Table - 6 Soil of the development zone in Narathiwat province

Item	Peat		Acid sulfate soil		Alluvial soil
	Thick peat	Shallow to moderately thick peat	Potential acid sulfate soil	Actual acid sulfate soil	
Series name	Narathiwat	Kab Daeng	Rangae, Thon Sai Chain Yai, Pattani	Munoh	Bang Nara, Chon Buri Tak Bai
Thickness of peat	> 100cm	40～100cm	< 40 cm	< 40 cm	-
decomposed rate of peat	More or less undecomp. Fibers or woody fragm.	Somewhat well	weakly	weakly	-
Pyritic mud clay	Underlying material	50～100cm From the soil surface	Within 1m from surface	Within 1m from surface	Deposits are underlain by the pyritic mud the depth between 1.5 to 2m
Jarosite mottle	-	-	Absent	Within 1m from surface	-
Crops and plants	Paddy rice, most land have been abandoned	Paddy rice, Banana, Vegetable crops.	Melaleuca etc acid-tolerant plants	Melaleuca etc acid-tolerant plants	Paddy rice. Yield can be relatively high.
Mainly occupation	Bacho swamp	To Daeng swamp	Some swampy areas of Narathiwat province	To Daeng swamp	The border of the swamps. Alluvial plain

Source : Making from Second International Soil Management Workshop (1986)

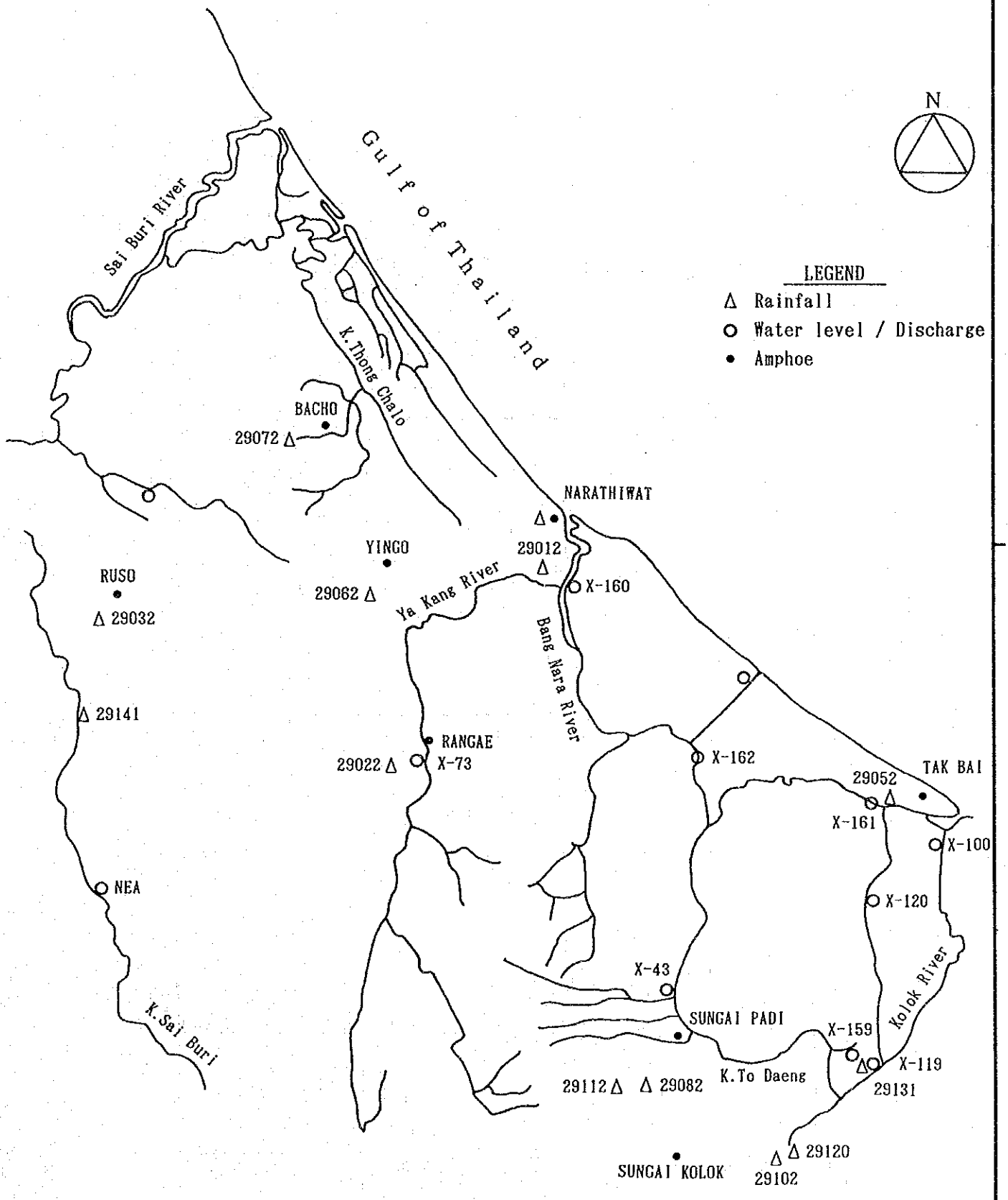
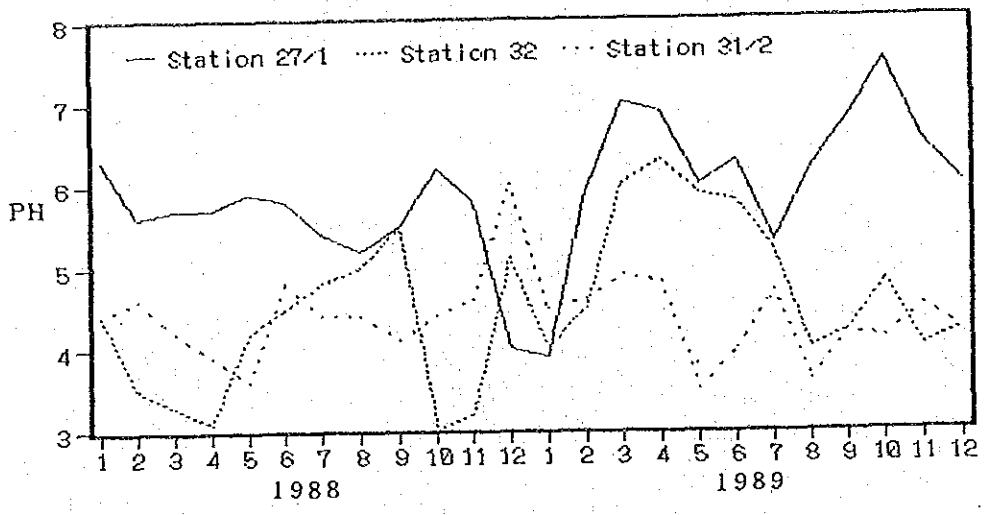
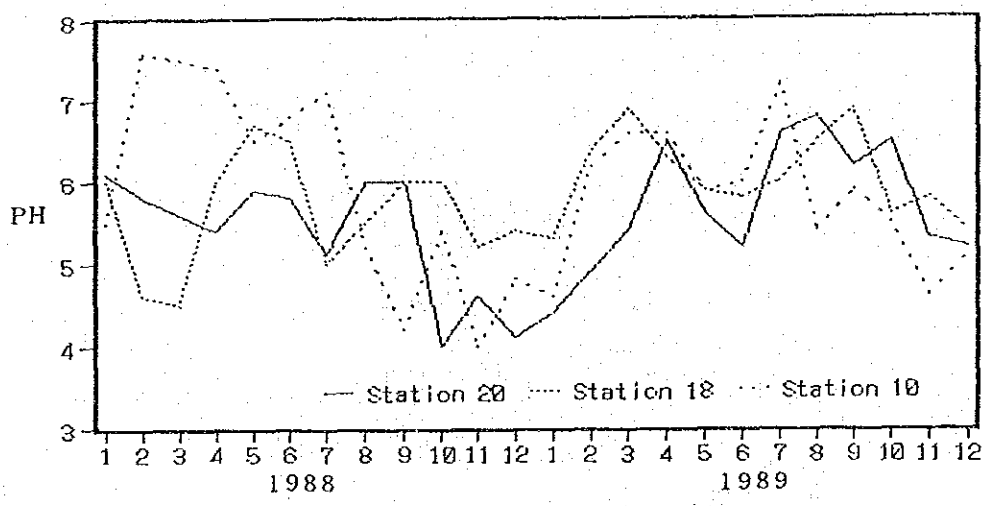


Figure-1 Hydrometeorogical Stations

BACHO AREA



YAKAN/BAN NARA RIVER



KOLOK CANAL

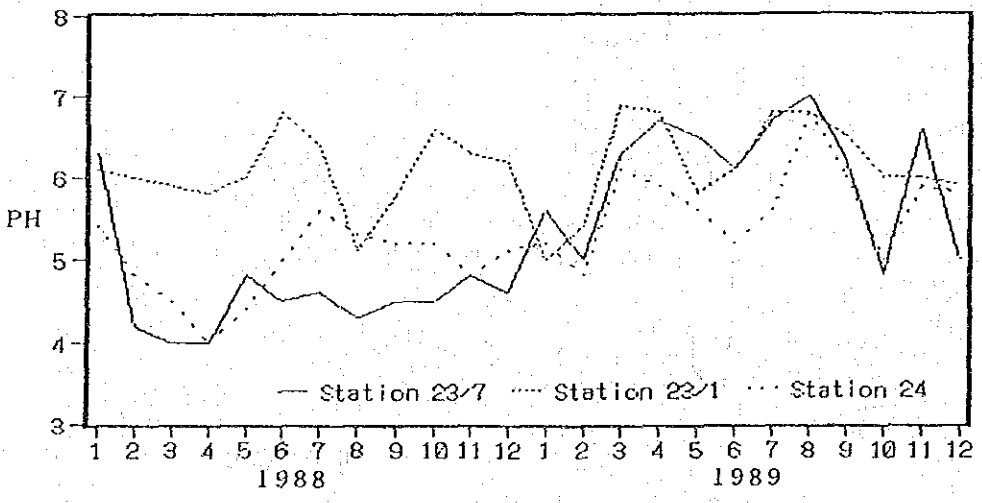
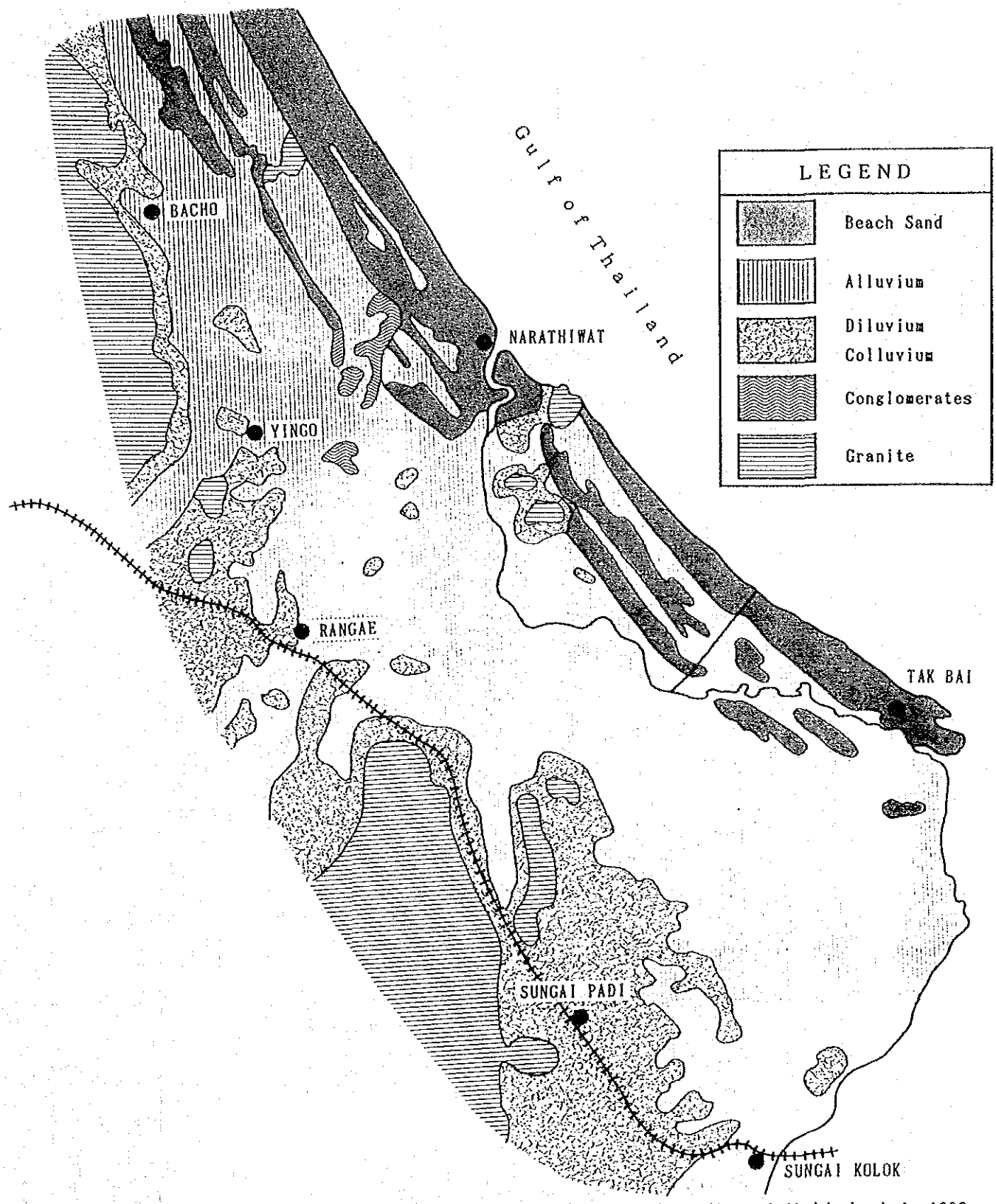


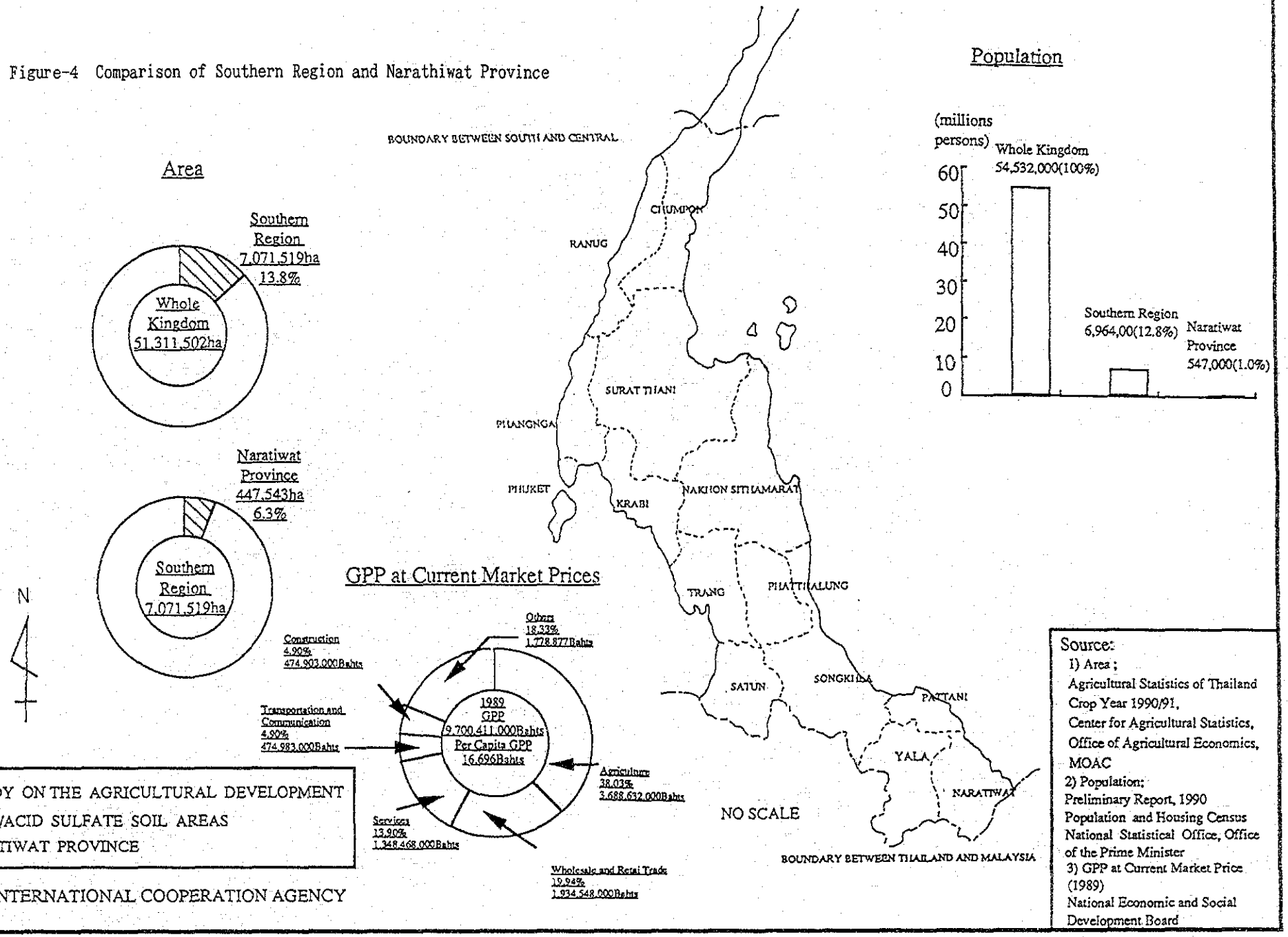
Figure-2 Monthly Variation of pH



Sources : 1) Aerial photograph interpretation and field check in 1992.
2) Final report for the feasibility study on the Bang Nara irrigation and drainage project, 1986, JICA.

Figure-3 Regional Geology

Figure-4 Comparison of Southern Region and Narathiwat Province

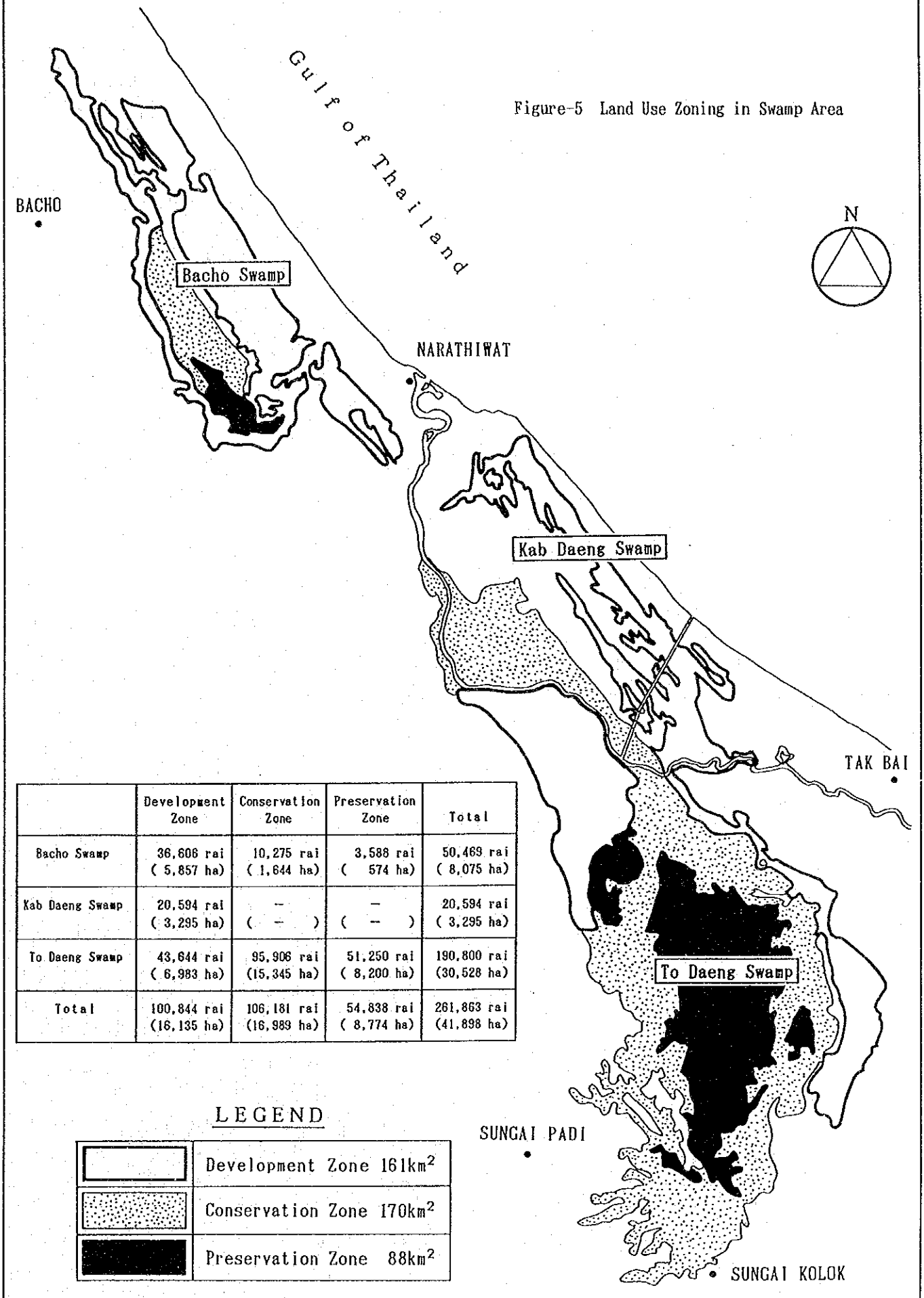


Source:
1) Area ;
Agricultural Statistics of Thailand Crop Year 1990/91,
Center for Agricultural Statistics, Office of Agricultural Economics, MOAC
2) Population;
Preliminary Report, 1990 Population and Housing Census
National Statistical Office, Office of the Prime Minister
3) GPP at Current Market Price (1989)
National Economic and Social Development Board

THE STUDY ON THE AGRICULTURAL DEVELOPMENT FOR PEAT/ACID SULFATE SOIL AREAS IN NARATIWAT PROVINCE

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure-5 Land Use Zoning in Swamp Area



	Development Zone	Conservation Zone	Preservation Zone	Total
Bacho Swamp	36,606 rai (5,857 ha)	10,275 rai (1,644 ha)	3,588 rai (574 ha)	50,469 rai (8,075 ha)
Kab Daeng Swamp	20,594 rai (3,295 ha)	– (–)	– (–)	20,594 rai (3,295 ha)
To Daeng Swamp	43,644 rai (6,983 ha)	95,906 rai (15,345 ha)	51,250 rai (8,200 ha)	190,800 rai (30,528 ha)
Total	100,844 rai (16,135 ha)	106,181 rai (16,989 ha)	54,838 rai (8,774 ha)	261,863 rai (41,898 ha)

LEGEND

	Development Zone 161km^2
	Conservation Zone 170km^2
	Preservation Zone 88km^2

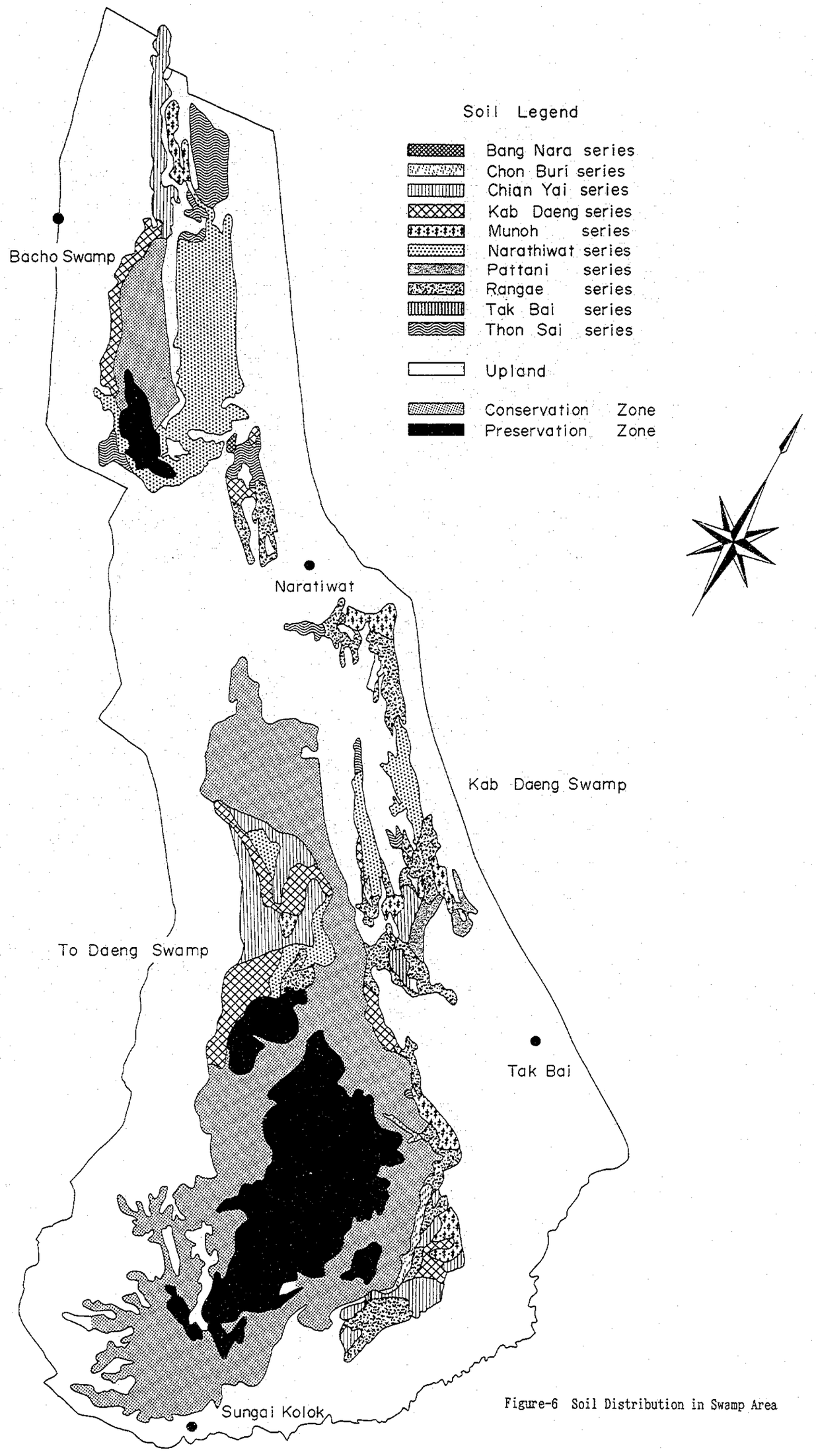


Figure-6 Soil Distribution in Swamp Area

CHAPTER 4

FEASIBILITY STUDY AREAS

CHAPTER 4 FEASIBILITY STUDY AREAS

4.1 Selection of Feasibility Study Areas

4.1.1 Subdivision of Development Zone

According to the government policy, agricultural development should be carried out only within the development zone in the designated land use zones, as described in paragraph 3.7. Complying with the policy, in order to select representative pilot areas for F/S, the development zone was subdivided into eleven (11) areas as shown in Figure-7, considering the following;

- Soils distribution and topographical conditions
- Existing roads and drainage canals
- Beneficial area, irrigation/drainage systems and future expansion plans of the existing relevant projects

The physical and social properties of the areas are outlined in Appendix G-5.

4.1.2 Selection Criteria for Representative Pilot Areas

In order to select representative pilot areas from the subdivided areas, essential criteria were made by examining the factors needed for the agricultural development plan.

(1) Soil condition

Main difficulty in developing swamp areas is the soil problem. The soil improvement techniques are still different depending on the properties of the soil. Therefore, techniques that will be developed for the selected pilot areas must be applicable to other similar areas for further development.

(2) Availability of water resources

In general, scale of agricultural development project is largely dependent on availability of water resources. Also, the availability throughout the year is one of the important factors for land use planning.

Most of the development zones are regarded as rainfed area at present. However, under irrigation plan, water use will be different from area to area,

depending on relevant irrigation projects. Therefore, the areas have been selected from the following typical areas.

- Area which is delineated as a rainfed for the future and needs to develop new water resources for development.
- Area which is delineated as an irrigable area in near future and is expected to enjoy irrigation water.
- Area which is enjoying irrigation at present

Namely, various studies on land use and farming practices under different water use conditions in the above types of areas are very essential for the methodology of project planning.

(3) Environmental impact

In the development zone, the biggest environmental problem will be intolerable acid damage caused by outflow of acid-water originating from developed areas. Acid-water should be accumulated and drained toward the sea by some proper drainage facilities.

Some of the areas are equipped with proper drainage canal system near by, but some of them may require a new canal system with development. Considering the purpose of pilot area, monetary inputs may be required for development of soil improvement techniques and farming. Therefore, the areas have been selected on the basis of the following.

- Area which has a possibility of easy drainage of acid-water from economical viewpoints.

(4) Social factors

Besides the above physical factors, social factors are also taken into consideration to select the areas. In the selected areas, various activities will be carried out in both administrative and farmer levels. It may be expected that to produce immediate effect from the project implementation, not only facility construction, but also strengthening farming practices and farmers' organization will be required. Accordingly, the areas have been selected from the following areas.

- Area where land procurement is easy.
- Area which has easy access for construction works.
- Area in which related farmers are cooperative.

In the selection, the divided areas were evaluated from viewpoint of the development potential. The result is shown in Appendix G-5.

Evaluation of potentiality, however, is based on the relative comparison with divided areas, considering their various characteristics. The results are summarized as follows.

- Potential acid sulfate soil is distributed in the N-1 area of the north, which will be relatively easy to deal with if supply of water is abundant. But, water resource is lacking for development in this area. The N-3 area is a peat soil area bordering the conservation and preservation zones. Drainage practices in the peat layer may cause negative impact to the ecosystem in their limited and narrow zones. In the N-4 area, various developments are being carried out. Therefore, various land use including agriculture may be developed in the future.

- In the middle area, peat and potential acid sulfate soils are prevailingly distributed. All areas except some parts of the M-2 area need to prepare proper water source to develop the area, but some areas may be included in the beneficial area by Bang Nara project, depending on the scale of development. The M-5 area has the Bang Nara river as a drainage canal. However, it will be difficult for all of the areas to drain off acid-water from peat layer since they are located in the low and flat land.

- In the south area, potential and actual acid sulfate soil areas are widely distributed. A part of the S-1 area and the settlement area in the S-2 area are supposed to be supplied water from the Muno canal. Regarding the drainage, both areas are incorporated in the Muno project drainage system. Therefore, new construction and rehabilitation of canal will be additionally required.

4.1.3 Selection of Areas

Based on the above criteria, the following representative pilot areas have been selected for F/S study.

- Bacho area (N-2) A = 2,640 ha
- Kab Daeng area (M-2) A = 502 ha
- Mu No-Koknai area (S-1) A = 756 ha

Selected areas are shown in Figure-7.

Agricultural development in the development zone will be conducted based on the F/S study results of the selected three areas. Then, divided areas will be grouped into the following types of the F/S areas for future development approach.

Approach type	Area	Approximate area(ha)
Bacho type (N-2)	N-1,N-3,N-4 M-1,M-5	7,880
Kab Daeng type (M-2)	M-3,M-4	2,880
Mu No-Kokunai Type (S-1)	S-1,S-2	1,930

4.2 Bacho F/S Area

4.2.1 Location

This study area is located in the northern part of Amphoe Muang in Tanbon Khok Kian. The villages include; Ban Khok Kian, Ban Bu Ke Ya Mu and Ban Bu Ke Chu Do covering an area of 2,640 ha. The area is encircled by highway 42 in the south and west, 4136 in the east, and by a connecting road between Amphoe Bacho and Ban Thon in the north.

4.2.2 Physio/Topography

This area lies within the vast Bacho swamp and is covered mainly by melaleuca and wild grasses. The area has an elevation between 3~4 m with a gentle slope from south to north. Although outside of the eastern and western boundary has a good road infrastructure, there are only two roads within the area.

The area is a coastal plain bounded by sand dunes to the east and west. Granite hills are seen in the north end, and conglomerates hills are in the

south end. The depth to the basement (granite) is shallow, 20-30 m. The coastal plain is composed of alluvium mainly marine clay.

Groundwater table was less than 1.0 m below the surface in most of the area and around 1.0 m in the east sand dune area, according to the field survey conducted in November '92. The water quality varied much depending on the locality in the surrounding area (refer to Figures D-1 and D-9, Appendix D).

4.2.3 Soil and Land Use

(1) Soil

The soil of this area consists of Narathiwat and Thon Sai series. In the two series, Narathiwat series occupies about 98% of the area. Thon Sai series is only distributed in a small area of 2% (refer to Figure-8 and Figure E-5, Appendix E). Narathiwat series belongs to the group of thick peat, generally over 1.0 m in thickness, and it can be divided into three strata with a pH less than 4.5. The substratum of the peat layer consists of marine clay and beach sand, adjacent to sand dune.

According to the recent survey, the thickness of peat layer varies from site to site (refer to Figures E-1, E-2 and Table E-6, Appendix E). Shallow peat area with a thickness of less than 1.0 m, was found in a small portion of the northern part. The reasons are that a main drainage canal accelerated subsidence and burning has consumed the peat, moreover, the substratum of this portion is sand with high permeability. Such being the case, this portion will be most suitable for agricultural development. On the other hand, the portion which is located in the upstream of the main canal is covered with thick peat layers, so that it will not be suitable for agricultural use. The result of chemical analysis is shown in Tables E-11 to 13, Appendix E.

The mean value of subsidence during the last nine years has become about 4 cm per year. Details are shown in Table E-4-4 in Appendix E.

(2) Land use

The F/S area is almost entirely occupied by the melaleuca forests with only very small portions used as trial plots of DLD. Based on the survey and topographical map (1:5,000), present land use condition is summarized as follows (refer to Table E-7 and Figure E-8).

Land or Cropping Area	Area (ha)
Melaleuca forest	2,599
Canal	33
Road	3
Trial field	5
Total	2,640

Land Settlement Cooperatives was allocated a part of the area to the fifty four farmer's, but no cultivation is conducted in the allocated area.

4.2.4 Agriculture

The area is surrounded with the sand dune in which cashewnut, coconut, para rubber and paddy rice are grown, and ground-nut, mungbean, corn, cassava and vegetables are also planted in some small areas. As for livestock farming in the surrounding areas, cows, buffalos and swine are few. Chickens and ducks are raised to some extent. Fish culture is not prevailing in spite of some small ponds excavated in the sand dune.

In this area, no crops are cultivated, although various trials for cultivation have been carried out in the experimental fields. Considering the present growing conditions in the fields, some crops such as corn, sugar cane, eggplant, oil palm, pineapple and papaya may be grown, if proper liming and fertilizing are done. However, bad management of shallow groundwater table may be harmful to the crops. Some farmers are experimentally cultivating various crops in their swampy farm, but crop growing is not as satisfactory as in other general soil areas. Among vegetable crops, chili and eggplant, however, are cultivated relatively well. According to the farmers, pineapple is most beneficial in their planting crops. Para rubber and fruit trees are also cropped experimentally in the area.

4.2.5 Irrigation and Drainage

No irrigation system has been tried in this area. But for drainage, there is a 12 m wide canal with six connecting canals passing through the middle of the area. Including 7 km of natural canal, the total length is about 22 km. Of which 7.5 km lies in the F/S area. The 1.2 km long connecting canals have a width of about 3 m and drain water from deep inside of the swamp.

In the main canal, there are three gates at different places in order to control the excessive drainage from the swamp or to prevent intrusion of saline water from the sea. In the rainy season, some low lying areas along the canal banks suffer from flooding every year. RID has a plan to straighten the main canal to protect the water quality of natural canal from degradation. The major problem of Bacho canal is the blockade by sand dune at the outfall to the sea. The blockade keeps the canal inactive for most of the year. Only at the beginning of December, the canal becomes active for a few weeks when the sand dune is flushed away by flooded flow. The existing drainage system of Bacho F/S area is shown in Figure-9.

4.2.6 Farm Economy

(1) General

There is no village and no farming activities in this area. Therefore, the farm economic survey was carried out in the selected 8 villages and Bacho Land Settlement Cooperatives on the margin of Bacho swamp. In this section, the results of the survey are summarized. The details are shown in Appendix I.

The average family size is 6.1 persons of which 2.9 persons are active. The average of land holding per farm is 22.0 rai of which 9.6 rai are located in the peat swamp area. Farmers cultivate in average 2.2 rai of paddy, 1.4 rai of rubber, 2.9 rai of coconut and 0.6 rai of vegetables etc. The average age of a family head is 50.8 years. Sixty-four (64) percent of family heads have completed primary school 4 levels.

(2) Employment and occupation

In the Bacho area, farmers are mainly engaged in the production of paddy, rubber, coconut, vegetable and livestock raising, and a combination of these activities. 90 percent of family heads are engaged in non-farm activities which means that only 10 percent are full time farmers.

For the working status of family members, 2.9 persons are engaged in some working either permanently or temporarily. This is a very important contribution to the household cash income.

(3) Land holding and land utilization

The average land holding of 22.0 rai is owned by the farmer himself. This figure is lower than the provincial average of 25 rai. The land under cultivation accounts for 11.1 rai or 50 percent of the land. The land utilization in the Bacho area is as follows.

Description	Acreage (rai)
Under cultivation	11.1
House	1.3
Rent out	
with charge	0.1
no charge	0.0
Fallow	9.5
Lease hold	0.0
Total area	22.0

Note; Number of plots is 3.6
The surveyed farmers are located on the margin or outside of the F/S area.
Source; Farm economic survey, October 1992

(4) Farm household income

The cash income per farm is 44,432 Baht which comes from both the farming and non-farming activities excluding non cash income. The gross farm income accounts for 13,347 Baht, while the non-farm income in monetary term is 33,307 Baht, or 2.5 times as much as the farm cash income.

The farm expense is 17 percent of the gross income or 2,222 Baht which implies that agriculture in the Bacho area is extensive. The farmer spends 30,925 Baht for living and saves a total of 13,507 Baht (see Table-7).

(5) Agricultural activities in the peat swamp land

In average, farmers have 9.6 rai of land in the peat swamp area including both in and outside the F/S area. Half of peat land holding is under

cultivation with an area of 4.3 rai of which 3.0 rai are for mostly young rubber plantations.

There are 5.4 rai of fallow land in the peat swamp land. The survey shows that 53.6 percent of farmers had cultivated in the peat swamp land before,and they could get approximately 80 kg of paddy per rai before the adverse soil conditions caused by the development of acid sulfate soils began. A few farmers make handicraft goods from natural bush and charcoal in the swamp.

4.3 Kab Daeng F/S Area

4.3.1 Location

This area is located in Tambon Praiwan of Amphoe Tak Bai, along the eastern side of Thanon Tak Bai. North is bounded by a road at Ban Sapom and south is by Nam Baeng canal. F/S area covers 502 ha of the villages Ban Sapom and Ban Khok Kraduk Mu.

4.3.2 Physio/Topography

This area lies within the Kab Daeng swamp. Although elevation of surrounding area is between 2~5 m. The area is located in a long and narrow band of the coastal sand dune with an elevation of about 2.0 m.

The area is in a coastal plain composed of alluvium, being bounded by sand dunes elongating northwest-southeast. Shallow groundwater table was 1-4 m below the surface in the sand dune areas according to the field survey conducted in October '92. The water quality (pH) varied between 3 and 7 in the area. However, the places of pH 3 and 4 are limited. EC is less than 300 µs/cm in the area (see Figure D-10, Appendix D).

4.3.3 Soil and Land Use

(1) Soil

Soil of this area consists of four kinds of soil series, which are Narathiwat, Kab Deang, Rangae and Thon Sai series. Among the series, Narathiwat is distributed in 77% of the total area. Thon Sai, Kab Daeng and Rangae series occupy 10%, 7% and 6%, respectively. Kab Daeng series with a peat thickness of less than 1.0 m lies in the southern part (see Figure-10).

Narathiwat and Kab Daeng series in this area have a hemic surface soil with a moderate level of decomposition. The pH is around 5, which is higher

than that of the Bacho F/S area in all horizons. This can be due to the oxidization of pyrite in the substratum being prevented by flooded soil.

Rangae and Thon Sai series belong to the potential acid sulfate soil and include pyrite within one meter from the surface layers. Rangae series can be divided by severity of pH in surface soil into two: soils with pH 4.5-4.9 and pH 4.0-4.4.

Thon Sai series distributes between the sand dunes and consists of a rough and loamy texture, compared to that of the Rangae series, and pH range between 4.0-4.9. The results of soil survey are shown in Figure E-3 and Tables E-8 and E-11 to 13 in Appendix E.

(2) Land use

The area was developed a few years ago for paddy cultivation, but yields were very low. At present, it is almost entirely occupied by the melaleuca forests, though in some portions, paddy culture is performed only in the rainy season. And other portions, cashew nut plantations are seen. If farmers could manage the area through a suitable technology, it could be highly productive for paddy. Based on the field survey and topographical map (1:5,000), present land use is as follows (refer to Figure E-9, Appendix E).

Land or Cropping Area	Area (ha)
Melaleuca forest	385
Cashewnut field	16
Grass land	12
Canal	12
Road	6
Vegetable crop field	1
Village, non-agricultural use	70
Total	502

A part of north area has been allocated by Forestry Department to farmers, but the rest remains unallocated.

4.3.4 Agriculture

There is no systematic farming activities in this area. In most parts of the surrounding areas, agricultural conditions are the same as in the Bacho area, in which cashewnut, coconut and paddy rice are prevailing, and para rubber, ground-nut, mungbean, corn, cassava and vegetables are few.

As for livestock, rearing of cows and buffalos seems to be more active than in the Bacho area. Free raising is generally done in the garden. Fish culture is not prevailing, same as in the Bacho.

In some parts of abandoned land, farmers attempt to cultivate paddy after burning the melaleuca forest in the area with shallower peat layer.

4.3.5 Irrigation and Drainage

This area does not have any irrigation network at present. RID has a plan to irrigate in the near future. According to the plan, water will be pumped by two 0.3 m^3/s capacity pumps from Nam Baeng canal and supplied to the area through an irrigation canal network.

In this area, drainage is accomplished by two drainage canals with different lengths run from north to south. The longer one starts from the northern boundary of the area and passes through the middle. It has a total length of 7.2 km upto the gate, just before the outfall to the Nam Baeng canal. To facilitate drainage from low lying areas in the right side of the canal, there are a few connecting canals. Another drainage canal, only about 500 m apart toward Thanon Tak Bai has a length of about 1.6 km, flow directly to the Nam Baeng canal.

Regarding fresh water source, Nam Baeng canal is the only one. Though before making any use of this water, quality has to be taken into consideration, because blockade by sand dune at the outfall to the sea for most of the year makes the canal water stagnant and additional inpouring of drained water makes it worse. RID has been encountering this problem. Flooding does occur in this area every year, but depth and duration are less than the other two F/S areas. Detail of the existing drainage mechanism and future irrigation plan is shown in Figure-11.

4.3.6 Farm Economy

(1) General

Though a few vegetable cultivation is observed in the small limited area, the agricultural activities in this area can be considered nil. Therefore, the farm economic survey was carried out in the selected 8 villages on the margin of the Kab Daeng F/S area. In this section, the results of the survey are summarized (the details are shown in Appendix I).

The average family size is 5.7 persons of which 3.1 persons are active. The average land holding per farm is 19.7 rai of which 4.1 rai are located in the peat swamp area. The cultivated land per farm is 3.4 rai of paddy, 3.5 rai of rubber, 2.5 rai of coconut, 0.7 rai of vegetable and 0.5 rai of other crops. The average age of a family head is 51.4 years. Sixty-three (63) percent of family heads have completed primary school 4 levels.

(2) Employment and occupation

The cultivated crops in the area are similar to those in the Bacho area, and are mainly included paddy and rubber with this latter crop being more important than at Bacho. Half of the family heads are engaged in non-farm activities. Most farmers depend on the family labor for agricultural production and partly on some hired labor specially during the harvest season.

For the working status of family members, 3.1 persons get an employment opportunity in Muang Narathiwat either permanently or temporarily. Some of the Muslim youth are earning cash income from daily wage labor in Malaysia.

(3) Land holding and land utilization

The average land holding per farm is 19.7 rai of which 19.6 rai are cultivated by owner, 0.1 rai is rented out to others. The land under cultivation accounts for 14.1 rai or 72 percent of the area, which shows more efficient land use than in the Bacho area. The land utilization in the Kab Daeng area is as follows.

Description	Acreage (rai)
Under cultivation	14.1
House	1.1
Rent out	
with charge	0.0
no charge	0.1
Fallow	4.5
Lease hold	0.2
Total area	19.7

Note; Number of plots is 3.9.
The surveyed farmers are located on the margin or outside of the F/S area.
Source; Farm economic survey, October 1992

(4) Farm household income

The net cash income per farm household is 47,704 Baht excluding non cash income. Farm gross income amounts to 15,797 Baht, while non-farm income in monetary term is 35,960 Baht, 2.3 times as much as the farm cash income.

The farm expense is 26 percent of the gross income or 4,053 Baht which is lower than the regional average of 38 percent. The farmer spends 29,071 Baht and saves a total of 18,633 Baht. This saving is the highest of the three areas (see Table-7).

(5) Agricultural activities in the peat swamp land

On average, farmers have 4.1 rai of land in the peat swamp including both in and outside the F/S area. Sixty one (61) percent is under cultivation with an area of 2.5 rai which is mostly for young rubber plantation. There is 1.6 rai of fallow land. The survey shows that 43.8 percent of the farmers had cultivated the peat swamp before. They could get approximately 90 kg of paddy yield per rai before development of acidity.

4.4 Mu No-Koknai F/S Area

4.4.1 Location

The area is located within the Tambon Pron and Tambon Kun Thong of Amphoe Tak Bai. The villages include; Ban Khok Chum Bok, Ban Khok Yang, Ban Khok Nai, Ban Khok Krathom, Ban Khok Thurian and Ban Khok Ku Wae, covering an area of 756 ha. The area is about 5 km away from Tak Bai main township and on the right side of the highway to Sungai Kolok.

4.4.2 Physio/Topography

Originally this area is a part of To Daeng swamp with flat landscape. Most of the area has been cleared up. The elevation of the area falls between 1~2 m. The area has a good road network system due to the provision of dikes along the irrigation canals.

The northwestern part of the area including Khok Nai village is a coastal plain, where sand dunes are formed. The southern part is a flood plain of the river Kolok. Shallow groundwater table was less than 1.0 m below the surface in the alluvial area and 1.5-3 m below the surface in the sand dune areas. The water quality (pH) varied mostly between 2 and 4 in the alluvial area, and above 5 in the sand dune areas (see Figure D-11, Appendix D).

4.4.3 Soil and Land Use

(1) Soil

This area is almost completely occupied by acid sulfate soil, which can be divided into actual and potential ones. Actual one consisted of Muno series, occupies 36% of the area. Potential one includes Rangae and Thon Sai series which occupy 55% and 6%, respectively. The peat soil belongs to the Narathiwat series distributes in only a small portion, 3% of the area (see Figure-12).

Percolation rate of Muno series is generally poor in the subsoil due to high viscosity. However, in the soil profile dug in the area, the presence of some cracks is observed in the subsoil. The cracks may produce jarosite and higher rate of percolation. The Range and Thon Sai series have pyrite inside of the substratum. The former is clayey and the latter is loamy. Detailed data are shown in Figure E-4 and Tables E-9, E-11 to 13 in Appendix E.

(2) Land use

From the central to the southern part of this area, land was developed for paddy field several years ago, but the farmers later gave up cultivation due to high acidity. Recently, this area has become a pasture area with melaleuca occupying a portion. Some parts of the land with high ground elevation levels have been used for para-rubber plantation. The northern part of this area is mostly occupied by melaleuca forests because of bad soil conditions. However, small areas of grassland can also be seen. Based on the survey, present land use was found as follows (refer to Figure E-10, Appendix E).

Land or Crops	Area (ha)
Pasture	374
Melaleuca forest	164
Waste lands	67
Villages	36
Natural forests	35
Para-rubber forests	21
Canals	19
Paddy fields	15
Coconuts	14
Roads	10
Others	1
Total	756

Most of area has been allocated to farmers, except for a part of area adjacent to the conservation zone in the swamp.

4.4.4 Agriculture

Most of the area is not used for agricultural activities. In the low-lying land, only paddy rice is cultivated, due to poor drainage ability of prevailing heavy clay. On the other hand, in the surrounding higher elevation land, coconut and para rubber are planted. Vegetables are also cultivated in the garden for private use. Livestock farming is more active than those in the other two F/S areas, since the grass land is extended. It has been said that

the grass in this acid soil area is not suitable for feeding, due to low nutrient. Recently, the land seems to be fertilized by the stool and urine of animals.

There are some fishery ponds in the area, which get water directly from the irrigation canal close to them. Average size of one pond is 1.0 rai, and it is operated cooperatively by four farmers.

4.4.5 Irrigation and Drainage

This area has a proper irrigation system constructed by RID. Irrigation is accomplished by taking water from Muno canal by gravity. The source of Muno canal is Kolok river. Depending on the discharge in the canal, pumps are also used to withdraw water, especially during the months of February, March and April. Present system has a command area of 6,200 rai, of which 3,000 rai is under paddy cultivation.

Overall drainage in this area is accomplished mainly by three natural canals originating from To Daeng swamp. These are Klong Khok Phai, Klong Khok It and Klong Khatom. After traversing the F/S area, they join near the high way. After taking a new name as Klong Lan, it falls into Pu Yu. Gates are installed in each canal, which are supposed to be handled according to the concept that water level is maintained at 0.5 to 1.0 m of elevation for conservation of swamp forest. Northeast and west area suffer from severe flooding at a depth of 0.5 m to 1.0 m for a period of about one to two weeks. Details of the existing irrigation and drainage systems are shown in Figure-13.

4.4.6 Farm Economy

(1) General

Paddy and rubber cultivation can be seen in the small limited area. But, most of the area is occupied by abandoned land in which agricultural activities are not recognized. Therefore, the farm economic survey was carried out in the selected 7 villages on the margin of Mu No-Koknai F/S area. In this section, the results of the survey are summarized (the details are shown in Appendix 1).

The average family size is 4.7 persons of which 2.8 persons are active. The average land holding per farm is 24.7 rai of which 8.4 rai are located in the swamp area. Farmers cultivate in average 10.6 rai of paddy in the wet season, 0.6 rai of paddy in the dry season, 0.7 rai of rubber, 3.2 rai of

coconut, 0.5 rai of vegetable and other. The average age of a family head is 51.4 years. Eighty-six (86) percent of the family head have completed primary school 4 levels.

(2) Employment and occupation

Paddy is the dominant crop in the area. Ninety-five (95) percent of the farmers answered that paddy farming is the most important activity.

For the working status of family members, 2.8 persons are engaged either permanently or temporarily in some kind of work. The main farm operators, 67 percent of family heads, work only on agricultural production activities. This figure is higher than the other 2 areas.

(3) Land holding and land utilization

Out of 24.7 rai of the average land holding, 24.2 rai are used by owners and 0.5 rai are rented out to others. In addition to the area of 24.2 rai, 1.2 rai of land is borrowed from others for cultivation. The land utilization is as follows.

Description	Acreage (rai)
Under cultivation	14.5
House	1.1
Rent out	
with charge	0.1
no charge	0.5
Fallow	8.6
Lease hold	1.2
Total	24.7

Note; Number of plots is 4.2.
The surveyed farmers are located on the margin or outside of the F/S area.
Source; Farm economic survey, October 1992

(4) Farm household income

The net cash income per farm household is 34,754 Baht excluding non cash income. Farm gross income accounts for 17,360 Baht, while non-farm income in monetary terms is 22,192 Baht, 1.3 times as much as the farm cash income.

The farm expenses amount to 28 percent of the gross income or 4,798 Baht which implies that agriculture is more intensive than the other 2 areas. The farmer spends 29,751 Baht for living and saves a total of 5,003 Baht (see Table-7).

(5) Agricultural activities in the Peat Swamp Land

On average, farmers have 8.4 rai of land in the peat swamp area including both in and outside of the F/S area. Half of the peat land holding is under cultivation with an area of 3.5 rai which is mostly for young rubber plantation. There is 4.9 rai of fallow land in the swamp land. The survey shows that 59.6 percent of farmers have cultivated in the swamp area before. They could get approximately 83 kg per rai of the paddy before developing soil acidity.

Present conditions of three areas are summarized in Table-8.

Table-7 Farm Cash Income and Farm Expense per Farm

(Unit; Baht)

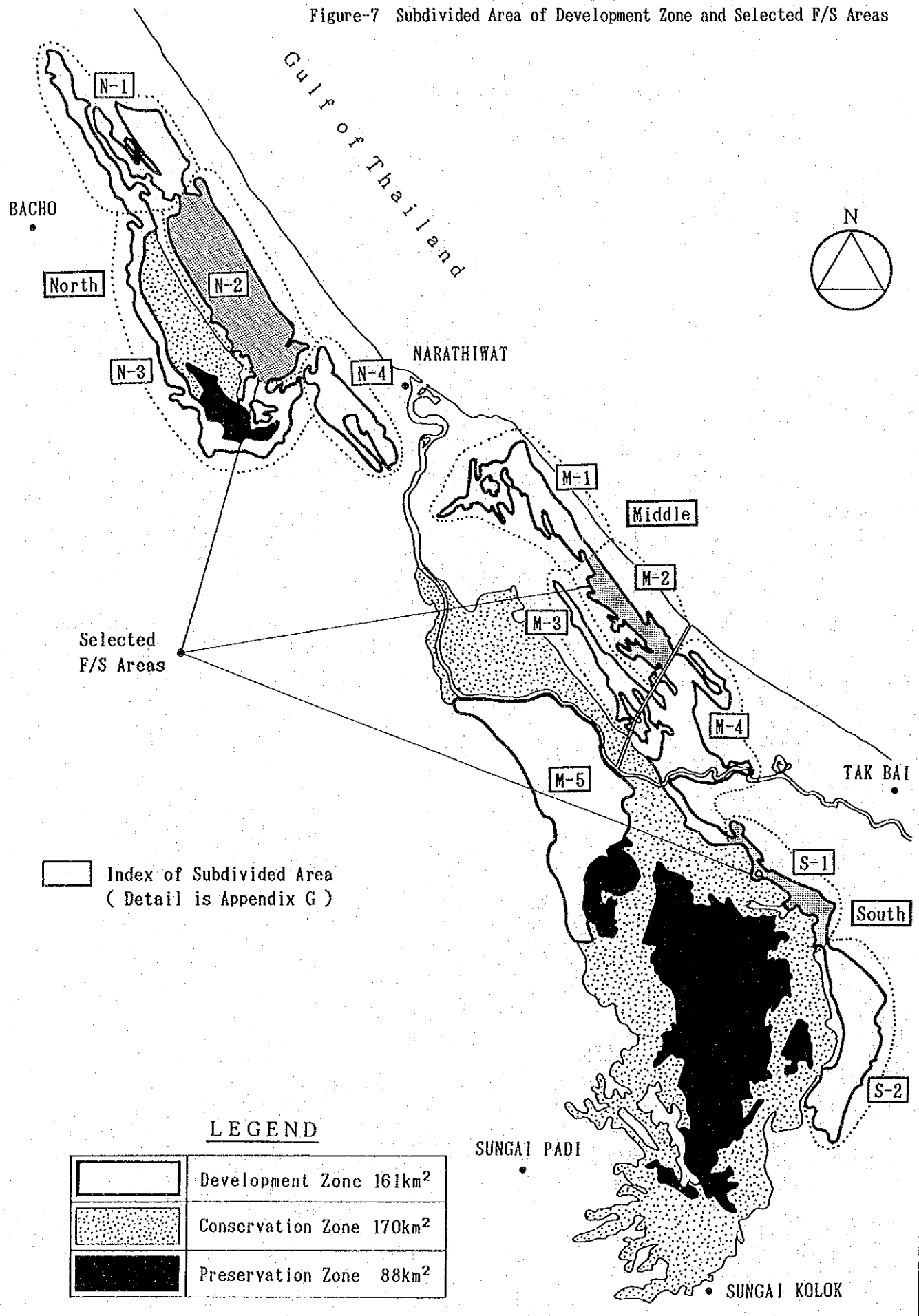
Items/Areas	Bacho	Kab Daeng	Mu No-Kokunai
1.Cash Farm Income	13,347	15,797	17,360
2.Cash Farm Expense	2,222	4,053	4,798
3.Net Farm Income(1-2)	11,125	11,744	12,562
4.Non Farm Cash Income	33,307	35,960	22,192
5.Farm Household Net Cash Income(3+4)	44,432	47,704	34,754
6.Farm Household Expense	30,925	29,071	29,751
7.Cash Saving(5-6)	13,507	18,633	5,003

Source ; Farm Economic Survey, 1992
Note ; The surveyed farmers are located on the margin or outside of the F/S areas.

Table-8 Summary of Feasibility Study Areas

Items	Bacho	Kab Daeng	Mu No-Koknai
Study Area (ha)	2,640	520	756
Soil (distribution rate)			
Thick peat	Narathiwat(98)	Narathiwat(77)	Narathiwat (3)
Shallow peat	-	Kab Daeng (7)	-
Potential acid	Thon Sai (2)	Thon Sai (10) Rangae (6)	Rangae (55) Thon Sai (6)
Actual acid	-	-	Muno (36)
Elevation (EL.m)	3.0～4.0	2.0±	1.0～2.0
Groundwater table (m) (below ground surface)	1.0±	1.0～4.0 (Sand dune)	1.0～3.0 (Sand dune)
Present land use	Melaleuca	Melaleuca	Pasture Melaleuca
Surrounding Agriculture (outside of the F/S areas)			
Crops	Paddy, Rubber Cashewnut	Same as Bacho	Paddy, Coconut Rubber
Livestock	Small (Chicken)	Same as Bacho	Cattle, Larger than two areas
Inland fishery	non	non	A few
Irrigation/Drainage			
Water resources	non	Available except for a part	Available for a part
Drainage canal	Existing	Existing	Existing
Inundation damage	Near by canal 0.5～1.0 m About two weeks	Less than two areas	A part of area 0.5～1.0 m About two weeks

Figure-7 Subdivided Area of Development Zone and Selected F/S Areas



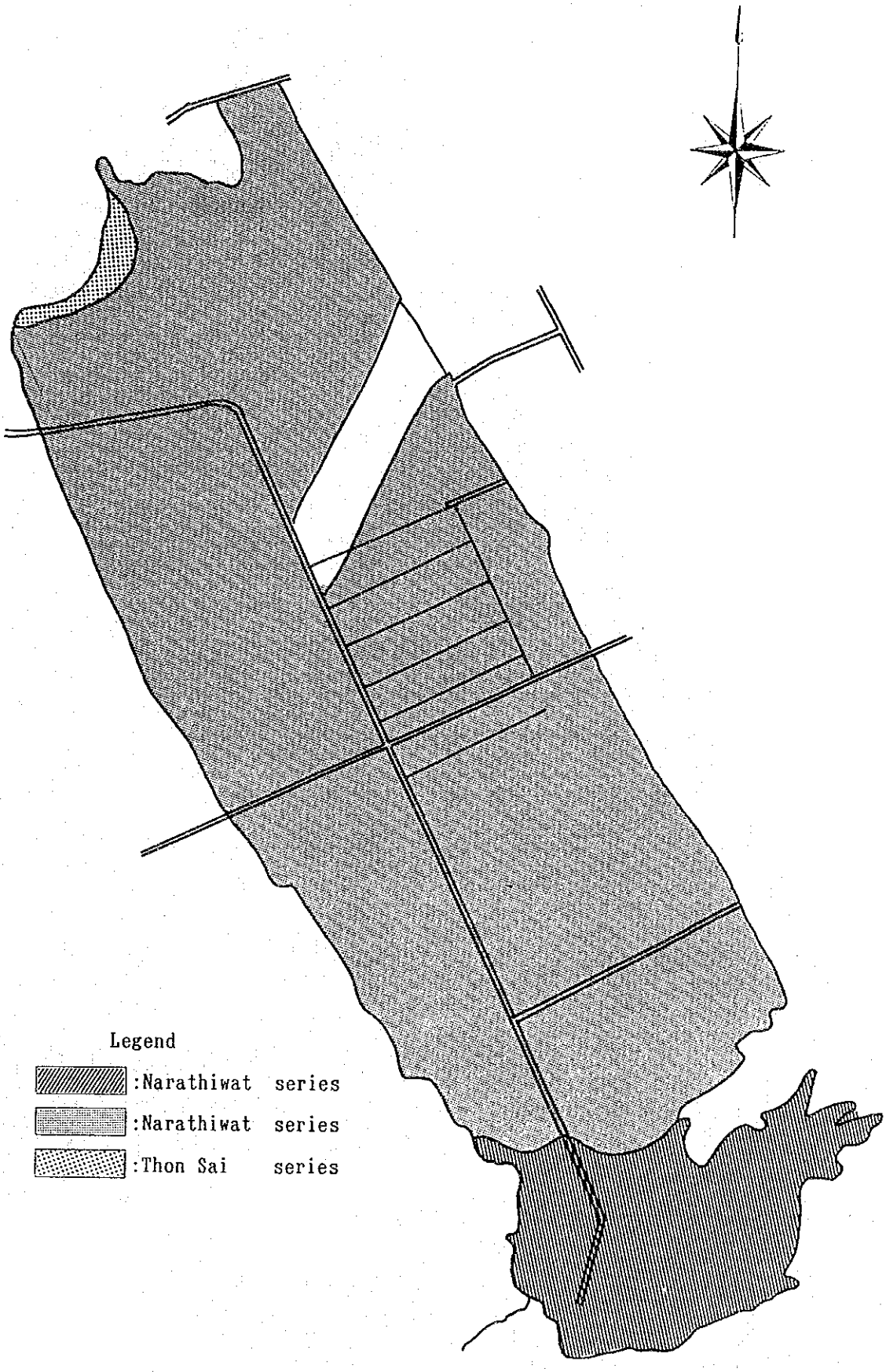


Figure-8 Soil series and Distribution in Bacho F/S area

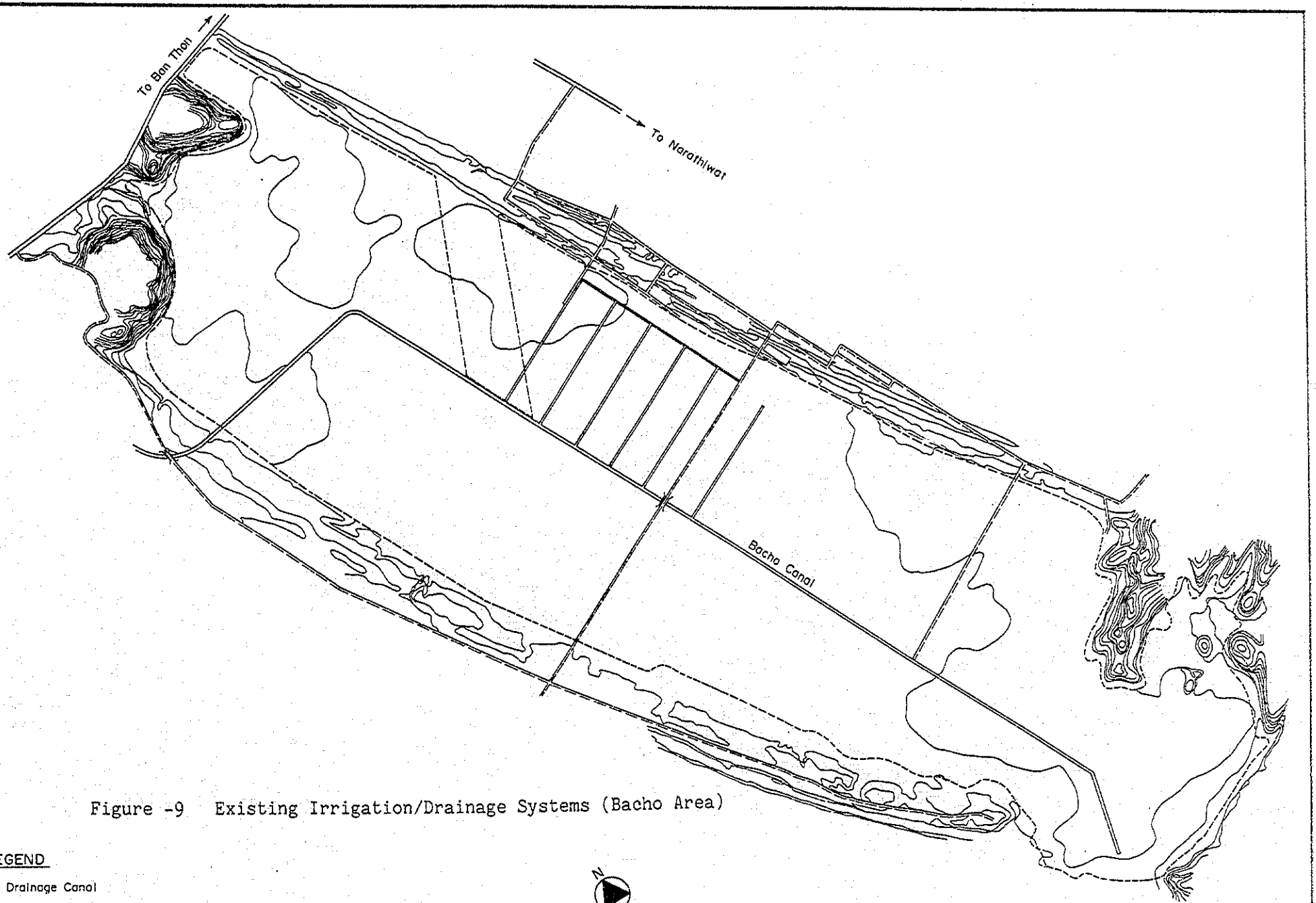


Figure -9 Existing Irrigation/Drainage Systems (Bacho Area)

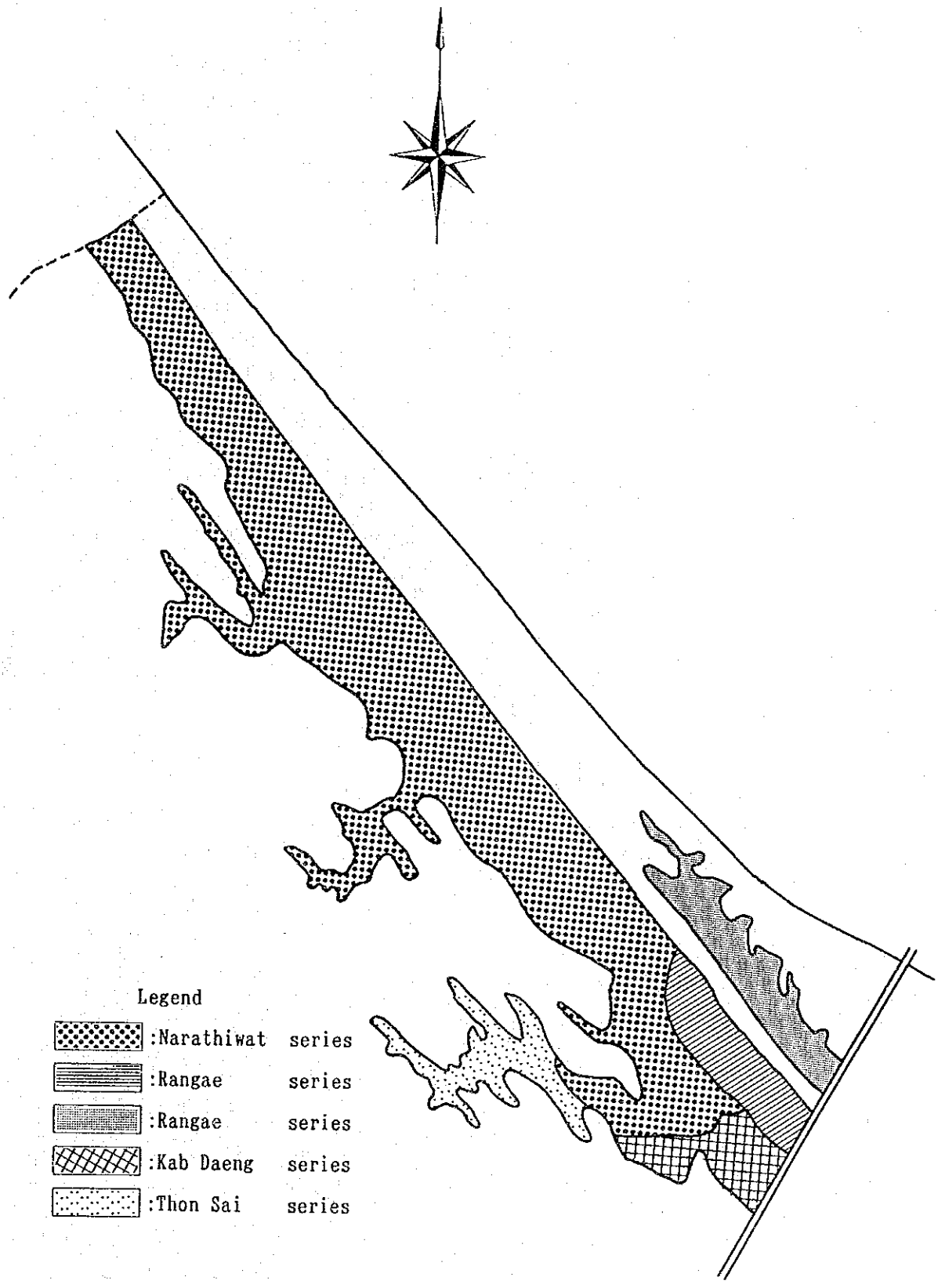


Figure-10 Soil series and Distribution in Kab Daeng F/S area

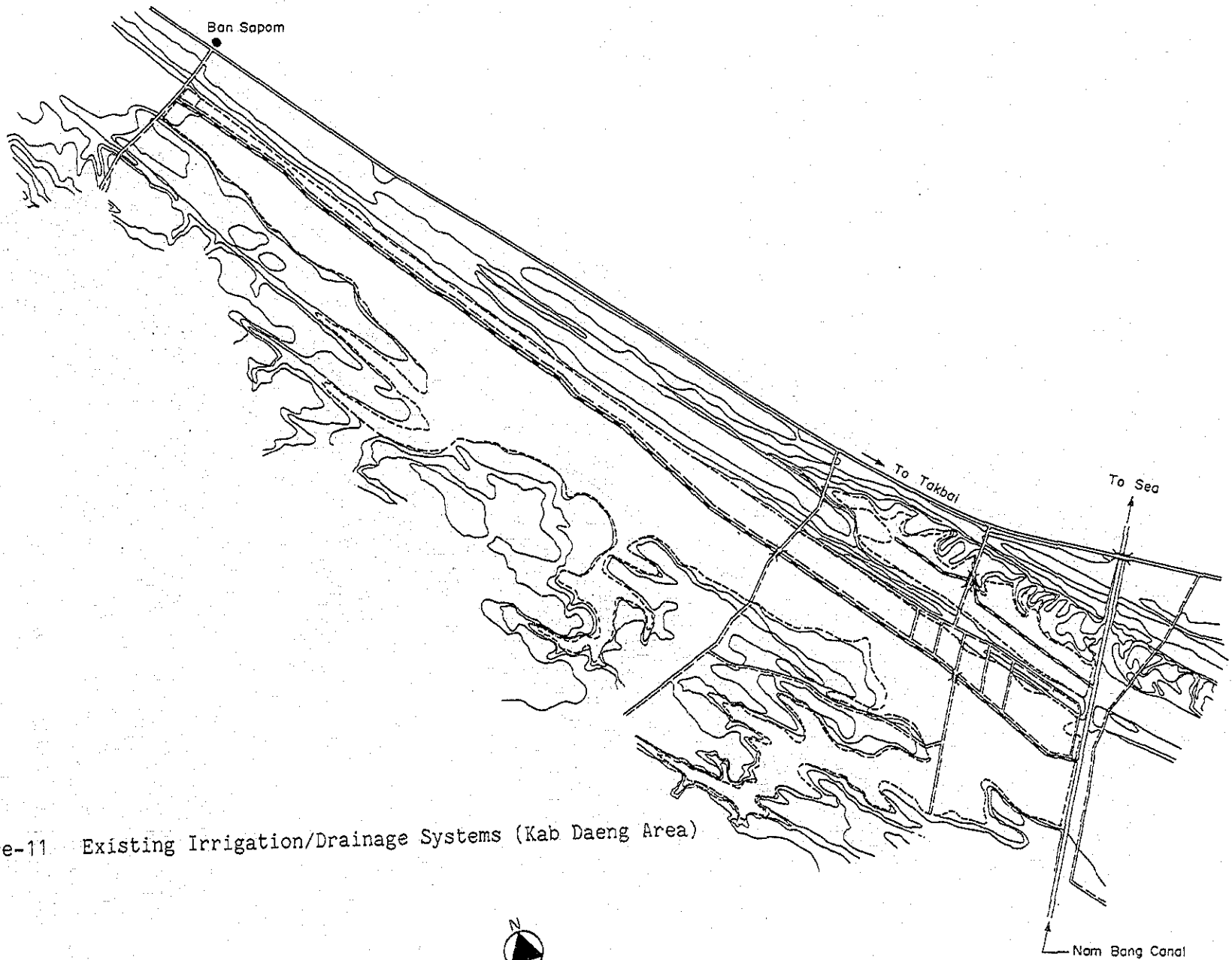


Figure-11 Existing Irrigation/Drainage Systems (Kab Daeng Area)

LEGEND

- Drainage Canal
- Road
- Project Boundary

N

0 500 1000m

S = 1:25,000

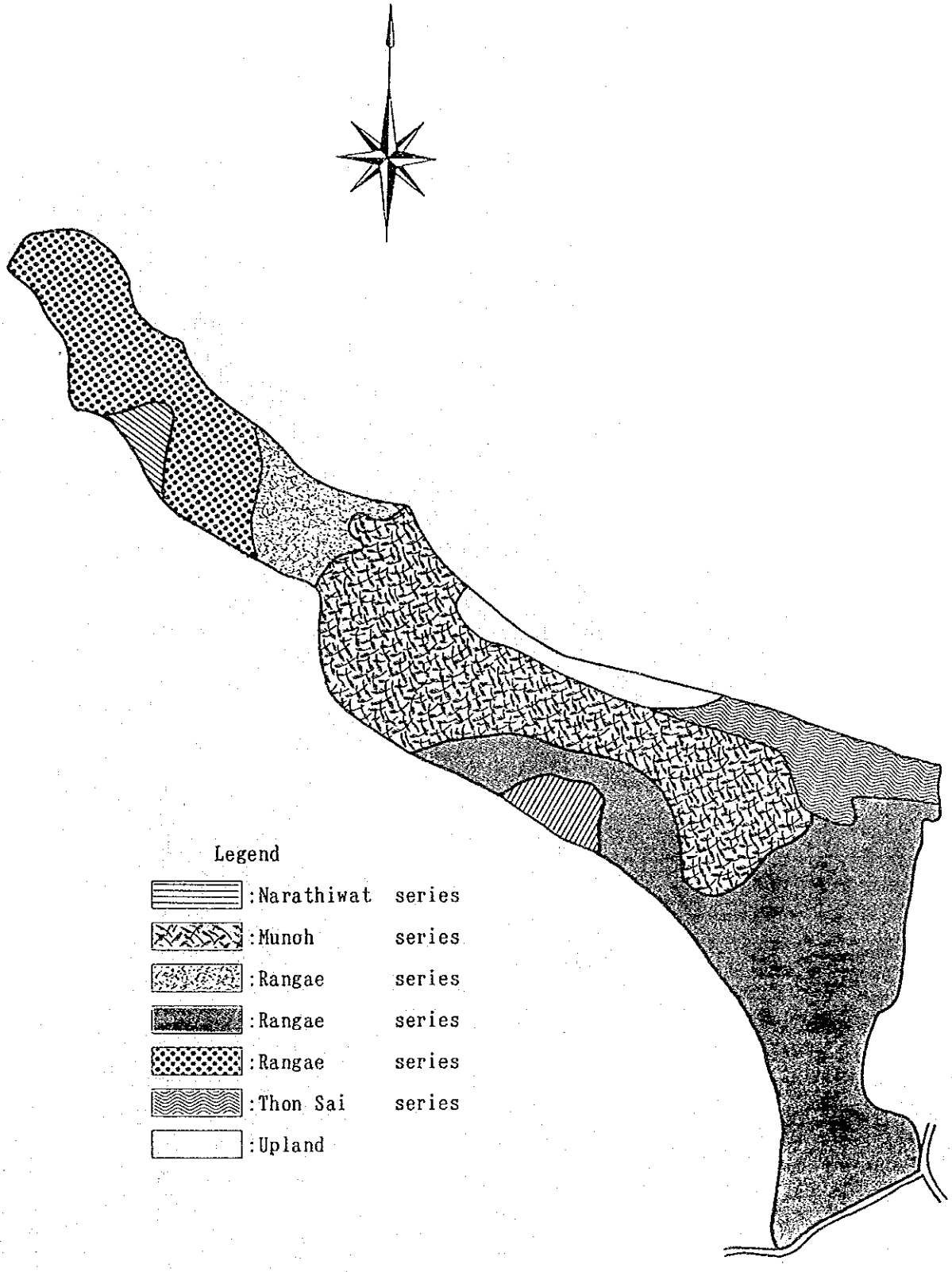


Figure-12 Soil series and Distribution in Mu No-Koknai F/S area

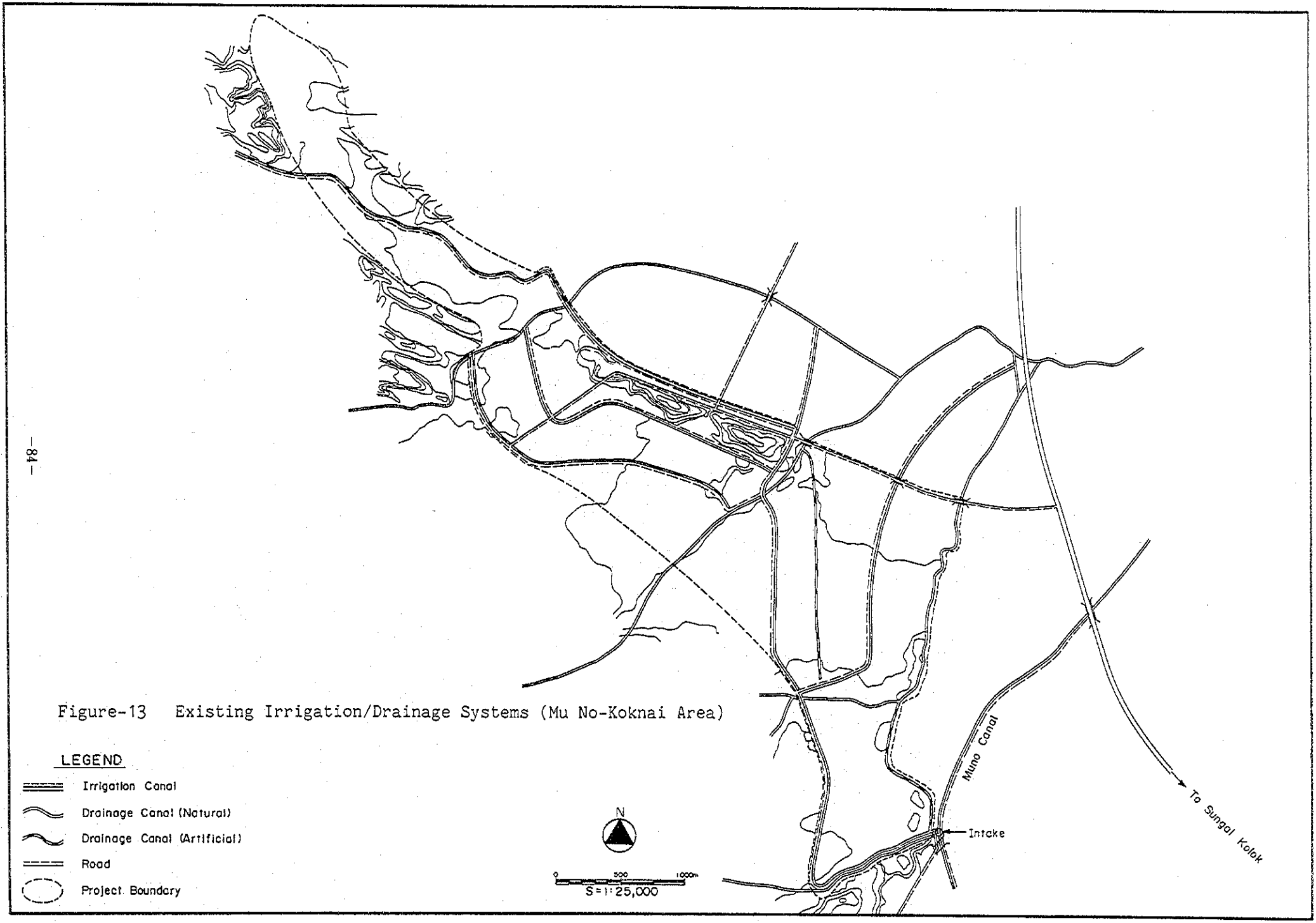


Figure-13 Existing Irrigation/Drainage Systems (Mu No-Koknai Area)

CHAPTER 5

DEVELOPMENT PLAN FORMULATION

CHAPTER 5 DEVELOPMENT PLAN FORMULATION

5.1 Objectives and Project Component

5.1.1 Development Objectives

Narathiwat Province can be characterized mainly as an agricultural area, in which most of the people are engaged in agricultural activities, and agricultural sector shares 40% of the provincial economy. However, widely distributed peat/acid sulfate soils obstruct the growth of crops in this region. As a result, farmer's income is very low compared with the other southern region and national average. Under this situation, development objectives were formulated as follows;

- To increase farmer's income and minimize regional differences for stabilization of their living by means of improvement of agriculture in peat/acid sulfate soil areas from viewpoints of soil, farming practices and agricultural infrastructures, and
- To conserve regional environment and natural resources by introducing sustainable agriculture in problem soils, and
- To establish a development strategy that will work as a model for other similar soil areas.

5.1.2 Basic Approach

Already some attempts at small scale reclamations have been made in the swamp area. Also, reclaimed lands were always abandoned after a few years due to poor soil productivity. Such attempts are changing natural swamp area into marginal land. Therefore, sustainable long-term land use planning should be introduced for moderate and systematic development in swamp area, taking changeable soil characteristics due to land reclamation into consideration.

Main subject for such planning is soil improvement. The improvement strategy should be workable at administrative level, and techniques should be practicable as a part of daily farming in farmer's level. It should be established keeping close combination with all possible measures in various fields, taking into account of farmers' economical conditions. Farming program should be designed based on an elaborate introduction plan of acid-tolerant crops and should cope with the expected soil productivity in the process of soil improvement.

The peat swamp development schemes mostly involve forest clearing, burning, drainage, and construction of road and polder dike. All these practices will give significant impacts on the surroundings. Their positive and negative effects will vary depending on development design and management systems. It is, therefore, necessary to evaluate environmental impact carefully.

From viewpoint of ecosystem in swamp area, a part of development zone bordering preservation zone may be playing an important role as a buffer area between development and preservation. Ecological value may not appear in cost-benefit on an economical basis, but in a growing demand at global level to maintain valuable ecosystem, preservation of ecological value in swamp area should be taken into consideration in development plan formulation.

5.1.3 Project Component

In order to attain the above development objectives, the following components have been incorporated for carrying out.

1) To develop cultivatable land with agricultural infrastructure for stable farming activities and environmental preservation in swamp areas.

2) To provide on-farm facilities and soil materials with newly reclaimed land for improvement and conservation of soils and introduction of acid-tolerant crops.

3) To promote farmer's organization aiming at stabilization of their living, through farming activities on developed field.

4) To strengthen research and investigation activities to improve farming techniques in reclaimed land.

Considering a cost-benefit of the above mentioned project, input requirements cannot but rise to get a certain amount of agricultural outputs, as far as the soil improvement is required additionally, compared with development on other general soils. Also, costly operation and maintenance such as periodic fertilization and liming are also indispensable for sustainable farming practices.

5.2 Development Plan Formulation in Bacho F/S Area

5.2.1 Basic Approach

Development constraints in this area are existence of thick peat, lack of irrigation water and inundation.

(1) Possibility of water resources development

Water resources development with good quality is essential for crop growing. Its present condition is outlined as follows.

- Surface water development
  At present, this area is not included in the Sai Buri river development project. Then, the Pa Ra Du Be river which is one of tributaries of the Yakang would be regarded as a water source. According to the field investigation, however, much flow was not recognized except in wet season. There is another constraint which is that intake water should be lifted and conveyed through the conservation area into the study area. In any case, surface water development will encounter many difficulties, from viewpoint of the cost-benefits.

- Groundwater development
  At present, possibility is not certain because of lack of data on physical conditions. Moreover, development of groundwater itself, and operation and maintenance of supply system generally become very costly. Ultimately this cost would go on the shoulder of the farmers. At initial stage, uncertainty of sufficient production in the newly developed peat area, would put the farmers at risk for paying the money back. Preliminary analyses on this are shown in Appendix D-1.

- Construction of irrigation ponds
  As an alternative, ponds are taken into consideration. They are planned in and around the F/S area to store irrigation water during the wet season. But those ponds have to be capable of storing a large amount of water that will be needed for agricultural use. On the other hand, there is hardly space left in sand dune areas for constructing a large scale pond. Construction of ponds and irrigation canals in the peat area will also require good amount of investment for physical improvements to secure water quality and to prevent subsidence. Therefore, construction of large

scale ponds for agricultural use will be impractical at the initial development stage of peat area.

Considering the above facts, systematic water resources development can not be expected at present. Therefore, development is largely restricted to small scale.

(2) Irrigation water supply in peat soil

The most effective way to supply irrigation water with good quality is by gravity from ground surface into root zone. It prevents capillary water with bad quality to move upward into root. In peat layer with high permeability, however, a lot of water is required as a countermeasure against capillary rise. Therefore, this way can not be applied in this area, due to lack of good quality water.

It is planned to supply water by capillary rise from shallow groundwater into root zone. In peat, however, capillary acid-water has to be neutralized before it reaches root. Then, it has to be treated with lime for neutralization.

(3) Necessity of drainage

Drainage is sufficiently needed to convert undeveloped peat area into cultivated one to produce a certain bearing capacity and aeration of soil. However, rapid drainage has to be avoided progressing unequal subsidence.

5.2.2 Land Use Planning

(1) Zoning

Based on the various conditions, this area is subdivided into three blocks which are designated as follows.

- Development block
  This block will be reclaimed as a cultivable land. Canal system and water control facilities will be provided for better management of groundwater movement. On-farm facilities will also be constructed for farming activities.

- Water retention block
  This block will be used as water conservation land and kept submerged as long as possible to minimize the peat wastage. Runoff water during wet

season is supposed to be stored and regulated temporarily in this area to alleviate flooding damage into the downstream area. Storage water will be used gradually for irrigation purpose in the development block.

- Undevelopment block
  This block will not be developed immediately. Therefore, subsidence, burning, submergence and decomposition of peat will take place as usual, unless any special care is taken.

The above blocks will be enclosed by roads or dikes, and water in the blocks will be controlled by some check facilities, in different ways.

(2) Alternative land use plans

Based on the above concepts, the following alternative plans are considered.

Case-1; More attention to development is paid to only the land settlement areas already allocated by the Bacho Cooperatives, as shown in Figure-14. Southern area of the central road is used as a water retention block. Downstream area is considered as undevelopment block.

Case-2; In addition to the development block in the above Case-1, southeastern part is also included in the development, of which depth of peat layer is considered to be relatively shallow with average from 1.0 m to 1.5 m. Adjacent upstream areas are planned to keep as water retention block, as shown in Figure-15.

Case-3; Under the same concepts as the Case-1 and 2, agricultural use is maximized in the swamp area. The development blocks are delineated based on the water balance study for water requirement. Their allocations are planned by taking account of the peat soil distribution, and the new route of the drainage canal connected with the present canal which is planned by RID, as shown in Figure-16.

In each case, infrastructures are provided with same improvement level. The land use and construction cost are shown as follows.

Items	Unit	Case-1	Case-2	Case-3
1. Land use				
- Development block	ha	225	618	909
- Water retention block	〃	1,020	827	1,071
- Undevelopment block	〃	1,395	1,195	660
Total		2,640	2,640	2,640
2. Construction cost	1,000 Baht	46,100	111,800	188,200
(Cost per ha)*	Baht	205,000	181,000	207,000
(Cost per rai)*	〃	32,800	28,900	33,100

* Area is based on the development block.

As an evaluation from the economical viewpoints of unit construction cost, the case-2 is lowest. However, for development in this area, the following points are considered.

- In general, development approach should be showed by a strategy of minimizing soil disturbance.
- Farmer would be reluctant to start cultivating in peat land, provided that land would be reclaimed incompletely, because of uncertain factors on agricultural inputs and outputs.
- Already allocated land has to be developed urgently for encouraging settlers to stabilize agriculture.
- Case-2 and 3 can be carried out in future, based on an economical viewpoint of outcomes from case-1.
- From technical point of view, uncertain factors such as detailed distribution of peat thickness and physical conditions of subsoil beneath the peat layer, still remain to be studied before overall agricultural use of peat land.

Taking DLD's basic policy and intentions of relevant agencies into consideration, case-1 is recommended for feasibility study.

5.2.3 Water Resources Development

Southern part with 1,020 ha will be used as a water storage area, in which rainwater will be conserved in the peat layer as much as possible during the wet season. Storage water will be supplied gradually to the adjacent development block with shallow goundwater for following dry season crops. Amount of water to be conserved was planned based on water balance study with average rainfall between the two blocks, presented below.

(1) Evapotranspiration (ETo)

ETo was calculated on the basis of FAO recommended Penman method.

Unit : mm/day

Month	J	F	M	A	M	J	J	A	S	O	N	D
Eto	4.6	5.0	5.0	4.9	4.2	3.7	3.3	4.1	3.6	3.6	3.3	3.4

(Detail of the calculation is presented in Table C-1, Appendix C)

Relation between rainfall and evapotranspiration shows that water shortage generally takes place from January to April.

(2) Water requirement

It was estimated on a 10-day basis with effective rainfall and consumptive use of crops. Percolation loss from substratum was assumed at 1.0 mm per day.

Development block

Effective rainfall is applied at 75% of rainfall and not exceeded by an amount of consumptive use of proposed crops.

Water retention block

Water will be consumed in this block for its own forest community plants. Its amount was estimated based on rainfall and consumptive use of community plants.

Water balance study

Results are summarized as follows.

Block	Area(ha)	Water requirement
Development block	205	344 mm (704,000 cu.m)
Water retention block	10,200	566 mm (5,773,000 cu.m)

Note: - Kc was applied at 1.0 for forest plant in water retention block. (Detail is shown in Appendix G-6).
- Water requirement in development block is shown in Table G-5-B in Appendix G.

(3) Required storage capacity

It was estimated at 6.3 MCM, based on the above water requirements for both blocks. In this estimation, the value of efficiency is applied at 50% as conveyance loss from water retention block to development one, taking account of unknown factors in groundwater movement (refer to Table G-6-B, Appendix G). As a result, required water level comes to EL 3.9 m in the water retention block. Its standing depth of water is shown from 0.5 to 0.7 m on the ground surface at the central road. Water can move easily in peat layer due to its high permeability and porosity.

5.2.4 Soil Improvement Plan

(1) Burning

Initially, the burning of peat wood, roots and weed are necessary for constructing farm to not only help supply the required amount of lime, phosphate, potash, and copper sulfate but also remove the obstacle for farming. The burning also constitutes a means to control diseases and insect pests, but it has to be necessary to carry out intentionally considering the surrounding environment.

When burning is carried out, there are risks that fire may spread out extensively in the area. A better way would be to assemble the burning materials such as stumps and weed in a separate place and spread their ashes in the developmental area after burning under proper management. This method, however, has a drawback that effects of pest control will be limited.

(2) Study on improvement method

The soil has to be neutralized for crop growing by supplying some soil ameliorative materials. The value of soil pH 5.0 has to be set for

neutralizing target, because aluminum becomes active if the pH lowers than 5.0. To attain the target, there are two methods; Soil dressing and application of lime.

- Soil dressing

  Soil dressing is the best way to correct some synthetically related problems found particularly in fabric peat. Though this method is not generally practical in Thailand from a viewpoint of cost-benefit, the following consideration is taken.

  Ideally, the materials for soil dressing should include liming materials such as Dolomite. However, these materials should be applied to intensive agriculture in parts of the development zone, because they are very expensive, more than lime dust.

  On the other hand, cheaper materials can be obtained from the near-by swamps. Therefore, the Team surveyed the surrounding swamps to search for appropriate materials (refer to Figure E-5 and Tables E-10 and E-10-2), but most of the fertile soils in these areas are used for paddy or para-rubber cultivation, making it difficult to obtain good dressing materials. Materials found in the dug out sites on the hills in the surrounding swamps are unsuitable for soil dressing due to the presence of gravels which are rather appropriate for road construction. And as the results of the survey in upland and mountain foot, the lateritic soil used for making road has a high acidity (pH less than 4.0) and is, therefore, unsuitable as a dressing material. It is observed that good soil exists in the layer of about 1 m depth from surface, which is suitable for dressing. The volume of deposit is considered to be enough for covering the whole peat area. However, as their pH is almost lower than 5.0, it is necessary to apply it together with some lime (refer to Table E-10, Appendix E). In soil dressing, the rhizosphere of crop is different by each crop, but requirement is planned uniformly at 20 cm of depth on the peat surface.

- Application of lime

  The most effective liming material is lime dust from the Yala and Songhkla provinces, which contains a carbonate equivalent as high as 70-91 percent (refer to Table E-14-1, Appendix E). Lime requirement can be determined by the Woodruff method for pH 5.0, which is 30 t/ha considering the Narathiwat soil series in this area (refer to Table E-14-4, Appendix E). The lime has to be applied every four (4) years, as the neutralizing effect is not

continuous. The necessary amount for next four (4) years has to be adjusted to get the pH suitable for crop growing.

Economic comparison

The comparison of the economic effects of both measures is shown below.

① lime

Liming cost per ton

Item	Cost (Baht)	Remarks
Materials	300	Including cost of transportation
Labor cost for application	120	(1.2 person/ton)
Total	420	

If the project life is assumed 30 years, liming is required 7.5 times. As a result, total cost comes to 94,500 Baht per ha.

② Soil dressing

Unit cost per m^3

Item	Cost (Baht)	Remarks
Materials	70	Including cost of transportation
Labor cost for application	50	(0.5 person/m^3)
Total	120	

As soil material is applied only in the first year, total cost comes to 240,000 Baht per ha.

As adding up the cost of lime dust for neutralization is necessary, the soil dressing is more expensive. Therefore, in the beginning stage of development like this area, soil improvement should be carried out by application of lime. If an intensive agriculture can be developed in future, soil dressing becomes economical.

(3) Application method of lime

In general, the method of liming is broadcasting on the field. In paddy cultivation, the lime is mixed with soil at 15 cm depth; in the case of non flooded annual crops, ridges are made following the lime broadcasting and, as a result, the lime is incorporated into the ridges; in fruit cultivation, the

lime is uniformly mixed with the soil of the hole dug for the tree and its amount depends on the ratio of inter-hole distance and depth of the hole. Before cropping, it should be adjusted to get the pH suitable for crop growing. Further, when soil is adjusted every four (4) years, lime requirement is determined by Woodruff method (refer to Table E-14-3, Appendix E).

(4) The application of major elements

The major elements, particularly, phosphorus, and potassium are required for protecting against active aluminum. Application of potassium is also a good remedy for excess iron.

(5) The application of trace elements

The application of trace elements (Cu, Zn, B) is also necessary. These elements can be supplied in the fertilizer form as 20 kg/ha of copper sulfate, 20 kg/ha of sine sulfate and 20 kg/ha of borax, respectively or 4,080 kg of each fertilizer for the 204 ha of cropping area. Careful application of borax is necessary for an adequate supply of boron which is needed in only a small range. Foliar application of these fertilizer may be usually carried out whenever necessary. Further, it can be application of slow-release fertilizer and the slag including trace elements.

5.2.5 Agricultural Development Plan

(1) Crop selection

Soil acidity could not be neutralized completely, because of existence of organic acid, even if liming is applied on the field equipped with irrigation/drainage facilities. Therefore, crops are selected based on the following considerations.

- It can be grown even if soil pH lowers less than 5.0.
- It can be grown in 25 to 29 °C of average temperature.
- For paddy rice, local variety has high suitability for acid soil and is more productive than HYV.
- For upland crops, it has strong endurance for inundation. Cropping of vegetables may suffer injury by continuous cropping. In order to avoid such damage, crop rotation circled by vegetables, gramineous crops and

pulse crops should be applied for purification of soil, deep plowing and increase in soil fertility.

- It is chosen from the crops producing by way of trial, based on their marketing values.

- For tree crops, it is recommended to plant on raising bed. It is chosen from the crops with low height growth due to weak bearing capacity of peat soil.

As a result, the following representative crops are selected.

① Paddy crop: local variety

② Upland crop: Dent corn, Baby corn, Mungbean, Soybean, Long bean, Chili, Eggplant, Tomato, Cucumber, Okra, Swamp cabbage and Chinese Kale are suitable after neutralization.

③ Tree crop: Oil palm, Pineapple, Banana, Papaya, and mulberry are suitable. Considering marketability of oil palm, banana, and papaya, or technique of silkworm rearing, it is recommended to plant pineapple which is shrub, suits for acid soil, and has high marketability.

(2) Proposed cropping pattern

Proposed cropping area is planned at 204.4 ha (1,272.5 rai), based on the block area and amount of land required for infrastructures. Cropping acreage is allocated in a way of 120.6 ha, about 60% of whole area for paddy which is the main crop, and about 25% for upland crops. In addition, pond for inland water fishery with the area of 2.16 ha (13.5 rai) is planned.

As for cropping site, upland field is planned in the area close to village, so that farming can be practiced intensively. Tree crop is planted in relative higher elevation area for making raised bed. Paddy may be cropped in lower lying area near Bacho canal. Cropping pattern is summarized as follows.

Paddy crop : 120.64 ha (754 rai)
It is cropped during wet season.

Upland crop : 51.2 ha (320 rai)
Double cropping is recommended, except for severe rainy

season by applying crop rotation of gramineous crop, pulse crop and vegetable.

Tree crop : 30.4 ha (190 rai)
Pineapple is planted as a year-round cultivation.

Proposed cropping pattern is shown in Figure-17.

(3) Cultivation method for peat soil area

Following considerations should be taken for crop cultivation in the peat soil.

1) Planting density should be low compared to the standard level since peat soil is less nutrient.

2) Micronutrients (copper, zinc, iron, and boron) should be supplemented. Especially, iron is important for paddy crop to prevent sterility. Ten to twenty times of boron is needed for dicotyledonous plant than for monocotyledonous plant because physiological disorder occurs easily.

3) Groundwater has to be controlled under 60 cm as peat soil is weak, has high moisture holding ability and less bearing capacity. A principal rafter should be taken if a prop is needed.

4) Crop rotation helps to avoid replant failure of vegetables. Eventually, gramineous crops clean the soil, pulse crops improve soil fertility while vegetables are cultivated. However, three to five years fallow is required for Solanaceae crops (chili, tomato, eggplant, green pepper, or potato) which are easy to fail. Two to three years fallow is expected for ground family (cucumber, watermelon, melon, or pumpkin).

(4) Crop yield

A certain amount of crop yield could be expected at an initial stage of cropping, if lime dust is applied precisely, at an average of 4.8 ton per rai for keeping soil pH 5.0. However, soil fertility is low and micronutrients deficiencies is common in peat. In order to achieve expected yield, in addition to nutrients like nitrogen, phosphorus and potassium, application of Ca, Mg, B, Cu, Fe and Si will be required.

Generally, in peat soil, neutralizing is difficult, since acidity is produced anew as organic acid in peat is soluble. Therefore, it will be difficult to attain a standard target, as long as peat exists.

The target is determined by considering the experimental results in PRDSC, nutrient requirement, statistical data in the region and farm economy survey. Proposed targets of major crops are shown in Table-9.

(5) Production

Production is estimated based on the above mentioned target and cropping acreage, as shown in Table-10.

In practice, there are many choices for upland crops. In the table, as an example, most beneficial one is rotation of baby corn, yardlong bean and chili, depending on marketing prices.

As for livestock planning, the following can be produced after harvesting in this area.

Crop	Yield (kg/rai)	Area (rai)	Production (ton)
Rice straw	187.5 *	754	141
Residue of corn and bean	1,500	213	320

Note *: This is assumed at about half of rice yield.

(6) Inland fishery development plan

Fish culture can be practiced as a side job of agriculture. Major fishes in this region are catfish and tilapia. Their growing period is about three months. Fingerlings can be obtained from DOF, Narathiwat. Excretion of livestock and rice bran are also available for fish growing.

A pond is planned in the area near by sand dune, supposing that it could be well managed by a farmer's group. Total area comes to 21,600 sp.m for 54 families, as 400 sq.m per one family. Liming is required at the rate of 6.0 to 8.0 ton per rai at the initial stage before rearing. After the first year of farming, its requirement will be reduced on the average 3.5 ton per rai. After five years, liming may be reduced gradually.

Fishing opportunity is expected two times a year. First catching should be performed by using nets and the second by complete drainage. Total production comes to about 40.0 ton, according to the standard of DOF. As a result, a family could gain about 5,000 Baht a year, if all conditions inclusing bait are well operated.

(7) Livestock development plan

In this area, pasture is not cultivated, but straw and remains of corn and vegetables are taken as feed. 2,190 kg of dry pasture is needed annually to raise a cow in this area, and feeding has to be done every day. Therefore, it is recommended to graze the cows in the paddy field after harvesting or give them remains of corns and vegetables in the garden. In this way, 4 cows can be raised per farmhouse.

Chicken can be also raised by rice bran and corn. Necessary amount of feed amounts to 33 kg in a year so as to rear 1.5 kg chicken. If a family raises twenty chickens, as an example, feed requirement is assumed at 660 kg. Amount of rice bran and corn produced from a family is not enough to raise them. Then, dent corn has to be cropped widely for getting additional feed.

Utilization of feces of farm animals

It is estimated that a cattle can produce 5.5 ton of feces per year. Of which night production is assumed about 1.0 ton. Therefore, if a family could get an average of 4.0 ton from four cattle, it would be used as a compost for cropping field.

Chicken manure could be also produced. Amount is assumed about 1.1 ton a year, if a family raises twenty chickens. This manure is useful as a fertilizer for cropping on acid soil because it contains much phosphorus.

5.2.6 Agricultural Infrastructure Development Plan

(1) Land reclamation

In order to make cultivatable land, cutting, bush clearing, uprooting, removal of stumps, firing and land grading are required in the development block.

(2) Irrigation planning

Sub-irrigation method is applied in this area, of which water will be supplied by capillary rise from shallow groundwater maintained at required level. In upward movement of water, acidified water is most likely neutralized by lime. Groundwater is supposed to recharge from water retention block through some culverts under road. Seasonal water requirement of proposed crops is calculated as shown in Figure-18. Maximum requirement comes to 0.136 cu.m/s in first decade of February (details are shown in Table G-5-B, Appendix G).

(3) Drainage planning

This area is one of the sub basins connected with each other in a comprehensive drainage basin. Gravity drainage is possible, as long as overdrainage which may cause unexpected subsidence is carefully avoided. But if the area is allowed to drain unconditionally during flooding, inundation damage would spread all over the low-lying downstream area where inundation occurs every year.

Therefore, in order to cope with the flooding, overall canal improvements are required in the whole basin. On the other hand, from a view of overall agricultural benefits in the basin, this area may play the role in flood control, until all of the canal improvements are completed. Therefore, even if a drainage system would be improved in this area, inundation damage would remain to some extent.

Development concept

Drainage problem is approached as follows.

① Water retention block functions as a flood control reservoir, in order to mitigate the hard gate operation of Bacho canal and the inundation damage in the development block.

② Canal network is provided in the development block to drain continuous heavy rainfall.

A) Flood control

For the study on flood mitigation, run-off simulation model was prepared assuming the following conditions (refer to Appendix C-2).

- 400 mm of three-days rainfall of 5-year return period was applied.

Design Rainfall at Bacho Station Unit : mm

Return Period	Daily Max	3 days	Annual
2	161	283	2326
5	213	400	2850
10	244	472	3161

- Calculation was conducted on a hourly basis.
- Control data on water level at the terminal gates was structured in the model.
- Relation between inundation area and water depth was prepared from the topographical map of 1:5,000.

As a first step, the model was verified through some trials. Then, computation was carried out for two cases i.e. without flood control measures (existing condition) and with flood control measures (assuming water retention block as a flood control reservoir).

As an example, the results of the analysis show that flood control measures reduce the inundation depth and period not only in the northern part (undevelopment block) but also in the development block in the downstream of the water retention block. In this case, standing water depth and duration of downstream area is shown in the table below.

Flooding Condition in Downstream Area

Flooding Damages	Flood Control in Water Retention Block	
	Without Measures	With Measures
Peak standing depth (m)	0.60 (EL 3.50)	0.47 (EL 3.37)
Inundation period (days) (over 30 cm)	5.5	2.8

According to the simulation result, in this case, peak standing water depth would come to 0.82 m (EL 3.72 m) in the water retention block. As a conclusion, if water retention block works as a flood control reservoir, flooding damage could be alleviated in the downstream area, making gravitational drainage in the development block easier. The proposed flood

control plan includes a check structure at the crossing point of central road and Bacho canal.

Height of road / dike

The height of central road is planned based on both the storage capacities required for irrigation water requirement and flood control. It is desirable to be as low as possible due to the unknown factors such as sealing material, basement and rainfall. However, the present height is high enough to meet both requirements.

B) Provision of drainage canal in the development block

During the flooding, flood damage of crops would occur according to the degree of water depth and duration on the farm land. In this area, paddy, upland and tree crops will be planted in the wet season. Also, there is no significant difference of land elevation. Then, design drainage discharge is planned in case of upland crop, since excess rainfall should be drained most quickly among three crops. As a result, it is estimated at 0.0147 cu.m/s/ha, considering one-day rainfall of 5-year return period is drained in a day, with 60% of peak run-off coefficient. In the development block, canals have already been constructed. Their capacities are enough for drainage of required amount of discharge.

New shallow ditches will be constructed in the field to control groundwater table and subsidence. At the beginning stage, the interval and depth will be 30 m and 0.7 m, respectively. These dimensions were decided from the study and past experience in other peat soil areas. They may be readjusted, monitoring the development of subsidence.

C) Necessity of water management

Drainage condition in the development block will be improved more than the present level, if upstream water retention block will function as a flood control and constructed canal will work properly. Drainage problem in this area, however, will depend on the operating way of the gates installed at the terminal points of the Bacho canal. If gates are not operated properly, flooding damage may occur in the development block. Pumping drainage is the best way for minimizing flood damage. However, it is not applied since rapid drainage by pump from the upstream area leads to stagnation of drained water in the downstream area unless rehabilitation of the canal and control of the gates are not performed properly. In order to operate the gate for flood control, it

is necessary to cooperate with RID. Blockade at the outfall, however, will have to be improved.

(4) Farm road and dike plan

In the proposed three blocks, water control techniques are different from each other. Therefore dike or road will be constructed as a boundary of the blocks. During construction, a physical measure is required to prevent groundwater movement from block to block and subsidence, because peat soil has weak and high permeability. For this purpose, road or dike with strong foundation may be required to act as an interception layer. Therefore peat soil under road or dike may be replaced by clayey material. Widths of dikes are planned at 3.0 m, considering their functions as farm roads.

(5) On-farm development plan

On-farm facilities such as roads and ditches are required for effective farming practices and water management. In the development block, farm land of 20 rai per one family has been allocated to a total of 54 families by the Cooperatives. Accordingly, the facilities are planned along the present plot boundary. However, land reallotment may be required so that proposed cropping programs can be implemented most effectively.

(6) Inland fishery pond

A pond of 21,600 sq.m. size is planned next to the sand dune by excavating peat layer. Clayey materials will be used for making stable slope, bottom and dike, so as to secure water quality.

5.2.7 Future Prospect of Development

In the planning, for convenience the area will be divided into three blocks, considering the basic ideas that development in peat soil area should be slow and development constraints related to lack of water resources and flooding damage. Out of them, development approach is taken into only the development zone. The other two blocks remain undeveloped for the time being. However, the idea of zoning is not fixed. Undevelopment block will possibly approach development block, in parallel with development practices in the development block, by planning new zoning in the undevelopment zone. Approach is generally taken as follows.

① A new development zone is designated in the undevelopment zone, based on the distribution of peat thickness and severity of inundation damage.

② Road/dike is constructed as a block boundary.

③ After cutting of melaleuca and burning, liming is carried out for soil improvement.

④ After this, grass is cropped on the reclaimed land. If drainage condition is good, forage crops such as corn and sorghum may be planted.

⑤ Farm animals are raised on these areas. As a result, soil fertility will be improved gradually.

⑥ On-farm facilities will be constructed for introduction of profitable crops based on the outcomes from the development block. If irrigation water is available and groundwater table will be maintained at shallower level during crop growing, paddy rice may be introduced in the area.

As for water retention block, large scale land reclamation can not be carried out due to the given functions of flood control and water storage for dry season. However, a part of area adjacent to the sand dune may be developed based on the outcomes from the development block, according to the above mentioned approach. For approach, technical guidelines prepared by the Team is useful.

As a first approach, however, development has to be devoted to the development zone to materialize the proposed plan. Through this approach, new water resource development like Sai Buri river shall be examined for future prospect of development.

5.3 Development Plan Formulation in Kab Daeng Area

5.3.1 Basic Approach

(1) Water use condition and land-use zoning

Most parts of this area are supposed to be irrigated by Bang Nara Project. Main irrigation and drainage canal system planning have already been prepared by RID.

The prevailing soil is Narathiwat series with average 1.0 to 1.5 m thickness of peat. The others are Kab Daeng and Thon Sai series of potential

acid sulfate soil. Under these situations, zoning of land is considered as follows.

Unit : ha

Soil	Agriculture land		Other Land Use Area	Total
	Irrigable Area	Unirrigable Area		
Peat (thickness)				
- less than 1.0 m	-	30.6	-	30.6
- 1.0 to 1.5 m	327.3	40.9	-	368.2
Potential acid				
- Rangae series	-	-	70.2	70.2
- Thon Sai series	-	33.1	-	33.1
Total area	327.3	104.6	70.2	502.1

(2) Necessity of water management

Plan formulation for irrigation/drainage system has done by RID. However, the following problems may encountered by this area, with ever-changing character of peat.

After completion of the irrigation and drainage system, irrigated agriculture will be possible. Unfortunately, continuous cultivation in peat soil may cause rapid decomposition of peat and unequal subsidence. These adverse situations would be accelerated, especially after completion of the rehabilitation of central main drainage canal. The capacity of the canal will be decreased as subsidence progresses and inundation damage will be widened. It is essential for sustainable farming to avoid excessive drainage. Proper water management facilities are required in this area to control drainage.

5.3.2 Alternative Development Plan

Based on the above concept, the following alternative plans are considered.

Case-1: In addition to the main irrigation/drainage system as mentioned above, on-farm facilities will be constructed. Proper water management facilities are also planned to avoid overdrainage, which are check gates and dikes planned based on the profile of drainage canal and topographic condition. Shallow farm ditches are also required to drain and control water in peat layer. In this case, however,

subsidence may increase due to intensive farming practices. It is shown in Figure-19.

Case-2: Development plan is conducted based on the presupposition that peat soil may subside in continuous farming. That is, central main drainage canal is excavated in advance to secure enough flow, even after long-term subsidence. Water management facilities are also needed due to the topographic condition. Farming can be practiced more intensively than case-1. It is shown in Figure-20.

For each case, construction cost is estimated as follows.

Items	Unit	Case-1	Case-2
Direct Construction cost	1,000 Baht	54,600	56,100
Development area	ha	502	502
Unit cost			
per ha	Baht	108,800	111,800
per rai	"	17,400	17,900

(No alternative plan has been made for unirrigable area)

As an evaluation from the above economical viewpoints and DLD's basic policy, Case-1 is proposed for feasibility study. Case-2 is applicable under a proper monitoring of subsidence that may develop after completion of the Case-1, in cooperation with RID in future.

5.3.3 Soil Improvement Plan

In this area, peat and potential acid sulfate soils are distributed. Improvement techniques for peat soil is the same as in Bacho area, due to the Narathiwat series.

(1) Burning

In initial construction stage of farm, burning is carried out in the peat soil area with Narathiwat and Kab Daeng series as in Bacho area.

(2) Liming

After burning, liming has to be done. Lime requirement is estimated by Woodruff method, based on the improvement target of soil pH 5.0. The amount is calculated by soil series as follows.

Soil Series	Area (ha)	Requirement per ha
Narathiwat	309	25
Kab Daeng	28	20
Thon Sai	40	12
Rangae	25	12
Total	402	

Total requirement comes to 9,065 ton.

(3) Application method of lime

Application method for peat soil is almost same as in Bacho area. In the potential acid sulfate soil area, in addition to liming, groundwater table has to be maintained at higher level of pyrites layer. Also, it is more effective for soil improvement to wash off acid substance accumulated in the topsoil by leaching with irrigation water and rainwater, before liming. Further, plowing is also required for mixing with original soil and lime after broadcasting. If this mixing is not carried out, lime materials may be lost from the surface by heavy rain or irrigation water supply. For upland and tree crops, application method is the same as in Bacho area.

(4) The application of major elements

The major elements are required for maintaining soil fertility. Application of phosphoric acid is more effective for this soil area. Magnesium and potash are also important.

(5) The application of trace elements

Trace elements are also applied as in Bacho area. Total 6,740 kg of copper sulfate, zinc sulfate and borax is required for peat soil area of 337 ha in this area. Fertilizing may be carried out by foliar application. Further, there is a slow-release fertilizer for this application.

(6) Soil dressing

If intensive agriculture will be practiced in future from economical viewpoint, mineral soil of 20 cm in thickness may be put on the ground surface of peat soil.

5.3.4 Agricultural Development Plan

(1) Crop selection

This area is divided into irrigable and unirrigable areas. Irrigable area is covered with peat soil. It will be difficult to neutralize by liming, due to gradual solution of organic acid. Accordingly, paddy rice is selected as a main crop, because it is capable of growing in moderate acidity of less than pH 5.0.

Unirrigable area is covered with sandy potential acid sulfate soil and peat soil. Paddy rice is chosen for peat soil area, as in irrigable area. For sandy potential acid sulfate soil area, upland crops are introduced due to relatively good condition of drainage. Crops are selected by considering the suitability of temperature, pH reaction and drought resistance, as described below.

① Paddy crop
Local variety is recommended for the time being, due to its acid-tolerance. It may be changed to improved one (HYD), when soil acidity is decreased.

② Upland crop
Crop rotation by vegetables, gramineous crops and pulse crops are applied to avoid injury by continuous cropping. In addition to the crops selected in Bacho, groundnuts and watermelon are introduced. Tree crops are not planned in this area.

(2) Proposed cropping pattern

Proposed cropping area is planned at 402.0 ha (2,512.5 rai). Single and double croppings of paddy rice are introduced in both irrigable and unirrigable areas. Cropping acreage except for about 2.0 ha of fishery ponds is as follows.

Paddy : 325 ha (2,031 rai)

- Double cropping area : 300 ha (1,875 rai)
  - Major rice : 300 ha
  - Second rice : 90 ha (30% of 300 ha), Cropping area for dry season was determined based on the Bang Nara Project.
- Single cropping area : 25 ha (156 rai)

Upland crop : 75 ha (469 rai), Double cropping is applied by crop rotation, as in Bacho.

Proposed cropping pattern is shown in Figure-21. Farming can be practiced by using prevailing farm machinery in this region.

(3) Crop yield

Crop yield could not reach at a standard level immediately, though irrigation water would be supplied into this area, due to low soil fertility, micronutrients deficiencies and existence of organic acid. The target of major crops were determined by considering various conditions, as shown in Table-11.

Table-11 Crop Yield (kab Daeng Area)

Items	Unit	Yield
Paddy		
Major rice Local	kg/ha	2,344 (375)
Major rice HYV RD-13	"	2,800 (448)
Second rice Local	"	2,720 (435)
Second rice HYV RD-7	"	3,000 (480)
Upland		
Sweet corn	t/ha	11.3 (1,800)
Baby corn	kg/ha	4,250 (680)
Mungbean	"	750 (120)
Yardlong bean	"	2,500 (400)
Chili (fresh)	"	5,000 (800)
Chinese kale	"	6,900 (1,100)
Short cucumber	"	7,800 (1,250)
Water melon	t/ha	25 (4.0)

( ) : kg or ton per rai.

(4) Production

Production is estimated based on the target and cropping acreage. As for paddy rice, it is shown as follows.

	Paddy	Area (rai)	Yield (kg/rai)	Production (ton)
Double	Major rice	1,875	375 (448)	703 (840)
	Second rice	563	435 (480)	245 (270)
Single	Major rice	156	375	59

Note: ( ) shows the case of HYV, which is assumed after five years, in this study.

For upland crops, there are many choices as mentioned in Bacho. In case of most beneficial combination of rotation cropping, their productions are estimated as follows.

Crops	Area (rai)	Yield (kg/rai)	Production (ton)
Baby corn	313	680	213
Yardlong bean	313	400	125
Chili	313	800	250

In connection with livestock development plan, the following amount of feed is produced from this cropping pattern.

Crops	Area (rai)	Yield (kg/rai)	Production (ton)
Rice straw			
- Major rice	2,031	187.5 *	381
- Second rice	563	217.5 *	122
Total			503
Residue of corn and bean	313	1,500	470

* : It is assumed at about half of total yield.

(5) Inland fishery development plan

Fish culture can be practiced as well as in Bacho. A total of 16 ponds with a size of 1.0 rai are planned for this area. The number was decided, assuming that total number of families for this F/S area comes to 128 on the

basis of average farm land holding and the size is 200 m^2 per family. As a result, each pond will be managed by eight families.

The ponds are planned to be scattered in irrigable area. Fishing can be done three times in a year, if the ponds are well managed. It may be carried out after drainage from the pond. In this case, total production comes to about 72.0 ton per annum, according to the standard of DOF. Necessary food is available at DOF and rice bran is also useful.

(6) Livestock development plan

Livestock farming can be practiced by utilizing rice straw and residue of corn and bean produced in this area, as well as in Bacho. A family will be able to rear 3.5 head of cattle based on the amount of food available.

Chicken can be also raised by rice bran and corn. Cattle and chicken droppings can be also utilized as a fertilizer for soil improvement.

5.3.5 Agricultural Infrastructure Development Plan

(1) Land reclamation

In order to develop cultivatable land for farmers, a series of works from bush clearing to land grading is required. The work flow is same as the Bacho.

(2) Irrigation planning

In irrigable area, irrigation water is supposed to be supplied by gravity from turn out installed along the main or lateral irrigation canals already planned. However, groundwater table should be maintained at required level compatible with rooting zone of crops, for minimizing percolation loss.

In unirrigable area, rainwater has to be conserved in peat layer for as long as possible. Seasonal water requirement of proposed crops is calculated as shown in Figure-22. Maximum requirement in irrigable area is 0.2 cu.m/s at second decade of January (refer to Table G-5-K, Appendix G).

(3) Drainage planning

In this area, gravity drainage would be possible, but excessive drainage has to be avoided by proper water management. Paddy is the main crop in rainy season, and the field is capable of retaining excess water within allowable depth and duration.

Considering above characteristics, economic point of view and field interviews on flooding condition, 421 mm of three-day rainfall with five-year return period was applied for planning.

Design rainfall at Muang Narathiwat Station

Return Period	Daily Max.	3 days	Annual
2	174	288	2,337
5	238	421	2,749
10	277	515	2,993

Based on the above consideration and the study results of Bang Nara Project, unit drainage discharge is designed at 12.4 lit/s/ha. The capacity of central main drainage canal was planned at 5.75 cu.m/s at the terminal point. Flow capacity is sufficient for drainage from the service area estimated based on the above unit discharge.

New shallow ditches with 30 m interval will be constructed in the irrigable field under the same concept as Bacho. For the purpose of water management, check structures are newly planned at two sites along the central main drainage canal, in addition to the present structure at the terminal point. Their locations are based on the topographical slope and the thickness of peat.

RID has plan to construct a new drainage canal along the Nam Bang canal into the sea. After completion of this canal, acid water from this area will be drained directly into the sea. If this plan is implemented together with the improvement of irrigation system, it will prevent the quality of irrigation water in the Nam Bang canal from worsening.

(4) Farm road and dike plan

Groundwater table has to be maintained as high as possible throughout the year. For this, dikes are planned at two places. In order to prevent water movement through the peat layer, banking with clay material is required.

(5) On-farm facility development plan

On-farm facilities such as farm roads, ditches and culverts, are also provided for effective farming and water management. Their facilities are essential for an agriculture in peat soil area. The locations are planned based on the present allocated plots. In the implementation stage, however,

plot reallotment may be needed in some area. Southern parts of this area have been allocated to farmers by Forestry Department, but the rest remains unallocated. Above all, understanding and cooperation among relevant farmers are required for conducting a successful agriculture. The rate of land loss for on-farm facilities is assumed at 8% and 3% in irrigation and nonirrigated areas, respectively.

(6) Inland fishery pond

Pond size is planned to be 1.0 rai and the number is sixteen. In this peat soil area, substratum is clayey soil. Then, from technical viewpoint, if the bottom, slope and enclosed dike will be made in the excavated peat layer, clayey material will be placed on their surface.

5.4 Development Plan Formulation in Mu No-Koknai F/S Area

5.4.1 Basic Approach

(1) Development constraints

A part of this area is included in the Muno Project. In this port, canal systems have been constructed to serve the agricultural land. The rest, however, is in the rainfed area. Some areas are likely to be flooded every year since they are situated in the low-lying land.

As for the soil, both actual and potential acid sulfate soils are mainly distributed, which are obstructing the agriculture in this area.

(2) Development concepts

In plan formulation, the way of soil improvement/conservation and the alleviative measures for inundation damage are the key factors.

For soil improvement, leaching before liming and cropping is most effective as a first step. Then, in order to make it more effective, sufficient leaching water and drainage canals to drain acidic water produced in field are required. The more soil is acidic, the more intensive canal network is useful.

As for inundation, some facilities to protect flood water intrusion are required. Especially, acid water coming from To Deang swamp should be led smoothly to the sea.

(3) Land use zoning

Zoning of agricultural land use is prepared based on the irrigation and drainage conditions and the soil distribution, as follows.

Unit : ha

Area	Agricultural Land (Soil)			Total
	Actual acid	Potential acid	Upland	
Low-lying area				
- Irrigable	177.2	232.3	-	409.5
- Unirrigable	-	103.2 *2	17.0	120.2
High-elevation area				
- Irrigable	-	-	-	-
- Unirrigable	-	162.0 *1	-	162.0
Total	177.2	497.5	17.0	691.7

Note: *1) Changing to actual acid soil.
*2) Peat soil exists in this area, but is negligible for planning.

Feasible development strategy are examined by this zoning.

5.4.2 Alternative Development Plan

Based on the above concepts, the following alternatives are considered.

Case-1: Development will be carried out only in irrigable area. However, different development level will be applied by each land use zoning. Intensive shallow ditch system is provided for the area with actual acid soil like Muno series. For the potential acid soil areas with rangae series, extensive one is planned. Agricultural land is enclosed by polder dikes to prevent flood water intrusion.

Case-2: Development concept is same as the Case-1. On-farm works, however, are different. That is, the intensive shallow ditch systems are applied in the irrigable areas with both types of acid soils for further soil improvement. Construction cost is higher than the Case-1.

Case-3: As for flooding problems in this area, the following choices are considered.

3-① Installation of pumping station

A pump will be installed for an enclosed area. Also, when gravity

drainage is no longer possible, inundation water can be drained by pump into adjacent canal. The more water is pumped out from the enclosed area, the more damage is spread over the surrounding area, due to insufficient flow capacity of the existing canals.

3-② Improvement of the main drainage canals

All of the existing drainage canals connecting to the Pu Yu regulator are basically improved to cope with the flooding. This case, however, should be approached based on the comprehensive analysis on flood problem in the whole Mu No basin. Large scale pumping station may have to be planned at the terminal point of the canal, if necessary. And, in the implementation stage, the improvement shall be started from downstream, so it will take long term to complete the improvement for this upstream area.

3-③ Construction of protection dikes

This area is located close to the conservation zone of To Daeng swamp. Some dikes are planned between the To Daeng swamp and the area, to deal with the flooding problems as an urgent theme. The purpose is to protect and regulate run-off from the swamp into the low-lying land, and to define land-use boundary between the two land-use zones. As a result, a part of the area may be defined as a buffer zone between the conservation and development areas.

These cases are shown in Figure-23, 24 and 25. For an evaluation of the above alternatives, the following should be taken into consideration.

- In general, development in acid soil area should be carried out under a strategy minimizing natural disturbance to environmental conservation.
- In this area, however, demand for cultivatable land is rising since irrigation canals have been constructed in a part of the area.
- From an economical viewpoint of soil improvement, leaching is moderate to reduce initial acidity of topsoil. For precisely this, canal network is required.
- Flooding water also alleviates soil acidity, if it drains smoothly within allowable period. On the other hand, prolonged flooding may prevent soil improvement.

- In case-1 and 2, flooding damage can not be alleviated completely. Produced acid water might remain in the enclosed area until the time when the present three drainage canals become available, because their capacities could not catch up with the flooding. In worst case, acid affected water might be stagnant in the surrounding areas.

- Accordingly, flooding condition should be improved as possible.

- In order to conserve the environment in the swamp, land use zoning should be defined by constructing some roads or dikes. Their constructed facilities can help local farmer to understand the zoning. Otherwise, farmer may unconsciously repeat intrusion into the swamp and attempt undesirable small reclamation.

Based on the above consideration, case-3-③ is proposed for feasibility study. Construction costs of each case are estimated approximately as follows.

Items	Unit	Case-1	Case-2	Case-3
Direct Construction cost	1,000 Baht	41,900	44,600	79,400
Development area	ha	427	427	692
Unit cost				
per ha	Baht	98,200	104,400	114,700
per rai	"	15,700	16,700	18,358

5.4.3 Soil Improvement Plan

The following is planned based on the existence of acid sulfate soils.

(1) Leaching

Before liming, acid substance is washed off from the topsoil by leaching. In paddy field, at least two cycles of washing and draining are necessary after land preparation. Although relation between necessary amount of leaching water and washed acidity is not clear, it becomes effective to use heavy rainfall in this region and irrigation water. According to the experiments conducted by the Team and Pikun Thong Royal Development Study Center, leaching effect is recognized. Judging from the laboratory test carried out by the Team, lime requirement will be able to be reduced by about 5% at a time if leaching is properly carried out (refer to Tables E-15 and E-16, Appendix E).

(2) Liming

Liming has to be carried out for neutralization of soil. Lime requirement is estimated as in the other two F/S areas, as follows.

Soil Series	Mapping Unit	Area (ha)	Lime requirement	
			ton/ha	ton/area
Rangae	No. 34	266	16	4,256
	No. 35	74	12	888
	No. 33	30	12	360
Muno	No. 19	237	20	4,740
Thon Sai	No. 49	36	12	432
Narathiwat	No. 25	22	28	616
Total		665		11,292

Note: Mapping unit is referred to Table E-2 in Appendix E.

(3) The application of fertilizer element

This is the same as in potential acid sulfate soil area in Kab Daeng.

5.4.4 Agricultural Development Plan

(1) Crop selection

This area is covered with acid sulfate soil, which is divided into irrigable and unirrigable areas. The former lies in low-lying land and the latter exists in both higher and lower elevation parts of the area. For irrigable area, paddy rice and upland crops are selected since irrigation water is available. On the other hand, for higher elevation part in unirrigable area, tree crops are chosen. In lower one, only pasture can be grown due to the prolonged inundation. For crop selection, suitabilities for temperature and pH reaction are taken into consideration. For upland crops, wet endurance is also a key factor.

① Paddy rice

Local variety can be introduced for the time being, due to its strong acid-tolerance. HYV may be applied when soil is neutralized to a pH level of 5.5 to 6.0 by liming and leaching.

② Upland crops

Crops with moderate acid tolerance such as mungbean, sweet corn and watermelon, are suitable after neutralization, as in Kab Daeng.

③ Tree crops

As a profitable crop, Arometic coconut is recommended after soil is neutralized. Pineapple is also recommended for intercropping.

(2) Proposed cropping pattern

Proposed cropping area is planned at 665 ha (4,156.25 rai). In irrigable area, double cropping will be applied for paddy rice and upland crops. But, second rice is planned in 104 ha, 30% of major paddy field, due to the limited water resource. The planned cropping acreage is as follows.

Unit : ha

Crops	Irrigable Area (ha)		Unirrigable Area (ha)
	(Wet)	(Dry)	
Paddy			
Major rice	345(2,158)	-	-
Second rice	-	104 (647)	-
Upland crops *1	54 (338)	54 (338)	-
Tree crops			
Arometic coconut	-	-	160 (1,000)
(Pineapple) *2	-	-	96 (600)
Pasture	-	-	103 (644)
Subtotal	399 (2,496)	158 (985)	263 (1,644)
Fishery pond	2.6 (16.25)×3=7.8 (48.75)		

Note: *1: Double cropping except in heavy rainy season. Rotation is carried out by gramineous crop, pulse crop and vegetable.
*2: Intercropped in the coconut field.
( ): rai

Proposed cropping pattern is shown in Figure-26.

(3) Crop yield

If successful leaching and liming are done, crop yield might reach at a standard level within short term. The target is determined by studying the

outcome from the experimental fields of PRDSC and other collected data, as shown in Table-12.

(4) Production

Production is estimated based on the target and cropping acreage, as shown in Table-13.

In upland crops, there are many combinations for crop rotation. Most profitable one is the rotation of baby corn, yardlong bean and chili, according to the present market price.

Twenty trees of Arometic coconuts can be planted per rai at intervals of about 9 m. A crop will be possible after 5 years from plantation. For feeding for livestock, the following is expected to be produced from this cropping system.

Crops	Area (rai)	Yield (kg/rai)	Production (ton)
Pasture	644	438	282
Rice straw			
- Major rice	2,158	187.5 *	405
- Second rice	647	217.5 *	141
Residue of corn and bean	225	1,500	338
total	4,840		1,166

Note: *: Assumed as half of the yield.

(5) Inland fishery development plan

Fish culture can be practiced as in the other two areas. The size of one pond would be 0.77 rai. Total 21 ponds are planned, assuming that total number of families is 168 in the area based on a size of average land-holding area in surrounding areas, and one family has 155 sq.m. of pond. Eight families will manage one pond. Their ponds are planned to be scattered in the irrigable area.

Allowing three months for growing period, three annual catches are expected if the ponds are well managed. In this case, annual production is estimated at 94.5 ton per annum, according to the standard of DOF. On the other hand, bait requirement amounts to 4.8 ton per one pond in a year.

(6) Livestock development plan

Livestock farming can be practiced by utilizing some feeds produced additionally from this area, as in the other two areas. 6 kg of dried grass is required per day for a cattle of 250 kg in weight. Therefore, requirement amounts to 2,190 kg per annum. On the other hand, total amount of annual produced feed is assumed at 1,166 ton.

Accordingly, one family will be able to raise theoretically three cattle in future. Chicken can also be raised by rice bran and corn. For rearing, cropping of dent corn is recommendable for getting feed, as well as the other two areas. Cattle dropping and chicken manure can be utilized as a effective fertilizer for accelerating soil neutralization, due to high phosphorus content.

5.4.5 Agricultural Infrastructure Development Plan

(1) Land reclamation

In order to develop cultivatable land for the farmers, a series of works from bush clearing to land leveling is required only in one part of the area.

(2) Irrigation planning

In irrigable area, irrigation water is supposed to be supplied by gravity from turn out already constructed. Seasonal water requirement of proposed crops is calculated as shown in Figure-27. Maximum requirement is estimated for irrigable area at 0.51 cu.m/s, from first to second decade of January (refer to Table G-6-M, Appendix G).

(3) Drainage system planning

From the technical viewpoints for effective leaching and alleviation of flooding, drainage planning is summarized as follows.

- To drain excess rainfall and acid water produced from the area
- To protect the area from flood intrusion caused by insufficient capacities of downstream canals.
- To protect the area from flooding coming from the back swamp

1) Construction of drainage canal in the area

During flooding, excess water has to be drained within allowable levels of depth and duration of standing water. In low-lying land of this area, paddy is the main crop for rainy season. The paddy field is capable of retaining water. From economic viewpoints and field interviews, therefore, three-day rainfall of five-year return period is applied for planning purpose.

Design rainfall at Takbai Station Unit : mm

Return Period	Daily Max.	3 days	Annual
2	156	295	1,696
5	220	423	2,182
10	261	495	2,543

The design rainfall is 423 mm, which is almost equal to that of Kab Daeng. Therefore, unit design discharge is planned at 12.4 lit/s/ha.

2) Construction of polder dike

The area has to be protected against overflow of the existing canals during flooding season. For this, polder dikes are to be constructed along the canals. Height is planned at 1.0 m, based on the field interviews on past standing water depth. Width of dike is designed at 3.0 m, considering some functions as a farm road.

3) Construction of dike for land use zoning

The area has also to be protected from acid water originating in the swamp. For this purpose, there are two measures. One is to improve all of canals involved. The other is to construct dikes along the swamp. In this study, the latter plan was applied, taking a concept of land use zoning in swamp area into consideration.

In this case, a part of swamp area plays a role as a flood control. Such dikes, however, would raise water level and prolong submergence which might give negative impact into valuable ecological system in the swamp. Therefore, in order to examine the hydrological change with construction of dike, a run-off simulation model was prepared. The model was made under the following conditions (refer to Appendix C-3).

- Drainage area and its condition were based on the map of 1:50,000.

- 423 mm of three-day rainfall of five-year return period was applied, and calculation was conducted on a hourly basis.
- Some data such as culverts and pipes under road were structured in the model as parameters.

Simulation study, as an example, shows that peak standing depth of water in the swamp would reach to a level of 5.0 to 10.0 cm higher than the present one, if one-third of swamp area is regarded as a flood control reservoir. The elevation would be EL 2.0 m to EL 2.5 m, if the base elevation of swamp is assumed at EL 1.5 m. As a result of flood control, peak inundation depth in the downstream paddy field would be reduced to some extent. In practice the depth and duration will vary, depending on the capacities of the check structures along the dike and their operation. There is a recommendation that the water in the swamp should not be higher than EL. 3.5 m, and it should not stay for longer than 15 days in order to support the peat swamp ecosystem.

As an overall evaluation, flood control could be carried out without any damages, as far as water management could be operated precisely. Therefore, dikes and some check structures are proposed. Height of dike is designed at 2.5 m, based on the elevation of agricultural land and swamp area.

Before implementation, however, a comprehensive study on hydrological and ecological systems in the swamp is required for further development.

(4) On-farm development plan

Introduced crops can only be grown successfully in a field drained by intensive network of shallow ditches. In actual acid sulfate soil area, fields are arranged between the ditches with 30 m interval, 1.0 m in width and 0.7 m in depth, considering hydraulic conductivity of soil and past experiences in similar soil areas in other countries.

In potential acid soil area, ditch interval is planned at about 50 m, from economic viewpoints. For draining washed water quickly, more small ditches might be required, if necessary. Their ditches should be constructed by beneficial farmers.

As other facilities, small water control weirs and gates are planned along the canal to maintain groundwater table at required level as long as possible, since lower groundwater table may lead to oxidation of pyrites.

In irrigable area, most parts of land have been allocated to farmers. Therefore, in practice, the existence of meandering and irregular plots will obstruct the layout of proposed ditch system, during the implementation stage. In that case, land reallotment will be required. Rate of land loss for facilities is assumed at 5 to 6% in on-farm development area. In order to achieve effective leaching and farming, such ditch system is essential. Traditional farming without a proper ditch system would cause negative impact to surrounding environment. Therefore, cooperation and understanding among farmers are essential before implementation.

(5) Inland fishery pond plan

Fishery ponds are also developed in this area, as in the other F/S areas. The pond is constructed by excavating acidic layer and enclosed by a dike.

Before fish growing, the bottom and the slope are to be fertilized by liming. Amount of lime requirement is assumed at 6 to 8 ton per rai at the initial stage. After first year of growing, requirement could be decreased to an average 3.5 ton per rai, and it would decrease more gradually, depending on severity of acidity.

5.5 Environmental Effect

5.5.1 General

The basic technique for reclaiming any peat swamp is to drain out the water from the swamp. The reclamation, and then agricultural development practices may impact on the surrounding environment in many ways, such as loss of plant/aquatic communities and disturbance to the wildlife. On the other hand, proper planning and management can improve overall socio-economic condition and bring benefits to the inhabitants.

5.5.2 Bacho F/S area

Proposed development plan will include clearing of forests, use of lime, introduction of new cropping pattern, construction of infrastructures and so on. However, proposed development area is not very large. Therefore, it is envisaged that possible impact on the environment would be minimum. On the other hand, implementation of the project will improve socio-economic conditions.

According to the new drainage plan, more control gates on the existing road and one on the Bacho canal will be constructed, and rain water will be allowed to inundate the upstream side. This new water management plan will check excessive drainage and keep the swamp wet. This will help not to cause bush firing and will retard subsidence rate in the area.

Regarding water quality, drained water from the swamp will be acidic but would not be higher than the present level. However, monthly monitoring of water quality especially during the dry season at Bacho canal upstream and just below the down stream of the proposed development area is needed.

Due to the proposed plan, impact on wildlife habitat and vegetation community would not increase from the present level, because of involvement of small area and ongoing development/experimental activities in the same area. However, basic survey on the present status of wildlife/vegetation in the surrounding area should be carried out and yearly comparison of numbers and species should be monitored.

In general, drainage will affect the aquatic animals' life in the swamp. However, if drainage is performed slowly, aquatic animals will find their new place like main canal. Disturbance may cause loss to some species, when overall development is carried out rapidly.

In the clearing process, trees like melaleuca and reed grass may be lost. Therefore, considering their economic value, regeneration in the other areas should be considered. Intentional burning should be controlled by introducing laws if necessary. Also an appropriate cropping pattern should be introduced to keep the green at its best level.

Actual impact due to the implementation of this small project may not be precisely understood. A good monitoring system of environmental components will definitely help to learn the negative/positive trends and accordingly precaution may be taken for future development plans. However, possible impact on the environment with and without project is presented in the Table-14.

5.5.3 Kab Daeng F/S Area

In this area, agricultural practices have been taking place for a long time. Burning or subsidence has not been reported as any severe threat to the surrounding environment. However, water in the Nam Baeng canal is becoming

more acidic due to the blockade at the outfall. In fact, this may be the main problem in this area.

Proposed development plan will introduce a better drainage system to maintain a balance of water quality between in the low land swamp and in the Nam Baeng canal. Plan will also propose a cropping pattern keeping harmony with the surrounding areas and present cultivation practices, which will increase the production and pursue the improvement of socio-economic conditions.

With the removal of blockade, implementation of proposed development plan will help to improve the overall environmental conditions in the area. But, the project may have an impact on the plant community. A basic survey of environmental components especially water quality in the drainage canal in the area and in the Nam Baeng canal will be needed after project implementation. Monitoring of time to time data, particularly in dry season, will be useful for any precautionary measures. Extent of positive and negative impacts with and without project is tabulated and presented in Table-14.

5.5.4 Mu No-Koknai F/S Area

Mu No-Koknai area falls within the ongoing Muno project area. Due to extensive reclamation and development practices, original environmental condition has been changed completely. Even in the changed condition, the area is still influenced by the surrounding To Daeng peat swamp and a few natural drainage canals that originate from the swamp. Excessive drainage from the swamp may be a threat to the plant community in the swamp.

Proposed development plan will introduce an effective irrigation and drainage network in the area. It will suggest an appropriate operation of the control gates in order to check excessive drainage from the swamp. Protection dikes will be constructed for controlling flood hazards in the rainy season. In this case, careful observation of the water level inside the swamp has to be taken into consideration. Because, for sustaining peat land ecosystem, recommended maximum water level should not be higher than EL 3.5 m and water should not stay more than 15 days.

Proposed plan will introduce such a cropping pattern that will bring the waste land into cultivation with appropriate crops. Therefore, production will increase and improve the economic condition of the local people. New cropping pattern will also compensate for lost green. However, monitoring of water

level in the swamp and downstream water quality is highly essential for better gate operation and to discover any negative impact due to the implementation of the proposed plan. Table-14 shows the possible impact with and without project.

In this study, environmental effect was examined preliminarily, considering the implementation process of proposed plan. For further development, environmental impact assessment study shall be carried out in accordance with the Enhancement and Conservation of National Environmental Quality Act, 1992.

5.6 Agricultural Supporting Services Development Plan

5.6.1 Necessity

Peat/acid sulfate soils have various disadvantages for farming, so that traditional agricultural skills developed on mineral soils can not be applied directly. In order to attain the development target, there is a essential need for research and training combined with farming and cropping systems, water control techniques, inputs and outputs requirement.

For this purpose, agricultural supporting services development project is proposed together with improvement of infrastructures. A series of service activities would enable farmers to obtain new farming techniques for problem soils, which is useful for them to stop destructive attempt to the preserved swamp forest. As a result, this project would help for conservation of natural environment in the region.

5.6.2 Plan of Operation

It is the important key to work out farming and cropping techniques. Then, it is proposed that an experimental fields are prepared as demonstration farms in the developed areas. These farms will be used to develop site-oriented farming methods through experimental activities and to train farmers.

Pikun Thong Royal Development Study Center has some experimental farms, but they can not be used for the proposed purposes, because severity of soils and improvement level of infrastructures provided in their farms are different from those of feasibility study areas.

Demonstration farm should be taken as a rental basis from the farmers. In the farms, proposed crops are planted and various experimental activities are

carried out in cooperation with farmers. Certain farmer's organizations by beneficiary farmers are also established through various activities.

A brief description of the proposed plan is furnished below.

(1) Demonstration farm and building

About 3.0 ha of land is needed for each study area. In the selected farms, proposed paddy, upland and tree crops are planted for study. Some spaces for buildings are required to carry out various activities. For this purpose, about 270 to 500 sq.m will be required for each area. But for Kab Daeng, the buildings of Pikun Thong Royal Development Study Center may be used.

(2) Scope of works

- Study for soil improvement and conservation
- Study for irrigation and drainage methods
- Study for cropping system
- Study for farming method
- Study for farm inputs and outputs management
- Establishment of farmer's organization
- Training for farming techniques

(3) Staffing

Some staffs will be needed to meet the above requirements. Fields of the staffs are; soil, agriculture, irrigation/water management, agriculture service and administration. Above staffs are composed of qualified foreign experts and related government officials under a leadership of Pikun Thong Royal Development Study Center.

(4) Implementation period

Service period is planned for three to four years by area, considering amount of study required. After completion of this project, all outcomes and facilities are transferred to farmers and operation/maintenance groups organized in this project.

5.7 Proposed Facilities

5.7.1 Land Reclamation

In order to develop cultivatable land, cutting, bush clearing, uprooting, removal of stumps, firing and land grading are needed.

5.7.2 Agricultural Infrastructure

According to the development plan, F/S level design was carried out for each area. The quantities are shown in Table-15.

(1) Drainage canal

Earth canal will be constructed along the farm road.

Unit design discharge

Bacho area	14.7 ℓ/s/ha
Kab Daeng area	12.4 "
Mu No-Koknai area	12.4 "

Type of canal

				1/5000		1/10000	
Type	B	H	A	V	Q	V	Q
I	1.0	1.0	2.5	0.20	0.51	0.29	0.72
II	2.0	1.0	3.5	0.22	0.77	0.31	1.09

Note : Capacity is calculated by Manning formula
B; Bottom (m), H; Water depth (m), A; Flow area (sq.m), V; Velocity (m/s), Q; Discharge (cu.m/s)
Coefficient of roughness is 0.035.

Check gate

The following check gates are planned in the drainage canals.

Type	Size of gate (m)	Number of gate
I	1.0 × 1.0	1
II	2.0 × 1.5	1

Road crossing

Reinforced concrete pipe of diameter 300 mm to 1,000 mm will be installed at the place where canal crosses the road or dike.

(2) Dike/Road

Dike is designed at 3.0 m of width with laterite pavement.

Type	Width (m)	Height (m)	Remarks
I	3.0	1.0	Peat soil area
II	3.0	1.0	Acid soil area
III	3.0	1.8	Peat soil area
IV	3.0	2.5	Acid soil area

There are some measures against soft ground of peat soil. For the F/S areas, two methods are considered. One is utilization of sand or plastic sheet at the basement to prevent differential settlement and slope/base failure. The other is replacement method by using clayey material. The former method is only effective for temporary road in shallow thick peat and should be applied together with another method, if long-term structural stability as road/dike is necessary. Then, for the two peat soil F/S areas, the replacement method is applied since clayey soil can be prepared from the surrounding areas.

(3) On-farm facilities

Ditch

Ditch with bottom width of 0.3 m and depth of 0.7 m will be constructed at an interval of 30 m or 50 m.

Farm road

Width of 2.0 m and 0.1 m thickness of laterite pavement are designed as a farm road.

Farm turn out (FTO)

In the crossing of farm road and canal, reinforced concrete pipe of 500 mm with slide gate of 0.6 m × 0.6 m will be constructed.

Stop log weir

A stop log weir made of concrete will be installed along the ditch in one hectare.

(4) Check structure

Intake culvert

Reinforced concrete pipe of diameter 1,000 mm will be laid under the dike as a intake facility, in Bacho area. Slide gate of 1.0 m × 1.0 m will also be installed at one side for control of water flow.

Check gate

Check gate structures are planned in the canal, as follows.

Type	Size of gate (m)	Number of gate
I	2.0 × 2.0	1
II	4.0 × 2.0	2

In Bacho and Kab Daeng areas, pile foundation is planned due to weak base.

(5) Inland Fishery Pond

In peat soil area, the depth of pond will be 1.8 m including dead water depth of 0.3 m. Slope will be 1:2. and clay coating will be provided for maintaining water quality and stable structure. The thickness will be 0.2 m, about 10% of water depth.

In acid soil area, digging will take place up to the acidic layer, and small dike will be built by using excavated soil. Clay coating will be provided at the bottom, the slope of pond and the surface of dike to prevent rain water from acidification.

In both soil areas, small pond at the bottom for fish growing during dry season is planned. The depth is designed at 1.0 m with the area of one-third of bottom area, according to the criteria of DOF.

5.7.3 Agricultural Supporting Service Facilities

(1) Demonstration farm

Land for demonstration farms will be rented tentatively from the farmers to carry out various activities. The required area is as follows.

Bacho : 3.0 ha
Kab Daeng : 3.0 ha
Mu No-Kokhai : 3.0 ha

(2) Building

Building will be built on the public land. The required space is as follows.

Unit : m^2

Item	Bacho	Kab Daeng	Mu No-Koknai
Office	100	100	100
Meeting room	50	20	50
Lecture room	100	-	100
Laboratory	-	-	-
Farm tool house	100	100	100
Warehouse	50	-	50
Garage	50	50	100
Total	450	270	500

(3) Machinery and Vehicles

The requirement is as follows.

Item		Required Number		
		Bacho	Kab Daeng	Mu No-Koknai
Tractor	30 pcs	1	1	1
Pick-up	2200 cc	1	1	1
Station wagon	2200 cc	1	1	1
Motorcycle	100 cc	3	2	3
Trailer		1	-	1
Hand Sprayer		3	2	2

(4) Laboratory equipment and materials ..... one set

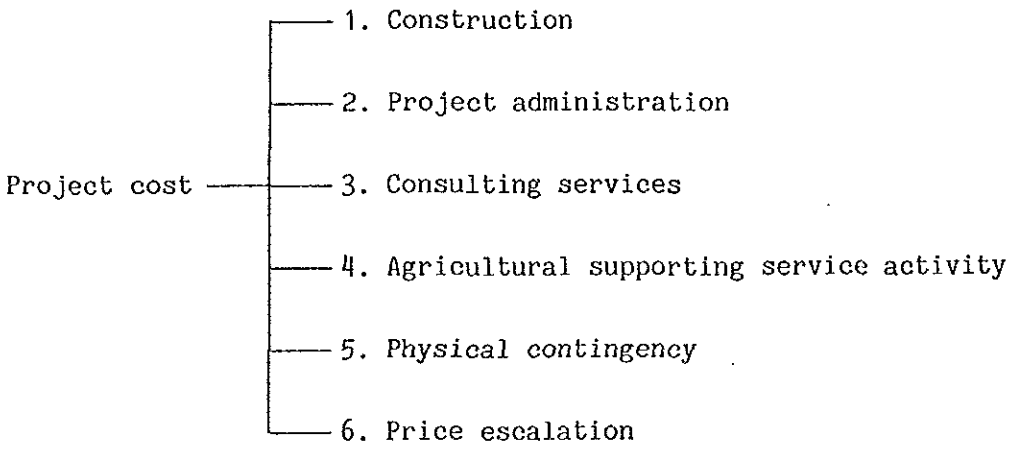
5.8 Project Cost

5.8.1 Basic Condition

(1) Implementation mode

The construction works shall be carried out on a contract basis, considering the characteristics and the scale of the project.

(2) Component of project cost



1. Construction cost

This item includes the construction costs estimated based on respective unit costs including construction materials, fuel and oil, labor, and depreciation and repairing cost of the construction equipment, and overhead of contractor.

2. Project administration

Project administration under construction is consisted of salary of temporary employees, communication, water and electric supply charge of temporary office, etc.

3. Consulting services

This cost includes consulting fees for detailed design of the proposed facilities and construction supervision, survey and investigation cost. The cost shall be estimated at about 10% of 1, 2 and 4.

4. Agricultural supporting services activity

This item covers the cost for agricultural supporting services activities to be conducted in the demonstration farm. The major one is the cost of experts required for activities, which is estimated based on the number of staff and their expenses.

5. Physical contingency

The allocation of contingency is made to cover minor differences between the actual and estimated quantities, unexpected difficulties in construction works and so forth. The contingency equivalent to 10% of the above-mentioned items has been applied.

6. Price escalation

Price escalations of 1.0 percent per annum for the foreign currency portion and 5.0 percent for the local currency portion are allowed respectively.

(3) Unit prices of materials

The unit cost is estimated based on the data collected from DLD, taking into account the costs such as efficiency of the construction equipment, labor, materials, and operation cost of the construction equipment. Applied unit cost is based on Thai fiscal year 1992 prices. The rate of foreign and local currency portions is applied by basic materials. Details are shown in Appendix K.

(4) Overhead cost

Overhead cost for construction works is applied at 25% of materials and labor costs, which is consisted of management, profit, tax, compensation fund and insurance.

5.8.2 Construction Method

Such major construction materials as sand, gravel, laterite, cement products, etc., are easily procurable around the study areas. As for construction equipment, there are several companies which have required equipment.