The Bang Nara river basin has an unique problem with relation to its location and population composition, indicating that majority of the population are Thai Muslim with culture, language and value different from the Buddhist society. The Fifth Plan mentions that this different social structure has posed the problems for the Government's development effort in terms of the management of education, family planning and social welfare programmes as well as generating other social-psychological and security problems in the border Changwat. Reform of the public management of rural development with a greater sense of local participation as well as the improvement in efficiency of the administration system and in style of the Government agencies' coordination are included in the Fifth Plan. The social development policy is specifically aimed at encouraging a Thai identity and social integration with Thai values while maintaining the religious harmony, through expanding education and promoting youth development and roles of the women groups. It is additionally noted that support of the Thai Muslim culture has been provided with the establishment of the Center for Southern Thailand Studies at the Pattani campus of the Prince of Songkhla University under the assistance of Japan's Toyota Foundation.

While the Fifth Plan emphasizes the need to promote the diversification to enable the economic activities of the border area to be integrated into the regional and national economic structure, the scope of development for the industrial and commercial sectors, however, is quite limited and the increases in agricultural productivity only remain the primary means for promoting the economic growth within the Bang Nara river basin.

(4) The national policies and development strategies need to be examined within the context of specific conditions applying in the Bang Nara river basin. The Government specifies that the prime objective of the proposed Project is to improve the standard of living and socio-economic well-being of the inhabitants in the Bang Nara river basin through the development of agriculture and related infrastructure.

To achieve the prime objective, the control and development of Mae Nam Bang Nara that is currently tidal and brackish have been conceived by the Government as a pre-requisite to subsequently implement the programme designed under the Fifth Plan.

More particularly, the development of the Bang Nara river basin has been envisaged to encompass the following:

- To provide effective measures to alleviate the annual inundations prevailing in the low-lying land along Mae Nam Bang Nara so as to safeguard existing and future development;

- To develop and manage the water resources of Mae Nam Bang Nara for agricultural and domestic use;

- To intensify the agricultural development and related activities such as livestock; and

- To provide adequate rural infrastructure.

These objectives have formed the basis of investigations for the formulation and preparation of a development plan to be included in the proposed Bang Nara Irrigation and Drainage Project.

CHAPTER 3 THE STUDY AREA

3.1. Location and Socio-Economic Overview

3.1.1. Location

The Study area is located in the northeastern part of Changwat Narathiwat which lies in the southernmost part of Thailand, bordering upon Malaysia on the east coast of the Peninsula. Narathiwat is surrounded by Changwat Pattani on the north, Changwat Yala on the west, Malaysia on the south, and by the Gulf of Thailand on the east. With the land area of about 4,200 sq.km, it is situated some 1,200 km from Bangkok.

It is situated along the both sides of the Mae Nam Bang Nara in the northeastern part of Changwat Narathiwat and covers portions of 4 Amphoe, i.e., Muang Narathiwat, Yingo, Rangae, and Tak Bai. The area lies almost parallel to the eastern coast of Peninsula with its southern tip almost bordering upon Malaysia. The number of Amphoe, Tambol, and Muban concerned with the Study area is as follows:

Amphoe	Tambol (Total)	Muban
Muang Narathiwat	5 (7)	34
Yingo	1 (6)	3
Rangae	4(10)	20
Takbai	5 (8)	22
Total	15(31)	79

3.1.2. Socio-Economic Overview

The smallholders in the Study area have long been plagued by the unstable rainfed paddy production. The major part of the rubber planted area has also been constantly damaged by the flood with its replanting with high yielding varieties being very slow. The farm households thus supplement their income through off-farm employment in the neighborhood

such as in Malaysia, but their income level remains low and some are barely on the poverty line at present. Socio-economic backwardness in the Study area relative to the other southern provinces and neighboring Malaysia is evidenced by the major economic indicators such as income and wage level.

Depressed socio-economic situation thus justifies the urgent measures to be taken for the development of the Study area. The land settlement projects being undertaken by the Thai government in the Study area is small in scale and has had limited impact on the agricultural production partly due to the acidic sulphate soils. For development of the stabilized agriculture in the Study area, an alternative has been conceived to develop the water resources in the Mae Nam Bang Nara through construction of tidal regulators and provision of acidic water control facilities and irrigation/drainage facilities.

3.2. Characteristics of The Target Group

3.2.1. Household and Farm Characteristics

The socio-economic characteristics of the target group in the Study area have been investigated primarily through the farm economic survey among the farm households and the Muban headmen as well as the interview at the various local government and non-government institutions. Findings on the major aspects of the target group are presented in this section.

(1) Farm Economic Survey

The farm economic survey was conducted in August 1985 and February 1986 for 144 sample farm households and 24 Muban headmen. The survey was also conducted in the same period intensively for extension offices, cooperative offices and water user's groups. For selection of sample households, a multiple stage stratified sampling method was employed. Out of 79 Muban in the Study area, 24 were selected purposely to

represent the various administrative, topographic, and other socio-economic conditions. The sample households were selected from among different farm types (paddy farm and rubber/paddy farm) and farm size classes (below 10 rai, 10-15 rai, over 15 rai). Given the farm type and size, the samples were randomly selected with the assistance of Muban headmen. The total sample households of 144 represents about 1.5 percent of the total farm households in the Study area.

(2) Population and Family Size

The population in the mid-1985 residing within the boundary of Study area of some 46,700 ha or 467 sq.km numbers about 63,800 inhabitants which correspond to 26.0 percent of the total population of 4 Amphoe concerned. It is distributed over 79 Muban, which gives an average of 810 people per Muban. (See Table VI-1-3 in Appendix VI).

Amphoe	Population		Household		Area
	Total	Farm	Total	Farm	(sq.km)
Muang	29,070	25,202	5,152	4,503	172.2
Yingo	1,604	1,207	616	479	12.8
Rangae	14,700	10,207	2,644	1,899	147.5
Takbai	18,436	16,145	3,253	2,783	134.5
Total	63,810	52,761	11,665	9,664	467.0

The farm population constitutes approximately 83 percent or about 52,800 persons in 9,700 families which is the target group in the Study area. The average population density in the Study area is 137 per sq.km..

Population growth rate in 4 Amphoe concerned slightly increased from 2.0 percent in the latter half of the 1970's to 2.1 percent in the early 1980's (for details, see Table VI-1-4 in Appendix VI). The crude birth and death rate for Narathiwat in 1984 is 27.2 and 5.0, respectively. Continuation of this trend suggests an aging population in Narathiwat in line with the general demographic development in Thailand (See Table VI-1-5 in Appendix VI).

According to the 1980 Population & Housing Census, the dominant ethnic group living in Narathiwat is the Jawi speaking Thai Muslim who account for 78 percent of the changwat population whereas the remaining 22 percent is the Thai Buddhist. The field survey indicates that although the above two ethnic groups often live in the same Muban and occasionally help each other during the agricultural peak season, additional caution and effort would be necessary in planning the post-project development of the Study area.

The average family size in 4 Amphoe concerned is 5.5 persons as shown in VI-1-6 of Appendix VI which is considerably higher than the Narathiwat average of 4.8 and the Southern Region average of 5.2. According to the farm economic survey conducted, the average family size observed is 5.3 persons, and shows a positive correlation between the farm size and the family size (See Table VI-1-7 in Appendix VI).

(3) Migration Pattern

While the permanent migration remains negligible probably due to an ethnic difference and a relatively low level of information, the seasonal migration into Malaysia even during the farm peak period is quite a common phenomenon among the Muslim residents. Unless there is a significant reduction of the labor demand in Malaysia, the more urgent drive for supplementing the farm income would, in the foreseeable future, be likely to maintain the current level of temporary migration especially among the Muslim people.

(4) Employment Pattern

1) Farm Employment

The smallholders of the target group mainly engage in the production of paddy, rubber,(or a combination of the two), livestock, and some minor crops. Most farmers depend on the family labor and partly on some hired and exchange labor especially during the peak

period. On-farm employment in the paddy production is characterized by a high labor force participation rate during the peak period, drawing the female, child, and old labor force.

The labor requirement for rubber is rather constant except for the flowering and the rainy season. Coconut and other tree fruit growing is also popular, though small in scale and often confined to homestead area. Vegetables are also grown in a very small scale wherever the dry season irrigation is available. Livestock and poultry raising is commonly pursued by the majority of farmers, requiring a constant labor supply throughout the year. Small scale fishery is also practiced in nearby streams and ponds/swamps primarily for household consumption.

2) Off-Farm Employment

Water and land related problems together with lack of employment opportunities in Muban typically cause most of the farm operators and their male family members to work off-farm even during the farm peak periods, which often accounts for a significant portion of the farm household income. It is noted that a unique employment pattern or division of labor has developed among the target group wherein the female are often responsible for subsistence farming whereas the male of comparatively young age group frequently seek for off-farm earning opportunities even during the peak agricultural period to supplement the family cash income. This is simply attributed to the smallholding and water shortage that cannot provide sufficient on-farm work.

The farm economic survey indicates that some 80 percent of the household heads is earning off-farm income from such activities as day wage labor both in agriculture and construction work in Tambol or Amphoe centers and in Malaysia. The number of Thai laborers working in Kelantan State of Malaysia just across the border reportedly exceeds 15,000 per year lately.

Dimensions of off-farm work as investigated in the Muban headmen survey are summarized below:

Place of Work	Tambol	Amphoe	Changwat	Malaysia
No of Cases Reported(Total 12)	10	6	2	10
Age of Those Concerned	20-40	17-41	18-45	18-37
Part of Households Concerned(%)	30	34	20	30
Average Duration per Year (Days)	96	113	65	70
Period Most Concentrated in	Apr.-Aug.	Mar.-Aug.	Apr.-Aug.	Apr.-Aug.
Average Daily Wage (Baht)	55	56	60	148

Though some discrepancy exists, the Muban headmen report that on average, about one third of the households are concerned with the off-farm work, and among those concerned, about one third each worked off-farm at Tambol, Amphoe & Changwat, and Malaysia, respectivley. Average duration of work ranges from two to three months in the dry period of March to August. Wage earned in Malaysia is on average 2.6 times higher than the wage available in the Study area.

As for the current problem of off-farm employment, it is noted that the respondents cite the conflict with farm labor as relatively serious problem in addition to other common problems such as lack of job opportunity and low level of wage and skill.

(Unit: %)

Problem	No	Serious	Very Serious
1. Lack of Information	92	8	0
2. Low Wage	79	20	1
3. Low Skill	77	22	1
4. Conflict with Farm Labor	68	32	0
5. Lack of Job Opportunity	69	29	2

(5) Farm Characteristics

1) Farm Size

The size of farm area operated inclusive of area rented-in and operated free of charge among the households surveyed is estimated as follows:

(Unit: Rai)

Farm Size	Paddy Farm	Mixed Rubber/Paddy Farm	Average
Small	7.4	8.9	8.1
Medium	12.1	13.6	13.1
Large	18.4	21.8	20.8
Average	11.7	15.7	14.0

The size of area operated ranges from 7 to 22 rai and the average is 14 rai (2.2 ha) (for details, see Table VI-1-8 in Appendix VI).

The smallholding prevalent in the Study area is in general not considered a problem among the respondents. Those who consider it a problem cite such reasons as long distance and difficult way to the field, and difficulty in mobilizing machinery.

(Unit: Percentage)

	Farmers			Headmen
Is Small Holding A Problem?	Small	Medium	Large	
Yes	8	8	9	8
No	92	92	91	92

2) Farm Size Distribution

Development of farm size distribution in the Study area can only be indirectly established by making use of the information contained in the 1963 and 1978 Agriculture Census Reports, assuming that the distribution in the Study area does not significantly differ from that of the Changwat Narathiwat. In the two census period of 15 years, annual average decline of 0.8 percent in the total area of holding and annual average increase of 0.7 percent in the number of holding together contributed to the annual average decline of 1.5 percent in the farm size under the estimated average population increase of 2.6 percent in the corresponding period (See Table VI-1-9 in Appendix VI). The proportion of large size farms declined in the said period from 45 percent to 38 percent.

The established system of inheritance of farm land among the dominant Thai Muslim families must have already reached a point where the smallholding can no longer sustain a subsistence agriculture. Permanent outmigration of the Muslim families is very unlikely given the language, ethnic, and religious differences. Continuation of the existing small economic resource base in Narathiwat would be capable of supporting only a limited portion of growing labor force without any incentive.

The cultivable land resource in the Study area has almost been exhausted and further reclamation of the forest areas is constrained by the environmental consideration. The remaining option is, needless to say, development of thus far flood-prone and low fertility fallow land into high fertility cultivable area. Any attempt to further avoid the increased pressure on land would inevitably involve some institutional change in land which must carefully be enacted if it were to succeed.

3) Farm Fragmentation

Land ownership in the Study area is characterized not only by smallholding but by fragmentation. The cultivable land gets fragmented primarily as a result of the Islamic code of inheritance together with strong identification with the land. Land purchase/sale, new land clearing, and land rental also contribute to the fragmentation but these are limited in the Study area. Multiple ownership is infrequently encountered (more than 90 percent of farmers are reportedly sole owners). The following table gives some details of land fragmentation among the farm households interviewed during the Phase I Field Work:

Farm Size	Ave.Size of Holding (rai)	Ave.No. of Plots (No.)	Ave.Size of Plot (rai)	Proportion of Farm Households with 1 Plot (%)	2 Plots (%)	More Plots (%)	Total (%)
Small	7.8	2.3	3.4	16.7	54.2	29.1	100
Medium	12.8	3.0	4.3	20.8	29.2	50.0	100
Large	23.3	3.5	6.7	4.2	33.3	62.5	100
Ave.	14.6	2.9	5.0	13.9	38.9	47.2	100

Most of the farm households report the holding of more than one plot under cultivation. Household with one plot is more often observed for small and medium size classes. Significantly, 47 percent of the households report 3 or more plots cultivated. A further fragmentation may be expected, but this may be to a lesser extent due to a large number of farm families already holding a smallest area of land.

4) Farm Endowment

The endowment of tools/equipment and machinery for farm production among the sample households is characterized by the low level of mechanization. For land preparation, more than one half of the sample households use their own puddling machine or iron buffalo which on average costs ฿20,000. Sprayer and water pump are owned by about 10 percent of those interviewed each, costing about ฿500-700 and ฿3,000, respectively. Paddy harvesting is commonly done by small hand equipment (mostly by Kae and partly by hand sickel). Many types of farm equipment are held by the sample farmers, but large and costly ones are mostly confined to those for land preparation and others are minor items in terms of the estimated value. (for details, see Table VI-1-10 in Appendix VI).

5) Homestead Endowment

The endowment of farm households with durable consumer goods must have improved significantly over the past years if the changwat average is taken as an indicator.

(Unit: %)

Item	Study Area Average	1970 Changwat Average	1980 Changwat Average
Bicycle	53.3	46.4	47.1
Motor Cycle	39.0	21.7	45.4
Hand Loom	3.7	n.a.	n.a.
Modern Stove	0.0	n.a.	n.a.
Refrigerator	7.8	8.7	10.5
Food Cabinet	36.5	n.a.	n.a.
Medicine Cabinet	7.6	n.a.	n.a.
Radio	79.4	57.2	92.8
TV Set	22.6	7.0	15.6
Sewing Machine	14.4	n.a.	n.a.

Source: Farm Economic Survey, 1970 and 1980 Population and Housing Census

In the two-census period of 1970 and 1980, possession of such items as motor cycle, radio, and TV set increased almost by two-fold. In the Study area, such items as radio, bicycle, and motorcycle are owned by many households.

6) Land Tenure and Title

According to the 1983 Intercensal Survey of Agriculture, the owner operator dominates the land holding pattern accounting for probably more than 90 percent, and the remaining is tenant and partial tenant (for details, see Table VI-1-11 in Appendix VI). The pattern of land tenure tends to shift from one form of tenure to more than one form of tenure. Average size of holding is estimated at 17.7 rai (2.7 ha). The land registrar in Amphoe Offices reports that absentee landlord comprises 5-10 percent of the total land holding in the Study area. The number and area of holding in the Study area is estimated as follows:

Amphoe	Under 6 rai	6 - 9.9 rai	10 - 39.9 rai	40 rai and Over	Total No. of Holdings
Muang	842	865	2,526	270	4,503
Yingo	89	92	269	29	479
Rangae	355	365	1,065	114	1,899
Takbai	521	534	1,561	167	2,783
Total	1,807	1,856	5,421	580	9,664
%	18.7	19.2	56.1	6.0	100.0
Area of Holding					
Total (rai)	6,956	14,409	104,013	40,247	165,625
%	4.2	8.7	62.8	24.3	100.0

Source: Estimation based on 1983 Intercensal Survey of Agriculture, National Statistical Office

According to the Amphoe Offices concerned, 5-10 percent of the land holding in the Study area is characterized by Sor Kor 1 and the remaining by Nor Sor 3 or higher land title. This is also confirmed by the result of farm economic survey as in the following table (for details, see Table VI-1-12 in Appendix VI).

Sample Size	Total Area Owned(rai)	Title Deed(rai)	N.S.3K & N.S.3(rai)	S.K.1 (rai)	Others (rai)
144	2,252	25	1,980	82	165
Distribution(%)	100.0	1.1	87.9	2.6	7.3

The price of land investigated in the survey ranges as follows and it appears to be determined by the imputed rent derived from the land for various purposes(see Table VI-1-13 in Appendix VI).

(Unit: ฿/rai)

Paddy Area	Upland Area	Rubber Area	Homestead Area
11,073	13,673	15,489	22,265

(6) Farm Production

1) Input Supply

Though some households report the difficulty in securing the input materials such as fertilizer and pesticide, farmers in the Study area do not appear to have much problem in securing input supply,

(Unit: %)

Problem	Fertilizer	Manure	Seed	Pesticide
Yes.	19	0	2	13
No.	81	100	98	87

2) Source and Adequacy of Crop Water Supply

By far the most of the paddy and rubber fields are rainfed, but it is noted that about two thirds of the respondents consider the water supply as adequate, though presumably at less than the preferred level of water supply.

(Unit: %)

Type of Farmer&Field	Source			Adequacy		
	River/Swamp	Rainfed	Others	Adequate	Not Adequate	Excessive
Paddy Farmer						
- Paddy Field	2	97	1	67	26	7
Mixed Farmer						
- Paddy Field	2	98	0	55	30	15
- Rubber Field	0	99	1	97	2	1

3) Credit Status and Purpose

Summary of the credit status and purpose, for which it is obtained, is given below:

	Paddy Farm	Mixed Farm	Total
Sample Size	59	85	144
Sample Concerned (%)	17	28	24
Credit Status Per Sample Concerned			
Debt at the Beginning(฿)	4,300	5,150	4,900
Loan Made(฿)	8,550	8,200	8,300
Interest Rate (%)	14	14	14
Repayment(฿)	7,300	6,000	6,380
Debt at the End of Year(฿)	7,250	9,100	8,600
Borrowed from*/	R.N.C.B.	R.N.C.B.	-

*/----- R:Relatives, N:Neighbor, C:Cooperative, B:Bank,

About a quarter of those interviewed made use of the credit in the year prior to the survey period. There appears to be no significant difference in terms of the accumulated debt between the paddy and rubber farms. The paddy farmers used the credit for the purpose of land preparation and other non-agricultural purposes whereas the rubber farmers borrowed the credit for purchasing the calves.(for details, see Tables VI-1-14 and VI-1-15 in Appendix VI).

4) Dimensions of Rent-In and Out

Renting in and out of the farm and homestead area is practiced only among 10 to 20 percent of those interviewed and it accounts for about 10 percent of the area operated. They are normally practiced among the relatives and neighbors and the rent is commonly paid in the form of share cropping of 50 percent. Though the extent of labor exchange system was not explicitly investigated, the farm economic survey revealed that it is prevalent among the landlord, relative, and neighbor during the peak period.

	Paddy Farmers	Mixed Farmers	Total
Rent In			
Sample Concerned (%)	27	13	19
Rent from whom (%)			
- Relative	38	64	48
- Neighbor	56	36	48
- Temple	6	0	4
Purpose	Paddy, Home	Paddy	-
Average Area (Rai)	5.5	5.0	5.3
Area Concerned (%)	13	9	11
Rent paid in the form of			
- Cash (฿150-200/rai)	13	0	7
- Paddy (30kg/rai)	6	0	3
- Share (1/2)	56	82	67
- Share (1/3)	25	28	22
Rent Out			
Sample Concerned (%)	10	5	7
Rent to whom			
- Relative	33	75	50
- Neighbor	67	25	50
Purpose	Paddy	Paddy	-
Average Area (Rai)	11.3	6.0	9.2
Area Concerned (%)	10	4	7
Rent paid in the form of			
- Share (2/3)	17	25	20
- Share (1/2)	50	75	60
- Share (1/3)	33	0	20

5) Crop Production

The summary of the annual average planted and harvested area and the yield for 1983-85 period among the sample households is given below (for details, see Table VI-1-16 in Appendix VI):

Crop	Planted Area (Rai)	Harvested Area (Rai) (%)	Planted Area Base Yield (Kg/Rai)
Paddy, Local	998	794 (80)	190
Paddy, HYV	85	72 (85)	204
Rubber, Local	323	227 (70)	101
Rubber, HYV	230	90 (39)	57
Sweet Corn	0.7	0.7 (100)	743
Cucumber	5	5 (100)	1,219
Stringbean	2.8	2.8 (100)	682
Gourd	0.5	0.5 (100)	833
Coconut	9.5	9.5 (100)	870 Fruit

In the said three-year period, the proportion of harvested area remained rather stable, thus the yield per planted area also remained constant.

6) Crop Disposition

The farm economic survey shows the percentage of crop disposition for different farm types and crops as follows (for details, see Table VI-1-17 and VI-1-18 in Appendix VI). Majority of rubber and upland crops are sold to the market whereas about 10 percent of paddy is sold for cash. The farm household normally sell their products to the merchant at the household area or at the market.

Crop and Farm Type	Total (ton)	Consumed (%)	Seed (%)	Rent (%)	Stored (%)	Sold (%)	Others (%)	Ave Price (฿/ton)
Paddy - Paddy Farm	120.5	63	3	7	5	14	8	2,882
- Mixed Farm	95.2	80	4	4	4	6	2	-
Rubber - Mixed Farm	53.4	0	0	1	0	89	10	13,179
Upland Crops	15.8	5	1	0	0	94	0	-

(7) Fishery

The fresh water fish in the Study area is either purchased or caught in the pond/swamp area, whereas almost all of the marine fish is purchased.

(Unit : %)

	Purchase	Raise in Pond/Swamp	Raise in River/Sea	Catch in Pond/Swamp	Catch in River/Sea	Others
Fresh Water Fish	40	3	0	35	6	17
Marine Fish	99	0	1	0	0	0

The annual fish yield per family engaged in the fishery is 85 kg and majority of the fish caught are consumed at home.

(Unit : kg/Family/Year)

Yield	Bang Nara	Other River	Pond Swamp	Others
Fresh Water Fish	8	5	64	8

(Unit : Percentage)

Disposition	Home Consumption	Sold to Market	Others
Fresh Water Fish	85	8	7
Marine Fish	70	30	0

(8) Household Income

1) Farm Income

Farm income comprises non-cash income (value of home consumption) and cash income from the sale of crops and livestock. The Study area lies in the paddy deficient region, thus the sale of it is quite limited among the majority of farmers. Rubber and livestock are two dominant sources of the farm cash income followed by some other crops like

coconut and fruits (See Table VI-1-19 in Appendix VI). Marketing of vegetables and other upland crops is negligible, which is attributed to lack of dry season irrigation and higher off-farm income earning opportunities. Farm cash income among the households interviewed accounts for about 22 and 46 percent of total household income respectively for paddy farmers and mixed paddy/rubber farmers, whereas the farm non-cash income for about 37 and 25 percent for the respective farmers (See Table VI-1-22 in Appendix VI).

2) Off-Farm Income

About one third of the households surveyed have their members contributing to the household cash income through off-farm agricultural work, primarily in rubber tapping. This source of income, however, contributes only 5 - 10 percent of the household income both for paddy and mixed rubber/paddy farmers.

As far as the off-farm non-agricultural work is concerned, about three fourths of the sample households have their members engaging in this type of work, contributing about 25-30 percent of the household income. The important source of off-farm non-agricultural income for the sample households are government services and selling home-made products (See Tables VI-1-20 and VI-1-21 in Appendix VI).

(Unit : ฿)

Farm Type	Farm		Off-farm		Total	Per Capita Income
	Cash	Non-Cash	Agri.	Non-Agri.		
Paddy Farm	5,250	8,850	2,650	7,300	24,050	4,650
Mixed Farm	13,400	7,200	1,150	7,400	29,150	5,300
Average	10,200	7,800	1,750	7,350	27,100	5,100

3) Income Level

Despite some inconsistency in the survey data due to probable response error and small sample size, Phase I and II Surveys brought about the similar result, and the table above gives a good picture of the income level among the households interviewed. Annual average per capita income ranges from ฿4,700 to 5,300, the average being ฿5,100. Per capita income of mixed farms is 14 percent higher than paddy farm (for details, see Table VI-1-22 in Appendix VI).

To facilitate the evaluation of this level of per capita income, two indicators are employed, i.e., the poverty line and the average rural income in Thailand. On the basis of the poverty line of ฿2,000 per capita estimated by the World Bank for 1976, the 1985 poverty line is calculated at ฿3,870 taking into account the annual rate of inflation of 7.6 percent during the relevant period. Similarly the annual average rural per capita income was ฿3,600 in 1979 or ฿5,580 in 1985 prices.

Considering these two indicators, it is probable that some small and medium size paddy farms in the Study area are on the poverty line. On average, the income level of sample households appears nearly 10 percent lower than the average rural residents in Thailand.

(9) General Agricultural Problems

Serious agricultural problems cited by the farmers and Muban headmen are mostly confined to those relating to the external and physical factors, such as water shortage, flood, insect and rats, and soil fertility. In general, as far as the agricultural production is concerned, the technical and distribution/marketing services are not considered as deterrent factors of production in the Study area.

(Unit: %)

Problem	No	Minor	Serious	Very Serious
1. Soil Fertility	61	15	16	8
2. Small Holding	64	21	8	7
3. Water Shortage	22	32	33	13
4. Flood	22	33	36	8
5. Insects & Rats	6	38	44	13
6. Weed	35	38	26	1
7. Plant Disease	27	56	17	0
8. Lack of Knowledge	51	41	8	0
9. Lack of Advice	57	35	7	0
10. Low Farmgate Price	53	25	21	1
11. Transport/Market	71	21	8	0
12. Poor Water Quality	68	16	13	4

1) Storage Problem

In storing the farm products, the most respondents report the damage caused by the rat and the mold.

(Unit: %)

Problem	No Storage	Storage Too Small	Poor Storage	Rat	Mold
Yes	4		21	92	35
No	96		79	8	65

2) Marketing Problem

Marketing problems center on the socio-economic factors such as few buyers, low price, and fraud of buyers rather than on the physical ones.

(Unit: %)

Problem	Bumper Crop	Poor Product Quality	Lack of Transport	Few or No Buyers	Low Price	Fraud of Buyers
Yes	3	10	7	15	30	18
No	97	90	93	85	70	82

3) Livestock Problem

Livestock problems appear to be minor in extent, but there appear to be many who are seriously affected by the lack of capital and grass

land. The evidence is confirmed by the farmers in the Study area who make use of the credit for the purpose of purchasing the calves.

(Unit: %)

Problem	No	Moderate	Serious
1. Lack of Labor	93	5	2
2. Lack of Pasture	64	19	17
3. Expensive Feed	78	14	8
4. Lack of Capital	70	19	11
5. Low Product Price	71	19	10
6. Disease	56	35	8

(10) Aspects of Flood and Damage

Aspects of annual flood in the latest five years from 1980 to 1984 were investigated in the farm survey. The flood is concentrated in the November - February period with the average flood height in the paddy field of 1.2 m lasting for about 5 days.

	Farmers	Muban Headmen	Average
Flooded Month (%)			
- Oct.	1.6	0	0.4
- Nov.	1.7	0	1.3
- Dec.	50	40	48
- Jan.	17	28	20
- Feb.	31	32	31
Flood Height (m) in the Paddy Field (Household)			
- 1980	0.6	1.4(0.6)	0.8
- 1981	0.9	1.2(0.6)	0.9
- 1982	1.1	1.1(0.8)	1.1
- 1983	1.5	1.6(0.7)	1.5
- 1984	1.6	1.8(0.7)	1.6
Flood Duration (days)			
- 1980	2.9	5.3	3.5
- 1981	3.7	4.1	3.8
- 1982	4.7	3.8	4.5
- 1983	6.8	6.2	6.6
- 1984	7.2	6.7	7.0

Damage on road appears most seriously felt with 40 percent reporting serious deterioration of its conditions, lasting for 5 days

on average. In terms of actual value of damage on housing and others, it is noted that the flood has a considerable influence on spreading skin diseases among the respondents.

Damages on	Frequency	Duration (days)	Minor (%)	Serious (%)	Very Serious (%)
Road	Once a Year	4.9	61	30	9
Temple	Once a Year	1.3	90	10	0
Electricity	Once a Year	-	0	100	0
Health Center	Once a Year	1.1	50	33	17

Value of Damage on	Farmers (฿/household)	Muban Headmen (฿/Muban)
Housing	0	7,850
School	0	0
Commuting	0	0
Shopping	0	0
Diseases	13	1,700
Poultry	0	120

The following table, on the other hand, shows the farmer's estimate of production loss due to flood and others. As high as 30 percent of the paddy field is damaged and thus unharvested, with 15 percent due to the flood and the remaining due to the drought and rat & insect.

(Unit: %)

Production Loss due to	1980	1981	1982	1983	1984	Average
Paddy Field						
- Flood	6	13	12	17	20	14
- Drought	3	7	11	8	13	9
- Rat, Insect	11	11	9	5	8	7
Total	20	31	32	30	41	30
Rubber Field						
- Flood	-	-	-	-	-	1
- Drought	-	-	-	-	-	2
- Ant	-	-	-	-	-	5
Total	-	-	-	-	-	8

Another aspect of flood damage was investigated in terms of productive days lost and extent and types of diseases contracted.

	Farmers	Muban Headmen	Average
Days lost for			
- On-Farm Work	8.7	3.4	7.4
- Off-Farm Work	4.4	4.9	4.6
- Schooling	6.2	7.5	6.5
- Market	3.9	3.2	3.7
Diseases Contracted (%)			
- Skin Diseases	39	33	38
- Cold	14	25	17
- Others *	-	-	13

* Others include Diarrhoea, Stomachache, Broken Leg, Cholera,etc.

On average the productive days lost ranges from 4 to 7 days, while nearly 70 percent of the respondents report the contraction of diseases due to the flood.

3.2.2. Social Services and Conditions

(1) Primary and Secondary Education

The existing primary and secondary educational institutions have been discussed in para. 3.5.6. "Health and Education" in this chapter. Field survey shows that 90 percent of the household members aged 7-13 are enrolled in the primary school, whereas less than 50 percent of those aged 14-18 are in the secondary school and among those aged 19-22, less than 20 percent proceed to the tertiary education in the Study area. Average years of education for those who are still attending school as well as those who have already completed are about 4 years. (for details, see Table VI-2-1 of Appendix VI).

Age	School Status	Persons (%)		Ave. Years Completed
0 - 6	- Pre-School	85	(100)	-
7 - 13	- Attending	126	(90)	3.6
	- Completed	14	(10)	3.5
14 - 18	- Attending	51	(43)	9.5
	- Completed	69	(57)	6.7
19 - 22	- Attending	10	(17)	10.4
	- Completed	48	(83)	6.9
Above 23	- Attending	1	(0)	10.0
	- Completed	360	(100)	3.4
Total		770		4.1

Though the secondary education is an important means to get rid of the rural poverty, many parents appear to expect their children not to advance to the secondary or tertiary level and instead expect them to remain in their Muban, which may be attributed not only to the high cost of education and transportation/accommodation but also presumably to their attitude of resigning to the present status.

(2) Public Health

The major aspects of public health conditions such as health personnel, institutions and facilites, incidence of diseases, infant and maternal mortality, causes of death, etc in the Study area have also been described in para. 3.5.6. "Health and Education" in this chapter. The following table shows the prevalent diseases contracted among the local residents interviewed.

(Unit: %)

	Stomachache	Backache	Headache	Trachoma	Skin Disease	Others
Adult	48	48	52	6	44	25
Child	33	2	42	8	46	21

Note: Others include cold, eye problem, malaria, filariasis, typhoid, etc.

Source: Farm Economic Survey

In addition to the common diseases such as stomachache, backache, and headache, both the adult and children appear to suffer from skin diseases which is partly attributed to the effect of annual flood.

(3) Problem with Infrastructure

The present social infrastructure in the Study area is by no means low by the rural standard of Thailand. The farm survey shows, however, that road, health center, and sanitation are the three important facilities for which improvement is sought by comparatively a large portion of the respondents.

(Unit: %)

Problem with	No	Minor	Serious	Very Serious
Road	42	31	23	4
School	79	19	2	0
Health Center	43	19	32	6
Electricity	73	11	11	4
Drinking Water	75	10	6	8
Market	65	15	17	4
Sanitation	14	57	14	14

(4) Government Services Received

The farm economic survey shows that the farm households are visited monthly by the extension workers and community development workers and less frequently by other government officers. Many of the farmers have occasional or regular access to the credit and fertilizer provision and the general extension services. The community development workers are also considered highly instrumental in helping improve the living environment through organizational activities.

Type of Visiting Officers	Annual No. of Visits
Extension Officer	9
Comm. Dev. Officer	11
Roving Officer	1
Others	1

(Unit: %)

Type of Assistance Received	Never	Sometimes	Regularly
1. Credit for Input Materials	49	25	26
2. Credit for Tools/Equipment	75	14	11
3. Fertilizer	51	28	21
4. Seeds	63	29	8
5. Insecticide/Pesticide	68	27	5
6. Extension Service	18	54	27

The farmers have also received various vocational training courses, though limited in extent except for sewing cloth which is considered relatively beneficial.

Type of Training Received	(%)
Sewing Cloth	41
Weaving Mat	3
Carpentry	2
Weaving Cloth	1
Hand Craft	2
Reading & Writing	2
Engine	1
Food	4

On the whole, these government services are evaluated adequate and beneficial by the respondents except for certain areas where the services are not regularly provided.

(5) Government Assistance Needed

The Government assistances most needed are in the economic or income generating field rather than social field as identified in the survey.

(Unit: %)

	Type of Assistance Needed	Very Important	Less Important	Not Important
1.	Marketing/Transport	25	33	42
2.	Input Supply	32	44	24
3.	Extension Service	28	50	22
4.	Provision of Credit	20	39	42
5.	Irrigation Water	86	10	3
6.	Drinking Water	9	16	75
7.	Health	19	25	58
8.	School	3	20	24
9.	Vocational Training	31	45	24

Improvement in the irrigation water supply is considered most important, followed by assistance in input supply, vocational training and extension services. These results confirm to a considerable extent justification of the proposed Project that the supply of irrigation water together with intensified extension services and other institutional support would meet the most important requirement of the residents.

(6) Rural Employment Generation Projects

In an effort to reduce the rural-urban disparity, the Government initiated in 1980 (2523) "Rural Employment Generation Program" in the provinces throughout the country including Narathiwat. The Program aims, through infrastructure, production, and institutional development projects, to provide increased employment and income during the dry season. The executing agencies are Tambol councils supervised by Amphoe officers.

The average project is very small in size and is characterized by intensive use of labor and local materials. Information on the Program obtained from the Amphoe offices as summarized in Tables VI-2-2 and VI-2-3 of Appendix VI) indicates that the number of projects undertaken is rather small and so is the size of the project in terms of the labor days generated and the cost.

3.2.3 Institutional Aspects

Understanding of institutional aspects in the Study area, i.e., farmer's organization, their attitude toward the probable changes and their participation in the proposed Project during the implementation and development stage is quite essential for planning the institutional arrangements as to the smooth transformation of the present traditional rainfed agriculture to the modern irrigated agriculture.

(1) Farmer's Organizations

There exist in the Study area a number of different types of organization or group, which may be classified into economic, social and other minor groups. A farmer on average appears to have membership of at least one or two groups. The water users' group is not found in Muban where the household survey was conducted, but it actually exists where the RID projects have been constructed. The organizations engage in a wide range of activities but the membership rate is high only among the economic groups such as BAAC, credit cooperative, and agricultural cooperative groups, but the meeting does not appear to be regularly held except for the extension group.

Group	Existence (%)	Membership Rate(%)	No.of Meetings Held Per Year	Participation Rate of Meeting
1. BAAC	100	23	3	93
2. Credit Coop.	67	25	3	90
3. Agri. Coop.	17	21	2	100
4. Extension	8	19	12	80
5. Livestock Raising	17	11	2	100
6. Water User	0	-	-	-
7. Tambol Council	83	2	4	100
8. Wat Council	50	4	3	98
9. Masayit Council	50	8	7	96
10. School Committee	75	7	2	99
11. Folk Scout	92	17	1	82
12. Village Development	83	12	4	97
13. Volunteer Protection	75	16	4	99

Among the above groups, BAAC, Tambol Council, and Village Development Groups are regarded as successful groups, for which the major reasons cited are (1) committee has power, (2) good cooperation and (3) responsible members. Equivalently, those groups that are short of these characteristics are unsuccessful ones. In addition to the groups listed above, there reportedly are some informal or ad hoc but successful farmer groups (activities) which are mobilized for road and canal construction in the Study area.

(2) Dimensions of Major Groups

The groups surveyed in detail are : (1) extension groups, (2) cooperatives, (3) water users groups, and (4) community development groups, and (5) others.

- Extension Groups

* These comprise of farmer group, woman group and youth group and the ratio of members in the registered groups out of the total farm households remains 2-3 percent for the respective group (See Table VI-2-4 in Appendix VI).

* In addition to the regular extension services, the groups registered at the Changwat Office are entitled to various promotion programs with some material assistance in the form of farm input.

* Farmer and woman groups tend to be organized among either only Thai or Muslim households whereas youth group is often set up jointly by the two ethnic groups of young people.

* The most active group identified is the rubber sheet processing groups which report the production of higher quality sheet and the increased bargaining power for the price of sheet.

- Cooperatives (see Table VI-2-5 in Appendix VI)

  * There is approximately one cooperative in each Amphoe with the membership ratio in the four cooperatives concerned ranging from mere 3 to 22 percent and the per capita deposit of ฿500 to ฿3,400.

  * Services rendered by these cooperatives are mostly confined to the credit provision to the members with the fund primarily coming from BAAC.

  * In regards to the amount of credit, as reported by BAAC in Narathiwat, agricultural cooperative deals a very minor portion relative to the informal and BAAC groups.

  * Provision of farm inputs by the cooperative still remains small in volume and marketing of farm products is almost non-existent.

- Water Users Groups (WUG)

  * For the sole large-scale project of Muno, RID plans to set up about 50 WUG in the total net irrigation area of 6,700 rai with each group consisting of 30 to 50 members. The beneficiary farmers among existing group contributed portion of their land for construction of on-farm facilities, cooperate among themselves in canal cleaning, and cultivate two crops per year. No water charge is collected.

  * No WUG exists for the medium-scale drainage projects of Nam Baeng and Bacho. No action for establishment of W U G is taken yet for the Pileng project which is due completion in 1987.

* For the medium scale Klai Ban project, RID is negotiating with the beneficiary farmers regarding the construction of on-farm facilities and is planning to set up 3 WUG consisting of 135 members.

* Out of 63 small-scale irrigation programs completed in Narathiwat, 23 WUG are established among both Thai and Muslim farmers, with the members in each group ranging 20 to 300 and organized under 10-20 committee members (See Table VI-2-6 in Appendix VI).

* Groups receive initial orientation and technical assistance from such government agencies as RID, DOLA, DOAE, CDD, DOF, and LDD and are supported by the technical advisory council consisting of officers from the above agencies and Muban leaders.

* The beneficiary farmers often donate land for construction of not only the major RID facilities but also the on-farm facilities.

* Groups often take their own initiatives in the construction of on-farm facilities and in the canal or ditch cleaning with voluntary supply of labor and material.

* In case where the members have a little prior knowledge on the group work or potential benefit, they often have no access to the irrigation or a considerable number of members do not contribute their labor for ditch construction or cleaning.

* In W U G under SSIP, there is at present no water charge or fee imposed, but one group is planning to collect it beginning the coming harvesting period(1986).

* Though activities in WUG under SSIP are still rather preliminary and simple in nature, the cooperative spirit shown by the farmers is quite encouraging.

* Continuous Government support especially from Amphoe office, RID and DOAE is quite important for the successful O & M of irrigation projects. For dimensions of 8 WUG surveyed in detail in the Study area, see Table VI-2-7 in Appendix VI.

- Community Development Groups

* These comprise of leader group, woman's job training group, youth group, saving group, etc.

* In addition to the Tambol level worker (officer), CDD has a leader volunteer in every Tambol and a volunteer in every Muban who work in close cooperation both with the officers and the Muban leaders.

* There are reportedly 32 saving groups set up in Narathiwat by CDD. With the average membership of 30 farmers and the reserve fund of ฿30,000 per group, the group is ready to provide a loan that carries an interest rate of 12.5 percent without any mortgage requirement.

* Group or Muban leaders are encouraged to hold occasional meetings to clearly identify the problem and its solution, capacitating themselves so that they make cooperative efforts for community development.

* The local farmers often carry out successful community development work especially when they receive various forms of the Government assistance.

- Others

* Other economic group commonly identified is the informal credit group, whose aim is essentially to gain access to the formal credit for the purpose of livestock purchasing and raising as well as for

rubber replanting. Members of informal groups assemble themselves for the sole purpose of gaining access to the credit and are jointly liable for credit repayment. Once the repayment is completed, the informal groups are dissolved as easily as they are assembled. Thus, according to the Narathiwat Branch of BAAC, the informal groups surpass the formal BAAC groups in terms of not only the number of credit applications but the amount of credit provided.

* Social groups include Tambol council, Mosque & Temple council, School committee, etc. Tambol council is made up of representatives from each Muban such as Muban headman and leader farmer, but its importance appears to be limited with a little budget to work with.

(3) Farmer's Attitude

The field survey indicates that since both the dominant Muslim and the minority Thai have the similar physical endowment and are influenced by the similar socio-economic conditions, they appear to share common attitude in many respects, but on the other hand, a clear distinction in attitude lies in certain respects between the two ethnic groups. In general, all of the Muban headmen interviewed were confident that there is in their Muban a collective effort to organize a voluntary group, identify their problems and play an active or autonomous role in solving them.

As far as the attitude toward the Government officers is concerned, the local farmers are often confused with the discrepancy in the advice from non-coordinated Government officers, but they appear to show the highest respect for Amphoe Officers.

(4) Attitude Toward Change

Most of the farmers in the Study area expressed an interest in the flood mitigation and the availability of wet and dry season irrigation. Some of the farmers have seen or heard of irrigation/drainage schemes nearby their village or in other parts of the Changwat Narathiwat and thus are aware of the potential benefits of such projects. The following table shows the farmer's acquaintance with irrigation/drainages projects. The Muban headmen naturally have more knowledge on the projects.

Farm Size	Successful Projects	
	Farmers Having Seen(%)	Reasons(No.)
Small Farmer	46	Flood Control (12)
Medium Farmer	25	Irrigation Water (10)
Large Farmer	21	Good Drainage (6)
Headman	75	Second Crop (5)
Average	42	Higher Crop Yield (4)
		Protection of Soil Intrusion (1)

Farm Size	Unsuccessful Projects	
	Farmers Having Seen(%)	Reasons(No.)
Small Farmer	8	Excessive Drainage (5)
Medium Farmer	17	Poor Operation (Water Stealing)(4)
Large Farmer	17	Poor Drainage (2)
Headman	25	Poor Water Quality (2)
Average	17	No Flood Control (1)
		Water Shortage in the Upper Area (1)
		Farmer's Burden (1)

The overall performance of the irrigation/drainage projects in Narathiwat appears to be evaluated good, however, in certain cases where their land lies in the direct beneficiary boundary of a scheme, the

farmers complained of the deteriorating conditions occasioned by a small scale drainage project which had an excessive drainage effect during the transplanting season and limited drainage effect during the flooding season.

The farm survey also shows that, in general, even if an equal income is assured, nearly almost all farmers revealed preference for agriculture rather than non-agricultural employment, while only about a quarter of the farmers preferred their children to engage in non-agricultural work in future.

(5) Farmer's Participation

This includes participation in construction works, contribution of land for the project facilities, cooperation in land lease arrangement and water use, and willingness to pay the water charge for cost recovery of the project and cooperation in land lease arrangement and water use.

1) Participation in On-farm Work and O & M

To the direct question of whether the farmers are willing to take part in the project or not in terms of construction of on-farm work and O & M of the facilities, three quarters responded positive whereas the remaining answered negative or were undecided since they have not observed the project and were not aware of the potential benefit.

The willingness of the farmers in the Study area to take part in the construction of the project was also confirmed by their interest in having the project implemented, their constant search for off-farm cash opportunities even during the farm peak season, their desire to acquire construction skill as evidenced in the survey, as well as the Government effort to generate income and employment opportunities through various Muban construction and development projects.

2) Compensation Required for Contribution of Land

The Table below shows that 70 percent of the respondents are willing to contribute part of their land to the project if compensated in cash or land of equivalent value. In actual implementation, however, individual land may not readily be acquired, but this result shows the strong interest of the farmers in the project implementation.

(Unit: %)

Type of Compensation	Yes	No.	Undecided or Do not know
1. Cash Settlement	73	13	15
2. Land of Equivalent Value	69	15	16
3. No Compensation Required	7	78	15

3) Lease Arrangement

The lease arrangement of the land that would be necessary for the dry season crop production in the future was found to be acceptable among 70 percent of the households interviewed.

	Farmers			Muban
Lease Arrangement Acceptable	Small	Medium	Large	Headmen
Yes	63	72	78	70
No	37	28	22	30

The reasons cited among those who considered the arrangement unacceptable are (1) cultivate one's own land only, (2) lack of labor, (3) sufficient land available, (4) too small a farm size, and (5) widespread farms.

4) Willingness to Pay

Nearly 70 percent of the respondents showed their willingness to pay the irrigation water charge, with the rate being higher for the dry season crop. "Others" in the table below include those who are undecided or are up to the RID's direction. This can be interpreted that many of the farmers are aware of the potential benefit of the irrigation project and the cost needed to provide the service.

(Unit: %)

	Farmers		Headmen		Total	
	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season
Willing to Pay?						
Yes.	69	81	42	50	63	73
No.	17	6	16	8	17	6
Others	14	14	42	42	21	21
Part of Crop Farmers are Willing to Pay for Irrigation (%)	10	12	3	4	9	10

Part of the crop farmers are willing to pay for irrigation water may serve as a good indicator of their actual willingness or ability to pay, as shown above. Interestingly, the farmers gave higher percentage than the Muban headmen and the both were willing to pay more for the dry season services, with average being about 10 percent. If this figure is translated into the monetary terms, say, 10 percent of the current paddy production corresponds to about ฿1,200 per hactare.

5) Dry Season Crops and Problem

Majority of the farmers showed interest in growing dry season crops if adequate water supply is assured. The survey reveals that in addition to the ordinary dry crops such as vegetables, groundnut, and mungbean, more than half of those answered positively were interested in second paddy production.

(Unit: %)

Intension & Type of Crop	Farmers	Headmen	Total
Grow Dry Season Crop?			
Yes.	89	100	93
No.	11	0	7
1. Paddy	30	88	54
2. Vegetable	64	79	70
3. Groundnut	6	79	37
4. Cassava	0	4	2
5. Maize	9	50	26
6. Mungbean	27	38	32
7. Water Melon	6	4	5
8. Sweet Corn	6	0	4
9. Soybean	3	0	2

As the following table shows, the farmers do not anticipate any serious or conflicting problem after the dry season crops are introduced, except for some who have some uncertainty in production technique and marketing.

(Unit: %)

Type of Problem	Yes	No.	Do not know
1. Conflict with Off-Farm Employment	13	85	2
2. Hired Labor Not Available	16	84	0
3. Market Uncertainty	25	75	0
4. Lack of Knowledge	21	78	1
5. Unreliable Water Supply	18	67	15

3.2.4. Rural Sociology

This section deals with sociological aspects of the Muban life in the Study area as identified during the field survey.

(1) General

The majority of target group are characterized by smallholding under the traditional rainfed agriculture with low productivity. Cultivation of paddy and other minor crops are essential for home

consumption. Income disparity is primarily determined by the size of rubber area, livestock production, and off-farm employment opportunities.

Crop failure of certain extent is regularly anticipated posing a constant threat to their existence. Anticipating the crop damage due to regular flood, drought, rats, etc., farmers often leave a significant portion of cultivable land fallow, withholding unnecessary labor and material input which would better be used for cash earning opportunities. In this respect, they are, irrespective of the ethnic difference, safely regarded as risk averters responding rationally to the given circumstances.

Except for the Pileng land settlement area where the newly settled families come from all other parts of Thailand, most of the families have settled in the Muban for long time and developed close relationship among themselves.

(2) Labor Custom and Rent

Family labor is normally sufficient for the paddy production except for the harvesting work in which hired labor is occasionally employed. This is partly attributed to increasing labor cost. Due partly to the increasing pressure on land, hired labor in paddy production is on the declining trend, while in rubber tapping one third of labor requirement is met by hired labor, with typical 50 percent of the share cropping. Increasing pressure on land and proximity to the Malaysian border provide an environment where the young male of 20 to 40 years of age seek off-farm work even during the peak farm period.

Renting of farmland accounts for about 10 percent of total holding area and is prevalent only among the relatives and close neighbours. Rent is typically paid in a piece rate, i.e., rent in cash per paddy area planted, rent in paddy per area harvested and rent in rubber per quantity tapped.

(3) Cooperation and Village Leadership

The observation of activities of water users groups under SSIP reveals that, in general, the villagers in the Study area have a rather good cooperative spirit among themselves, which materializes into the most fruitful action in a cohesive manner whenever the Muban leader has a great ability to induce villager's participation in various community projects. Where there is successful water users group, there is often a persuasive leader working behind it. Persuasive ability of the leader may be ascertained by the ability to (1) be well aware of the Muban problems and organize a meeting or maintain frequent and smooth communication, (2) help settle the various disputes, (3) maintain a favorable economic status, (4) maintain a very good personality, (5) win the villager's confidence, and (6) maintain a good human relation.

The Muslim religious leader in the Study area plays an important role similar to that of Buddhist monk as in other parts of Thailand and therefore is frequently better entrusted and heard by the villagers than the Government officers whenever some important advice is needed.

Other than Muban leaders, religious leaders, Tambol level extension workers, and Muban level volunteers in their respective field, the Government officers who enjoy the highest confidence among the villagers are Amphoe level officers, because of their frequent visit to Muban and thus closest communication with the villagers on their problems.

(4) Muban Organization

The Muban organization appears well established under the Muban council comprising headman, his assistant and other leader farmers. The villagers in the Study area are typically divided into several sub-groups of 10 farmers or so each. The leader farmer of the group who is often the Muban council member represents and serves for the interest of the respective sub-group farmers. He is also responsible for relaying to his members the important issues discussed and decision made in the Muban council. He may concurrently serve as a contact farmer through whom the Tambol extension officer or the volunteer extension worker provides the extension service.

In addition to the volunteer extension worker, three types of volunteer, i.e., community development volunteer, health volunteer, and education volunteer establish the network of communication and help strengthen the Muban organizational activities and improve the Muban living environment, in cooperation with the respective Government agency.

(5) Muslim and Buddhist

The generally low level of education and difference in language, culture and other behavioral patterns among the Muslim residents pose a considerable difficulty for the Government officers in general communication with and dissemination of information to the Muslim. These circumstances impose additional costs on the local Government in its effort to institute various socio-economic measures, a typical example of which is the case where the Government officers often have to employ Jawi interpreters in addressing to the Muslim residents on various occasions. This difficulty, however, has been gradually

overcome as an increasing number of Muslim students enroll at the Thai Government schools and advance to higher educational institutions. Good assimilation as a result of good school policy has been reported in nearby Changwat Pattani as well.

Though the two different ethnic groups, i.e., Muslim and Buddhist, generally reside in different Muban and carry out independent social and economic activities, they live in a harmonious manner and occasionally cooperate each other in the form of hired labor in paddy work and rubber tapping. Independent economic activity is typically identified in agricultural extension groups of farmers and their wives. These groups are organized separately between the Muslim and the Buddhist. Assimilation or friendly relationship can be observed in the agricultural youth extension group which typically consists of both the Muslim and the Buddhist young farmers.

Further assimilation would be possible as the physical, socio-economic and institutional development envisioned in the proposed Project provides more income and thus educational opportunities for the dominant Muslim.

Though as compared with the Buddhist residents, the Muslim tend to have a simpler mode of life, given the various constraints, they make a rational choice making best use of the opportunities available.

This implies that, in addition to the continuous Government assistance in various technical and input subsidy programs which help eliminate the constraints on the part of farmers, improvement of external factors especially marketing and price incentives for farm products is another prerequisite to induce the beneficiary farmers to undertake the design cropping scheme under the proposed Project.

(6) Migration

While the permanent migration to other Muslim dominant southern provinces may exist, ethnic difference, low level of education and information, and comparatively modest living standard hinder the migration to the central or other parts of Thailand.

Seasonal migration for a few to several months to Malaysia even during the peak farm period is quite common especially among the Muslim residents. Though the off-farm work in Malaysia provides a good income earning opportunity among the migrants, they tend to return to their Muban as soon as their cash requirement is met. Unless there is a significant reduction of the labor demand in Malaysia or equivalently an increase in labor demand in the Study area, the necessity of supplementing farm income would, in the foreseeable future, be likely to maintain the current level of temporary migration.

(7) Items Stolen

The farm survey shows that about one third of the respondents report such items as cow/buffalo, rubber sheet, and poultry being stolen before as follows:

(Unit: %)

	Farmers	Headmen	Total
Has any item ever been stolen?			
Yes.	19	67	30
No.	71	33	70
Items stolen			
1. Bicycle	0	25	13
2. Motorcycle	0	13	7
3. Poultry	14	25	20
4. Cow/Buffalo	43	88	67
5. Rubber Sheet	43	13	27
6. Vegetable/Upland Crops	0	13	7
7. Banana	0	13	7

(8) Disputes & Settlement

The Muban headmen responded that the majority of disputes arise over the conflict regarding the demarcation of land border followed by the damages caused by the cattle intrusion into the paddy and upland field. Dispute over the irrigation water has not been identified in the survey.

(Unit: Number)

Reasons for Disputes		Settlement of Disputes by	
Stolen Cattle, Baffalo	1	No dispute	1
Cattle intruding into the paddy & upland field	4	Priest	0
Land Border	9	Village Headman	11
		Tambol Headman	1
		Others	0

These disputes are understandably settled by the Muban headman who commands the highest respect among the Muban people.

3.3. Area Resources

3.3.1 Topography and Geology

(1) General

The Study area ranges from 0 to +20 m in elevation, classified mainly into (1) swamp, (2) delta and flood plain, (3) beach ridge and old lagoon and (4) monadnock. Mae Nam Bang Nara lies in the Delta at Narathiwat Side, the Swamp in the mid-course and the Beach Ridge and Old Lagoon along the Nam Baeng channel to its outlet to Mae Nam Kolok.

The Swamp occupies major part of the Study area and has been developed for the paddy field. Most typical among the remaining is the To Daeng Swamp which is outside the Study area and shows an extensive inland fresh water forested peat swamp being the largest in Thailand. The extent of To Daeng swamp forest has been reduced to 125 sq.km by 1980 at a pace of 35 to 40 percent over the past 20 to 25 years with the forest exploitation and land clearing.

The exclusive nature of To Daeng Swamp has been, for recent ten years, recognized with the great interest in its conservation by the Thai and international authorities. At present, a part of the acidic water originated from the organic soils and acid sulfate soils with the past exploitation of To Daeng Swamp flows into Mae Nam Bang Nara through Khlong Nam Baeng, Khlong Sg. Padi and Sg. Padi diversion drain. (For details, see Appendix XII.)

The geological information indicates that the Study area is composed of (1) Alluvium, (2) Colluvium and Residuum (Quaternary to Recent Age) and (3) Granite (foundation rock, Triassic Age). The alluvium has the beach sand along the coast and the marine clay of 10 to 20 m-thickness above the sand and gravel layer with the surface peat in places covering the greater part of the Study area. The colluvium and residuum with clay, sand, gravel and laterite directly cover the granite and are seen in the hilly area.

Another feature of the hills is the outcrop of granite being weathered, and the porphyritic granite and granodiorite are often used for the rock quarries. There is no current and prospective mining operation in the Study area.

As far as the seismicity is concerned, the Study area lies within the western portion of the seismically stable Sunda Shelf, and it has been explained that the structures are unlikely to experience ground accelerations greater than 0.03 g, arising from the earthquake activity. (Refer to para. IX-1-1 of Appendix IX.)

(2) Existing Mapping and Photography

(i) Existing Maps

Existing maps and photographs collected for use on the Study as topographical information are shown in Table II-1-1 of Appendix I-1 and

notes are as follows :

° Mapping scale 1:250,000, SERIES 1501S, 3 sheets, produced by US Army in cooperation with RTSD in 1976, which provides the map information of year 1969 with original 100 m contours and supplementary 50 m contours at the vertical datum of Mean Sea Level at Ko Lak. This is suitable for use to make location maps or for use to get rough information of the Study area and its vicinity.

° Mapping scale 1:50,000, SERIES L7017, 21 sheets, produced by US Army / RTSD with aerial photogrammetric mapping method, information in the years of 1968 to 1974, printed in the years of 1972 to 1983, which provides original 20 m contours with supplementary 10 m contours.

Vertical datum is on Mean Sea Level at Ko Lak. Horizontal grids are on zone 47N and zone 48N of UTM coordination. Elevations and contours are scarce of accuracy. Discrepancies are partially seen from other scaled maps.

This is suitable to use for measuring catchment areas, looking over land uses and so on and is unsuitable to find out new information of public institutions or facilities, like as roads, canals, bridges and other facilities.

° Mapping scale 1:25,000, SERIES L8019, 11 sheets, produced by US Army /RTSD with aerial photogrammetric mapping method in 1983, which provides map information of year 1982 with original 10 m contours and supplementary 5 m contours.

Vertical datum is on Mean Sea Level at Ko Lak, horizontal grids are on zone 47N and zone 48N of UTM coordination. This is enough to cover the Study area, but does not cover the catchment area of Mae Nam Ya Kang.

° Mapping scale 1:10,000
- for use on Mu No Project, 28 sheets,
- for use on Bacho Project, 28 sheets,

produced by RID with topographical ground survey mapping method in 1976 for Mu No Project and in 1975 for Bacho Project which covers the entire Study area with 0.5 m contours. Vertical datum is on Mean Sea Level at Ko Lak as same as RTSD mappings. Elevations and contours are not coincident with those of RTSD maps.

° Plan / Profile of Mae Nam Bang Nara, Plan (1:4,000), 17 sheets, produced by RID with the topographical ground survey mapping method in 1984 which provides plan and profile of whole section along Mae Nam Bang Nara from one river mouth at Narathiwat to another river mouth at Taba. Vertical datum is on Mean Sea Level at Ko Lak.

° Cross-Sections of Mae Nam Bang Nara, scale V=1:100, H=1:500, 25 sheets, produced by RID in 1984 to correspond to Plan / Profile of Mae Nam Bang Nara described above which provides cross section figures in 500 m interval each on Plan / Profile. Vertical datum is on Mean Sea Level at Ko Lak.

. Plan, Profile/Cross Sections of Mae Nam Yakang, scale 1:10,000 for plan in 7 sheets, scale H=1:20,000 and V=1:100 for profile in 2 sheets, and scale H=1:200 and V=1:100 for cross sections in 22 sheets, produced by RID in 1985 upon the Study Team's request for the 40.5 km section of X73A to the confluence with Mae Nam Bang Nara which provide the cross sections in 500 m interval. Vertical datum is on the Project datum as stated later.

. Mapping scale 1:1,000

- for use on Upper Tidal Regulator Site of Bang Nara Project, 13 sheets,
- for use on Lower Tidal Regulator Site of Bang Nara Project, 9 sheets,

produced by RID with topographical ground survey mapping method in 1982 both for Upper and Lower. 0.5 m contours are provided. Vertical datum is on Mean Sea Level at Ko Lak. Condition of elevations and contours is as same as other mappings.

. Plan, Profile/Cross sections of Khlong To Che, scale 1:4,000 for plan and V=1:100 and H=1:4,000 for profile in 5 sheets, and scale V=1:100 and H=1:200 for cross sections in 13 sheets, produced by RID in 1986 upon the Study team's request for the 15.52 km section from its confluence of Mae Nam Bang Nara to the point of upstream. Vertical datum is on the Project datum as stated later.

. Mapping scale 1:2,000 for three sample areas, produced by RID with topographical ground survey mapping method in 1986 upon the Study Team's request. 0.5 m contours in general and 0.25 m contours in flat area are provided. Vertical datum is based upon RTSD. About 200 ha was mapped for each area, location of which is explained in Chapter 5.

. Drawings of other existing projects,

- Regulator and Canal drawings of Nam Baeng Canal,
- Regulator and other drawings of Pileng Project,

drawn by Design Division of RID in 1981 based on topographical maps surveyed in 1979.

(ii) Orthophotomaps

. Orthophotomaps, scale 1:10,000 in 58 sheets, produced by RTSD with photogrammetric and orthophoto production method, using aerial photograph at scale of 1:25,000 taken in June 1982, for use on Golok River Basin Development Study. 5 m contours drawn by photogrammetric instrument and 1 m contours drawn by interpolation method which coincide with the contours of mapping produced by RTSD at scale of 25,000, may be used for information of the To Daeng Swamp.

(iii) Photography

. Photographs at scale 1:15,000, contact prints, taken by RTSD in 1984 for use on land development projects of DLD, not enough to cover the Study area. The remaining photographs taken in 1975 to cover a whole of the Study area were available since the middle of August.

(iv) Other Information

. Besides the information described above, there are mosaic photograph taken by LANDSAT and other photographs for topographical information at Pikulthong Center.

(3) Levelling Survey for Vertical Control

(i) Vertical Datum of the Project

At the beginning stage of Phase I Study, it has been decided that the Vertical Datum on Bang Nara Project makes to coincide with the RID Datum which is based on the Thai National Datum, since maps and other information used by the Study Team are produced based on the Thai National Datum or RID Datum.

The Datum used on levelling survey is based upon EL+10.100 m at BM 2778 C which is located in the center of the second column from the Thai side of the Mae Nam Kolok- Rantau Panjang railway bridge.

(ii) Levelling Survey for Vertical Control

Levelling survey for vertical control was carried out by the topographical survey teams of RID during the Phase I field work. Actual field works for levelling survey were carried out by 2 parties formed from 4 survey teams under supervising by the Study Team. Adopting a way of "the same time levelling by 2 teams using 2 levels" instead of a way of "go and reverse levelling", the field works for levelling survey were started from BM 2778 C to existing benchmarks and various points. Levelling works by 4 teams were advanced along highways, roads and canals, travelling sections of levelling traverses, as like as section from BM 2778 C to Mu No, from Mu No to Tak Bai, from Tak Bai to Nam Baeng ..... up to station X73 A. Repeating "foresight and reversesight" in each section, accurate levelling traverses were carried out to make misclose less than the value specified. In the case of that misclose value was not less than the value specified, benchmarks of check points were relevelled in the misclosed section.

During levelling survey, more than 30 numbers of existing benchmarks, staff gages at existing water level gage station of 6 places and benchmarks newly placed at 3 water level recorders which were brought by the Study Team, and total distance of all levelling traverses approximately took 150 km.

Survey field books have been arranged into a file and kept by the Survey Counterpart at Survey Division of RID in Parket. (Refer to Table I-1-2 of Appendix I.)

(iii) Information of Elevations to be involved in the Study

Initial information of the benchmarks surveyed by the RID surveyors during 24 June to 19 July 1985 had been deemed doubtful, and then additional levelling works between BM D (Ban Manang Ta Yo) and BM 2 (Ban Pa Ye) with a distance about 30 km to verify the closure error of basic network were carried out by the RID surveyors.

The levelling works made by RID have revealed the above closure error of 0.06 m which is less than the value of misclose to be permitted.

Information of Elevation to be involved in the Study is shown in Table 3-1. Table 3-2 shows the information of reference benchmark for comparison.

Table 3-1 Elevation of Maps and Water Level Recorders

(Unit : EL-m)

No.	Item	Reference Benchmark		Elevation based on RTSD		
		No.	Belonging	Original	After JICA checking	Difference
				(EL-m)	(EL-m)	(m)
A.	Basic Benchmark					
	Sg. Kolok Railway Bridge (*/ ----- EL 10.392 m.	2778 c based on Malaysian National Datum)	RTSD	10.100*/	10.100*/	±0
B.	Topographical Maps					
B.1	Topo-Map "Mu No" (1:10,000, 1976)	Not identified		-	-	
B.2	Topo-Map "Bacho" (1:10,000, 1975)	Not identified		-	-	
B.3	Topo-Map "Pi Leng Project"	BM-Regulator	RID	N.A.	3.647	
B.4	Topo-Map "Nam Baeng Project"	BM 3-Regulator	RID	3.500	3.397	-0.103
B.5	Plan/Profile "Bang Nara" (1984)	Not identified		-	-	
B.6	Topo-Map "UTR" (1:1,000, 1982)	BM3 BM4	RID RID	1.986 2.899	1.860 2.766	-0.126 -0.133
B.7	Topo-Map "LTR" (1:1,000, 1982)	CHP 241300 CHP 243717 CHP 571541	RID RID RID	N.A. N.A. N.A.	1.258 0.795 0.974	
B.8	Plan/Profile "Ya Kang" (1985)	BM ④ BM Hydro X73		N.A. N.A.	15.561 18.375	
C.	Water Level Recorders	(GZ = Gage Zero)				
C.1	X100 (Ta Ba Immigration Jetty)	BM2 GZ	RID RID	1.389 N.A.	1.209 -1.770	-0.180
C.2	X119 (Mu No Intake)	BM Hydro No. 3 GZ	RID RID	5.546 N.A.	5.405 -0.129	-0.141
C.3	X43 (Khlong Sg. Padi)	BM Hydro ③ GZ	RID RID	N.A. N.A.	8.555 4.272	
C.4	X73 (Mae Nam Ya Kang)	BM ④ BM Hydro X73 GZ	RID RID RID	N.A. N.A. N.A.	15.561 18.375 9.461	
C.5	Narathiwat Habor	BM ⑤ GZ	RID HD		1.545 -2.588	
C.6	Nam Baeng Regulator	BM3 Upstream GZ Downstream GZ	RID RID RID	3.500	3.397 -0.445 -0.542	-0.103
C.7	X73A (Mae Nam Ya Kang)	GMX73A GZ	RID RID		27.511 22.929	
C.8	X160 (JICA-Bang Nara U/S)	BM ▽ GZ	RID RID		1.194 -1.557	
C.9	X162 (JICA-Bang Nara M/SO	CHP 244507 GZ	RID RID	1.902	1.737 -1.835	-0.165
C.10	X161 (JICA-Bang Nara D/S)	CHP 244473 GZ	RID RID		1.354 -1.559	

Table 3-2 Reference Benchmarks for Comparison

(Unit : EL-m)

Benchmark	Origin	Elevation (A)	Elevation (B)	Diff. (A)-(B)	Location/Remarks
2778C	RTSD	10.100	10.100	±0.000	Sg. Kolok Railway Bridge
ARMY 1	- do -	11.886	11.886	±0.000	Sg. Kolok
ARMY 21	- do -	2.630	2.453	+0.177	Pu Yu Canal
ARMY E746	- do -	3.273	3.248	+0.025	Tak Bai Police Station
ARMY CHE 3	- do -	2.401	2.565	-0.164	Bank To Lang
ARMY P722	- do -	2.859	2.763	+0.096	Narathiwat City Hall
RID 018	RID	9.305	9.288	+0.017	Highway Route 4057
RID 017	- do -	6.499	6.466	+0.033	- do -
RID 016	- do -	6.554	6.523	+0.031	Mu No Intake
BM 3	- do -	3.397	3.500	-0.103	Nam Baeng Regulator
BM 3	- do -	1.860	1.986	-0.126	UTR-1 Site
BM 4	- do -	2.766	2.899	-0.133	- do -
BM 2	- do -	1.209	1.389	-0.180	Taba Immigration Jetty
HYDRO No.3	- do -	5.405	5.546	-0.141	Upstream Mu No Intake
CHE 244507	- do -	1.737	1.902	-0.165	JICA-Recorder No.1

Notes : (A): Elevation from Actual Field Survey Results

(B): Elevation from Description given by RID

(3) Geology

(a) Area Geology

The geology in and around the Study area consists of granite which constitutes the bed rock of this area as is seen outcropping in the mountainous area, colluvium and residual soil which form the foothills, and alluvium which accounts for most of the Study area and forms the coastal plain. (Refer to Figures I-2-1 and I-2-2 of Appendix I.)

Granite

Most of the mountains adjacent to the Study area are composed of granitic rocks of the Triassic age such as granite, porphyritic granite, granodiorite, etc.

Porphyritic granite contains feldspar of around 2 x 5 cm maximum and can be seen in the borrow area near Royal Palace and in the waterfall of Sg. Padi. Granodiorite is quarried by Thai Rock Ltd. as crushed stone. These granitic rocks are generally subjected to weathering in many parts. The unweathered parts are left in the form of boulder which is peculiar to granite. Their distribution beneath alluvium is explained in para.(b), but in the neighborhood of the flood plain in the watershed of Mae Nam Ya Kang and further north, they lie slightly shallower and frequently distributed within 30 m in depth.

Colluvium and Residual Soil

This stratum belongs to the Quaternary to Recent age and consists of clay, sand, gravel and laterite. Of these, laterite is not distributed much. Its major distribution is seen in the monadnock (Mu No project borrow area) near Sg. Kolok. As for the thickness of colluvium and residual soil, a maximum of 30 m has been confirmed directly covering granite.

Alluvium

This stratum consists of beach sand that forms the beach ridges, marine clay which is distributed over the entire area with the thickness of around 10 to 20 m, and sand and gravel distributed beneath marine clay. In the swamps, the surface layer is covered with peat.

The overall layer thickness is thin in and around the flood plain of Mae Nam Ya Kang and toward further north, and most thick in the vicinity of the NBR with the maximum thickness of 106 m or more.

Mineral Deposits

According to the survey and field reconnaissance of Sahat Muenlek *[1] al, mineral resources have hardly been developed in the survey area yet, except the quarries of granite near Khao Tanyong and Ban Ai Ku Bu (Sg. Padi).

(b) Subsurface Geology

The geological profile of the Study area was inferred from the boring logs of existing wells and other data, as are shown in Figure 1-2-3 of Appendix I.

The sedimentary basin of alluvium formed by granite and colluvium and residual soil is generally shallow in the north of the line that connects Khao Tanyong and the town of Rangae, and

*[1] Source: Sahat Muenlek, Assanee Meesook, Phanu Thongchit. Geology and Mineral Resources of Sheet Narathiwat and Betog Southern Peninsular Thailand, Preliminary Report, 1982. DMR.

particularly shallow around the area where monadnocks are scattered. In the area of beach ridges, on the other hand, the basin is generally deep between the towns of Narathiwat and Tak Bai (except near Khao Tanyong), being 76 m or deeper in the town of Narathiwat, 78 m or deeper around NBR and 106 m or deeper near Pu Yu Regulator. According to the results of electric prospecting conducted by GRBDS, it tends to become deeper toward the sea from about 4 km on the Malaysian side of Mae Nam Kolok. From the foregoing results, it is inferred that the swamp area and the beach ridge area which constitute the main sedimentary basin become deeper toward the sea. However, as can be seen from the distribution of monadnocks, underground distribution of granite is not considered to be uniform, but different in some parts.

As for geological profile of alluvium, the marine deposit clay layer which probably extends over the Study area is distributed from the surface layer to EL-20 to -30 m or so, and in areas where beach ridges are distributed, beach sand (fine to coarse) is distributed above the clay layer to the depth of EL-10 to -20 m or so. Beneath the clay layer, sand (fine to coarse) and gravel (ø1 to 4 mm, sub-angular to sub-rounded) dominate with intercalations of thin layers of clay.

The thickness of sand and gravel is influenced by the depth of sedimentary basin.

3.3.2. Climate

(1) General

There are four meteorological observatories in and around the Study area, namely, Narathiwat, X45, X119 and DLD. The Narathiwat station among them is operated and maintained by the Meteorological Department, and has the longest data. The stations of X45 and X119 are controlled by RID. There are many observatories which observe only an amount of daily rainfall. The climatical elements such as atmospheric pressure, temperature, relative humidity, cloudiness, dew point, visibility, wind, rainfall and number of days with mist, fog and thunderstorm have been observed at the Narathiwat station since 1951.

In or around the Study area, the climatological data including temperature, wind speed, relative humidity and pan evaporation, have been observed at the stations DLD and Mu No (X119), but those data can not be applied for the Study in the Project since the observation period is too short to obtain the representative data of the area. Since the evaporation has been measured only for three years (1982 to 1985) and the readings are often lacked in this period, the data observed in the neighbouring station have been applied. Location and elevation of the meteorological stations are as follows:

Station	Narathiwat	Pattani	Songkhla	X45
Latitude	6°25', N	6°47', N	07°12',N	06°19',N
Longitude	101°49', E	101°10', E	100°36',E	101°30',E
Elevation* of station(m)	2	5	4	about 30
Height* of barometer(m)	5	9	5	
Height* of thermometer(m)	1.23	1.5	1.3	
Height** of thermometer(m)	12.5	27.0	18.0	
Height** of raingauge(m)	0.80	0.75	0.87	

Note: Observation period: Since 1951.
* : above MSL, ** : above ground
Location is shown in Figure II-1-1 of Appendix II.

- Temperature

  The annual variation in temperature is generally small. The monthly mean temperature ranges between 25.9°C in December and 28.5°C in April, and those annual average is 27.2°C. Incidentally, annual mean maximum temperature and annual mean minimum temperature are 31.5°C and 23.1°C, respectively. (Refer to Figure to Figure II-1-2 of Appendix II.) The extreme maximum temperature and extreme minimum temperature were recorded at 36.9°C in May and 17.1°C in January during the period of 1951 to 1980.

- Relative Humidity

  Relative humidity is generally high. The annual mean relative humidity for recent 34 years shows 80.7 percent. The minimum value is 77.9 percent in April and the maximum value is 86.1 percent in November. From January to September, it is almost 80 percent, and during the rest three months, it becomes about 85 percent. (Refer to Figure II-1-2 of Appendix II.)

- Evaporation

  The class A pan evaporation data recorded at three stations (Narathiwat, Songkhla and X45) have been referred to for evaporation analysis in this Study. Narathiwat and Songkhla stations are located adjacent to sea-shore and X45 station exists rather inland. The annual evaporation at Songkhla station is observed the highest value of 1,868.6 mm, the next is 1,465.5 mm at Narathiwat, the last is 1,391.8 mm at X45. The evaporation in the seaside area seems to become higher by wind effect.

  The change in monthly mean evaporation among these three stations shows almost similar trend, and the respective maximum values have been recorded between February and May (6.4 mm/day in March at Songkhla, 5.2 mm/day in April at X45, 4.8 mm/day in April at Narathiwat) and minimum values between November and January so-called "Northest Monsoon season" (3.8 mm/day in November at Songkhla, 2.3 mm/day in December at X45, 2.7 mm/day in December at Narathiwat). The variation in monthly mean evaporation shows a

very similar tendency to the change in sunshine duration, while it shows an opposite trend toward the change in cloudiness. The quite closed correlation seems to be considered among pan evaporation and sunshine duration and cloudiness. (Refer to Figures II-1-2 and -3 in Appendix II.)

- Atmospheric Pressure

  The annual mean pressure is 1,010 mbs, while the monthly mean pressure ranges between 1,008 mbs in May and 1,012 mbs in January. The mean daily range shows almost the same and small throughout the year (annual average of mean daily range is 3.9 mbs). It is general that the pressure becomes slightly lower in the dry season and higher in the rainy season. The atmospheric pressure in the Study area is generally a little bit lower than that of northern place because the area is near to equator. However, no remarkable low pressure does occur since domestic depression, tropical storm or typhoon seldom takes place. (Refer to Figures II-1-3 to -5 of Appendix II.)

- Sunshine

  Monthly mean sunshine hours at Narathiwat vary in wide range between 5.3 hr/day in November and 9.1 hr/day in February with an annual total of 2,628 hours. They vary with almost same tendency at Songkhla also, the minimum one 5.3 hr/day in November, the maximum one 9.2 hr/day in February, and the annual total 2,625 hours. (Refer to Figure II-1-2 of Appendix II.)

- Wind

  The variation in monthly mean wind speed at Narathiwat indicates that the maximum speed is 2.5 m/s in February and the minimum on eis 1.3 m/s in July. On the other hand, the monthly maximum mean wind speed is 14.9 m/s in December. The extreme maximum wind speed is recorded at 30.8 m/s from the northeast direction in November 1962 during the last 35 years. The wind direction is mainly northeast or east at the incidence of more than 85 percent between

November and April so-called "Northeast Monsoon Season". It changes from south, southwest or west (total percentage is 42 percent to 58 percent) between June and September so-called "Southwest Monsoon Season". The wind blows to every direction during the other months. (Refer to Table 3-3 in this Chapter and Figure II-1-6 of Appendix II.)

(2) Rainfall

i) Location of Rain Gauge Stations and Observation Period

The rainfall has been observed at the following 13 stations in the Study area, its surroundings and the Bang Nara basin. The observatories of Narathiwat, Tak Bai, Rangae, Yingo, Sg. Padi, Sg. Kolok, Waeng, Bacho, Ruso are under the jurisdiction of Meteorological Department.

The stations at the Muno Project Office (X119), Pileng Project Office, X45 are operated and maintained by RID. There is one station under DLD near the Nam Baeng Tidal regulator.

In addition, the three Tipping Bucket Type Rain Gauges were installed along Mae Nam Bang Nara at the beginning of September 1985 under JICA. Because there is no hourly rainfall data within this Study area, therefore, one gauge was provided at the RID Pileng Project Office. And, since rainfall in the mountainous area affects for the run-off, two sets were installed at Lingae School and Bukit Forest Office. (Refer to Figure II-1-7 of Appendix II.) Among these stations, hourly rainfall data have been available at

Table 3-3. CLIMATOLOGICAL DATA AT NARATHIWAT STATION

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
Temperature (°C)													
Max.	29.9	30.9	32.0	33.1	33.0	32.6	32.2	32.2	32.0	31.0	29.5	29.0	31.5
Mean	26.1	26.9	27.7	28.5	28.4	28.0	27.6	27.5	27.4	27.0	26.3	25.9	27.2
Min.	22.2	22.4	22.8	23.5	23.9	23.5	23.2	23.2	23.1	23.2	23.1	22.8	23.1
Monthly Mean Relative Humidity (%)	81.0	79.1	78.3	77.9	79.3	79.0	79.6	79.8	80.3	83.1	86.1	84.6	80.7
Monthly Mean Evaporation* (mm/day) (Class A pan)	3.6	4.1	4.5	4.8	4.6	4.1	4.1	4.2	4.1	4.0	3.4	2.7	4.0
Monthly Mean Sunshine - Duration* (hr/day)	8.3	9.1	8.7	8.9	7.6	6.8	6.8	6.8	6.3	5.8	5.3	5.8	7.2
Pressure (mbs. + 1,000)													
Mean	12.0	11.5	10.7	9.4	8.5	8.7	8.8	8.9	9.4	10.0	10.5	11.4	10.0
Extremely Max.	18.9	19.0	18.3	15.9	14.7	14.1	14.4	15.0	15.5	15.9	16.9	17.8	19.0
Extremely Min.	4.9	5.0	3.5	3.1	2.7	2.7	2.3	2.5	2.2	2.2	4.1	4.2	2.2
Mean daily range	3.5	3.7	4.1	4.1	4.0	3.7	3.7	3.9	4.3	4.3	3.9	3.6	3.9
Mean Cloudiness (%) Percentages of total sky covered with cloud	70	63	59	58	73	75	75	78	78	79	81	79	72
Wind Speed (m/s) and Direction (%)													
Mean	2.3	2.5	2.2	1.9	1.6	1.4	1.3	1.4	1.5	1.4	2.3	1.7	1.8
Max.	13.7	11.9	12.0	11.7	13.4	12.1	14.4	13.7	13.6	13.5	14.6	14.9	13.3
Extremely Max.	20.6	17.0	20.6	18.0	25.7	23.1	28.3	25.7	23.1	28.3	30.8	23.1	23.7
NE and E direction	100	100	100	100	72	50	47	31	38	59	85	97	
SW and S and W direction	0	0	0	0	20	42	42	58	54	24	9	3	

Note: * Annual mean evaporation = 1,465.5 mm, Annual mean sunshine hours = 2,628 hrs.

Narathiwat, Mu No Project Office, X45, Lingae School, Bukit Forest Office and Pileng Project Office, as collected below:

Station	Period of Data Collected
Narthiwat	1975-1984 (except 1978 and some months).
X119	some days in November & December, 1983.
X45	some days in 1982 & 1983.
Lingae School	(stations established by JICA) September 1985-January 1986.
Bukit Forest Office	
Pileng Project Office	

Daily rainfall has been observed for a long period at Narathiwat from 1910 - up to now and Tak Bai, Rangae, Yingo and Sg. Padi from 1922 up to present. Since the old data have often the lack of readings, and the 30-year data are sufficient for the analyses required for the Study, the data observed in last 31 years before 1985 have been collected. The daily rainfall data at the Narathiwat station are sufficient for use, and the data at Tak Bai, Rangae and Yingo are also useful even though some lacks are recognized. (Refer to Figure II-1-8 of Appendix II.)

ii) Annual Rainfall and Monthly Rainfall

Being compared with the other regions of Thailand which have 1,000 to 2,000 mm of annual rainfall, the southern part of Thailand has much annual rainfall (2,000 to 3,000 mm). The range at Narathiwat and Yingo (about 500 mm) issmaller than that of Tak Bai and Rangae (about 1,000 mm). (Refer to Figures II-1-9 and -10 of Appendix II.)

At the Waeng and Sg. Kolok stations which are located upstream of Mae Nam Kolok being adjacent to the southern part of the Study area, there are high annual rainfall such as 3,157.2 mm and 2,874.7 mm, respectively. And high rainfall such as 2,860.7 mm is also recorded at the Pileng Project Office although the observation period is recent four years.

At the Narathiwat, Bacho and X119 stations which are located adjacent to the Gulf of Thailand, annual mean rainfall is about 2,500 mm. On the other hand, it is about 2,200 mm at the stations of Ruso, Yingo Sg. Padi, DLD and Tak Bai, of which the first three stations are located between the mountainous region and the last two are along the coast. The smallest rainfall (1,620.2 mm) has been recorded at the Rangae station among all these stations.

The greatest single influence on the rainfall pattern is caused by the northeast monsoon during the period of November to January which accounts for about 50 percent of annual rainfall. Heavy rainfalls particularly in spells of three to five days occur during this period resulting in frequent floodings and inundations in the Study area that have damaged the traditional main-season paddy. The rainfall is of highly seasonal nature with the period of February to April for low average rainfall that also affects the main-season paddy growth after flowering. It has been understood that rainfall in this period has a very high variability and February especially can be moderately wet or very dry.

The months of May to August during the southwest monsoon have moderate rainfall averaging about 200 mm per month, since the Study area is like a rainfall shadow area from this direction. During this period, the off-season paddy and field crops cannot growth without having irrigation. Although the inter-monsoon months of September and October have dependable rainfall varying from 150 to 300 mm per month, there would be some opportunities to miss the timely transplanting of main-season paddy. (Refer to Figure II-1-11 of Appendix II.)

iii) Daily Rainfall

The maximum daily rainfall during the recent 31 years at the main stations are as follows:

Station	Rainfall (mm)	Occurrence
Narathiwat	625.9	2 January 1955
Tak Bai	427.8	6 January 1967
Rangae	306.3	6 January 1967
Yingo	316.3	22 December 1984
Sg. Padi	622.0	20 November 1974
Sg. Kolok	319.2	22 December 1984
Waeng	310.0	4 January 1975
Bacho	376.0	6 January 1967
Ruso	325.6	4 Jnuary 1975

Note: A daily rainfall is measured from 7:00 A.M.

The probable daily rainfall is estimated by means of "Iwai Method" at the four stations, as follows:

(Unit: mm)

Return Period (year)	Narathiwat	Tak Bai	Rangae	Yingo
2	163.0	158.4	68.7	126.2
5	254.0	238.2	143.2	249.4
10	323.0	304.3	211.2	356.0
20	395.1	377.6	291.5	447.6
30	439.1	424.3	344.9	556.5
50	496.8	487.4	419.5	664.7
100	579.8	581.4	535.1	829.0

The result shows that the maximum daily rainfall (625.9 mm) recorded at the Narathiwat station is more than the probable rainfall once in 100 years.

Consecutive Days	Total Rainfall (mm)	Beginning Date	Return Period (year)
2	693.1	5 Jan. 1967	40
3	808.7	4 Jan. 1967	30
4	906.2	27 Nov. 1959	30
5	926.7	26 Nov. 1959	30
6	973.7	27 Nov. 1959	30
7	1,053.0	24 Nov. 1959	40

Note: These data were classified by calendar year for application to this analysis. (Refer to Figure II-1-12 of Appendix II.)

It can be mentioned that a heavy rainfall for consecutive 5 days from 20 to 24 December 1984 was recorded 543.3 mm at Narathiwat station which corresponds to that once in five years. This rainfall has been employed as the target heavy rainfall for hydraulic simulations study to give proper gate opening width of the proposed tidal regulators. Among these stations, it is similar that they have peaks in 20th and 22th day or only in 22th day. In 1985, there were neither heavy rainy days nor flood. Figure II-1-14 of Appendix II shows the distribution of rainfall at the stations in and around this area during the period from 10 to 23 December 1985. Almost of them have the same tendency and characteristics that they have a peak rainfall in 12th or 13th day. (Refer to Figure II-1-13 of Appendix II.)

iv) Hourly Rainfall

In order to determine the characteristics of hourly rainfall in this area, the correlation analysis of hourly rainfall ha sbeen made by using the six different days' hourly rainfall at Narathiwat station. But correlations of each rainfall are not significant. On the other hand, the hourly rainfall is compared with the data obtained from the newly established three JICA provided stations. When it is compared with the same days' hourly rainfall, they show almost same trend although the intensive peaks of rainfall are different. (Refer to Figures II-1-15 and -16 of Appendix II.)

v) Areal Rainfall

To estimate the areal rainfall in the basin and the Study area, the Thiessen Method which can be calculated by the point rainfall by providing a weighing factor for each station has been adopted:

$$R = \sum_{i=1}^{n} R_i \cdot A_i / A$$

where R: Areal Rainfall (mm)
Ri: Observed Rainfall (mm) at each station
Ai: Area of corresponding polygon within basin boundary (sq.km)
A: Total area (sq.km)

As a result of this calculation, the areal rainfall in this area is approximately 2,000 mm in a year with an appropriate collation with the isohyetal map of southern Thailand. (Refer to Figure II-1-9 of Appendix II.)

3.3.3. Soils

(1) General

i) General Condition

The soils in the Study area are mainly acidic and infertile owing to their parent rocks as granite and the active weathering through the leaching of bases generated by intensive rainfall and high temperature. From the aspects of soil and water quality, generally it cannot be asserted that the Study area is blessed with its natural conditions for irrigated agriculture development. In other words, the agricultural development has been stagnant for long time because of the adverse situations including poor soil and water quality. To overcome the imperfect inherent nature of the Study area, it is essential to start immediately an integrated program to collect sufficient basic data and information about the land and water resources. Several institutions such as DLD, DOA and PSU as well as RID have started their special activities in this area to promote the agriculture.

ii) Previous Studies

The soils in this area have been studied since the late 1960s by DLD as a leading agency; as the results, the following soil maps have been published so far:

- Reconnaissance Map of Peninsular Thailand (scale 1:750,000) by F.J. Dent, DLD/FAO, 1972.
- Detailed Reconnaissance Soil Map of Narathiwat Province (scale 1:100,000) by DLD, 1975.
- Semi-Detailed Soil Map of Lowlands in Coastal Plain in Narathiwat Province (scale 1:25,000) by DLD, 1985.

In addition, further detailed soil maps for particular areas have been prepared as below:

- Semi-Detailed Soil Map of Pileng Project (scale 1:25,000) by DLD, 1984.
- Detailed Soil Map and Soil Suitability Map of Muban Manao Project (scale 1:10,000) by DLD, 1984.
- Detailed Soil Map of Muno Livestock Project, Station 3 of Pikulthong Educational & Development Center by DLD, 1984.
- Semi-Detailed Soil Map and Soil Suitability Map of Resettlement Area of Muno Project (scale 1:25,000) by DLD, 1985.

Based on the above soil maps, a pair of comparison maps of scale 1:100,000 showing the chronological change of soil properties in the coastal plain of Narathiwat Province between 1968 and 1984 has been made by DLD. Besides, a generalized map of soil associations in the Kolok River Basin has been made based on the Detailed Reconnaissance Soil Map of Narathiwat Province (1975).

iii) Present Study

Owing to the vigorous activities of relevant agencies to the land resources, the data about general properties of soils and their distribution pattern in the Study area have been already collected. Accordingly, the present study has been carried out aiming at the following points:

- To review the existing data and to check the validity of the above-mentioned soil maps for use in agricultural development planning.
- To make the supplementary soil survey, with particular emphasis on: a) depth of pyrite enriched horizon, b) thickness of organic horizon, and c) depth and thickness of spodic horizon.
- To obtain specific information required for planning the conservation and improvement measures of problem soils.

- To determine the irrigation suitability classification of the various soil series.

iv) Methodology

The field survey was carried out during two periods from July 8 to 21,1985, and from January 16 to February 16,1986. The survey party was composed of a JICA expert and RID counterparts from Geotechnical Division and from Narathiwat Irrigation Office.

The topographical maps of 1:50,000 scale and the aerial photos taken in March 1984 of approximately 1:15,000 scale were used as base maps. Totally 125 soil profiles were investigated either by test pit digging or auger boring. For organic soils in swamp area, a peat sampler having a sharp edge was used. The location of these soil profiles are shown in IV-1 of Appendix IV. The general information of soil profile sites are also listed in IV-5-1 and IV-5-3 of Appendix IV.

The soil profiles were examined to the depth of about 1.2 m in test pits and of 1.5 m by auger boring. In the swamp areas, thickness of organic layer was checked by the peat sampler to a depth of about 3 m. For profile description, the following references were used as the guidelines:

- Soil Survey Handbook for Thailand by F.J.Dent and C.Changprai, DLD/FAO, 1973.
- Guidelines for Soil Profile Description by FAO, 1977.

For laboratory analyses, 199 disturbed soil samples were taken from every horizon of 49 profiles. And 60 undisturbed soil samples were taken from topsoils of 20 profiles using a core sampler with 100 cc volume. These samples were delivered to the Pikulthong Center and analyzed for the following items:

- Particle size distribution
- pH (H_2O and KCl)
- Organic matter
- Total nitrogen
- Electrical conductivity
- Cation exchange capacity
- Exchangeable cations (Ca, Mg, K, Na)
- Exchange acidity
- Total extractable aluminium
- Water soluble sulfate
- Available phosphorus
- Lime requirement
- Bulk density
- Water retention (1/3 and 15 atm.)

In addition to the above routine analyses, the pyrite oxidation tests were made for the reduced layers of lowland soils. The samples collected in the first half were tested by freeze drying method, on the other hand, those in the second half were tested by slow oxidation method. Methods of these analyses are indicated in IV-2 of Appendix IV.

(2) Soil Classification

i) Landforms in Study Area

In general, the Study area has a gentle slope towards the Gulf of Thailand. The landforms in the area can be grouped into eight types as below:

Landforms	Area		
	(rai)	(ha)	(%)
1) Beach ridges & sand bars or dunes	46,060	7,370	15.8
2) Depression between beach ridges	7,190	1,150	2.5
3) Former tidal flat	76,250	12,200	26.0
4) Flood plain, levees & breach deposits	30,500	4,880	10.4
5) Low terrace	77,190	12,350	26.4
6) Middle terrace	9,750	1,560	3.4
7) Hills & foothill slopes	13,380	2,140	4.7
8) Domed bogs	26,310	4,210	9.0
Water bodies	5,250	840	1.8
Total	291,880	46,700	100.0

The soils and their distribution patterns are highly correlated with the landform on which they occur. Figure 3-1 is a schematic cross-section along a line connecting Ban Ko Sawat and Ban Pawai for showing an example of landform - soil relationships. For the Study area as a whole, the landform - land use - soil relationships are summarized in Table 3-4. The service area of the Bang Nara water storage consists of paddy rice area in depression, former tidal flat and low terrace where Hydromorphic Alluvial Soils, Low Humic Gley Soils occur predominantly.

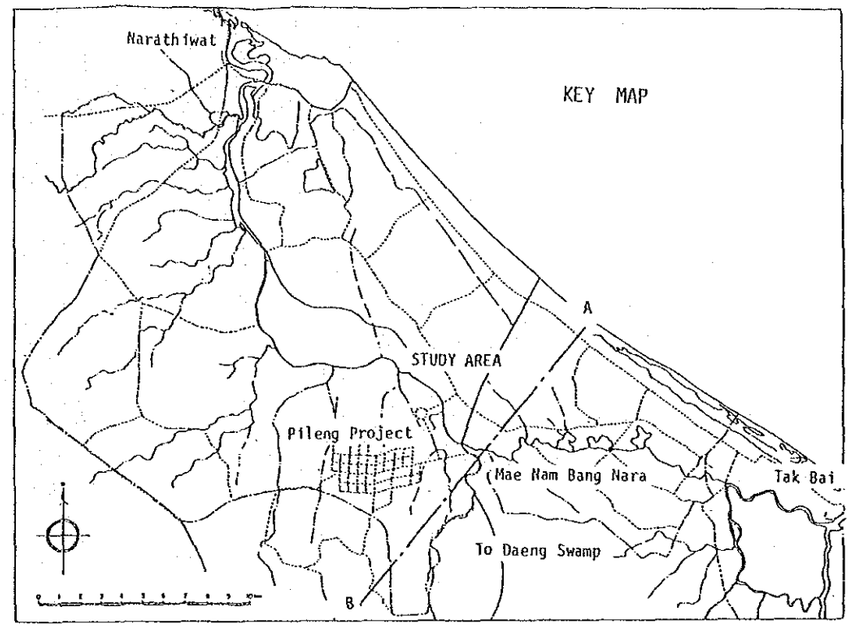
ii) Soils in Study Area

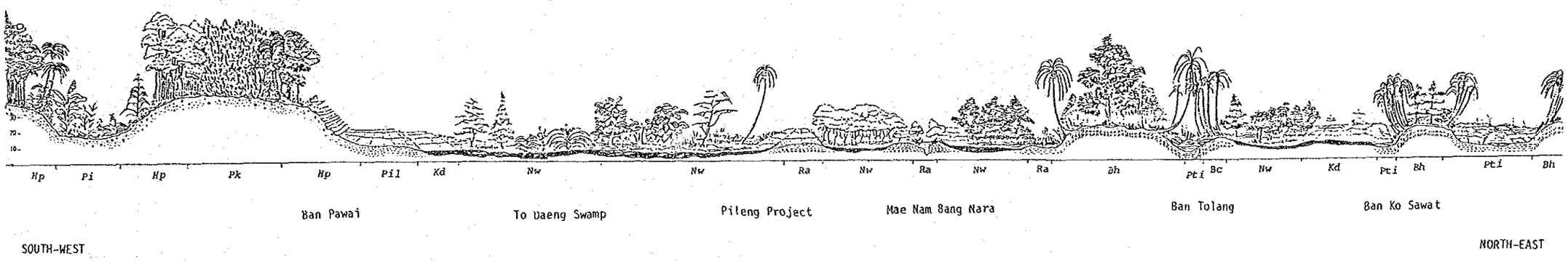
Based on the soil maps prepared by DLD (1975 and 1985), a soil map of the Study area is drawn as Map-1. The extents of soil series are given in Table 3-5. And the correlation between soil series, USDA Soil Taxonomy, FAO/UNESCO and National systems is given in Table 3-6.

a) Soils of Beach Ridges and Intervening Depressions

Sand bar and dune formations are found along the shores of the present coastline. A consistent northward tidal current in the Gulf of Thailand forms sand bars or dunes, and a narrow strip of lagoon has been left behind the dunes. Owing to the recession of coastline, a typical landform of the east coast of Peninsular Thailand, composed of a series of alternating parallel beach ridges and intervening depressions has been formed behind a strip of new sand bars or dunes.

Figure 3 - 1. Schematic Cross Section Showing Landform - Soil Relationships



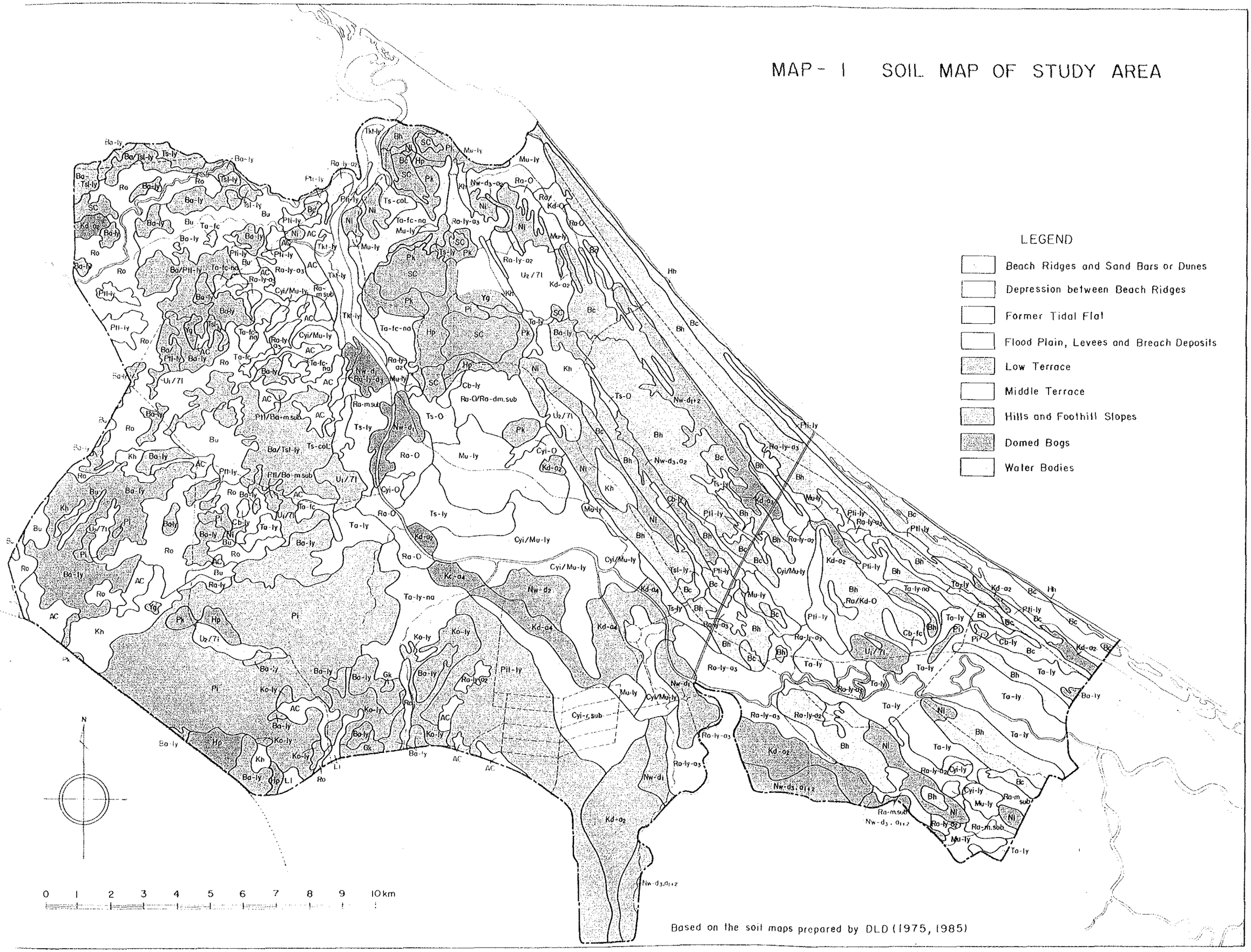


Modified from the drawing in the Report on the Environment of Bang Nara Project, RID (1984)

Table 3-4. Summary of Landform-Land Use-Soil Relationships

Landform	Major Land Use	Soils
Beach ridges & sand bars or dunes	Village, coconuts/cashew, idle/pasture	Regosols, Groundwater Podzols (Ustipsamments, Quartzipsamments, Tropohumods)
Depression between beach ridges	Paddy, idle/pasture	Hydromorphic Alluvial Soils (Fluvaquents, Sulfaquents)
Former tidal flat	Paddy, idle (abandoned)	Hydromorphic Alluvial Soils (Tropaquepts, Fluvaquents, Tropaquents, Sulfaquents)
Flood plain, levees & breach deposits	Village/fruit trees, rubber/coconuts maize/groundnuts, rice	Low Humic Gley Soils, Red-Yellow Podzolic Soils (Tropaqualfs, Paleaquults, Paleudults)
Low erace	Paddy, idle/pasture, rubber/coconuts	Low Humic Gley Soils (Tropaquepts. Paleaquults, Tropaquults, Plinthaquults)
Middle terrace	Rubber	Red-Yellow Podzolic Soils, Reddish-Brown Lateritic Soils (Paleudults)
Hills & foothills slopes	Rubber, forest	Gray Podzolic Soils, Red-Yellow Podzolic Soils (Paleudults, Dystropepts, Tropudults)
Domed bogs	Swamp forest, paddy, pineapple/rubber	Peat & Muck Soils (Organic Soils) (Tropfibrists, Sulfihemists)

MAP - I SOIL MAP OF STUDY AREA



Based on the soil maps prepared by DLD (1975, 1985)

Table 3-5. Soil Series and Their Extent in Study Area

Soil Series	Map Symbol	Area rai	rai	ha	ha	%	%
Beach Ridges & Sand Bars or Dunes							
Hua Hin	Hh		1,310		210		0.5
Bacho	Bc		11,380		1,820		3.9
Ban Thon	Bh		33,370		5,340		11.4
Depression between Beach Ridges							
Pattani	Ptl-ly		5,540		870		1.9
Takua Thung	Tkt-ly		1,750		280		0.6
Former Tidal Flat							
Tak Bai	Ta-ly	13,060		2,090		4.5	
	Ta-fc	560		90		0.2	
	Ta-fc-na	3,560		570		1.2	
	Ta-ly-na	4,060	21,240	650	3,400	1.4	7.3
Rangae	Ra-ly-a_2	4,190		670		1.4	
	Ra-ly-a_3	10,250		1,640		3.5	
	Ra-m-sub	2,310		370		0.8	
	Ra-o	2,500		400		0.9	
	Ro-o/Ra-dm,sub	2,310		370		0.8	
	Ra/Kd-o	1,560	23,120	250	3,700	0.5	7.9
Nuno	Nu-ly		6,130		980		2.1
Chian Yai	Cyl-ly	310		50		0.1	
	Cyl-o	690		110		0.2	
	Cyl-r,sub	4,380		700		1.5	
	Cyl/Nu-ly	12,870	18,250	2,060	2,920	4.4	6.2
Thon Sai	Ts-ly	5,630		900		1.9	
	Ts-col	880		140		0.3	
	Ts-o	1,000	7,510	160	1,200	0.3	2.5
Flood Plain, Levees & Branch Deposits							
Chon Buri	Cb-ly	880		140		0.3	
	Cb-fc	690	1,570	110	250	0.2	0.5
Alluvial Complex	Ac		7,060		1,130		2.4
Sai Buri	Bu		6,810		1,090		2.3
Ruso	Ro		15,060		2,410		5.2
Low Terrace							
Pileng	Pll-ly		14,130		2,260		4.8
Khok Kian	Ko-ly		3,300		560		1.2
Tha Sala	Tal-ly		750		120		0.3
Pattalung	Ptl-ly	1,310		210		0.4	
	Ptl/Ba-m.sub	250	1,560	40	250	0.1	0.5
Bangnara	Ba-ly	18,880		3,020		6.5	
	Ba/Ptl-ly	2,810		450		1.0	
	Ba/Tsl-ly	4,560		1,050		2.2	
	Ul/ul	2,500	30,750	400	4,920	0.9	10.6
Sungai Padi	Pl		19,560		3,130		6.7
Sungai Kolok	Gk		380		60		0.1
Nam Krachai	Nl		6,560		1,050		2.2
Middle Terrace							
Kohong	Kh	5,060		810		1.7	
	U2/71	4,250	9,310	680	1,490	1.5	3.2
Lamphu La	Ll		440		70		0.2
Hills & Foothill Slopes							
Huai Pong	Hp		3,060		490		1.1
Phuket	Pk		4,810		770		1.7
Yi-ngo	Yg		630		100		0.2
Slope Complex	SC		4,880		780		1.7
Domed Bogs							
Narathiwat	Nw-d_1	4,750		760		1.6	
	Nw-d_1+2	2,880		460		1.0	
	Nw-d_2	1,560		250		0.5	
	Nw-d_1, a_1+2	2,880		460		1.0	
	Nw-d_1, a_2	1,190	13,260	190	2,120	0.4	4.5
Kap Dang	Kd-a_2	8,620		1,380		3.0	
	Kd-a_3	310		50		0.1	
	Kd-a_4	120	13,050	660	2,090	1.4	4.5
Water Bodies	W		5,250		840		1.8
Total			291,880		46,700		100.0

Table 3-6. Soil Series and Comparison with Soil Taxonomy, FAO/UNESCO and National Systems

Soil Series	Symbol	USDA Soil Taxonomy: Subgroup	USDA Soil Taxonomy: Family	FAO/UNESCO	National 1/
BEACH RIDGE & SAND BARS OR DUNES					
Hua Hin	Hh	Typic Ustipsamments	Sandy, siliceous, non-acid	Eutric Regosols	Regosols
Bacho	Bc	Typic Quartzipsamments	Sandy, siliceous	Dystric Regosols	Regosols
Ban Thong	Bh	Typic Tropohumods	Sandy, non-cemented	Humic Podzols	Groundwater Podzols
DEPRESSION BETWEEN BEACH RIDGES					
Pattani	Pti-ly a_1	Sulfic Fluvaquents	Coarse-loamy, mixed, non-acid	Dystric Fluvisols	Hydromorphic Alluvial Soils
Takua Thung	Tkt-ly a_1	Typic Sulfaquents	Fine-loamy, mixed, potential acid	Thionic Fluvisols	Hydromorphic Alluvial Soils
FORMER TIDAL FLATS					
Tak Bai	Ta-ly a_2	Typic Tropaquepts	Fine-loamy, mixed, acid	Humic Gleysols	Hydromorphic Alluvial Soils
	Ta-na-ly a_2	" "	Fine-loamy, mixed, non-acid		
	Ta-fc-ly a_1	" "	Fine, mixed, acid		
	Ta-fc-na-ly a_1	" "	Fine, mixed, non-acid		
Rangae	Ra-ly a_2	Sulfic Fluvaquents	Fine, mixed, acid	Dystric Fluvisols	Hydromorphic Alluvial Soils
	Ra-m.sub-ly a_2	Tropic Fluvaquents	Fine, mixed, acid		
	Ra-dm.sub-O a_3	Typic Tropaquepts	Very fine, mixed, acid		
Muno	Mu-ly a_4	Sulfic Tropaquepts	Fine, mixed, acid	Thionic Fluvisols	Hydromorphic Alluvial Soils
Chian Yai	Cyi-ly a_3	Typic Sulfaquents	Fine, mixed, acid	Thionic Fluvisols	Hydromorphic Alluvial Soils
Thon Sai	Ts-ly a_3	Tropic Fluvaquents	Fine-loamy, mixed, acid	Dystric Fluvisols	Hydromorphic Alluvial Soils
	Ts-co.l-ly a_2	" "	Coarse-loamy, mixed, non-acid		
FLOOD PLAIN, LEVEES & BREACH DEPOSITS					
Chonburi	Cb-ly a_2	Typic Tropaqualfs	Fine-loamy, mixed, non-acid	Gleyic Luvisols	Low Humic Gley Soils
	Cb-fc-ly a_1	" "	Fine, mixed, non-acid		
Sai Buri	Bu	Aeric Paleaquults	Fine-loamy, mixed	Gleyic Acrisols	Low Humic Gley Soils
Ruso	Ro	Typic Paleudults	Fine-loamy, mixed	Orthic Acrisols	Red-Yellow Podzolic Soils
LOW TERRACE					
Pileng	Pil-ly a_3	Typic Tropaquepts	Fine, mixed, acid	Humic Gleysols	Hydromorphic Alluvial Soils
Khok Kian	Ko-ly a_1	Typic Paleaquults	Fine-loamy, mixed, acid	Gleyic Acrisols	Low Humic Gley Soils
Tha Sala	Tsl-ly a_2	Typic Tropaquults	Clayey, kaolinitic, acid	Gleyic Acrisols	Low Humic Gley Soils
Pattalung	Ptl-ly a_2	Plinthic Paleaquults	Clayey, kaolinitic, acid	Gleyic Acrisols	Low Humic Gley Soils
Bangnara	Ba-ly a_2	Typic Paleaquults	Clayey, kaolinitic, acid	Gleyic Acrisols	Low Humic Gley Soils
	U1/71	Plinthic Paleaquults	" " "	Plinthic Acrisols	
Sungai Padi	Pi	Aeric Paleaquults	Loamy-skeletal, mixed	Gleyic Acrisols	Low Humic Gley Soils
Sungai Kolok	Gk	Typic Tropaquults	Fine, kaolinitic	Gleyic Acrisols	Low Humic Gley Soils
Nam Krachai	Ni	Oxic Plinthaquults	Coarse-loamy, siliceous	Plinthic Acrisols	Low Humic Gley Soils
MIDDLE TERRACE					
Kohong	Kh	Typic Paleudults	Coarse-loamy, siliceous	Orthic Acrisols	Red-Yellow Podzolic Soils
Lamphu La	Ll	Typic Paleudults	Fine, kaolinitic	Dystric Nitosols	Reddish-Brown Lateritic Soils
HILLS & FOOTHILL SLOPES					
Huai Pong	Hp	Typic Paleudults	Fine, kaolinitic	Orthic Acrisols	Gray Podzolic Soils
Phuket	Pk	Typic Paleudults	Fine, kaolinitic	Orthic Acrisols	Red-Yellow Podzolic Soils
Yi-ngo	Yg	Typic Tropudults	Loamy-skeletal, mixed	Orthic Acrisols	Red-Yellow Podzolic Soils
DOMED BOGS					
Narathiwat	Nw-Oi d_1, m, a_2	Typic Tropofibrists		Dystric Histosols	Organic Soils
	Nw-Oi d_1 & d_2, m, a_3	" "			
	Nw-Oi d_2, m, a_2	" "			
	Nw-Oi d_3, m, a_2	" "			
Kap Dang	Kd-Oi a_2	Typic Sulfihemists		Dystric Histosols	Organic Soils

1/ Soil classification was based on the descriptions of Great Soil Group of South-east Asia prepared by Dudal, R. and Moormann, F. R. 1964, with modifications introduced by the Soil Survey Division that will be referred to as National Classification.

The relief of beach ridge and sand dune formations is mainly undulating with slope ranging from 2 to 4 percent. Soils on them are very deep, grayish brown or yellowish brown, sand or loamy sand, showing little accumulation of organic matter. They are subject to moisture stress because of their excessive drainage and low water retaining capacity. These soils are Regosols (Psamments) and such soils as Hua Hin and Bacho series have been identified. The former is found on younger sand bars or dunes close to the coast, usually containing shell fragments, and the latter occurs on the undulating relief of inland beach ridges. Most lands have been cleared of the original vegetation of rough sparse grasses with some dry open forest and are used for village sites including horticultural gardens or small-scale coconuts or cashew plantations or pasture for grazing.

In lower positions on old beach ridge formations, the soils having a spodic horizon (ortstein) at various depth are found. They are Groundwater Podzols (Typic Tropohumods) and classified as Ban Thon series. These soils are recognized as problem soils because of their poor fertility of surface soil overlying a cemented spodic horizon.

In the intervening depressions and estuaries, soils are formed of marine and brackish water deposits. The relief is flat or nearly flat and slopes are less than one percent. Flooding takes place by impounded rain water or river water during the rainy season. Flood depth is commonly shallow but it sometimes exceeds one meter in places close to creeks. Soils are very poorly drained ranging from waterlogged dark sands with peaty surface horizon to finer textured gray or brown sandy clay loams which overlie dark sands, marine clay or buried peaty subsoil. Gray and pale olive soils are classified into Hydromorphic Alluvial soils (Aquents). The soils in depressions have a pyrite enriched horizon in subsoil and are defined as potentially acid sulfate soils, because the soil reaction becomes extremely acid after oxidation. These soils are identified as Pattani series. Mainly paddy is grown in these areas but locally the soils are ridged for the cultivation of vegetables or fruit trees.

In the estuarine areas, soils are saline and are identified as Takua Thung series. Predominantly such saline soils are under mangroves and salt-tolerant shrubs.

In similar position of swampy depressions, Organic Soils or Peat and Muck Soils (Histosols) occur. These organic soils, which consist of woody, less decomposed peat accumulation, are discussed in the later section " Soils of Domed Bogs ".

b) Soils of Former Tidal Flat

Former tidal flats of brackish water deposits occupy a relatively large area between the beach ridges and swamp forest. Flash flood or prolonged deep flooding which damages the crops, occurs every year during the rainy season. The relief is flat and slopes are less than one percent.

The soils are poorly drained, gray to grayish brown clay with mottling and gleying. They are Hydromorphic Alluvial Soils (Fluvaquents and Tropaquepts) including actual and potential acid sulfate soils. Five soils such as Tak Bai, Rangae, Muno, Chian Yai, and Thon Sai series have been identified. They are classified by the depth of jarosite- or pyrite-rich horizon depending on the drainage status. These soils are principally used for paddy growing or rough grazing due to their deep flooding.

Actual acid sulfate soils occupy a little extent in the Study area at present. Only Muno series have been identified as actual one which is characterized by the occurrence of straw yellow jarosite mottles causing extremely acid reaction (pH less than 4.0). Such a low PH mobilizes aluminium and causes aluminium toxicity. Potential acid sulfate soils such as Rangae, Chian Yai and Thon Sai series, on the other hand, are found in the lower part of back swamps adjacent to flood plain, and occupy larger extent in the Study area. Under present conditions, these soils do not show extremely acid reactions, however,

they are rapidly transformed into actual one by drainage and aeration because they have bluish green marine deposits rich in pyrite in subsoils. Acid sulfate soils are recognized as problem soils and are discussed in the later section.

c) Soils of Flood Plain and Levees

Flood plain and levee formations of recent riverine alluvium occur along the tributaries of Mae Nam Bang Nara where a distinct levee-basin landscape is seen. The lands are flooded by river and rainwater for various periods each year depending on position and receive additions of fresh alluvium.

The flood plains are flat to nearly flat relief and are characterized by poorly drained soils with gray, grayish brown or yellowish brown colors and clay loam texture. The levees are nearly flat to flat relief having slopes less than 2 percent with undulating micro-relief where movement of stream channels have occurred. The soils are moderately well drained, stratified and fine-loamy. The presence of mica flakes indicates the recent deposition. Soils in the lower positions are mottled throughout the profile. Those in the higher positions have no mottles in the surface layer but mottles appear in the subsoil. Soil reaction ranges from slightly acid to very strongly acid. Chonburi and Sai Buri series are identified in these areas.

Soils in the higher positions are subject to only short flooding during the rainy season but the damages by flash floods occur in some places. They are mainly used for upland crops, horticulture or village sites. On the other hand, those in the lower positions on levees are flooded by impounded rain and river water to the depth up to 1 m during the rainy season. The soils are used for rice growing, in addition, upland crops are grown during the off-season to a minor extent in areas where local irrigation is available.

The higher portions include old levees and areas of breach deposits with nearly flat to gently undulating relief with slopes ranging from one to 3 percent. Soils are well drained, fine-loamy texture with yellowish brown or red color. Some distinct mottles may occur in the deeper subsoil. Soil reaction is slightly acid. They are identified as Ruso series which are classified as Red Yellow Podzolic soils (Typic Paleudults).

d) Soils of Low Terrace

Low alluvial terraces of semi-recent or old riverine alluvium have been formed as the result that the rivers and streams have lowered their courses and have created new flood plain at slightly lower levels. Therefore, the soils do not receive additions of fresh alluvium and are more matured than those of flood plain. Clay illuviation has brought about the formation of an argillic horizon in most soils.

The low terraces have nearly flat relief with slopes not exceeding 2 percent. The soils are poorly drained and flooded during the rainy season. The crop damages are sometimes severe. These soils are mainly used for rice growing, and some upland crops are grown during the off-season in the area where irrigation is available.

Soil texture is either fine loamy or clayey and color shows a wide range from gray to brown with distinct, prominent red and yellowish brown mottles occuring throughout the profile. Gleying of subsoils indicates the incidence of present flooding and high water table.

Soil reaction varies widely from slightly acid to very strongly acid. These soils commonly belong to Low Humic Gley Soils (Paleaquults) and include the most intensive cropping areas in the Study Area, while they are principally deficient in nutrients. Both drainage and fertilizer application are required for more productive cropping. Various soil series have been identified as Pileng and Khok Kian series in lower portion, Bangnara, Tha Sala, Pattalung series in mid-portion, and Sg. Padi, Sg. Kolok, Nam Krachai series in upper portion of the low terraces.

e) Soils of Middle Terrace, and Hills & Foothill Slopes

Middle terraces of old alluvium, which are found in positions above nearly flat low terraces, have undulating relief with slopes ranging from 2 to 8 percent. These terraces are interrupted by many small tributaries. Soils of middle terrace are characterized by well drained, loamy soils that have yellowish brown or red colors. Gravel bands or plinthite horizon are present in places. Soil reaction is very strongly acid and natural fertility is low. These soils are Red-Yellow Podzolic Soils or Reddish Brown Lateritic Soils (Typic Paleudults), and Kohong and Lamphu La series are identified. The soils are exclusively used for rubber plantations, otherwise covered with secondary forest. Cultivation of upland crops requires fertilizer inputs and erosion preventative measures.

Parent materials include residuum and colluvium derived from granite and related rocks. Foothill slopes of colluvium have rolling relief with slopes ranging from 4 to 20 percent, predominantly exceeding 8 percent. Generally, granite derived soils are deep, well drained, yellowish or reddish brown sandy clay or sandy clay loam overlying kaolinitic clayey subsoils. Soil reaction is very strongly acid and natural fertility is principally low. They are Gray or Red-Yellow Podzolic Soils (Typic Paleudults), and Huai Pong, Phuket and Yi-ngo series are identified.

Tropical evergreen forests remain in places but predominant soils have been cleared and used for rubber plantations. Under forest cover, the soils are stable but become susceptible to erosion when cleared. Therefore, the soil conservation measures should be undertaken.

f) Soils of Domed Bogs

Domed peat bogs have been formed after infilling of lagoons. The soils consist of various thickness of organic layer. In the upper horizon, woody peat is undecomposed. Soils are saturated throughout the year.

The organic layer has very low bulk density and commonly pH values lower than 5.0. The C.E.C. is very high, but nutrient levels are low (oligotrophic). The underlying materials mostly consist of marine or brackish deposits enriched in pyrites. Drainage causes shrinkage and subsidence of peat and oxidizing pyrites if present. Therefore, drainage works should only be attempted if water table can be controlled sophisticatedly. They are classified as Organic Soils or Peat and Muck Soils (Tropofibrists or Sulfihemists) and have been identified as either Narathiwat or Kap Dang series. They restrict the agricultural use due to their unfavorable physical and chemical properties.

The peat bogs are predominantly covered by fresh-water swamp forests which are determined to be environmentally preserved. The To Daeng swamp is situated adjacent to the Study area. According to the previous study by ^{14}C method (Hasting, 1982), the peat accumulation was estimated as around 4,000 years old.

iii) Morphology and Chemical Properties of Study Area Soils

Typical soil profile and major characteristics of each soil series, which have been made based on the data collected by DLD, are summarized in IV-3 and IV-4 of Appendix IV. Soil profile descriptions of test pit and columnar sections of auger boring made in the Study area are given in IV-5-2 and IV-5-4 of Appendix IV. Chemical properties of topsoils and subsoils are summarized in Table 3-7. And average physical properties of topsoils are given in Table 3-8 (for details in IV-6 of Appendix IV).

The natural fertility of soils is estimated as shown in IV-7 of Appendix IV, based on the following chemical properties of topsoil as indicated in Soil Interpretation Handbook for Thailand by DLD (1973).

For Paddy Rice : - C.E.C.
- Base Saturation Percentage
- Organic Matter Content
- Available Phosphate Content
- Soil Reaction, in case of soils having jarosite layer within 1 m depth.

Table 3-7. Chemical Properties of Soil Series

Soil Series	Pit Nos.	Horizon	Texture	pH 1:1 H_2O	pH 1:1 KCl	EC $\times 10^3$ 1:5 mS/cm	Organic Matter %	Total N %	Exchangeable Cations (me/100g) Ca	Mg	K	Na	Exchange Acidity me/100g	C.E.C me/100g	Base Saturat. %	Extract Al me/100g	Soluble SO_4 me/100g	Available P ppm	Lime / * Requirement ton/ha
Bc	2,13,34, 36	topsoil subsoil	LS-SCL	4.4-5.5 4.1-5.3	3.7-4.8 4.0-4.6	0.008-0.026 0.006-0.013	0.75-4.17 -	<0.02-0.12 -	0.10-3.49 0.22-2.97	0.03-1.25 <0.001-0.22	0.03-0.08 0.02-0.07	0.06-0.23 0.04-0.21	2.19-8.08 0.84-19.47	1.31-5.59 0.40-7.04	8.1-37.6 11.0-60.3	0.10-1.34 0.09-1.34	0.03-0.09 0.02-0.08	2.12-23.64 -	1.89-5.12 -
Bh	1,7,10	topsoil subsoil	S-LS S-SL	3.9-4.7 4.4-5.0	3.2-4.6 4.0-5.1	0.009-0.037 0.007-0.029	0.29-1.04 -	<0.02-0.04 -	0.14-0.96 0.09-7.61	0.03-0.15 0.02-0.22	0.04-0.05 0.04-0.08	0.08-0.21 0.12-0.23	0.76-5.38 0.78-40.62	0.40-5.13 0.11-32.07	7.2-57.3 2.2-35.0	0.66-1.31 0.33-4.26	0.02-0.07 0.02-0.08	1.56-5.48 -	2.27-8.15 -
Pci	33	topsoil subsoil	SL LS	4.4 4.1-4.9	3.8 3.7-3.9	0.044 0.019-0.095	1.26 -	0.06 -	1.05 0.32-0.99	0.22 0.16-0.70	0.04 0.03-0.04	0.06 0.08-0.10	3.21 1.44-2.54	1.58 1.24-1.80	29.9 31.0-37.9	0.06 0.13-0.25	0.14 0.03-0.29	13.28 -	2.00 -
Ta	5,7,9,27, 35	topsoil subsoil	L-C SL-C	3.6-6.4 2.6-6.8	3.4-5.7 2.6-5.8	0.033-0.644 0.024-1.590	3.46-10.05 -	<0.02-0.51 -	0.98-12.04 0.34-11.02	0.09-8.08 0.14-7.26	0.07-0.34 0.05-0.36	0.12-0.47 0.10-0.89	1.44-32.17 1.66-30.46	4.16-26.22 3.79-15.34	8.8-70.7 12.3-74.4	0.01-4.44 0.01-18.92	0.06-1.84 0.03-37.81	2.69-35.55 -	4.05-27.30 -
Ea	11,12,32, 39	topsoil subsoil	CL-C SL-C	3.9-5.43 2.4-5.8	3.5-3.8 2.2-5.5	0.043-1.434 0.043-2.480	2.93-6.91 -	0.12-0.40 -	0.73-14.36 0.81-18.48	0.49-8.14 0.06-11.63	0.04-0.49 0.03-0.41	0.10-3.24 0.06-1.42	12.61-19.97 3.43-48.02	6.56-17.84 1.58-35.20	9.0-56.8 9.4-84.3	1.54-3.82 0.50-6.54	0.12-3.74 0.08-13.41	4.80-13.71 -	9.82-20.00 -
Mu	4,17,19, 30,50	topsoil subsoil	SiL-C CL-C	3.2-4.2 2.4-4.2	3.2-4.0 2.3-3.8	0.077-0.734 0.113-4.037	4.18-25.79 -	<0.02-1.11 -	1.22-5.30 0.88-18.53	0.08-1.16 0.03-9.98	0.05-0.34 0.04-0.16	0.12-0.77 0.06-1.46	8.12-51.78 6.54-39.28	4.96-33.44 4.73-16.47	6.5-41.7 6.5-68.5	0.38-10.38 1.32-31.94	0.15-1.17 0.25-62.05	9.52-54.68 -	14.25-34.70 -
Cyl	47	topsoil subsoil	C C	4.5 4.1-4.4	3.8 3.3-3.4	0.026 0.016-0.033	9.60 -	0.39 -	2.34 1.22-4.29	0.98 0.74-1.66	0.16 0.08-0.12	0.13 0.08-0.12	18.87 10.18-18.26	13.33 7.38-12.23	29.6 10.6-31.6	2.27 1.52-3.38	0.03 0.01-0.03	22.24 -	32.03 -
Ta	40	topsoil subsoil	SiC SCL-C	4.1 4.1-4.2	3.4 3.5	0.034 0.023-0.026	6.76 -	0.29 -	4.06 <0.001-1.81	0.40 0.03-0.05	0.11 0.09-0.08	0.13 0.08-0.08	16.82 5.98-9.07	11.26 4.29-6.85	23.6 2.3-17.2	2.43 1.25-2.29	0.04 0.01-0.03	6.56 -	31.05 -
Cb	15,29	topsoil subsoil	SiC-C SL-C	4.3-4.7 3.6-5.0	3.6-3.8 3.4-4.4	0.017-0.057 0.016-0.559	1.22-2.12 -	0.10-0.13 -	2.18-4.59 1.37-5.14	0.70-1.67 0.38-2.57	0.15-0.20 0.05-0.30	0.11-0.27 0.10-0.16	5.63-6.97 1.66-8.94	5.65-7.95 3.20-6.11	31.4-54.2 35.3-73.4	0.62-1.01 0.52-0.99	0.05-0.15 0.02-1.57	3.87-4.54 -	4.55-8.71 -
Bu	20	topsoil subsoil	C SiC-C	4.6 5.0	3.8 3.8	0.023 0.010-0.011	1.32 -	<0.02 -	1.37 0.31-1.83	0.03 0.94-1.09	0.14 0.08-0.16	0.17 0.14-0.15	8.60 6.03-7.89	5.80 5.58-6.27	10.6 20.6-28.5	1.40 2.65-3.79	0.05 0.04-0.10	6.02 -	8.01 -
Ro	21	topsoil subsoil	SiC C	4.8 5.0-5.1	3.9 3.8-3.9	0.026 0.009-0.012	3.24 -	0.22 -	0.45 0.25-0.26	0.23 0.01-0.66	0.25 0.18-0.26	0.15 0.12-0.13	13.51 8.69-9.46	9.54 7.69-8.64	7.4 5.7-13.0	3.46 3.63-4.14	0.10 0.04-0.05	8.22 -	12.08 -
Pil	18,46	topsoil subsoil	LS-C SCL-C	4.6-5.1 4.1-4.6	3.9-4.1 3.4-3.7	0.010-0.068 0.012-0.191	2.17-2.67 -	0.02-0.07 -	0.91-3.52 0.02-2.48	0.05-1.08 1.10-0.80	0.04-0.13 0.05-0.13	0.08-0.27 0.08-0.21	1.66-13.83 5.42-13.72	1.12-11.03 3.05-13.15	26.6-40.3 4.7-22.7	0.21-3.45 1.02-8.04	0.02-0.26 0.01-0.43	5.95-12.04 -	3.27-15.58 -
Xo	24,42	topsoil subsoil	L-SCL LS-C	4.4-4.8 4.6-5.1	3.9-4.2 3.9-4.8	0.013-0.030 0.010-0.023	0.68-2.59 -	0.02-0.13 -	0.48-2.83 0.08-1.26	0.11-0.50 0.03-1.05	0.05-0.27 0.05-0.42	0.04-0.11 0.04-0.19	2.77-9.29 1.22-4.81	2.47-4.91 0.90-6.37	17.7-27.6 17.0-37.8	0.80-2.00 0.09-2.49	0.01-0.05 0.01-0.08	3.62-8.51 -	4.91-9.42 -
Tal	23,38	topsoil subsoil	C SCL-C	4.1-4.4 4.1-4.7	3.4-3.9 3.5-3.9	0.029-0.040 0.013-0.026	3.12-4.12 -	0.02-0.21 -	0.70-0.82 0.44-2.98	0.39-1.11 0.09-1.21	0.14-0.17 0.03-0.18	0.08-0.29 0.06-0.32	12.89-17.04 4.87-14.61	9.95-11.63 3.05-10.85	7.1-15.6 13.9-23.0	2.15-3.75 0.63-4.21	0.03 0.01-0.03	6.43-8.01 -	12.96-16.16 -
Ba	8,22,25, 41,44	topsoil subsoil	L-C CL-C	4.3-4.8 4.3-5.1	3.5-4.0 3.6-3.9	0.009-0.040 0.006-0.019	1.11-4.09 -	<0.02-0.20 -	0.38-4.28 0.23-3.51	0.02-3.01 0.01-0.91	0.07-0.19 0.06-0.25	0.08-0.25 0.09-0.31	4.98-12.95 4.00-11.48	2.57-9.33 2.48-11.26	5.7-37.4 7.5-33.9	0.89-3.74 1.59-4.12	0.02-0.09 0.01-0.07	3.42-14.44 -	4.61-13.09 -
Pi	49	topsoil subsoil	SCL CL-SC	4.8 4.4-4.6	4.0 3.6-4.0	0.019 0.011-0.013	1.91 -	0.10 -	0.28 1.02-1.43	0.08 0.08-0.16	0.08 0.03-0.09	0.08 0.04-0.06	6.42 3.21-4.98	3.16 2.02-3.05	7.5 24.1-31.1	0.57 0.41-0.75	0.03 0.01	3.74 -	5.07 -
Ki	16,37	topsoil subsoil	SL SCL	4.6-5.0 4.4-4.9	4.1-4.4 3.9-4.2	0.010-0.023 0.006-0.009	2.45-4.16 -	0.10-0.15 -	1.03-4.20 0.65-1.16	0.04-0.62 0.02-0.24	0.03-0.06 0.04	0.06-0.10 0.10	4.32-12.80 2.30-4.10	2.87-6.50 1.57-4.62	13.5-31.5 18.2-36.5	0.58-2.64 0.63-1.51	0.03-0.07 0.02-0.04	6.27-6.49 -	4.42-13.89 -
U2/71	28	topsoil subsoil	SL LS-SL	4.3 4.1-4.4	4.0 4.0-4.4	0.020 0.009-0.011	2.67 -	0.09 -	2.04 0.86-1.21	0.21 0.001-0.02	0.05 0.02-0.03	0.06 0.06-0.06	7.08 3.87-6.75	3.16 1.69-2.14	45.0 32.3-24.8	0.90 0.38-0.67	0.05 0.01	1.87 -	4.64 -
Pk	14	topsoil subsoil	SL SCL	4.8 4.8-4.9	4.2 4.1	0.018 0.010-0.011	1.07 -	0.02 -	1.03 1.54-1.69	0.14 0.03-0.27	0.06 0.04	0.09 0.08-0.09	4.25 3.32-3.54	2.63 4.48-4.59	23.5 32.4-38.5	0.99 1.32-2.97	0.12 0.05-0.08	4.62 -	2.77 -
Nu	3	topsoil subsoil	OM OM	4.7 5.0	4.0 4.4	0.100 0.094	15.93 -	0.84 -	4.40 22.02	1.27 6.70	0.34 0.52	0.96 2.13	27.26 64.77	24.89 36.67	20.4 32.6	1.01 0.78	0.40 1.10	7.57 -	3.58 -
Kd	26,31,45, 48	topsoil subsoil	OM OM-C	3.9-4.7 3.0-5.0	3.4-3.9 2.9-4.3	0.043-0.643 0.018-1.359	6.60-45.93 -	0.02-1.25 -	1.81-9.29 0.42-5.68	0.18-2.25 0.04-3.99	0.07-0.32 0.03-0.27	0.06-0.42 0.06-1.80	12.06-53.78 3.32-32.31	9.72-43.86 2.15-28.97	10.1-29.8 2.9-32.9	0.76-10.53 0.21-8.48	0.06-3.57 0.05-8.76	4.08-31.95 -	14.67-35.06 -

/* --- To neutralize (PH 7.0) topsoil.

Table 3-8. Average Physical Properties of Topsoils

Soil Series	Pit Nos.	% Water Retention 2/		Available Water %	Bulk Density g/cm^3
		1/3 atm.	15 atm.		
Bc	2	14.53	12.07	2.46	1.18
Pti	33	19.93	13.60	6.33	1.30
Ta	6,9*/,35	33.87	29.25	4.62	1.14
Ra	11,12,32,39	35.59	30.73	4.86	1.22
Mu	4,17,19	65.09	48.70	16.39	0.81
Cb	29	24.67	18.36	6.31	1.39
Tsl	38	34.52	29.33	5.19	1.31
Ba	8,41	28.97	24.93	4.04	1.27
U2/71	28	16.04	11.39	4.65	1.33
Pk	14	35.74	33.69	2.05	1.20
Kd	31,45 1/	136.60	114.50	22.10	0.45

1/ excluded from calculation.

2/ 1/3 atm. ≒ pF 1.8 (field capacity)
15 atm. ≒ pF 4.2 (wilting point)

For Upland Crops : - C.E.C.
- Base Saturation Percentage
- Available Phosphate Content

The natural fertility of Study area soils can be summarized as shown below. Most soils have low natural fertility except for the soils in former tidal flat and flood plain. It is mainly due to the intense weathering through leaching bases by heavy rainfall and hot temperature.

Soil Series	Natural Fertility */	
	For Paddy Rice	For Upland Crops
Bacho	L - M	L - M
Ban Thon	L	L
Pattani	L	L
Tak Bai	ML- M	ML-MH
Rangae	L - M	L - M
Muno	ML- M	ML
Chian Yai	ML	ML
Thon Sai	ML	ML
Chon Buri	L -MH	L -ML
Sai Buri	L	ML
Ruso	L	ML
Pileng	L -ML	L -ML
Khok Kian	L	L
Tha Sala	L -ML	L -ML
Bangnara	L -ML	L
Sungai Padi	L	L
Nam Krachai	L	L
Kohong	L	L
Phuket	L	L
Narathiwat	ML	ML
Kap Dang	L -ML	L -ML

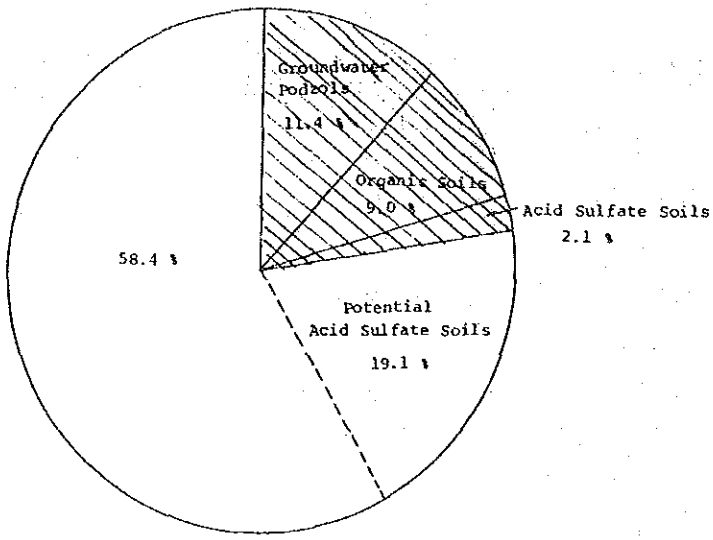
*/ L: low, ML: moderately low, M: Moderate,

MH: Moderately high, H: High

(3) Problem Soils and Their Improvement

i) Problem Soils

As shown in Map - 1, the Study area includes problem soils*/, that is, groundwater podzols, organic soils (peat and muck soils) and acid sulfate soils. The proportions of these problem soils are shown as below:



The total extent of the problem soils is 65,800 rai or 10,530 ha, namely, 22.5 percent of the whole Study area. These problem soils are mostly left idle at present and would be excluded from the service area in the proposed Project. In addition to the problem soils, potential acid sulfate soils occupy 56,170 rai or 8,970 ha, namely, 19.1 percent of the whole Study area. The service area would include a considerable extent of the potential acid sulfate soils, therefore, the proper measures to prevent these soils from their acidification would be required.

*/....The term "problem soils" refers to those which have certain chemical or physical characteristics which restrict agricultural development.

a) Groundwater Podzols

Groundwater Podzols (Ban Thon series) have a spodic horizon which is dark brown humus-iron hard pan (ortstein) with varying thickness and depth. In some places, the spodic horizon lies at 40-60 cm deep and inhibits root penetration.

Overlying white sandy layer (albic horizon) is very low in natural fertility and has less retentivity of applied fertilizers. The soils are usually acid throughout, and are low in C.E.C. and low in base saturation percentage as well. At present, these soils are used mainly for coconuts or cashew plantation, but the growth of these trees are poor. The following measures are considered:

- To utilize the lands for pasture and plant leguminous shrubs and return the animal husbandry waste to the soils.
- To break the hard pan by rake-dozer in case that the hard pan exists at shallow depth.

b) Organic Soils (Peat and Muck Soils)

Organic Soils (Narathiwat and Kap Dang series) are distributed in the swamp areas and their fringe. Melaleuca leucadendron grows as a dominant species at the peripheries of swamp forests. The soils have a thick organic layer and the underlying materials consist of marine or brackish sediments enriched in pyrites. These soils are permanently waterlogged, and the subsidence occurs after drainage. They have very low bulk density and have weak bearing capacity. Their C.E.C. values are high but inherent fertility is low. Soil reaction is commonly acid.

Figure 3-2 shows the distribution of swamp areas which have been classified into three categories, that is, development, conservation and preservation zones. In the Study area, the swamp areas to be developed include Pileng project and Kap Daeng areas. The Pileng land settlement project has been already commenced with construction of dikes, drainage canals and regulators. In Kap Daeng swamp area, on the other hand, the development has been still small-scaled.

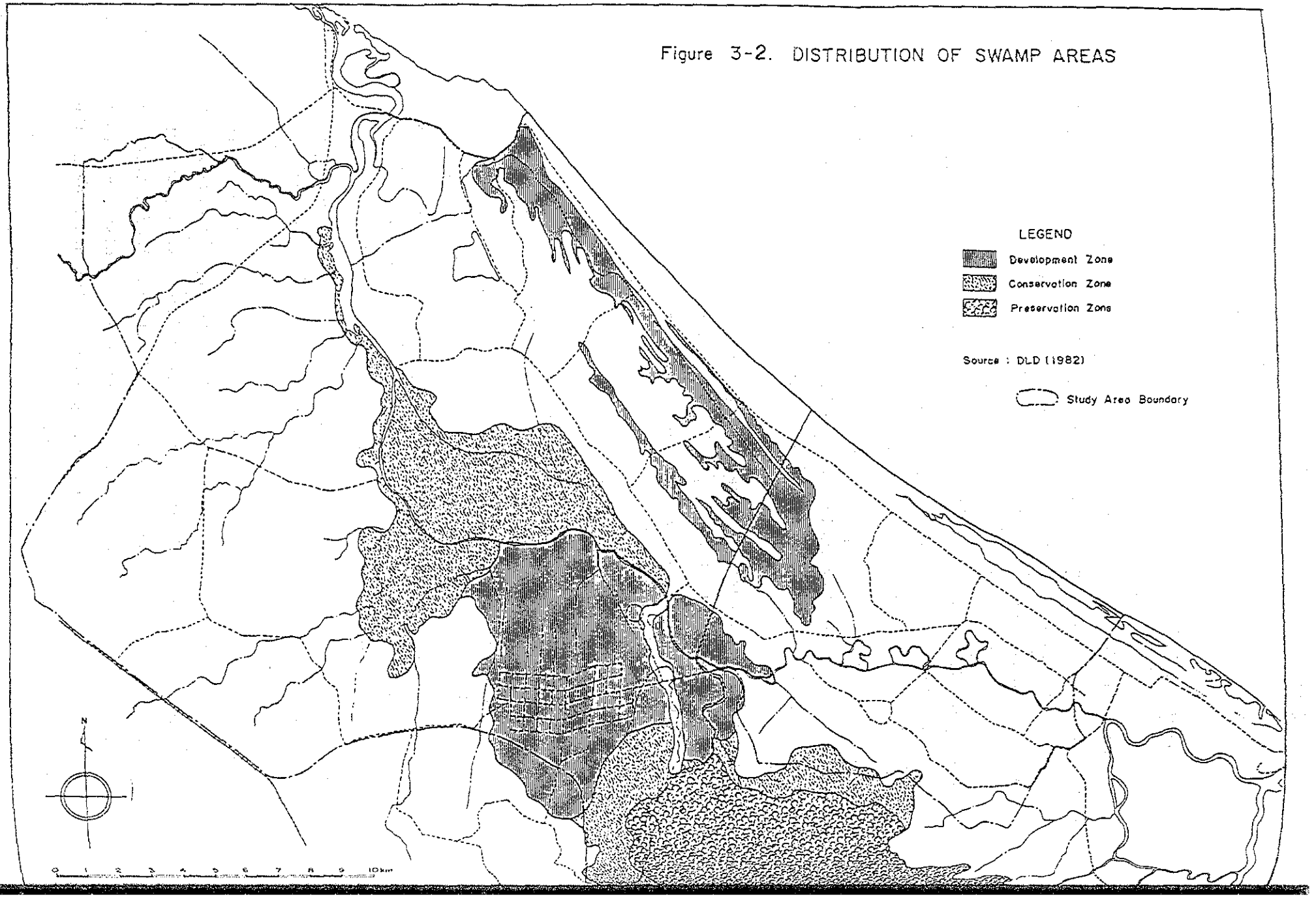


Figure 3-2. DISTRIBUTION OF SWAMP AREAS

The fringes of swamp forests have been reclaimed for agricultural use by digging drainage canals, however, such reclaimed lands contain the several problems to be solved. For example, the subsidence due to the shrinkage of peat has been caused by burning and drainage works. And the underlying marine deposits enriched in pyrite have been exposed to oxidation. As the results, potential acid sulfate condition has been changed to actual one. Such chlonological change in soils between 1968 and 1984 was studied by DLD.

Finally, it has been concluded that the development of organic soils should be left for future consideration.

c) Acid Sulfate Soils

Acid sulfate soils have been formed from the oxidation of pyrites derived from marine deposits. The pyrite (FeS_2) is transformed to jarosite ("cat-clay", $KFe_3 (SO_4)_2 (OH)_6$) by oxidation. Acid sulfate soils can be divided into two status, that is, actual and potential acid sulfate soils. The potential acid sulfate soils have a pyrite-rich horizon in substratum which has not been oxidized. The actual acid sulfate soils are characterized by straw yellow mottles of jarosite which releases sulfate so that these soils show extremely acid reaction for at least 2-3 years under the prevailing climatic condition. The jarosite in actual acid sulfate soils is not reversed to pyrite again by submergence, but transformed into Fe(OOH), $Fe(OH)_3$, Fe_2O_3 and FeO under reductive conditon.

The extreme acidity of soils causes aluminium and iron toxicity, low availability of phosphorus, poor physical properties and low activity of soil microbes. The soil productivity is greatly hampered by them. The result of pyrite oxidation test is summarized in Figure 3-3 and detailed in IV-10 of Appendix IV . As shown in this figure, potential acid sulfate soils dominate actual ones. These soils have a possibility to change into actual one by oxidation, therefore, they should be prevented from the oxidation induced by excessive drainage or excavation.

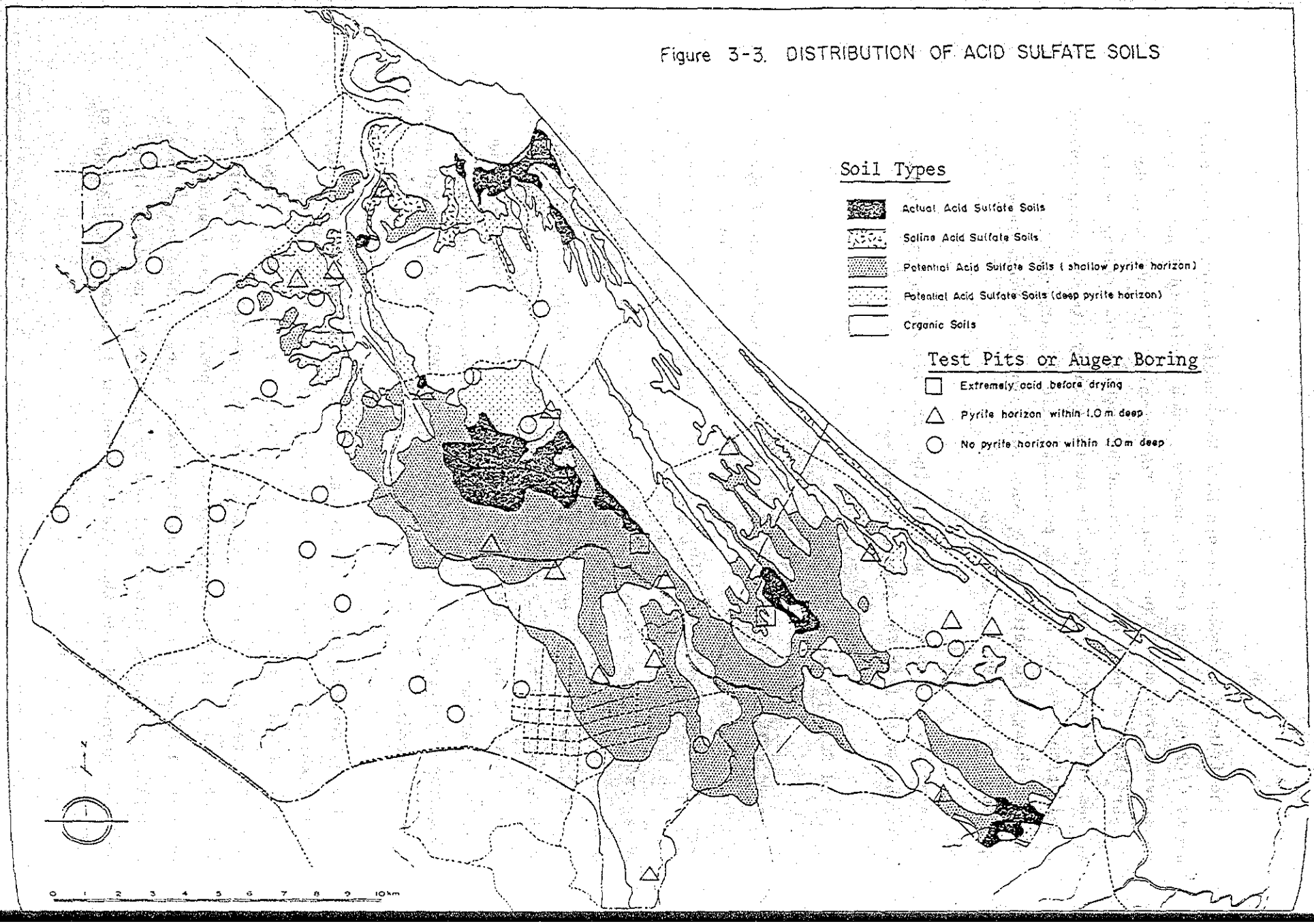


Figure 3-3. DISTRIBUTION OF ACID SULFATE SOILS

The amelioration methods would be different between potential and actual acid sulfate soils as below:

Actual acid sulfate soils

- To wash out sulfate by water flushing.
- To apply liming materials such as lime dust.
- To apply sufficient amount of fertilizers such as rock phosphate.
- To apply MnO_2 to prevent crops from iron toxicity.
- To introduce acid tolerant crops/varieties.
- To make pre-flooding for paddy cropping.

Potential acid sulfate soils

- To maintain the groundwater table at shallower depth than pyrite-rich layer by careful groundwater control.
- To introduce double cropping if sufficient water is available during the dry season.

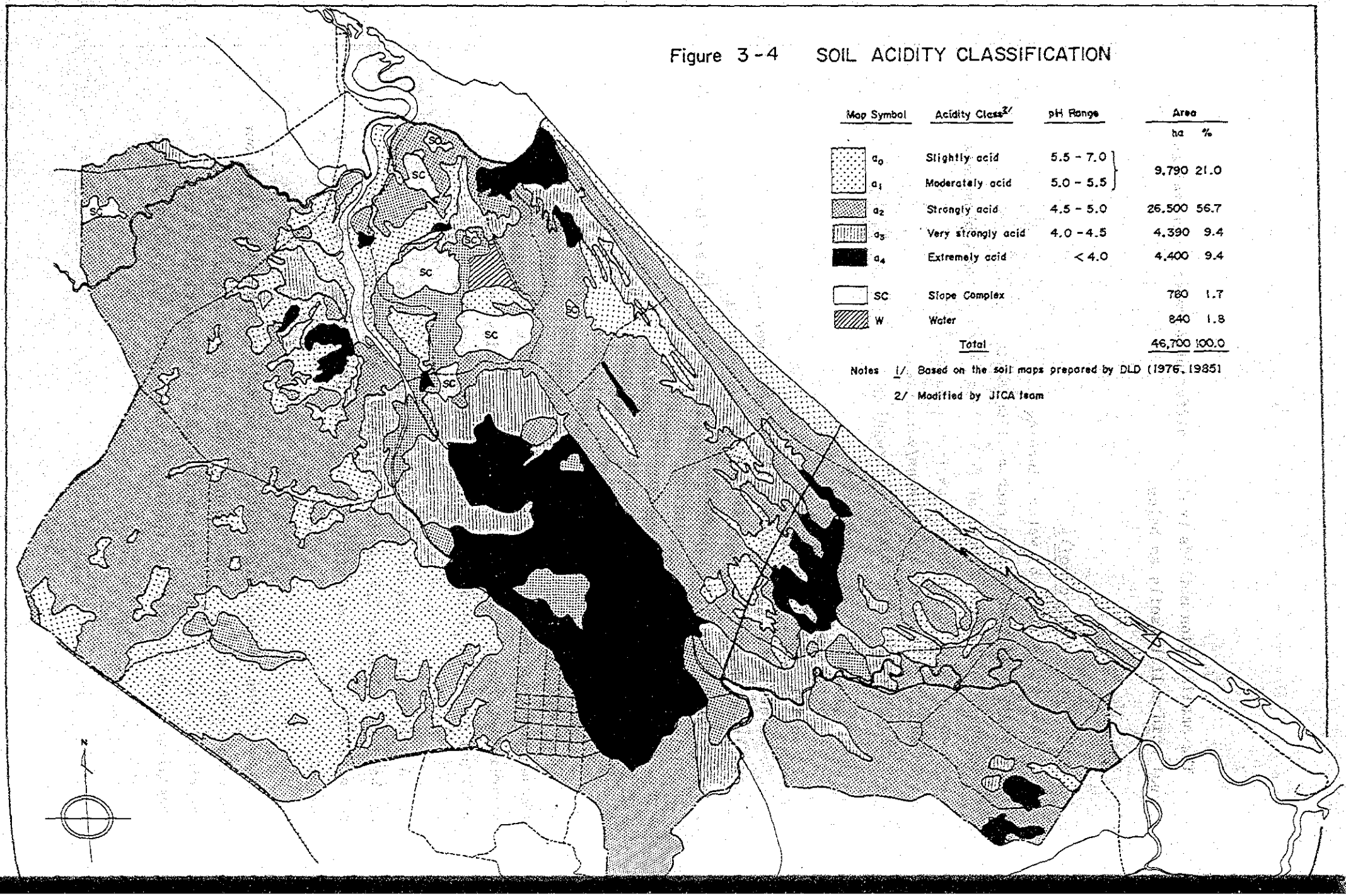
ii) Lime Requirement of Acid Soils

Most soils are acidic and infertile because the bases have been leached out from the soils under the tropical rain climate. Accordingly, it is necessary to correct the acidity to an allowable level and to apply fertilizers for any kind of cropping.

A soil acidity classification map (Figure 3-4) has been drawn based on the data collected during the field survey in addition to those collected by DLD. Five acidity classes are defined by the pH range of topsoil.

Correction of the soil acidity can be made through 1) to flush out the soluble sulfate from the topsoil, and 2) to apply the liming materials to the topsoil. Application of liming materials is most convenient method to correct the soil acidity where inexpensive liming

Figure 3-4 SOIL ACIDITY CLASSIFICATION



Map Symbol	Acidity Class 2/	pH Range	Area ha	Area %
a_0	Slightly acid	5.5 - 7.0	9,790	21.0
a_1	Moderately acid	5.0 - 5.5		
a_2	Strongly acid	4.5 - 5.0	26,500	56.7
a_3	Very strongly acid	4.0 - 4.5	4,390	9.4
a_4	Extremely acid	< 4.0	4,400	9.4
SC	Slope Complex		780	1.7
W	Water		840	1.8
	Total		46,700	100.0

Notes 1/ Based on the soil maps prepared by DLD (1976, 1985)

2/ Modified by JICA team

materials are available. Different soils have different buffer capacity to the applied lime, therefore, buffer curves of the Study area soils are shown in IV-8 of Appendix IV. The requirement of lime by soil series to raise the pH value up to 6.0 is given below:

Calcium Carbonate Requirement	Soil Series
Less than 1 ton/ha	Hua Hin, Bacho, Pattani, Tak Bai (non-acid), Chon Buri, Khok Kian, Bangnara (red-mottled), Phuket, Yi-ngo
1-5 ton/ha	Ban Thon, Takua Thung, Sai Buri, Ruso, Pileng, Tha Sala, Pattalung, Bangnara, Sungai Padi, Sungai Kolok, Nam Krachai, Khong, Lamphu La, Huai Pong, Narathiwat
6-10 ton/ha	Tak Bai, Rangae, Chian Yai, Thon Sai, Narathiwat (acid), Kap Dang
More than 10 ton/ha	Muno, Chian Yai (acid), Kap Dang (acid)

The soils where a large amount of liming materials is prerequisite for cropping could not give a sustainable return under the prevailing conditions. Therefore, these lands consisting of Muno series as well as a part of Chian Yai and Kap Dang series would be excluded from the agricultural development plan.

Presently, lime application experiments are being conducted by the Pikulthong Center. The experimental results are demonstrated in farmer's plots in eight satellite villages of the Center (See IV-9 of Appendix IV).

In the Study area, the most effective available liming material is considered as lime dust from dolomitic limestones in Changwat Yala and Songhkla, of which calcium carbonate equivalent is determined as high

as 78-92 percent. The price is not cheap, namely, ฿100-150 per ton in 1986 exclusive of transportation costs. The residual effect of this material has not been known, however, it seems to be within a range from 2 to 5 years.

Finally, the main problems, i.e. acid soils and acidic water problems would be improved from the following three aspects;

1) Water management (drainage control):
   - potential acid sulfate soils : to keep the groundwater level shallower than the pyrite-rich layer.
   - actual acid sulfate soils : to wash the soluble sulfate out by flushing or ponding.

   By tidal regulators which keep the water level high in Mae Nam Bang Nara during the dry season and prevent the soil from excessive drainage.

   By river tributaries and drainage canals with water level control gates.

2) Soil improvement:
   By liming.
   By phosphate application.

3) Cultivation techniques:
   By selection of acid tolerant species and varieties.
   By pre-flooding in case of rice cropping.

(4) Land Classification

i) Soil Suitability

Soil suitability for each crop is evaluated in terms of the following limiting factors:

s: soil limitations in the root zone including unfavorable texture, shallow hard pan, or low fertility
m: lack of moisture for crop growth
t: unfavorable topography
f: flush floods or prolonged, deep flooding
d: impeded drainage
e: erosion hazard or past erosion damage
a: extreme soil acidity
x: soil salinity

The suitability classes of each soil series for major crops are shown in Table 3-9, and extent of each class by crops are summarized in Table 3-10.

The principal limitations of the Study area soils are drainage-related in lowlands, on the other hand, low fertility and erosion in uplands. About 60 percent of the Study area are suitable for rice cropping. The major constraints on rice cropping are periodical flooding, moisture stress and topography as well as soil acidity which is variable depending upon the soil water regime.

Meanwhile, the present cropped area and average yield of paddy are shown in Figure 3-5. As shown in this figure, areas getting the highest yield are located in the low-lying lands along Mae Nam Bang Nara though their cropped area is less than the other areas. The fact could be explained by the water availability in spite of their unfavorable soil conditions.

Table 3-9. Soil Suitability Classes of Soil Series and Association

Soil Series	Map Symbol	Soil Suitability Class: Rice	Upland Crops	Vegetables	Forage & Pasture	Tree Crops
Beach Ridges & Sand Bars or Dunes						
Hua Hin	Hh	5 smt	4 sm	5 sm	4 sm	5 sm
Bacho	Bc	5 smt	3 sm	3 sm	2 sm	4 sm
Ban Thon	Bh	5 smt	3 sm	3 sm	2 sm	4 sm
Depression between Beach Ridges						
Pattani	Pt1-ly	3 fsm	3 fd(a)	3 fd(a)	3 f	4 fd(a)
Takua Thung	Tkt-ly	2 fsx	3 fdxa	3 fdx(a)	3 fx	4 fdx(a)
Former Tidal Flat						
Tak Bai	Ta-ly	2 fs	2 fd	3 fds	2 f	4 fds
	Ta-fc	2 fs	3 fds	3 fds	2 f	4 fds
	Ta-fc-na	1	3 fds	2 fd	2 f	4 fd
	Ta-ly-na	1	2 fds	2 fd	2 f	4 fd
Rangae	Ra-ly-a_2	2 fs	3 fd(a)	3 fd(a)	3 fs	4 fd(a)
	Ra-ly-a_3	3 fsa	3 fda	4 fda	3 fsa	4 fda
	Ra-m.sub	2 fs	3 fd(a)	3 fd(a)	3 fs	4 fd(a)
	Ra-o	3 fs	4 fds(a)	4 fds(a)	3 fs	5 fds(a)
	Ra-dm.sub	3 fsa	3 fda	4 fda	3 fsa	4 fda
	Ra-o/Ra-dm.sub	3 fsa	4 fdsa	4 fdsa	3 fsa	5 fdsa
	Ra/Kd-o	4 fsa	4 fdsa	4 fdsa	4 fsa	5 fdsa
Muno	Mu-ly	4 fsa	4 fdsa	4 fdsa	4 fsa	5 fdsa
Chian Yai	Cyi-ly	3 fsa	3 fdsa	3 fdsa	3 fsa	4 fdsa
	Cyi-o	3 fsa	4 fdsa	4 fdsa	3 fsa	5 fdsa
	Cyi-r.sub	3 fsa	4 fdsa	4 fdsa	3 fsa	5 fdsa
	Cyi/Mu-ly	4 fsa	4 fdsa	4 fdsa	4 fsa	5 fdsa
Thon Sai	Ts-ly	3 fsa	3 fda	3 fda	3 fa	4 fda
	Ts-col	4 fsa	3 fa	3 fa	3 fa	4 fda
	Ts-o	3 fsa	4 fdsa	4 fdsa	3 fsa	4 fdsa
Flood Plain, Levees & Breach Deposits						
Chon Buri	Cb-ly	2 fs	3 fd	3 fd	2 fs	3 fd
	Cb-fc	1	3 fd	3 fd	2 fs	3 fd
Alluvial Complex	AC	3 fs	3 fd	3 fd	2 fs	3 fd
Sai Buri	Bu	2 fs	2 fd	2 fd	2 fs	3 fd
Ruso	Ro	2 fsm	2 fd	1	1	2 f
Low Terrace						
Pileng	Pil-ly	2 fs	3 fd	3 fd	3 fs	3 fd
Khok Kian	Ko-ly	2 fsm	3 fd	3 fd	3 fs	3 fd
Tha Sala	Tsl-ly	2 fs	3 fd	3 fd	3 fs	3 fd
Pattalung	Ptl-ly	2 fs	3 fd	3 fd	3 fs	3 fd
	Ptl-m.sub	3 fs	4 fds	4 fds	3 fs	5 fds
	Ptl/Ba-m.sub	3 fs	4 fds	4 fds	3 fs	5 fds
Bangnara	Ba-ly	2 fs	3 fd	3 fd	3 fs	3 fd
	Ba-m.sub	2 fs	3 fd	3 fd	3 fs	3 fd
	Ba/Ptl-ly	2 fs	3 fd	3 fd	3 fs	3 fd
	Ba/Tsl-ly	2 fs	3 fd	3 fd	3 fs	3 fd
	Ul/71	2 fs	3 fd	3 fd	3 fs	3 fd
Sungai Padi	Pi	2 fst	2 ds	3 ds	2 s	3 ds
Sungai Kolok	Gk	2 fst	2 ds	3 ds	2 s	3 ds
Nam Krachai	Ni	4 fsmt	2 ds	3 ds	2 s	2 ds
Middle Terrace						
Kohong	Kh	4 smt	2 s	3 sm	2 sm	1
	U2/71	3 smt	2 s	3 ds	2 s	2 ds
Lamphu La	Ll	4 smt	2 s	2 s	2 sm	1
Hills & Foothill Slopes						
Huai Pong	Hp	4 smt	2 st	3 st	2 st	2 s
Phuket	Pk	5 smt	4 st	3 st	2 st	1
Yi-ngo	Yg	5 smt	4 ste	4 ste	2 te	3 ste
Slope Complex	SC	5 smt	5 ste	5 ste	5 ste	5 ste
Domed Bogs						
Narathiwat	Nw-d_1	4 fs	5 fds	4 fds	4 fs	5 fds
	Nw-d_{1+2}	5 fsa	5 fdsa	5 fdsa	5 fsa	5 fdsa
	Nw-d_2	5 fs	5 fesa	5 fdsa	5 fs	5 fdsa
	Nw-d_3, a_{1+2}	5 fs	5 fdsa	5 fdsa	5 fs	5 fdsa
	Nw-d_3, a_2					
Kap Dang	Kd-a_2	4 fs	4 fds	4 fds	3 fs	4 fds
	Kd-a_3	4 fsa	5 fdsa	5 fdsa	4 fsa	5 fdsa
	Kd-a_4	4 fsa	5 fdsa	5 fdsa	4 fsa	5 fdsa