes along the south boundary of the project and meets Nakhon Chaisi river at Bang Phra. Main drainage canal of the Kamphaeng Saen, which was a branch of Tha Sarn river having a dual-purpose of irrigation and drainage, has reconstructed as main drainage canal by RID under the Mae Klong irrigation project. The Tha Rua system, covered a drainage area of about 17,100 ha, has a main canal of about 34.3 km in length with drainage capacity of 53.96 m^3/sec and 8 laterals having total canal length of about 129.8 km. Main canal, Tha Rua river, is equipped with head regulator and tail regulator as the water regulation facilities.

Nakhon Chaisi Drainage System - Besides the two systems as aforementioned, this system directly drains the excess water to the Nakhon Chaisi river through natural creeks and drainage canals. Its drainage area is about 3,800 ha. Main drainage in this area runs away through four natural creeks and Rang Yao canal into the Nakhon Chaisi.

Drainage Canals

A drainage modulus of 0.42 l/s/rai (or 2.625 l/s/ha) was applied to the design of drainage canals constructed under the Mae Klong Project. The modulus has been calculated based on the probable maximum daily rainfall of 150 mm not exceeding one in 10 years, drainage for a five-day period, and a total loss of 25% during the drainage period. All drainage canals constructed are of earth canal with the side slopes of 1:1.5 to 1:2.0 depending on designed discharge. No operation and maintenance road is constructed along the canals.

Problems and Needs

Floods from the Mae Klong - The high floods in recent years in the Mae Klong river occurred in 1969, 1972 and 1974. It is reported that several hundred hectares of farm land near the Malaiman highway suffered inundation for 2 days from the overflows of the Tha Sarn river originated from the floods of the Mae Klong river in August, 1974. While the construction of the Sri Nagarind dam on the Khwae Yai river is under way, and the EGAT has a plan to construct the Khao Laem multi-purpose dam in the Khwae Noi river, for the purposes of hydropower generation, flood control, irrigation and so forth. After completion of these dams, the frequency and magnitude of flood in Mae Klong river would considerably lower so that spillage through the Tha Sarn and Tha Rua rivers will no longer be necessary.

Floods from the Nakhon Chaisi - No severe flood in the Nakhon Chaisi river has been recorded since the Bumibol and the Sirikit dams was constructed and regulated flood at Chainat diversion dam. The Nakhon Chaisi river, however, rises to EL 2.0-2.1 m at Bang Pla and to EL 1.5-1.7 at Bang Phra, and it continues for about one month. Water surface of Nakhon Chaisi rises up gradually from August to September,

and rapidly rise in October, and reach at the maximum in and around the end of October and/or early November, and lower down gradually from November to February. It is comparatively stable from March to July.

Water level fluctuation pattern as mentioned above presents the fact that the water level is not affected by the rainfall in the Kamphaeng Saen area, as most of catchment area of the Nakhon Chaisi belong to the Greater Chao Phya River Basin. It is also derived from the fact that peak water level in the Nakhon Chaisi usually occurs in November though the maximum rainfall in the Kamphaeng Saen area is mostly recorded during the period of September-October. Consequently, in the lowlying area along the river, inundation occurs every year due to the intrusion of water through the canals which have no sluice gate.

Flood from Tha Sarn river - Four regulators in the Tha Sarn river which runs down along the northern boundary of the Project Area, are operated to check up the water level high so as to irrigate the areas mainly in left sides of the canal. According to the water level record, the Kamphaeng Saen regulator check up the water level in some two meters high. In addition, the left bank area, which is the second stage-area of the Greater Mae Klong Project, has not yet been equipped with irrigation systems, and the Tha Sarn canal will still be used for irrigation purposes. Under the circumstances that the regulators cannot be removed, the construction of new drainage systems with flood protection dike and more drainage canal will be needed for drainage improvement of the right bank area.

Lack of Drainage Facilities - For effective water control and management at on-farm level, the farm plot should be equipped with adequate facilities not only in supplying the correct amount of water at the right time for irrigation purpose but also in draining the excess water within the time in order that any crops will not be damaged. However, most of paddy field and depressions, especially in the lowland are distressed with abundant excess water due to lack of drains and unlinked channels to existing main and lateral drainage canal. On the other hand, there are some control facilities in the main drainage canals but none in the laterals and on-farm. These conditions also bring about drainage problems to certain portion of the Project Area.

(3) On-Farm Facilities

Farm Ditch

Farm ditches with a total length of 304 km have been constructed under the Dikes and Ditches Project initiated in the area in 1969. The farm dithces were constructed as a measure to expand irrigated area in a large area by available water through completed main irrigation system but have had effect on the area to a certain extent. However, there are some problems in the distribution of water through existing farm ditches and facilities due to lack of topographical maps in the design stage. These on-farm facilities have to be improved and/or reconstructed in order to introduce HYV cultivation and double cropping in the both seasons in the Project Area.

Main problems of the existing farm ditches in the area are summarized as follows:

- Spare density of farm ditches (average: 10.9 m/ha). Consequently, most of farm plots are irrigated by plot-to-plot method.

- Unsuitable alignments that left topographical conditions out of consideration. It resulted in floods caused by excess water of the upstreams and water shortage at the same time in a service unit.

- Inaccurate boundary of service units equipped with straight and standard alignment of ditches with space 300-400 m and inadequate ditch capacities for its service area due to lack of detailed topographic information.

- Lack of water operation and maintenance of facilities. Many ditches are left unrepaired, specially at borrow pit crossing point along the laterals and sub-laterals.

- Difficulty in conducting better water control without adequate control and distribution structures in the cause of farm ditches which some are more than 2 km and branch minor ditches without control facilities.

Drainage Facilities and Farm Roads

Drainage facilities at farm level have scarcely been constructed, which resulted from the fact that efforts have been made by farmers only for storing the deep water for irrigation. Under this condition, planting broadcasting local variety rice in the lowland is inevitable. Although the main drainage canals have been constructed for better water operation, additional construction of laterals and farm drains is necessary to link to the main canals.

Farm roads to access farm plots are very limited. As for farming road, the service road along the irrigation canals and feeder roads connected to each village are used. Therefore, provision of farm roads for hauling agricultural inputs and outputs is indispensable.

Land Tenure and Size

According to survey of the sample area selected for the study, conditions prevailed with regard to land tenure and plot size/shape are different to each other in each sample area. As for the land tenure, owner/operator are more in the higher area and less in the lower area. Farm plot (landholding size) is larger in size and good in arrangement like a latticework, in the flat lowland area and getting smaller and unsystematic as it goes from middle to higher part. The size of farm plot is mostly 2 to 3 ha, with 0.4 ha as the smallest one, and farm plots are mostly shaped in rectangle varying in length of plot from 250 to 350 m. In general, the farm plot is composed of several sub-plots of which the area varies between 0.06 ha and 1.6 ha. This sub-plot is a unit for farming practice and water management.

(4) Operation and Management

The water management in the RID is under the control of the Water Operation Board, which is to formulate a general policy on water operations. The Board consists of four members. The Director General of RID is the chairman. Under the Board, there is Water Operation Center. This Center is headed by the Executive Secretary of the Board, who is responsible for the water management as to water release from reservoirs and allocation of water to project areas downstream.

The operation and maintenance of the project completed is undertaken by the regional office The project engineer of Kamphaeng Saen Sub-Project Office is under the regional director of Region X, RID. Under the project engineer, three water masters are responsible for delivering the irrigation water with assistance of 24 zone men who operate and maintain the facilities and water delivery to the area covering about 1,600 ha (10,000 rai).

Quantity of water to be delivered to the laterals are estimated by zone men in accordance with the request from farmers every week. The regional director decides quantity of water to delivery at the main intake of the Vajiralongkorn dam. And gate tenders operate the gates and checks in the canal based on the capacities estimated by each lateral and/or sub-lateral, under the project engineer of sub-project. Only three common irrigators who are responsible for checking the quantity of water to supply to the farm land through farm ditches for the area of about 160 ha (1,000 rai) are presently assigned in the Kamphaeng Saen sub-project area due to shortage of O & M fund. The O & M roads along the canals are already provided or scheduled to be constructed. It would be provided for irrigation canals but not for drainage canals. The telephone services are available only to connect between regional office and sub-project office headquarters but no provision within the Project Area.

3.4. Social and Environmental Aspects

Out of the total population, about 80% of peoples live in rural area and employ in agriculture. Of industrial employment, about 78% engage in the primary industries, which is occupied by a majority of employment, and only 4% in secondary industries and 18% in tertiary industries (1976). Agricultural population is about 2.5 million persons and account for 59% of total population. Allowing for these figures and rate of export earnings (60%) occupied by the agricultural production, it could be said that Thailand is supported by agricultural societies.

Nakhon Pathom province has a population of about 518,000 with a population density of about 238 persons/km^2, which is considered high rate against the national value of about 84 persons/km^2 (1976). Of about 63,000 households in the province, about 66% occupies farms. The average size of farm land held by a farmer is about 3.87 ha (24.2 rai) which is almost the same as the national size in 1976. Agricultural products account for about 35.8% of provincial Gross Domestic Product; manufacturing sector, 20.8%; service sector, 43.4%

in 1977. The rate for agricultural product is a little higher than the national rate.

In the Project Area, most people engage in agriculture. The villages, consisting of 20 to 560 houses, located along the roads and rivers, hilly land and/or the relatively dried and elevated land.

The farm family size is about 5-7 persons and composes a nucleus family. Many people transmigrate to Bangkok and others every year as indicated in 1.8% of annual population growth rate. Of annual average farmer's income, about 71% gain from crops production and 13% from animal husbandry and 16% from wages for agricultural works and other sources. There are little employment opportunity. The unit society of peoples in the rural community, which organize with people living in a village and keep on face-to-face association. The farmers conduct themselves in a group of this community. Therefore, most of people, as constituent members of village, have certain connections among them. On the basis of emotional strings dwelling in such personal connections, peoples keep mutual cooperation and assistance. Through this exchange, solidarity among them exists. "Long Khaek" is one of its examples, which is requested by land owner to help each other in the cultivation, transplanting and harvesting. However, it might be limited in terms of cooperation. Those relations in the long run have relied on the related union which composed of families. Under such relations, a patriarch becomes manager of a cooperative farming and possess the land. The daughter and her husband and the relatives who do not get a share of the land engage in agriculture managed by the patriarch, as landless farmer.

The farm plot is extended centering the village in every direction. Most of farmers commonly have a land near the village and some have in a distant place and/or in the neighboring village areas. Thus, the boundary of villages including its area is not clear. Geographical boundary, however, is clear in an administrative district of villages. There is a Phuyaiban (chief of village) in every village,

who manages all of administrative matters on the villages with one or two assistants.

Their way of life was dependent upon the self-sufficient economy but has been changed by the influence of commodity economy. Their commodities are available in the town where there are Wat (temple). Most of agricultural inputs and outputs take at the gate through merchants due to little vehicles owned by the farmers. Their drinking water is obtained from the stored rain or shallow well. There are elementary schools in every village. The enrollment is so high in junior classes (4 years) but lower in senior classes.

3.5. Present Agricultural Conditions

(1) Farm Population and Labors

The Project Area contains about 65,500 population, of which some 68% is regarded as the agricultural population. The annual population growth rate is calculated at about 1.8%, which is much lower than the national average of 2.8% since 1973, due mainly to the social depletion that the population pours out to such urban areas as Bangkok and neighboring provincial capitals. The total farm households of 6,620 families is accounted for about 67% of the total households in the Project Area. However, about 14% of farmers are landless farmers. This labor force plays valuable in agriculture.

Available farm labor forces were estimated to about 25,500 persons, which correspond to 3.85 persons/farm, based on available force in ages of 16 to 60. Labors actually to be engaged in farming were assumed to be about 90%, excluding students, employment other than agriculture, unworkable persons, etc. Assuming that the number of working days in a month was 25 days and housekeepers could work only half-day, the working day per farm was estimated to be 75 man-day (3.0 man-day/day on average).

Agricultural population and farm labor forces available in 1990 are shown as follows:

	Population in 1979		Population in 1990		Workable day/year ('000 M-D)
	Total (person)	For Agriculture (person)	Total (person)	For Agriculture (person)	
Male	32,741	21,734	24,190	14,320	3,866
Female	32,767	22,620	25,170	14,070	2,806
Total	65,508	44,354	49,360	28,390	6,672

(2) Farm Size Distribution

According to DLD survey data (1975/76) on agricultural land tenure, there are 4,448 full owner-operator or about 67% of the total farmers in the Project Area, 341 farmers or about 5% for partial tenants and 886 farmers or about 13% for full tenants. Besides these farmers who operated their land land and rented land, landless farmers were accounted to 945 farmers or about 14.3% of total farmers. The average farm size operated by a farmer is about 4.0 ha (or 25 rai) per farm but its size has a great difference in distribution. The average farm size operated by owner-farmers and pure tenants are about 3.8 ha/farm and 4.2 ha/farm, respectively, which are around the average value in the Project Area. While partial tenants operate an average farm size of about 7.0 ha/farm. The land tenure is summarized as follows:

Farm Size (ha)	No. of Farm (No.)	(%)	Area of Farm (ha)	(%)
Less than 1.6	1,716	30	2,309	10
1.6 - 3.2	1,503	26	4,031	18
3.2 - 4.8	1,032	18	4,495	20
4.8 - 6.4	492	9	2,630	12
6.4 - 8.0	437	8	3,072	13
More than 8.0	495	9	6,293	27
Total	5,675	100	22,830	100

Farmers who operate farm size of less than 1.6 ha share 30% in the number with 10% share in the acreage. Comparing this with the national average of 10% and 2% shares (in case of less than 1.6 ha) in number and acreage, respectively, it can be said that the size of farms operated by more than half of farmers is very small in the Project Area.

(3) Cultural Practices

Cultivation

Plowing and harrowing in paddy field are mechanized in about 80% of the works and the remaining is done by animals and/or manpower. However, about 37% of farmers who have a power tiller operated in mechanized culture and the remaining is cultivated under the terms of lease and hire. While in the sugarcane land, cultivation is carried out by using big size tractor which has been hired. For making high ridge in the vegetable land, cultivation is performed by manpower.

Seed and Transplantation

Majority of seeds are supplied by farmers themselves. A quantity of seed for transplanting paddy averaged to about 81 kg/ha (13 kg/rai) and for the broadcasting is about 169 kg/ha (27 kg/rai), which have more than 30% of standard quantity recommended by the extension officer. Pulling of seedlings and transplanting are carried out by hand. Nursery of sugarcane is planted for every three years with about 2 to 6 tons/ha in its quantity.

Fertilization

Fertilizer application is practically low in Thailand. Farmers apply fertilizer to about 38% of cropped land for wet season paddy and 85% for dry season paddy and most of fertilizer is Ammo-phos (16-20-0 and 20-20-0), which is applied at about 49 kg/ha and 140 kg/ha in its average quantity for the wet and dry season transplanting paddy, respectively, according to the survey (RID, February 1979). Farm land

for broadcasting paddy is applied with ammo-phos for about 10% of the cropped land about 15 kg/ha in average quantity to planted land. Fertilizer is applied to most of sugarcane land, because sugar mill manager and/or quarterman for cane production supply fertilizer to farmers with the condition of paying after harvesting. Its average quantity is about 156 kg/ha of ammo-sulfate. Fertilizer application for vegetable land, for example, in cucumber, is about 156 kg/ha in average quantity of ammo-phos.

Chemicals

Farm land is treated with chemicals at the area rate of 17% by pesticide and 25% by herbicide for wet season transplanting paddy and 55% by pesticide and 49% by herbicide for dry season paddy, respectively, according to the RID survey (February 1979). The dry season paddy land treated with chemicals is generally large as compared to the treated land for wet season paddy. While for sugarcane, the land is treated with about 10% of planted land with herbicide. Besides these chemical treatments, the land damaged from rats in the eastern part of Project Area is reported. This area is however not clear in its hectarage. Thus, this land has not been cultivated according to farmers' reports. Therefore, rat control program should concentratedly be made in this area where it was proposed to plant wet season crops before the completion of the project.

Harvesting and Drying

Harvesting of paddy is mostly undertaken by manpower. In general, paddy is harvested by cutting at the middle of the stem and bundling it up. After harvesting, the paddy is dried up to medium conditions in the field and hauled out from the field. The bundled and hauled paddy is placed on the roads, canal bank, and other places for drying. Dried paddy is again hauled to farm stead or roads near the village by using cart and threshed by animals and/or power tillers. While some of the variety having high shedding habit is harvested in the matured conditions and threshed by hand in

the field. Paddy is sorted by winnower and/or winds after threshing and sold to merchants. There are no driers available and only depends on the sun.

Harvesting of sugarcane is also undertaken by manual labor. The cane is transported to sugar mills directly from the field by trucks sent from the mills, after harvesting.

(4) Cropping Pattern and Productions

Sugarcane

Sugarcane is planted in the area along the Malaiman road and in comparatively elevated area in the west part of the Project Area, which covered an area of about 4,680 ha. Planting of canes is ratooning and renewed every three years. Land preparation and nursery plantation are currently carried out in the period from January to May. Harvesting is generally undertaken from December to April. Average yield of sugarcane is about 45 tons/ha at present, according to RID survey data (February 1979) and collected information. Sugar content rate is low at about 8.5%. Molasses contains the rate of 50 kg per ton of cane.

Paddy

Lower lands in the said hilly land and mostly in northern and central part of the Project Area are planted with paddy which cover an area of about 7,080 ha during the wet season. The wet season paddy is planted in the land where water is not so deep and is generally sown during the period of May to June, transplanted in June to August, and harvested in November to December. Local variety having photo-sensitive habits is used for broadcasting culture. HYV is planted in the area where the water is ensured by the Mae Klong Irrigation Project, which covers an area of about 4,130 ha. The average yield of wet season paddy is 2.6 tons/ha in irrigated land and 2.0 tons/ha in rainfed land, while 1.6 ton/ha is for broadcasting paddy in rainfed land.

Dry season paddy is planted during the period of February to April and harvested in May to June. The dry season paddy is planted in the lower land where water is available. The area directly irrigated through the laterals and farm ditches cover about 4,760 ha, which is about 40% of total area planted with dry season paddy (about 11,900 ha). As HYV is used for dry season paddy, the yield is high. It is about 2.8 tons/ha in well irrigated land and 2.4 tons/ha in poor irrigated land where water is poorly available by pumping up from the creeks connecting to Nakhon Chaisi river.

Double cropping for paddy is undertaken in the area where water is adequately available. Its area is about 4,340 ha or about 36% of the total dry season paddy land.

Cropping calendar for paddy vary depending on water availability, as follows:

	Wet Season Rice		Dry Season Rice
	Broadcasting	Transplanting	Transplanting
Single cropping			
Land preparation	late Mar. to Jun.	Apr. to mid-Aug.	Mid-Jan. to mid-Mar.
Transplanting	late Apr. to Jun /*	mid-Jun. to Aug.	Mid-Feb. to mid-Mar.
Harvesting	mid-Nov. to Dec.	mid-Nov. to Dec.	Late May to June
Double cropping			
Land preparation	-	Jun to mid-Aug.	Jan. to early Apr.
Transplanting	-	mid-Jul. to mid-Aug.	Mid-Feb. to mid-Apr.
Harvesting	-	late Oct. to Nov.	Late May to Jun.

/* --- seed broadcasting.

Vegetables and Others

Vegetables and other crops, such as sweet potatoes, cucumbers, guinine melons, cowpeas, water melons, chinese cabbages, chili peppers, etc., are planted under the high ridged cultivation in the elevated area and along the Nakhon Chaisi river. This cultivation is not

recommendable to extend the area, because it needs high technology, such as construction of high ridge in the field, more labor force, irrigation facilities, fertilizer applications, chemical spray, etc., and enough funds. Vegetables are common planted twice a year.

Orchards are also planted under the high ridged cultivation in the land where equipped with dikes around.

Present Production

Present production for paddy and sugarcane in the project is estimated as follows:

	Planted Area (ha)	Production (ton)
Dry Season Paddy	7,080	15,790
Wet Season Paddy	11,900	31,420
Total	18,980	47,210
Sugarcane	4,680	210,600

(5) Farm Income

General

Farm management in the Project Area is roughly classified into three: only paddy cultivation; paddy and other cash crops such as sugarcane, vegetables, orchards, etc., and other agricultural industries including animal husbandry. According to RID survey data (February 1979), farmers planted paddy account for about 97% of total farmers, while 70% of farmers plant only paddy for their management. About 70% of produced rice is sold in case the farmer has an average farm size of 3.8 ha. Farmers which has small-size farms, however, consume their products for home consumption. Poultry and animal breedings are mostly pig, ducks, hens and cocks. About 90% of farmers are breeding one or more poultries and/or animals.

Income

According to RID survey data (February 1979), farmers having a farm land of about 3.84 ha (24 rai), gain an annual income of about 33,300 bahts, which compose of about 23,800 bahts from farming, 4,300 bahts from animal husbandry and 5,200 bahts from other sources. Net income is estimated to be about 22,300 bahts by reducing expenditures of about 11,000 bahts. Living expenditure is reported to be about 13,200 bahts, which is quite low because it excludes home consumed value of produced crops. Thus, it has a high as compared to national value.

3.6. Present Agricultural Institutions

(1) Research and Institute

In and around the Project Area, Rice Experimental Stations in Suphanburi and Ratchaburi, Field Crop Experimental Station in U Tong, Sugarcane Experimental Station of MOI in Tha Muang and Irrigated Agricultural Experimental Station in Kamphaeng Saen are existing. Ratchaburi Agriculture College is located in Ratchaburi. The Kamphaeng Saen Campus of Kasetsat University, which was built near the Project Area in October 1979 is to be provided with necessary research and experimental facilities and such facilities required for agricultural extension and training.

Activities to be assumed by the Rice Experimental Station include improvement and spreading of HYV and research on cultivation techniques and application of fertilizer and chemicals on rice cultivation. Field Crop Experimental Station works for variety improvement and research on cultivation techniques for such field crops as cotton, sorghum, maize, oil seed, root crop, sugarcane and fruit trees. Research activities for sugarcane and experimental station and irrigated agriculture station are limited.

(2) Extension Service and Training

The Project Area is located under the jurisdiction of the Ratchaburi Regional Office, Department of Agricultural Extension. Furthermore, there are provincial and district extension offices under the Regional Office, and presently the district office is provided with 4-5 extension workers. Considering the number of farm households to be served by a district office, the ratio is rather insufficient at some 1:2,740.

To cope with this low capability for the services, the Government has been actively implementing the National Agricultural Extension Project for 33 provinces in the country as the first phase with having the financial assistance by the World Bank. Under the project, extension offices are to be established up to village level, and in case of Nakhon Pathom Province, 75 of additional extension agents are to be provided. This ratio will be improved to 1:1,000 level. Furthermore, the World Bank project proposed to assign contact farmer in the rate of 1 to 10 farmers and to carry out extension services through contact farmers.

Training programs for DEOs and EAs are held at irregular intervals, are not always on topical technical subjects and are often mainly oriented woards extension methodology. While the government has a program to provide education and training programs for those government employees (COLC, RID, ALRO, DAE, ARD, etc.) concerned with the irrigated agriculture development in the Greater Chao Phya and Mae Klong Basin under the technical cooperation program of Japanese government on irrigated agriculture development. Main facilities for the education and training center was completed in the Suphanburi Rice Experimental Station in 1978. Chao Phya pilot farm and Mae Klong pilot farm which is designed to play a role as the sub-center for the said training center are presently under construction.

(3) Agricultural Input Supply

Seed

The High Yielding Varieties of rice in Thailand are registered as RD variety produced in the rice experimental station. These varieties have a strain of high production yield as well as good quality as maintained with Thai Grain Standard Class 1 milled rice. The production of foundation seed for rice rests with the Department of Agriculture, through its rice experimental stations. Some foundation seed is sold directly from the stations to farmers, but mostly is channeled through the DAE in order to multiply the seed through a contract system with private farmers. However, supervision of the contract growers is lax. Some certified seed is sold directly from the seed growers to farmers. The Seed Division, Department of Agriculture, handle the certified seed to collect from the seed growers and send to the Processing Plant Center, which are provided in five regions, in order to improve its quality, sorting and storing it. Farmers can buy the certified seed directly from the seed center or from the MOF through Extension Officers. However, the route to buy the seed through MOF sometimes take a lot of time for the delivery. Farmers get the seed from their neighbors and the seed growers. However, most farmers use their produced paddy as a seed for subsequent planting.

Fertilizers

In Thailand, most of chemical fertilizers (90% of total consumption) are imported by private trading firms and sold to farmers through wholesaler in Bangkok. According to the survey carried out by Kasetsat University in 1975, farmers buy fertilizers from merchants at about 70% of requirement, cooperatives at about 20% and extension office at about 10%. Farmers in the Project Area can purchase the fertilizer at any time and in any places in the area. Fertilizers used are mostly Ammo-phos.

Chemicals

Similar to fertilizer, farmers usually buy agro-chemicals from the merchants in the area. For the sake of giving guidances for farmers in selecting and applying suitable agro-chemicals depending on the pests and insects, the district extension office distributes agro-chemicals free for farmers registered in the farmers' group and in case of damage area with more than 80 ha. The quantity as supplied free by the extension office is estimated to share about one-third of the total consumption in the area and the remaining is bought by farmers themselves or provided by land owners.

(4) Credit and Marketing

Credit

Financing to farmers by the Bank for Agriculture and Agricultural Cooperatives (BAAC) has been made through two channels; direct financing to individuals and through extension offices or cooperatives, and the debtors include two kinds; namely, the group of farmers and individual farmers.

Credit is classified into three types, (1) short-term credit (when repayment is within one year), (2) medium-term credit (when repayment is within three years), and (3) long-term credit (when repayment is within ten years). Another kind of credit is called special credit. This special credit is provided for the new comers in farming with a long-term credit, which repayment is within five to fifteen years with a grace period of one or two years for which the said comers pay its interest only.

However, farmers borrowed money from relatives, merchants, neighbors and others in most cases. The sources of farmers' loan is accounted to be about 32% from relatives, 18% from merchants, and 16% from neighbors. On the other hand, a loan from the Bank and Agricultural Cooperatives and through the farmers' group account to about 10% and 14% of the total loan.

Marketing

Marketing of agricultural products are mostly handled by merchants and/or brokers. Farmers generally sell paddy to rice mills near the villages and other crops to brokers. They sell little crops through agricultural cooperatives due to poor management for marketing. Most of their products are dealt with merchant by reason of convenience for selling, high price, free-charge of transportation, advance payment, etc. Thereby, about 78% of farm products are on sale in their villages and the remaining (22%) are brought to sell rice millers and in the market. Marketing of sugarcane is handled by brokers.

(5) Farmers' Group

Farmers' participation in the group activities in the following groups and organizations still remains at low level in the Project Area. Most of them are aiming to obtain a loan.

Agricultural cooperatives are organized aiming at not only sufficient supply of agricultural credit but also timely supply of input materials and marketing of farm products. The participation is only by 15% of farmers.

Farmers group as promoted by the Department of Agricultural Extension is organized separately at village level and compose of 20 to 30 members in accordance with the crops and natures of farming practices such as rice, field crop, fruit trees, vegetables, livestock, and so on. However, they should not overlap each other farming practices. Members of this group may have an advantage in gaining loans from BAAC and other financial institutions for purchases of land, farming machine and animals and other fund for farm management. Another advantage is in supplying farming inputs and having special services by extension agents through the organized group. However, participation by farmers remains at low level at only 10%. This group may become an Agricultural Cooperative by resolution

of the general assembly.

For aiming at water management, People's Irrigation Association was organized. However, activities by this association have gone down due to shortage of fund. Whereas, RID intend to establish Water Users' Association as legal group.

Table 3-1. Summary of Climatological Data

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total/annual
Rainfall(mm)[a/]													
Average	3.5	9.9	14.6	48.1	117.5	118.4	121.5	143.4	250.2	214.0	50.7	4.5	1096.3
Maximum	38.0	77.6	53.7	169.4	233.5	291.4	243.4	245.0	503.9	418.0	172.0	56.0	1396
Minimum	0	0	0	0	6.4	7.4	3.5	21.7	78.1	52.5	0	0	652
Nos. of rainy day	1	1	1	3	8	8	8	10	13	10	3	1	
Mean temperature(°C)[b/]	24.8	26.4	28.8	30.3	29.0	28.6	28.2	28.0	27.6	26.9	24.6	23.1	27.2
Relative Humidity(%)[b/]	69	67	65	65	72	72	72	74	77	78	77	72	72
Evaporation(mm)[b/]	153	164	226	246	189	192	177	174	147	141	143	162	2114
Wind velocity(m/s)[b/]	1.8	1.8	2.3	2.2	1.8	2.3	2.2	2.2	1.4	1.6	2.4	2.8	2.1
Sunshine Houns [b/]	7.75	8.03	7.85	8.35	6.37	5.67	5.00	4.24	5.32	6.44	7.60	8.24	6.74

Data; Kamphaeng Saen Station,

a/ period of observation; 1952-78

b/ period of observation; 1973-78

CHAPTER IV. THE PROJECT

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4.1. Project Component

The Kamphaeng Saen Agriculture Development Project would (i) upgrade existing irrigation and drainage systems on purpose to increase agricultural productions and raise the level of farm management through extending irrigation services by converting the currently rainfed land and uncommandable land into irrigated land and increasing double cropping land, (ii) develop on-farm facilities such as farm ditches, drains and roads, in order to carry out proper water management, elevate agricultural productivity and promote new farming techniques and (iii) strengthen O & M capabilities at field level in order to effectively manage the system.

At present the objective area of project works is about 17,200 ha, which consists of all paddy and fallow land and a part of sugarcane land. Net irrigable area in future would be about 16,380 ha, taking into account available water supply and farm loss by construction of on-farm facilities.

As above-mentioned, the project would include the following components:

i) Upgrading irrigation and drainage systems - through improvement of existing irrigation and drainage canal and facilities and construction of new drainage canals and farm-to-market road in the irrigable area of about 16,380 ha;

ii) On-farm development - through improvement of existing ditches and construction of new farm ditches, drains and roads on the area of about 17,200 ha included land levelling and replotting in some area;

iii) Strengthening O & M capability - through increasing of O & M staff and provision of equipment, vehicles, telecommunication facilities, working stations, etc.

4.2. Irrigation Planning

(1) Irrigation Method

The project would upgrade the function of existing system to bring into full operation within the quantities of water and FSL available to obtain through existing canals at Malaiman highway (20.9 m^3/s in max.). Therefore, some of laterals in its downstream and some of sub-laterals would be improved with raising up the FSL in order to irrigate more land by gravity system. Though efforts would pay to heightening FSL as much as possible, some area might be left as uncommandable area because FSL at Malaiman highway crossing point is fixed. These areas which consist of mostly sugarcane and upland crop land, would be irrigated by pumping system due to high elevated land.

(2) Irrigation System

Existing irrigation system would be subdivided into three based on canal systems; namely, 1R-1L-5L, 2R-1R-1L-51 and 2L-5L. About 4,000 ha of land is presently supplied with water of Nakhon Chaisi river, even though this area was included in the Mae Klong Irrigation project area. Under the project, water would be provided to irrigate those areas and rainfed area. These areas are not yet irrigated due to inadequacy of on-farm facilities, although water is available. The gross area of each sub-irrigation systems are as follows:

Sub-System	Available Water (m^3/s)	Commandable by Facilities (ha)	Irrigable Area by Water	
			Wet Season (ha)	Dry Season (ha)
1R-1L-5L	9.45	6,137	7,470	7,307
2R-1R-1L-5L	4.30	3,311	3,545	2,918
2L-5L	7.15	3,992	5,055	5,055
Total	20.90	13,440	16,070	15,280

As shown in the above table, the area which is irrigable under the FSL in existing lateral and sub-laterals for each sub-system are smaller than the area to be irrigated by presently available water for the project. This means that existing lateral and/or sub-laterals should be improved in order to use the available water in full operation.

(3) Unit Water Requirement

Consumptive use for crops was estimated by evaporation value (computed by Penman method) and crop coefficient. Crop coefficient which has been used in the study of Mae Klong Irrigation Project and commonly used in Thailand, was adopted in this study.

Percolation value, which depends upon soil texture, was assumed at 1 mm/day for both wet and dry seasons, because soils in the Kamphaeng Saen area as well as Mae Klong river basin area is predominantly high-clayed soil and poorly drainaged. Percolation value for upland crops was assumed to include into farm irrigation losses.

Water requirement for land preparation was assumed at 200 mm for paddy land, 50 mm for sugarcane land and 40 mm for upland crop land. Land preparation water for paddy (200 mm) would be supplied at an initial date for land preparation. Subsequently, the water corresponding to evaporation and percolation would be supplied during land preparation period of 30 days.

Effective rainfall was estimated at 75% of daily rainfall with the maximum value of 200 mm per month and 70 mm per 10-day for paddy and 150 mm and 50 mm for sugarcane and 120 mm and 40 mm for upland crops, based on rainfall data from the Kamphaeng Saen station and conclusion of the master plan study.

Water losses consist of farm losses, conveyance losses and operation losses. Some of the water distributed to farm plot might lose by seepage through levee of the plot, overflowing, water operation errors in the farm plot. These losses might be indefinite depending on development level of on-farm facilities, irrigation method, quantity of supply water, etc. Thereby, the water losses at field level was estimated at average value, which is 30% of supplied water in the field for paddy and 40% for other crops. These farm losses would include farm ditch conveyance losses.

The conveyance loss is caused in the main canal while the necessary water is conveyed through the canal system to the farm ditches. The necessary water to be diverted from the Mae Klong river includes the conveyance loss. The operation of diversion facilities, which should be made to adequately meet the water requirements, will unavoidably cause losses, particularly in the wet season. These water losses were determined as the operation losses in the systems.

Taking account of these losses, irrigation efficiencies were asssumed as follows:

Item	Irrigation Efficiency
Farm Irrigation Efficiency	70% for paddy, 60% for upland crops (including sugarcane)
Operation Efficiency	90%
Conveyance Efficiency	95% for concrete-lined canal
Overall Efficiency	about 60% for paddy; and, about 51% for upland crops

Unit Water Requirement

Unit water requirement for every month and 10-day was estimated, taking into account evapotranspiration, percolation, effective rainfall with return-period of 5-year, and proposed cropping calendar. Maximum water requirements would take place in last day of land preparation period for three cropping calendars of paddy and on the last 10 days of April for sugarcane. Project water requirements for each cropping pattern are summarized in Table 4-1.

(4) Water Demand and Supply

The maximum overall water requirement would take place on the last 10 days of April for dry season crops, taking into account the unit water requirement for each calendar and proposed land use. In order to supply the water to all arable land in future, the maximum water demand were estimated at about 24.1 m^3/sec and 28.5 m^3/sec for wet and dry season crops, respectively. While the water presently available through three existing laterals is 20.9 m^3/sec, the arable land could irrigate to only some limited area, even in the wet season. The paddy field (15,180 ha) should have the first priority to obtain water. However, about 1,200 ha of sugarcane land is presently irrigated by pumping up the water from the laterals and ditches. Taking account of these conditions, available water could be allocated to the sugarcane area of 1,200 ha and paddy land of 15,180 ha. Nevertheless, only 14,870 ha or about 98% of paddy land could be irrigated in the dry season.

Although the total water is enough to irrigate all wet season paddy land (15,180 ha) and sugarcane land (1,200 ha), in case of each sub-system, the land belong to lateral 2R-1R-1L-5L could irrigate limited land. Thereby, for this area only, beginning of land preparation in cropping calendar has been amended to delay 20 days from the original one.

In case of cropping pattern type 2, the water would be required for dry season paddy before harvesting and for wet season paddy in early stage of its land preparation in April. Since this type was

applied to the area where drainage condition would not be improved and the water is limited to irrigate the whole Project Area in April, priority for irrigation was given to dry season paddy cropping. As a result, however, an area of about 310 ha could not be irrigated for wet season paddy land (Table 4-2).

Under the project, the irrigable areas are as follows:

(Unit: ha)

Sub-System	Season	Cropping Pattern for Paddy				Sugar-cane	Total
		Type 1	Type 2	Type 3	Sub-total		
1R-1L-5L	Wet	540	1,118	5,046	6,704	766	7,470
	Dry	540	1,428	4,573	6,541	766	7,307
2R-1R-1L-5L	Wet	-	-	3,382	3,382	163	3,545
	Dry	-	-	2,755	2,755	163	2,918
2L-5L	Wet	-	592	4,192	4,784	271	5,055
	Dry	-	592	4,192	4,784	271	5,055
Total	Wet	540	1,710	12,620	14,870	1,200	16,070
	Dry	540	2,020	11,520	14,080	1,200	15,280

Although wet season paddy requires considerable water during the period of late July to early August (later part of land preparation period), rainfall amount is sometimes almost neglible. Therefore, water management as well as cropping schedule specially for land preparation should be worked out carefully. In order to control the peak demand, it is suggested that schedule of land preparation should be taken longer in its period, or increase the prepared land in S-shape in practices of water management.

(5) Water Management

Water delivery to the lateral and sub-lateral canals would be on a constant and continuous supply basis, and be varied only depending upon the cropping schedules of sub-areas and climatic conditions. Flexibility would be provided for implementing rotational irrigation along the sections of laterals only during the land preparation period and also during critical periods of water shortage for the supply.

It is envisaged that rotational irrigation would be the basis of water distribution. This would presuppose the training of the water operators and common irrigators on the intricacies of water management and the related agricultural practices. Initially though, there may be a transition period where the usual method of simultaneous irrigation would continue to be practiced until all concerned are prepared to adopt the new method of rotational irrigation. However, discharge control would be done strictly by gate keepers and common irrigators upon instruction of the water master and water operator. For effective water management, all farm plots commanded by one turn-out would follow only one cropping pattern. This is especially important when crop diversification is considered. This would minimize difficulties connected with the application and removal of water and possible misunderstanding among water users.

Under the proposed practices, each rotational area as irrigation unit is about 40-60 hectares. The area is subdivided into 4-5 rotational units about 8-12 hectares. The rotational interval is based on a certain number of days, each unit getting its share of irrigation delivery and time proportional to its unit area.

Implementing rotational method necessitates the availability of water control and measurement facilities, scheduling and planning, working knowledge and active participation of both systems' personnel and water users. Since rotational irrigation means the supply of the correct amount of water at the right time and the proper sequence, orderly farming operations within a rotational area have to be planned and scheduled. Formation of a water users' association in each rotational area becomes imperative to facilitate communication, cooperation and participation in activities involving the water users as a group in the basic irrigation unit.

It is important to provide water measuring devices to effectively operate regulating and control structures in implementing improved water management. Water measuring devices would have to be installed

at the place near the intake at the branching points of main canals, laterals, and sub-laterals and at the farm turn-outs where farm ditches begin.

4.3. Drainage Improvement

(1) Drainage Method

Drainage problems still exist in the Project Area, although the main drainage canals were improved. On the other hand, rainfall is not much, as the maximum daily rainfall in 5-year return period is about 107 mm. However, some areas are flooded with deep water every wet season due to inadequate drainage capability in the low land and flood from Nakhon Chaisi and Tha Sarn rivers. High water level of these two rivers currently appear in November to December, which delay about one month from rainy month of September to October in the Kamphaeng Saen area. Therefore, by taking measures rapidly to drain excess water in the lowland occurred in the rainy month and prevent the Project Area from flood from the rivers, the drainage problems would be solved. Although natural drainage is principal, some local areas might be left a little inundated, specially in the lowest places. Pumping drainage would not be economical. About 910 ha of swamp would remain even in future with project.

(2) Drainage System

The Project Area could not protect flood from the rivers, because existing drainage canals in the lowland is used as dual purposes of drainage and irrigation without control gates. Therefore, proposed drainage systems would be bounded by existing canals, new ditches and farm roads and provide with control gate to protect many farmland the intrusion of flood water. However, the outside area of these flood protection dikes would be improved not more than present conditions [refer to para. (4)] below.

(3) Unit Drainage Discharge

Most of rainfall have been recorded at 3 to 5 days successively, in general, according to the record of successive rainfall in Kamphaeng Saen area. In the light of these conditions, the project would apply a unit drainage discharge of 37.5 mm/day (or 4.34 l/s/ha) for design of drainage canals, which is the capacity to drain the maximum 5 days successive rainfall with 5 years return-period (187.5 mm) within 5 days.

As for drainage in other than paddy land, specially in sugar-cane land, the drainage discharge would require more than in the paddy land. As a result of this, unit drainage discharge other than the paddy land was estimated at 74.8 mm/day (or 8.66 l/s/ha), in order to drain the maximum daily rainfall with 5-year return period within a day.

Permissible water depth for paddy vary in the growing stage of paddy. Critical period is immediately after the transplanting, which is required in shallow water depth permissible and short inundation period for paddy. According to the proposed cropping calendars, transplanting period for wet season paddy would be undertaken during the period of May to early August. In the Project Area, heavy rainfall was mostly recorded in September to October and was low in the frequency of its occurrence during the transplanting period. As to comparatively heavy rainy month of August in the transplanting period, average monthly rainfall was 143.4 mm (275.2 mm in max. and 21.7 mm in min.). When flood depth analysis transplanted paddy was made by using the maximum 5-day successive rainfall including the maximum daily rainfall of 106.9 mm in 5-year frequency, the maximum water depth was not exceeded 200 mm and left inundated water within 6 days. These conditions would be permissible for paddy.

(4) Measures

Plan of Approach

The causes of drainage problems in the area are classified broadly into three, for which technical countermeasures would make flood protection, drainage of excess water and drainage improvement at on-farm level which would be undertaken in on-farm development works.

Flood Protection

Flood from the Mae Klong river: The possibility to suffer the area from flood of the Mae Klong river would be diminished with the progress of flood control project for said river.

Flood from the Nakhon Chaisi river: Although the possibility of severe floods has been reduced as the result of flood control project of the Chao Phya river, a plan of flood protection against the Nakhon Chaisi river that occurs once in several years would be required with the purpose of introducing HYV and double cropping of rice into the area along the river. Possible technical measures need to construct flood protection dikes and sluice gates. Consequently, the depth of floods would be less than 0.5 meter.

Flood from the Tha Sarn river: The withdrawal of the regulators on the canals has to wait until the construction of irrigation systems completes on the left bank area of the river. For the drainage improvement of the right bank area, it is recommendable to construct flood protection dikes along the river.

Drainage of Excess Water

Drainage improvement of swampy area: Drainage improvement works will be composed of construction of canals and control gates and improvement of the existing canals. Full development of swamps for agriculture would call inevitably for installation of a pumping station for drainage use, which might not be justified from the economic point of view. Main purposes of the project are to stabilize paddy cropping, and to improve the farm land for mechanized culture, by accelerating the disposal of excess water through well-designed canals when the water levels in the main drainage canals are low.

Improvement of drainage system: In addition to flood protection works and drainage improvement of swampy area, reasonable drainage system would be provided based on a function of existing main drainage canals and facilities in the Project Area. This plan would be closely connected with on-farm development schemes.

Drainage Improvement of Each System

Gross project area of 28,000 ha would be divided into four (4) drainage areas for the improvement of drainage conditions. Respective condition prevailed and countermeasures for drainage improvement for each drainage system are as follows:

Kamphaeng Saen Drainage System: This system covers 18,149 ha of gross area which is bounded by the Malaiman highway, irrigation canals of 1R-1L-5L, 8L-1R-1L-5L and 2L-5L and the proposed flood protection dike (6.7 km connecting the terminal points of 8L-1R-1L-5L and 2L-5L) along the Nakhon Chaisi River. When water level is high at the Nakhon Chaisi River, drainage cannot be functioned. In the analysis on drainage function under the above-mentioned conditions,

design rainfall adopted annual rainfall in 1969 which was almost same amount of its 5-year return period and design flood water level in Nakhon Chaisi River applied the actual hydrograph recorded at Bang Pla in 1974 which has shown the maximum water level in the latest 7 years. As a result of this analysis, maximum water level and inundated area were EL 2.07 m and about 6,650 ha in the condition without the project, respectively. With the project, those conditions would be mitigated to EL 1.89 m in the maximum water level and about 4,790 ha of inundated area. That is, well drainage area would increase from 11,500 ha to 13,360 ha after the project. Assuming that this plan is a separate drainage project, IRR was estimated at about 35%.

Tha Sarn Drainage System: 6,385 ha of gross area is covered by this system as bounded by the Tha Sarn river, 1R-1L-5L and 8L-1R-1L-5L irrigation canals. Water level at the Tha Sarn river is maintained at high with regulator since the water in this drainage canal is utilized as an irrigation water source for the East Malaiman area. To protect the water intrusion from the canal to the project area, a flood protection dike (about 24 km) should be constructed along the Tha Sarn river. Excess water in the area shall be discharged below the check structures in the Tha Sarn River through the main drainage canal (borrow pits for embankment material) along the embankment. The field cost for this plan was estimated at about ฿14 million and IRR at about 44%. Therefore, this plan would be technically sound and economically feasible.

Nakhon Chaisi Drainage System: Lowland of 1,768 ha along the Nakhon Chaisi River is the area covered by this system. Affected by high water level in the Nakhon Chaisi River, poor drainage and inundation by river water occurred again.

For the improvement, polder dikes and pumping facilities for drainage purpose are required though such measures would not be economically justified. Therefore, for this system, no provision of facilities other than farm drains would be provided under the project.

Tha Rua Drainage System: This system covers 1,698 ha area in narrow shape as bounded by the Tha Rua river and 2L-5L canal, for which no other provision than drainage ditches shall be considered for the same reason as the Nakhon Chaisi drainage system.

4.4. On-Farm Development

(1) Basic Concept

For levelling up of agricultural productivity through introduction of HYV varieties, enlargement of double cropping area and crop diversification, improvement of technical infrastructures at on-farm level is vitally important. To this end, technical countermeasures at on-farm level should be planned and implemented in conformity with the close relationship with the farming practices projected, but not independently.

In the Project Area, main irrigation and drainage systems have been completed. Irrigation water for dry season cropping is to be released from the Sri Nagarind reservoir in near future. On the other hand, in view of the agriculture in the area, several developments have been observed recently, i.e. expansion of dry season transplanting rice farming instead of wet season broadcasting rice farming, considerable extension of double cropping of rice where it is favored with better irrigation and drainage conditions and mechanized plowing and harrowing. In this case, better understandings by farmers on the project to be implemented should be fully secured and necessary guidances and trainings for farmers are to be duly accomplished for this purpose. In this connection, it is considered that any planning and implementation

of on-farm developments be further progressed based on the well-coordinated program by the agencies concerned with the initiative by the government, but reflecting the farmers' opinion as much as possible.

Technical approach of the development at on-farm level would consist in part or all the following:

i) Construction of minor irrigation and drainage systems which can be controlled in accordance with the necessity in water management;

ii) Construction of roads for purposes of O & M facilities and efficient farming practices;

iii) Land levelling aiming at improvement of water control capability; and,

iv) Reparcelling of farm plots for higher water management practices and more efficient farming practices.

For effective water management, a turn-out shall command a service unit/irrigation unit of about 40-60 ha and this unit be subdivided into 3-5 sub-units. In this case, the ditch as taken off from the turn-out is called main farm ditch, which functions only for water conveyance to each sub-unit, and water can be taken to each farm plot directly from the minor farm ditches. Farm roads (2-3 m width) would be provided along every main farm ditch for efficient farming and O & M purposes.

(2) Types of On-Farm Development

Referring to the present conditions prevailed in the Project Area, past experiences in on-farm development in other areas in Thailand and the current government's policy, the following three (3) types of on-farm development have been worked out.

Type	Description
A	At least 70% of the area, for which this type of development be applied farm plots would be directly connected with farm ditches and drainage ditches. While at the maximum, some of the area may be obliged to be supplied with irrigation water by so-called plot-to-plot irrigation and drainage. Farm ditches, drains and roads would be provided along the existing boundary lines. No land levelling is to be undertaken in this type of development.
B	Every farm plot be connected directly with farm ditches, drains and roads. Plot rearrangement is to be undertaken only when required. Farm ditches, drains and roads should be in principle located along the existing boundaries. In some cases such facilities would cross the existing farm plots as required, plot rearrangement might be necessary. Land levelling is to be carried out only for aiming at better water control at farm level.
C	Technically, this type provides the highest standard of on-farm facilities. Every farm plot would be provided with farm ditches, drains and roads, and plot would be rearranged to be in rectangular shape through land levelling and replotting.

A-type is to be applied to the area along the Nakhon Chaisi River, which would suffer from flood of the river even in future and would not be economical in supplying water by the gravity system due to elevated land and far from the laterals. Thereby, some of the area, would be irrigated by pump owned by farmers' themselves.

B-type is to provide farm ditches, drains and roads for facilitating agricultural practices immediately based on requirement of farmers taking into account the effective water distribution as the

main purpose. This method would be low-cost and quick yielding. Land levelling and rearrangement of plot might be carried out in some area by technical judgment.

C-type is to be applied to the area, where farmers actively manage their farming, and to form a model of comprehensive rural development in future. As for applying this type to some area, complete agreement of all farmers is principally important because farmers should fully financne the cost of land levelling and others which do not belong to commonly used facilities.

(3) Criteria for Development Planning

On-farm development plans complying with the above-mentioned three types of improvement should be implemented in accordance with the following criteria:

Type A

i) Production target: Target yield at more than 3.3 tons/ha.

ii) Plot arrangement: No replotting is carried out.

iii) Farm ditches: Located on the existing farm plot boundary lines and in principle farm ditches be extended to command four plots at the terminal point. Interval between farm ditch and drain should be 400 m at the maximum. However, more than 70% of farmers in the service area should obtain the water directly from the ditches.

iv) Farm drain: To be located on the existing farm plot boundary lines and in principle farm drains be extended to cover four plots at the terminal point.

v) Farm roads: To be located along farm ditches with the width of 3.0 m.

vi) Land levelling: No levelling be undertaken.

Type B

i) Production target: Target yield at more than 4.2 tons/ha.

ii) Plot arrangement: Replotting would be made only in case the plot be crossed by ditches.

iii) Farm ditches: To be located, in principle, on the existing farm plot boundary lines. Interval of farm ditch with farm drains should be 200 m at the maximum. FSL shall be at least 10 cm higher than ground surface.

iv) Farm drains: In principle, located on the existing farm plot boundary lines. Design water level be same with that of ground surface elevation.

v) Farm roads: Located on the existing farm plot boundary lines. The width should be 3.0 m and the road surface be 30-50 cm higher than ground surface.

vi) Land levelling: No levelling for replotting purpose. Levelling could be made only for betterment of water control at farm level.

Type C

i) Production target: Target yield at more than 4.8 tons/ha.

ii) Plot arrangement: Standard size is 160 m x 50 m (5 rai). Farm ditches and drains be located alternately for every 160 m distance. Replotting should be necessary.

iii) Farm ditches: Located along the shorter side of plot. The maximum length is 750 m. FSL should be 25 cm higher than ground surface.

iv) Farm drains: Located along the shorter side of plot. Designed water level would level with ground surface.

v) Farm roads: To be located along farm ditches. The width should be 3.0 m and the road surface be 30-50 cm higher than ground surface.

Plans and designs of on-farm facilities for each development type were worked out based on the topographical and cadastral maps of sample areas, covering an area of about 2,620 ha in 10 sample areas. The costs for on-farm development were estimated based on the layout and design for these areas.

Planning indicators of development level for each type are as follows:

Planning Indicators of On-Farm Facilities

Item	Type A	Type B	Type C
Ditches (m/ha)	44	71	75
Drains (m/ha)	27	47	45
Roads (m/ha)	38	64	67
Moved earth vol. (m^3/ha)	-	-	315
Field cost (฿/ha)	8,270	10,770	20,500
(฿/rai)	(1,320)	(1,720)	(3,280)

(4) On-Farm Development Plan

The gross Project Area of 28,000 ha could be divided into four zones in accordance with the topographic conditions, present land use, land tenure and so forth. Development plan for each type was worked out based on these zoned areas.

i) Higher part-sugarcane zone: (Zone I)

Conditions: EL 3.0-7.0 m. Higher rate of owner/operator.

Development plan: Type A should be applied for sugarcane area. Road width is to be designed wide enough for stake truck.

ii) Higher part-paddy/sugarcane zone: (Zone II)

Conditions: EL 3.0-5.0 m. Higher ate of owner/operator (80%-100%). Averaged plot size at 1.4-1.7 ha.

Development Plan: Separated irrigation/drainage systems should be provided for sugarcane area and paddy field area. Type A would be applied for sugarcane area as same with the above. For the paddy field areas where completely drained and comparatively flat, Type C should be applied. For those which might leave a little inundation and/or rolling land, Type B is considered.

iii) Middle part-paddy zone: (Zone III)

Conditions: EL 2.0-3.0 m. Rate of owner/operator at 70-80%. Sugarcane is cultivated only partially. Averaged plot size at 1.5-1.7 ha.

Development Plan: For the areas where drainage problems are not encountered, Type B or Type C should be applied. For the areas which left a little inundation water, Type B should be applied.

iv) Lower part-paddy zone: (Zone IV)

Conditions: EL 1.0-2.0 m. Flat lowland. Lower rate of owner/operator at less than 50%. Regularly inundated by flood water.

Development Plan: For the areas which could be protected from flood water after construction of protection dike, Type B should be applied. For the areas where flood water from the river brings about inundation, Type A should be applied.

The area for each development type was worked out, based on topography, drainage, land tenure, etc. As a result of this, the area where Type C could be applied was initially estimated to be

3,120 ha. However, under the project, Type C area would be adopted one-half of initially estimated area, taking into account economic analysis, the farmers' willingness for development, development staging, etc. The area for each development type are as follows:

Type	Paddy (ha)	Sugarcane (ha)	Total (ha)	Total (%)
A	2,655	1,220	3,875	23
B	11,675	-	11,675	68
C	1,650	-	1,650	9
Total	15,980	1,220	17,200	100

4.5. Proposed Agriculture Development

(1) Proposed Land Use

According to land classification, an area of about 17,880 ha and 2,080 ha suitable for paddy and paddy/upland crops, in which about 14,640 ha of area is used as paddy land and the remaining is for sugarcane and hallow land. An area suitable for upland crops of about 2,960 ha would be left for sugarcane and upland crop in the future.

It is assumed that sugarcane cropped land would not change rapidly in its hectarage because most of the areas for sugarcane are made on a contract between sugarcane manager and farmer and sugar mills also would maintain their business. In addition, upland crop area would be managed same as the present cropping because the land is suitable for upland crops and could not be irrigated by the gravity system. On the other hand, hallow land would be reclaimed by drainage improvement and used as paddy land after the project.

As a result of the above conditions, the land use of entire area and projected irrigable area would be formed as follows. These areas have taken consideration of lost land for the right-of-way of on-farm facilities.

Land	Present		Future with Project	
	Project Area	Irrigable Area	Project Area	Irrigable Area
Paddy	14,640	14,640	15,180	15,180
Sugarcane	4,680	1,220	4,660	1,200
Upland crops	1,490	-	1,470	-
Orchard	680	-	680	-
Fallow land	1,340	1,340	-	-
Sub-total	22,830	17,200	21,990	16,380
Non-arable land	5,170	-	6,010	820
Total	28,000	17,200	28,000	17,200

(2) Cropping Pattern and Yield

Cropping Pattern

Upon completion of the project, the area would ensure enough irrigation water, improve drainage conditions and develop on-farm facilities. HYV (RD-7, 11) would be used in the majority land and HYV resistance for deep water (BKK 6986-147-2 or RD-5) would be planted in lowland where there is a little inundation left. Taking these conditions into account, proposed cropping pattern for paddy could be classified into three, as follows:

Type I: For external area of the Klong Tha Sarn embankment in the northern part of the Project Area, low-lying paddy fields below EL 2.0 m, 540 ha (Type A of on-farm development).

The river water increase by checking up for irrigating the Mae Klong Project Stage II area has resulted in increasing the field water level by around EL 2.5 m or 0.50 m in water depth at the end of August and September. Therefore, the deep-water resistant strains (photo-sensitive) would be suggested to this area. Cropping pattern of this type is as follows:

	Wet Season	Dry Season
Land preparation	Mid-May to early July	Late Dec. to mid-Feb.
Transplanting	Mid-June to early Aug.	Late Jan. to mid-Mar.
Harvesting	Late Nov. to mid-Jan.	Early May to end June

Type II: For external area of embankment in the southern part of the Project Area, paddy fields below EL 1.5 m, 2,020 ha. (Type A of on-farm development).

This area has been inundated with increase in water level of the Nakhon Chaisi river and standing of water in the area. The water level in the area has increased at the end of October through the beginning of December. Therefore, the cropping pattern should be established to finish harvesting of the wet season paddy by the time when the water level increases with advancing the paddy cropping. The cropping pattern is as follows:

	Wet Season	Dry Season
Land preparation	Mid-Apr. to early Jun.	Mid-Nov. to early Jan.
Transplanting	Mid-May to early Jul.	Mid-Dec. to early Feb.
Harvesting	Late Aug. to mid-Oct.	Late Mar. to mid-May

Type III: For central part of the Project Area, the paddy fields free from floodings, 12,620 ha.

This area occupies most part of the Project Area and land consolidation by Type B or Type C would be executed together with construction of irrigation and drainage facilities. Therefore, the HYV should be introduced to establish the paddy double cropping. The cropping pattern is as follows:

	Wet Season	Dry Season
Land preparation	Mid-Jun. to early Aug.	Mid-Dec. to Mid-Feb.
Transplanting	Mid-Jul. to early Sept.	Mid-Jan. to Mid-Mar.
Harvesting	Early Nov. to end Dec.	Mid-May to early Jul.

In future, the sugarcane planting, which is currently carried out in May-June when the wet season starts, should be made smoothly on schedule after the third harvesting so that proper irrigation can be made for yield increase with well growth in the early stage. And

in ratooning, intertillage, weeding, fertilization and irrigation should be properly practised immediately after harvesting, in order to increase the yield. The cropping pattern of sugarcane is as follows:

Land preparation	Early Jan. to end Apr.
Planting	Early Feb. to mid-May
Harvesting	Mid-Dec. to mid-Apr.
(Ratooning)	(mid-Dec. to mid-Apr.)

The diversified cropping pattern should be introduced in future for vegetable growing with such crops to meet the local farming condition and demand as sweet potatoes, melons and cucumbers, tomatoes, chillis and other local vegetables which have high productivity. However, the project could not supply the water for the diversified crops due to no water available.

Yield

The yield in future were estimated taking into account the type for development, effective water management, improvement of extension services, HYV introduction, increased fertilizer, completion of treatment, etc.

		Future	
	Present (ton/ha)	Without Project (ton/ha)	With Project (ton/ha)
PADDY			
Wet Season			
Rainfed Broadcasting	1.6	2.0	-
Transplanting A	2.0	2.3	-
Irrigated Transplanting A	-	-	3.3
Transplanting B	2.6	3.2	4.2
Dry Season			
Irrigated Transplanting A	2.4	2.8	4.3
Transplanting B	2.8	3.4	4.6
SUGARCANE	45.0	60.0	80.0

NOTE: A is for land irrigated with extensive water operation, and
B is for land irrigated with intensive water operation.

Upon completion of the project, the production would be increased from about 47,200 tons/year at present to 124,400 tons/year in future with project for paddy and about 210,600 tons/year to 303,600 tons/year for sugarcane.

Item	Area (ha)	Production ('000 ton)
Wet season paddy	14,870	60.4
Dry season paddy	14,080	64.0
Total	28,950	124.4
Sugarcane with project	1,200	96.0
Sugarcane without project	3,460	207.6
Total	4,660	303.6

(3) Future Cultural Practices

Cultivation

Plowing and harrowing the paddy field would be mechanized from 80% at present to 90% in future. Rate of cultivator holdings would increase. This cultivator should be used cooperatively. Cultivation for sugarcane land might not change in its practices.

Seeding and Transplanting

Quantity of seed use for paddy would be decreased to reasonable quantity of 45 kg/ha with advice of extension officers. On the other hand, mechanization of transplanting could not be expected even at full development stage.

Fertilizers and Chemicals

Increasing rice productions of HYV mostly depend on heavier fertilizer application. Improved paddy field which would ensure enough water and could control the water depth would encourage use of fertilizers. The fertilizer commonly is ammonium phosphate through the country. Under the project, is is assumed that urea would be used for supplementary source of nitrogen from an economic

point of view, though ammo-phos will continue to be used as a basic fertilizer.

In order to control pest, it is expected that chemicals would be treated throughout the Project Area with adequate service of extension officers. It is assumed that herbicide treatment may increase because little farmer undertakes weeding at present.

(4) Farm Labor Supply and Requirement

The labor requirements for the proposed cropping pattern was estimated at about 2,595,000 man/year, 1.68 times as many as the present.

The busiest season for farming works is in July when transplanting of the wet season paddy and harvesting of dry season paddy coincide each other.

The required machine power will be 46,300 units/day by 6-10 Hp power tillers, which is equivalent to 1.67 times as many as the present. These machine powers would be mobilized for preparatory works of the dry season paddy cropping.

The labor supply will be short to the required labors to cover the busiest season (July), however, the shortage may be supplied by employing the labors from non-farm households and in outside area.

4.6. Project Works and Costs

(1) Upgrading of Irrigation and Drainage

Irrigation Works

As the FSL of the existing lateral and sub-laterals are low, an area of about 13,440 ha could be irrigated when on-farm facilities would be completely provided. Whereas, the water available at the point of Malaiman highway is enough to irrigate an area of about

15,870 ha for wet season crops. Therefore, in order to use the available water as effective as possible, FSL of existing laterals and sub-laterals should be improved by rising the water surface.

The project would then undertake in heightening the canal in 0.2 to 0.6 m for 6 laterals/sub-laterals with a total length of about 53 km, replacement of 20 culvert road crossing by bridges, improvement of 4 turnouts, rehabilitation of existing turnout and construction of foot bridges. The heightening of canal works consist of construction of additional canal side wall and concrete lining with a length of about 22.2 km.

Sub-System	Existing Canal			Improved With Project	
	Capacity (m^3/sec)	Nos.	Length (m)	Nos.	Length (m)
1R-1L-5l	9.45	5	36,550	4	24,112
2R-1R-1L-5L	4.30	5	46,912	1	6,010
2L-5L	7.15	2	35,610	1	17,652
Total	20.90	12	119,072	6	47,774

Drainage Works

Drainage works are composed of widening of existing drainage canals in total length of about 108.3 km, construction of 68.3 km-new lateral, construction of 24 km-feeder road along the Tha Sarn River, and drainage control gates for flood control, improvement of a drainage sluice, installation of gates at the conjunction point with existing creeks and farm ditches for flood control and construction of service road in the bank of canals. 15-drainage siphon across the existing laterals/sub-laterals would be equipped with control gates under the project. Main works are as follows:

Sub-System	Drainage Area (ha)	Canal Length			Service Road (m)
		Present (m)	Improved/* (m)	Constructed/* (m)	
Tha Sarn	4,373	53,385	16,033	8,840	24,873
Kamphaeng Saen	17,397	86,472	46,787	89,406	136,193
Tha Rua	1,688	28,560	0	0	0
Nakhon Chaisi	4,542	32,040	5,450	10,080	15,530
Total	28,000	200,457	68,270	108,326	176,596

/* --- With Project.

(2) On-Farm Facilities Development

The project would develop on-farm facilities covering an area of about 3,875 ha for Type A, 11,675 ha for Type B and 1,650 ha for Type C. Each farm plot would be equipped with an irrigation inlet and drainage outlet. Farm ditches would be equipped with turnout which would be double orifice type or equipped water measuring devices, diversion boxes for each sub-irrigation unit, control structures, pipe crossing, road crossing and others for water distribution. Farm road would have 3 meters wide.

Development Type	Present Area (ha)	Projected Area	
		Lost Land (ha)	Developed Land (ha)
Type A for sugarcane field	1,220	20	1,200
for paddy field	2,655	95	2,560
Type B for paddy field	11,675	605	11,070
Type C for paddy field	1,650	100	1,550
Total	17,200	820	16,380
(%)	(100)	(4.8)	(95.2)

(3) Provision of O & M Facilities

In order to strengthen O & M capability, under the proposed organization, the project would provide with 6 water masters' quarters, and 18 additional working stations, since 20 working stations for

zonemen and gate tenders have been built.

Procurement of equipment, vehicles and instruments for O & M would be made under the project. The communication facilities and telephone networks between the office, water master quarters, working stations and gate tenders' house would be provided.

(4) Procurement of Equipment and Materials

Construction Equipment

The period for procurement of construction equipment has an influence on construction schedule. The equipment should be delivered to the project site at least up to early part of wet season in second project year. The construction equipment would be procured for force account works of drainage and on-farm facilities works. Materials including gates would be procured in the country. This procurement also must comply with the project construction schedule.

Equipment for O & M

Vehicles and telecommunication facilities among the equipment for O & M would be procured up to second project year. Construction equipment for O & M would only prepare necessary ones up to the end of the project construction, after checking the equipment used for construction.

(5) Construction Method and Schedule

Construction Method

Most of construction works in Thailand have been undertaken on force account basis, although some projects have been undertaken on contract basis. However, it may require a number of staff. For purposes of executing the project by adequate number of staff and fostering the contractor for agricultural development works, contract method should be taken up by the project.

Under the project, most of irrigation works, improvement of drainage canals and about 40% of on-farm facilities work would be undertaken by contract basis, and the remaining would be done by force account. The contract works for on-farm facility might bring about some problems. This trial might not be effective to reduce the number of staff in the project office. However, it is expected that this trial would bring about good result in the project implementation stage or in new projects in future.

Construction Schedule

The project works consist of preparation of construction works, such as additional studies, surveys and detail designs, and construction works. The preparation works would be mainly carried out in the first project year, specially the procurement of construction equipment and detailed design of project works, implementation planning and schedule. Construction works would start from the second project year and be scheduled for 5 years, taking into account the force account works' progress. The total project implementation period then would be six years, FY 1980/81 to 1985/86.

(6) Cost Estimate

The cost was estimated based on the layout, standard design, etc. The unit cost for on-farm development works for each development type was estimated based on the planning and design for sample areas, which were selected in 10 sample areas with the total area of about 2,620 ha. The total cost for the on-farm works was estimated by unit cost and area for each development type.

Physical contingency was assumed at 10% for civil works. Annual inflate rate due to expected price increase over the implementation period was assumed at 9% for civil works and 7% for equipment and services.

The project costs are estimated at ฿654.10 million as shown in Table 4-3 and summarized as follows:

Item	Local Currency (mil. ฿)	Foreign Currency (mil. ฿)	Total (mil. ฿)	Rate of Foreign Currency (%)
Total without price increase	281.19	220.31	501.50	44
Expected price increase	93.01	59.59	152.60	39
Total project cost with price increase	374.20	279.90	654.10	43

Table 4-1. Summary of Project Water Requirement

	Cropping Pattern 1			Cropping Pattern 2			Cropping Pattern 3		
	Wet Season	Dry Season	Annual	Wet Season	Dry Season	Annual	Wet Season	Dry Season	Annual
	(mm)								
Paddy									
Land preparation									
Saturation	200	200	400	200	200	400	200	200	400
Additional water	144	146	290	157	127	284	139	137	276
Sub-total	344	346	690	357	327	684	339	337	676
Crop water requirement									
Evapotranspiration	682	505	1,187	353	437	790	411	551	962
Deep percolation	160	80	240	80	80	160	90	90	180
Sub-total	842	585	1,427	433	517	950	501	641	1,142
Total field water requirement	1,186	931	2,117	790	844	1,634	840	978	1,818
Less effective rainfall	290	8	298	98	0	98	254	26	280
Net field water requirement	896	923	1,819	692	844	1,536	586	952	1,538
Farm irrigation efficiency (%)	70	70		70	70		70	70	
Farm water requirement	1,280	1,318	2,598	988	1,206	2,194	837	1,360	2,197
Conveyance & operation eff.(%) a/	85.5	85.5		85.5	85.5		85.5	85.5	
Diversion water requirement	1,497	1,542	3,039	1,156	1,410	2,566	979	1,591	2,570
Sugarcane									
Evapotranspiration			1,120						
Less effective rainfall			304						
Farm water requirement			846						
Overall irrigation efficiency (%) b/			51						
Diversion water requirement			1,659						

Note: a/ Estimated efficiencies- conveyance 95% and operation 90%

b/ Estimated efficiencies- farm 60%, conveyance 95% and operation 90%.

Table 4-2. Estimated Cropping Area and Water Requirement for each Sub-system

Sub-system & Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1R-1L-5L												
Cropped area												
Paddy : Wet season-1 a/ (ha)	→				←				540			
-2 (ha)				←		1,118			→			
-3 (ha)						←		5,046			→	
Dry season-1 (ha)	→	540				→						←
-2 (ha)	→	1,428		→							←	
-3 (ha)	→		4,573			→						←
Sugarcane : (ha)						766						
Water requirement (m^3/s)												
Monthly average	7.19	8.88	8.95	8.94	5.13	4.85	7.64	6.06	2.17	3.39	3.86	4.04
10-day base	7.76	9.45	9.21	9.45	5.90	3.60	8.98	8.83	3.60	4.41	4.15	6.18
2R-1R-1L-5L												
Cropped area												
Paddy : Wet season-3 b/ (ha)					←				3,382			→
Dry season-3 (ha)	→		2,755			→						←
Sugarcane : (ha)						163						
Water requirement (m^3/s)												
Monthly average	2.92	3.69	3.89	4.01	1.72	0.26	2.85	3.70	1.04	2.30	2.77	1.83
10-day base	3.36	4.09	4.00	4.30	2.37	0.11	3.45	4.12	1.68	3.32	3.40	2.17

Table 4-2. (continued)

Sub-sysyem & Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
2L-5L												
Cropped area												
Paddy : Wet season-2 (ha)				←		592			→			
-3 (ha)						←		4,192		→		
Dry season-2 (ha)	→	592	→		←						←	
-3 (ha)	→			4,192	→							←
Sugarcane : (ha)	→					271	→					
Water requirement (m^3/s)												
Monthly average	5.14	6.36	6.54	6.65	3.33	2.97	5.29	4.28	1.58	2.40	2.24	2.37
10-day base	5.72	6.96	6.64	7.04	4.24	3.74	6.36	6.40	2.55	3.03	2.71	4.09

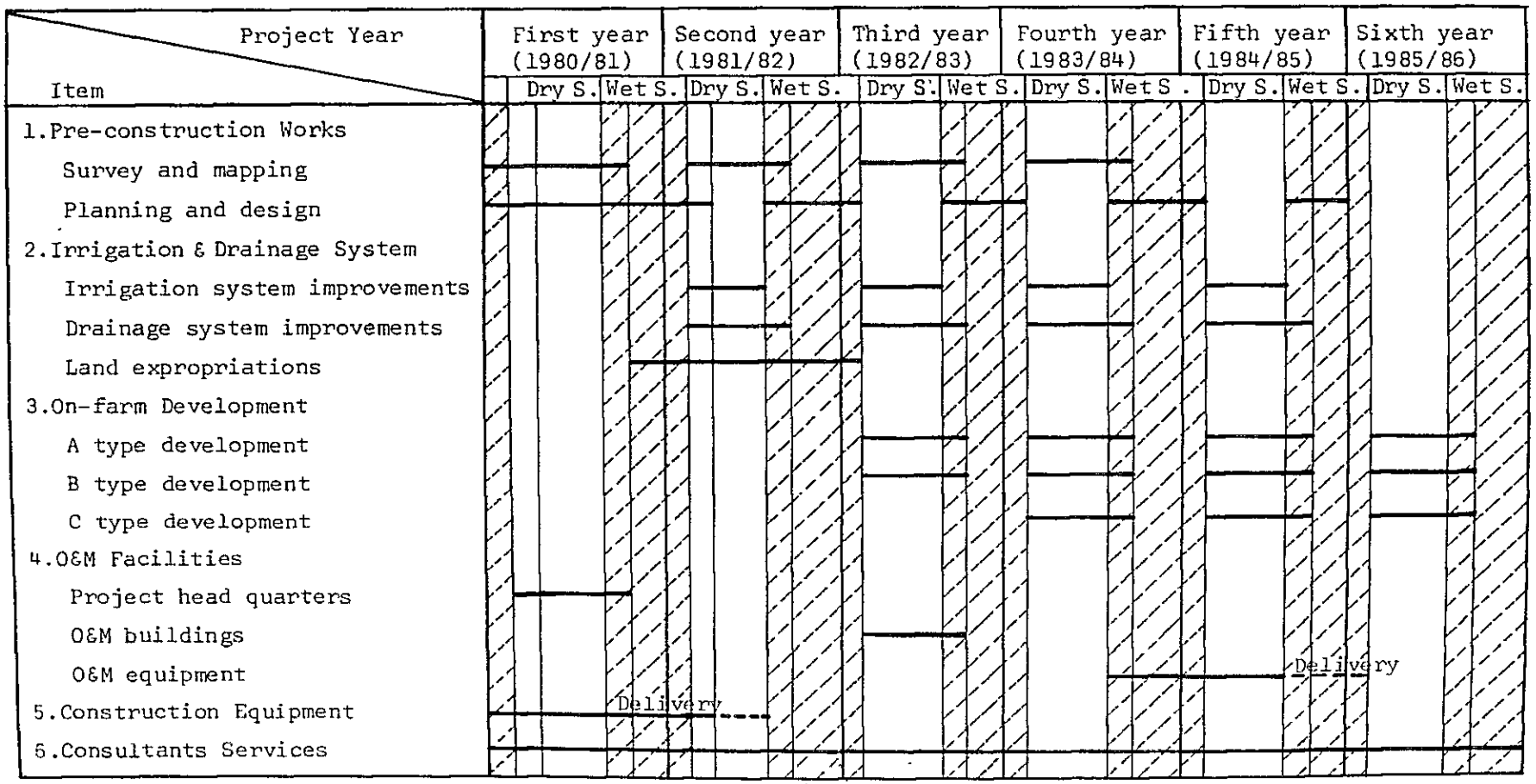
Note a/ -1, -2 and -3 are cropped area by cropping pattern of type 1, type 2 and type 3 for wet and dry season paddy.

b/ The area estimated by tentative (revised) cropping calendar which start on the first part of June, 20-day delayed from standard one of type 3 for wet season paddy.

Table 4-3. Cost Estimates

Item	By Baht			By US.$			Foreign Rate
	Local	Foreign	Total	Local	Foreign	Total	
	(Baht'000)			(US$'000)			(%)
A. Irrigation & Drainage Systems							
1. Irrigation system	44,630	20,640	65,270	2,231	1,032	3,263	32
2. Drainage system	19,690	20,030	39,720	984	1,002	1,986	50
3. Land expropriations	6,270	0	6,270	315	0	315	0
4. Physical contingencies (10%)	7,060	4,070	11,130	353	203	556	37
5. Engineering, admin. etc.(10%)	12,240	-	12,240	612	-	612	0
Sub-total	89,890	44,740	134,630	4,495	2,237	6,732	33
B. On-farm Development							
1. A type development	20,270	12,810	33,080	1,014	640	1,654	39
2. B type development	89,820	50,480	140,300	4,491	2,524	7,015	36
3. C type development	22,680	11,150	33,830	1,134	558	1,692	33
4. Physical contingencies (10%)	13,280	7,440	20,720	664	372	1,036	36
5. Engineering, admin. etc.(10%)	22,790	-	22,790	1,139	-	1,139	0
Sub-total	168,840	81,880	250,720	8,442	4,094	12,536	33
C. O & M Facilities							
1. Project head quarters	900	220	1,120	45	11	56	20
2. O & M buildings	5,040	1,260	6,300	252	63	315	20
3. O & M equipment	560	10,700	11,260	28	535	563	95
4. Physical contingencies (10%)	590	150	740	29	8	37	20
5. Engineering, admin. etc.(10%)	820	-	820	41	-	41	0
Sub-total	7,910	12,330	20,240	395	617	1,012	61
D. Construction Equipment	3,110	59,100	62,210	155	2,955	3,110	95
E. Consultants Services	11,440	22,260	33,700	572	1,113	1,685	66
Total A-E	281,190	220,310	501,500	14,060	11,015	25,070	44
F. Expected price increase	93,010	59,590	152,600	4,650	2,980	7,630	39
Ground Total	374,200	279,900	654,100	18,710	13,995	32,705	43

Figure 4-1 Project Implementation Schedule



NOTE: Project Year is shown as Fiscal Year in Thailand.

CHAPTER V. PROJECT MANAGEMENT AND ORGANIZATION

CHAPTER V. PROJECT MANAGEMENT AND ORGANIZATION

5.1. Project Management and Coordination

(1) Project Management

The RID has a great deal of experience on the execution of irrigation project as well as on-farm development project. The Executing Agency shall be the RID for the Kamphaeng Saen Project for the smooth and effective execution and success of the Project.

Inasmuch as implementation of several projects in the Greater Mae Klong Basin area are scheduled, the Mae Klong Project Director would be appointed with the same level as Deputy Director General and responsible for the implementation of all expected projects in the Mae Klong Project area and concurrently he should assume the duty for supervising and assisting the Kamphaeng Saen Project execution.

The project manager, under the Mae Klong Project Director, should be directly responsible for the execution of the project. Under him, five (5) section chiefs, project engineer for engineering, construction and equipment management and project officer for administrations and project supporting services should be assigned for the project.

Under the proposed organization, all design and construction would be carried out in the project site with assistance of staffs of Design Division, Construction Division, Roadway Divison, Survey Division and Land Consolidation Section of O & M Division of RID in Bangkok. All equipment procured for the project would be undertaken by the Procurement and Property Division in collaboration with Mechanical Engineering Division. Topographical mapping has been carried out by the Topographical Survey Division under the financial assistance of IBRD. However, additional and/or supplementary survey for detail design of irrigation and drainage canals, roads, facilities and on-farm facilities would be undertaken by staff of the project office (Fig. 5-1).

For preparation and issuance of Royal Decrees concerning the execution of the project under the Land Consolidation for Agricultural Act (1974), COLC would act as main Executing Agency, before the construction period in areas to be incorporated under the project. The Provincial Land Consolidation Officer would carry out the field level functions of COLC, especially to promote on-farm development among farmers in the project area.

Responsibility for cadastral surveys and issuance of title deeds in all parts of the project area subject to on-farm development would rest with the Land Department of the Ministry of Interior. The Land Department, which has recently increased its staff for this, is presently carrying out the said cadastral surveys in the project area under the Chao Phya Irrigation Improvement Project II.

(2) Project Coordination

To ensure smooth cooperation between all Departments engaged in the project, the Project Coordinating Committee chaired by the Undersecretary of Agriculture would be established. The Committee would include the Project Coordinator, the Director-General of RID, the Mae Klong Project Director, the Project Manager and representative of the Ministry of Interior, Budget Bureau, Ministry of Finance and other department and offices related with the project implementation. The Deputy Undersecretary of State for Agriculture would be appointed as Project Coordinator. His principal duties would include coordinating all project activities among the agencies related to the project; ensuring the actions requiring higher approval by immediately bringing to the attention of the Undersecretary and/or Minister; and, to exercise such powers in the implementation of the project. The Committee would also has full power of all project activities, so as not to consume a long time specially for procurement, budgeting, staffing and the appointment of consultants. This Committee would also be able to expand those activities as a coordination for the implementation of future projects in the Greater Mae Klong area, if required.