the sales and purchasing through the agricultural cooperatives organized by farmers and to increase the efficient utilization of the cooperative. Especially, since rice-milling facilities mut be expanded for increasing production of paddy, the cooperatives should carry out milling services not leaving to non-farmer private enterprise. At present, the total production of unhulled rice in Changwat Petchaburi is about 180 thousand tons, and the production in the Project Area is about 70 percent of the above, i.e. 130 thousand tons. The total production of unhulled rice in the Project Area in the fifth year after completion of the Project is expected to be about 240 thousand tons.

Meanwhile, present milling capacity in Changwat Petchaburi is about 180 thousand tons (12 hours operation per day: Changwat office of Ministry of Industry). But about one third (60,000 tons) of it is processed by small millers, and the quality of the milled rice is poor. Therefore, for the future increase in paddy production, milling plants having modernized equipment should be provided by the agricultural cooperatives to secure high quality.

Since the cooperative milling plants are expected to provide the capacity of some 100 thousand tons, the Ban Lat cooperative and Muang cooperative which have provided the facilities already, and the Khao Yoi cooperative which has handled considerable amount of paddy, are recommended as proposed plant sites in terms of favourable locational conditions. The design capacity of new milling facilities should be about 200 tons/day.

Capacity of Rice-cleaning

(Unit: to/day)

Name of Amphoe	Present Capacity	New Facilities	Total
1. Amphoe Ban Lat. Cooperatives Ltd.	40	200	240
2. Amphoe Muang Cooperatives Ltd.	24	200	224
3. Amphoe Khao Yoi Cooperatives Ltd.	-	100	100
Total	64	500	564

5-2-4. Irrigation and Drainage

(a) Irrigation and Water Requirement

Since subsurface drainage is not adopted in the Project from the viewpoint of economy, complete salinity leaching effect can not be expected. However, the leaching water is contained in the water for land preparation, but not in the irrigation water after transplanting, taking into account the fact that the groundwater table becomes comparatively low in the land preparation season moreover the low soil salinity concentration in the said season will give favourable effects to the paddy growing.

The water involved in the crop water requirements are those for crop consumptive use, land preparation/pre-irrigation for uplands, percolation, and effective rainfall. These values were determined by actual measurement or empirical formula as follows:

- Crop consumptive use (Cu):

Crop consumptive use is obtained by multiplying evapotranspiration (ETo) by crop factor (Kc) for different growing stages of the crops. These values are measured by RID at water use experimental stations, which has reported that Penman method was best suited out of various

calculation method of crop consumptive use (Irrigated Agriculture Section, O & M Div. RID, 1980). In the Project, evapotranspiration was estimated by modified Penman method (Crop Water Requirements, FAO, Irrigation & Drainage Paper 24, 1977) employing the weather records at Hua Hin weather station to determine the crop factor on the basis of the observation values of RID.

The monthly mean evapotranspiration obtained by the above equation is shown as follows. The details are illustrated in A. Hydrology, Appendix.

Monthly Mean Evapotranspiration

(Unit: mm)

Month	ETo
Jan.	152
Feb.	154
Mar.	190
Apr.	196
May	173
Jun.	154
Jul.	152
Aug.	144
Sep.	137
Oct.	140
Nov.	145
Dec.	146

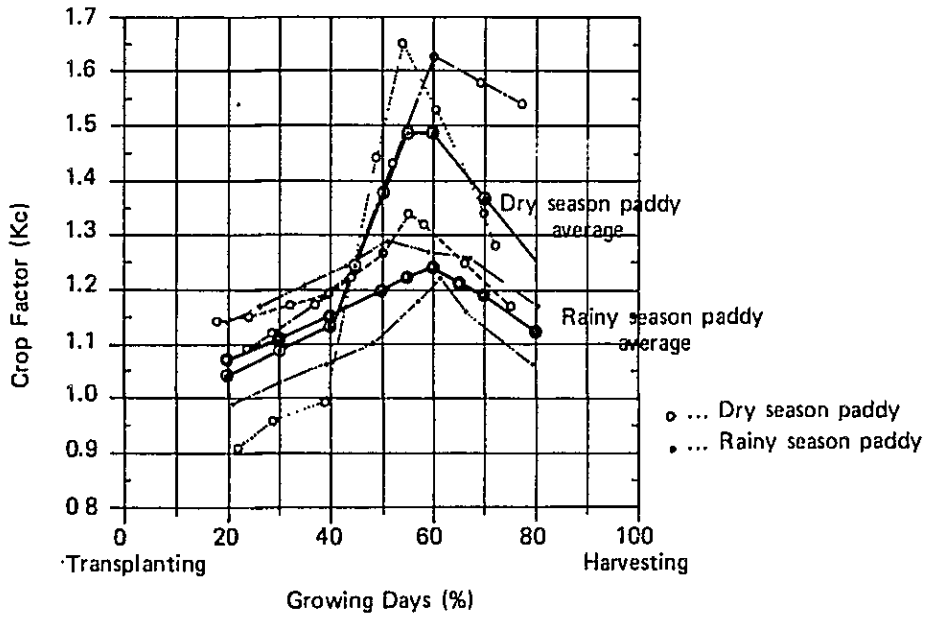
According to the experiments carried out at three water use experimental stations of Phetchaburi, Mae Tang and Samchook by RID (1978 - 79), the variations of the crop factors of the paddy plants for their growing days indicates that there are some differences between those of the dry season paddy and those of the rainy season paddy and the crop factors of the dry season paddy have higher values at the peak than those of the rainy season paddy does.

The figure illustrating the relationship between the paddy growing days and the crop factors based on the RID's data is attached hereto for references. In this figure the numbers of the growing days cover the period from transplanting to the harvest of the paddy.

The monthly mean crop factors of the rainy season and the dry season paddy, which can be specified by the RID's measured data, can be shown as follow; and the crop factors for the period of nursery and land preparation was set out by 1.00 and those of the upland crops were determined by the values obtained in the Mae Klong Irrigation Project.

Crop Factors

Growing Stage (month)	Rainy Season HYV	Rainy Season LV	Dry Season HYV	Dry Season Upland Crops
1	1.03	1.01	1.03	0.5
2	1.13	1.12	1.28	0.8
3	1.21	1.22	1.26	1.1
4	1.00	1.12	-	0.9
5	-	1.00	-	-



- Land preparation/pre-irrigation (LP):

No measured data are available for the above values of Land preparation for the objective Area, but the proposed value of the Land preparation was estimated at 200 mm including 50 mm of the requirements for initial leaching, taking into account the current values of 150 mm for land preparation and physical properties of the soils in the Area. When the soils in the Area, having about 45 percent in porosity, are filled with water onto 70 percent of the porosity in the soils 300 mm below the surface, and when the flooding depth over the field is kept at 50 mm, the water requirements are estimated at 145 mm. The water requirements for pre-irrigation of the upland cropping was designed by 50 mm according to the results of the study in the Mae Klong Irrigation Project.

- Percolation (P):

The Phetchaburi Water Use Experimental Station has carried out the measurement of the percolation to make report by 1.54 mm/day on an average. According to the percolation measurements conducted in this study at 30 points in the Area, most of the small percolations were observed at the low-lying points, while these values ranged below 2.0 mm/day. Based on these data, the designed percolation was determined at 1.5 mm/day. For upland irrigation, the percolation can be regarded as irrigation losses.

- Effective rainfall (Re):

The RID carried out the analysis of the daily effective rainfalls for the paddy fields in the study of the Mae Klong Irrigation Project on the assumption that, in consecutive raining days, the effective rainfalls of the following day would be half in amount of that in the previous day, and the analysis was conducted for 10 years with the data available at 11 observation points to estimate

the monthly effective rainfalls in percentage against the monthly rainfalls. In the Master Plan Study for the Greater Mae Klong River Basin Development Project (JICA, 1980), the JICA team made a Tank Model Analysis, in replacing the RID's estimation, with the data available at 21 points for computing the daily effective rainfalls for 26 years and estimate the percentage of the effective rainfalls on both the monthly basis and the 10-day basis. The percentage of the monthly basis effective rainfalls was estimated at almost the same as those which the RID could computed. This study will apply the values obtained in the Master Plan Study of the Great Mae Klong River Basin Development Project.

Effective Rainfalls

(Unit: mm)

Crops	Effective Rainfall	Max. of Eff. Rainfalls	
		Monthly	10-day
Paddy	Rainfall x 0.75	200	70
Upland crops	Rainfall x 0.75	120	40

The computation for the canal section was made taking the minimum monthly rainfalls with 5-year return period as design rainfall for determination of the effective rainfalls. The probable monthly minimum rainfall as Phetchaburi observation station is shown as follows.

Probable Monthly Minimum Rainfalls

(Unit: mm)

Month	Return Period		Month	Return Period	
	2 Years	5 Years		2 Years	5 Years
Jan.	1.2	-	Jul.	115.8	77.8
Feb.	3.6	-	Aug.	121.8	70.7
Mar.	5.2	-	Sep.	171.8	116.4
Apr.	11.9	2.1	Oct.	248.0	153.7
May	122.5	68.1	Nov.	71.9	25.5
Jun.	89.0	43.7	Dec.	4.2	-

- Irrigation efficiency:

Water losses in the course of irrigation works shall be specified into two, those caused as conveyance losses in the canals and those in the course between the irrigation ditches and the fields. In the lined canals, the irrigation efficiency shown in the following table will be secured through uplevelling of the farmers' water management techniques when the Irrigation Improvement Project and On-farm Development Project are completed.

Irrigation Efficiency

(Unit: %)

Items	Paddy	Other Crops than Paddy
Field Efficiency	70	60
Conveyance Efficiency	85	85
Overall	60	50

- Total Irrigation requirement:

As a result of the reservoir operation study mentioned in the following paragraph, the proposed irrigable areas under the irrigation by existing Kaeng Krachan reservoir (700 MCM) were estimated at 52,600 ha in the rainy season and 18,200 ha in the dry season. According to the cropping pattern and the aforesaid irrigation plan, the irrigation requirements in the average year were estimated at 6.35 MCM per annum, and the monthly requirements brokendown as below.

Monthly Irrigation Requirements (MCM)

Month	Irrigation Requirement	Month	Irrigation Requirement	Month	Irrigation Requirement
Jan.	38	May	9	Sep.	56
Feb.	50	Jun.	73	Oct.	5
Mar.	65	Jul.	110	Nov.	37
Apr.	64	Aug.	103	Dec.	25

- Peak irrigation requirement:

The canal capacity is determined by the peak irrigation water requirements. The designed irrigation requirements in this study was taken by 10-day basis peak water requirements which were derived from the design rainfalls based on the minimum monthly rainfalls with the 5-year return period. The proposed cropping pattern provides five cropping types in rough classification. The perenial cropping in uplands and orchards, which occupy a limited small areas, are classified into one type for easy handling in the study. Based on the cropping calendar, estimation of the water requirements on the 10-day basis was made as shown below for the peak water requirements per hectare by cropping types.

Peak Irrigation Water Requirements

Cropping Type	ℓ/s/ha	Time of Occurrence
Rainy Season Paddy, LV	1.30	2nd Decade of July
Rainy Season Paddy, HYV	1.31	1st Decade of August
Upland Crops/Tree Crops	1.06	April
Dry Season Paddy, HYV	1.82	2nd Decade of February
Dry Season, Mungbeans	1.53	2nd Decade of April

The peak irrigation requirements of the paddy that covers the largest irrigation areas shall take place in the land preparation period. The unit peak water requirements shall become largest in the amount in the course of the dry season paddy cropping when little effective rainfall can be expected.

However, the canal capacity in the Project is designed based on the water requirements for the land preparation in the rainy season paddy cropping, because the limited availability of water sources in the Area has restricted the dry season paddy cropping

by about 14 percent of that for the rainy season paddy cropping. The peak water requirements for the rainy season paddy cropping have differences in the amounts and the time of occurrence between the LV and the HYV. The peak requirements for the HYV rainy season paddy appears in the second decade of July, when the LV requires the water of 0.9 ℓ/s/ha. The weighted average of these values by the cropping ratio of HYV to LV (HYV : 70 percent, LV : 30 percent) becomes 1.19 ℓ/s/ha. The design capacities of the proposed canals for the Project were determined by taking the design discharges of 1.19 ℓ/s/ha for the paddy fields and 0.35 ℓ/s/ha for the upland crops/tree crops, respectively, whereas the design discharge for the ditches was not taken by the weighted average values but by 1.12 ℓ/s/ha of the peak water requirements at on-farm level for the HYV rainy season paddy.

The total peak water requirements for the whole area was estimated at 59.3 m^3/s which can be broken down as below. For references these values cited above are ranged within the diversion capacities of the Phet diversion dam.

Peak Water Requirements

Canal System	Irrigable Area (ha)			Peak Water Requirements (m^3/s)
	Paddy Field	Upland/orchards	Total	
Left Bank	12,100	690	12,790	14.64
Right Bank	29,500	3,210	32,710	36.23
Extension Area	7,100	-	7,100	8.45
Total	48,700	3,900	52,600	59.32

(b) Reservoir Operation

For increasing the land productivity of the Phetchaburi Area, a plan was made to introduce the rainy season irrigation for the 7,100 ha of the Extension Area and to increase the irrigable areas for the dry season paddy cropping in the whole Project Area. Since this Irrigated Agriculture Development Project will not develop any further water sources for irrigation, the reservoir operation study on the existing Kaeng Krachan reservoir was conducted to have a knowledge about the acreage irrigable in the dry season under the proper operation of the reservoir with various cropping pattern by different cropping acreages. The said study was made in the following condition for seven years (1974 - 1980) providing the available hydrological data and information.

Proposed irrigable areas: The acreage of farm lands in the Area will be reduced from present 56,450 ha to 52,600 ha due to deduction of lands for public use such as roads, canals, etc. The above proposed farm lands include 45,500 ha (41,600 ha of paddy fields & 3,900 ha of uplands/orchards) in the existing Phetchaburi Project Area and 7,100 ha (paddy fields) in the Extension Area. The Project will give the first priority in land use to the successful irrigation for the Extension Area in the rainy season and the second to the dry season irrigation, besides the perenial cropping in the uplands/orchards in the existing Phetchaburi Project Area and the rainy season irrigation for paddy cropping.

The second cropping (in the dry season) in the Paddy fields was planned by mungbeans which provides the considerable aridity-resistance and are expected to have a large demand, and their cropping acreage will be about 7,300 ha, 15 percent of the total paddy fields.

Water demand: The Kaeng Krachan reservoir effective (storage of 700 MCM) has been supplying the water to irrigation, municipal and industrial use, river maintenance and power generation, the water demands of which were estimated respectively as follows.

- Irrigation: Irrigation water requirements for seven years were computed according to the effective rainfalls estimated by using the records kept at the Phetchaburi observation station.

  When the irrigation requirements are below the peak water requirements, the water level in the canals will stay below the designed full water supply level to result in losing the proper function in diversing the water. This study took the minimum discharge for the canal maintenance by 15 percent of the peak water requirements (7.50 m^3/s)

- Municipal and industrial use: The water supply to the municipal and industrials use will be made as what it has been made by 2.34 m^3/s to Phetchaburi and Cha-am and to the cement plant.

- River maintenance: The reservoir release shall be made so that the discharge of the Phetchaburi river should not be below 5.0 m^3/s at the immediate downstream of the Phet diversion dam.

- Power generation: The reservoir release for power generation should be kept in its release level according to the actual results recorded by EGAT for the necessary study period.

Water sources: The inflow to the Kaeng Krachan reservoir (2,210 km^2) has been recorded since August, 1974, by EGAT on the daily basis. The local runoff discharge from the residual areas (1,850 km^2) lying between the reservoir and the diversion dam were estimated at 40 per-

cent of the inflow to the reservoir as a result of analysis on the intake amount at the diversion dam and the discharges to the downstream. The Extension Area, which is outside the coverage of the existing Phetchaburi Project, has depended its irrigation water sources for paddy cropping upon the rain waters and the excess water from the existing Phetchaburi Project Area and being traversed with the every drainage canal that was provided in the Phetchaburi Project, will be able to utilize the return flow from the upstream for irrigation, when the irrigation/drainage facilities are constructed in the area. The return flow survey carried out in this study has revealed that about 25 percent of the water taken in the upstream areas (equivalent to 63 percent of the designed irrigation losses) will be available for irrigation in return flow in the Extension Area.

Water balance: The Kaeng Krachan reservoir operations study was made on the monthly basis for the period from August 1979 to December, 1980 with paddy cropping acreage varied. The designed reservoir release was determined by the larger one of the two, the discharges to the downstream demand (irrigation, municipal/industrial use, and river maintenance) and power generation demand. The reservoir losses was estimated based on the correlations of the stored water and the losses.

The following two standards were set up for deciding the proper scale of the irrigation system.

- In 1980, the wet year, the reservoir should fully store the water (Actually, however, the reservoir was not filled up with water in 1980)

- The stored amount at the end of 1980 should not be below the actual amount stored therein (150 MCM)

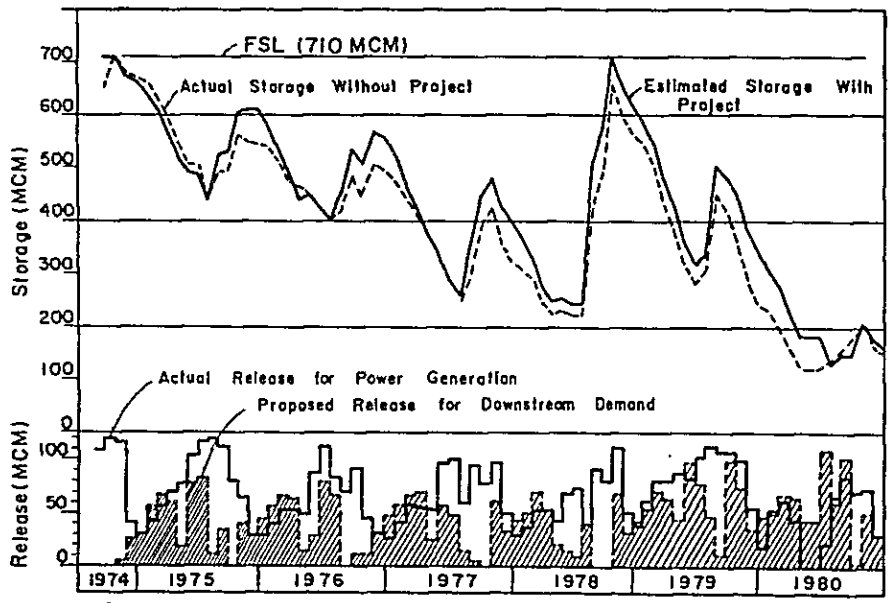
The area of 18,200 ha shown below is the maximum irrigable area in the dry season to meet both the above two conditions, and was taken as the proposed irrigable area in the dry season in this study.

Irrigable Area in the Dry Season

Crops		Acreage (ha)
Paddy Field	Paddy	7,000
	Upland Crops	7,300
Upland & Orchards		3,900
Total:		18,200

The results of the reservoir operation study are illustrated in the following figure, clarifying that the water fully stored in the reservoir in 1978 (710 MCM at total storage) drawn down to only 170 MCM (effective water : 160 MCM) at the end of 1980. The water stored in such little amount cannot be supplied to irrigation for the proposed irrigable area, and actually the Phetchaburi O & M Office stopped the irrigation water supply in that year.

Fluctuation of Storage



The records of inflow to the reservoir are available only for 16 years from 1955 to 1964 and from 1975 to 1980, excepting the dam construction period between 1965 and 1974. The rainfall records observed in the mountain catchments for the reservoir are available for one year only. The continuous rainfall observation in Phetchaburi city has been made since 1955. And there is very low correlation between the rainfalls observed in the mountain and the plain area where Phetchaburi city is located.

Under such circumstances, although the statistical evaluation of the extraordinary drought in 1980 is difficult, the storage draw-down in 1980 could be explained from the hydrological data for three years 1978 to 1980; namely, the annual rainfall recorded in the Project Area were below the average annual rainfall to a great extent in two consecutive years of 1979 and 1980; particularly in 1979, the minimum rainfall in the past 28 years was recorded, which caused the increase in the water demand mainly consisting of irrigation requirements, while the inflow to the reservoir was nearly the averaged amount in 1979 and the smallest inflow in 1980.

Storage in the Recent Three Years

Items		1978	1979	1980	Average
Demand	(MCM)	405	715	671	541 1/
Release	(MCM)	825	1,045	772	873 1/
Storage at Year-end	(MCM)	620	345	170	-
Inflow	(MCM)	1,086	813	579	837 2/
Rainfalls	(mm)	1,144	435	756	1,055 3/

Note: 1/: 6-year Average (1975 - '80)
2/: 16-year Average (1955 - '64, '75 - '80)
3/: 28-year Average (1953 - '80) at Phetchaburi city.

The aforesaid analysis will allow to suggest that 1979 and 1980 are the consecutive drought years that would have considerably low probability of recurrence in future. The study on land use and cropping pattern indicates that it was unavoidable to stop irrigation in the dry season in 1981 and to delay in land preparation in the rainy season in the same year, and it is considered inevitable in planning the projects of agricultural development that there would be some decrease in production in such extraordinary consecutive drought years as 1979 to 1980.

The successful irrigation water supply to the area of 52,600 ha including 7,100 ha of the Extension Area, depending the necessary water sources upon the existing Kaeng Krachan reservoir, will be ensured through the provision of such civil works as improvement of the existing earth canals into the concrete-lined canals and construction of the on-farm facilities as well as such upgrading works as effective water management for reducing the water losses by engagement of the water users' association to the services.

(c) Irrigation Systems

The construction of the new canal system from the diversion dam to the Extension Area of 7,100 ha will be unfeasible due to huge investment to be required, while (a) the increase in the existing canal capacities and (b) the dual use of the existing drainage canals for irrigation and drainage will be considered reasonable for the purpose. The former plan (case (a)) will require to increase the capacities of 20 canals of 33 canals on the right bank, and the total length of the canals to require improvement will be about 161 km, equivalent to about 60 percent of the total length of the canals on the right bank, of which 121 km is the concrete lined canals. Such capacity increase of the existing canals, however, has not been adopted in this study in due consideration of the fact that the large amount of cost will be needed for improvement of such long concrete canals, which have been functioning well under the present conditions.

Contrarily, the latter plan (case (b)) will be unfavourable in water management.

In taking into account the facts that all the existing earth canals should be improved into concrete lined canals, most of the existing concrete canals should be hightened with their side walls so as to increase the FWSL, and the canals would discharge the water at full water level only in the land preparation period, the irrigation method for the Extension Area is proposed herein as follows; the water supply to the said area should be made in the better use of the existing canal capacities to spare for the purpose around the period of the peak water requirements, and when there would be further short supply in irrigation water, the necessary amount of water should be conveyed to the area before land preparation period through the existing canals so that the water can be stored in the dual purpose canals to be constructed in the Extension Area for the timely water supply therein. This plan will take advantage in saving the construction costs, except those for the dual purpose canals (irrigation/drainage) in the Extension Area.

The water balance analysis for the Extension Area, conducted in taking the design rainfalls by the minimum rainfall with 5-year return period, revealed that the water storage to be required for the area would be 6.5 MCM, which excludes the runoff discharges by rainwaters in the Area. Consequently, the further study on the runoff discharge in the Area will allow the proposed water storage to be reduced in its amount.

The irrigation system-wise irrigable areas and peak water requirements are shown as follows.

Irrigable Areas and Peak Water Requirements

Canal System	Irrigable Areas (ha) Paddy Field	Upland, Orchards	Total	Peak Water Requirements (cu.m/s)
Right Bank: No.1	5,660	800	6,460	6.90
No.2	4,950	830	5,780	6.08
No.3	18,890	1,580	20,470	22.65
Extension	7,100	-	7,100	8.31
Sub-total	36,600	3,210	39,810	43.94
Left Bank	12,100	690	12,790	14.40
Total	48,700	3,900	52,600	58.34

(d) Rehabilitation and Construction of the Canals

To obtain effective water supply to the fields, three lateral canals with concrete lining are to be constructed on the left bank. The Extension Area in the right bank is divided into five irrigation blocks, considering topography, the elevation, and drainage system, and the earth canals with dual purpose of irrigation and drainage are to be constructed along the boundaries of each block. Total length of newly constructed canals is 11,050 m at left bank and 108,800 m at right bank, totaling 119,800 m.

The necessary discharge capacity of each canal is obtained multiplying irrigable areas commanded under the respectives canals by peak unit water requirements (1.17 ℓ/s/ha for paddy, 0.35 ℓ/s/ha for upland crops). Sixteen canals out of whole existing 41 canals are short in the capacity and five canals out of which are earth canals. The capacity of the earth canals will be increased by improving into concrete lining.

The hydraulical study found that the existing lining canals have no necessity of widening the canals but the increase in capacity could be secured by hightening of the lining side walls. Lining works of five canals out of existing 20 earth canals are made to increase the capacity, while the lining works of remaining 15 canals are to be also made to increase the irrigation efficiency and to alleviate the labor for O & M.

On the other hand, on top of the problems of discharge capacity increase, the full supply level of the existing canals will be raised as high as possible to increase the irrigable areas by gravity. The earth canals and the concrete lining canals which are of short in capacity are so designed as to elevate the full supply level by rehabilitation works mentioned above. Other canals are to be rehabilitated by elevating the concrete lining walls as well as by improving the facilities such as checks, drops and road-crossing structures, etc.

The construction and rehabilitation of canals are outlined as follows:

Construction and Rehabilitation of Canals

- Unit: m -

Canal System	Construction	Rehabilitation		Total
		Lining	Hightening	
Right Bank No.1	-	14,986	7,475	22,461
No.2	-	17,331	1,100	18,431
No.3	-	52,025	102,369	154,394
Extension	108,800	-	-	-
Sub-total	108,800	84,342	110,944	195,286
Left Bank	11,050	82,211	17,260	99,471
Total	119,850	166,553	128,204	294,757

(e) Surface Drainage

It is considered that no rehabilitation of the existing drainage canals with average drain capacity of 27 mm/day is necessary any longer to increase the capacity. Since, drainage troubles causing the discharge decrease in the existing drainage canals are due to growth of water weeds and heavy sediment, the proper operation and maintenance can clean the away.

Furthermore, the improvement of water intake by construction/ rehabilitation of the irrigation canals and provision of farm ditches will allow to prevent the drainage canals from reducing in the capacity because of the drainage canals would be used exclusively for drainage.

As mentioned already, there are no serious drainage problems in the Area, excepting for some small ill-drained areas found sporadically. The drainage ditches with drainage capacity of 27 mm/day, which are to be provided in the on-farm development project, will enable to improve the drainage conditions at the on-farm level. In the Extension Area, however, the water intake by damming-up of the water level in the dual-purpose canals will not improve the drainage conditions in the fields adjacent to the Extension Area, although not aggravates the present conditions. These areas were estimated at 3,500 ha extending in the low-lying flat lands at the elevation below EL.2.0 m.

(f) Subsurface Drainage

The survey on the seasonal fluctuation of the soil salinity concentration at 108 points in the four sample areas revealed that the number of the samples at top soils showing higher

concentration in the rainy season than in the dry season occupied 50 to 80 percent of the total sample numbers, although varying from one sample area to another, and the samples at the subsurface soils also showed a similar tendency. It is considered that such a phenomenon has resulted from the fact that the paddy field soils were under inundation or excessive saturation before paddy havesting when the dry season survey was carried out in December and January, while those top soils were still affected by salinity concentrated during the dry season when the rainy season survey was carried out in June and July, before the land preparation. Owing to the above-mentioned facts, the tendency of the groundwater table in the test boring was lower in the rainy season than in the dry season. And salinity of the groundwater at 32 points out of 48 samples was lower in rainy season than in dry season. Number of top soil samples which showed more than 10 mmho out of 108 samples was 42 points in the dry season survey and 44 points even in the rainy season survey. This phenomena suggests that in the fallow paddy fields during the dry season, salinity in the top soils was considerably accumulated in the period of land preparation.

Comparing the salinities of leachate before the test and on the following day of the start of the test/during the process of leaching test, it was found that the salinity on the following day was distinctly low, even though there were some differences (11 - 18 percent), and the decreasing rate of salinity of the more sandy soils was larger in its tendency. Judging from these results, it seems that the salt leaching with land soaking (100 mm) for the top soils (0 - 40 cm) is more effective than for those subsurface soils deeper than 40 cm from the surface. And the degree of decrease in salinity of groundwater in puddling season is, except some cases, slightly lower than in land soaking

season, and it seems that the difference in the amount of puddling water does not affect so closely to. It is considered that one of the causes of these decrease in the effect of desalination will be the decrease in permeability of the soils due to poor subsurface drainage systems.

Remarkable durability of leaching effect can be little expected after the reduction occurred in land preparation and puddling periods. The groundwater salinity at these points 20 cm below the surface was measured by some 3 mmho before testing, while that measured 40 cm below the surface was as high as 7.6 to 11.5 mmho. Such high concentration could be reduced to some extent by irrigation, but the concentration had risen again within several days after irrigation. The cause of these phenomena may be considered as follows: salinity of soils irrigated decreases temporarily owing to the leaching effect of soil salinity through downward movement of irrigation water, but the salinity shows again high values because of mixing with existing groundwater having relatively high concentration of salinity together with high groundwater table. And the field surface at the sampling points was a little high in elevation due to uneven land preparation before the test; therefore, the salinity accumulation in top soils might be promoted. Under these circumstances, it is probable that the salinity leached from surrounding soils might get into that reduced salinity to result in relatively high salinity. Referring to the above tendency, it may be necesarry to make the field leveling even in the land preparation and to provide appropriate irrigation and drainage facilities. Furthermore it was clearly recognized from the results of initial salt leaching that the soils plowed have higher effect of salt leaching than the soils uplowed.

In order to increase the leaching effect of soil salinity, it is necessary to take countermeasure to lower the groundwater table by open canal drainage or conduit drainage. The former requires many labor for operation and maintenance of the facilities and the intervals between open canals must be short in the poor permeability soils like this Area. Therefore not only many ditches are required but also inconvenience for the cultivation is brought about. On the other hand, the construction of the latter is expensive. In the Project Area, in order to lower the groundwater table deeper than 0.5 m below ground surface, it is necessary that the depth of conduit is 1.0 m and the intervals between conduits is, depending on the permeability coefficient of the soils, five to ten meters. Furthermore, another difficult problem of the subsurface drainage is that almost all soils affected by salinity more than 6 mmhos/cm, lie in the low-lying falt land of at the elevation less than 2.0 m, and drainage pumps are required to drain the groundwater from these lands to the Gulf of Thailand. Such subsurface drainage is not adopted in this agricultural development from the viewpoint of project economy and of the present stage of agriculture development in Phetchaburi area. To examine the subsurface drainage project for leaching of salinity should be reasonable in the case where it is needed to increase further agriculture production in the Area after the completion on On-farm Development Project.

5-2-5. On-farm Development

(a) Alternative Study of On-farm Development Levels

Ditch and Dike Project, which was carried out together with Phetchaburi Irrigation Project, aiming at making improvements in irrigation system at on-farm level, brought about a stabilization of cropping in the rainy season and an increase in the

cropping areas in the dry season to a certain level. The survey conducted in this study found that the ditches are more density provided, the more crops are yielded in the rainy season. However, on-farm facilities should be developed in many ways for higher productivity in agriculture through giving a diffusion of HYV paddy with high sensitivity to water management, diversifying the crops grown, increasing the unit yield, and so on.

From an engineering point of view, the followings can be employed as effective methods for the agricultural development at on-farm level.

(1) Construction of terminal system of irrigation and drainage for water control.

(2) Construction of roads for effective farming and operation and maintenance of the facilities.

(3) Reshaping of farm plots and land levelling for more effective farming and water management

In both Chao Phya project and Mae Klong project, the appropriate level of on-farm development has been studied from various viewpoints of cost, economy, probable reaction of farmers, balance in the local development stage, financial restrictions, etc. In the present project the following three alternative plans of different development levels are prepared based on the results of survey on the actual agricultural conditions in sample areas and examples in other projects that have been made in the past:

(Type A)

Farm ditches

(1) All plots shall adjoin the farm ditch at one of the width side of the plots, or shall have the inlets to allow the irrigation directly from the ditches.

(2) For more efficient control of irrigation water, the length of any ditch, therefore, shall be 500 m at maximum.

Drains

All farm plots shall adjoin the drain on the opposite of the farm ditch, or shall have the outlet.

Roads

All farm plots shall adjoin the farm roads, or shall provide accesses to the farm roads.

Reshaping of plots

All the farm plots shall be reshaped in rectangule, for which land leveling shall be made. The standard size of a rectangular plot shall be 160 x 50 m (0.8 ha), although the length of the width sides may be varied in accordance with the specific repartion plans. One plot shall be divided into four equal parts to save the costs for land leveling when the necessity arrises.

(Type B)

Farm ditches

(1) All farm plots shall adjoin the farm ditches, or be equipped with the farm inlets so as to make direct irrigation.

(2) As a general rule, all farm ditches shall be provided on the borders between the plots, or existing ditches shall be used with improvement works, if necessary. Farm plots may be further divided if required for taking the hydraurically best alignment of ditches so as to make the proper use of the water.

(3) For efficient control of irrigation water, the length of any ditch, therefore, shall be 1,000 m at maximum.

(4) A main farm ditch shall be provided separately if required for preventing any ditch from exceeding 1,000 m in maximum length.

Drains

(1) All farm plots shall adjoin the drains, or be equipped with the outlets to allow the direct drainage.

(2) As a general rule, drain shall be provided on the borders between the plots.

Roads

(1) As a general rule, no farm road shall be constructed.

(2) The O & M roads of 3.0 m in width shall be constructed on one side of the main farm ditch.

(3) The O & M roads with 1.0 m in width shall be constructed on one side of each farm ditch.

Reshaping of plots

No reshaping shall be made, except that if the farm ditch or drain segments any plots, reshaping shall be made for smooth exchange of a portion of the plot with that of the adjacent plot. Land leveling also shall be made if required for the easy exchange and readjustment of the lands.

(Type C)

Farm ditches

(1) The farm plots owned by 70 percent of land owners concerned shall adjoin the farm ditches, or be equipped with the farm inlets so as to make direct irrigation.

(2) The farm ditches shall be constructed on the borders between the farm plots.

Drains

(1) The farm plots owned by 70 percent of land owners concerned shall adjoin the drains, or be equipped with the outlets to allow the direct drainage.

(2) The drains shall be constructed on the borders between the farm plots.

Roads

As a general rule, no road shall be constructed except that O & M roads of 1.0 m in width shall be constructed on one side of every farm ditch.

Reshaping of plots

No reshaping of plots shall be made, nor land leveling shall be made.

In Thailand the land Consolidation Act is applied to on-farm development projects in which 70 percent or more of the farm plots of land owners related to the project are provided with both intakes for direct water supply to the farm plots from the ditches and outlets for drainage. In this connection, Type A is the development plan that is the most intensive in engineering aspects. Type B is considered to meet

the repuirements that no plot-to-plot water management should be made in any agricultural development at the on-farm level. Type C is considered as the most extensive development project.

(b) Case Study

Case studies were made of five sample areas in applying the aforesaid on-farm development plans. Among Type A, B and C, in Type A, where reshaping of farm plots is required, the densities of roads and ditches are little different by areas, while in Type B and C, where reshaping of farm plots is not required, the densities of roads and ditches are different depending on the size of lands owned. The cross sections of both farm ditches and drains were designed as earth ditches based on the unit water requirements and the drainage modulus, respectively, set out in the irrigation and drainage plan. The main ditches were designed in concrete lining in considering the expected function as lateral canals.

With regard to the direct construction costs of civil works including the depreciation cost of construction machineries, Type A (which includes the costs of land leveling) is the most expensive in its costs, requiring the cost as much as 2.3 times that of Type B.

Summary of Case Study

Items	Type A	Type B	Type C
Density (m/ha)			
- Farm ditch	75	39	33
- Drain	60	31	24
- Farm road	65	5	-
Construction Cost of Civil Works ($/ha)	1,100	478	387

(c) Proposed Type of On-farm Development

The survey made in the Area revealed that, as a general tendency, the lower the density of irrigation ditches, the smaller the yield of paddy in the rainy season. The tendency seems to suggest that more widely the plot-to-plot irrigation is made, the more difficult the control of irrigation water becomes, so that the yield of paddy is smaller. Basing on the results of field survey a conclusion was made that the basic concept of on-farm development project lies in the fact that all plots should be provided with controllable on-farm facilities. The development levels that follow this concept are Type A and B.

From the engineering viewpoint, Type A, involving reshaping of farm plots, is a full-scale development project. Although the on-farm development by Tyne A is costly, it will generate greater benefits to bring economical feasibility, Tvpe A, however, has some problems, if Type A on-farm development is wholly introduced in the present project, that such a costly project will compete unfavorably with other similar-nature projects in other areas under the financial restriction of the country. Reshaping of farm plots requires the land leveling, equivalent to about 40 percent of total construction costs, which may arise a question whether or not fully beneficial land owners can bear 100 percent of costs for land leveling. If Tvne A is carried out without land leveling, the Project will produce less benefits. Full realization of the anticipated benefits of the Project of Type A will require the high-leveled farming techniques of farmers and their positive attitude toward upgrading the level of farming practice. However, the current study period was too short to cover the wide area in details on this problem. The other reason not to employ Type A is that the dry season cropping in the paddy fields is limited to only less than 20 percent of the area due to shortage of water resources.

The foregoing considerations have led to the conclusion that it is still earlier to introduce Type A into the Project and Type B, which is relatively easy to level up to Type A, is practically adoptable. There will be, however, some serious problems left in agricultural development in the low-lying area even after the completion of the Project, because in the area the drainage condition will remain the same as it is and the engineering measure to lower the groundwater table will not be employed. In due consiuation of these matters, the low cost Type C should be applied for these lands exposed unfavourable conditions.

5-3. Construction Plan and Project Cost

5-3-1. Construction Plan

(a) Irrigation Improvement Project

The three new irrigation canals, namely, 2R-Extra, 1R-1R, and 2R-1R shall be constructed for correcting the imbalance of arrangement of the existing irrigation canals in the left bank area. The new canals shall be lined with concrete having 5 cm thickness, and provided with head regulators, tail regulators, bridges and crossing structures over the drainage canals. One of the embankment crests shall be used as 4.0 m wide laterite paved roads for O & M of the canals. The irrigation canals shall be constructed by excavating the compacted embankment into the required cross-sections.

Irrigation canals to be provided for dual purposes of irrigation and drainage in the Extension Area shall be of earth canals, the crests of which shall be used as 6.0 m wide O & M roads in taking into account the low density of the roads in the Extension Area. Also, since the elevation of the Extension Area varies between 1.0 m in the northern part and elevation above mean sea level (EL) 2.5 m in the southern part, the new irrigation canals shall be located in five blocks respectively, and the water levels in the canals shall be controlled by gate. Excavation of 80 m wide canals shall be carried out by motor scrapers, scraping dozers, and drag lines.

The new irrigation canals are detailed in the following list.

Construction of Canal

Canal	Length (m)	Structure	Appurtenant Structure		
			Check	Bridges	Others
Left Bank Area					
2R-Ex	4,300	Concrete lining	2	2	1
1R-1R	2,550	"	2	2	1
2R-1R	4,200	"	2	2	1
Sub-total	11,050		6	6	3
Extention Area					
I	17,400	Canal	3	2	-
II	19,800	"	2	2	-
III	33,150	"	6	3	-
IV	22,050	"	5	2	-
V	16,400	"	2	4	-
Sub-total	108,800		18	13	-
Total	119,850		24	19	3

Concrete Lining of Canal

All existing earth irrigation canals shall be lined with 5.0 cm thick concrete. The lining shall be made by stripping the surface layer of the existing canals, and replacing it with borrowed earth to be compacted, and securing the required section. All existing appurtenant structures shall be removed, and new appurtenant structures such as check gates, bridges and crossing, totalling 164 in number, shall be constructed. The whole length of the irrigation canals to be lined with concrete is 166,553 m as shown in the following table:

Irrigation Canals	Length(m)
Left Bank	
Main	33,730
1R	26,460
1L-1R	2,824
2R	8,087
1L	5,300
1R-2L	5,810
Right Bank No.1	
Main	7,560
1R-2R-1	2,526
1L-2R-1	2,300
1L-1	2,600
Right Bank No.2	
Main	7,056
1R-2	6,500
1R-1R-1R-2	3,775
Right Bank No.3	
Main	15,400
1R-3	4,000
2R-3	3,075
3R-3	8,000
2L-3	14,000
1L-2L-3	4,675
2L-2L-3	2,875
Total	166,553

Rehabilitation for raising the full supply level in the existing concrete lined irrigation canal shall be made by providing the upright reinforced concrete walls with the embankment crest. The maximum heightering hydraurically allowable was obtained by making an analysis of a longitudinal section of the canals; however, in any case, the height of the side walls shall not exceed 0.5 m so that the existing lining wall can be prevented from adverse affect in the stability. There are 21 irrigation canals requiring heightening of the side walls, and the whole length of these canals is 128,204 m shown in the following list:

Irrigation Canals Requiring Side Wall Heightening

Irrigation Canals	No. of Lines	Length of Canal by Heightening					Total
		0.1	0.2	0.3	0.4	0.5	
Left Bank	2	-	-	17,260	-	-	17,260
Right Bank No.1	2	-	1,325	1,300	-	4,850	7,475
Right Bank No.2	1	1,100	-	-	-	-	1,100
Right Bank No.3		2,822	30,371	41,782	27,394	-	102,369
Total		3,922	31,696	60,342	27,394	4,850	128,204

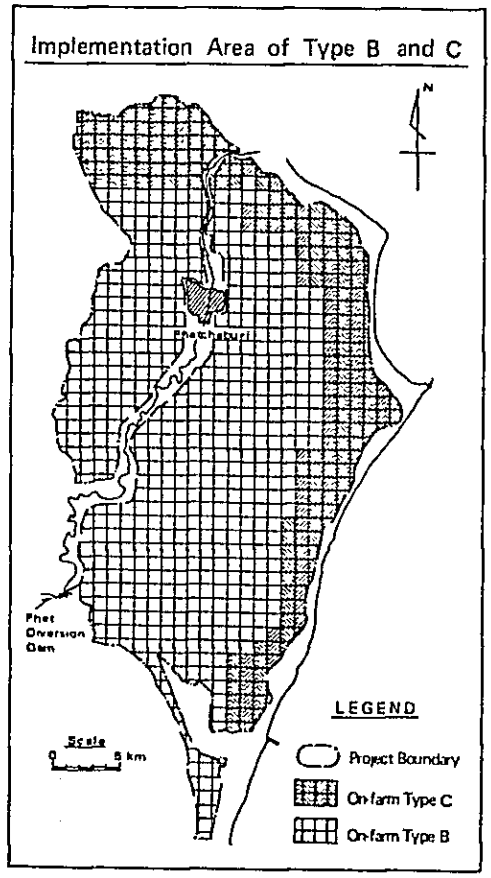
(b) On-farm Development

Construction works of the on-farm development shall comprise the new construction and improvement of the farm turnout at main or lateral canals and the construction of the ditches and/or main ditches, drains, checks, division boxes, road-crossings and so forth. The main ditches as well as the irrigation canals shall be lined with 5.0 cm thick concrete, while both ditches for irrigation and drainage shall be of earth ditch. The construction of both main ditches and ordinery ditches for irrigation shall be made by the same method as that for the irrigation canals, except for borrowing the embankment materials from the borrow pits in the Area. Land leveling is not proposed in the on-farm development; however, when the farmers wish to

execute the land leveling on condition that they should bear the necessary cost for land leveling, it is desirable that the land leveling is included in the Project. The terminals of the draining ditches shall be provided with checks to reuse the return flow when necessity requires.

The project plan of on-farm development has depended on the results of the case study for the sample areas. The development level at Type B, a modification of the most extensive Type C will be applied to the Area, excep for the area which employs the Type C development due to unfavourable conditions of drainage and salinity of soils.

As a result of analysis of all the Area in terms of the ground elevation, land slopes and soil salinity concentration, it has been decided that the most extensive Type C shall be employed for the area along the littoral areas, as shown in the drawing at right side.



The areas of on-farm development by Types are shown in the following table. Type B shall be applied to 70 percent of the whole area, while Type C 30 percent.

Areas of On-farm Development by Types

- Unit: ha -

Irrigation System	Type A	Type B	Total
Right Bank No.1	6,110	350	6,460
Right Bank No.2	5,550	230	5,780
Right Bank No.3	17,040	3,430	20,470
Extension Area	-	7,100	7,100
Left Bank	7,390	5,400	12,790
Total	36,090	16,510	53,600

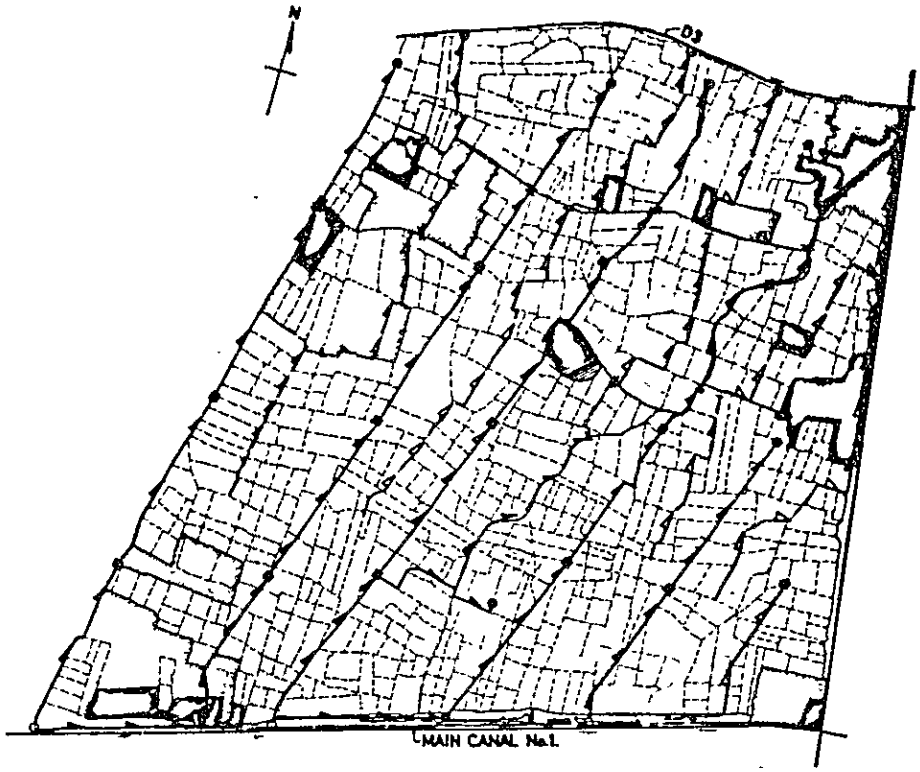
The preliminary design of on-farm development works has been made of five sample areas, and the typical layouts of Type C and B has been shown in the following figures. The quantity of construction works for the total area of 1,258 ha of the sample areas is given below:

Edimated Quantity of On-farm Development Works

Type	Area (ha)	Main Ditch (m)	Length (m) Farm Ditch	Drain	Road	Appurtenant Works (No. of Works)
A	1,258	6,360	38,580	37,910	6,360	209
B	1,258	-	39,600	29,790	-	165

Case Study of Sample Area for On-farm Development

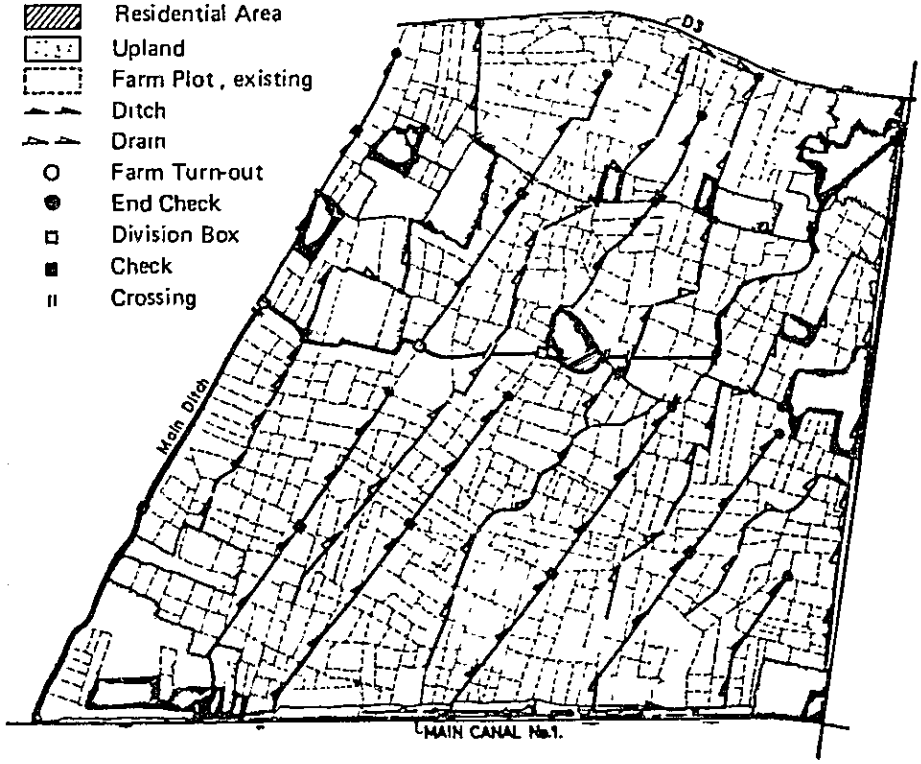
– Sample Area No. 1 –



Type A

LEGEND

- Residential Area
- Upland
- Farm Plot, existing
- Ditch
- Drain
- Farm Turn-out
- End Check
- Division Box
- Check
- Crossing

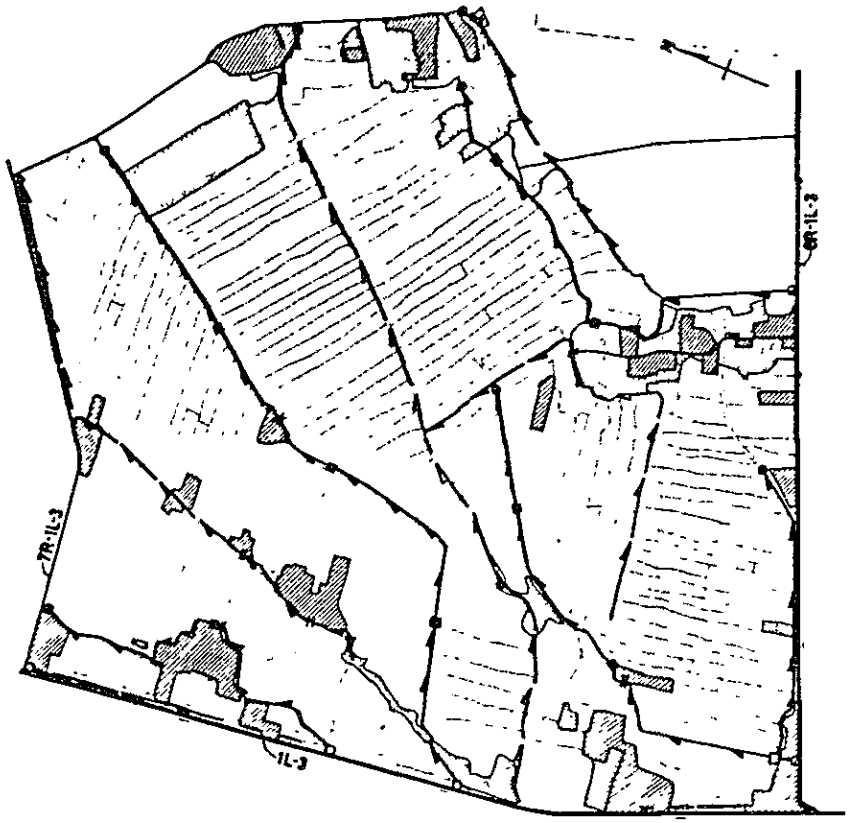


Type B

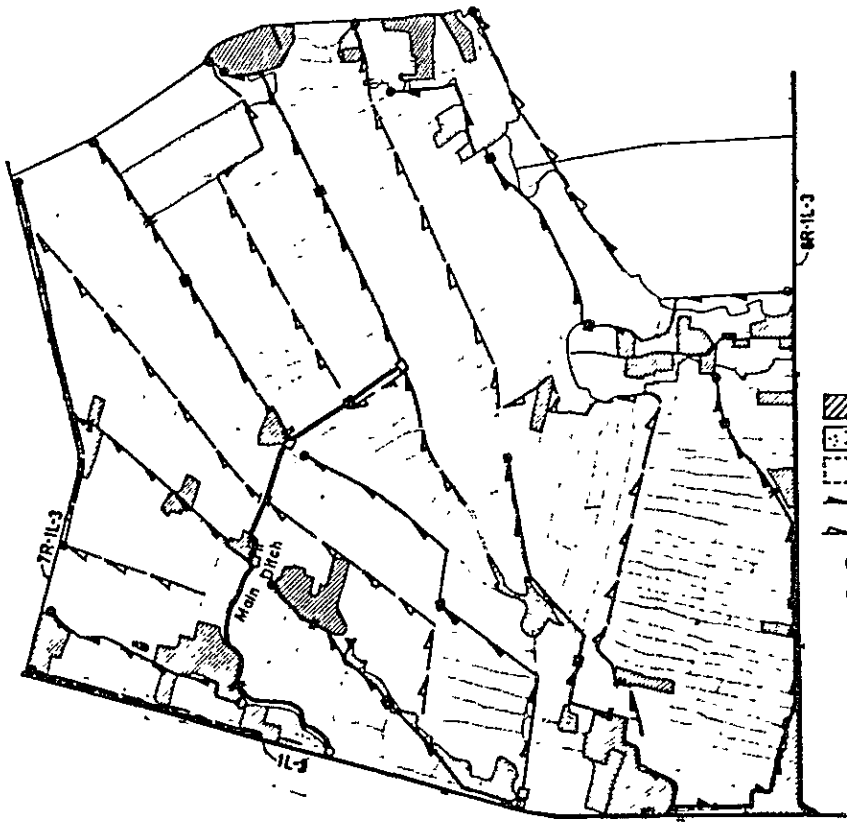
Scale

0 400 m

Case Study of Sample Area for On-farm Development
– Sample Area No. 3 –



Type A



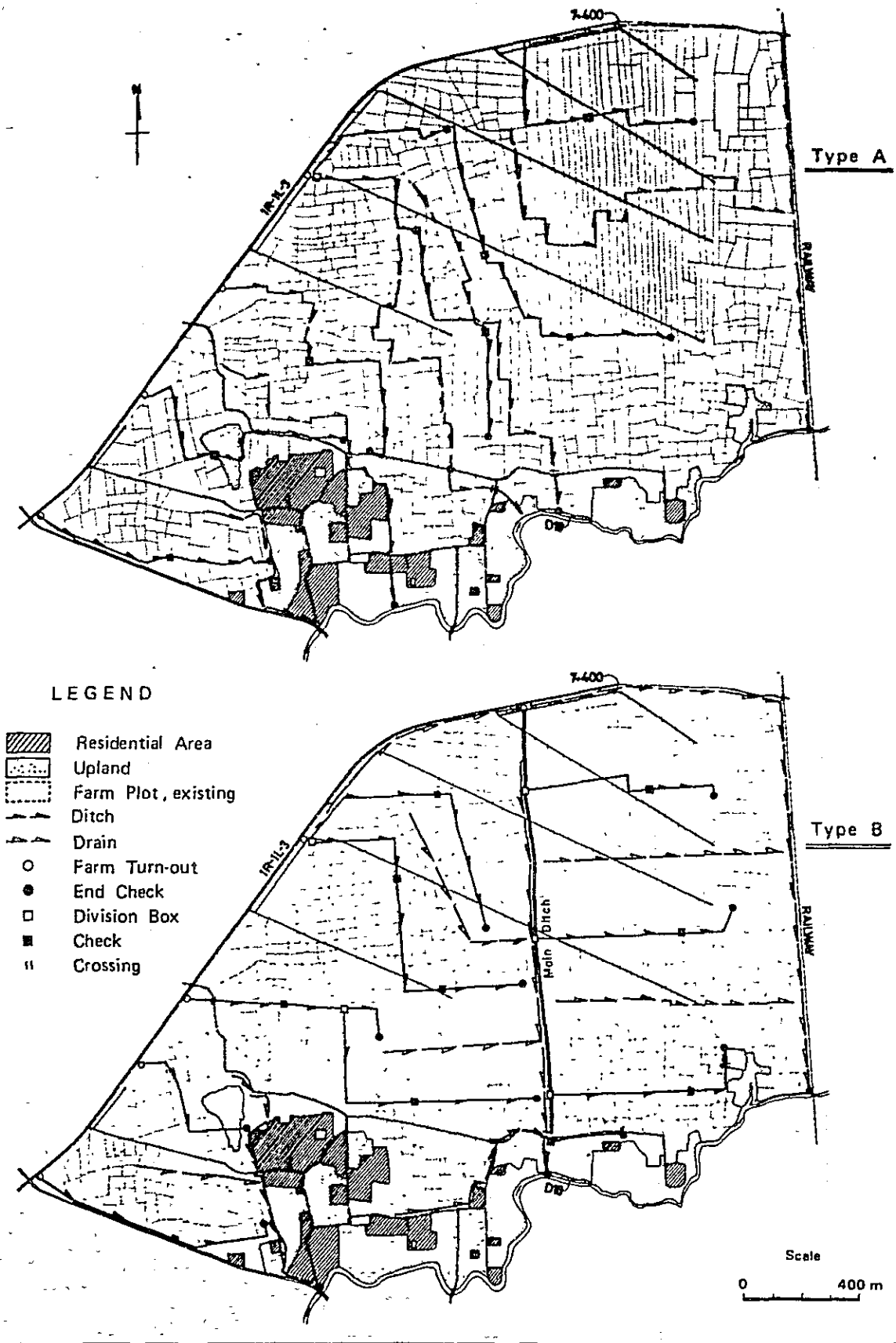
Type B

LEGEND

- Residential Area
- Upland
- Farm Plot, existing
- Ditch
- Drain
- Farm Turn-out
- End Check
- Division Box
- Check
- Crossing

Scale
0 400 m

Case Study of Sample Area for On-farm Development
– Sample Area No.5 –



5-3-2. Construction Schedule

The Phetchaburi Irrigated Agricultural Development Project, comprising the irrigation improvement project and the on-farm development project, shall be started with the irrigation improvement project where irrigation canals and their appurtenant structures are to be constructed or improved. The on-farm development project shall be started with the area in where the irrigation improvement project is completed. The Extension Area shall make a partial use of the existing irrigation canals in the upstream of the area, and of the return flow from the upstream as irrigation water; therefore, the project of the Extension Area shall not be carried out until considerable improvements are made of the irrigation canals and on-farm facilities in the upstream areas.

Since most of the existing irrigation canals have become more or less different in the states from the original design, it is required to conduct surveyings of both cross-section and profile so that the actual knowledge can be obtained for these facilities. Three years before the irrigation improvement project is commenced, survey works shall be started, including the preparation of the topographic maps (scale of 1:4,000) covering the area for the on-farm development project. Construction works for both irrigation improvement and on-farm development will require 12 years for completion,

Construction Schedule

Work Items \ Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Survey & Design	■	■	■												
Project Office			■	■											
Land Acquisition			■							■	■				
Purchase of Machinery			■	■	■	■	■	■	■	■	■	■	■	■	
Irrigation Imporvement Project				■	■	■	■	■			■	■			
On-farm Development Project						■	■	■	■	■	■	■	■	■	■
Project Administration			■	■	■	■	■	■	■	■	■	■	■	■	■

and the total project works including surveying and the detailed design will take 15 years for completion, as scheduled in the above time table.

Annual Quantity of Works

Year	Irrigation Improvement Works (m)			On-farm Development (ha)		
	Construction	Rehabilitation	Total	Type B	Type C	Total
4	-	33,387	-	-	-	-
5	4,300	59,448	63,748	-	-	-
6	6,750	79,950	86,700	2.930	1,130	4,060
7	-	81,170	81,170	2,092	3,760	5,852
8	-	40,802	40,802	3,702	510	4,212
9	-	-	-	4,556	442	4,998
10	-	-	-	5,028	975	6,003
11	37,200	-	37,200	4,987	1,318	6,305
12	71,600	-	71,600	2,963	899	3,862
13	-	-	-	3,723	25	3,748
14	-	-	-	6,109	351	6,460
15	-	-	-	-	7,100	7,100
Total	119,850	294,757	414,607	36,090	16,510	52,600

5-3-3. Project Cost

(a) Construction Costs

The project cost was estimated at the 1981 price level. The construction costs of the irrigation improvement project were estimated based on the quantity and the unit prices employed by RID. In calculation of the construction costs of on-farm development project, the average cost per hectare worked out for the sample area was multiplied by the area covered by the Project. The estimated construction costs include the depreciation costs of the construction machinery.

Not only construction machinery, but equipment and devices required for operation and maintenance and of the canals, roads and structures shall be purchased. The expenses of purchasing

the required machinery include tbe cost of spare parts. Four office buildings for the project implementation shall be constructed. The expenses required by RID for the detailed design and supervision of the works and those required for the consulting services to assist RID have been computed in the estimate. The amount of physical contingencies was estimated ten percent of the total construction costs, giving consideration to the fact that the major civil works are the rehabilitation of the existing canals and the construction of specifically large-scale structures is not involved. With regard to the price escalation, the estimation was made by nine percent per annum for local currency portion, while 5.7 to 9 percent per annum for the foreign currency portion for the period 1981 to 1990 and 5.7 percent per annum for 1991 and forward.

The total costs for the implementation of the Project amount to ฿2,216.7 million (approx. US$96.4 million) exclusive of the contingencies for price escalation. The required costs per hectare of beneficial area are ฿42,100 (equivalent to US$1,830). The total required costs including the contingencies for price escalation are estimated at ฿5,378.9 million.

The foreign currency portion included in the construction costs of ฿2,216.7 million exclusive of the price escalation is ฿816.9 million, or corresponding to 37 percent of the total amount. The directly defrayable foreign currency shall cover part of the purchase of machinery and consulting fees, totalling ฿476.7 million. The main portion of the foreign currency, indirect foreign currency, shall be used for the pruchase of cement, reinforcing bars, fuel, oils, and the like. The following table shows the estimated annual expenditures.

Construction Cost

Work Items	Baht (million ฿)			US Dollars (million $)		
	Local	Foreign	Total	Local	Foreign	Total
1. Civil Works						
1.1. Irrigation Improvement Project						
- Rehabilitation	417.9	171.0	588.9	18.2	7.4	25.6
- Construction	278.3	113.8	392.1	12.1	5.0	17.0
Sub-total	696.2	284.8	981.0	30.3	12.4	42.7
1.2. On-farm Development Project	315.3	140.8	456.1	13.7	6.1	19.8
1.3 Depreciation Cost of Machinery	(16.4)	(189.5)	(205.9)	(0.7)	(8.2)	(9.0)
Total (a)	995.1	236.1	1,231.2	43.4	10.3	53.6
2. Machinery and Equipment						
2.1. Construction Machinery	32.5	376.9	409.4	1.4	16.4	17.8
2.2. O & M Equipment	1.4	16.8	18.2	0.1	0.7	0.8
Total (b)	33.9	393.7	427.6	1.5	17.1	18.6
3. Project Office	7.3	3.6	10.9	0.3	0.2	0.5
4. Land Acquisition	58.3	-	58.3	2.5	-	2.5
5. Consulting Services	30.8	83.0	113.8	1.3	3.6	4.9
6. Project Administration	146.9	26.2	173.1	6.4	1.1	7.5
Total (c)	243.3	112.8	356.1	10.5	4.9	15.4
Total (a + b + c)	1,272.3	742.6	2,014.9	55.3	32.3	87.6
7. Physical Contingencies	127.5	74.3	201.8	5.6	3.2	8.8
8. Price Escalation	2,358.3	803.9	3,162.2	102.5	35.0	137.5
Total (d)	2,485.8	878.2	3,364.0	108.1	38.2	146.3
Total	3,758.1	1,620.8	5,378.9	163.4	70.5	233.9

Note: Exchange rate ....US$1.00 = ฿23.

Schedule of Expenditures

(Unit: Millions Baht)

No.	Year	Civil Works				Machinery and Equipment	Others	Total	Physical Contingencies	Total
		Irrigation Improvement	On-farm	Depreciation Cost	Total					
1	1984	-	-	-	-	-	56.9	56.9	26.6	83.5
2	1985	-	-	-	-	-	41.5	41.5	24.5	66.0
3	1986	-	-	-	-	30.0	26.9	56.9	38.5	95.4
4	1987	61.1	-	(7.7)	53.4	40.1	35.0	128.5	107.0	235.5
5	1988	133.3	-	(18.0)	115.3	69.5	35.2	220.0	215.5	435.5
6	1989	143.4	35.6	(25.4)	153.6	57.1	18.3	229.0	264.2	493.2
7	1990	166.5	46.9	(29.6)	183.8	25.7	20.7	230.2	314.6	544.8
8	1991	110.7	35.0	(20.3)	125.4	25.4	22.2	173.0	266.6	439.6
9	1992	-	45.4	(7.8)	37.6	21.7	5.8	65.1	108.2	173.3
10	1993	-	52.7	(9.3)	43.4	21.5	27.5	92.4	181.7	274.1
11	1994	136.9	53.3	(27.3)	162.9	52.4	41.6	256.9	569.3	826.2
12	1995	229.1	37.0	(35.7)	230.4	58.3	6.4	295.1	723.3	1,018.4
13	1996	-	38.9	(7.0)	31.9	14.4	6.4	52.7	139.2	191.9
14	1997	-	48.5	(7.8)	40.7	11.5	6.4	58.6	175.9	234.5
15	1998	-	62.8	(10.0)	52.8	-	5.3	58.1	208.9	267.0
Total		981.0	456.1	(205.9)	1,231.2	427.6	356.1	2,014.9	3,364.0	5,378.9

(b) Operation and Maintenance Costs

The O & M of the facilities to be proveded under the Project will be carried out by the Phetchaburi O & M Office, RID for those main irrigation and drainage facilities which will be rehabilitated or newly constructed and the roads. The costs required for these O & M services comprise the working expenses such as personnel costs for the staff concenred and the costs for repair of the facilities, and the other costs for renewal or replacements of the machinery and equipment. The costs required regularly shall be defrayed by ฿13.3 million per annum immediately after completion of the Project and onward.

The O & M services for the on-farm facilities will be carried out by the water users' associations consistive of the beneficiary farmers under the control of RID. The initial investment of ฿1.5 million will be required for those costs of preparatory works for establishment of the associations, building for three offices, purchase of machinery and equipment, and the operation and maintenance costs required regularly were estimated at ฿3.8 million in the stage of project completion, including the payments for the executive members of the association, personnel costs for the staff concerned, repair costs for the facilities, etc.

5-4. Implementation and Operation of the Project

5-4-1. Implementation and Coordination

The RID is well experienced in the execution of both irrigation projects and on-farm development projects, and will be the executing body of the Phetchaburi Irrigation Project with sufficient knowledges and experiences.

A well-qualified person for the Project execution will be assigned as Project Manager. The Project shall be carried out under close cooperation of the existing O & M Office and road construction office. The Project Manager should be a person fully influencial to supervise the both office chiefs of O & M Office and road construction office for successful implementation of the Project works. The Project Manager will administer engineering division, construction division, machinery and materials division, supporting division, and general affairs division. The Project office shall be fully responsible to carry out all designs and construction works that are executable in the field office, and the works other than specified above should be carried out along with RID's policy under the assistance of the respective divisions of RID for budgeting, procurement of machinery and equipment, etc.

The Coordination Committee should be established so that the arrangements can be made smoothly with the Central Land Consolidation Office for issuing the Project-related Royal Ordinances and with the Land Department for issuing the Title Deed for land acquisition and authorization of execution of cadastral survey in the Project Area.

Another field level coordinating committee should be formed under the leadership of the RID, consisting of entities related to the present project such as the regional office of RID, regional

Land Consolidation Office, regional office of Land Department, regional Rural Development Office, regional office of Agricultural Cooperative Associations Department and the Land division of the Changwat Office. The field level coordination committee shall function to provide a good coordination and cooperation among the organizations and agencies concerned in the works such as preparation of cadastral maps, cadastration, land exchanges and readjustment, promotion of agri-supporting services and organizing the farmers' groups.

5-4-2. Operation and Maintenance

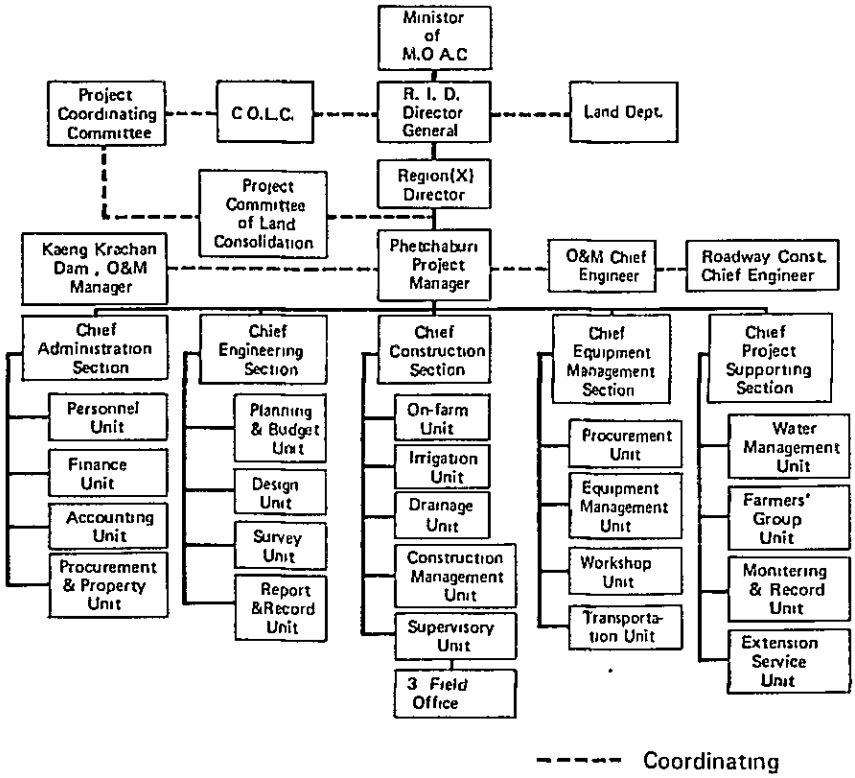
The irrigation facilities constructed or improved by the Project shall be under the operation and maintenance of the existing Phetchaburi O & M Office which shall be expanded and reinforced in function for the purpose. In the existing O & M Office, the Project Engineer will administer the O & M section, machinery and materials section, and general affairs section. In the future an agri-supporting service section should be provided additionally to these sections, which will be responsible for giving directions and guidance to farmers for planning distribution of irrigation water and cropping patterns.

The proposed O & M section shall have a water master who is responsible for O & M of the main canals, and each irrigation block shall have a zone man who is responsible for controlling the respective canals as well as at present.

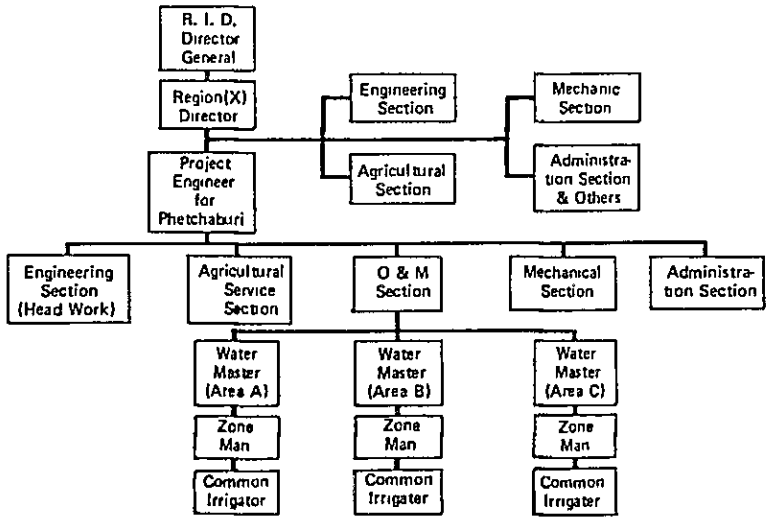
Also, as many common irrigators as possible shall be assigned for O & M of the ditches, distributing irrigation water, and possibly close contact with the representatives of the water users' associations.

The proposed agri-supporting section shall undertake the extension works of effective irrigation water use and advanced farming techniques among the farmers so that they can make best use of the water.

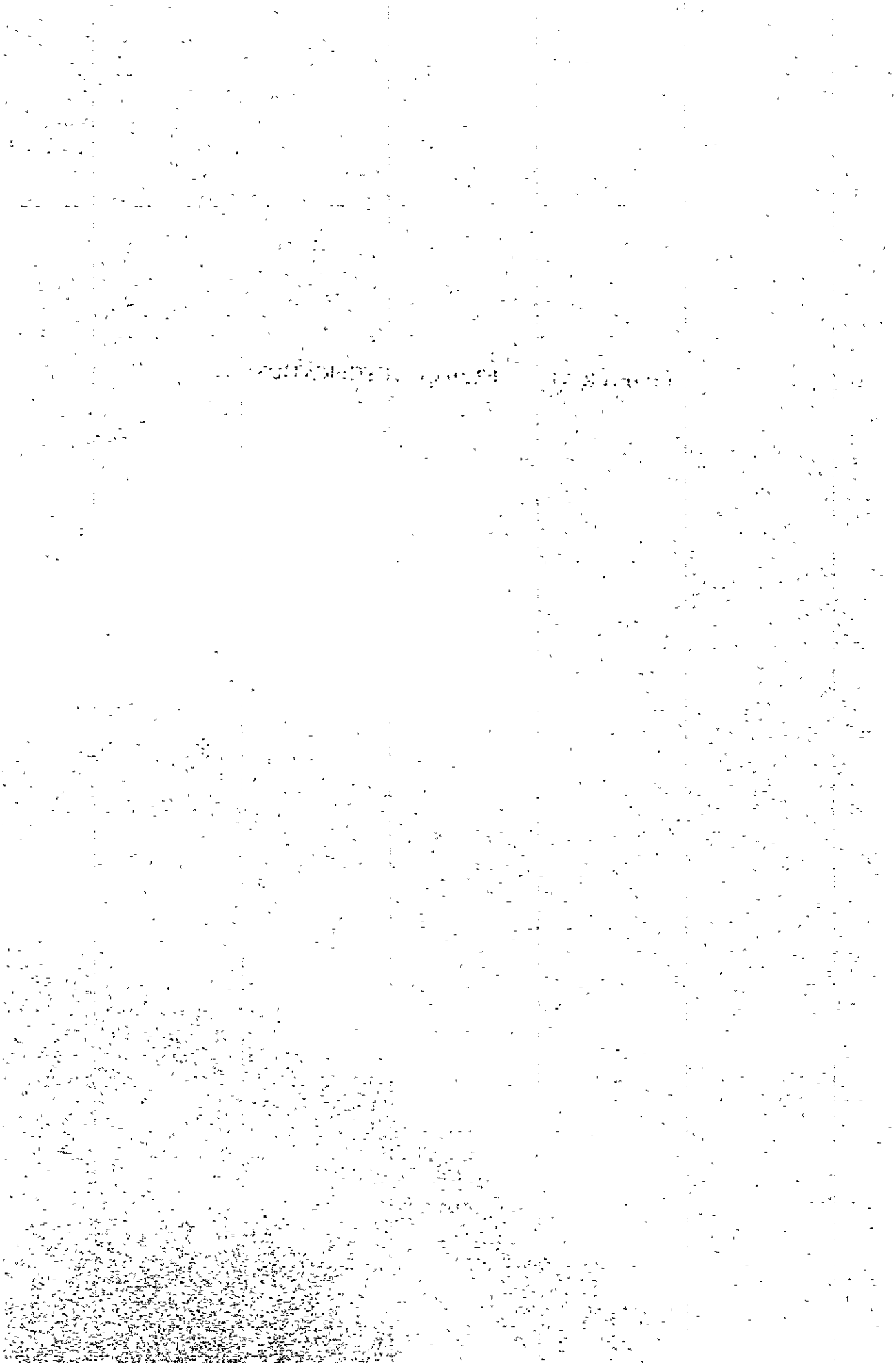
Organization Chart of Project Implementation



Organization Chart of Operation and Maintenance



CHAPTER VI PROJECT JUSTIFICATION



CHAPTER VI. PROJECT JUSTIFICATION

6-1. General

The project aims, among others, at improving the farm economy in the Project Area so as to contribute to the Thailand's national economy as a whole. At the Project-Area level, this can be obtained through stabilization and increase in farm production supported by more intensified land use as coupled with strengthening organizational set-up for water management. This involves also increase in employment opportunity for surplus labor and provision of cash income for improvement of farmers' living standard. At the national level, this is to comply with the requirements in national policies including stable supply of agricultural products, increase in foreign exchange earnings by expansion of export, increasing of employment opportunity, correction of income disparity by regions and so forth.

With implementation of the Project as stated in the previous chapters of the Report, benefits are to be generated through increase in crop production in the net area of 52,600 ha. The Internal Economic Rate of Return (IERR) has been applied to the evaluation of the Project from the standpoint of the national economy. In the economic analysis, all financial costs have been expressed in 1980 constant values. Taxes and transfer payment have been excluded and local costs have been evaluated in terms of border price equivalents. Apart from the profitability of the Project from the standpoint of the national economy, the farm budget analysis has been made for three farm models. The profitability of irrigation at farm level is related to the actual expenses incurred by the farms and the benefits they drive when the Project is put into effect.

6-2. Economic Analysis

6-2-1. Price Evaluation of Farm Inputs and Outputs

Tradable goods are valued in foreign exchange and converted to local currency and adjusted for local transport and handling. Non-tradable goods are converted to border price equivalents by making use of the conversion factors employed for the economic evaluation of the current RID's irrigation projects financed by the World Bank. The future price are based on the commodity price forecasts made for the above-mentioned irrigation projects. The official rate of foreign exchange used is ฿23 to one U.S. dollar.

(a) Crop Price

Paddy

Thailand exports more than one million tons of rice every year. The amount of rice exported by Thailand last these years exceeded two million tons. In Thailand the amount of rice exported occupies approximately 15 percent of the total export on an average; rice ranks first among the exported unit commodities in the total amount of export. When the Project is completed, increase in yields of rice will be not only supplied to the domestic markets, but exported to foreign markets; thus, the Project will greatly contribute to Thailand in encouragement of foreign trade which is one of the mainstay of the national policies.

In this evaluation, farm-gate price of paddy was determined with Free on board (FOB) price of exported rice of ฿9,015/ton at the Bangkok port.

Farm-gate Price of Paddy

- Unit: Baht/ton -

Items	Present (1981)		Future (1990)	
	Financial	Economic	Financial	Economic
1. FOB Bangkok Price (White Rice)	9,015	9,015	11,870	11,870
2. Farm-gate Price of Paddy	3,550	5,065	4,010	6,635

Mungbeans

Mungbeans account for a relatively smaller percentage of the total export; however, mungbeans have been in greater demand in recent years, and the amount of export thereof has been steadily increased. So the mungbeans produced in the Project Area are treated as one of the tradable commodities.

The farm-gate price of mungbeans was determined based on FOB price of exported mungbeans at the Bangkok port.

Farm-gate Price of Mungbeans

- Unit: Baht/ton -

Items	Present		Future	
	Financial	Economic	Financial	Economic
1. FOB Bangkok Price	8,815	8,815	10,180	10,180
2. Farm-gate Price	6,525	7,850	6,890	8,835

Vegetables and fruits

In the Project Area various vegetables, such as cucumbers, cabbages, pumpkins, onions, and the like, are cultivated. These vegetables have been prone to be the farmers' home consumptions as well as the products forwarded to the local markets in Changwat. It is expected that the Project will increase the production of the vegetables, increments of which will be forwarded to the local markets, in Changwat or the vicinity of the Prefecture. So the vegetables are treated as one of the commodities distributed in the domestic markets.

Also, many different kinds fruits are cultivated. It seems that most of the fruits are forwarded to the local market and those in Bangkok. The fruits are not treated as foreign-tradable commodities either.

Farm-gate prices of the vegetables and fruits are represented by those of cucumbers and bananas, respectively.

Farm-gate Price of Vegetables and Fruits

- Unit: Baht/ton -

Items	Present		Future	
	Financial	Economic	Financial	Economic
1. Vegetables (cucumbers)	4,930	4,930	5,210	5,210
2. Fruits (bananas)	3,180	3,180	3,360	3,360

(b) Fertilizers

In recent years Thailand has imported an increasing amount of fertilizers from foreign countries. For example, Thailand imported a total amount of 700-thousand tons of fertilizers with a payment of ฿28,140 million in 1979. Thailand has imported nitrogen, phosphoric acid, and potassium fertilizers every year, and it is expected that this tendency will be unchanged for some time to come. All fertilizers essensial to an increase in the production of crops are treated as tradable commodities, accordingly.

Farm-gate prices of fertilizers are shown by the amount of elements therein; the basic prices of Nitrogen, Phosphate, and Potassium are shown with the cost, insurance and freight (CIF) Bangkok of prices of Ammonium salfate, Super-phosphate and Potassium chloride respectively.

Farm-gate Price of Fertilizers

(Unit: Baht/ton)

Item	Present		Future	
	Financial	Economic	Financial	Economic
1. Nitrogen				
Bangkok CIF Price (Ammonium Sulfate)	2,945	2,945	5,360	5,360
Farm-gate Price of Ammonium Sulfate	4,210	3,570	7,185	6,265
Farm-gate Price of Nitrogen (Element Price)	20,540	17,410	35,050	30,560
2. Phosphate				
Bangkok CIF Price (Super-phosphate)	5,450	5,450	6,415	6,415
Farm-gate Price of Super-phosphate	7,130	6,255	8,825	7,575
Farm-gate Price of Phosphate (Element Price)	15,170	13,310	18,780	16,110
3. Potassium				
Bangkok CIF Price (Potassium Chloride)	3,105	3,105	3,565	3,565
Farm-gate Price of Potassium Chloride	4,655	3,850	5,795	4,645
Farm-gate Price of Potassium (Element Price)	7,760	6,410	9,660	7,740

(c) Farm Labor

Since farm labor can be defined as unskilled labor, the economic price of which was herein evaluated as an opportunity cost.

With the present cropping pattern, the annual farm labor required is 6,040,000 man-days, and 1,000,000 man-days are required in the busiest farming season of July. In the future it is expected that they annual farming labor required will be 6,380,000 man-days, and the labor of 1,040,000 man-days will be required in the busiest farming seasons of December. The wages for the busiest season are paid in cash or in kind (in rice, in most cases). The average wages paid in the busiest season are ฿34/day.

6-2-2. Benefit Analysis

(a) Beneficial Area

The construction works of the Project will be divided into irrigation improvement works and on-farm development works. The beneficial area of the Project was determined according to the construction schedule:

Area of Implementation by Years

(Unit: ha)

Year	1. Irrigation Improvement Project			2. On-farm Development Project		
	Paddy field	Upland	Total	Paddy field	Upland	Total
1987	3,779	246	4,025	-	-	-
1988	8,724	1,011	9,735	-	-	-
1989	9,600	615	10,215	3,870	190	4,060
1990	8,887	398	9,285	4,793	168	4,961
1991	10,610	1,630	12,240	4,585	518	5,103
1992	-	-	-	4,250	748	4,998
1993	-	-	-	5,755	248	6,003
1994	4,000	-	4,000	6,197	108	6,305
1995	3,100	-	3,100	3,390	472	3,862
1996	-	-	-	3,100	648	3,748
1997	-	-	-	5,660	800	6,460
1998	-	-	-	7,100	-	7,100
1999	-	-	-	-	-	-
Total	48,700	3,900	52,600	48,700	3,900	52,600

The irrigation improvement works, which aim at rehabilitation of the existing main irrigation canals and construction of new facilities, are expected to generate the initial benefits through securing the irrigation water. The on-farm development works which will follow the irrigation improvement works in consolidating the terminal facilities, will allow the total Project Area to produce the benefits. The both construction works will be carried out in the dry season, and paddy can be cropped in the rainy season even after starting the implementation, and production increase can be expected. However, the dry season cropping cannot be practised during the period of the Project implementation.

Beneficial Area by Year

(Unit: ha)

Year	Paddy			Mung-beans	Vegetable		Fruits	Total
	Rainy S. Local V.	Rainy S. H.Y.V.	Dry S. H.Y.V.		Rainy S.	Dry S.		
A. Irrigation Improvement Project								
1986	-	-	-	-	-	-	-	-
1987	1,094	2,685	-	-	101	-	145	4,025
1988	3,620	8,883	543	566	516	101	741	14,970
1989	6,399	15,704	1,797	1,874	768	516	1,104	28,162
1990	8,972	22,018	3,177	3,313	930	768	1,340	40,518
1991	12,044	29,556	4,454	4,645	1,600	930	2,300	55,529
1992	12,044	29,556	5,979	6,236	1,600	1,600	2,300	59,315
1993	12,044	29,556	5,979	6,236	1,600	1,600	2,300	59,315
1994	13,202	32,398	5,979	6,236	1,600	1,600	2,300	63,315
1995	14,100	34,600	6,554	6,835	1,600	1,600	2,300	67,589
1996-	14,100	34,600	7,000	7,300	1,600	1,600	2,300	68,500
B. On-farm Development Project								
1988	-	-	-	-	-	-	-	-
1989	1,120	2,750	-	-	78	-	112	4,060
1990	2,508	6,150	556	580	146	78	212	10,230
1991	3,836	9,412	1,245	1,299	359	146	517	16,814
1992	5,066	12,432	1,904	1,986	666	359	958	23,371
1993	6,732	16,521	2,515	2,623	768	666	1,104	30,929
1994	8,527	20,923	3,342	3,486	812	768	1,168	39,026
1995	9,508	23,332	4,233	4,414	1,006	812	1,446	44,751
1996	10,406	25,534	4,720	4,923	1,272	1,006	1,828	49,689
1997	12,044	29,556	5,166	5,387	1,600	1,272	2,300	57,325
1998	14,100	34,600	5,979	6,236	1,600	1,600	2,300	66,415
1999-	14,100	34,600	7,000	7,300	1,600	1,600	2,300	68,500

(b) Incremental Production

It will take five years after completion of the Project for the target yields to be accomplished; hence, the total 19 years will be required for the achieving the target yields in the entire Area from the start of the detailed design in 1984. Therefore, the target year of production will be 2002, and it was estimated that the target year would have a net incremental crop production of ฿584 million, while the same year will have a gross crop production of ฿1,966 million. 81 percent of the gross production (i.e., ฿1,596 million) will be accounted for by the paddy production in both the rainy and the dry seasons. This is the same amount of production as at present.

Incremental Production Value

(Unit: Million Baht)

Year	1. With Project			2. Without Project			Net Incremental production value
	Gross production value	Production cost	Net production value	Gross production value	Production cost	Net production value	
1986	1,086	418	668	1,086	418	668	0
1987	1,090	418	673	1,093	396	697	25
1988	1,094	417	678	1,120	393	727	49
1989	1,099	416	683	1,213	418	795	113
1990	1,104	416	688	1,322	446	876	188
1991	1,108	415	693	1,408	462	946	253
1992	1,112	414	698	1,553	509	1,044	346
1993	1,117	414	703	1,612	526	1,086	383
1994	1,121	413	708	1,665	544	1,120	412
1995	1,126	412	713	1,732	565	1,167	454
1996	1,130	412	718	1,795	586	1,209	491
1997	1,134	411	723	1,838	602	1,236	513
1998	1,139	410	729	1,884	618	1,267	538
1999	1,143	410	734	1,922	628	1,295	561
2000	1,148	409	739	1,947	633	1,314	575
2001	1,152	408	744	1,959	634	1,325	581
2002-	1,156	408	749	1,966	634	1,332	584

Projected amount of production for the year 2002 is as follows:

(1)	Paddy	240,500 tons
(2)	Mungbeans	7,300 tons
(3)	Vegetables	48,000 tons
(4)	Fruits	16,560 tons

The production of paddy, mungbeans, vegetables and fruits that would be obtained with Project will be greater by 97,700 tons, 5,800 tons, 17,400 tons, and 5,800 tons respectively than that without Project.

6-2-3. Cost Analysis

The Project costs employed in the cost analysis include those for detailed design, construction works, construction machinery, consulting services, administration and management, and contingency, but exclude those for land acquisition and interests during the construction period.

Without consideration given to future rise in the prices of commodities, the estimation is that the Project costs will amount to ฿2,216.7 million (with the cost of construction machinery estimated on a procurement basis). The Project costs are evaluated at the domestic market prices, therefore they require to be revalued as economic Project costs so that they may be compared with the economic value of the benefit provided thereby. For revaluation of the Project costs, taxes on the construction machines purchased directly from foreign countries and cement, steels, and fuel purchased indirectly therefrom are deducted from the costs, and their domestic purchase prices are determined by using the conversion factors to provide economic values. The costs of the construction materials and labor wages in Thailand also are evaluated with the coversion factors. The conversion factors used are those determined by the World Bank for Thailand. The conversion factors are also used for the estimation of the operation and maintenance costs of main facilities.

The on-farm development project includes a plan to establish the water users' associations, which will, consisting of all beneficial farms, serve for repartitioning of the lands and the O & M works of the irrigation ditches. The costs for the forming of the associations, preparation of land registers for on-farm development, meetings and management of the associations are all treated as Project costs. The financial costs related to the associations are re-estimated as economic value by using the same conversion factor of 0.96 for the public works as employed in the economic costs for main irrigation facilities.

As a result of the foregoing re-estimations, the financial Project costs of ฿2,216.7 million is converted into the economic Project cost of ฿1,712.6 million, and the average financial costs of ฿16.8 million for O & M of the main irrigation facilities and the associations into ฿16.2 million.

Project life is standardized by the physical useful life 20 years of the terminal irrigation and drainage earth canal. Therefore, the extension of Project evaluation is expected for 40 years since 1981.

- Evaluation of Project Economic Cost

(Unit: Million Baht)

Year	Investment Cost		O & M Cost	
	Financial	Economic	Financial	Economic
1984	62.6	49.2	15.5	14.9
1985	45.7	36.0	8.7	8.4
1986	62.6	53.5	8.7	8.4
1987	141.4	116.5	8.7	8.4
1988	242.0	197.4	9.2	8.8
1989	251.9	200.7	10.2	9.8
1990	253.3	195.0	11.4	10.9
1991	190.4	148.6	12.7	12.2
1992	71.6	57.8	13.7	13.2
1993	101.6	64.2	15.3	14.9
1994	282.6	195.4	13.9	13.3
1995	324.7	254.8	20.4	19.6
1996	58.0	46.3	15.6	15.0
1997	64.4	50.4	17.0	16.3
1998	63.9	46.8	20.4	19.6
1999	-	-	17.2	16.5
2000	-	-	18.7	18.0
2001	-	-	17.2	16.5
2002	-	-	23.5	22.6
2003	-	-	20.0	19.2
2004	-	-	19.6	18.8
2005	-	-	20.5	19.7
2006	-	-	17.2	16.5
2007	-	-	18.7	18.0
2008	-	-	17.2	16.5
2009	-	-	23.5	22.6
2010	-	-	20.0	19.2
2011	-	-	19.6	18.8
2012	-	-	20.5	19.7
2013	-	-	17.2	16.5
2014	-	-	18.7	18.0
2015	-	-	17.2	16.5
2016	-	-	21.7	20.8
2017	-	-	18.8	18.0
2018	-	-	18.2	17.5
2019	-	-	18.1	17.4
2020	-	-	18.1	17.4
Total	2,216.7	1,712.6	622.8	598.4

6-2-4. Internal Economic Rate of Return

The economic feasibility of the Project has been examined by employing the IERR method, by discounting two series of benefits and costs. The IERR is a rate at which the difference between the benefits and the costs is zero. The direct benefits of the Project are defined as the increases in final agricultural production attributable to the works carried out. What it involved is the net additional value added of the Area, i.e. the value added with Project less the value added without Project. The costs of the Project include public investments which are made in order to construct irrigation works and on-farm facilities and working capital for O & M of the Project including the costs for the water users' association.

Using the foregoing assumptions and discounting costs and benefits over a 40-year evaluation period, the IERR is 26 percent, which is considered feasible from the fact that the opportunity cost of capital in Thailand is regarded as around 14 percent.

6-2-5. Sensitivity Analysis

All forecasting involves uncertainty and all economic activity is subject to risk. Analyses have been made to test the sensitivity of calculation to these fluctuations, by using other parameters than those considered probable in the initial calculation. The parameter employed are delay in reaching target yields, reduction in target yields, price decline, increase in costs and extension of the construction periods.

The results of the various sensitivity tests have been assembled in the following table showing the IERR as exceeding 20 percent in any condition imposed; therefore, the feasibility of the Project has been sufficiently confirmed.

Sensitivity Analysis

Items	IERR (%)
1. 2-year delay in reaching target yield	23.3
2. 10 percent reduction in target yield	23.2
3. 10 percent reduction in paddy price	23.6
4. 10 percent increase in crop production cost	25.3
5. Combination 1 & 2	20.5
6. 10 percent increase in construction cost	24.2
7. 20 percent increase in construction cost	22.6
8. Extension of construction period to 18 years	25.7

6-3. Farm Budget Analysis

Financial analysis for farm budget has been made in the Presumption of cultivated fields of 2.1, 4.1 and 5.6 ha, with and without the Project respectively. The farm Type I having cultivated fields of 2.1 ha under analysis is completely-owner farmers. The farm Type II having cultivated fields of 4.1 ha is partial tenant farmer (half of the farm land is rented), while the farm Type III having cultivated fields of 5.6 ha is those which are located at the downstream of the main canals and near the seadikes along the coast, growing the rainy season paddy only.

At present the agricultural incomes of these farms are ฿16,340 (2.1 ha), ฿18,160 (4.1 ha), and ฿19,140 (5.6 ha). The survey revealed that the yearly average living cost of a six-member family in the Project Area is ฿20,280. Consequently, it seems that these farms have earned the non-agricultural income. However, the execution of the Project will make it possible for these farms to make their living with farm income only, even if they bear 90 percent of the direct costs of on-farm development works and 100 percent of the costs required for operation and maintenance of the irrigation facilities.

With regard to the cost recovery of the on-farm development project, the yearly charge has been estimated at ฿1,349/ha (for the development level A) and ฿1,611/ha (for the development level B) on condition that 90 percent of the Project cost of on-farm development would be collected over 10 years, after a two-year grace period, with interest at 12 percent. In addition, an annual O & M fee of/250/ha would be charged to the beneficiaries.

As mentioned above, although the Project will be more effective to the farmers on an average in the farm size, the farmers below the average in farm size will not always enjoy the Project benefits so as to be free from working for non-agricultural income and to be fully independent upon the farm income only. In the Project Area, about 76 percent of the total farmers (14,000 households) is presumably the owner farmers. The financial analysis was carried out for these farmers on the level of those below the average. As a result, the owner farmers with lands below 1.5 ha (35-36 percent of the owner farmers, and about 5,000 households in number) will have to be dependent upon the non-agricultural income even in "With-Project" condition. Under the circumstance, an intensive guidance and education should be given to these farmers on the farming techniques and cropping pattern through the Project works.

Farm Budgets

(Unit: ha, Baht)

Items	Type I		Type II		Type III	
	Present	Future	Present	Future	Present	Future
1) Operated land	2.1	2.1	4.1	4.0	5.6	5.5
2) Cropping						
a. Paddy Rainy S. Local V. .	1.7	0.5	3.2	1.0	5.4	1.6
b. Paddy Rainy S., H.Y.V.	0.2	1.3	0.4	2.5	-	3.9
c. Paddy Dry ., H.Y.V.	0.3	0.3	0.5	0.5	-	-
d. Other crops	0.4	0.6	0.5	0.9	-	-
3) Gross Production value	29,010	57,430	42,620	88,800	32,130	80,560
4) Production cost	12,670	22,900	18,640	38,220	12,990	38,430
5) Land rent fee	-	-	5,820	12,010	-	-
6) Net production value before project charge	16,340	34,530	18,160	38,570	19,140	42,130
7) Project charge						
a. O & M cost	-	430	-	820	-	1,130
b. Land improvement cost	-	3,380	-	6,610	-	7,550
Total	-	3,810	-	7,430	-	8,680
8) Agricultural income	16,340	30,720	18,160	31,140	19,140	33,450
9) Non-agricultural income	8,970	-	7,510	-	6,320	-
10) Farm income	25,310	30,720	25,670	31,140	25,460	33,450
11) Household expenditure	20,280	21,830	20,280	21,830	20,280	21,830
12) Disposable income	5,030	8,890	5,390	9,310	5,180	11,620

6-4. Socio-economic Impact

Besides the direct benefits mentioned above, the Project will create the direct and indirect benefits and affect the socio-economic development through various impacts to both farm economy in the Project Area and its vicinity as well as national or provincial economy. From the viewpoint of farm economy or national and provincial economy, the following impacts are considered.

Impacts for farm economy

i. This Project relization will improve the farmers' living standard together with increase the farm income. The increase in the farm income from the increase of agricultural income means the increase in consumption and saving. These increases will improve the farm families' living standard in the both aspects of quantity and quality.

ii. For making good use of water, this Project realization is on the assumption that the betterment or establishment of agricultural cooperatives and water users' associations by all beneficial farmers. These systems are assumed that the close communication between farmers, too. The close communication will influence on the technical uplevelling of crop cultivation and farm management of the farmers' around Project Area as well as in the Project Area.

iii. The O & M roads constructed by this Project would speed up in transporting the input and output materials.

iv. The total 780 thousand unskilled labors will be employed during the construction period of the Project. Many farmers will get the opportunity of employment in the Project Area.

Impacts for national and regional economy

v. This Project will considerably increase the production of farm products, especially paddy from the vast beneficial area of 52,600 ha. In future, the incremental production of paddy will be not only sold in the domestic markets, but also exported abroad, contributing to national trading policy. At present, the total production of paddy in the Project Area is 129,000 tons, which are supplied to 496,000 consumers (the yearly average consumption of paddy per head is 260 kilograms). As the population of changwat Phetchaburi is now 367,000, a portion of the rice has been sent out to other areas of Thailand or foreign countries. When the Project is carried out, an additional paddy production of will amount to 112,000 tons according to the estimation. When such an expected increase is realized, the number of people in the Project Area who receive the

supply of rice will become 925,000. Therefore, the Project will lead the nation to the stabilization in supply of rice and give great help by four percent increase in export amount in getting foreign currency.

vi. The economic feasibility of the Project is also confirmed by another index; that is the large Project in scale as the point of net incremental value of ฿58,400 million and beneficial farmers of 19,500. These indices are quite signifient for the development of Thailand on the economic base. Namely, the increase in agri-inputs and outputs caused by the Project will magnify the agribusiness directly or indirectly through distribution of these products.