FEASIBILITY REPORT

ON

THE PHETCHABURI-KAENG KRACHAN IRRIGATED AGRICULTURE DEVELOPMENT PROJECT

IN

THE KINGDOM OF THAILAND

VOLUME I MAIN REPORT

MARCH 1982

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

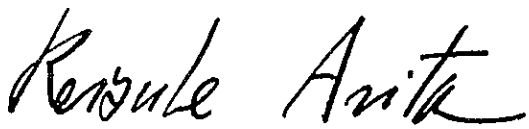
In responste to the request of the Government of the Kingdom of Thailand, the Government of Japan decided to conduct a survey on the Phetchaburi-Kaeng Krachan Irrigated Agriculture Development Project and entrusted the survey to the Japan International Cooperation Agency (JICA). The JICA sent twice to Thailand a survey team headed by Mr. Heijiro Yoshihara from November 1980 to January 1981, and June to August 1981.

The team exchanged views with the officials concerned of the Government of the Kingdom of Thailand and conducted a field survey in Changwat Phetchaburi area. After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

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

March, 1982



Keisuke Arita
President
Japan International Cooperation Agency

Mr. Keisuke Arita
The President of
Japan International Cooperation Agency
Tokyo

Dear Sir,

Letter of Transmittal

We have a great pleasure to submit herewith the report on the feasibility study for the Phetchaburi-Kaeng Krachan Irrigated Agriculture Development Project in the Kingdom of Thailand. The feasibility study has been carried out by the field investigations and home office works by two fiscal 1980 to 1981. The report has been prepared based on the results obtained through the analysis, study and discussion with the Royal Irrigation Department and other Thai authorities concerned along with the direction given by the Supervisory group of the Project.

The feasibility study has aimed at the irrigated agriculture development majoring the on-farm development for the gross project area of 74,000 hectares involving the area for the existing Phetchaburi irrigation project contemplated in 1942 by the Government of Thailand and the area extending between the said project area and the seadikes.

The Government of Thailand has made a request to the Government of Japan, since around 1976, for the technical cooperation on the irrigated agriculture development which was needed for the irrigation area in where the main irrigation facilities such as the storage dam, the diversion dam, and the irrigation canal were constructed. The official request for the technical cooperation on the Phetchaburi-Kaeng Krachan irrigated agriculture development was delivered to the Japanese authorities concerned in September, 1978.

The Project, proposed along the line laid down by the Government of Thailand for the irrigated agriculture development, is composed of an irrigation improvement project for the rehabilitation and construction of irrigation canals and an on-farm development project for the construction of terminal facilities. We are confident that the Project is a powerful measures to utilize more effectively the existing Phetchaburi project facilities constructed with a large investment of capital.

We sincerely wish to express our deepest gratitude to the Royal Irrigation Department and other Thai Government Agencies concerned, and the Ministry of Foreign Affairs of Japan, the Embassy of Japan in Bangkok, the Ministry of Agriculture, Forestry and Fisheries, Japan International Cooperation Agency and its Office in Bangkok, the Supervisory Group and the Japanese resident experts for agricultural development cooperation in Thailand for their close cooperation and worthly advices given to the team from time to time.

November, 1981

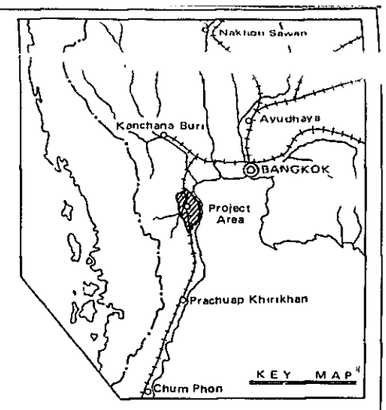
H Yoshihara

Heijiro Yoshihara
Team Leader for
the Feasibility Study on the
Phetchaburi-Kaeng Krachan
Irrigated Agriculture Development Project

PHETCHABURI—KAENG KRACHAN

IRRIGATED AGRICULTURE DEVELOPMENT PROJECT

PROJECT MAP



PROJECT SUMMARY

1. Project Area
   - Gross area : 74,000 ha
   - Net area : 52,600 ha
   - Paddy field : 48,700 ha
   - Upland : 3,900 ha
2. Irrigation Improvement
   - Rehabilitation of canals : 295 km
   - Construction of canals : 120 km
   - Irrigation requirement : 635 MCM p a
3. On-farm Development
   - Type C ,extensive : 16,510 ha
   - Type B ,semi-intensive : 36,090 ha
4. Cropping Intensity of Paddy Field : 129 %

LEGEND

- Boundary of Project Area
- Existing Diversion Dam
- Irrigation Canal (Construction)
- Irrigation Canal (Rehabilitation)
- Dual purpose Canal (Construction)
- On-farm Development (Type C)
- On-farm Development (Type B)

CONTENTS

VOLUME I. MAIN REPORT

GLOSSARY AND ABBREVIATION

Glossary and Abbreviation

MOAC	Ministry of Agriculture and Cooperatives
RID	Royal Irrigation Department, MOAC
DAE	Department of Agricultural Extension, MOAC
EGAT	Electricity Generating Authority of Thailand
JICA	Japan International Cooperation Agency
Changwat	Province
Muang	Capital of Province
Amphoe	District
Tambon	Sub-district
Muban	Village
O & M	Operation and Maintenance
HYV	High Yielding Varieties
LV	Local Varieties
IERR	Internal Economic Rate of Return
Rai	Unit of land measurement
Baht	Unit of Thai currency
mm	Millimeter
cm	Centimeter
m	Meter
cu.m	Cubic meter
MCM	Million Cubic Meter
cu.m/s	Cubic meter per second
km	Kilometer
sq.km	Square kilometer
g	Gram
kg	Kilogram
ton	Metric ton
ha	Hectare
El	Elevation above mean sea level
MSL	Mean Sea Level
^{o}C	Degree Centigrade
mmho/cm	Millimho per centimeter
HP	Horsepower
Kw	Kilowat

Units of Measure

Rai = 0.16 hectares = 1,600 sq.m
Hectare = 6.25 rai = 10,000 sq.m

SUMMARY, CONCLUSION AND RECOMMENDATIONS

SUMMARY

Background

1. Being one of the most important and traditional rice exporters in Southeast Asia, Thailand had already started planning, at the beginning of the 20th century, the establishment of its modern irrigation systems, some of which are still now in use. As a quick remedy for the world food crisis immediately after World War II, particularly the shortage in rice supply in Southeast Asia, the necessity and potential of increasing rice production and driving the export by the nation had drawn the international attention. The Chainat diversion dam and many related gravity irrigation projects, in the northern parts of the Chao Phya Plain (covering 600,000 hectares) were the Thailand's first development project financed by the World Bank (1950). Also in the Central Plain, the Greater Mae Klong Development Project and the Phetchaburi Irrigation Project were taken up. Those projects have allowed to provide many reservoirs, main and lateral canals, contributing to the stabilization of the rainy season cropping as well as securing the water sources for expansion of the dry season cropping. As a result, a gross agricultural production has increased although mainly attributed to enlarged cropland area, while insignificant in productivity improvement per unit area.

2. Under such circumstances, the Government of Thailand has planned promotion of the so-called irrigated agriculture development projects designed to permit the paddy double cropping and crop diversification available by more water use through on-farm developments. Not only did it enact the "Land Consolidation Act" in 1974 and the "Land Reform Acts" in 1975 but also reorganized its administrative structure by establishing the Central Land Consolidation Office in the Ministry of Agriculture and Cooperatives and by taking other measures. In this way, the Government has been tackling a series of the on-farm development projects in full scale in the areas where the main irrigation systems have been already provided. As of 1980, the farm ditches were provided for 1,273,000 hectares of farm lands of which 53,000 hectares in total were completed under the on-going land consolidation projects.

3. In 1976, the Government of Japan conducted a preliminary study for irrigated agriculture development projects in Thailand in response to the request by the Thai authorities concerned for that purpose. The both Governments have reached an agreement to undertake the irrigated agriculture development projects in the basins of the lower Chao Phya and the Mae Klong as part of the technical cooperation. Afterward, construction works for the pilot projects were designed for on-farm development in the basins of the two rivers, and the respective feasibility studies and a master plan study for the basin of the Mae Klong river have been carried out under the cooperation between the two Governments. The Phetchaburi Irrigated Agriculture Development Project, although covered by the original request of the Thai Government in 1976, was decided to be undertaken after completion of the Master Plan Study for the Greater Mae Klong river since it is outside the Mae Klong river basin, although adjacent to. In 1978, eventually, the definite request was made for cooperation in the Project.

4. The Phetchaburi Irrigation Project is staged into two; Stage I for construction of the Phet diversion dam and water distribution systems and Stage II for that of reservoir and additional water distribution systems. Starting from construction of the Phet diversion in 1942, the Stage I was completed with the Kaeng Krachan Reservoir, financed by the World Bank. The subsequent construction of drainage systems, farm ditches, and seadikes have also contributed greatly to the regional development majoring the agriculture development in the Phetchaburi area. The Royal Irrigation Department has difined the Stage I and II as the Phase I for the Phetchaburi River Basin Development Program, and the further irrigated agriculture development in the use of existing facilities as Phase II and the construction of the additional dams and reservoirs as Phase III.

Purpose and Scope of Study

5. The purpose of this study is to make a feasibility study of the irrigated agriculture development in the existing irrigation area and the area located between the existing irrigated fields and the seadikes taking into account the phased development mentioned above. The thorough study on present situations of land and water use, irrigation, drainage, and on-farm facilities systems, farm management, etc. was made together with surveys of soils, hydrology and irrigation, based upon which plans were made for development of irrigation, drainage, and on-farm facilities, farm management, and supporting services as well as the cost estimation and the economic evaluation of the Project.

General Descriptions of the Project Area

6. The Project Area belongs administratively to Changwat Phetchaburi, covering two cities and six Amphoes. The Area is bounded by the Gulf of Thailand on the east and by hilly land on the west, bordering the Greater Mae Klong Development Project Area. According to topographical maps prepared in 1980, it covers 63,900 hectares of existing irrigated area plus 10,100 hectares of areas extending along the seadikes; thus totaling 74,000 hectares in gross.

7. The Project Area is composed of fan of the Phetchaburi river and marine deposit flat lands, varying in elevation from 20 meters to one meter. 40 percent of the soils included in the Area is classified into the first and the second class lands in terms of the suitability for paddy fields; and 50 percent is accounted for by the soils that may be classified as the third class land due to restriction by excessive soil salinity, standing water, topography and soil moisture, and the remaining 10 percent of the soil composed of Tha Chin and Hua Hin serieses are regarded unsuitable for paddy fields due to excessive soil salinity, standing water, sandy soil, etc. In view that, out of the areas in third class, some 26,000 hectares (35 percent of the total) is composed of the soils lower in the paddy productivity, mainly because of excessive soil salinity and poor drainage. The important issue for the Area, therefore, is to improve production techniques adopted for those paddy fields.

8. In the Project Area, the rainy season normally continues for some six months from May to late October, and the annual precipitation averages closely 1,100 millimeters, out of which 94 percent is concentrated in the rainy season. The maximum annual rainfall ever recorded in the past was 1,627 millimeters (1966), whereas the annual record in 1980 registered only 435 millimeters. Out of 4,060 square kilometers of the catchment area of the Phetchaburi river, 2,210 square kilometers serve as the water source for the Kaeng Krachan reservoir to provide the annual inflow of 850 million cubic meter on an average.

9. In Changwat Phetchaburi, to which Project Area belongs, the Gross Provincial Products for 1978 marked by 258 million in US Dollars, is converted into per capita value of the inhabitants by 724 US Dollars, which are higher than 525 in US Dollars of the national average in the same year. The Gross Agricultural Products accounted

for 46 percent of the Gross Provincial Product, and the agriculture is one of the largest industry sectors of the Changwat. Except for two cities of Phetchaburi and Cha-am, the total population and the total households in the Area were estimated at 192,000 and 32,400, respectively, in 1979. Either of those figures stood at 53 percent of the comparable figures for the Changwat as a whole, the farm lands occupy approximately 60 percent of the total farm land area in the Changwat. Furthermore, the farm households in the Area was estimated at 17,900 in total with the farming population of 107,000. The average farm size is 3.15 hectares, almost equal to the Changwat average of 3.26 hectares.

10. Out of the total area of 74,000 hectares, 56,450 hectares will be cultivable. The paddy fields of 49,670 hectares account for 88 percent of the total farm lands. In the rainy season, almost all the area is occupied by paddy, while in the dry season, 12 percent is used for paddy cropping and five percent under upland cropping. The remaining 6,780 hectares (12 percent) are under upland cropping with cucumbers, pumpkins, melons, cabbages, chinese cabbages, etc. and also cropping with fruit and tree-crops such as lemons, mangoes, bananas, coconuts, sugar palms, etc.

11. The Kaeng Krachan reservoir as a source of water supply for the Phetchaburi Project has an effective storage capacity of 870 million cubic meters, being a multipurpose reservoir for irrigation, domestic and industrial water supply (685 million cubic meters), flood controls (170 million cubic meters), river conservation (15 million cubic meters) and power generation. Although there is no allocation of storage for power generation, the discharge from the reservoir is always controlled not to be below 10 cubic meters per second for hydropower generation. The existing irrigation system is composed of the four irrigation sub-systems of the left-bank, Numbers 1, 2 and 3 with the entire extension of its irrigation canals by 374 kilometers and the canal density of about 7.0 meters per hectare. As part of such irrigation project, drainage canals with a total length of 247 kilometers and the seadikes with 91 kilometers long have been constructed. Following the construction works of the main irrigation system, the farm ditches with the entire length of 1,529 kilometers (29 meters per hectare) were provided under the ditch & dike project for five years, 1964 through 1968.

Major Problems Involved in the Agriculture Development in the Project Area

12. Some 60 percent of the land in the Project Area is covered by soils whose parent materials are featured by marine alluvium, thus potentially giving rise to salinity problems in some form or other. Among others, the land extending along the shore in the northern and eastern parts of the Area (40 percent of the total area) is composed of soils substantially calling for desalination. In the dry season, more salinity is apt to accumulate in the top soil of fallow paddy fields, cyclically causing the soil pollution by salt and incomplete development of paddy seedlings for the transplanting in the rainy season. Although excessive soluble salts are easily leached by applying irrigation water, the effective irrigation and drainage facilities are essentially required for supplying and draining the considerable amount of water. Consequently, the dry season paddy cropping may be one of the effective measures to permit the leaching of soil salinity. Even if some fields are unavoidably left in fallow, it is advisable to leach away accumulated salinity to the possible extent, prior to ploughing for rainy season paddy cropping, through adequate drainage systems.

13. The paddy fields of 7,300 hectares in the extension area located downstream from the existing irrigated area are under cultivation depending upon an instable source of water supply such as surplus water from the upstream or rainwater, resulting in low productivity together with the soil salinity. Taking into consideration the fact that these fields provide a source to supply local inhabitants with their stable food and that this area has had no opportunity to conduct an isolated project, the area should be incorporated into the existing Phetchaburi irrigation area to secure the stable water supply including desalting water. Even in the existing irrigated area, the cropping intensity of paddy in the dry season is only 17 percent due mainly to the limited supply of irrigation water. Specifically, the paddy growing in the dry season is possible only in the fields where they are favorably irrigated, such as the upstream portions of the Project Area and the portions along the irrigation canals. The development of irrigation systems and the proper water management are of necessity for increasing the dry season cropping intensity.

14. The diffusion rate of high yielding varieties introduced in the rainy season is low (only 10 percent), whose yields also are relatively low as compared with those of traditional ones. This may be primarily attributable to the fact that the poor provision of on-farm facilities and uneven land leveling have caused the High Yielding Varieties with

high sensitivity to water management to be troubled in the early growth stage after transplanting.

15. The existing irrigation canals are 374 kilometer long, 55 percent of which is lined with concrete. The earth canals, accounting for 45 percent of the total, function poorly in discharge due to erosion on the slopes and heavy sediments in the canals, particularly in the left bank canals. Some of the farm lands along the irrigation canals are found to be impossible to take water from the irrigation canal by gravity. On the other hand, the irrigation canals are designed to produce head losses by many structures such as drops, checks, road crossings, etc. The study based upon topographic maps shows that the existing area irrigable by gravity system presently accounts for some 50 percent of the total farm lands, and the remaining farm lands are irrigated by surplus water from the upstream, which results in difficulty in on-farm level water management.

16. Based upon the recent three-year yield records of 273 farm households, an analysis was made on the correlation between the water use shown by the density of farm ditches and the distance from the diversion dam, and thereby, paddy yields in the area where gravity irrigation is possible have turned out to increase in proportion to the increase in the density of farm ditches, and to decrease in proportion to an increase in the distance from diversion dam. In the paddy fields where gravity irrigation is unavailable, there is no such correlation found out. This analysis shows that the general trend of paddy yields in the Area may indicate the major problems to be solved through the irrigation development project, although paddy yields are affected not merely by water use, but also by the features of soils, salinity, paddy varieties, the level of farming techniques, etc.

17. The groundwater table in the Project Area shows a tendency to annually increase with the dissemination of irrigation. The annual mean groundwater table of 0.8 meters below the surface in 1976 rose to 0.5 meter below the surface in 1979. Lowering the groundwater table below the root zone of paddy plants for leaching the soil salinity requires the installation of drainage pumping facilities for the low-lying lands, which occupy 60 percent of the total area.

18. The survey was made on the on-farm development for 50 farmers in the sample areas (five places with a total area of 1,490 hectares) selected for the purpose, and 84 percent of these farmers expressed the desire to practise the dry season paddy cropping if the water is available, and 86 percent wished that all fields should be linked with farm ditches. The investigation in the said sample areas shows that the number of paddy fields bordering irrigation ditches account for less than 30 percent of their total numbers, which suggests that the plot-to-plot irrigation rate is high. While the main and lateral drainage canals have been constructed, there are few drainage ditches connected with those canals.

19. Although the agricultural extension office has been provided in each Amphoe, extension agents are not always sufficient in numbers, and each agent is compelled to cover 1,100 to 1,800 farm households. In addition, they are suffering from the shortage in facilities and materials indispensable for their services. The services by an agricultural cooperative that has been established in each Amphoe are practically limited to credit service alone, except for the Ban Lat Agricultural Cooperative whose services are well balanced to cover a variety of fields. At present, the five water users associations, organized in 1969, are inactive in their services.

The Project

20. As regards the extension area located downstream of the existing irrigated area, irrigation water will be supplied to 7,300 hectares of the land used as paddy fields at present. Taking into account a decrease in the area of farm lands as a result of the implementation of the on-farm development, the possible beneficial area will amount to 52,600 hectares (paddy fields of 48,700 hectares, upland fields of 1,600 hectares, and orchards of 2,300 hectares). The bottleneck to enlargement of dry season paddy cropping area is the limited water source. As discussed below, improvement of the water use efficiency through upgrading the water supply practices and implementation of on-farm development would enable 14,300 hectares (29 percent of the paddy fields) to be used for the dry season paddy culture as the second cropping.

21. The double cropping for paddy culture calls for the introduction of high yielding varieties for the rainy season paddy cropping. Taking into consideration the levels of farming techniques and palatability of rice, it is planned to increase the diffusion rate of high yielding varieties up to 70 percent of the rainy season paddy. For upland field

crops as the second cropping of paddy, mungbeans may be most suitable since they are not only superior in drought resistance, but also high marketability in domestic and abroad. Of the second crops of paddy cropping, 7,300 hectares will be under mungbeans, and 7,000 hectares under dry season paddy. The area under upland field crops and tree-crops will not be enlarged; and attempts will be made to assure qualitative improvement through irrigation and betterment of cultivation techniques.

22. The forecast is made that, in the fifth year after completion of the two plans of irrigation improvement and on-farm development, the paddy yields will register 3.18 tons per hectare for the rainy season local varieties, 4.17 tons per hectare for the rainy season high yielding varieties, and 4.42 tons per hectare for the dry season high yielding varieties, by the combined effects of promotion of agricultural extension services, proper water management, etc. Thus, when the goal of development is attained, the annual paddy production will amount to 220,000 tons in terms of unhulled rice, 1.7 times as much as its present level.

23. In order to assure proper water management and maintenance of on-farm facilities based upon the proposed cropping plan, the organization and activities of the water users' association should be reinforced by encouraging beneficiary farmers to participate in these activities. The water users' association will be responsible for maintenance of the system downstream from farm turnouts installed in an irrigation canals and for the water management under the supervision of the Royal Irrigation Department. The National Agricultural Extension Services Program now being put into action will cover Changwat Phetchaburi by 1982, which will enable to increase extension agents in number at the rate of one for 600 farm households. Vehicles and audio-visual equipment also will be available in order to assure more efficient extension services in this Project Area.

24. The quantity of water to be consumed for paddy culture has been calculated on the basis of an observation conducted by the Royal Irrigation Department at the Water Use Experimental Station on the assumption that the water for the puddling of a paddy field would be 200 millimeters including the water for the initial leaching of salinity accumulated in the surface soils. It is expected that the lining of each canal, the on-farm development, and appropriate water management would improve irrigation efficiency to

60 percent for paddy cropping and to 50 percent for other crops than paddy. Irrigation for 52,600 hectares in the rainy season, and 18,200 hectares in the dry season would require an annual average water of 625 million cubic meter from the diversion dam. The peak demand for irrigation water of 59.3 cubic meter per second will appear in August when the puddling of the rainy season paddy cropping takes place.

25. Based upon the proposed cropping pattern, water balance computation for the Kaeng Krachan reservoir (an effective capacity of reservoir: 700 million cubic meter) was made by applying the data available for seven years (1974 - 1980). It should be noted, however, that the study includes the minimum release to keep the discharge of the Phetchaburi river downstream from the diversion dam by 5.0 cubic meters per second and the supply of domestic and industrial water by 2.34 cubic meters per second. Furthermore, it must be added that the release for power generation is assumed on the basis of the actual values recorded in the period cited above, while the proposed release from the reservoir takes larger one of either actual release for power generation or downstream demand of irrigation, domestic and industrial supply and river conservation. The proposed plan can forecast that the reservoir operation would not become worse than at present. The most critical conditions imposed successively by the lowest precipitation in 1979 in the Project Area and the lowest inflow to the reservoir in 1980, dropped the water storage to a record of 1.7 billion cubic meter in 1980. It may be regarded, however, as an abnormal drought in the project planning.

26. In order to correct an imbalance in the layout of irrigation canals in the left-bank area, the three irrigation canals (concrete lining - 11 kilometers) and the earth canals for a dual use of irrigation and drainage with the total length of 109 kilometers in the extension area, where no irrigation network is available, will be newly constructed. All the existing earth canals of 167 kilometers will be concrete-lined for reducing the conveyance loss and saving of maintenance costs. The side slope of the existing concrete lining canals of 128 kilometers will be hightened in order to raise their full supply level by 0.1 to 0.5 meters.

27. The drainage system provided under the Phetchaburi Irrigation Project has generally resulted in amelioration of drainage conditions, except for scattered depressed areas. The construction of drains as part of the on-farm development will contribute to improvement

of drainage conditions on farm level, together with the drainage conditions of the depressed areas. The supply of enough water for the puddling will decrease the soil salinity, whereas the subsequent rise in water table will increase the soil salinity in some paddy fields. To make leaching of soil salinity more effective would call for measures to lower water table. It would be necessary, therefore, to lay closed conduits at intervals of some 10 meters in the fields with low permeability soils. Also, 60 percent of the Area would require pumping drainage although the Project will not employ this method from the economical viewpoint. The initial leaching of soil salinity, when puddling, will reduce the damage to some extent to the young seedlings immediately after transplanting.

28. The following three options have been set up in order to examine the development levels of on-farm facilities suitable for the Area. Type A represents the most intensive development, according to which every farm plot is rearranged into rectangle so as to increase the efficiency of water management and field labor, for which land leveling will be required. Type B would provide irrigation and drainage systems in every field. However, the length of ditches would not exceed at most 1,000 meters in order to facilitate water control; the layout of the canals may, if necessary, segment the fields. In such case, however, re-adjustment may be conducted for the divided lots. Type C represents an extensive development, according to which fields owned by 70 percent of land owners would be allowed to carry out direct irrigation and drainage to and from their fields; farm ditches and drains will be located on the boundary of their owned lands.

29. According to the case study conducted in the sample areas, the cost per hectare for the on-farm development would be 1,100 in US Dollars for Type A, 478 in US Dollars for Type B and 387 in US Dollars for Type C. Type A involving rearrangement of farm lots and land leveling is expected to be highly effective, although expensive. The basic way of approach to the on-farm development program for the agricultural development is that plot-to-plot irrigation and drainage is undesirable. Taking into account the financial pressure, farmers' burdens, farmers' farming technical levels, limitations of the water sources in the dry season, etc., it would be a premature to employ Type A on a full scale. From such viewpoint, it has been concluded that the application of Type B to the Project would be more reasonable. In view of drainage conditions in the low-lying extension area and its vicinity and also in the areas not to employ the leaching of soil salinity by means of under drain, the lower cost Type C

will be adopted in the area with limitations in agricultural production. Consideration of various conditions such as topography, ground elevation, and soil salinity has resulted in that 70 percent of the Project Area would adopt Type B and the remaining 30 percent Type C.

30. In order to attain the irrigated agriculture development in the Phetchaburi area, it is proposed to execute the irrigation improvement project for the construction and rehabilitation of main irrigation systems as well as the on-farm development project including the upgrading of supporting services. Not only can the irrigation improvement project generate a development benefit independently but also can serve as a prerequisite to increasing the effects of the on-farm development project. The general descriptions of the Project Area summarized as follows:

a. Irrigation improvements project:
   - o Construction of irrigation canal: 120 kilometers
   - o Lining : 167 kilometers
   - o Rehabilitation : 128 kilometers

b. On-farm development project:
   - o Construction of on-farm facilities: o Type B ..... 36,100 hectares
     o Type C ..... 16,500 hectares
   - o Supporting services : o Procurement of Operation and Maintenance equipment
     o Organization of water users' association

Construction Schedule

Work Items \ Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Pre-construction Works															
Irrigation Improvement Project															
On-farm Development Project															

31. The construction costs of the Project would be 2,216.7 million in Baht (1,830 of US Dollars per hectare) excluding a contingency for price escalation. However, the costs for organizing the water users' associations have been included in the Operation and Maintenance cost, but not in the construction cost.

Project Cost

(Unit: million in Baht)

Work Items	Local Currency	Foreign Currency	Total
1. Civil Works			
1.1. Irrigation Improvement Project			
- Rehabilitation	417.9	171.0	588.9
- Construction	278.3	113.8	392.1
Sub-total	696.2	284.8	981.0
1.2. On-farm Development Project	315.3	140.8	456.1
1.3. Depreciation Cost of Machinery	(16.4)	(189.5)	(205.9)
Total (1)	995.1	236.1	1,231.2
2. Machinery and Equipment	33.9	393.7	427.6
3. Others	243.3	112.8	356.1
Total (2)	1,272.3	742.6	2,014.9
4. Physical Contingency	127.5	74.3	201.8
Total (3)	1,399.8	816.9	2,216.7
5. Price Escalation	2,358.3	803.9	3,162.2
Total (4)	3,758.1	1,620.8	5,378.9

Note: Foreign exchange rate: US Dollar 1.00 = Baht 23.00

32. The economic evaluation of this Project has been made on the Internal Economic Rate of Return from the viewpoint of national economy on one hand, and on the beneficiary farmers' financial analysis from the viewpoint of their farm economy on the other. The Internal Economic Rate of Return has been estimated at 26 percent, indicating the Project to be economically feasible. The sensitivity analysis with targets and conditions in alternate has indicated that the Internal Economic Rate of Return in any cases exceeds 20 percent and the Project was found feasible even in the following cases.

	Internal Economic Rate of Return (percent)
Two-year delay in target	23.3
10 percent decrease in target yields	23.2
10 percent decrease in rice price	23.6
10 percent increase in crop production cost	25.3
20 percent project cost overrun	22.6
Three-year delay in completion	25.7

A financial analysis was made on the three of the farm size (5.6 hectares, 4.1 hectares and 2.1 hectares). The analysis suggests that the farmers in the Project Area would be able to earn the annual disposable income of 8,000 to 11,000 in Baht in keeping the present standard of living, even if they bear 90 percent of the cost for the on-farm facilities and 100 percent for the Operation and Maintenance cost.

CONCLUSION AND RECOMMENDATIONS

Conclusion

1. The Project has been based upon the outcome of the existing Phetchaburi Irrigation Project

In Thailand, the irrigated agriculture development projects have been launched after World War II in the basin of the Chao Phya river located at the central delta, under the cooperation of international financing agencies on a large scale. The Phetchaburi Irrigation Project is one of the projects undertaken in the peripheral area of the delta of the Chao Phya river together with the Mae Klong Irrigation Project.

The said project has provided the so-called modern irrigation system from the Kaeng Krachan storage dam to farm ditches through the Phet diversion dam and main/lateral irrigation canals, which has allowed to develop rapidly the tropical brushes with coconuts and rain-fed paddy fields scattered there around. This project area has covered some 50,000 hectares of paddy fields producing the paddy of about 130,000 tons per annum.

2. The Project plays an organic part of the phased development plan

A concept of the Phetchaburi Irrigation Project might originate in 1910's; the first survey was conducted in 1936. The development of the area has been taking a considerably long time under the deliberate contemplation. The construction of the Phet diversion dam and the main and lateral irrigation canals was the Stage I; subsequently, that of the Kaeng Krachan reservoir and additional canals was the Stage II. Furthermore, a series of these works has been integrated into Phase I with Phase II and III. In Phase II, those existing facilities will be fully used to tackle the on-farm development. Phase III is expected to assure the full development of the area and its vicinity by constructing additional dams and reservoirs. The present survey is included in Phase II, which is featured by the role in such long-term development program.

3. The Project can be found fully feasible from the both viewpoints of national economy and farm economy

The development of the Project, as discussed above, corresponds to the present situation of the irrigated agriculture development as a whole. An attempt to make the most of the effect of the existing irrigation and drainage systems through on-farm development would be in accord with the principle of investment "the greater effect by less investment".

The Internal Economic Rate of Return for the Project has been estimated at 26 percent, and at 20.5 percent in the minimum rate by the sensitivity analysis on the condition of 90 percent of attainment in target yield with two-year delay. Also, this area having the present output of some 130,000 tons (unhulled rice) is expected to have the further potentiality to produce paddy by 220,000 tons per annum through the Project.

Meanwhile, from the angle of the farm economy, although the insufficiency of living costs defrayable by farm income is now covered by non-farm income, most of farm family would be able to earn a sufficient livelihood with farm income only even if they would bear 90 percent of construction costs of on-farm development works and 100 percent of costs for Operation and Maintenance of the system.

4. The Project is composed of the following two components

The existing irrigation and drainage systems have much room for improvement. Furthermore, fully effective utilization of the facilities will call definitely for more on-farm developments. In other words, the Project comprises two aspects; 1) irrigation improvement to upgrade the existing irrigation systems and to construct new facilities, and 2) on-farm development. The former is considered as a prerequisite to assuring the more effective implementation of the on-farm development.

5. In making a plan of on-farm development, case studies have been made for three of options with different levels of land consolidation; Type A(intensive), Type B (semi-intensive) and Type C (extensive). A survey of field condition has revealed that the higher the extent of plot-to-plot irrigation has become, the more difficult the adequate water management would become, to result in a cause of the low yield. The basic

approach to on-farm development is to provide every farm plots with terminal irrigation and drainage facilities in replacing with plot-to-plot irrigation and drainage, to which the Type A and B will conform. The Type A, however, calls for so huge costs for land leveling that it seems to be early to employ it for the Project in view of farmers' potential, financial burdens and a limitation of water availability during the dry season. Under these circumstances, the Type B has been proposed as the best available one. However, Type C will be proposed for the areas located in low-lying lands where salt problems will be hardly solved as subsurface drainage is not employed from the viewpoint of project economy.

6. The Project is designed not merely to increase the cropping intensity of the dry season paddy, but also to stabilize the rainy season cropping in the rain-fed fields along the seadikes.

At present, about 8,000 hectares are under the dry season paddy and the upland field crops. However, the Project will expand such area up to over 18,000 hectares.

And, the Project will incorporate into the irrigation area some 7,600 hectares of the rain-fed paddy fields along the seadikes, in order to increase paddy production through effective irrigation including initial leaching of salinity.

The Project will increase the land use ratio from the present 117 percent to 135 percent. Further increase in the dry season paddy cropping would be impossible unless an additional development of the water resources is implemented. In this connection, the agricultural labor supply in the Area is enough to cope with any demand even at the peak for the rainy season paddy cropping. However, in the dry season are there slack time in farming works.

7. Problems of Soil Salinity

An increase in the agricultural productivity of the Area requires the reduction of soil salinity, for which the lowering of groundwater table may be essential. However, a greater part of the high salinity farm lands is located in the low-lying lands at the elevation below 2.0 meters, having considerably impermeable soils. For improving these conditions, open drains or conduits will be deemed most efficient. Since, however, these facilities are very costly, the Project has not involved the construction of the sub-surface drainage system in the Plan.

Recommendations

1. Early Commencement of the Works

As mentioned above, inasmuch as the Project is feasible from both the standpoints of national and farm economy, it is recommendable to start the works as early as possible.

However, the Project, covering a large area of about 60,000 hectares, will require a huge investment for about 15 years after its commencement. In order to implement the Project in the early stage even if the financial constraints should exist, the irrigation improvement project to upgrade the existing facilities could be started as an independent project under the Irrigated Agriculture Development Project.

The internal economic rate of return for the irrigation improvement project only has been estimated at 27 percent, while that for the other component, on-farm development, which could be individually implemented after the completion of the said irrigation improvement project, has been estimated at 26 percent.

This means that the implementation of the irrigation improvement project as an independent project from the on-farm development project is feasible in view of economy.

2. Expansion and Reinforcement of Water Users' Association

The successful agricultural production after implementation of on-farm development project requires the formation and aggressive activities of water users' associations. Specifically, this is because, following the water distribution and the operation and maintenance services responsible by the Phetchaburi Project Operation and Maintenance Office for main and lateral irrigation canals, the farmers carry out water distribution and the operation and maintenance of farm ditches from the turn-outs. Also, it will become necessary to collect water charges. These fundamental services will require to provide the buildings, office equipment, and others, at least, for performing the works smoothly.

3. Strengthening of Supporting Services

The agricultural production in well consolidated fields needs to introduce the modern agricultural techniques and to strengthen the organization of agricultural extension services as well as the agricultural cooperatives for maintaining a highly advanced farming in the Area.

In order to make the enormous amount of investment most effective, it is desirable that those activities of extension offices and agricultural cooperatives can be employed in the Area as the Project along the national policy and under the foreign aids.

CHAPTER I INTRODUCTION

CHAPTER I. INTRODUCTION

1-1. The Background of the Cooperation in Irrigated Agriculture Development Project in Thailand

Thailand with its rich agricultural resources, the traditionally largest rice exporter in the southeast Asia, has carried out many irrigation and drainage projects since the days before World War II with its high technology. After World War II, the global food crisis - particularly rice shortage in Asia - allowed the country to draw a world-wide attention in its necessity and potential of paddy production increase. Actually, the Food and Agriculture Organization (FAO)'s investigation, International Bank for Reconstruction and Development (World Bank) finances, American aids in both capital and technology have enabled Thailand to encouragingly execute numerous irrigation and drainage projects in the Central Plain as well as north and northeast Thailand.

Many dams, main and lateral canals were constructed in these projects. As the result, Gross Agricultural Products increased steadily, but this was due mainly to extensive increase in cropping acreage resulting from these irrigation projects, whereas the increase in productivity per unit area was rather small. In other words, absence of secondary and tertiary canals, turn-outs and on-farm facilities has prevented full utilization of irrigation water, although completion of the dams and main canals has enabled to introduce the water to be ready for use. Such an inability in full-scale irrigation has resulted in partial drought or flooding which have annually made about 20 percent of the total paddy fields to become impossible in cropping or harvesting.

To improve the situation the Thai Government carried out the projects to consolidate on-farm facilities under the Dikes and

Ditches Act (1962). In the years from 1963 to 1969, the farm ditches had been constructed at on-farm level in about 800,000 hectares (ha) of irrigable area in the project on the force account basis of the Royal Irrigation Department (RID). These ditches under the Dikes and Ditches Act, however, turned out not to function effectively. The reasons are that there were many fields found under the plot-to-plot irrigation in the downstream portions from the ditches provided and also many fields found poorly irrigated due to insufficiency of the design capacity.

The continuous efforts to find a breakthough for such circumstances were made in the forms of several experimental projects of land consolidation under foreign aids. In 1974, eventually the Land Consolidation Act was enacted and, in 1975, Agricultural Land Reform Act successively. The Central Office of Land Consolidation was set up under the Ministry of Agriculture and Cooperatives (MOAC). The administrative system was reformed through these actions and the authorities concerned had begun to tackle the problems on the on-farm development of the existing irrigation projects with their energy concentrated.

With the background stated above, the Thai Government requested the Japanese Government to cooperate in Irrigated Agriculture Development for On-farm Development at four specific areas. Accepting this request for cooperation, the Japanese Government sent the preliminary survey team for the irrigated agriculture development in Thailand in the same year. The survey team, having made field investigations and frequent consultative meetings with the Thai authorities concerned, concluded that the basins of both the Mae Klong river and the Chao Phya river should be taken up as the objects of the studies. These studies have resulted in the Master Plan study of the Greater Mae Klong River Basin Development including the pilot project and the feasibility study of the said river basin, and the

Chao Phya River Basin Development Project including the pilot project and the feasibility study of the said river basin.

Since the Phetchaburi Irrigated Agriculture Development Project, included as one of the four objective areas of technical cooperation in 1976, adjoins to the southern area of the Mae Klong Basin, it was decided that this project would be undertaken after carrying out the above Mae Klong project. And the official request for cooperation was made in September, 1978. In response to the request, the Government of Japan sent a preliminary survey team to the field in November, 1979. The said survey team confirmed the requirements of the Thai Government, the proposed project area and the proposed Scope of Works for feasibility study through the field investigation and consultation with the Thai Government concerned for 18-day activities from November 14 to December 1, 1979.

The preliminary survey team confirmed the contents of the Terms of References for the feasibility study prepared by the RID as well as made a recommendation for scheduling that the first field investigation team would be dispatched around the middle of October, the outset of the rainy season, in 1980 so as to carry out the investigation available without detailed topographic maps, while to cooperate with RID in preparing the topographic maps with a scale of 1:10,000 for the Project Area, and in 1981 the investigation and study would be made to supplement the works in the previous year in planning for construction works based on the newly-prepared topographic maps and in conducting the farm management survey for the rainy season paddy cropping so that a series of these works could be completed in the end of March 1982.

Following the recommendation, the first feasibility study was carried out in the field from November 19, 1980 to January 31, 1981, and the home works followed. Furthermore, the second feasibility study was carried out in the field from June 22 to August 11, 1981, and the home works followed.

1-2. The Purposes and Scope of the Works

The purposes of the study are specified in the Scope of Works resulting from the consultative meeting between the preliminary survey team and the Thai Government. They are:

a. To formulate an Irrigated Agriculture Development Project, based on the staged development, and to study its feasibility; and

b. To train the Thai staff concerned through the study and survey.

The agreements on the staged development of the Project between the preliminary survey team and the Thai authorities concerned are as follows: that is, the Phetchaburi Irrigation Project, including Kaeng Krachan Storage Dam completed in 1966, is defined as Phase I, which should be divided into Stage 1 to provide the diversion dam and canals covering the irrigation of 34,200 ha and Stage 2 to provide the Kaeng Krachan Dam and reservoir covering the irrigation of 53,300 ha. Phase II aims at the on-farm development to utilize the existing irrigation-and-drainage systems and water resources available therefrom and achievement of Irrigated Agriculture Development; and Phase III aims at integrated development of the Phetchaburi Basin to construct new dams and reservoirs. Although the study of the Phetchaburi Irrigated Agriculture Development Project is included in Phase II, the evaluation and review of the existing facilities constructed in Phase I are covered by this study, taking into

account the relations with the development in Phase III. Such a strategy corresponds to the description on the staged development in the Scope of Works.

The term of "Irrigated Agriculture Development Project" is defined in the first request for cooperation made by Thailand, stated in 1-1. The definition of the term confirmed by the Thai authorities concerned for the survey team at that time was as follows:

> The term of "Irrigated Agriculture Development" means the integrated on-farm development based on land consolidation works which will result in paddy double cropping of and/or diversification of crops and increases in productivity.

This Irrigated Agriculture Development Project covers the integrated and wide range of works such as reinforcement of the so-called supporting services of agricultural cooperatives and other farmers' organizations, and extension of advanced agriculture by which farmers can modernize their management for themselves on the consolidated farm land, as well as land consolidation which is the center of the project leading to double cropping of paddy and crop diversification.

The minutes of discussion between Thai authorities concerned and the preliminary survey team clarify that the feasibility study teams aims at formulating a staged development plan for the irrigated agriculture and looking into its feasibility, and the said study should cover the following two items, accordingly. One is to evaluate the Phase I project and review the needs of rehabilitating and improving the existing facilities provided in Phase I including some new construction works.

The other is to plan the Phase II project of the Irrigated Agriculture Development Project with on-farm facilities consolidation. In order to achieve these purposes, the investigation began with collection and analysis of the existing data and information available about the current situation on the Project Area, being followed by mapping works in cooperation with Thai officials concerned and field investigations on meteorology, hydrology, topography, geology, soils, and so on. Furthermore, the fact-finding, review and evaluation were carried out for the existing major facilities, irrigation/drainage facilities, on-farm conditions, farm management, extension services, farmers' organization, etc.

With such knowledge on the present situation, a plan was studied and established for rehabilitation and upgrading of existing irrigation and drainage facilities, including some new construction, and then according to the said plan, an on-farm development plan was made up. In this planning, five Sample Areas were selected to represent each of the field conditions in the Project Area for applying different levels of consolidation to each sample area.

Although the gross area had been originally estimated to be 60,000 ha, the total Project Area was defined by 74,000 ha through studies. This includes the area for Phetchaburi Irrigation Project and the so-called Extension Area along the seadikes.

1-3. Outline of Investigation

The first survey team, consisting of 10 specialists, started the field works in November 19, 1980 and finished in January 31, 1981. During field works, the available data, information, topographic maps, published reports and so on were collected and reviewed. The field-investigation was carried out for soils, irrigation and drainage, state of land consolidation works and present agriculture and farm management, etc. Besides, basing on the results of investigation, frequent discussion meetings

were held between the Thai authorities concerned and the team to outline the irrigated agriculture development project.

The second survey team, consisting of nine specialists, started the field works on June 22, 1981 and finished on August 11, 1981. The investigation was made on the soils and the present state of land use, water use, farm management and soils in the rainy season to supplement the first survey made in the dry season. Furthermore, the data and information were collected additionally, and the detailed study was carried out on the land use and irrigation/drainage systems based on the newly-prepared topographic maps after the first survey.

As home works, preparation was made on the development plan for the Irrigated Agriculture Development Project which had been outlined by the first survey team, based on the supplementary investigation, additional data, detailed topographic maps and so on, which are described above, and a Project plan was formulated based on various computations and estimations.

In the second survey, besides the field survey for saline concentration in the soils, a salinity leaching test was conducted at paddy fields of the Phetchaburi Water Use Experimental Station of RID under the cooperation of RID so as to find the movements of soil salinity.

These field investigations were carried out with cooperation of the Thai Counterparts Personnel assigned from RID, and other Thai Officials of Operation and Maintenance (O & M) Office, Water Use Experimental Station, Central Office of Land Consolidation, Survey Division and other Governmental Organizations and Agencies concerned. The whole of the study of the Project was carried out under the guidance and directions of the Advisory Group.

Members engaged in the Survey and the Thai Officials concerned are listed below;

(1) Supervisory Group

Mr. Shigetoshi Morimoto	Director Design Division, Construction Department, Tohoku Regional Administration Office, Ministry of Agriculture, Forestry and Fisheries (MAFF)
Mr. Masaki Shimizu	Deputy Director, Project Planning Division, Planning Department, Agricultural Structure Improvement Bureau (ASIB), MAFF
Mr. Kazumi Miyamoto	Deputy Director, Disaster Prevention Division, Construction Department, ASIB, MAFF
Mr. Kohzo Yamashita	Deputy Director, Design Division, Construction Department, ASIB, MAFF
Mr. Kazutaka Ogawa	Deputy Director, Resources Division, Planning Department, Kanto Regional Administration Office, MAFF
Mr. Yoshimi Shiraishi	Deputy Director, Regional Planning Division, Planning Department, ASIB, MAFF
Mr. Shigeru Takeda	Deputy Manager, 2nd Technical Appraisal Division, Economic Research and Technical Appraisal Department, The Overseas Economic Cooperation Fund (OECF)

(2) Survey Team (Sanyu Consultants Inc.)

Mr. Heiziro Yoshihara	Team Leader
Mr. Kunio Ohta	Irrigation and Drainage
Mr. Kosaku Chichibu	On-farm Development
Mr. Yoh-ichiro Kuroda	Hydrology
Mr. Toshihiro Tohyama	Structure
Mr. Yutaka Tominaga	Design
Mr. Norio Koiwa	Soil
Mr. Makoto Yasuda	Geology
Mr. Tatsuo Hamajima	Agriculture

Mr. Tetsuo Dokiya	Agricultural Institution
Mr. Mitsutomo Anai	Agricultural Economy

(3) Counterparts Personnel

Mr. Udom Rakchanya	Director, Operation and Maintenance Division (O & M), RID
Mr. Sa-ard Mahakanjana	Director, Irrigation Regional Office X
Mr. Ratana Parnburanananth	Project Engineer, Phetchaburi O & M Project
Mr. Paisaln Thienklum	Chief, Irrigation Engineering Section, Irrigation Regional Office X
Mr. Anek Wichayakul	Chief, Ditch & Dike and Land Consolidation Section, O & M Division
Mr. Osot Chanvej	Agronomist, Irrigated Agriculture Section, O & M Division
Mr. Prasert Milinthangkul	Chief, Research and Applied Hydrology Section, Hydrology Division
Mr. Amnuay Somsin	Hydrologist, Research and Applied Hydrology Section, Hydrology Division
Mr. Danai Triyadhen	Chief, Land Classification Section, Soil and Geology Division
Mr. Arun Nanthawisaln	Geologist, Soil and Geology Division
Miss Supha Singintara	Chief, Economic Section, Project Planning Division
Mr. Pittaya Hiranburana	Economist, Economic Section, Project Planning Division
Mr. Narong Sopak	Mapping Expert, Aerial Photo Mapping Section, Topographical Survey Division
Mr. Nit Dhanunajarn	Mapping Expert, Ground Survey Section, Topographical Survey Division

CHAPTER II BACKGROUND

CHAPTER II. BACKGROUND

2-1. National Economy

2-1-1. Land and Population

The national land area is 514,000 km^2, which is about 1.4 times as much as that of Japan. The land can be roughly divided by topography into the mountainous area of the west, the north and the southeast, and the flat area of Central Plain and Korat Plateau in the northeast. The weather is of typical Asian monsoon type: from May to October, the humid southeastern monsoon from the coast brings rainfall most of which takes place in September; but on the contrary from November to April, the dry northeastern monsoon blows from the Continent bringing the dry season with little rainfall. However, the southern peninsula, influenced by the specific topography, has almost no dry season with the northeast monsoon rainfall as much as 2,500 millimeters (mm) per annum. The other areas of the country have recorded the annual rainfall by 1,500 mm on an average.

Administratively, the country consists of 72 Changwats. Economic divisions of the country, concentrating in agriculture, are in general the four regions: North, Northeast, Central Plain and South. The mountains and forest lands are predominant in the north region, and only about 20 percent of the lands is farm lands. The region occupies 18 percent area of the national land area and 22 percent of the total population. The soils are weathered and sterile in the northeast region which is centered with Korat Plateau: and though this region occupies 32 percent in the land area and 34 percent of the population of the country, its agricultural productivity is the lowest of the country. In the Central Plain which includes the fertile Chao Phya Delta, productivity of the crops such as paddy and many upland crops is high in coupling crop diversification. The region occupies 36

percent in the land area and 32 percent in the population of the national total. The south region is the area along Malay Peninsula, where fishing is prosperous and the major crops are coconut palms, rubbers and so on, besides paddy, occupying 14 percent in the land area and 12 percent in the population of the country. The Phetchaburi Irrigated Agriculture Development Project Area is located at the southern end of the Central Plain.

The national total of the population as of 1979 is 46,110,000, and the density of population is 90 persons per one square kilometer (sq.km). Since the population was 25,630,000 in 1960, the annual mean increase rate up to 1979 is 3.14 percent. The annual mean increase rate of the former decade, 1960 to 1969, however, is 3.27 percent, whereas that of latter decade, 1970 to 1979, decreases to 3.0 percent. Especially, when compared with 42,380,000 of 1975, the annual mean increase rate of these five years is 2.2 percent, which shows a decreasing tendency in general. The population of Changwat Phetchaburi to which the Project Area belongs was 362,000 in 1979 and 246,000 in 1960, and thereby the annual mean rate of increase up to 1979 is 2.05 percent, which is far below the national mean.

2-1-2. Scale of National Economy

According to the data available for these last three years, the Gross National Products (GNP) was ฿298.6 billion in 1975 (฿ 203.34 billion by 1972 constant value) and ฿473.63 billion in 1978 (฿264.06 billion by 1972 constant value). The growth rate during those years is 9.1 percent by annual mean by 1972 constant value.

The sectoral shares in GNP in 1978 are 27.5 percent for agriculture, forestry and fisheries, 2.2 percent for mining, 18.4 percent for manufacturing, 5.4 percent for construction, 6.2 percent for transportation and communication, and 19.8 percent for commerce. Agriculture, forestry and fisheries, having occupied 31.4 percent in 1975, resulted in decrease by nearly four percent within three years.

The average annual growth rate of the respective sectors for four years from 1975 to 1978 are 7.2 percent for agriculture, forestry and fisheries and 6.4 percent for commerce, both of which were marked below 10 percent, while 10 percent for mining, 11.6 percent for manufacturing, 17.4 percent for construction and 12.7 percent for power and water supply, all of which were marked over 10 percent.

GNP per capita increased from ฿7,132 in 1975 (฿4,856 by 1972 constant value) to ฿10,502 in 1978 (฿5,855 by 1972 constant value) and the annual average growth rate is 6.5 percent. The amount of ฿10,502 in 1978 is equivalent to US$525 on the assumption that one dollar is ฿20, which is fairly high in comparison with the average of Southeast Asian countries.

2-1-3. Economic and Social Development Plan

The economic development plan of Thailand was started later than other countries did, and the First Six-year Plan (1961 to 1966) was the initial attempt for the nation. In both the First and the Second (1967 to 1971), the raising of development funds and the investment plan for development were the major contents. The allocation for agriculture and irrigation was around 14 to 15 percent each, which was not always said to be an appropriate share for the importance of agriculture at that time.

In the Third Five-year Plan (1972 to 1976) taken up were the promotion of local development and the correction of regional income disparity in stressing the investment for encouraging education and so on. Investment for agriculture and irrigation was 14 percent of the whole, whereas occupying 32 percent of the total amount of budget for economic development. Although the target of Gross Domestic Products (GDP) increase was seven percent, it turned out to be 6.2 percent, and income per capita was 3.3 percent against 4.5 percent of the target. The actual growth rate of agricultural sector was 3.9 percent which was under the target growth of 5.1 percent. These were caused by bad weather in 1972 and 1976. Those which achieved more than target economic growth were manufacturing, transportation and communication, and so on. The total amount of export was increased by 14 percent, far more than the target of seven percent, which was caused by great increase in sugar export.

The Fourth Plan (1977 to 1981) stressed the policies of social fairness and consolidation of security rather than economic growth under the influence by change in international circumstances such as the unification of Viet-Nam. Economically, this was an emergency policy to overcome the depression at the end of the Third Plan 1977 through early 1978, but the actual growth rate of GDP turned out to be 6.2 percent which was below that was marked in the previous year (8.2 percent). This was caused by decrease in agricultural production as large as 2.8 percent of the previous year due to drought. Basic target of the Fourth Plan is 1) economic rehabilitation, 2) correction of income disparity, 3) control of the population growth, qualitative improvement of human resources and increase in employment opportunity, 4) control of fundamental resources and environmental conservation, 5) powerful national defence build-up, and so on. The targets of annual average increase were set at seven percent for GDP, five percent for Gross Agricultural Products, and 7.7 percent for Gross Non-agricultural Products, respectively. The

target of five percent for Gross Agricultural Products is higher than the actual results of the Second and the Third Plans, because the increase in agricultural productivity in these regions and the increase in farmer's income by diversification of agriculture are indispensable for correcting the income disparity among industries and regions, and especially for promoting the development of low-income regions. In view of investment, 15.5 percent of the total investment and about 41 percent of the investment for economic development are made for agriculture and irrigation. This is higher than those investments for agriculture and irrigation in the Third Plan by 1.5 percent for the rate of the total investment and nine percent for the rate of the economic development investment. These figures show the increasing importance of the development of agriculture and irrigation.

As for these targets, at the time to prepare the Fifth Plan, GDP are estimated to increase by 7.9 percent, Gross Agricultural Products by 3.9 percent and Gross Non-agricultural Products by 9.4 percent. The agricultural sector, which is expected not to achieve the target in its Gross Agricultural Products, has been still playing an important role in the national economy in spite of many difficulties involved in its achievement, although the target of GDP will be accomplished by successful achievement of the prospective non-agricultural sector over the target.

The draft of the Fifth National Economic and Social Development Plan, which was started in October, 1981, was announced officially in January, 1980 by National Economic and Social Development Board (NESDB). This plan stresses the decrease in absolute poverty and the qualitative advance of the life of the local people through economic stabilization and social security rather than the rapid economic growth. In order to accomplish the purpose, the

following five targets are set up;

1) decrease in absolute poverty and promotion of development of the underdeveloping regions,
2) economic and financial stability,
3) reorganization of agriculture and industry,
4) improvement of the social structure, and
5) economic development and establishment of national security,

In order to achieve these targets, the government will carry out the short-term adjustment policies necessary for curbing the gross national demand and reinforcing the domestic deposits in the future and the structural improvement policies to cope with the changing domestic and international circumstances as well as to consolidate the fundamental socio-economic system.

The short-term policies are to be executed along with the following directions; a. financial policy to decrease the deficits in trading and national finance, b. saving energy, c. trading policy to lower the import and to promote the export, d. fair price policy to both producers and consumers, and e. plan to create employment opportunities.

The structural adjustment policies can be summerized by the following ten items;

a. Regional and agricultural sectors: Specified into developing area and developed area. In developing area, investigations and training are to be carried out to execute the development of small-scaled water resources, the development of inland fisheries and other policies. In developed area, various kinds of services are to be rendered to promote the sale of agricultural products, prices control, financing, etc.

Especially in those area where irrigation projects have already been taken up, the government will extend the irrigating facilities and impose the water charges for better water use.

b. Industrial sector: Stress is placed on promotion of export, restriction of import, promotion of employment and dispersion of industries in the country.

c. Energy substitution: Mineral resource will be exploited, while import of petroleum shall not be increased more than what it is now in quantity. The domestic energy substitution is promoted.

d. Development of science and technology and conservation of environment: The system is to be established to provide farmers with basic technical knowledge on the selection of seeds and animals, pest control, etc. to realize economic and efficient farming. The development of techniques shall be promoted to change raw material export to processed or half-processed products export with higher values added. As for environmental policy, stress is laid on forest protection and afforestration, construction of waterworks and sewerage, regulation of groundwater utilization, etc.

e. Dispersion of ownership: Reformation of taxation system shall be established to mitigate the concentration of wealth and property to banks, manufacturers and commerce, and expansion of financing system is to be provided to prevent small farmers from selling their lands.

f. Reformation of administrative structure for development: Reformation of the administrative structure for development will be carried out for the consolidation of the administration.

g. Development of specific areas and communities in underdevelopment is to be made for releasing from poverty and correction of income disparity.

h. Population and employment: Employment rate shall be controlled under 1.5 percent per annum to cope with economic development.

i. Regional development and diffusion of social services to the local communities and human resources development shall be promoted.

j. Consistency in national economy and security.

2-2. Agricultural Sector

2-2-1. General Conditions

Of 514,000 sq.km of the national land, 186,000 sq.km is farm land, which is 36 percent of the total area (as of 1975). The forest land is 210,000 sq.km, equivalent to 41 percent. According to the Agricultural Census in 1963, the farm land occupied 22 percent of the national land, which shows a great increase in farm land area. The cultivable land was fairly expanded during the period of the Third Plan, to result in devastation of forest land resources. In the Fourth Plan the correlation of agricultural development and conservation of forest resources was discussed and this awareness of the problem is reflected in contemplaction of the Fifth Plan.

The statics of 1977 indicates that the number of farming family is 29,213,000, equivalent to 66.6 percent of the total population of 43,857,000. The number of farming households is 4,009,000, which is 51.2 percent of the total households of 7,825,000. The farming population including those for forestry and fishery is 15,451,000, corresponding to 63.2 percent of the total working population of 24,417,000. These show the over-whelming importance of agriculture.

The area of paddy field is 117,000 sq.km, which is 63 percent of the total agricultural land, and paddy cropping is found to be

important among others. The paddy cropping is not merely a part of the agriculture, but an important economic activity that has seriously affected the land use and the way of life of the Thai people in terms of history, society, and culture.

2-2-2. Agriculture in National Economy and Trade

As stated above, a greater part of the Thai people lives in the rural areas and are engaged in agriculture, but the share of agriculture in national economy and trade has been becoming smaller.

According to the statics by MOAC, the share of Gross Agricultural Products in GNP was decreased by about 10 percent to 29.9 percent in 1976, which had been 39.8 percent in 1960. This came from comparatively large expansion of non-agricultural sector with the progress of national economy. Although the increase rates of both agriculture and non-agriculture sectors are higher than those of other Asian countries, they tend to decline, and the problem is that the gap between the increase rates between the agriculture and non-agriculture is still rather large.

Of the agricultural sector, the most important crop is naturally paddy. The paddy production has been still increasing steadily after World War II, however, the relative share of paddy production in the total agricultural product has been decreasing with advance in diversification of crops and especially with increase in maize production since 1960. The paddy planting area was 67 percent of all area under crops in 1960's, which had been about 88 percent in 1950's. However, the paddy, cropped in the area slightly less than 70 percent of agricultural land, remains overwhelmingly important in Thai agriculture and economy. That is, so far as the share of paddy production in GNP is concerned, it remained 11 to 13 percent throughout 1960s and 1970s, but it would be 15 to 17

percent if the decrease in domestic price by export premium was taken into consideration. This value can be understood as extremely high as the share of the one crop production in GNP (For Japan, it is a slightly less than one percent).

The main factor of such an increase in paddy production was the increase in cultivatable area based on the development of irrigation facilities after World War II. Although the yield per unit area increased through 1969 to 1972, when the increase in production from 1960 to 1976 is viewed from Crop Statistics, increase per unit cultivable area remained mostly at 4.7 percent, whereas the annual average increase was 4.9 percent, and the production increase caused with the increase in crop per unit area was as small as 0.2 percent. The yield has remained as low as about 1.7 to 1.8 ton per ha.

The trading of Thailand has been made in the conventional way of developing countries which is to export primary products such as rice, tapioca, maize, rubber and tin and to import capital goods and industrial raw materials such as machines, steel and chemical products. Although both import and export have increased every year, there is a constant trade deficit caused by vigorous import demand due to the development of domestic industry, increase in demand for consumer goods, etc.

Rice is the most traditional export goods and was the major item of all the export before World War II. After the war the status of rice was lowered greatly and the share in all exports was 40 percent in 1950 - 1960, 35 percent in 1961 - 65, 25 percent in 1966 - 70 and 16.8 percent in 1971. Such decline in export resulted from an increase in the total amount of export, diversification in exported agricultural products and so on, but the other major cause is that the rice export after World War II has remained

constant in its amount in long term, although largely fluctuated by years. Paddy production before the war seems to have been export-orientated, whereas rice export after the war has been made by surplus rice. That is, the surplus of production, which is a balance by reducing the domestic demand from the production, is exported. Because the domestic demand keep a fairly constant level, the fluctuation of the export becomes bigger than that of the production, and moreover because of the increasing tendency in the demand in a long term, the export will become stagnant in a long term as well.

In 1978, for which the latest data/information are available, the agricultural, forestry and fisheries share 64 percent of the gross export of ฿83,070 million while the share of rice export is only 12.9 percent of the total. The changes from 1975 to 1978 indicate that the gross amount was increased by 26.6 percent whereas the agricultural, forestry and fisheries were increased by not more than 18.8 percent. This has resulted from the decrease in maize export and depressed sugar price rather than stagnation in rice export.

The premium system for rice export is one of the factors which affect the production and export of rice and have the relative importance of rice production in national economy. This is a kind of specific purpose tax, which is regarded as enforced savings for public investment to rice production. The premium functions to separate domestic price from international price in such way as when international price rises, domestic price is curbed through raising the premium.

As a result, however, it is considered that the rice price is kept low and the increase of production restrained, resulting in increasing consumption and contrarily decreasing export. Furthermore, because of the fairly high-rate and non-accumulative system,

this does not seem to be a modern system in its nature. However, the revenue from this source has been greatly contributing to the national finance in its long history.

2-3. Irrigation Projects

The Kingdom of Thailand, from the beginning of 20th century, had endeavoured to plan many modern irrigation projects under the technical guidance and assistances by the Netherlands and the Great Britain, and some of which were implemented. After World War II in order to overcome international food shortage the increase of Thai rice export and the necessity and potential of increasing rice production attracted the international attention. Especially Chao Phya Irrigation Project in the delta of Central Thailand was taken up by FAO, and then the world bank extended the financial aids to the Projects (1950). Around the delta, the Greater Mae klong Basin Development Project, Phetchaburi Irrigation Project and some others were taken up as well as diversion dam projects in North. All of these projects have been promoted rapidly under the international cooperations in technical and financial assistances by foreign countries.

The purpose of Chao Phya Project, which was the forerunner of the modern irrigation project in Thailand, was to stabilize and increase traditional rainy season paddy crops. In other words, the Project intended to stabilize the rainy season paddy crop by supplementary irrigation and to expand the irrigable area through controlling the flood water of the delta to stably supply to the wide area. Therefore, the irrigation was made by a fundamental and conventional flooding method. On the other hand, it was necessary to control irrigation water for introducing higher farming techniques such as employing improved varieties, transplantation, and fertilization, etc. The Thai authorities concerned established the Dikes and Ditches Act in 1962, and constructed farm ditches, in about 800,000

ha of the irrigable area in the Project areas for eight years from 1963 to 1969.

The Phetchaburi Irrigation Project Area as well as the Mae Klong Irrigation Project Area, being located in the peripheral area of the delta where the Chao Phya Project is located, has been provided with the so-called modern irrigation systems with a storage dam, diversion dam, main and lateral canals, and ditches as well were constructed under the Dikes and Ditches Act.

Thus, the ditches were constructed by 1980 to cover about 1,273,000 ha of benefical area in the whole country. The investgations in past years, however, have found that the farmers have not always evaluated the ditches so favourably, because the ditches sometimes functions ineffectively. One of the reasons is that because the ends of ditches are mostly left to let the water run down, irrigation water depends on slight change of altitude in the topography, and another is that many paddy fields cannot be well irrigated because of small designed irrigation requirements therefore.

In order to improve the insufficient ditch functions, an experiment on the land consolidation was made at the end of 1960, and based on the results the Land Consolidation Act was enacted in 1974 and the Agricultural Land Reform Act in 1975. The experimental projects were executed in the delta of Central Thailand under the technical cooperation by the Formosan team and the Dutch team. The Thai authorities concerned fully confirmed and recognized the effect of land consolidation project and the project was staged from the experiment in pilot and demonstration to implementation in national scale.

In 1976, the second year after the enforcement of Land Consolidation Act, the Thai Government requested the Japanese Government for formulating the Irrigated Agriculture Development Plans to center about the land consolidation project and studying its feasibility. In compliance with the request, the study for planning the Irrigated Agriculture Development Project majoring the land consolidation project was made for about 12,300 ha of the West Bank Tract of the Chao Phya river, and a pilot land consolidation scheme is now under way as a technical cooperative project for about 500 ha. In the Mae Klong Area as well, an investigation and study for Irrigated Agriculture Development Project for the total area of about 400,000 ha were carried out, and the on-farm developments (land consolidation) are being made in the level appropriate for each site of the two demonstration farms with 400 to 500 ha within the Project Area under the technical cooperation. The area of on-going land consolidation projects in Thailand cover 53,000 ha, including the above acreage as of 1980.

2-4. History of Phetchaburi Project

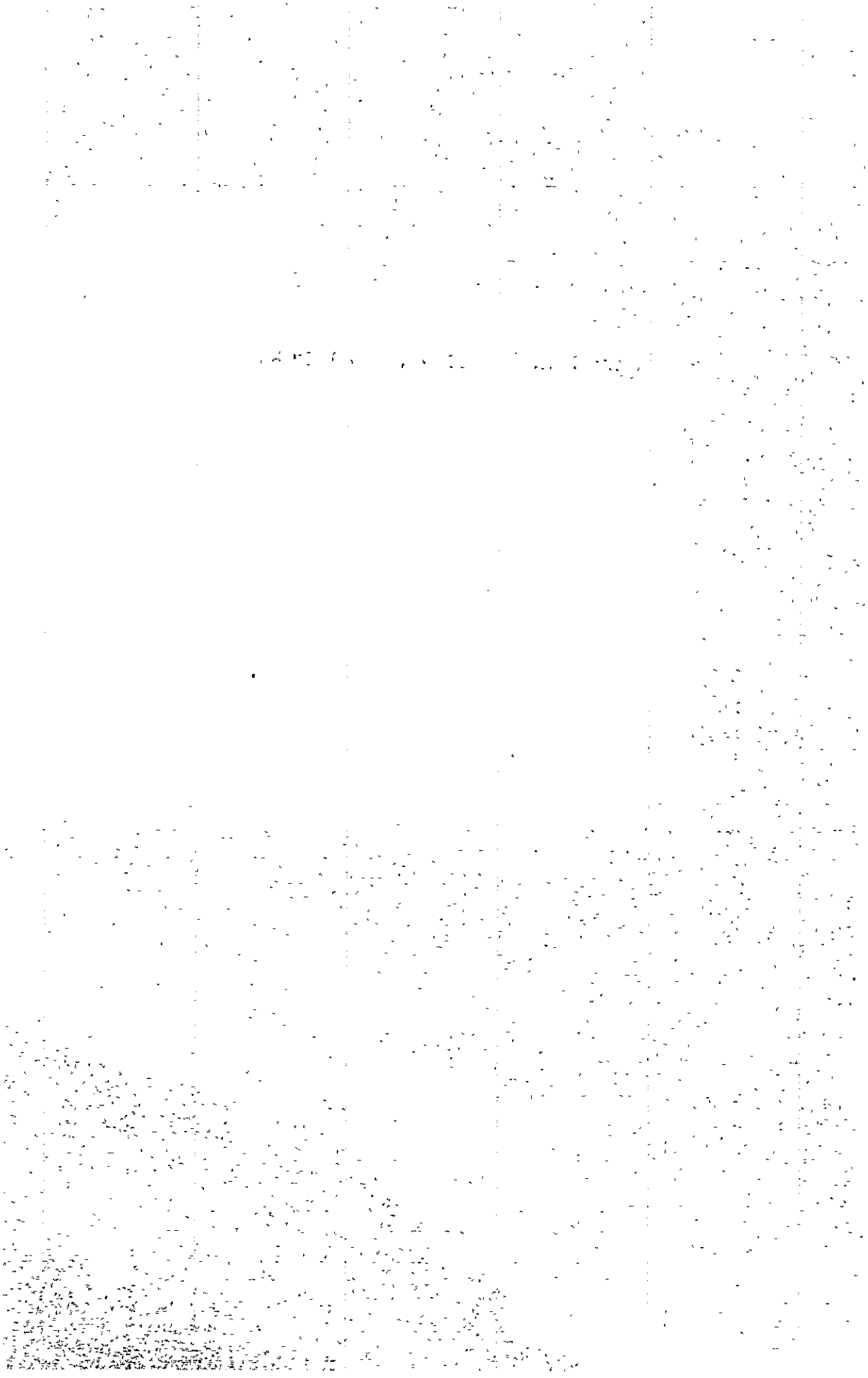
It was as early as in 1910's that a concept was formulated to construct a reservoir across the Phetchaburi river for developing the basin. In 1915, RID prepared the study report on the feasibility of a reservoir construction at Kaeng Krachan in the Phetchaburi river, and in 1936 a detailed feasibility study for the development of the Phetchaburi basin was made. In 1942 a staged development plan was worked out with the first stage for construction of the Phet diversion dam and irrigation canals system and the second stage for construction of Kaeng Krachan storage dam and the additional canal system.

The Phet diversion dam, construction of which was started in 1942, was completed in 1950 to commence the irrigation water supply to a part of the Area. In keeping pace with progress of the con-

struction works, the farm lands were expanded and the number of the inhabitants increased rapidly. Under the circumstances, the requirements for constructing a storage dam to promote the development of the Area was strongly raised by the local people, and the Thai Government decided to construct a storage dam at Kaeng Krachan point in 1958. The construction of multipurpose Kaeng Krachan reservoir for irrigation, water supply and flood control started in 1962 with a loan from the World Bank and completed in 1966. Following this, construction works of the canal system, drainage system, ditches, seadikes have been executed, contributing greatly to the local development mainly in the agriculture in the Phetchaburi Area up to date. In 1974 Electricity Generating Authority of Thailand (EGAT) constructed Kaeng Krachan Power Plant (19×10^3 kilowat (kw)) immediately downstream the dam in the use of the reservoir release.

RID takes the aforesaid completed projects as Stage I and Stage II in Phase I development, and set the further development of Phase II and Phase III. The development of Phase II covers the development of the irrigated agriculture in the use of existing reservoir and irrigation and drainage facilities, and the current study covers the feasibility study for Phase II Development. The purpose of Phase III Development is to develop the adjacent areas by additional construction of dams and reservoirs.

CHAPTER III GENERAL CONDITIONS



CHAPTER III. GENERAL CONDITIONS

3-1. Project Location and Area

The Project Area extends around Phetchaburi city, located about 150 km southwest of Bangkok, the capital of Thailand. The Area belongs to Changwat Phetchaburi administratively, and is situated in southern part of the Central Plain in terms of socio-economy. The Area, extending Lat. 12°50' - 13°15' N and Long. 99°50' - 100°05' E., is about 40 km long in SN and about 20 km wide in EW in forming an oval shape in general. The Area is bounded by the Gulf of Thailand on the east and by hilly lands on the west, being adjacent to the Greater Mae Klong Irrigation Project Area on the northwest.

The Project Area can be divided into two in view of the existing Phetchaburi Project; one is the first and second stage Phetchaburi Irrigation Project Area, and the other is the narrow strip land surrounded by seadikes outside the Phetchaburi Irrigation Area at east side border line. The gross area of the Project is 74,000 ha, of which 63,900 ha are the existing Project Area and 10,100 ha are the lands along the seadikes.

3-2. Physical Condition

3-2-1. Topography

The topography of the Project Area can roughly be specified into three; fan land, low-lying flat land, and residual hills.

The fan land extending to north with apex at the Phet diversion dam on the edge of southwest of the Area covers about 50 percent of the Area. This fan was formed by the sediments transported through the Phetchaburi river mainly in flood season and by the river

shifting frequently made so far. Of the old river courses, some relatively new traces running in parallel with the persent river course from Tha Yang are observed. Some of them form crescent lakes and shift to the present natural rivers in the mid- and down-stream. Around the diversion dam the elevation is about 20 m Mean Sea Level (MSL), whereas the edge of fan (the vicinity of Phetchaburi urban district), about 25 km away from the apex, is elevated about 3.0 m MSL, and the average slope is 1/1,000 or below.

The low-lying flat land mainly extends from north to northeast part of the Project Area. The elevation is less than 3.0 m with slight undulation, and the contour lines run intricately. The low-lying flat land is considered as the recent marine deposits in the alluvial age, and forms the flood plain of Phetchaburi river.

The fan and low-lying flat land are dotted with residual hills of independent peaks with steep precipices, mainly composed of lime-stone of paleozoic strata. These peaks occupy the area from 0.02 sq.km to 1.0 sq.km. And the specific difference in elevation varies from 40 m to 100 m or over.

3-2-2. Soils

From parent materials and land form, the soils in the Project Area can be classified into three as follows: an active tidal flat in the northern and eastern parts of the Area consists of marine deposit, while the majority parts in the southwest along Phetchaburi river consists of river alluvial deposit, forming semi-recent terrace. The transitional zone situated between the said two parts consists of the former tidal flats and the old marine terrace composed of old brackish water deposits.

The soil of the tidal flats distributing in the northern part and littoral zone of the Area is composed of the Samut Prakan

(25,700 ha) and Tha Chin (6,800 ha) soil series which occupies 47 percent of the Project Area. The Tha Chin Soil is unripen saline soil, mainly distributing in swamp areas, and some of these areas are utilized as paddy field, coconuts fields, fish ponds, or salt fields. The Samut Prakan soil is heavy clay soil, and the majority is already used as paddy field. In southern part, the sandy Hua Hin series is found sporadically, mostly used as residential lots, whereas some parts are used as paddy field.

However, a greater part of the said area is poor in vegetation only with cactus, thorn thrubs etc. growing. The main soils of the old tidal flat are the Bangkok and Rangsit soil series. These soils have developed over the semi-blackish water deposits, and are distributing in transitional zone toward the old marine terrace or semi-recent river deposit area (12,500 ha, 17 percent). Generally, these soils are slightly poor to poor drainage clay, clay loam or loam. The Bangkok series shows neutral to mild alkaline, whereas the Rangsit series is slightly acid to strong acid. The almost all these soils are utilized as paddy field. River alluvial deposits are the parent materials of semi-recent terrace which occupies the large part of south-west area along the Phetchaburi river (25,800 ha, 35 percent). Main soils in the area are the Tha Muang, Sapphaya, Chainat, Kamphaeng Saen, and Phetchaburi soil series. The Tha Muang, Sapphaya and Kamphaeng Saen series are well drained to moderately well drained soils developing on the natural levees. Generally, they are slightly acid to strong acid, sandy loam, loam or clay loam, and most of these are used as the residential lots, fruit garden, and upland field. On the other hand, the Chainat and the Phetchaburi series are distributing in the medium- or low-lying areas, and are slightly acid to slightly alkaline loam, silty clay or clay. The Chainat series is slightly poor drained soils, but the Phetchaburi series is slightly good drained one, and these soils are utilized as paddy field.

Classifying the soils in the Area from land suitability for paddy field, found that the Bangkok and the Rachaburi series were suitable for paddy field, the Rangsit, Chonburi, Phetchaburi and Sapphaya series ranked as second class due to some defects in the features of soils. The areas with these 1st or 2nd class soils are about 27,400 ha (37 percent) in total. The Samut Prakan series is the 3rd in grade due to the marginal land with salinity and flooding limitations, and the Kamphaeng Saen, Tha Muang, the semi-recent terrace soils, are also ranked by 3rd grade due to the marginal land with topographic and/or moisture limitations (approx. 36,600 ha, 49 percent). The Tha Chin and the Hua Hin series are determined as unsuitable soils for paddy cropping because of salinity, flooding limitations and sandy soil, and the area is about 10,000 ha, covering 14 percent of the total area. As stated above, the area that is expected to secure the average paddy production from the point of view of soils, is only 37 percent of the total area, and 36,600 ha, about 50 percent of the area, are the lands which have some defects in the soils. Of these lands, 25,700 ha, equivalent to 35 percent of the total paddy fields which belong to the Samut Prakan series have low paddy productivity due mainly to critical salinity, and poor drainage. This will be the future main subject for accomplishing the innovation of paddy production technology in these paddy field.

3-2-3. Climate

Thailand belongs to tropical Savanna climate zone, and its climate is roughly classified into the rainy season and the dry season. The rainy season in the Project Area lasts for about six months from May to the end of October, and the annual rainfall is about 1,100 mm on an average, 94 percent of which concentrates in the rainy season. The annual rainfall shows a considerably large fluctuation, and the highest ever recorded is 1,627 mm (in 1966), whereas the lowest only 435 mm in 1980.

The annual mean temperature is 27.5°C, and there is a slight difference only in monthly mean temperatures, however. It is hottest in April, and the monthly mean temperature is 29.4°C. On the other hand, it is December when the temperature becomes lowest. The monthly mean temperature is 25.2°C in December. The lowest temperature ever recorded is 13.9°C.

3-2-4. Rivers

The runoff from the Phetchaburi river catchment area of 4,060 sq.km is the main source of irrigation water for Phetchaburi area. The Phetchaburi river and its tributaries originate in the western mountainous areas bordering Thailand and Burma, and flow across the Phetchaburi plain in north-east direction to empty themselves into the Gulf of Thailand.

The measurement of the river discharge at Kaeng Krachan Dam site was started in 1954. An annual average inflow to the Kaen Krachan reservoir commanding the catchment area of 2,210 sq.km is 850 Million Cubic Meter (MCM). The largest inflow was 1,390 MCM in 1961, the second largest 1,090 MCM in 1978, and the smallest was 580 MCM in 1980. The annual average runoff ratio was estimated at 38 percent. The most of the inflow to the Kaeng Krachan reservoir, which was constructed across the Phetchaburi river, is controlled by this reservoir with 700 MCM of effective storage capacity for irrigation, power generation, domestic and industrial water supply, and river conservation. As a result of flood control by the reservoir (the effective storage for flood control: 170 MCM), no severe floods in down stream have been reported.

3-3. Socio-economic Conditions

3-3-1. General

Changwat Phetchaburi which includes the Project Area consists of two cities and seven Amphoes, and the total population in 1979 was about 362,000. The Project Area administratively includes two cities and six Amphoes, and the population in 1979 was about 272,000, equivalent to about 75 percent of the total population of the Changwat. In excluding the population of Phetchaburi urban district, it is about 192,000, equivalent to about 53 percent of the total population of Changwat. An average annual population growth rate in these recent three years is 1.6 percent, far lower than average national population growth rate in recent years, except for the Metropolitan area whose average annual population growth rate was estimated to be about three percent.

Gross Changwat products of Phetchaburi in 1978 was US$258 million, or corresponding to US$724 per capital, much higher than the average value of the whole country of US$525. The gross value of agricultural products was US$118 million, equivalent to 46 percent of the gross Changwat products, occupying the largest portion in the industrial sector. Of the gross agricultural products, crop output is highest by US$72 million, which occupies about 20 percent of the gross agricultural products. The second highest gross products to agriculture sector is wholesale and retail sector, which occupies about 20 percent of the gross Changwat products. As for manufacturing industry, there are only some minor scale processing factories for agricultural and forestry and marine products such as 363 rice mills, 16 noodle-making factories, 10 fish processing factories etc., besides one-cement factory, two pineapple canneries, one sugar plant. The total number of employees engaged in manufacturing industry was about 3,700 in 1979.

The Project Area is linked with Bangkok by railroad and Asia High-way running through the Area, and belongs to the Metropolitan area in its economy. The road networks within the Area is comparatively well arranged, and there are operation and maintenance roads of 370 km controlled by RID (partly unpaved), the seadikes of 94 km which are dually used as roads, Changwat roads of 122 km and Amphoe roads of 94 km (both paved road).

The diffusion rate of electricity within the Area has reached almost 100 percent. In the urban district such as Phetchaburi or other city and towns except littoral zones, water supply is provided, taking sources by rivers or groundwater. But the water supply of Cha-am city, the southern tip of the Area, has been dependent upon the Phetchaburi irrigation system.

3-3-2. Land Use

The development of the Project Area has been promoted by the completion of the diversion dam and irrigation canals in 1950 (the 1st stage project), and the completion of Kaeng Krachan reservoir and additional irrigation canals in 1966 (the 2nd stage project), with increase in arable lands to about 50,000 ha in 1970, which remains almost unchanged at present.

The rainy season paddy is cultivated all over the paddy field in the Area. The dry season paddy was cultivated in only seven ha in 1972. The dry season paddy cropping, however, had rapidly increased in its acreage by 2,290 ha in 1975, 5,208 ha in 1976 and 8,039 ha in 1979. Upland cropping for the dry season in paddy field as well had sharply increased from about 220 ha in 1972 to 2,723 ha in 1979.

As learnt from the present land use rate, out of the Project Area of 74,000 ha, the land available as the farm lands is 56,450 ha, which occupies 76.3 percent of the total area. The land use rate of farm lands of 56,450 ha is 95.3 percent in the rainy season, while 22 percent in the dry season. Upland field, fruit garden were calculated as being cultivated both in the rainy and the dry season.

The total paddy fields in the Area are 49,670 ha, all of which are cropped with rainy season paddy, whereas 5,820 ha of which are cropped with paddy and 2,520 ha are cropped with upland crops in the dry season. As a consequence, the land use rate of the paddy fields is 116.8 percent. The dry season paddy is cropped in the well-irrigated fields repeatedly year by year. As described above, in 1979, the dry season paddy was grown in more than 8,000 ha, recording the highest, but since then, the water shortage had resulted in decrease to 5,800 ha in 1980, and further sharply decreased to only 90 ha in 1981.

Fruit-trees orchards of 2,400 ha, upland of 1,700 ha exist in the elevated lands in the upstream area free from flooding, and pump irrigation was used in this area.

The fruit trees such as banana, coconut, lemon, and mango are cultivated. As the second crop of paddy mungbeans or vegetables are mainly cultivated. And main vegetables cropped in the Area are cucumber, challot, pumpkin, etc., and others are peanuts, beans, sugar cane, although small in production.

3-3-3. Farming Population and Number of Farm Households

The population and the number of households in the Project Area were estimated from the village survey data of Changwat Phetchaburi made by The Ministry of Interior, by using aerophotos, topographical map and administrative district chart. In this estimation, the urban district of Phetchaburi and Cha-am which have a small number of farm households, have been excluded.

The total population and the number of households of the Project Area were estimated at 192,000 and 32,400 in 1979 respectively, either of which is equivalent to 53 percent of the Changwat total of each item. The total population of the Area has been increasing at the annual rate of 2.1 percent since 1976 of 180,000, higher than the population growth rate of the whole Changwat (1.6 percent).

The number of farm households within the Area is 17,920, equivalent to about 56 percent of the total number of households. Since the Area includes administration and farm business center of Changwat Phetchaburi, the rate of farm households is lower than that of the whole Changwat (63 percent)

The total population of farm households of the Project Area was estimated at 107,300, and the average population per farm household is less than six. The working population for farming is less than 3.3 per household.

3-3-4. Major Crops

Major farm products in the Area are rice, vegetables and tree crops. Paddy fields occupy 88 percent of the total cultivated acreage, while upland is three percent, fruit orchards, four percent fallow land five percent, respectively. Upland crops are

mungbeans, vegetables including crops grown in the paddy field in the dry season, and tree crops are banana, coconut, lemon and so on. An average production of these major crops are given as follows:

Paddy	Rainy Season	Local V.	2.17 ton/ha
	Rainy Season	HYV	2.90 "
	Dry Season	HYV	3.00 "
Mungbeans			0.60 "
Vegetable			9.00 "
Banana			5.00 "
Coconut			4.00 "
Lemon			5.00 "

3-4. Irrigation and Drainage

3-4-1. Irrigation Facilities

The existing Phetchaburi Irrigation Project, depending water sources upon the Kaeng Krachan reservoir, started with the construction of the Phet diversion dam in 1942, and completed all the works in 1969, through provision of irrigation facilities, Kaeng Krachan reservoir and additional irrigation facilities. The general dimensions of the major irrigation facilities are given as follows:

1) Kaeng Krachan dam and reservoir

- Dam

  Type: Earth fill with rock facing for slope protection

  Dimension:

	Main dam	Sub-dam	Sub-dam
Height (m)	58	50	22
Crest length (m)	760	305	255
Crest elevation (MSL)	106.0	106.0	102.7
Volume (1,000 cu.m)	3,425	704	188

- Spillway

  Type: Overflow uncontrolled crest, open channel, unlined

  Crest elevation: 99.5 m MSL

  Designed flood: 1,260 cubic meter per second (cu.m/s)
  (water surface elevation - 102.7 m MSL)

- Outlet works

  Maximum discharge: 90 cu.m/s
  (water surface elevation - 99.0 m MSL)

  Discharge level: 65.0 m MSL

- Reservoir

  Catchment area: 2,210 sq.km

  Reservoir area: 50 sq.km (water surface elevation - 99 m MSL)

  Reservoir storage allocations:

Purpose	Storage (MCM)	Water Surface Elevation (m MSL)
Flood control	170	99.0 - 102.7
Irrigation	685	70.0 - 99.0
Conservation	15	65.0 - 70.0
Dead storage	10	Stream bed to 65.0

- Power plant: The power plant with the install capacity of 19,000 kw was constructed immediately downstream of the dam by EGAT in 1974.

2) Phet Diversion dam

The Phet diversion dam was constructed for 1942 - 1950 as the 1st stage project of irrigation development. In the 2nd stage project aming at increasing the irrigation area, the additional works for irrigation system were conducted with enlarging the capacity of the right main canal No.3.

Type: combination type of fixed and movable weir
Intake water level: 17.50 m MSL
Intake water: 58.7 cu.m/s
Diversion works: Manual operation slide gate

3) Irrigation canals

In the Phetchaburi irrigation project, all 45 routes of irrigation canals have been constructed, of which four routes belonging to the main canal No.1 system along the right bank are now used exclusively for domestic and industrial water supply. Accordingly, the irrigation canals are available with 41 routes.

Total Length of Irrigation Canals

- Unit: m -

Irrigation System	Main Canal	Sub-Main Lateral Canal	Total
Left Main Canal	36,330 (1)	65,741 (7)	102,071 (8)
Right Main Canal No.1	16,660 (1)	36,276 (5)	52,936 (6)
Right Main Canal No.2	19,556 (1)	16,525 (3)	36,081 (4)
Right Main Canal No.3	25,900 (1)	156,961 (22)	182,861 (23)
Total	98,446 (41)	275,503 (37)	373,949 (41)

Note: Figures in parenthesis show the number of canals

3-4-2. Irrigable Areas

The Project Area can be divided into two in terms of irrigation practices; existing Phetchaburi irrigation area and the outside area of the said irrigation project, extending along the seadikes (extension area). The detailed topographical map (scale of 1:10,000) which has been prepared by RID in 1981 shows that the farm land area of existing project area is 52,800 ha, and the irrigable area is 48,850 ha, except for the uplands scattered in and around residential lots. The irrigation for farm lands of 7,600 ha in the Extension Area

rely on excess water from upstream and rainfall. The irrigable area in the Project Area was estimated at 56,450 ha, in total.

The existing Phetchaburi irrigation area consists of four canal systems such as main canal No.1, No.2, No.3 on the right bank, and main canal on the left bank. While three canal systems on the right bank convey the water from Phet diversion dam, main canal system on the left bank from about 2.0 km upstream point of the Phet diversion dam to feed the water for irrigaing the farm land on the left bank of Phetchaburi river. The applicable area for irrigation of each canal system in the Project Area is as follows:

Irrigable Area

- Unit: ha -

Irrigation System	Paddy Field	Upland Field	Total
Left Main Canal	13,260	730	13,990
Right Main Canal No.1	6,070	850	6,920
Right Main Canal No.2	5,320	880	6,200
Right Main Canal No.3	20,100	1,640	21,740
Sub-total	44,750	4,100	48,850
Extension Area	7,600	-	7,600
Total	52,350	4,100	56,450

3-4-3. Water Use

The Kaeng Krachan reservoir (effective storage capacity: 700 MCM releases the water for irrigation, domestic and industrial supply, conservarion of rever and nower generation. The diversion plan at the diversion dam for irrigation, domestic and industrial supply and river conservation has been made out by the project engineer of Phetchaburi O & M Office. The reservoir

release is decided by Water Operation Center of RID through the negotiation with EGAT for giving instruction to the Phetchaburi Dam Office to release water. And, the minimum discharge amount for power generation is determined by 10 cu.m/s through agreement between RID and EGAT. The monthly average diversion demand is given below. The amount of annual total demand is about 840 MCM of which the demand for irrigation and domestic and industrial use if 600 MCM.

Monthly Water Demand at Phet Diversion Dam

- Unit: cu.m/s -

Month	Irrigation-domestic and Industrial Water	River Conservation	Total
Jan.	5	5	10
Feb.	10	5	15
Mar.	10	5	15
Apr.	10	5	15
May	10	5	15
Jun.	30	5	35
Jul.	35	5	40
Aug.	40	5	45
Sep.	40	5	45
Oct.	40	5	45
Nov.	35	5	40
Dec.	20	5	25

The record of water release from the reservoir can be summarized as shown below according to the EGAT. While the average annual inflow is 820 MCM, the average annual release is 870 MCM, and it was only in 1978 (wet year) when the release was lower than inflow. The reservoir surface elevation has not yet recovered to the full surface water level (99.0 m MSL) since the dam operation was started in 1974, whereas the drawdown took place up to 81.66 m MSL (storage: 150 MCM) at the end of December, 1980.

Reservoir Record

Year	Inflow (MCM)	Release (MCM)	Stored Water Surface Level at the End of December (m. MSL)
1975	892	960	95.63
1976	800	807	94.18
1977	753	886	89.18
1978	1,086	812	96.17
1979	813	1,097	86.23
1980	579	652	81.66
Average	821	869	-

The total rainfall in the Phetchaburi area in 1979 was only 435 mm, and also 753 mm in 1980, both lower than the average annual value, and no remarkable recovery of storage has been observed. For this reason, the Phetchaburi O & M Office took a measure to suspend the water supply for irrigation in the dry season in 1981 in addition to the restricting the discharge since the middle of 1980. RID has recorded the diverted water amount at diversion dam point and cropping area. The records show that actual discharged volume for the total cropping area of paddy fields in recent five years is 1,344 mm/year on an average, and due to the discharge regulation in 1980 decreased the amount to 1,126 mm.

Actual Intake

Year	Total Irrigated Area (ha)	Actual Intake (MCM)	Actual Intake (mm)
1976	56,930	803	1,411
1977	56,450	695	1,230
1978	56,565	791	1,398
1979	59,761	925	1,548
1980	57,546	648	1,126
Average	57,450	772	1,344

3-4-4. Drainage Facilities

As a part of the Phetchaburi Irrigation Project, the construction of drainage canals, seadikes and tide gates was planned, and the drainage canals and the tide gates discharging the water to the Gulf of Thailand have already been completed.

Drainage Canal

Drainage System	Total Length (m)	Drainage Area (ha)
Left Canal	23,255	4,510
Right Canal	223,952	42,020
Total	247,207	46,530

The seadikes under construction on the right bank are scheduled to be completed in 1982. The total 27 routes of the drainage canals, 23 routes of the right bank and four routes of the left bank shown above have been constructed. All drainage canals are of earth canal, having the excavation depth ranging 0.6 - 3.0 m, although 1.0 - 2.0 m is dominant. The drainage canals has been constructed nearly all over the area on the right bank, while those available in the upstream area on the left bank and water is drained to the Gulf of Thailand through natural rivers at the lower stream area.

In the right bank area, the seadikes with the total length of 90,987 m is planned to be completed in 1982. The crest width of the seadikes is 4 m and/or 6 m, and the height is 1 - 2 m. Laterite pavement crest is used for road as well. The crest height was designed to be 2.3 m MSL by adding 0.5 m of freeboard to 1.80 m MSL of a designed tide level.

3-4-5. Drainage Conditions

The construction of drainage canals have decreased the widespread inundation areas and no severe inundation damages have occured, except for some low-lying fallow lands. As a result of flood regulation by the Kaeng Krachan reservoir, no damages due to floodings from the Phetchaburi river have been reported. The construction of the seadikes scheduled to complete all the works in 1982, will prevent the sea water from intrusion into the Phetchaburi area. Drainage canals of the main or the lateral have been constructed, but few drainage facilities on farm levels are provided.

In the Dikes and Ditches project as well mentioned below, terminal drainage facilities have not been constructed. Such an absence of the on-farm drains has resulted from the fact that the irrigation has been practised instably due to shortage in irrigation canals and poor function of the facilities, and the local farmers have not had deep concerns with drainage practices in view of their traditional water management. For introduction of the paddy high yielding varieties (HYV) which has high response to water control and the second crop in the dry season require the construction of terminal drainage facilities capable of drainage control at on-farm levels.

Excess rainfall flows down to the lower area along the littoral zone through plot-to-plot drainage and/or drainage canals, and is temporarily inundated at the depressions by the influence of tide levels. There are gross 10,100 ha of lands between the existing irrigation area and the seadikes, of which 7,300 ha are utilized as paddy fields for the rainy season cropping. These paddy fields are not supplied with water from the Phetchaburi project but with the excess water from the upstream and rainfall. Under the condi-

tions the water is prove to be stored even in the rainy season, which results in the raise of water level of the drainage canals.

3-5. On-farm Facilities

The Dikes and Ditches project (established in 1962), the first on-farm development project in Thailand, was carried out in the Area for five years from 1964 to 1968. General dimensions of the constructed ditches are given below, and the total length is about 1,528 km as shown below. The Dikes and Ditches project, exerting a considerably favourable effects, have allowed the water management at on-farm level to be easier, the rainy season paddy cropping to be stabilized, and the dry season paddy cropping to be increased in its acreage. There are, however, much room left for improvement in various matters.

General Dimensions of Ditches

Structure:	Earth
Shape:	Trapezoid
Bottom width:	0.4 - 0.55 m
Side slope:	1 : 1.0
Depth:	0.85 m

Irrigation System	Length (km)	Commanding Area (ha)	Density (m/ha)
Left Main Canal	459.4	6,400	28.7
Main Canal No.1	194.7	5,800	30.4
Main Canal No.2	165.9	25,000	28.6
Main Canal No.3	708.1	16,000	28.4
Total (Average)	1,528.1	53,200	(28.7)

CHAPTER IV PROBLEM AND NEED

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4-1. Soils

Out of 74,000 ha of the Project Area, some 46,500 ha are covered by soils of which parent materials are marine deposites. This means that at least the land by some 36 percent of the Project Area potentially suffers more or less from the salinity. Among others the Samut Prakan series (about 25,700 ha or 34.8 percent) and the Tha Chian series (about 6,800 ha or 9.2 percent) that are distributed in the northern parts of the Project Area and in the areas from the coastline towards inlands are composed of saline soils substantially requiring salt leaching measures. On the other hand, the soils in the semirecent terrace located in the inland areas whose parent materials are the river alluvial deposits are not originally saline soils but composed of salt accumulated soils in spots as a result of the rise in groundwater table caused by the introduction of irrigated agriculture. A salinity survey conducted by RID during the dry season of 1975, revealed that the salt-polluted lands by over 6 millimho (mmho), which is considered to restrict crop fields except for salt-tolerable crops, are concentrated in the peripheral areas in the eastern parts and the northern parts of the existing farm lands with the exception of sporadical appearance in inland areas: particularly in the areas of the soils with the river alluvial deposits as parent materials. Out of the 518 survey sites, 304 (58.7 percent) seem to be non-saline soils (ordinary soils) indicating below 4 mmho while the remaining 214 sites (46.3 percent) are considered to be composed of either saline or saline-alkali soils. The extension area lying between the existing irrigation area and the seadikes has many ill-drained swamp lands, whose main soils are the Samut Prakan series, which are even now subject partially to the direct or indirect influence of the sea water or

brackish water. As shown by a survey conducted during the dry season of 1980-81, out of 96 survey sites, 70 revealed to have the salinity over 4 mmho in the top soils, while 57 indicating to have the salinity over 10 mmho.

As for the top soils in the five sample areas for on-farm development, the spots showing the salinity of over 6 mmho are as follows: Both of the Nos. 1 and 4 with the river alluvial deposits as parent materials, showed below four percent of the total. Likewise, the Nos. 3 and 5 with the marine deposits as parent materials showed 14-17 percent. Finally, the No.2 with the marine deposits as parent materials, showed the rate, as high as 40.6 percent proving the high correlation between the soil salinity and soil parent materials.

As for the relation between the paddy yields and the salinity in the top soils in the sample areas, paddy fields showing the average yield over 2.16 ton/ha were 37 spots (52 percent) out of the 90 spots surveyed in all. Meanwhile, out of the spots below the average yield (43 spots), 27 spots have been found to be composed of the soils with the high salinity of over 8 mmho. The results suggest the necessity of salt leaching for such soils as a prerequisite to assuring higher paddy production in the Area. The fundamental pattern leading to salinization in the Area may be classified into two as follows:

1) Direct or indirect salinization of the soils by infiltration of seawater or brackish water.

2) Salinization attributable to migration and deposition of salt in the process of the soil formation.

Additionally, another cause of salinization is the secondary salinization of the soils attributable to absence of drainage systems, and the rise in groundwater table, etc. resulting from the introduction of irrigated agriculture. It is presumed that these factors may have affected the salinization of the soils either on an independent or complex basis. The Project Area is exposed under various climatic conditions such as the dry season or the rainy season with relatively small rainfalls taking place sometimes for a long time. Hence, the fallow paddy fields in the dry season have caused more salt accumulation in the surface soils in cycle or in spots, but excess soluble salts may be easily leached. The general tendency, however, is that there occurs the accumulation of excess salts in the surface soils of the fallow paddy fields in the dry season due to the lack of adequate drainage systems and the shortage of irrigation water. Therefore, it is more desirable to make efforts to introduce the dry season paddy cropping in terms of desalting, so far as the circumstances permit. In case of leaving the fields unavoidable in fallow in the dry season due to water shortage, efforts should be made to practise a first plowing after the harvesting of the rainy season paddy and then keep those paddy fields in fallow. Irrigation and drainage through proper facilities should be made for leaching prior to starting land preparation for the rainy season paddy cropping.

4-2. Land Use

In the Phetchaburi Project, the dry season paddy cropping acreages have considerably decreased due to recent critical water shortage, although steadily increased in supply year by year. Particularly in 1981, the land use rate of the paddy field in the dry season was 16.8 percent and the dry season paddy cropping acreage occupied only 11.7 percent of the total acreage of the paddy fields. Basically, the dry season land use rate of the paddy fields depends greatly upon the development of water resources.

Taking into account the effective capacity of the Kaeng Krachan Reservoir of 700 million cubic meter, the dry season paddy cropping is expected to be increased.

In other words, a greater part of the dry season paddy cropping is carried out only in the paddy fields irrigated well by the main and lateral canals located at the upstream. On the contrary, there are few croppings found in the areas downstream far from the diversion dam or those areas with malfunctioning facilities (farm ditches) or with ill-drainage conditions even in the upper stream. Because, in those areas, paddy fields are mostly difficult to obtain the timely water supply to meet the requirements.

In the paddy fields that are fallowed unavoidably in the dry season, the yields of their crops are affected negatively by the accumulation of excess salts in the surface soils in the dry season.

The land located between the Phetchaburi irrigation area and the seadikes totals 10,100 ha, out of which 7,600 ha are available for rain-fed paddy cropping in the rainy season. Although this area will have potential to be developed with the completion of the seadikes in 1983, these paddy fields are extremely unstable in the water supply because of their unavailability of irrigation from the Phetchaburi Irrigation Project, only depending upon excess water or upon rain water. In addition, in these areas, the water has been stagnant in the paddy fields due to tidal change, and the water level in the drainage canals has been raised. Therefore, the land use for agriculture is restricted by water shortage, ill-drainage, soil salinity, etc. in this area.

The existing mangrove woods of 3,130 ha in the left-bank terminal of the main canal is included in the Stage II and planned to be developed into paddy fields. The land use in the area should

be studied from the angle of irrigation and drainage conditions, land productivity, and the economic value of mangrove resources, although such negative factors exist as soil salinity, etc.

The forests, wastelands, and marshlands of 7,870 ha are sporadically located in the Project Area, and the Project will not take a planned development for these lands in principle.

The upland fields and orchards of 4,100 ha in total are scattered in the Area, mainly located around the rural communities; and paddy fields are rarely found in co-existing with the upland fields or orchards. Thus, the difference in water use by those crops will cause no problems for the on-farm development.

4-3. Land Holding and Farm Size

The following is a summary of the land tenure and farm size based on the data of the land tenure in Changwat Phetchaburi (by the Ministry of Interior as of 1978):

Land Tenure in Six Cities and Amphoes Concerned, 1978

Classification	Farm Households		Area		Av. Size
	Numbers	%	Ha	%	(ha)
Owner Farmer	20,870	(76)	59,291	(66)	2.8
Tenant-owner Farmer	4,936	(18)	23,822	(27)	4.8
Tenant Farmer	1,788	(6)	6,055	(7)	3.4
Total	27,594	(100)	89,168	(100)	3.2

Source: Agricultural Census 1978, N.S.O.
A survey of Rural Communities by the Ministry of Interior as of 1978.

The number of owner farmers accounts for 76 percent of the total, being higher than some 60 percent in the Mae Klong irrigation project area (399,000 ha in 1976) but approximately equal to 78 percent in the Kamphaeng Saen area (22,830 ha). On the other hand, the cropping areas owned by the owner farmers in the total area is as low as 66 percent compared with 73 percent in the Kamphaeng Saen area. Tenant farmers occupy six percent and seven percent, respectively in terms of their numbers and cropping areas. These percentages are relatively lower than those for the entire area of Mae Klong (20 percent of the total farm households) and those for the Kamphaeng Saen (16 percent).

It appears that the tenant farmers are not in a position to introduce modern agircultural techniques because their farming conditions are generally unstable due to the high rents, insecure tenant rights, difficulty in securing credit services, etc. However, in view of the relatively small proportion of the tenant farmers in this Area, there does not seem to be a great hamper to implementation of on-farm development and subsequent introduction of modern agricultural techniques. A survey on the number of the tenant farmers by cities and Amphoes revealed that Phetchaburi city ranks first, having 662 tenant farmers (13 percent of the total farm households) with their farming area being 2,483 ha (13 percent of the total farming area). Next comes the Amphoe Ban Laem, occupying the estuary part of the Phetchaburi river and the northern half of low flatland along the coastline where 456 tenant farmers (31 percent) are engaged in farming in the area of 1,760 ha (31 percent). The third in numbers is the Amphoe Khao Yoi of seven percent. The remaining three Amphoes show below three percent both in terms of areas and farm household numbers.

According to a survey of rural communities by the Ministry of Interior in 1979, the average farm size in the Changwat Phet-

chaburi is 3.26 ha, being 2.68 ha for paddy farmers, whereas that in the area surveyed is 3.27 ha, being approximately equal to the average of the Changwat as a whole, while the paddy cropping acreage per farmer is 3.15 ha, being larger than the average. However, the figure is smaller than that of the Kamphaeng Saen area (4.0 ha) in the western part of the Central Plain.

4-4. Agricultural Production

4-4-1. Crops and Cropping Pattern

The main crop in the Phetchaburi irrigation area is paddy, whose cropping pattern is as follows:

1) Rainy season single cropping by transplanting
   - Traditional varieties (90 percent of the total paddy fields)
   - HYV (10 percent of the total paddy fields)

2) Dry season cropping by transplanting
   - HYV (10-15 percent of the total paddy fields)

Accordingly, the area with double paddy cropping both in the rainy and dry seasons accounts for 10-15 percent of the total paddy field, where the direct sowing of improved varieties, although negligibly small in acreage, is carried out in the rainy season.

Thus, the cropping rate of improved varieties for the rainy season paddy cropping is extremely low - only 10 percent. This is because on-farm conditions have not been sufficiently developed yet to introduce improved varieties. And yet the harvest of these improved varieties grown by 10 percent is relatively poor comparing with that of the local varieties due to the troubles in the initial growth stage after transplanting, resulting from the water shortage, inundation and poor land levelling, etc. The improved varieties are particularly vulnerable to these impediments.

In the dry season, some of the paddy fields are turned to be cropped with cucumbers, melons, pumpkins, etc. Among others, mungbeans have been introduced more than any other crops as a dry season upland crop in the paddy fields, as a major source of cash income for the local farmers. Mungbeans are cropped mainly in the fields over 2,000 ha in the upstream areas with favorable conditions.

The upland fields are mainly under shallot, cow peas, peanuts, cabbages, etc., which are grown with irrigation to enable triple cropping in a year in some places. Also, other places with a comparatively high elevation and poor irrigation in the Area are under tree crops such as bananas, mangoes, lemons, coconuts, etc.

As regards the cropping pattern in the Area, it seems that tree crops such as tropical fruits predominated before the completion of the Kaeng Krachan reservoir and the main and lateral irrigation system, while the rain-fed paddy fields existed sporadically among those brushlands or tree crops. After the irrigation systems were constructed in 1968; however, the paddy fields have been provided rapidly, eventually resulting in present cropping pattern. Under the circumstances, the fluctuation in acreage of paddy fields decisively depends upon the annual precipitation and the quantity of water supplied from the reservoir.

In 1972 - five years after the completion of the Kaeng Krachan Dam and irrigation systems in 1968 - the area of rainy season paddy cropping amounted to 51,700 ha, equivalent to almost all the Project Area, while that of the dry season cropping registered only 185 ha, mungbeans and other totalling 192 ha. Afterwards, the latter reached the record high by 8,039 ha under paddy, and 2,781 ha under mungbeans and others totalling 10,820 ha in 1979. The shortage of water at the end of 1980, however, led the cropping acreages to decrease to their levels in 1972.

4-4-2. Yield and Production

(a) Yield

In the Area, the main determinants of paddy yield per unit area may be grouped into four as follows:

1) The period of paddy cropping can be specified into two seasons of the rainy and the dry. Generally, the first cropping means the paddy cropping in the rainy season, namely the period of growth by and large June through December. The second cropping covers the paddy cropping in the dry season, namely the period of growth roughly February through June. The paddy cultivation with rain water only would call for the monthly precipitation of 200 - 250 mm. Especially for transplanting, water requirements for land preparation would be 150 - 200 mm within a short period. In this Area, the monthly rainfalls May through October can meet such requirements. Among these months the three months of August, September, and October would be quite satisfiable to the requirement. Judging from the conditions, it would be absolutely necessary to assure a supplementary supply of water from the reservoir in addition to the precipitation both in the said two seasons. Therefore, the quantity of such supplementary supply may be an absolute determinant for paddy yields.

2) It would become necessary for every field to have an irrigation system with such supplementary water supply in smooth. In the Area, the main and lateral irrigation systems, diversion works and farm ditches have been already installed by 1968 through Dikes and Ditches projects. However, topography in the benefited area is so

intricated that the ditch and dike system, employing the basin irrigation in priciple, cannot provide each field with water. Also, water supply facilities are incomplete with the thinly provided ditches. Besides, the farm ditches, which are of earth, suffer from the small cross-section, inability to keep water level properly, etc. As a result, the fields with poor conditions are found mostly in the downstream parts of the main and lateral canals where the farm ditches are provided thinly and the topographical conditions are complicated. Under the circumstances, the paddy yields largely depends upon the field conditions.

3) For the purpose, however, the improvement of cropping techniques, effective supporting services, and smooth supply of input materials are essentially required. The extent of improvement of the farming practice would affect significantly to paddy yields.

4) The downstream part in the Area, some of the coastal areas and a part of inland areas have considerably high salinity. Salinity in the paddy fields also is closely related to paddy yields.

(b) Yield by Plots and Present Production

The yield analysis made on the data for 314 sites surveyed in the sample areas has revealed that the paddy yields in the respective sites in the Project Area greatly vary with the extent of irrigation availability.

1) In the upstream of the main and lateral irrigation canals, the fields with the sufficient water level in the ditches, which are laid densely, can have the water enough to produce 3.00 ton/ha on an average.

2) In the paddy fields, although located in the relatively upstream of the main and lateral irrigation canals, the paddy fields under unfavourable conditions can produce a slightly low yields of 2.5 - 3.0 ton/ha, even though the farm ditches are densely provided.

3) The average yields of paddy somewhere at the downstream parts of the main and lateral irrigation canals and with unfavorable field conditions vary from 2.00 ton/ha to 2.50 ton/ha.

4) Some of the above-mentioned fields which are vulnerable to saline intrusion produce the average yield of 1.99 ton/ha only.

4-5. Irrigation and Drainage

4-5-1. Irrigation

(a) Canal Lining and Density

The existing irrigation canals were constructed as earth canals in the Stage I, some of which have been improved into the concrete lining in the Stage II for saving the maintenance costs of canals as well as increasing the efficiency of water conveyance. Out of the total canal length of 373,949 m, 55 percent is concrete lined. The such concrete lining are generally well-maintained. However, earth canals have been reducing their function of water conveyance due to slope erosion, sediments, and thickly growing water weeds. These phenomena are remarkably observed in the main irrigation canals on the left bank. In order to ensure the more efficient water management, the earth canals should be concrete lined. The total length and the density of canals in this existing irrigation system are as follows:

Lining and Density of Canals

Irrigation System	Total Length of Canals (m) Earth Canal	Lining Canal	Total	Irrigable Area (ha)	Canals Density (m/ha)
Left Bank	82,211	19,860	102,071	13,990	7.3
Right Bank No.1	14,986	37,950	52,936	6,920	7.6
Right Bank No.2	17,331	18,750	36,081	6,200	5.8
Right Bank No.3	52,025	130,836	182,861	21,740	8.4
	(45%)	(55%)	(100%)		
Total	166,553	207,396	373,949	48,850	7.7

The average density of irrigation canals in these areas is 7.7 m/ha. Although the canal density of the No.2 irrigation system on the right bank is as low as 5.8 m/ha, no particular problems have arisen in water distribution since the irrigation canal is running through almost the central part of this area. On the other hand, although the canal density of the left-bank main system shows the average value of 7.6 m/ha in this area, the strip-shaped irrigation area with comparatively intricate topography have caused some plots to become difficult in water distribution in the central and downstream parts. The additional provision of the lateral canals will be required for improving the situation.

(b) Canal Capacities

The following table shows the acreages of commanding areas by irrigation systems, canal capacities at the head of the main canals (the value for No.1 system excludes the potential demand for domestic and industrial water) and the designed peak water requirements:

Canal Capacities and Peak Water Requirements

Irrigation System	Irrigation Area (ha)	Canal Capacity (cu.m/s)	Peak Water Requirements (cu.m/s)
Left Bank	13,990	14.57	14.69
Right Bank No.1	6,920	9.60	7.96
Right Bank No.2	6,200	9.41	6.94
Right Bank No.3	21,740	22.82	21.74
Total (average)	48,850	56.40	(51.33)

Out of the four irrigation systems, the main canals for the three systems on the right bank have a capacity exceeding their peak water requirements. It seems that the present capacity of the main earth canals on the left bank have substantially declined below their designed capacity. The study of the capacities and the peak requirements of the entire 41 irrigation canals, found that the capacities of the six canals were more than 10 percent below their peak water requirements, while the 16 canals were more than 10 percent over. Therefore, it is necessary to establish each irrigation service area by the respective canals for securing their proper capacities.

The existing irrigation canals are so designed originally as to meet the supplemental requirements of irrigation for paddy cropping in the rainy season. However, the introduction of double paddy cropping in the future would call for a thorough study on the capacity of the canals sufficiently to meet the proposed cropping plan or on the plan of paddy cropping to match the capacity of the canals.

(c) Full Supply Levels

Some of the paddy fields along the canals are unavailable for receiving water from the canals by gravity. The Phetchaburi

O & M Office sometimes tries to raise the water levels of canals over their designed full water supply level by providing checks or other temporary facilities in the puddling season when their water requirements reach the peak, for extreme instance, their water level would be sometimes raised over the upper end of lining to ensure water distribution to possible many paddy fields. Meanwhile, the irrigation canals are so designed as to make a loss in water head through drops, checks, road crossing structures, etc. Out of the total 80 head loss sites (max. 2.55 m, and min. 0.10 m), the 33 sites have the head of 1.0 m or more. Also, the water levels of the five lateral canals have the loss of 1.0 m against that of the irrigation canals at the off-take points. It would be possible somewhat to raise the full supply level of the canals through improvement of those systems.

By using a topographical map (scale of 1 to 10,000 with the 1 m contour interval), the area to permit gravity irrigation by full supply levels designed for the existing canals has been calculated. The results were that 43 percent (21,100 ha) of the total paddy fields could be irrigated by gravity, in employing full supply levels originally designed. In practice, the water level of almost all the canals, as mentioned above, is now being kept some 10 cm higher than their full supply levels. In such case, some 51 percent (25,000 ha) of the paddy fields will be irrigated by gravity. However, it does not always mean that every plot unavailable by gravity irrigation should depend upon pump irrigation only. Some of these fields are irrigated either by daming-up of the water level of drainage canals or by excess water from the upstream. However, such time-consuming irrigation practices have made it difficult to provide the adequate and timely supply of the water.

(d) Present Irrigation and Paddy Yields

The yields of paddy are affected by various conditions such as drainage, soils, salinity, varieties, cropping techniques, etc. Based upon the last three-year data on the paddy yields (1978 - 1980) for the 273 farm households and the findings through a simple sampling conducted for yield survey at 14 spots, some analyses were made on the correlation between irrigation and paddy yields. The yield survey, confined to 36 sample plots, was made on the possibility of full water supply levels for gravity irrigation in looking into the respective irrigation conditions. Out of the 36 sample plots, the 16 plots were found unable to practise the gravity irrigation.

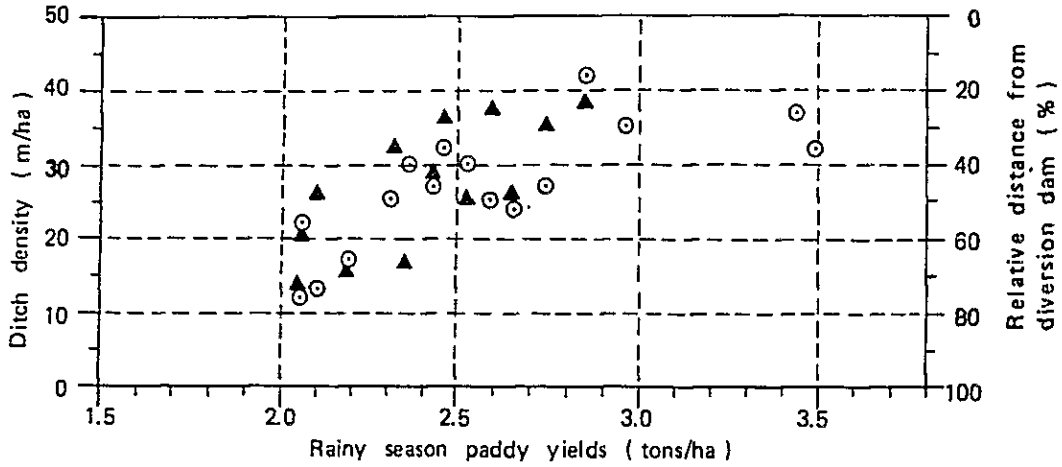
The study on the correlation between the density of the farm ditches and the paddy yields in the sample plots revealed that the plots unable to practise the gravity irrigation show low yields, in general, and no close relations were found between the ditch density and the yields. While, the plots irrigated by gravity have produced higher yields and the higher yields are found available with an increase in the ditch density.

In addition to irrigation conditions as seen above, the irrigation effect is largely affected by the capacities of the main and lateral canals to secure the sufficient water for the timely and adequate irrigation practices. In the decrease in conveyance capacity or in discharge amount the upstream plots are more advantageous to receive water in the same irrigation system. The said analysis employed the ratio of the maximum length of a irrigation system to the length of the objective plot from the diversion dam as the measurable indicator of the conveyance condition of the objective main or lateral canal. The analysis resulted in that the rainy season paddy yields showed a tendency declining to the distance from the diversion dam.

Irrigation and Rainy Season Paddy Yields

⊙.... Yields corresponding to ditch density

▲.... Yields corresponding to relative distance from diversion dam



The above-mentioned analysis has made paddy yields related directly to irrigation conditions. Virtually, the paddy yields are influenced by many factors. However, the analysis may suggests that improvement of the irrigation canals as well as the on-farm development is required for yield increase.

4-5-2. Drainage

(a) Surface Drainage

The water conveyance capacity of the existing main and lateral drainage canals varies from 24 mm/day to 37 mm/day, showing a weighted average of 27.2 mm/day which is higher than the designed drainage capacity of 22.5 mm/day for the Chao Phya and the Mae Klong areas. Some low-lying lands scattered in the Area are inundated due to poor drainage conditions. However, such ill-drainage has resulted from the fact that drain ditches connected with the main and lateral drainage canals have not been constructed.

However, the drainage conditions of these low-lying lands would be improved through provision of drain as part of the on-farm development project.

In the downstream of the Area, many drainage canals are concurrently used for irrigation and drainage purposes without any adequate facilities, resulting in a decrease in the water conveyance capacity in drainage. Such defects could be improved through the development of irrigation system and on-farm facilities.

(b) Subsurface Drainage

In the Project Area, the groundwater table has been rising from year to year. The fluctuation of monthly average groundwater table from 1967 through 1979 indicates that the table measured at 0.79 m deep below the ground surface in 1967 had been rising at the constant rate to reach the depth of 0.5 m below the ground surface in 1979. Also, the seasonal variation of the average groundwater table is found by 1.15 m deep below the ground surface in April, the hottest season of the year, and the rises from May in the begining of the rainy season through October and November to reach the highest, 0.25 m below the ground surface; after that, it continuously declines until next April. This is the pattern of the annual movement of the groundwater table.

Not only does the high groundwater table aggravate the physical and chemical features of soils in terms of cropping but also causes the upward movement of saline groundwater which gives salt damages to crops by promoting the salt accumulation in the root zone. These salt-polluted soils require to lower groundwater table for improving the soil features.

In the Project Area, however, the areas where the gravity

drainage would allow the groundwater table to be maintained lower than 0.5 m below the ground surface are limited to those at higher elevation due to the relative elevation difference between the land elevation and the tidal level, and these areas available for decreasing the groundwater table cover about 40 percent of the total area of the Project. The remaining 60 percent will inevitably require to provide the pumping facilities for successful drainage.

4-6. On-farm Facilities

The following five sample areas were selected out of the surveyed area to conduct the survey on the functions of the existing on-farm facilities, the present land and water use, etc. and also to conduct an interview with 50 farmers on the on-farm development.

Sample Areas

Sample Number	Gross	Paddy Fields	Upland Fields	Farm Ditch Density (m/ha)	General Conditions
No.1	283	217	43	35	Flat, well drained paddy fields
No.2	273	261	-	12	Low flatland, poor drained paddy fields
No.3	317	248	7	20	Rolling paddy fields
No.4	286	264	-	9	Paddy and upland fields in combination
No.5	331	268	41	23	Irregular-shape paddy fields
Total	1,490	1,258	91	20	

Out of the interviewee farmers, 56 percent knows that RID is now promoting the on-farm development project for improving irrigation and drainage on the farm level. And 84 percent has a desire to introduce dry season paddy cropping if allowed to secure irrigation water in the dry season.

Since the routes of the farm ditches under the Ditch and Dike Project are aligned in a straight line in parallel with each other at the interval of some 400 m, the farm ditches segment paddy fields into many farm plots. According to a cadastral survey conducted in the sample areas, the paddy fields owned by some 20 percent of the land owners were found divided by farm ditches. Under such circumstances, the farmers sometimes cross the farm ditches to access to their own farm lands, thus causing ditch breakages which result in remarkable decrease in the water distribution functions of the ditches.

A greater part of the farm ditches, which is dug out and of earth ditch, can keep so low a water level that the gravity irrigation is not available for many farm plots and also, some of them, having unsuitable gradient to the topographical conditions, cannot function well for introducing water to the farm plots, whereas causing the inundation in the low-lying plots. According to the farm survey, 83 percent of the total area of their fields depend upon the gravity irrigation, while the remaining 17 percent employing pump irrigation. Also, 73 percent of the farmers takes the irrigation water from the Phetchaburi irrigation system, while 23 percent depends upon water sources by the drainage canals, rainwater, or surplus water from the upstream.

In the areas surveyed, the density of farm ditches averages 29 m/ha, considerably lower than that of the Sapphaya area (56 m/ha) and the Boromphart area (38 m/ha), whose on-farm developments have been completed. According to a survey conducted in the sample areas, less than 30 percent of the total paddy fields is adjacent to farm ditches. This fact indicates that many of paddy fields are still controlling their water supply on the plot-to-plot basis. Eighty-six percent of the farmers has the opinion that all the paddy fields should have farm ditches.

4-7. Agricultural Supporting Services

4-7-1. Water Management Organization

The Phetchaburi O & M Office has the staff of 522 persons who are responsible for the maintenance of diversion dams, four main canals and lateral canals. The Project Area is divided into three districts with one water master each, responsible for water controls. Furthermore, the districts are subdivided into 33 zones by centering around the irrigation canals and bounded by the drainage canals for convenience for water controls by the zone men under the supervision of the said water master.

4-7-2. Agricultural Extension Service

In the Project Area, there is a model farm operated directly by the MOAC for the purpose of agricultural extension services, where experimentations and demonstrations are being made mainly for paddy culture on the farm of some 30 rai. Besides, demonstrations are held for improved agricultural techniques in about 100 farmers' fields in the Changwat. The Agricultural Extension Department has its extension offices on the levels of Changwat and Amphoes. The extension office for each amphoe has, on the average, five or six extension agents and staff.

Each extension agent is responsible for his services for 1,100 to 1,800 farm households. Therefore, the extension agents are not always sufficient in numbers. Especially, they are now suffering from the shortage of vehicles and materials for audio-visual education.

4-7-3. Agricultural Cooperatives

The Agricultural Cooperatives Promotion Department, the MOAC has an office of its own in each Changwat and Amphoe for the purpose of giving guidances and supervision of agricultural cooperatives. The Amphoe office coexists in the office of the cooperatives, and the officials in charge have given close guidance and administration to the cooperatives concerned. Among many cooperatives of the Amphoes, the Ban Lat cooperatives provides a high rate of membership and the services are considerably well balanced in the fields of marketing, purchases, and crediting. In contrast, however, the other Amphoe cooperatives are almost limiting their services to credit services with inactive works in the marketing, purchases, etc.

4-7-4. Water Users' Association

In the Phetchaburi irrigation project area, five water users' associations were established in 1969 with 4,402 farmers as their members. Since 1973, however, the benefited farmers have unpaid their association fee due to malfunction of the on-farm facilities of ditches and dikes and eventually the associations have become very dull in activities.

4-8. Farm Economy

In the Project Area, the farmers are engaged in cropping of paddy, vegetable such as mungbeans and pulses; cucumbers, cabbages, etc., and fruits such as banana, lime, etc. However, paddy culture plays a main role in the farming with dependency of 90 percent of the total cultivated area and 65 percent of the farm income.

With the cooperation of the Economic Section, the Planning Division of RID, the survey was conducted on the farm economy in December 1980. The Project covers so wide an area that 300 farm households in 17 communities were selected as objects by random sampling.

Summary of Farm Economy Survey

Amphoe	Tambon	Muban	Sample Numbers	Farm Size per Farm (ha)	Paddy Field per Farm (ha)
1. Muang	1. Dong Yang	1. Nong Bo	35	1.66	1.14
	2. Na Phan Sam	2. Bang Phrom	21	5.46	5.46
	3. Rai Som	3. Hua Non	11	9.85	9.78
	4. Nong Sano	4. Nong Sano	13	10.00	3.78
2. Khao Yoi	1. Nong Pla Lai	5. Kao Samo Rabang	10	5.89	1.97
3. Cha-Am	1. Na-Yang	6. Na-Yang	15	5.30	4.76
4. Tha Yang	1. Tha Yang	7. Sai Khan	12	2.26	1.07
	2. Tha Khoi	8. Sa Phra	11	4.24	3.29
	3. Map Pla Khao	9. Nai Dong	27	3.57	3.09
	4. Yang Yong	10. Nong Nam Thai	15	3.95	2.61
	5. Nong Chok	11. Nong Tao Pun	20	2.11	1.61
5. Ban Lat	1. Nong Krachet	12. Rai Phum .	10	3.12	2.58
	2. Ban Hat	13. Chang Kae (Rai Nong)	32	3.49	3.26
	3. Rai Sathon	14. Rai Sathon	22	2.55	2.32
	4. Nong Kapu	15. Ban Rai Khae	16	2.08	1.80
6. Ban Laem	1. Ban Khun Sai	16. Pa Khat	18	3.62	3.51
	2. Bang Khrok	17. Thung Fua	12	5.41	4.97
	Total		300	3.94	3.13

The average farm size per sample farmer is 3.13 ha of paddy field, 0.09 ha of upland field, and 0.72 ha of orchards, totaling 3.94 ha which are relatively higher than that of 3.26 ha (1978) in Changwat Phetchaburi. The farm size of almost all farm households ranges from 0.5 ha to 6.99 ha (265 farm households occupying 88 percent), out of which those with a farm size of 3.0 to 3.99 ha predominate in numbers, accounting for 35 percent (105 farm households). As for the land tenure types, partial tenant farmers are predominant in numbers, accounting for 47 percent, followed by the owner farmers of 45 percent, and then by the tenant farmers of eight percent. Almost all of the rented lands by farmers are paddy fields (98 percent), whose rents are largely payable in kind (91 percent) in the form of rough rice. In this case, the rents average 840 kg/ha. Since the average yield per hectare of the

rainy season paddy is 2,170 kg, the said rent corresponds to 39 percent of the harvested crop. However, the production costs of the rainy season paddy account for 40 percent of the harvested crop. In this way, such production costs plus rent come to 79 percent of the gross output. This means that the farm rents are a heavy burden upon tenant farmers' economy.

For the number of farm family members, those with six or five members are predominant, respectively accounting for 20 percent. Their average is 5.7 persons. About 59 percent of the family members belonging working group in 10 to 16 years of age are engaged in their own farming works and 15 percent supplies the hired labor to the other farmers; as a result, 74 percent of the working members is engaged in the farming works. Those who are working in other kind of industries occupy 24 percent. As for the farm households by fulltime and part-time farmer, the full-time farmers occupy 27 percent, while the part-time farmers of 73 percent are typically predominant in numbers. This is perhaps because they wish to earn more income from non-farm works in order to divert their surplus labor and to increase their home budget surplus as a result of limitations to irrigation water supply needed for their dry season cropping.

CHAPTER V THE PROJECT

CHAPTER V. THE PROJECT

5-1. Project Components

The purpose of Phetchaburi-Kaeng Krachan Irrigated Agriculture Development Project is to increase agricultural productivity by increase in the yield, the area of irrigated paddy fields and double cropping acreages, through which to assist the improvement of farm economy, and furthermore to contribute to the acquisition of foreign currency through export of rice. To attain this purpose, the Irrigation Improvement Project and On-farm Development Project have been proposed as Project Components.

The first necessity of the implementation of the Irrigation Improvement Project comprising the improvement of existing facilities and additional construction of facilities is that the present relatively low paddy yield prevailed in some parts of the Area should be increased to the level of high yields attained at the upstream area. The Irrigation Improvement Project is a necessary prerequisite to the successful implementation of the On-farm Development Project.

Full effect of On-farm Development can not be expected only through engineering works such as provision of irrigation and drainage facilities but requires the supporting services of the extension of the advanced farming techniques and proper water management as well. Therefore, this On-farm Development Project contains the supply of machinery and equipment for extension services as well as operation and maintenance of the irrigation system.

5-2. Development Plan

5-2-1. Land Use

(a) Expansion of Irrigation Area

The area commanded by the existing Phetchaburi irrigation system is 48,850 ha which is 87 percent of 56,450 ha of the present farm lands in the Project Area. The cultivated fields of 7,600 ha along the seadikes are cropped with the rainy season paddy by rain water and excess water from upstream.

In the flat area along the seadikes, the Tha Chin series and the Samut Prakan series are widely distributed. According to the soil classifications for paddy cropping suitability, both the soils restrain the paddy production by higher soil salinity. The dry season soil survey conducted in this study (96 places), 61 percent of top soil samples (0 - 30 cm from the ground surface) and 67 percent of sub-surface soil samples (30 - 60 cm), indicated the salt concentration of more than 6 mmho/cm that was recognized to have negative effect to the paddy production.

Even under such conditions, the area of 7,300 ha is cropped with the rainy season paddy as the food production area for the local inhabitants. The Project attempts to stabilize the paddy production through timely supply of irrigation water including initial salt leaching water.

For the effective salt leaching, the groundwater table should be lowered below the root zone. But since, however, the extension area lies in the low-lying land, artificial drainage by pumps is required to lower the groundwater table. The subsurface drainage, which requires the underdrains and pumping stations, in found economically unfeasible and will not be employed in the Project.

The salinity control will be made through leaching of the paddy fields during the period between the first plowing and the transplanting with sufficient irrigation water so that highly salt-vulnerable young seedlings immediately after transplanting can be alleviated in the expected salt damages.

The soil salinity control by leaching will serve to improve the present soil conditions for paddy cropping to some extent through lowering the soil salinity after transplanting, although having limitation in yield increase due to negligence of decrease in groundwater table.

(b) Increase in Dry Season Cropping

At present, as the second crop, the dry season paddy and the upland crops are grown in the fields of 8,340 ha on the annual average. These are limited to the paddy fields lying along irrigation or drainage canals so as to allow easy irrigation. The largest restriction in the increase in the dry season paddy cropping area is the limitation of water sources available in the dry season. Since the water resources development is out of the scope of works for the Project, the increase in the dry season cropping inevitably requires to expand the irrigable areas by the improvement of irrigation canals and on-farm development, proper water management, to reduce the irrigation loss.

The Kaeng Krachan reservoir operation study was carried out on several alternatives on the expected irrigable areas for the purpose of getting the area to be provided with irrigation water supply by the proper reservoir operation after the completion of the Irrigation Improvement and On-farm Development Project.

The said analysis have allowed to propose the plan that the dry season paddy cropping and the upland cropping as the second

crops can be introduced to the area of about 14,300 ha and the irrigation in the dry season can be secured for the total area of 18,200 ha involving the orchards and upland fields of 3,900 ha.

(c) Acreages by Land Classifications and Land Use Ratio

The Project Area shall cover the area of 74,000 ha in gross, including the existing irrigation area of 63,900 ha and the so-called Extension Area lying along the seadikes by 10,100 ha that shall be incorporated into the Project Area. In implementation of the Project, some farm lands should be deducted for public use to result in the net farm lands of 52,600 ha decreased from the current acreage of 56,450 ha. On the other land, the land use ratio for the dry season cropping will be increased to 135 percent from the present ratio of 117 percent by expansion of the cropping acreage. The acreages by land classification and the land use ratio are summarized as follows:

° Project area	74,000 ha
° Beneficial area	52,600 ha
° Irrigable area in the rainy season	52,600 ha
'Existing irrigable area	45,500 ha
'Paddy field	41,600 ha
'Upland field	1,600 ha
'Tree Crop field	2,300 ha
'Extension area	7,100 ha
'Paddy field	7,100 ha
° Irrigable area in the dry season	18,200 ha
(Existing irrigable area)	
'Paddy field 'Paddy	7,000 ha
'Upland crops	7,300 ha
'Upland	1,600 ha
'Tree Crop field	2,300 ha

° Lant utilization rate 135 %

° Paddy field utilization rate 129 %

5-2-2. Agricultural Development

(a) Selection of Proposed Crops

The proposed crops for the Project were selected in considering the land classifications, proposed land use, availability of water sources, farmers' technical level of farming, etc. The major crop is paddy as it is at present, and the next is mung-beans as the second crop. Paddy, needless to say, staple food in Thailand and the important export item, and the paddy production increase shall meets with the national policy. Mung-beans, arid-resistant with short cultivation period, are best-suited as the second crop in the dry season. Mungbeans, being of very wide use, have not only a large domestic demand, but also high marketability as promising export oriented crop.

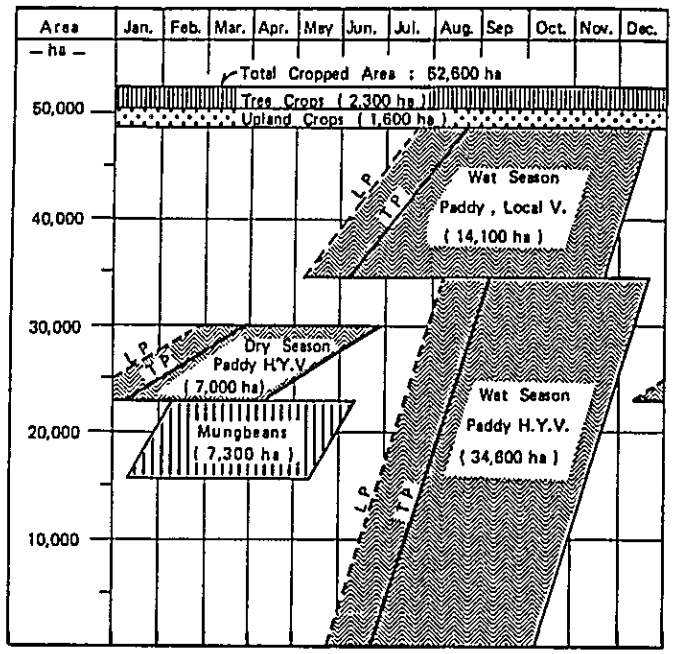
The population influx to Bangkok and the local medium or small cities has been increasing demands for vegetables and fruits. The Project Area is advantageous in vegetable production because of being closely located to the metropolitan area and convenient in transportation of the products. The Phetchaburi area is famous for its production of lemons (manan), bananas, mangoes, pineapples, etc. Such cash crops production as fruits and vegetables require the intensive inputs of capitals and labours as well as sophisticated techniques for successful sales and marketing of these products. Therefore, a sharp expansion of the cropping acreages should not be planned, whereas the introduction of irrigation and upgrading the farming techniques are proposed, instead, so as to increase their yields. Collecting, assorting and forwarding of these products should be carried out by collective works under the control of the agricultural cooperatives.

(b) Cropping Pattern and Calendar

The categories of the land to be irrigated by this Project are paddy fields, common uplands and orchards.
Paddy is to be grown in all the paddy fields in the rainy season, while paddy and mungbeans are to share the fields in the dry season. And the share of cropping acreages in the dry season will be determined in depending upon the availability of the water sources. In the common uplands and the orchards, perennial cropping of vegetables and the fruits will be practised.

The paddy cropping, although desirable to introduce the HYV, will be carried out with the local varieties in some parts in taking consideration of the public preference for rice and the farmers' skilfullness for HYV farming. Furtheremore, the local varieties will be obliged to be grown in some paddy fields where the irrigation and drainage conditions and on-farm conditions are unfavourable for HYV farming.

Proposed Cropping Pattern and Calendar



Note : LP = Land Preparation
TP = Transplanting

The HYV paddy with short growth period should be grown for introducing the double cropping a year. The study on the proposed paddy cropping has found that the HYV paddy should be grown in about 70 percent of the paddy fields in the rainy season.

The cropping calendar was determined as follows in taking into account the plants physiology, rainfalls, labour balance, preparation for cropping, O & M of facilities, etc.

Land preparation is planned to last 2.5 months for all of the Area just as it has been carried out for. For introducing the paddy double cropping, the puddling works are desirable to further shortened to 1.5 months; however, the capacity of the greater part of the existing idrigation canal should be improved to meet the requirements of such short period puddling works. The rainy season local paddy varieties should be carefully grown not to be later in transplanting than 20th of August because the yield decreases when the transplanting was carried out later than that data.

(c) Yield Projection

Based on the analysis of the present yields of the respective crops, the yields are forecasted to be achieved as follows in taking into account the improvement of irrigation facilities, on-farm development and expected upleveling of the farming techniques. The expected yields of paddy were obtained with different yields by respective on-farm development levels to be averaged by the cropping acreage ratio.

The forecasted yields require to be realized in the whole Project Area essentially by reinforcing supporting services such as proper water management, extension services, cooperative activities, etc., although successfully achieved already in the demonstration farms. The said forecasted yields are well expected to be realized in the Project Area, where the farmers have had experience of irrigated agriculture for some 10 years, within five years after project completion by the farmers' farming techniques to be graded up through the aforesaid various supporting services.

The target yields, when achieved, will produce about 220,000 tons of paddy per annum, which is about 1.7 times as much as the present production of 130,000 tons.

Yield and Production of Main Crops

Crops	Area (ha)	Yield Projected (ton/ha)	Production (1,000 ton)
Paddy field			
- Rainy season rice, LV	14,100	3.18	44.8
- Rainy season rice, HYV	34,600	4.17	144.2
- Dry season rice, HYV	7,000	4.42	31.0
- Dry season, mungbeans	7,300	1.00	7.3
Upland			
- Vegetables	1,600	15 x 2	48.0
Fruit	2,300	6.7	15.4

(d) Farm Input Materials

The amount of paddy seeds to be required in the Area, when realizing the production target, will be approximately 3,100 tons per year, 71 percent of which is to be the HYV.
At present, the paddy seeds have been distributed by the agri-

cultural extension offices, however, it is desirable in the future that the paddy seeds be distributed to the farmers through agricultural cooperatives under the supervision of Agricultural Extension Department. At present, the fertilizer is rarely applied to the existing rainy season paddy cropping, while ammophose is applied at the rate of 200 kg/ha to a few area of dry season paddy cropping fields under the guidance of agricultural extension offices.

A successful realization of the target paddy yield in the Project requires to dose fertilizers of 220 - 390 kg/ha. The realization of the target production requires to give input of fertilizer of 19,600 ton/year for the cultivation of paddy, upland crops and fruit trees, and 80 percent of the said amount is ammophose. The necessary fertilizer per unit area for paddy is shown in the following table.

Application Rates

	Fertilizer (kg/ha)	N-P-K
Dry season paddy, HYV	Ammophose: 300 Urea : 90	89-60-0
Rainy season paddy, HYV	Ammophose: 275 Urea : 35	60-55-0
Rainy season rice, LV	Ammophose: 200 Urea : 18	40-40-0

(e) Farm Labor Requirements and Mechanization

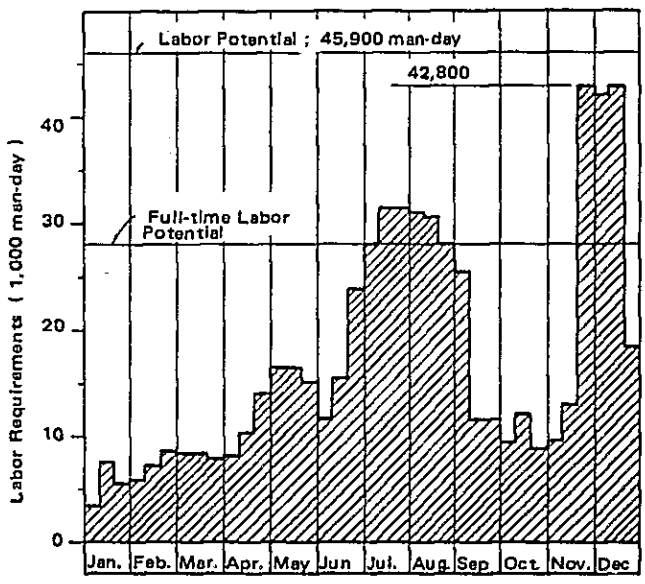
1990 was estimated to increase to 30,800 of male, and 33,200 of female. Taking the working ability of female by 80 percent of male, the total working population available in agriculture is estimated at 57,360. Considering the improvement of standard

of living in future and taking labour efficiency by 0.8, the manpower per day in the Area was estimated as 45,900. According to the proposed cropping pattern, the labor requirements calculated in ten-day basis are shown in the following figure, and the peak requirements take place in December, the harvest time of the rainy reason paddy. For the labor requirements in this period of 42,800/day, the labor potential is 45,900/day; thus labor supply in the Project Area will meet the demand. Meanwhile, since full-time labor potential is about 28,000/day, and hired labor is required in the period of transplantation of the rainy season paddy and harvest time.

Power-tillers 8 - 10 horsepower (HP) owned by farmers in the Area have been double in number in recent five years, and were estimated at 2,750 in 1981. These power-tillers have been used for land preparation, puddling, transportation and thrushing.

For about 55 percent of the paddy fields in the Area, mechanized works have been employed in plowing and puddling. The farming works in future will be carried out along with the schedule worked out for increasing the cropping intensity and irrigation efficiency, and the farm mechanization will be promoted further to meet the requirements.

Use of Labor for All Crops



The Project has worked out the plan to fully employ the power-tillers for plowing and puddling works, while to employ the manual labor for transplanting and reaping. Based on the aforesaid plan, the power-tillers of 5,600/day will be necessary for the achievement of the development target. In the Project Area, rental basis cultivation by 40 - 60 HP tractor has been well diffused, and these tractors together with the power-tillers to be purchased by individual farmers will be able to meet the mechanization demand of the Project.

5-2-3. Agricultural Supporting Services

(a) Water User's Association

Present water users' associations are in passive existence, in spite that the organization and activity of the water users' association is very important for the agricultural production after completion of on-farm development project. Specifically, while the Phetchaburi O & M Office controls the water distribution, O & M works covering the extent upto the main and lateral canals, the water users' associations should carry out the water distribution from the turn-outs and O & M works for the farm ditches. Hence, the irrigation section should be established in the beneficial area by about 200 ha on an average, which shall be sub-divided into several subsection with about 20 ha, and each subsection should have an elected farmers' representative as check leader, who is responsible for operation of the turn-outs for proper irrigation to meet the respective farmers' requirements and for O & M of the farm ditches. And the zone checker is to be elected for each irrigation section in corresponding to the zone man in RID O & M Office. The zone checker must serve to do an effective water management in taking always close contact with the O & M Office, for example, to notice timely and pertinently the water demand based on the cropping plan to zone man of RID.

The facilities such as an office building for the meeting of the related farmers and office works, transportation facilities and communication equipment, and other office supplies for the representatives are required for successful discharge of the duties.

And in future when the on-farm development is completed, the necessary operation and maintenance services of the irrigation/ drainage facilities will require the allocated charges to the farmers concerned at the reasonable rate, besides the national budget for the purpose. This cost or allocation should be collected from the relevant farmers as water charges by water users associations, which should provide the complete members' list carrying the acreages of the farm plots and numbers of the plots of those individual farmers belonging to the association.

Furthermore, an operation committee should be established to provide the fundamental rules for successful operation of the water users' association and management through consultative meetings by RID O & M office chief as president, water masters, zone men, zone checkers and representatives of cooperative and Amphoes extension offices, in taking into account the vitally important roles of water distribution, O & M of the facilities, etc. as the base of the local agricultural production

(b) Agricultural Extension Services

With completion of On-farm Development Project, highly advanced farming can be introduced into the well consolidated farm lands, and by that introduction the ultimate purpose of the Project, the increase of agricultural production and modernization of management will be realized. Application of such advanced

technology will allow to realize the agricultural production increase and the modernized farm management as the ultimate purpose of the Project. The agricultural extension works are prerequisites to expansion and reinforcement for accomplishing the purpose. The extension agents in Changwat Phetchaburi is assigned by one agent per 1,100 - 1,800 farmers at present; however, the National Agricultural Extension Service Promotion Project (NAESP), which will be taken up in Changwat Phetchaburi in 1982, has a plan to assign one agent per about 600 farmers.

The trainings of extension agents and farmers for short-, medium- and long-term as well as the reinforcement of the extension agents in numbers are essentially required. Such trainings and studies are desirable to be carried out in the various training and education centers/institutions provided in the adjacent areas of the Project Area.

Furthermore, since the current provision of the transportation facilities and audio-visual equipment that are essential for training and education is quite insufficient, these equipment and facilities should be fully supplied and provided for successful extention activities.

(c) Agricultural Cooperatives

After the completion of the Project, the cultivation will become intensive, and the purchase of input materials will increase owing to the introduction of high yielding varieties and more consumption of fertilizers and agricultural chemicals. And the marketing farm products will also increase. As a results, utilization of market by farmers will increase much more than before. In order that farmers can enjoy the reasonable sales profit of the farm products, if is necessary to activate