JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

MINISTRY OF AGRICULTURE AND COOPERATIVES
THE KINGDOM OF THAILAND

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

MAIN REPORT

NOVEMBER, 1993

SANYU CONSULTANTS INC.
in association with
TAIYO CONSULTANTS CO., LTD.

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PREFACE

In response to a request of the Government of the Kingdom of Thailand, the Government of Japan decided to conduct a feasibility study on Agricultural Development for Peat/Acid Sulfate Soil Areas in Narathiwat Province and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to the Kingdom of Thailand a study team headed by Mr. Jun-ichiro NAKAJIMA, SANYU Consultants Inc., from February to December, 1992.

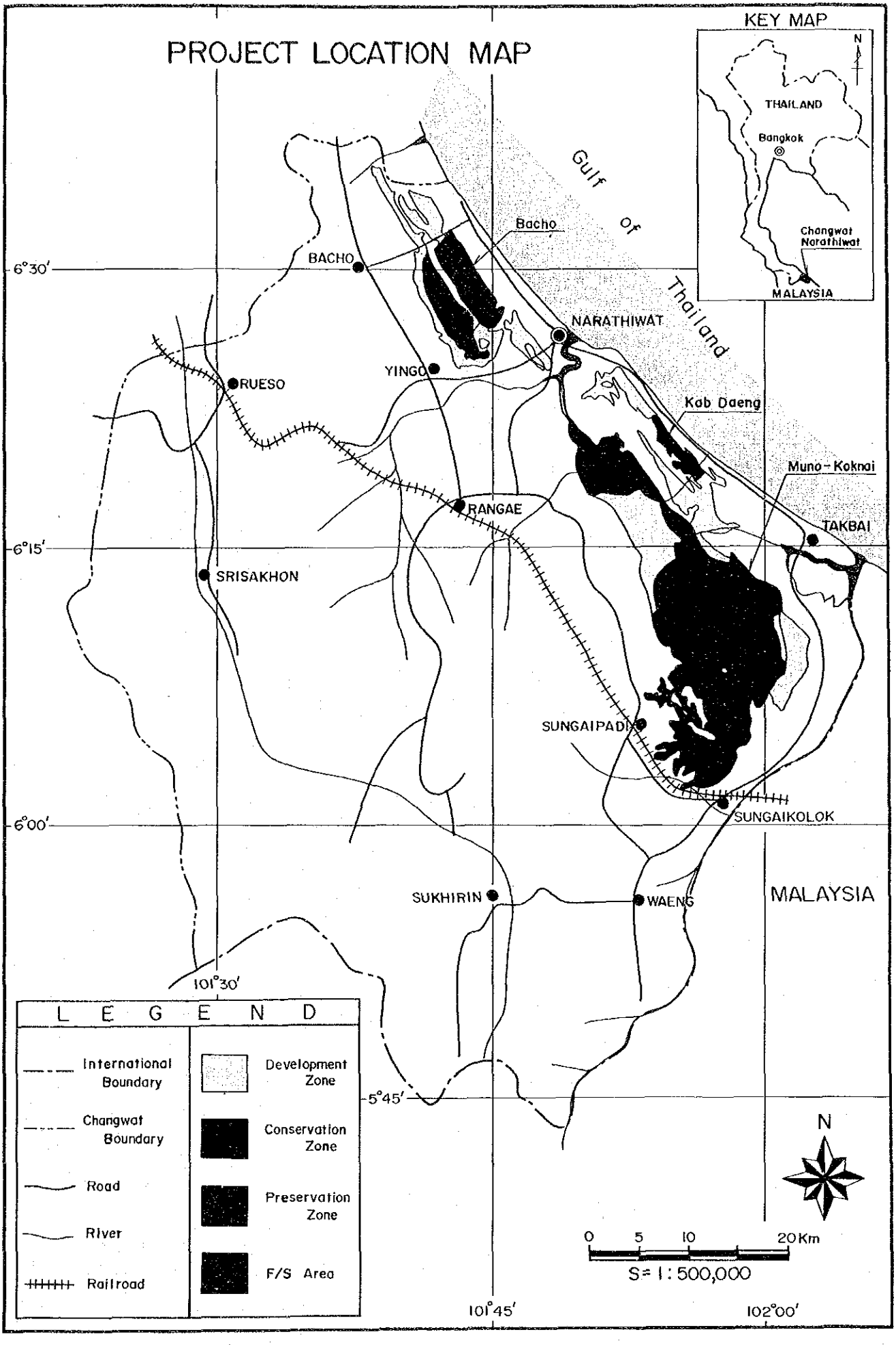
The team held discussions with the officials concerned of the Government of the Kingdom of Thailand, and conducted a field survey at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

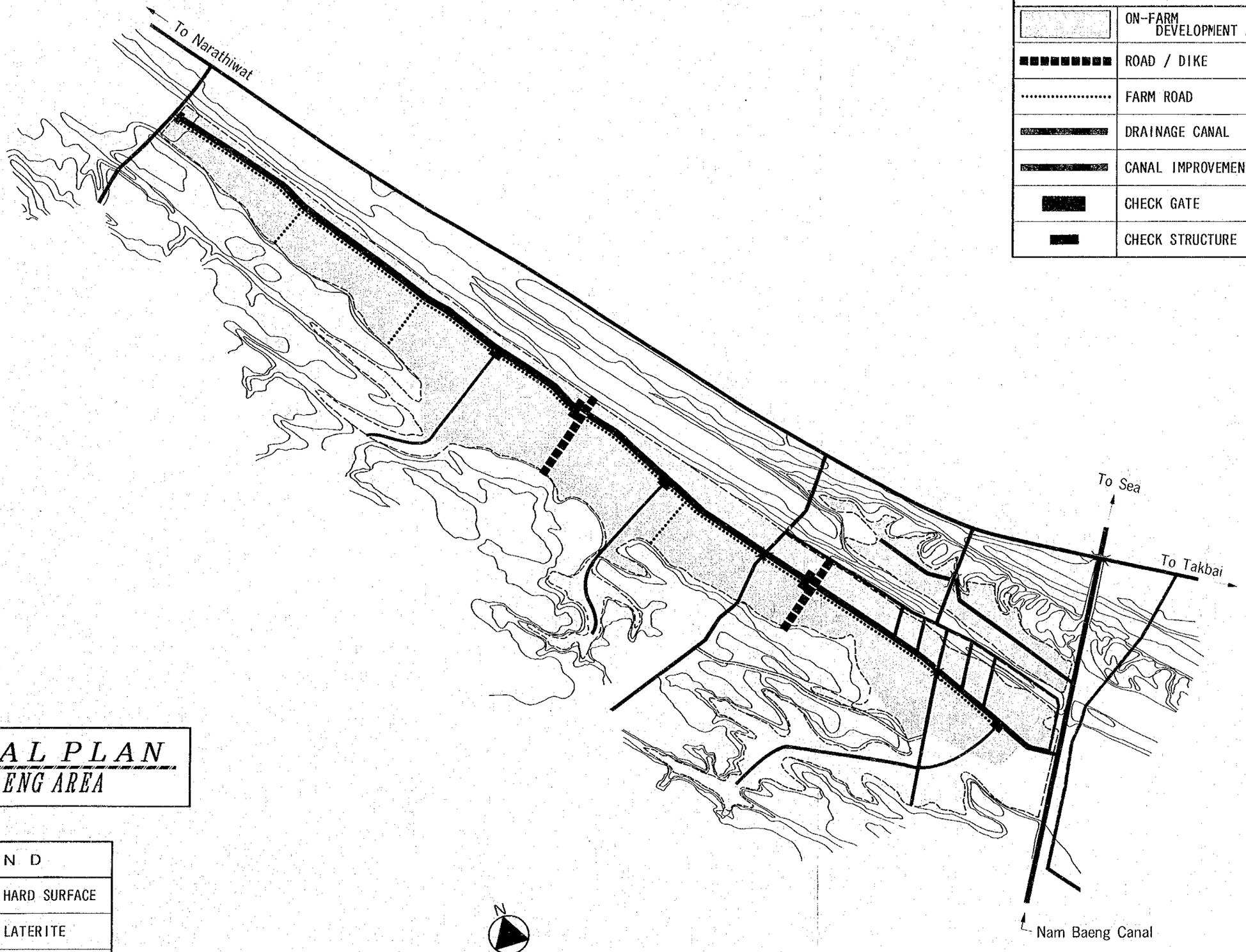
I wish to express my sincere appreciation to the officials concerned of the Government of the Kingdom of Thailand for their close cooperation extended to the team.

November, 1993

KENSUKE YANAGIYA
President
Japan International Cooperation Agency


PROJECT LOCATION MAP
KEY MAP
N
THAILAND
Bangkok
Changwat Narathiwat
MALAYSIA
Gulf of Thailand
Bacho
BACHO
NARATHIWAT
YINGO
RUESO
Kab Daeng
Muno-Koknai
RANGAE
TAKBAI
SRISAKHON
SUNGAIPADI
SUNGAIKOLOK
SUKHIRIN
WAENG
MALAYSIA
6°30'
6°15'
6°00'
5°45'
101°30'
101°45'
102°00'
L E G E N D
International Boundary
Changwat Boundary
Road
River
Railroad
Development Zone
Conservation Zone
Preservation Zone
F/S Area
N
0 5 10 20 Km
S= 1 : 500,000

DEVELOPMENT PLAN	
	ON-FARM DEVELOPMENT AREA
	ROAD / DIKE
	FARM ROAD
	DRAINAGE CANAL
	CANAL IMPROVEMENT
	CHECK GATE
	CHECK STRUCTURE



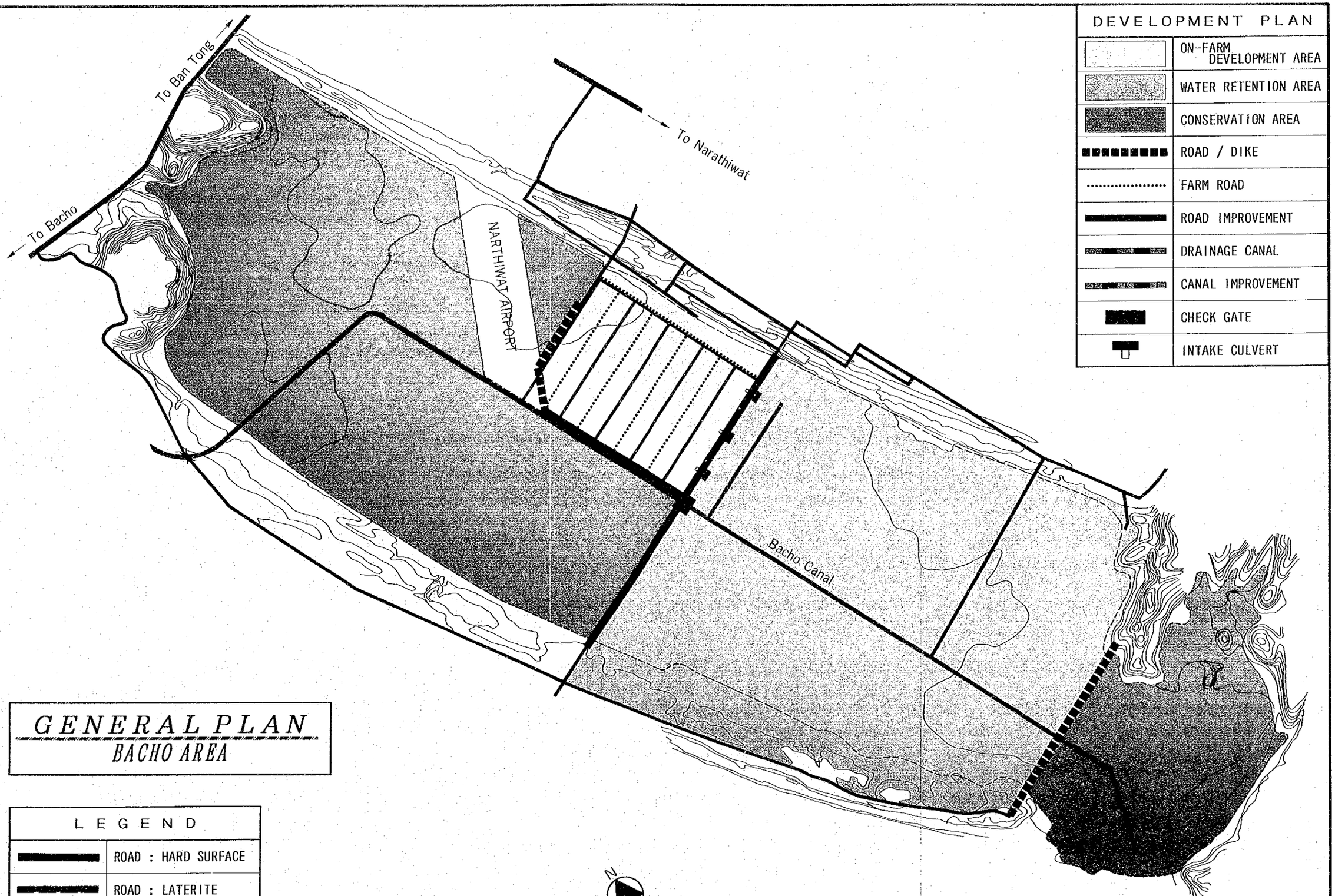
GENERAL PLAN
KAB DAENG AREA

LEGEND	
	ROAD : HARD SURFACE
	ROAD : LATERITE
	CANAL
- - - - - - -	F/S AREA BOUNDARY

N

0 500 1000m

S = 1 : 25,000



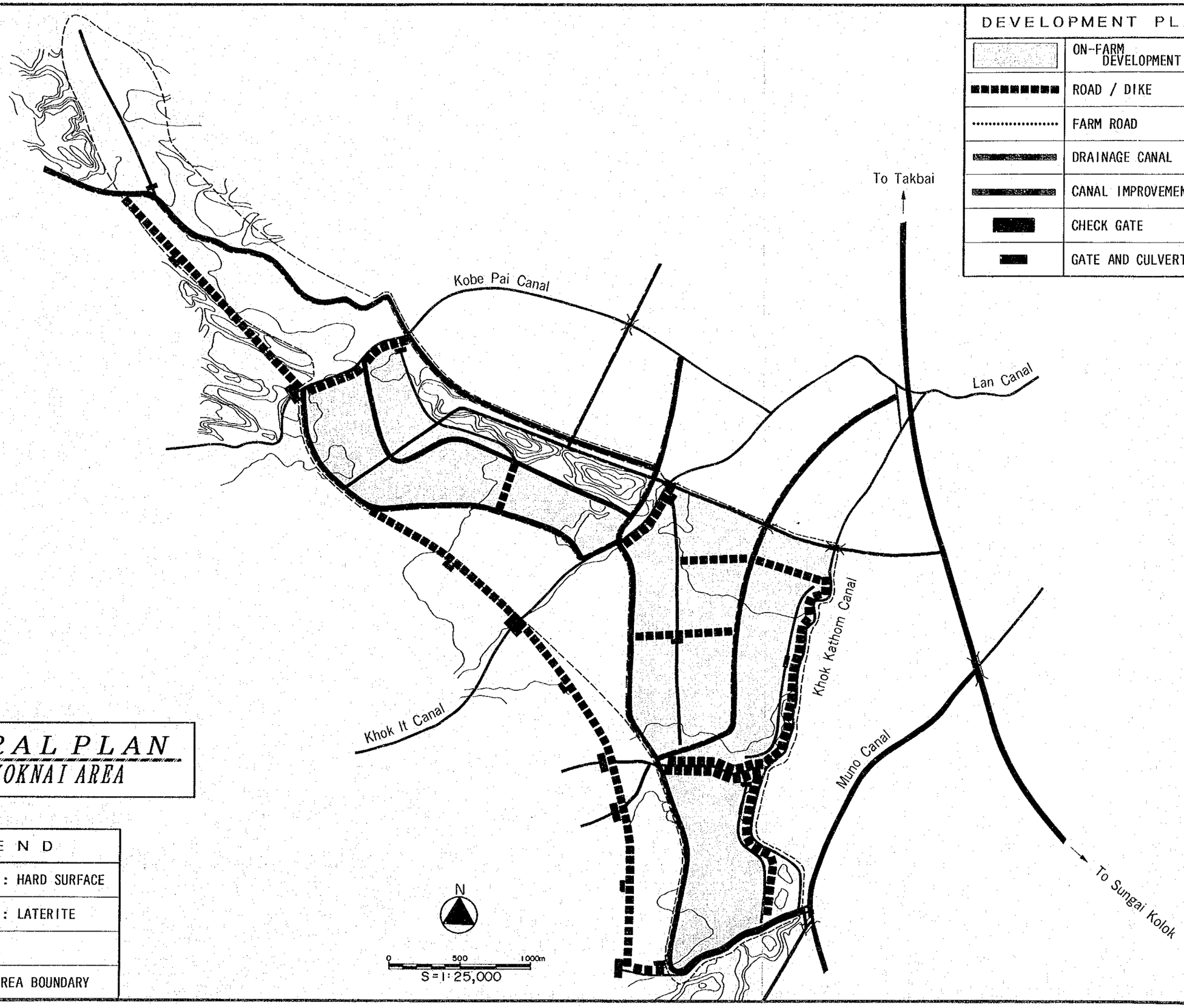
GENERAL PLAN
BACHO AREA

LEGEND	
	ROAD : HARD SURFACE
	ROAD : LATERITE
	CANAL
	F/S AREA BOUNDARY

GENERAL PLAN
MUNO KOKNAI AREA

DEVELOPMENT PLAN	
	ON-FARM DEVELOPMENT AREA
	ROAD / DIKE
	FARM ROAD
	DRAINAGE CANAL
	CANAL IMPROVEMENT
	CHECK GATE
	GATE AND CULVERT

LEGEND	
	ROAD : HARD SURFACE
	ROAD : LATERITE
	CANAL
	F/S AREA BOUNDARY



S U M M A R Y

1. BACKGROUND

1.1 Background

(1) There exist seven kinds of problem soils for agricultural use in the Kingdom of Thailand. This report is prepared based on the Scope of Works (S/W) conducted between the Department of Land Development (DLD), Ministry of Agriculture and Cooperatives, the Kingdom of Thailand and the Japan International Cooperation Agency (JICA) for the Study on the Agricultural Development for Peat/Acid Sulfate Soils Areas in Narathiwat Province dated November 27, 1991.

1.2 Socio-Economic Background

(1) The Thai economy has grown rapidly and has become increasingly internationalized. Although the Gross Domestic Product (GDP) share of the agricultural sector in the national economy gradually declined, the sector is still important to the Thai economy as the agricultural employment share remains as high as 64 % of total employment. There is still a need for agricultural development which will support overall economic expansion.

(2) Related to the agricultural development policy, the Seventh National Economics and Social Development Plan has emphasized the necessity of extending public services and subsidization to the lands with problem soils. Moreover, development of problematic soil areas is considered to be an important national policy.

2. PRESENT CONDITIONS OF THE STUDY AREAS

2.1 Narathiwat Province

(1) Narathiwat province is located in the extreme southern part of Thailand, about 1,500 km away from the capital.

(2) The province is categorized as a tropical country with hot climate and heavy rainfall. Average annual rainfall is quite high, about 2,500 mm, of which 50 % falls during the months of November and December. Average temperature and humidity are 28 °C and 76 %, respectively.

(3) The topography of the province consists of swampy forests and plains land along the Gulf of Thailand and hills/mountains scattered in the south and west. Two big swamps, Bacho in the north and To Daeng in the south, are also important geographical features of the province.

(4) In Thailand, peat and acid sulfate soils occupy 45,000 ha and 852,000 ha, respectively. Sixty-four percent i.e. 29,000 ha of peat and 2 % i.e. 19,000 ha of acid sulfate soils are found in the coastal low land of the province.

(5) The changes in land use patterns reveal that there has been a drastic reduction of swampy forest. One reason being, it can be cited that swamp areas have been developed because of strong demand for agricultural land due to the increased population growth.

(6) The main economic activities of the southern region are para rubber and oil palm plantations, coconut and fruits cultivations, tin-production and mining. In the province, agriculture shares 38 % of the Gross Provincial Product (GPP). About 75 % of the provincial population is engaged in agricultural activities. The agriculture, however, is inclined to para rubber production. The annual population growth rate of the province is one of the highest in Thailand. Seventy-eight percent of the population is Muslim. The per capita GPP is 16,696 Baht, lower than the national and southern regional levels, covering approximately 67 % and 76 % of their gross products.

(7) Major parts of agricultural land are covered by perennial crops of about 188,000 ha, of which para rubber field occupies about 94 %. Paddy field is only 11 % of the whole agricultural land, which means the province has a shortage of rice and needs to import it from other provinces.

(8) The main income sources of farm households in the province are para rubber plantation (43 %), farm custom works (18 %) and non-farm custom works (11 %). Total average income accounts to 29,000 Baht a year, which is 52 % and 67 % as much as the southern region and the whole country, respectively.

2.2 Swamp Area

(1) The Pikun Thong Royal Development Study Center was established to serve as a central office to conduct research and experimentation on agriculture,

animal husbandry, fishery and forestry in the peat/acid sulfate soil areas in the southern region.

(2) Thai government classified the swamp area into three zones of development, conservation and preservation for the sake of future land use and environmental conservation. Among them, development zone is designated to be developed for agricultural production. The area is approximately 101,000 rai (16,100 ha), 38 % of total swamp area.

(3) There are 10 different soil series in the swamp area. According to their characteristics, they can be divided into five groups; thick peat soil, shallow to moderately thick peat soil, potential acid sulfate soil, actual acid sulfate soil and alluvial soil. As for distribution of their soils in the development zone, acid sulfate soils, peat soils and alluvial soil occupy 52 %, 43 % and 5 %, respectively. Fertility of these soils except alluvial soil is low due to acidity.

(4) Ecological balance in peat land consists of vegetations like melaleuca and inhabitant of wildlife categorized into birds, mammals, amphibians and reptiles, and aquatic animals. In the development zone, however, valuable ecosystems to be preserved were not recognized.

2.3 Feasibility Study Area

(1) Based on the S/W, three areas were selected for feasibility study from the development zone, considering soil conditions, availability of water resources, environmental impact and social factors. The selected areas are outlined as follows.

(2) Bacho area is located in Tambon Khok Kain, covering an area about 2,640 ha. Most parts of the area are occupied by thick peat. No water resource for development exists. In this area, no agriculture is practiced except for surrounding sand dune areas. A part of the area was allocated to the farmers by the Land Settlement Cooperatives, but no crops are grown at present. The whole area is occupied by the melaleuca forest.

(3) Kab Daeng area is located in Tambon Priwan, covering an area of 502 ha in a long and narrow band of sand dune. Most of the area is included in the beneficial areas of the Bang Nara Project. Therefore, irrigation/drainage facilities are supposed to be constructed by RID in the near future. Most parts are covered with peat soil, but, potential acid sulfate soils are also distributed in limited areas. The area was developed for paddy

cultivation. At present, however, it is almost entirely abandoned and occupied by the melaleuca forest.

(4) Mu No-Koknai area is located in Tambon Pron and Kun Thong, covering an area of 756 ha. Part of the area has an irrigation system constructed by RID. This area is almost entirely covered by acid sulfate soils. Especially, actual acid sulfate soil of Muno series occupies 36 % of the area. An attempt to develop this land was abandoned due to severe acidity. Recently, it has become waste land except for some parts of pasture land.

3. DEVELOPMENT PLAN

3.1 Basic Approach and Development Objectives

(1) Already some attempts at small scale reclamations have been made by farmers in the selected three areas. 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. On the other hand, from the viewpoint of the natural environment, preservation of valuable ecosystem should be taken into consideration in development plan formulation.

(2) Considering various physical and social conditions, development objectives are formulated as follows.

- To increase farmer's income and minimize regional differences for stabilization of their standard of living, by means of improving farming practices, agricultural infrastructures and soil conditions.

- To conserve regional environment and natural resources by introducing sustainable agriculture in problem soils.

- To establish a development strategy that will work as a model for other similar soil areas.

3.2 Development plan in Bacho Area

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

(2) Under such constraints, development cannot be approached extensively and simultaneously. Therefore, for convenience, the area is subdivided into three blocks; development block, water retention block and undevelopment block. Development works will be carried out in the development block. Water retention block will be used as an area for flood control and water storage for development block, by means of conserving rainwater during wet season. Undevelopment block will not be developed immediately.

(3) In general, development approach should be slow as there are many uncertain factors for overall agricultural use of peat. As a result, only the land settlement area already allocated by the Land Settlement Cooperatives is designated as a development block because it has to be developed urgently to encourage settlers for stabilizing agriculture. This is also based on the distribution of thickness of peat layer. The southern area of the central existing road will be used as a water retention block. Conserved rainwater in this block will be supplied gradually by movement of shallow groundwater into the rooting zone of crops in the development block.

(4) Based on the above mentioned ideas, agricultural infrastructures such as road/dike, check gate, drainage canal and on-farm development facilities, are planned to be constructed in some places for stable farming activities in the development block. In addition, by utilizing those facilities, it will be possible to control flow of acid water and to maintain groundwater table during dry season, which will keep the area green and prevent wastage of peat.

(5) In order to develop cultivatable land, a series of works from melaleuca forest clearing to land leveling are required, as a first step. In those works, the burning will be carried out carefully not only to remove the obstacle for farming, but also to supply the lime, phosphate, potash and copper sulfate into the peat soil.

(6) After this work is completed, the peat soil has to be neutralized for crop growing. For this purpose, there are two methods; soil dressing and liming. For this area, the liming method will be applied from the

economic viewpoint and difficulty in getting soils with good quality for crop growing. The value of soil pH 5.0 is set up for neutralization because aluminum becomes free if the pH falls to less than 5.0. As a result, the lime requirement comes to 30 ton per ha.

(7) Even if liming is applied, however, it will be difficult to neutralize and maintain completely the required level of soil pH for crop growing due to the existence of organic acid in peat. Therefore, when the pioneer crops were selected for this area, pH reaction was considered as a basic condition. Wet-endurance and shallow root system were also taken into consideration. As a result, local variety of paddy, sweet corn, baby corn, mungbean, chili, short cucumber, yardlong bean and chinese kale as an upland crop and pineapple as a fruit tree are planned to be introduced.

(8) A fishery pond is planned so that fish culture can be practiced as a side job of agriculture. Major fishes are catfish and tilapia. Their rearing period is about three months if farming is well managed. In construction, however, clayey soils are placed on the bottom, slope and dike as the pond will be built in peat layer.

(9) Proposed cropping area is planned as paddy field of 120.6 ha, upland crop of 51.2 ha, fruit trees of 30.4 ha and fishery pond of 2.2 ha. Total comes to 204.4 ha. Double cropping by introducing crop rotation is recommended for only upland crops, except during severe rainy season.

(10) In order to continue cropping, management of the field is essential. As for liming, it should be applied every four years, considering the pH suitability for introduced crop, as liming effect will decrease gradually. The application of major and trace elements are also required. Especially, phosphatic fertilizer is necessary. As another farming strategy, farm animals can be raised in the future by utilizing rice straw, residue of corn and bean produced in the area. In this case, their feces and urine can be used as a fertilizer for soil improvement.

(11) In the undevelopment block, decomposition and burning of peat will be repeated unless any other measures are taken. Therefore, in order to change from peat area into agricultural land, bush clearing and burning will be carried out in parallel with development in the development block, by zoning the area into a new development block. After construction of dike and liming, grass will be grown in the reclaimed area. As the soil productivity improves with livestock farming, the area will become fit for

crop growing. The crops will be selected based on the outcomes of the development block. However, the first approach has to be devoted to the development block so as to materialize the proposed plan.

3.3 Development Plan in Kab Daeng Area

(1) Main irrigation/drainage system planning has already been prepared by RID. After improvement of the system, irrigated agriculture will be possible. However, continuous cultivation of the peat soil may cause the rapid decomposition of peat and unequal subsidence which will spread inundation damage in this area. It is essential for sustainable farming to control drainage, which may be achieved by maintaining water quality in the Nam Baeng canal.

(2) For this reason, check gate and road/dike as water management facilities are planned at two places along the existing drainage canal. In addition, construction of drainage ditches and on-farm facilities is also planned for effective farming and drainage control.

(3) Soil improvement techniques are the same as in Bacho area. Lime requirement is estimated by soil series distributed in the area. The amount comes to 9,065 ton for whole cropping areas.

(4) If soil improvement/conservation could be carried out by periodic fertilizing and liming and water management, paddy rice could be chosen for the irrigable peat soil areas, and upland crops and paddy rice could be introduced for the unirrigable potential acid sulfate soil and peat soil areas, respectively.

(5) As for paddy rice in the irrigable area, local variety is recommendable for the time being. However, it might be changed to improved one as soil acidity is neutralized and second rice could be introduced. As for upland crops, groundnut and watermelon are introduced in addition to the crops selected in Bacho. However, crop rotation by vegetables, gramineous crops and pulse crops are applied for upland crop cultivation. Sixteen ponds with a size of 1.0 rai are also planned in the irrigable area.

(6) As a result, proposed cropping acreage is as follows.

Paddy rice ; 325 ha
Double cropping ; 300 ha (Major rice 300 ha, Second rice 90 ha)
Single cropping ; 25 ha
Upland crops ; 75 ha
Fishery ponds ; 2 ha
Total ; 402 ha

(7) If livestock farming can be practiced in the area, like in Bacho, their droppings could be utilized as a fertilizer for soil improvement.

3.4 Development Plan in Mu No-Kokunai Area

(1) A part of this area is included in the Muno Project, and canal systems have been constructed to serve the agricultural land. Development constraints for agriculture are the existence of acid sulfate soil and the inundation with acid water. In plan formulation, therefore, the way of soil improvement/conservation and the alleviative measures for inundation damage are the key factors.

(2) As for soil improvement/conservation, leaching and liming are recommended for this area. According to the experiments on leaching conducted by the Team, it is concluded that washing and mixing soil with water are effective for removal of oxidized substances. Therefore, before liming and cropping, leaching has to be carried out as much as possible by using heavy rainfall during wet season. Intensive drainage network is planned so as to operate flow of acid water more effectively.

(3) Lime requirement is estimated according to the distributed soil series, as in the other two areas. The required amount comes to 11,292 ton for the whole cropping area. If leaching and management of groundwater table are properly carried out, periodic requirement may be reduced gradually.

(4) As for inundation problem, small scale dikes are planned along the existing drainage canal for preventing flood intrusion. In addition, construction of protection dikes is planned between the To Daeng swamp and the area against intrusion of acid water coming from the swamp. These dikes are also useful as a land-use boundary between the conservation and development zones. The existence of a dike would help local farmers to understand the zoning and to stop unconscious and destructive reclamation attempts to the conserved swamp forest.

(5) Farming can be practiced in this area with periodic leaching, liming and fertilizing. Proposed crops are paddy and upland crops for irrigable area, and then, for unirrigable area, tree crop and pasture are introduced in the higher and lower elevation lands, respectively. As for paddy, improved variety may be introduced after the soil is neutralized to the pH level of 5.5 to 6.0. Same upland crops as the Kab Deang are recommended after soil improvement. As for tree crops, arometic coconut is proposed as a profitable one and pineapple is planted for intercropping.

(6) Twenty-one fishery ponds with a size of about 0.8 rai are planned, as well as the other two areas. As a result, proposed cropping area except for the ponds of about 3.0 ha is as follows.

Crops	Cropping Area(ha)	Irrigable area(ha)		Unirrigable Area(ha)
		Wet season	Dry season	
Paddy	345	345	104	-
Upland crops	54	54	54	-
Tree crops	160	-	-	160
Pasture	103	-	-	103
Total	662	339	158	263

Domestic animals can be raised as in the other two areas, as farming practices are stable. Cattle droppings and chicken manure are used for accelerating soil improvement due to high phosphorus content. Recycled agriculture by using various residual products in the area is required for sustainable farming and improvement.

(7) As a result of construction of protection dikes, the inundation damage in the downstream paddy fields can be reduced, as the run-off of acid water can be regulated in the swamp. However, proper monitoring and water management are required for minimizing environmental impact to the ecological system caused by conserving rainwater temporarily in the swamp. For this, some check gates are planned along the dikes.

(8) As for inland fishery pond, it has to be well managed by farmers so as to attain the projected target of production. Especially, liming is essential for maintaining water quality.

3.5 Environmental Effect

(1) There are many inhabitants of plant community, wildlife and aquatic animals in the swamp forest. The inhabitants are very sensitive to natural disturbances. Therefore, if the development zone is widely and rapidly disturbed, it may give negative impact into the ecological balance in the conservation and preservation zones.

(2) In the selected three areas, however, development process may not give more negative effect on the natural environment than the present level, because the reclamation works have already been attempted in all areas and proposed development practices are of small scales. In Bacho area, new water conservation plan will keep the peat wet and prevent undesirable burning and wastage of peat. In Kab Daeng area, proposed development plan will introduce a better management system to control drainage of acid water. In Mu No-Koknai area, introduction of new cropping pattern will also compensate the lost green. In each area, proposed development practices will stop the present deteriorating tendency of the environment.

3.6 Agricultural Supporting Services Activities Plan

(1) Peat/Acid sulfate soils have various disadvantages, so that traditional agricultural skills developed on mineral soils can not be applied directly. In order to attain the development target as mentioned above, agricultural supporting services project is proposed together with improvement of infrastructures for research and training combined with farming and cropping systems, water control techniques, inputs and outputs requirement.

(2) It is the important key for project implementation to work out farming and cropping techniques. Therefore, it is proposed that the experimental fields are prepared as demonstration farms in the developed areas. Also, site-oriented new farming methods will be developed through introduction of new cropping systems and experimental activities in the farms.

(3) For project implementation, qualified experts (local and foreign) will be recruited from the agencies concerned under a leadership of Pikun Thong Royal Development Study Center. Implementation period is planned for three to four years depending on the area, considering scope of works required. All outcomes are transferred to the operation and management group organized in this project.

3.7 Facilities Planning

(1) In order to change the swamp forest to cultivable land, cutting, bush clearing, uprooting, removal of stumps, firing and land grading are required. Proposed facilities are canal, dike/road, check gate, on-farm facilities and pond.

(2) For facilities planning, it was considered that peat has high permeability and weak foundation for civil works. Some spaces for buildings, machinery and equipment required for various services are planned for agricultural supporting activities.

3.8 Project Cost

(1) Project cost consists of construction, project administration, consulting services, agricultural supporting activity, physical contingencies and price escalation. The cost is as follows.

F/S Area	Agricultural land(ha)	Project Cost (million Baht)		
		F.C.	L.C.	Total
Bacho	225	52	46	98
Kab Daeng	432	50	49	99
Mu No-Koknai	720	69	75	144
Total	1,377	171	170	341

Project implementation schedule is planned for each area and programmed to allocate five to six years from fund arrangement to completion of agricultural supporting activities.

(2) The project consists of many components. Therefore, under the project committee organized by government agencies concerned, OLD shall be the executing agency, who is fully responsible for the all components by getting the support of Pikun Thong Royal Development Study Center. A farmers organization shall be set up during the project implementation in order to play a vital role to extend the soil improvement and water management techniques.

(3) In addition, the operation/maintenance organization shall be set up under a leadership of Pikun Thong Royal Development Study Center for further development in other similar soil areas, who shall monitor the environmental change, operate/maintain the constructed facilities and review the outcomes of the project.

4. PROJECT JUSTIFICATION

4.1 Basic Concept

(1) In general, the cost of this type of project to attain a certain level of agricultural outputs is higher than that on the mineral soils, making benefits from agricultural production low.

(2) This area is faced with many social and environmental problems such as increasing population pressures, strong demand for agricultural land, stabilization of living, swamp forest conservation and acid-water pollution. Considering such characteristics of this area, the social benefits derived from the project implementation are greater than the agricultural benefits.

4.2 Economic Analysis

(1) Agricultural benefits consist of production benefits of introduced crops and inland fisheries, and damage reduction benefits by inundation prevention. An incremental benefit approach method which compares "with project" and "without project", is used to calculate benefits. The project life including construction period is 30 years.

(2) The project's economic internal rate of return (E.I.R.R.) is estimated at 0.4 % for Bacho, 4.7 % for Kab Daeng and 5.3 % for Mu No-Koknai, which are fairly low compared with the opportunity cost rate of capital.

(3) The reason why the rates are low is as follows. The improvement level of agricultural infrastructure is higher than usual, because more adequate water and farm management methods are necessary for agriculture on those problem soils. The plan takes these necessities into consideration. As well, the costs for agricultural supporting services are incorporated to engage farmers in a sustainable agriculture. The service activities are necessary in the initial development stage. However, they could be

diminished as the outcomes from the initial project become useful, when similar projects will be developed in the other areas.

(4) Then, the economic viability without supporting services is also discussed for the projects targeting the whole development zone in the swamp. As a result, the E.I.R.R. comes to 4.6 %, 8.9 % and 9.6 % for three similar soil areas of Bacho, Kab Daeng and Mu No-Koknai areas, respectively. Even in this case, the cost for agricultural infrastructure development is 25 to 30 % higher than an ordinary one due to the special characteristics. Therefore, the viability is low.

(5) Besides the quantified agricultural benefits, the following effects are expected through the project implementation.

- Systematic development practices will prevent the current desultory reclamation attempts in the swamp areas, which would help the conservation of natural swamp forest.

- New agricultural land will be supplied to the farmers who do not have farmland, which would contribute to the stabilization of their standard of living.

- Run-off of acid-water will be controlled for the environmental conservation in the surrounding areas.

- The social effects such as stable supply of major food sources and creation of employment, will contribute to the stabilization of the people's livelihood in this region.

4.3 Financial Analysis

(1) In order to evaluate a financial impact on beneficial farmers through project implementation, farm budget analysis was carried out based on the standard farm models of surrounding areas due to no agricultural activities in the F/S areas. The result shows that the financial value of agricultural incomes and the farm economic surplus will increase by about 26,000 to 30,000 Baht and about 9,000 to 18,000 Baht, respectively. Therefore, the farm management will be improved higher than the present level.

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

(1) The concept of the project meets the aims of the land use development policy for waste and problematic soil areas of the 7th National Economics and Social Development Plan. In this study, the development plan has been formulated, considering soil improvement/conservation techniques and conservation of natural environment. Furthermore, the project has been formulated based on the institutional system and engineering capability of OLD and other governmental agencies concerned.

(2) In this study, three areas with different characteristics were selected from the development zone in the swamp area, and development plans were formulated for each area. The development concepts derived from this study could be applicable to about 12,700 ha of other similar soil areas, as models. Therefore, if the similar projects would be spread out on the whole development zone after completion of the pioneer projects in the three areas, the project definitely could contribute to the creation of new agricultural land, the increase in agricultural production, the stabilization of farmer's livelihood and the conservation of regional environment.

(3) The project would produce many social benefits, although the economic viability in a quantifiable sense is low. As a conclusion, therefore, the proposed project is considered to be feasible.

5.2 Recommendation

It is recommended to implement the proposed project with due attention to the following.

(1) For the smooth and successful implementation of the project, it is a prerequisite to carry out the agricultural supporting services for study, research and training on farming practices in those problem soil areas, in addition to the improvement of infrastructure.

(2) The development practices are out of the ordinary. An incomplete improvement of infrastructure and farm management may worsen regional environment by producing much more acid-water than the present level. To avoid such a situation while farming is practiced, it is prerequisite from

the initial implementation stage to have positive participation of related farmers for cooperation and understanding about the project.

(3) In order to develop similar projects into the swamp area, it is necessary to establish the organization to monitor the environmental change and review the outputs of the implemented projects for following project formulation.

(4) In the development plan for Mu No-Koknai area, the construction of protection dikes was proposed for alleviation of inundation damage. For developing such dikes into the whole conservation zone along the swamp, it is prerequisite to study the influence of construction on the ecological system from viewpoints of hydrologic cycle in the swamp.

CONTENTS

APPENDICES

A. GENERAL

B. PROJECT RELATED ORGANIZATIONS

C. HYDROMETEOROLOGY

D. HYDROGEOLOGY AND GROUNDWATER

E. SOIL AND LAND USE

F. AGRICULTURE

G. IRRIGATION/DRAINAGE

H. ENVIRONMENT

I. AGRO-ECONOMY

J. LEACHING TEST IN FIELD LEVEL

K. COST ESTIMATE

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS AND ACRONYMS USED

AGENCIES

BAAC	: Bank of Agriculture and Agricultural Cooperatives
CDD	: Community Development Department, MOI
CPD	: Cooperatives Promotion Department, MOAC
DOA	: Department of Agriculture, MOAC
DLD	: Department of Land Development, MOAC
DOAE	: Dapartment of Agricultural Extension, MOAC
DOF	: Department of Fisheries, MOAC
DOH	: Department of Highway, MOC
DOL	: Department of Lands, MOI
DOLA	: Department of Local Administration, MOI
FAO	: Food and Agriculture Organization of the United Nations
HD	: Harbor Department, MOI
JICA	: Japan International Cooperation Agency
LDD	: Livestock Development Department, MOAC
MD	: Meteorological Department, MOC
MRD	: Department of Mineral Resources
MOAC	: Ministry of Agriculture and Cooperatives
MOC	: Ministry of Communication
MOF	: Marketing Organization for Farmers, MOAC
MOI	: Ministry of Interior
MOPH	: Ministry of Public Health
NEA	: National Energy Authority
NEB	: National Environmental Board
NESDB	: National Economics and Social Development Board
NSO	: National Statistical Office
OAE	: Office of Agriculture Economy, MOAC
PER	: Provincial Electricity Authority
RFD	: Royal Forestry Department, MOAC
RID	: Royal Irrigation Department, MOAC
PRDSC	: Pikun Thong Royal Development Study Center

GENERAL

B	: Baht
BM	: Bench Mark
EL	: Elevation Above Mean Sea Level
GDP	: Gross Domestic Product

GNP	: Gross National Product
GPP	: Gross Provincial Product
GRP	: Gross Regional Product
M.	: Million
NPV	: Net Production Value
WL	: Water Level
cu.m	: Cubic Meter
MCM	: Million Cubic Meter
Kw	: Kilowatt
l	: liter
ha	: Hectare
m	: Meter
kg	: kilogram
km	: kilometer
sq.m	: square meter
ton	: Metric ton
hr	: Hour
min	: Minute
sec	: Second
°C	: Degree Celsius

CLOSSARY

Changwat	: Province
Amphoe	: District
Tambon	: Sub-District
Muban	: Village
Mae Nam	: A large river
Khlong	: A tribuary of the large river

UNIT OF MEASUREMENT

1 rai	: 0.16 ha, 1,600 sq.m
1 ha	: 6.25 rai, 10,000 sq.m

THAI FISCAL YEAR

October 1 to September 30

Thai year 2535: AD 1992

CHAPTER 1

INTRODUCTION

CHAPTER 1 INTRODUCTION

1.1 Background

There exist seven kinds of problem soils for agricultural use in the Kingdom of Thailand. Especially, along the south-east coast of Thai peninsula, saline, peat and acid sulfate soils have been found so far, and the entire area covered with those soils amount to approximately 620,000 ha.

Regarding such areas in Narathiwat province, unfavorable areas are covered with peat and acid sulfate soils, which mostly exist in swampy land and total about 27,000 ha according to DLD's investigation. Agriculture of the province has occupied a very important position in the provincial economy since former times until now, as shown in statistics of GPP. Concerning its future, it can be assumed that it will remain the same situation or will get much worse in the future, because the area of cultivated land per farm household will decrease due to increasing population. Even at present, farmer's annual income from farming has been stagnant, less than the national level.

The Thai Government, therefore, launched agricultural development in those areas affected by soil problems, which is an important policy to stabilize the farmers' livelihood in the province bordering Malaysia. However, agricultural development techniques for those poor quality soils have not yet been established, and moreover, high monetary inputs are also continuously required for soil improvement. For these reasons, most of those areas have been abandoned. Based on the Government policy, the Department of Land Development (DLD) was assigned to be a task force, responsible for land conservation and optimal land use by participating as a member of the agricultural and rural development committee. The Pikun Thong Royal Development Study Center (PRDSC) was initiated by His Majesty the King to do research on the problem soils for agricultural use in 1982. As a result of their efforts, the areas concerned in the province were classified into three zones, preservation, conservation and development zones, but research for suitable techniques to solve the problems is needed. In order to achieve the Government policy in this aspect, the Thai Government requested technical cooperation from the Japanese Government.

In response to the request from the Thai government, the Government of Japan conducted a preliminary survey on the agricultural development for peat/acid sulfate soil areas in Narathiwat Province, through JICA. And a Scope of Works (S/W) was concluded between DLD and JICA on November 27, 1991. Based

on the Scope of Works, a study team was dispatched on March 1, 1992 to perform the survey. The results of the study have been compiled and presented in this Report.

1.2 Objectives of the Study

The objectives of the study are:

1. to conduct feasibility study on the agricultural development of peat/acid sulfate soils in pilot areas in Narathiwat Province,
2. to formulate technical guidelines for the improvement and conservation of peat/acid sulfate soil areas in Narathiwat Province,
3. to pursue transfer of technology to the Thai counterpart personnel in the course of the Study.

1.3 Study Area

In accordance with the Scope of Works, the study area covers the Narathiwat Province in Peninsular Thailand, wherein peat/acid sulfate soil areas in coastal wet land will be the major focus point of the Study. Representative pilot areas to be selected for feasibility study are limited within the "Development Zone" area, following the land use designation of the Thai Government regarding the coastal wet land of the Narathiwat Province, while the total acreage of such pilot areas will not exceed 5,000 ha.

CHAPTER 2

SOCIO-ECONOMIC BACKGROUND

CHAPTER 2 SOCIO-ECONOMIC BACKGROUND

2.1 National Economy

2.1.1 Land utilization and Population in Thailand

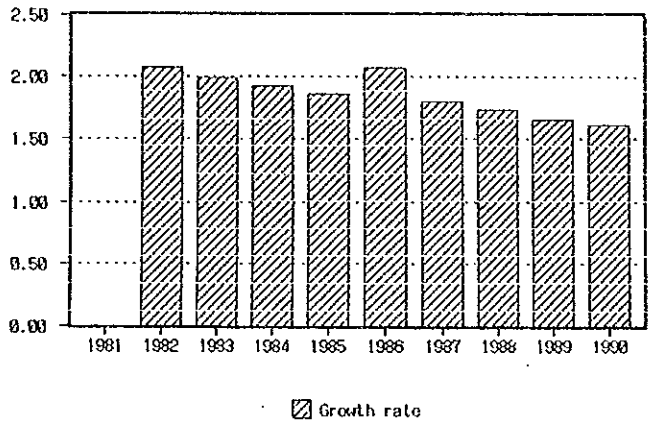
(1) Land utilization

The National land area of Thailand is approximately 51.3 million ha, of which about 46% (23.6 million ha) is utilized as farm holding land, about 28% (14.4 million ha) as forest land and the remaining 26% (13.3 million ha) is used as unclassified land.

(2) Population

According to the data from Agricultural Statistics of Thailand, the annual growth rate of the population shows a decreasing trend in recent years.

Population Trend



2.1.2 National Economy

The Thai economy has grown rapidly and has become increasingly internationalized. During the Sixth Plan period, the Thai economy growth has skyrocketed with the gross domestic product expanding at an average of 10.5% per year, representing the highest average growth rate of the past 25 years. Furthermore, the economic structure has become more outward-oriented and

internationalized, as indicated by the increase in the proportion of international trade to GDP, from 60% in 1986 to 80% by 1991.

2.1.3 National Development Plan

Thirty years have passed since the First National Economic and Social Development Plan (First NESD Plan) was started, and the period of the Sixth NESD Plan was terminated at the end of September, 1991, and then the Seventh NESD Plan started. Major development targets of economic and social development during the Seventh Plan (1992-1996) have been announced officially as follows:

(1)	Economic growth : 8.2% per year as composed to constant 1972 price	
	-Agriculture sector	: 3.4%
	-Non-agriculture sector	: 8.6%
(2)	Per capita income (Baht/year)	: 71,000 (about ¥355,000)
(3)	Export of goods	
	-Average value	: 1,063.0 billion Baht
	-Average growth rate per year	: 14.7%
(4)	Import of goods	
	-Average value	: 1,358.0 billion Baht
	-Average growth rate per year	: 11.4%
(5)	Trade balance	
	-Average value	: 313.0 billion Baht
	-Trade balance/GDP	: 9.4%
(6)	Inflation	: 5.6%
(7)	Number of population	: 61.0 million
	-Population growth rate	: 1.2%

2.2 Agriculture

2.2.1 Agricultural Sector in National Economy

When compared to the average world agricultural growth rate of 1.5%, agricultural production during the last NESD Plan grew at an average rate of 3.4% per year. The rate was stagnant. This was attributable to the weakening price of major world commodities since 1989 and the climatic conditions characterized by continual droughts towards the end of the last NESD plan.

GDP and Agriculture

(Unit: Million Baht)

Year	Total GDP	Agriculture	%
1981	760,195	162,987	21.4
82	820,002	156,836	19.2
83	910,054	185,628	20.4
84	973,412	175,190	18.0
85	1,014,399	169,895	16.7
86	1,095,368	178,140	16.3
87	1,253,147	205,592	16.4
88	1,506,977	250,384	16.6
89 r	1,775,978	266,379	15.0
90 p	2,051,208	254,523	12.5

Note: r = Revised data, p = Preliminary data
Source: Agricultural Statistics of Thailand 1990/91, MOAC. Originally from NESDB

Although the status of the agricultural sector in the national economy has fallen from 18.0% in 1984 to 12.5% in 1990, livestock and simple agricultural processing sub-sectors play an important role in the sector.

Shares of Agricultural Sector in GDP

(Unit: %)

Year	Crops	Livestock	Fisheries	Forestry	Agro-Service	Agro-Processing
1981	64.9	9.7	6.5	5.9	4.1	8.9
82	63.8	8.9	7.0	5.5	4.5	10.3
83	65.2	10.2	6.7	4.9	3.3	9.7
84	64.5	9.6	6.5	5.3	3.9	10.2
85	61.9	8.8	7.5	5.3	4.4	12.1
86	60.1	11.1	8.6	5.0	4.0	11.2
87	59.8	10.9	9.7	4.7	3.9	11.0
88	64.0	9.8	8.6	3.6	3.5	10.5
89 r	62.9	10.7	8.0	2.8	3.5	12.1
90 p	59.0	12.6	8.8	2.2	3.7	13.7

Note: r = Revised data, p = Preliminary data
Source: Agricultural Statistics of Thailand 1990/91, MOAC.

2.2.2 Diversified Thai Agriculture

In the decade of 1950, about 90% of the total cropped areas were used to grow rice. Afterwards, commercial crops production had been developed through an expansion of the commodity economy. These commercial crops were represented by cassava, sugar cane, maize, rubber and so on.

In the decade of 1980, new commercial crops such as mungbean, soybean and onion were extended. The cropped areas have been extended through reclamation of forest land and wild plain. Consequently, forest land has been reduced rapidly.

2.2.3 National Agricultural Policy

The Seventh NESD Plan emphasizes that the GDP share of the agricultural sector gradually declined. Nevertheless, the sector is still important to the Thai economy as the agricultural employment share remains as high as 64% of total employment. Although the agricultural sector has increasingly diversified its production to over 400 types of product, these are generally small quantities and do not lend themselves to export promotion. Agricultural export continues to be dominated by a few items of primary commodities while export volume of other field crops, such as vegetables and fruits, remains low, resulting in a low overall value of these export items. Nevertheless, there are still opportunities for agricultural development, particularly of high value added items, which will support overall economic expansion during the Seventh NESD Plan period.

(1) Targets of agricultural development

The Target of an average overall economic growth rate of 8.2% per year assumes that the agricultural sector will be able to attain an average growth rate of 3.4%. At this rate of expansion, the sector will need a restructuring of the processing industry, together with a more intensive application of higher agricultural technology to boost productivity.

(2) Guideline for agricultural development

i. Emphasize efficient use of natural resources to serve as an agricultural production base and to preserve resources for the future by stressing the following:
   - Special protection of fertile agricultural areas

- Support systematic land use to reduce potential conflicts, between farmers and those in other non-farm groups
- Formulate a land use plan as well as demarcate clear zoning of land use under the law
- Encourage a more efficient use of water

ii. Support research, development, and transfer of technology in agriculture, together with the provision of necessary inputs to production by doing the following:

- Support the private sector with the government playing the leading role in research and development and encourage the use of seedlings, plant varieties and animal stocks
- Encourage agricultural workers to optimize chemical fertilizer use and ensure adequate supply of high quality fertilizer
- Encourage correct use of chemical products and reduce their uses in the future
- Enhance productivity and the efficient use of agricultural machinery
- Expand the scope of agricultural credit and encourage contract farming business
- Restructure agricultural production in line with the local conditions and market demand
- Support development of the agro-processing industry
- Improve the agricultural and cooperative development system
- Formulate an agricultural production restructuring plan
- Improve and develop the capacity of the information system
- Provide management and administration training

2.2.4 Agricultural Development Policy and its Guideline related to the Study

On the basis of the Seventh NESD Plan, the Rural Development Plan has been proclaimed as a precise policy and practical guideline which gives a special importance to solving the problems of poverty in 38 provinces, 288 districts and 12,555 villages along with development in general areas.

In the Rural Development Plan (1992-1996), results of development and the existing aspects of the problem, and a related matter regarding this study is stated. It showed concern about the degradation of soil both by nature and by human deeds, such as doing salt-farming in the northeastern region.

Following these stated constraints, the Plan stated that this problem was caused by the need for agricultural land which is the result of the past

population growth. The number of rural households increased from 6 million in 1984 to 6.5 million in 1988. In Narathiwat province, the population increased from 458,000 in 1981 to 581,000 in 1989, about a 27% increase. On the other hand, the agricultural areas only increased from about 20 million ha in 1984 to 23.6 million ha in 1988, only about 18% increase.

(1) Development guideline stated in the Seventh NESD Plan

The Seventh NESD Plan has emphasized the following as Specific Guidelines and Measures for management of natural resources.

- Designate the land use zoning in accordance with land capabilities and the area potentials
- Extend public services and subsidization to the lands with problem soils such as peat, acid, saline and sandy texture soils
- Accelerate the implementation of soil and water conservation programs using simplified techniques which are workable and practical based on technical support provided by the Government
- Establish a soil development village in every Amphoe, to serve as the local center of technical knowledge

(2) Development Guideline stated in the Rural Development Plan

Related to this study, it is stated that the Guidelines for Development of the Natural Resources and the Environment should be as follows;

- Improve and alter the problematic soil for agricultural use, i.e, improvement of salty soil, strong sandy soil, including the improvement of the soil which lacks organic substances and soils of specific areas which have other intricate problems, so that it can be used correctly and suitably. Moreover, the wrong category of land use should be replaced according to the technological method.
- Regarding the areas with acute problems beyond the capability of the farmers or any conservation activity which each farmer cannot perform by himself, the government will be the party to solve the problems. Moreover, the Government should encourage the acceleration of the survey of soil data so as to give an accurate guideline on land use.
- As for soil data system, assist in improving the soil data system so that the same system is used by every individual working unit, and by encouraging the use of technology which can be accomplished by providing equipment and utensils for orientation course for training

personnel to use computers, to develop the characteristics of a network so that a common data base can be made.

- The development of the natural resources outside the conservation areas shall have the following implementation guideline:
  - Improve and increase efficiency in using the existing local natural resources to the highest level and to comply with the economic development of the province.

CHAPTER 3

PRESENT CONDITION OF THE STUDY AREA

CHAPTER 3 PRESENT CONDITION OF THE STUDY AREA

3.1 Physical Features

3.1.1 Location

Narathiwat province is located between the longitude 101°-12'~102°-05' and latitude 5°-44'~6°-38' in the extreme southern part of Thailand, about 1,150 km away from the capital. South and south-eastern boundary of the province forms the border line with Malaysia. West and north are bounded by Yala and Pattani provinces.

3.1.2 Topography

The topography of Narathiwat consists of hills/mountains scattered all over the province, swampy forests and plains land along the gulf of Thailand. The longest stretch of hills starts from Amphoe Si Sakhon in the west and continues down to Mountain Ba Tu Ta Mong of Amphoe Sukhirin in the south. Altitudes of these hills/mountains varies from 200m to 1,300m. Three big swamp forests, Bacho in the north, Kab Daeng in the middle and To Daeng in the south are also important geographical features of the province. The province is also blessed with huge gentle slopes, where para rubber is grown.

3.1.3 Climate and Hydro-meteorology

(1) Climate

Thailand may be categorized as a tropical country with a hot climate and heavy rainfall. In general, it has two seasons namely, rainy and dry. Unlike other regions, the study area has a longer rainy season (June through February) and shorter dry season (March, April and May). Annual average rainfall is quite high, about 2,500 mm. Of which 50% falls during the months of November and December. All year round the climate is humid with high temperature. Average temperature and humidity are 28°C and 76% respectively. Heavy rainfall causes annual inundation in the low lying areas. The area also experiences reasonable number of thunderstorms every year, especially, during the months of May, June, July and August.

(2) Hydro-meteorology

The hydrological feature of Narathiwat province is rather complicated. Apart from the three big swamps, there are four big rivers, namely, Kolok, Yakan, Bang Nara and Sai Buri traverse in the province. In order to mitigate floods, to facilitate the drainage from the swamps and for irrigation purposes, there are three big artificial canals, Bacho canal for Bacho swamp, Nam Baeng to mitigate flood in Bang Nara and a connection canal from Kolok river to irrigate Mu No project area. Most of the rivers and canals are controlled by regulators on up and downstreams for restricting salt water intrusion or to raise the water level for irrigation.

Royal Irrigation Department (RID) has observation stations to record water level and discharge of the main rivers. But the observation period is very short in most cases. Figure-1 shows the observation stations operated by RID.

1. Rainfall

Daily rainfall data from seven stations have been collected. The stations are Bacho, Muang, Yingo, Rangae, Tak Bai, Mu No project and Sungai Kolok. Monthly and annual average rainfall of study related stations are presented below.

Unit: mm

Station	J	F	M	A	M	J	J	A	S	O	N	D	Total
Bacho	102	34	64	57	156	129	162	135	194	242	522	595	2437
Muang	72	38	70	68	159	115	138	145	181	263	610	519	2379
Takbai	33	24	55	34	66	114	91	100	153	172	420	496	1820

Note: Data period, 1971~1989

2. Temperature

Daily data from Narathiwat, Pikun Thong Development Study Center and Mu No project station were collected. Since the Narathiwat station has the longest record, data of this station were used for analysis. Monthly average is presented in the table below.

Station : Narathiwat Unit: °C

J	F	M	A	M	J	J	A	S	O	N	D
26	27	28	29	29	29	28	27	28	28	26	25

Note: Data period, 1961~1991

3. Humidity

The province has very high percentage of humidity. Some of the months have average maximum of 99 percent. However, daily average on monthly basis is presented below.

Station : Narathiwat Unit: %

J	F	M	A	M	J	J	A	S	O	N	D
78	77	76	76	74	74	74	71	75	77	77	77

Note: Data period, 1961~1991

4. Evaporation

Daily data from Narathiwat, Mu No project and Pikun Thong Development Study Center were collected. Considering the continuity, data from Mu No project station were used for analysis. Monthly average is presented below.

Station : Mu No project Unit: mm

J	F	M	A	M	J	J	A	S	O	N	D
72	93	105	113	98	91	96	96	92	88	64	59

Note: Data period, 1981~1990

5. Sunshine

Sunshine data was not available in any of the stations in Narathiwat. Therefore, data from Songkla station were collected. From the monthly total, daily average was calculated and presented below.

Station : Songkla Unit: hours

J	F	M	A	M	J	J	A	S	O	N	D
8.2	8.9	8.5	8.8	7.5	6.9	7.0	6.9	6.3	5.9	5.3	5.9

Note: Data period, 1971~1989

6. Windspeed

Data from Narathiwat and Mu No project stations were collected. Considering the continuity, Mu No project's data were used in the analysis. Monthly average is presented below.

Station : Mu No project Unit: km/hr

J	F	M	A	M	J	J	A	S	O	N	D
1.64	1.87	2.03	1.99	1.71	1.64	1.64	1.66	1.66	1.52	1.35	1.65

Note: Data period, 1981~1990

7. Sedimentation

Only RID has the facility for suspended sediment data collection in Kokok river. The station at X119A covers a drainage area of 1358 sq.km. From the analysis of six years data (1981-1987) it was found that the river carries annually an average 204,600 tons of suspended sediment.

8. Discharge

Although RID has many observation stations, they do not have enough discharge data. However, data of three rivers, namely, Yakan, Kolok and Sungai Padi were collected and reviewed. It was found that the range between maximum and minimum discharges of these rivers is very wide. From five years of monthly data (1986~90), Yakan has a maximum discharge of 238 m^3/sec in November and minimum 2 m^3/sec in July at X-73. Kolok discharged maximum of 283 m^3/sec in December and minimum 5 m^3/sec in May at X-119.

9. Water quality

The water in most of the rivers/canals is relatively acidic. Operation and Maintenance (O&M) section of RID measures the water quality of all rivers

and canals in the province. Presently available three years data (1988-1990) were collected. Observation stations are presented in Table C-1 in Appendix C. In this section, using the collected data, monthly variation of pH in major rivers/canals is presented in Figure-2. O&M section has only two months data on Dissolved Oxygen (DO). According to the data, DO varies between 4~5 mg/liter, which can be considered as a standard value.

3.1.4 Hydrogeology and Groundwater

(1) Geology

The study area is formed with coastal and flood plain of the Bang Nara and the Kolok rivers. The basement is granite rocks dated Triassic age. The area is bounded by the granite mountains to the west. In the vicinity of Narathiwat, there are hills composed of granite e.g. Khao Tanyong in the east and Tertiary conglomerates in the west. In the north around Bacho swamp, the depth to the basement is shallow 20-30m. On the other hand, alluvium is very thick in the area along the Ya Kang and the Bang Nara rivers, as well as in the southern coastal plain, where it is more than 150m thick in the vicinity of Tak Bai (see Figure D-1, Appendix D). In the coast, sand dunes lie elongating parallel to the sea shore line. Bacho and to Daeng swamps are situated in the flood plain bounded by those sand dunes. As other major geological formations, there are colluvium and diluvium. Colluvium is deposited at the foot of the hills and mountains, and diluvium (terrace deposit) is deposited along the Ya Kang river and the middle stream of the Kolok river, some of which contain laterite. The geological condition of the study area is shown in Figure-3 and Table-1.

(2) Groundwater

During the field observation conducted in March '92, shallow groundwater table was observed at 1-2m below the surface in alluvium area, and 2-6m below in diluvium, colluvium and sand dune areas (see Figure D-2, Appendix D). In the rainy season, groundwater tables rise as high as the surface water levels, being replenished by surface water (see Figure D-3, Appendix D).

Concerning the water quality, the pH values vary between 5 and 6 in most of the area. However, there are some places in the upstream of the rivers, where the pH values fall down to the level of 4 (see Figure D-4, Appendix D). EC values are high in the deltas of the Kolok, the Bang Nara rivers and in some areas in the east of Amphoe Bacho (see Figure D-5, Appendix D).

Since deep groundwater is confined, the groundwater table is high. The static water level is found at 2-3m below the surface on the feet of the mountains, 1-2m below the surface in the sand dune area (see Figure D-6, Appendix D). This means the head gradually becomes lower, groundwater flowing down to the alluvium and the sand dune areas. The water quality is good in general except for the deltas where very deep estuaries were formed long time ago (see Figure D-8, Appendix D).

Table-1 Major Geological Formations and Hydrogeological Characteristics

Formation	Beach sand	Alluvium	Diluvium Colluvium	Granite
Age	Quaternary to Recent	Quaternary to Recent	Holocene	Triassic
Thickness	max. 23m	max. >150m	max. 30m	—
Permeability	>800m/d avg. 300m/d w. old beach sand aquifer	avg. 10m/d w. sand aquifer	avg. 20m/d w. gravel aquifer	Permeable only in fractured zone
Water quality	very good	poor-fair depending on mineral content of clay	good poor in laterite area	good
Aquifer classification	good	poor	good	aquiclude

3.1.5 Soil and Land Use

(1) Soil

In Thailand, there are seven kinds of problem soils. They are Saline soils, Acid sulfate soil, Sandy texture soils, Ground water podzols, Vertisols soils, Peat soils and Skeletal soils which have been obstructing agricultural activities. Among them, peat and acid sulfate soils occupy 45,000 ha and 852,000 ha respectively. Sixty four (64) percent of peat and two (2) percent of acid sulfate soils are found in the province. The distribution is shown in the table below.

Distribution Area of Peat / Acid Sulfate Soils

Unit : 1,000 ha

Location	Total available land	Peat soil	Acid sulfate soil
Thailand	51,300	45 (**)	852 (*)
Peninsular	-	43 (**)	88 (***)
Narathiwat	-	27 (***)	19 (***)

Source : FAO yearbook 1990

* Reconnaissance Soil Map scale 1:500,000, Soil Survey Division and Classification Division, DLD.

** Classification characterization and utilization of peat land

*** Semi-detailed survey in 1984, with soil map scale of 1:25,000, Soil Survey and Classification Division, DLD

Note; In peninsular, Trat province is not included.

Concerning peat soils, the area in the southern provinces is about 45,000 ha. Of which the province has the biggest share as shown below.

Ranking	Province	Distribution Area (ha)	Remark
1	Narathiwat	26,600	
2	Nakhon Si Thammarat	12,300	
3	Chumpon	2,700	
4	Trat	1,917	south east coast
5	Songkhla	887	
6	Phattalung	446	
7	Pattani	180	
Total		45,030	

Source : DLD

In the province, peat and acid sulfate soils are mainly distributed in two big swamp areas, namely, Bacho and To Daeng.

(2) Land use

The changes in land use pattern in seven years from 1978 to 1985 are presented in Table-2. The analysis of collected land use data reveals that there is a drastic reduction of the swampy forest areas, which has dropped down to 70% of 1978. During this period, some parts of the original swamp areas have completely been cleared up. As a cause, the increased need of agricultural land due to the population growth can be cited. Although agricultural land has increased by 20%, the paddy field areas have not increased because of an increase in waste land after a few years of cropping due to the unsuitability of the soils. This increased agricultural land is predominantly used for rubber plantation. The areas covered by natural pasture have shown a decreasing tendency. Land use in recent years is shown in Figure E-6, Appendix E.

3.2 Socio-Economic Conditions

3.2.1 Regional and Provincial Economy

(1) Southern region

The southern region covers an area representing approximately 14 percent of the total area of Thailand or 71,000 sq.km, meanwhile its population in 1990 is about 13 percent of whole Thailand or approximately 7.5 million. The main economic activities are para rubber plantation, oil palm plantation, coconut cultivation, fruits, tin-production and mining.

The Gross Regional Product (GRP) was 161,284 million Baht in 1989 (at current market price) which contributed approximately 10 percent to that of the whole country. The per capita GRP was 21,958 Baht, lower than the national average of 24,760 Baht.

Agriculture is the most important sector which contributed 32.9 percent to GRP and among the agricultural items, crops' sector is a main contributor and accounted for 57.5 percent.

Other sectors such as mining, manufacturing, and construction accounted for respectively 5.2, 5.4 and 5.8 percent of GRP from 1985 to 1989 are shown in Table I-1-1, Appendix I.

(2) Narathiwat province

Narathiwat province is one of the fourteen (14) provinces in the southern region. The province covers an area of 4,475 sq.km and has a population of 560,263 as of 1990. The most important economic activity is agriculture, especially, para rubber cultivation.

The Gross Provincial Product (GPP) was 9,700 million Baht in 1989 (at current market price) which contributed 6 percent to that of the southern region. The per capita GPP was 16,696 Baht, lower than the national and southern regional average, covering approximately 67 percent and 76 percent of those values.

Agriculture sector is the most important which produced 38 percent of GPP. Crops as a dominant subsector contributed 30.2 percent to the GPP and 79.4 percent of agricultural production value. The main crops are para rubber, rice, fruits etc. Main livestock are cattle, buffalo, goat etc. This subsector contributed 12.6 percent to the agricultural sector. As for fishery, there are 18,920 fishery households. Until now, this subsector contributed 8.8% to agricultural sector. It will become more important in the near future when the commercially based inland fishery starts, which involves 607 farmers, 936 ponds or 221,549 sq.m. of pond area. The contribution of forestry to agricultural sector was as low as 2.2% as of 1990, Agro-processing such as extraction of coconut oil, smoked rubber sheet, rice milling and the like occupy 13.7% of agricultural value and play an important role in the sector as well.

Secondary important sectors are wholesale and retail trades which contributed 19.9 percent to GPP. The GPP from 1985 to 1989 are shown in Table I-1-2, Appendix I.

3.2.2 Administration

(1) Division of administration

The administrative area of Narathiwat province is divided into 12 districts (Amphoes), 77 sub districts (Tambons), and 492 villages (Mubans). The administrative divisions are illustrated in Figure I-1-1, Appendix I.

(2) Central administration

There are 81 organizations in the province which work under the control of the central government, of which the Ministry of Agriculture and Cooperatives has a special characteristic to act as a center for research and to promote agricultural activities.

(3) Regional administration

The regional administration is comprised of provinces and districts. Various Ministries, Bureaus and Departments have their provincial and district level offices to function on a regular basis. The total number of these offices is 28.

(4) Local government administration

The local government administration of the province is comprised of one provincial Administrative Organization, two Municipalities and eight Sanitaries.

3.2.3 Population and Land holdings

(1) Population

According to the statistics of June 30, 1990, there is a total population of 560,263 in the province, out of which 281,558 are male and 278,705 are female. There are 105,028 households in the province. Seventy eight (78) percent of the population is Moslem, twenty one (21) percent is Buddhist. The populations of the southern region and the Narathiwat province (including GRP and GPP) are illustrated in Figure-4. The populations in each Amphoe are shown in Figure I-1-2, Appendix I.

The annual population growth rate of the province is one of the highest in Thailand. During the last two decades, it showed 2.73% which was higher than the national average of 2.04% and the southern region average of 2.20%. The growth patterns are shown in the table below. It can be seen that the province has a high population growth despite the decreasing trend recorded at the national level.

Population Growth during the Last Two Decades

Area/Year	Population (1,000 persons)			Average growth rate (%)		
	1970	1980	1990	1970 to 80	1980 to 90	1970 to 90
Narathiwat Province	327	398	560	1.98	3.47	2.73
Southern Region	4,510	5,974	6,964	2.85	1.55	2.20
Thailand	36,379	46,718	54,532	2.53	1.56	2.04

(2) Land holdings

According to the Agricultural Statistics of Thailand, Crop Year 1990/91, there are 55,302 agricultural households and the farm size per household is 4.0 ha (see Table-3). Eighty (80) percent of farm holding land or 179,066 ha are cultivated by owners, 13 percent of that is rented to other people free of charge (see Table-4).

In Thailand, the legal system of land right is based on the Land Code of 1954. The Department of Land (DOL) has a duty for the allocation and acquisition of state land. The DOL issues several land documents, especially, NS-4 (Title Deed), NS-3 and NS-3K as the legal recognition. According to the provincial office of DOL, the land right of the province is classified as 3,254 ha under NS-4, 32,615 ha and 32,525 ha are under respectively NS-3 and NS-3K, and the rest falls in other categories (refer to Tables I-1-3 and I-1-4, Appendix I).

3.2.4 Rural Area Development Plan

(1) Present level of the villages in the province

A survey of fundamental data at village level (Kor Chor Chor 2 Kor) was carried out in 1990 by NESDB to cope with the Seventh National Economic and Social Development Plan. According to the results, the level of development of the villages in the province was three kinds, i.e. 55 villages (11.7%) were backward, 319 (67.6%) were middle-level and the rest 98 villages (20.7%) were progressive.

Based on NESDB Plan, backward and moderately progressive villages are supposed to be developed by the governmental authorities. Therefore, 79.3% of the villages are considered under the governmental rural development plan of the province.

(2) Income

In Narathiwat, the principal occupation is agriculture. Hence, the agricultural goods producer has earned the highest income in the province. Business and service sectors earned secondary income.

In 1986, a survey was carried out on the average income per head per year, which was 12,505 Baht, ranking the 11th highest in the southern region. In 1987, the average income per head per year was 14,345 Baht, it increased to 15,547 Baht in 1988, still ranking the 11th highest in the region for those respective two years.

(3) Rural area development plan

Prior to the formulation of the rural development in the Seventh National Economic and Social Development Plan, NESDB had reviewed outcomes and problems of past rural development in order to draw up development guidelines of the Seventh Plan. As the result, in the plan, it is described that 182 millions rai of cultivated land has been stricken with problematic soils. In order to cope with the problems, establishment of soil development villages in every Amphoe, is clearly mentioned in specific guidelines and measures. Especially in Narathiwat province, development of its unfavorable area will be an important part of the regional rural development policy.

(4) Master plan for the agricultural development of Narathiwat province

MOAC formulated a master plan for agricultural development of Narathiwat (1992-1996) in 1990, in line with the national agricultural development plan. It can be pointed out that the agricultural constraints of the province comprise nine aspects i.e. income, marketing, production, resource, government agency, farmer's technology, farmer's grouping, credit and extension. The development strategies are formulated by each constraint. In this master plan, there are six important projects, namely, project for multi-production at farmer level, project for coastal marine cultivation, project for meat cattle, project for goat and sheep, project for cashewnut and project for fruit tree.

The purpose of agricultural development in the Narathiwat province is basically to increase farmer's income, which consists of applying measures for the improvement of agriculture. These measures consist of mainly two; one deals with an efficient land use including the promotion of irrigation, crop diversification and cash crop etc., and the other with the economical use of waste land.

3.3 Agricultural Conditions

3.3.1 Present agricultural land use

Agricultural land in Narathiwat province covers 394,391 ha, which consists of about 88% of the whole area of the province. Major part of cultivated area is covered by perennial crops of which 94% is rubber. The rubber land mainly occupies fertile area near mountains. Paddy field is only 43,000 ha, 11% of the whole area.

Present Agricultural Land Use in Narathiwat Province

	Crop	Area (rai)	Area (ha)	Ratio (%)
1.	Paddy Field	269,771	43,163	11.0
	Rainfed Paddy Field	142,177	23,548	6.0
	Irrigated Paddy Field	122,594	19,615	5.0
2.	Perennial Crop Land	1,176,857	188,297	47.7
	Orchard Land	5,303	848	0.2
	Para Rubber Land	1,102,827	176,452	44.7
	Coconut Land	68,125	10,900	2.8
	Others	602	96	0.0
3.	Range Land	27,252	4,361	1.1
	Natural Pasture Land	3,404	545	0.1
	Waste Land	23,848	3,816	1.0
4.	Forest Land	991,066	158,570	40.2
	Evergreen Forest	891,422	142,627	36.2
	Peat Swamp Forest	93,853	15,016	3.8
	Plantation Forest	5,791	927	0.2
	Total	2,464,946	394,391	100.0

Source; DLD, 1987

3.3.2 Agricultural Production

(1) Rice

Total rice production in the province is shown as follows.

	Planted area (rai)	Harvested area (rai)	Production (ton)	Yield (kg/rai)
Thailand	61,994,000	58,770,000	19,072,000	325
Narathiwat	192,402	171,932	53,364	310

Source: Agricultural Statistics, Thailand, crop year 1983/84, 1987/88 and 1990/91, Average for a period from 1982 to 1991

The demand of rice in the province can be estimated at about 120,000 tons, based on the population and past trend of the rate of demand, which means the province has a shortage of rice of about 67,000 tons. The shortfall is met by importing from other provinces. The province has no special measures against this problem. However, it is recommended to promote effective use of land through an improvement of waste land. Average yield of the province is lower than that of Thailand due to low productivity of second rice, as shown below (refer to Tables F-1-1 and F-1-2, Appendix F).

Unit: kg/rai

	Total yield	Second rice	Major rice
Thailand	325	580	305
Narathiwat	310	437	305

(2) Groundnut

The cultivated area of groundnut in the province is only 0.13% of that of the country. The yield is increasing gradually, and is slightly higher than the national average (refer to Table F-2, Appendix F).

	Planted area (rai)	Harvested area (rai)	Production (ton)	Yield (kg/rai)
Thailand	775,000	750,000	160,000	213
Narathiwat	1,041	970	222	229

Source: Agricultural Statistics, Thailand, crop year 1983/84, 1987/88 and 1990/91, Average for a period from 1982 to 1991

(3) Mungbean

The cultivated area is only 7.3% of the total area in the country. The yield has been decreasing recently, but is still slightly higher than the national average (refer to Table F-3, Appendix F).

	Planted area (rai)	Harvested area (rai)	Production (ton)	Yield (kg/rai)
Thailand	3,850	2,924	309	106
Narathiwat	281	149	21	141

Source: Agricultural Statistics, Thailand, crop year 1983/84, 1987/88 and 1990/91, Average for a period from 1982 to 1991

(4) Para rubber

The cultivated area of para rubber in the province occupies about 8-9% of that of the country. The yield of the local variety is almost same, but, that of the improved one is about two times as much as the national one (refer to Tables F-4-1 and F-4-2, Appendix F).

	Planted area (rai)	Harvested area (rai)	Production (ton)	Yield (kg/rai)
Thailand	10,996,000	10,273,000	1,097,000	100
Narathiwat				
Local one	188,109	-	20,872	111
Improved one	752,633	549,288	124,770	227
Total	940,742		145,642	155

Source: Agricultural Statistics, Thailand, crop year 1990/91
Agricultural office 1991/92, in Narathiwat

(5) Coconut

The cultivated area of coconut in the province is about 2.7% of that of the country. The yield is about 80 kg/rai higher than the national average (refer to Tables F-5-1 and F-5-2, Appendix F).

	Planted area (rai)	Harvested area (rai)	Production (ton)	Yield (kg/rai)
Thailand	2,455,000	2,163,000	1,426,000	659
Narathiwat	67,538	61,070	44,988	737

Source: Agricultural Statistics, Thailand, crop year 1990/91
Agricultural office 1991/92, in Narathiwat

(6) Vegetables

Twenty-two (22) different kinds of vegetables are grown in Narathiwat province. They are mainly cultivated by trial and error. According to the data in 1989, short cucumber occupies the biggest cultivated area. Following this, there are yardlong bean and angled loofah, etc (refer to Table F-6, Appendix F).

(7) Fruit tree

According to the data in 1989, main planting crops are durian, rambutan and longkong (refer to Table F-7, Appendix F).

(8) Livestock

a) Fodder crop

Orientalis grows everywhere as a natural vegetation. Livestock does not eat them after the heading stage. Homata, Luzi and Crieping are expected as improved species for livestock promotion.

b) Livestock

Farm animals such as cattle and chicken are being raised (refer to Table F-8, Appendix F).

(9) Forest

Main species in Narathiwat are Canua motlyeyana Pierre ex Dubard, Stereculia bicolor Mast and Schina Wallichiikorth.

(10) Inland fishery

Main fish species available in Narathiwat province are Catfish, Nile Tilapia, Chinese Carp, Silver carb and Tyicogaster (refer to Tables F-10-1 and F-10-2, Appendix F).

3.3.3 Agro-economy

(1) General

In the province, agriculture always has been at a key position, which has contributed approximately 38 percent to the GPP, and about 75 percent of the provincial population are engaged in agricultural activities. From 1981 to 1989, the agricultural sector achieved 10.36 percent of average annual growth, which is higher than the total GPP growth of 9.86 percent. It can be said that agriculture contributed a great deal to the successful economic growth of the province.

Staple food such as rice and vegetables could not be sufficiently produced for the domestic demand. In addition, the province has the local disadvantage of domestic consumer's market because of its location. Considering such conditions, agriculture is the most important sector and a main economic activity but is very fragile due to its monocultural structure with rubber plantation.

Considering the change of land use in the province from 1978 to 1985, it can be found that the increase of agricultural land depends on the decrease of natural swamps and forests. With the increasing necessity to preserve swamps and forests, some farmers are ending up without enough land.

(2) Farm economy

The average farm household in the province has 25 rai (4.0 ha) of farm land, of which 19 rai (3.0 ha) are under tree and fruit crops cultivations. 4.2 rai (0.6 ha) is under paddy cultivation, and other crops are cultivated in small areas. The farm types are the combinations with para rubber, paddy, vegetables and livestock, etc.

The farm income comes from both farming and non farming activities, the proportions of these two income sources in the total farm income are 55.7% and 44.3% respectively. The national averages for these proportion are respectively 40.4% and 59.6%, showing the high dependency of the farmers on farming activities. (Agricultural Statistics, 1990/91)

In addition, according to the above mentioned statistics and the office of agro-economic zone 24, the main income sources of farm households in Narathiwat are para rubber (42.8% of the total income), farm custom work (17.9%) and non-farm custom work (11.0%). The total income accounts to 28,956 Baht a year, 52% of the average income of the southern region and 67 percent of the national average.

3.3.4 Agricultural Supporting Services

(1) Extension service

The Department of Agricultural Extension (DOAE) is a leading agency for extension services and is performing these services with one provincial office and several district offices. In the province, 55 DOAE officers are engaged in extension activities with local farmers. An extension officer covers approximately 1,000 farmers in average. In addition to the DOAE, the Department of Land Development (DLD), the Department of Cooperative Promotion, (DOCP), the Department of Livestock (DOL), the Department of Fishery (DOF) and the Pikun Thong Royal Development Study Center (PRDSC) are also participating in extension services.

The PRDSC is also providing extension services to local farmers, especially, in selected pilot villages including the coordination between farmers and government agencies.

(2) Farmer's organization

In the province, various farmer's organizations have been established to bring economic benefits to farmers. The actual activities of those groups are mostly limited to credit services. The existing cooperatives concerned with agriculture in the province are classified into 3 types, namely, the agricultural cooperative, the land settlement cooperative and the credit cooperative. These cooperatives and their members are shown in Appendix I. The most active cooperative is the Tak Bai agricultural cooperative which, however, covers only about 20 percent of the farmers.

The registered farmer's groups which are established for main occupations at the village level are directed by the DOAE. There are 23 registered farmer's groups of which half is engaged in paddy farming and 7 groups in horticultural crops.

(3) Farmer's credit

The organization of farmer's credit can be divided into two types i.e. an institutional organization and a traditional one. The institutional organizations for farmer's credit are commercial and governmental banks. The traditional organizations for farmer's credit come from relatives, neighbors, and merchants etc. The data of traditional farmer's credit are not available. The Bank for Agriculture and Cooperative provided loan service to a total of 29,836 families or approximately 38 percent of the total agricultural households in 1991, classified into individual farmers; 24,200 and farmers organized into some groups; 5,636. Details are summarized in Table I-1-5, Appendix I.

(4) Study and research

The Pikun Thong Royal Development Study Center (PRDSC) and the Narathiwat Animal Nutrition Research Center (NANRC) are today the main centers for studying the agricultural development of the Narathiwat province.

At PRDSC, studies along with research and experimentation on crop cultivation and animal husbandry are being conducted. The selection of appropriate forage, the analysis of production and response to fertilized application are now being experimented by NANRC, as research topics.

3.3.5 Marketing

(1) Present situation

For agricultural marketing, the important farm product from the province is para rubber. Other farm products are insufficient for home consumption. Their products are imported through Hat Yai market in Songkla or Hua-it in the Nakorn Sitamarat Province from the central and northern regions etc.

In regard to trading at the border with Malaysia, there are some communication routes. It is well known that people speaking the same language used to carry in and out consumer's goods including farm products at the border area.

(2) Marketing center

There are four important marketing centers in the province. These centers mentioned below have been established considering the population, the infrastructure and the location of the area.

- Muang Narathiwat Municipality Area (Amphoe Narathiwat)
- Tambon Sungai Kolok Municipality Area (Amphoe Sungai Kolok)
- Ban Ta Ba boundary Area (Amphoe Tak Bai)
- Tanyong Mas Sanitary Area (Amphoe Rangae)

Each district has at least one or more daily or weekly markets which are for the trading of agricultural products.

(3) Marketing level of major crops

There are three levels of markets, namely, a market at the village level, a market at the district level, and a market at the provincial level. The farmers sell products to merchants at the each level of markets. The weight of their levels by major crops is tabled as below.

Weight of Three Levels of Markets by Major Crop

Unit: %

Crops	Village	District	Province
Rubber	35	45	20
Paddy	80	10	10
Coconut	70	10	20
Longkong	80	5	5
Rambutan	80	5	5
Mangostin	95	5	-

(4) Marketing margin

The office of agricultural economic zone 24 reported that in the province, the proportion of marketing margin to the farm gate price differs according to the crops as presented below.

Marketing Margin by Major Crops

Unit: %

	Rubber	Coconut 1)	Longkong	Rice	Rambutan
Average margin	8.9	52.7	8.7	4.5	42.1

Note: 1) dry flesh

3.4 Agricultural Infrastructures

3.4.1 Water Sources

There are three natural rivers which can serve as water resources for irrigation purpose.

(1) Ko Lok river

This is an international river with the total length of about 103 km. Its origin is in Waeng District and flows through Sungai Kolok District and then into the Gulf of Thailand at Tak Bai District.

(2) Sai Buri River

It flows through Cha Nae and Rueso Districts, and runs into the Gulf of Thailand in Sai Buri District. Its length is 180 km with average width of 120 m, depth of 6 m in average, and its annual runoff is 1,000 to 5,000 MCM with the catchment area of 2,180 sq.km. RID has a Development Project in this river basin.

(3) Bang Nara river

This river is different from the above two rivers, because it is a tidal river running along the coastal land and has two mouths. Its catchment area is about 1,500 sq.km and the length is 60 km. Ya Kang river is one of the tributaries of this river, which flows into Bang Nara river with moderate water quality.

(4) Others

There are many swamps in the province, which are regarded as water conservation area. However, water coming from the swamps is not useful for irrigation purpose due to its acidity.

3.4.2 Relevant Development Projects

Many public development projects have been implemented in the province by relevant agencies. Main projects are as follows.

(1) Large scale irrigation project

1) Muno Project

This project is a water resources development project for drainage, flood mitigation, salinity control, water storage and irrigation for agriculture and land reclamation purposes, which is located in the areas both in Sungai Kolok and Tak Bai Districts. The main facilities are consisted of the irrigation and drainage canals, regulators and dikes. Construction of these facilities has completed by RID in 1984. In this connection, Muno Village Livestock Project was initiated in 1983 under the MOAC, which is situated along the right bank of Muno canal in Ban Khok Sai. The existing conditions of this project are summarized as follows.

- To give cultivation right to the settlers for stabilizing their living standards. Twelve (12) rai for farm land and three (3) rai for residential use are allocated to each family.
- At present, the allocated farm land is used for meadows due to the acid soil.
- As a first initiative, 1,500 rai (240 ha) of the project area of 2,400 rai (384 ha) were allocated to 100 families. 900 rai (144 ha) of remaining area is unsettled at present.
- Project area is supposed to be supplied irrigation water throughout the year from the Muno canal.

(2) Medium scale irrigation project

1) Phru Bacho Mai Kaen Project

This is a settlement project planned for agricultural development around the Bacho swamp area. From the viewpoint of improvement of physical condition, this project will drain excess water from swamp as quick as possible and to conserve water in the canal to maintain water level. For this purpose, drainage canals and regulators were constructed by RID. In connection with

this, Bacho Land Settlement Cooperative Project was started in 1975 under the MOAC. The outline of the project is as follows.

a) Objectives

- To allocate farm land to the settlers, in order to prevent encroachment into the preserved forest area.
- To improve rural infrastructure such as school and public health, for stabilization of their standard of living.
- To encourage the strength of farmers' organization

b) Target and progress

- Project area is 90,000 rai (14,400 ha). Also, forest area to be preserved is 15,500 rai (2,480 ha).
- 11,950 rai (1,912 ha) was allocated to 1,509 households in 1992. At present, the other areas are illegally occupied or abandoned.

2) Nam Baeng Project

The main purpose of this project is to drain flood water around To Daeng swamp as quickly as possible and to store water in the dry season. Drainage canal has been constructed by RID.

3) Pi Leng Project

This is an agricultural development project for the new settlers. Project area is partly low land, located along the Bang Nara river. Therefore, project type is drainage and conservation for swamp area. In connection with this, Pi Leng Land Settlement Cooperative Project has been operating. The objectives of the project are as follows.

- To allocate land for new settlers.
- To assist and strengthen agricultural extension and supporting services.
- To improve rural and agricultural infrastructures.

At present, a plot of 5 rai for residential purpose and 20 rai for cultivation are allocated to each household in five villages. As a whole, 684 families obtained their own land. Present land use is as follows.

Preserved forest land	;	8,385 rai (1,342 ha)
Public use land	;	1,007 rai (161 ha)
Allocated land	;	24,124 rai (3,860 ha)
Total		33,516 rai (5,363 ha)

Out of these families, 360 households are Buddhist and 324 households are Moslem. Common facilities, such as schools and temples, were provided considering this condition.

(3) Small scale irrigation project

In the Province, 102 projects had been implemented from 1977 to 1990.

(4) Bang Nara River Basin Development Project

This project is a large scale water resources development project which is operated by RID. It consists of tidal regulators and closure dams at two locations to prevent sea water intrusion into the river and also to serve as a fresh water reservoir for cultivation and domestic consumption. The above main structures were constructed by Japanese grant aid. Irrigation system will be provided by RID to serve the project area. Also, the area suffers from flooding will be drained and provided with drainage canals to develop such area into cultivated area. The total beneficial area is approximately 105,000 rai (16,800 ha). A part of development zone in the study area is supposed to be irrigated and drained in future, under this project (refer to Figure G-3-G, Appendix G).

(5) Sai Buri River Basin Development Project

This is an on-going irrigation project, which is supposed to develop the downstream area of right bank for irrigation and domestic consumption, by constructing a regulator in Raman District and irrigation canal system for paddy fields in Bacho, Sai Buri Districts. The beneficial area is about 44,500 rai (7,120 ha). In this area, 8,000 rai (1,280 ha) is irrigable even in dry season, but this project does not cover the swampy area (refer to Figure G-2-G, Appendix G).

Details of the above relevant projects are shown in Appendix G-1.

3.4.3 Irrigation and Drainage System

In the province, almost all of the agricultural land is under rainfed condition. In the coastal plain, some areas are under plot-to-plot irrigation

system. Sowing and transplanting take place from October to November in general, depending on rainfall pattern. Considering limited water resources, further systematic canal networks may be required.

Low lying areas along the coast are subjected to severe flooding every year. Intrusion of sea water should be prevented. For these purposes, canals, regulators and dikes may be required. Soil conditions in many areas have prevented the introduction of effective irrigation and drainage systems.

3.4.4 Agricultural Infrastructure Facilities

(1) Irrigation and drainage facilities

Canals, small ponds and culverts under roads exist as dual-purpose facilities i.e. for irrigation and drainage. Borrow pits are also used for water storages. Regulators or check gates are generally operated not only for drainage of surplus water but also for conservation of water in dry season. Some of the facilities constructed in swamp area are subjected to severe acid damage.

(2) Farm road

Except for trunk and main roads, the conditions of the farm road system are poor. Some of them are with narrow track and pavement. Especially in swamp area, most of them are unpaved. New construction of farm roads, therefore, will be required for effective farming activities.

(3) Agricultural facilities.

According to the provincial data, main agricultural facilities such as rice mills, oil mills and farm products are as follows;

Type	Number of facilities
Coconut oil mill	3
Rice mill	398
Wood furniture	9

3.5 Rural Infrastructure

3.5.1 Communication and transportation

The province has good communication and transportation systems. People can travel to and from Narathiwat by public railroad system using Sungai Kolok

and Tanyongmas railway stations. The province has fairly good road systems of 1,042 km under the responsibility of four government agencies. There is an airport located at Ban Thon, about 13 km from Narathiwat town. There are three flights a week.

3.5.2 Public Utility

(1) Electricity

Electricity is supplied by Narathiwat Province Electricity Authority and Sungai Kolok Electricity Authority. There is a plan to supply electricity to all villages by 1992.

(2) Water supply

Narathiwat Water Supply Authority was established in 1956 with a capacity of 480 cu.m/day. The capacity was increased to 960 cu.m/day in 1966 and 7,200 cu.m/day in 1992. Besides Narathiwat, there are also Water Supply Authorities in Sungai Kolok District, Ruso District and other municipal villages. Many villages have their own groundwater wells.

(3) Telephone

Narathiwat Telephone Authority is responsible for all telephone services. At present, there are five telephone offices serving seven districts. There is a plan to extend full services to all districts by 1993.

(4) Post and telegraph

Every district in the province has a post and telegraph office.

3.5.3 Religion and Education

The majority of the people in the province are conservative Muslims. Some of them have Muslim principles leading to an unwillingness to accept changes from their old lifestyle. They do not want to send their children to government schools but rather send them to Muslim schools. Because of this, the illiteracy rate is high. Thai government is strongly determined to help them to speak, read and write Thai language because it is the National language. There are 426 schools in the province. According to the statistics of 1991, the number of students attending basic curriculum is increasing. Number of schools is shown in Table H-9, Appendix H.

3.5.4 Public Health

Based on the latest provincial data of 1992, the province has 126 health centers. However, the ratio between doctors and population is low, such as one doctor to 11,000 persons and one dentist to 72,000 persons. People still suffer from some infectious diseases such as Filaria, Malaria, etc. Data on public health are shown in Table H-10, Appendix H.

3.6 Pikun Thong Royal Development Study Center

3.6.1 Background

Pikun Thong Royal Development Study Center was established in 1982 to serve as a central office to conduct research and experimentation on agricultural development methods and technology in the problem soil areas. Moreovers, the center is making efforts for research on the utilization of peat and acid sulfate soils, including crop cultivation, animal husbandry, fishery and forestry. Besides conducting the above, the center also provides proper occupation training such as handicrafts, carpentry and building work to the people in the relevant villages.

3.6.2 Location and Area

The center is located in Muang District and covers a total area of 200 acres (94 ha) including experimental fields with various soils for research and experimentation. A reservoir with capacity of 2 million cu.m was also provided for water distribution to the experimental fields.

3.6.3 Objectives

- To study and solve the problem of soil condition in water-logged areas.
- To serve as a center for research and experimentation.
- To serve as a center for demonstration and transfer of knowledge conducted from the research and experiments.
- To serve as a center for training and development of occupation in agriculture and local handicrafts.
- To increase income and improve the standards of living of the people.
- To apply the results of the studies as models for other development areas.

3.6.4 Administration

The above activities are undertaken on an intersectional basis involving related agencies such as DOAE and RID under MOAC, working together under the framework of the master plan administered by the Pikun Thong Royal Development Study Center Committee. The committee consists of various administrative organizations in the provincial level. The chairman is governor. As for administration, DLD is a leading agency due to soil problems as main subjects. Stationed engineers and experts for soil improvement are a few. Therefore, necessary staff and labor are mobilized or hired from related agencies, if necessary.

3.7 Land Use Zoning in Narathiwat Swamp Area

3.7.1 Background

At present, peat swamps and marsh lands in the province are being developed and brought under cultivation area for poor and landless farmers by various public agencies. However, unsuitable reclamation resulted in aggravation of environment. In order to resolve this problem, therefore, land use for peat swamp area has been designated in the new policy of the Thai Government. Also, swamp areas were classified into the three zones of development, conservation and preservation (refer to Figure-5).

3.7.2 Development Zone

This is a zone where swamp forest has already drained by various development projects and being replaced by cultivated land. This zone, therefore, is designated to be developed for agricultural production. Area of this zone is approximately 101,000 rai (16,100 ha), 38% of total swamp area.

3.7.3 Conservation Zone

This is a zone where natural swamp forest have been affected through deforestation and burning, but no cultivation is taking place. Also, it is not involved in development projects at present. This zone, therefore, is protected against further aggravation of original swamp forest and should be improved and recovered through reforesting or other conservation measures. Area covered by this zone is about 106,000 rai (17,000 ha), 41% of total swamp area.

3.7.4 Preservation Zone

This zone falls under primary peat swamp where natural peat swamp forest is still not deforested. This zone, therefore, is strongly preserved to maintain swamp land ecosystem. This zone is about 55,000 rai (8,800 ha), 21% of the total swamp area.

3.8 Distribution and Characteristics of Peat and Acid Sulfate Soils in Swamp Areas

3.8.1 General Distribution and Soil Series

A general distribution regarding the soils in the study area is shown in the Table-5. Out of 42,000 ha of total swamp area, peat covers about 27,000 ha (65%), acid sulfate 14,000 ha (33%) and the rest 1,000 ha (2%) is by alluvial soils. According to the detailed soil map (S=1:25,000) prepared by DLD in 1985, peat soil covers 40% of 16,135 ha of the development zone. A summary of the detailed soil maps is presented in Figure-6. Distributed areas by soil series are summarized in Table E-1 in Appendix E and detailed data on soils are shown in Tables E-2 and E-1-2 in Appendix E.

There are ten (10) different soil series in the swamp areas. According to their characteristics, they can be divided into five (5) groups, such as; Thick Peat Soil, Shallow to Moderately Thick Peat Soil, Potential Acid Sulfate Soil, Actual Acid Sulfate Soil and Alluvial Soil, as shown in Table-6.

(1) Thick peat soil group

In this group, thickness of peat layer is over one meter (1.0 m) consisting of underdecomposed fibers, woody fragments etc. However, boring data in the reclaimed area show that the thickness of peat layer exceeds three meters (3.0 m) and surface soils are more decomposed, and some parts are paved with charcoal fragments caused by burning. In general, these soils are very acidic. Narathiwat series soil belongs to this group and is distributed largely in Bacho and To Daeng swamp area.

(2) Shallow to moderately thick peat soil group

This group has a peat layer of thickness from forty to one hundred centimeters (40~100 cm). Under the peat, usually unripe marine clay with pyrites is found. The peat layer is well decomposed and extremely acidic. Kab Daeng series belongs to this group.

(3) Potential acid sulfate soil group

Soils in this group consist of a thin peat layer on the surface and weakly developed texture in the subsoil. Yet the subsoils are very compact. A common phenomenon of these soils, is the presence of pyritic mud clay within one meter (1.0 m) from the ground surface and does not include jarosite mottles. Usually these soils are acidic but oxidation increases the acid level more. Chain Yai, Pattani, Rangae and Thon Sai series belong to this group.

(4) Actual acid sulfate soil group

Characteristics of this group are the same as the potential acid sulfate soil, but clay layer contains yellow colored jarosite mottles. Muno series belongs to this group.

(5) Alluvial soil group

These soils are found along the fringes of the swamps. It is believed that the deposit of riverine materials has formed this group of soils. As in the peat soil, a layer of pyrites mud is found within 1.5 to 2.0 m depth from the surface. Bang Nara, Chon Buri and Tak Bai series belong to this group.

3.8.2 Physical and Chemical Properties

In describing properties of swamp area soils, above mentioned five groups have been simplified into two (2) groups, i.e. peat group and acid sulfate group. General chemical properties are shown in Tables E-3-1 and E-4-4, Appendix E.

(1) Physical properties

- Peat soils

  Peat soils have a fine texture with good permeability. The hydraulic conductivity ranges from 0.001~0.002 cm/sec. Moisture ratio generally varies from 500 to 1000%, but in case of well decomposed peat, it is 200 to 500%. These properties help the fast and easy expansion of plant root systems. The soils have an excellent water holding capacity and moreover, presence in the lowlying areas has an advantage of water availability. The thickness of peat layer changes depending on the degree of decomposition, mode of formation, topographic condition etc. The bulk density and bearing capacity are very low, about 0.1~0.32

g/cc and 0.04~0.18 kgf/cm^2 respectively. When drainage is carried out, subsidence occurs at high rates.

- Acid sulfate soil

  These soils have low percolation rate and high viscosity. Firm compaction and plastic like nature make drainage difficult. Tilling is also difficult when the soil is dried.

(2) Chemical properties

- Peat soils

  Usually peat soils contain more than 20% of organic matter in its soil matrix. The color is brownish black to black. The C.E.C. values are very high, more than 100. Due to easy leaching of soluble elements like potassium, inherent fertility is low. Due to the high buffering capacity, peat soils have a higher tolerance to the overdose of chemical fertilizers. Presence of pyrites (usually 1 to 4%) in the lower layers, makes the peat soils very acidic. But where sulfur is present in the sandy substratum, acidity is less. It was observed that if the lower layers are enriched with mud clay/unripe sediments, presence of total sulfur is very high. When this sulfur is oxidized, the peat soils turn into typical acid sulfate soils.

  Total nitrogen concentration is high, contrary to the available nitrogen, but the deficiency of nutrients like Cu, Zn, Fe etc. is common. Humus substance of peat soils have a strong chelating action. The base saturation is also low.

- Acid sulfate soils

  Oxidation of pyrites forms this kind of soil. The oxidation produces sulfuric acid and thus very high acidity. The pH is below 4.0. On the surface (0~15 cm), the color is dull yellow brown, but the subsoil has a yellowish gray. Deeper layers are bluish gray. When saturated by water, then it is called potential acid sulfate soils containing high pyrites sulfur. Lowering of groundwater table by drainage, acidity may increase sharply, and affects the plant growth. When pyrites layer in the substratum is oxidized, jarosite is formed and the soils are termed as actual acid sulfate soils. High level of acidity causes aluminum and iron toxicity, low availability of phosphorous, poor physical properties and low activity of microbes.

3.9 Natural Environmental Condition in the Swamp Area

3.9.1 General

As for law related to environmental improvement and control in Thailand, the Enforcement and Conservation of new Environmental Quality Act was taken effect from October, 1992. According to the regulations, project executing agency has to prepare an Environmental Impact Assessment report (EIA) and submit to the Office of Environmental Policy and Planning (OEPP), when the agency shall carry out development practices. In this case, EIA should conduct based on the guideline of the act. Under such situation, the Team carried out the survey on environment.

Development is conducted within the development zone designated by the government. However, environmental effect may be spread over the surrounding areas. Survey items to be carried out may be limited in a field of natural resources such as forest, water and biology, considering the characteristics of development zone. Then, in this study, natural resources in the swamp area including development zone were surveyed and studied for getting basic data to evaluate the environmental impact.

The natural environment of Narathiwat province is influenced mainly by mountainous forests, peat swamps, four major rivers and the gulf of Thailand. Plant community of the swamps includes forests, shrubs and wild grasses etc. Wildlife community comprises birds, mammals, amphibians and reptiles. Reclamation of some parts of the swamps has been taking place for a long time through draining out of water from the swamps, clearing trees and construction of infrastructures. The problems of the area has been encountering due to reclamation are; increased acidity, high subsidence rate, increased bush fire, deforestation and decreasing trend of plant and wildlife community.

3.9.2 Peatland Ecosystem

Under normal oxygen rich conditions, dead plants decompose, eventually being mineralized into carbon dioxide and water. But under the condition of low temperature, high acidity, low nutrient supply, water logging and oxygen deficiency, the decomposition process is retarded and dead plants are accumulated to form peatland.

The genesis and characteristics of peatland ecosystems are so varied that it is difficult to generalize. Some peatlands are highly acidic and nutrient-

deficient and some are neutral and nutrient-rich. Therefore, peatland can be either the least or most productive part of wetland. The peatland ecosystem plays an important role in the hydrologic cycle and acts as a climate regulator which is vital to the ecological balance of the environment. Most of the swamp forests are dominated by vegetations like melaleuca, sogo plant, reed grass and the wildlife community. All peatlands can bring multiple benefit for mankind if the relevant ecosystem elements and their functions are managed sensitively.

3.9.3 Present Condition of the Narathiwat Swamps

(1) To Daeng swamp

The results of the surveys by different agencies on the present conditions are presented below.

Plant community

Suzuki and Niyomdham (1992) recognized 22 plant communities in this swamp. They categorized them into three groups; (a) Forest vegetation, (b) Shrub vegetation and (c) Grassland vegetation. The names of the communities are presented in Table F-2, Appendix F.

Wildlife

Information about wildlife in this area is scarce. However, according to the survey data, four groups of wildlife were recognized, which are; (1) Birds, (2) Mammals, (3) Amphibians and (4) Reptiles.

(1) Birds: The survey revealed that number and species of birds are different from zone to zone. It was reported that there are 46, 90 and 28 species in the preservation, conservation and development zones respectively.

(2) Mammals: The survey found 10 species in the preservation and 8 species in the conservation zones. In the development zone, there were no mammal species.

(3) Amphibians: Total 14 species were found. Of which 8 in the preservation zone and 6 in the conservation zone. Out of 8 species, 4 species were in abundance. In the conservation zone, presence of 3 species was high.

(4) Reptiles: In the preservation and conservation zones, recognized species were 12 and 8 respectively. Only 2 species out of 12 were found

in abundance in the preservation zone. In the conservation zone, only two species were in abundance.

Water quality

Acidity: Water in the upstream and surrounding swamp was not so acidic. The pH value was found between 5.0~6.0. But in the downstream, it was 3.7~4.7. These values decrease in the dry season.

Alkalinity: Alkalinity was found very low all around the swamp, below 10 mg/liter compared to the standard value 100~150 mg/liter.

Dissolved Oxygen (DO):
DO values in the upstream were found between 4.4~7.2 mg/liter, which may be considered a good value when compared with the lower limit (4.0 mg/liter) for a good stream ecosystem. But the DO values in the swamp were very low with 0.3 and 0.6 mg/liter during the wet and dry season respectively.

Pesticides: The study did not find any trace of DDT or Aldrin in the water samples, indicating that swamp water has not been polluted by pesticides.

Aquatic animals

Plankton: Abundance of plankton was found to be low, and varied from location to location. The rainy season survey found 5,480, 1,860 and 640~11,640 unit/cu.m in the upstream, swamp and downstream respectively.

Fishes: Eighteen (18) families of fishes with 42 species were found. Family names and species of the recognized fishes are presented in Table H-3, Appendix H.

(2) Bacho swamp

To reclaim agricultural land, considerable drainage activities have been taking place for a long time in this swamp. The results of these activities have caused increased natural and artificial bush fire, and to some extent loss of plant community and disturbance to the aquatic and wild life community. Absence of required plant nutrients and unavailability of fresh water, most of

the reclaimed lands are left abandoned, allowing secondary forest to regenerate. At present, majority of the land is covered by Melaleuca, Rhynchospora trees or by reed grasses.

Aquatic animals: In general, water quality is good for growing aquatic animals. The survey identified fourteen (14) families with thirty one (31) species. Among the species, Cyprinids was ranked first.

Aquatic weeds: There were total eleven (11) species of aquatic weeds recognized in the area which proves rather a high diversity of plant community and ensures food supply for a wide range of invertebrate habitat.

Macro-invertebrate: The survey found high Benthos density in the area. Out of total four (4) classes and twelve (12) families, Gastropoda was ranked first with 13,508 ind/cq.m followed by Lumbicidae with 3,080 ind/cq.m. Detailed data are shown in Tables from H-4 to H-8, Appendix H.

(3) Kab Daeng swamp

It can be said that plant and wildlife communities will not vary substantially than that of To Daeng and Bacho swamps. Subsidence, bush fire or disturbance to the wildlife community have not been reported as a major problem, but acidic water is drained from the low lying areas to the Nam Baeng canal. Canal water is getting more acidic due to the fact that the water stays inactive for most of the year. This is because of a natural blockade formed by the sand at the outfall to the sea.

3.9.4 Problems in Reclaiming Peat Swamp and Impact on Environment

In the present reclamation process, burning is the main problem. If burning is widespread, then surrounding air becomes polluted with smoke, dust and gases. Drainage may also pollute the down stream water bodies and threaten aquatic animals. There are many ways that development process may have impacts on natural resources in conservation and preservation zones. For this reason the ecosystem is very sensitive to disturbances.

However, in the development zone, components of valuable ecosystem which are considered to be affected by development activities are not recognized. If the following development process is applied, it may give negative impact into the ecological balance in the conservation and preservation zones.

- Rapid drainage from peat layer
- Unsystematic land reclamation works
- Rapid and large construction practices of road and canal
- Construction of unsystematic drainage canal

Table-2 Change of Land-use on a 7 Years Period

Land utilization	1978		1985		Index
	Area(ha)	%	Area(ha)	%	1985/1978
1. City, Village	16,096	3.6	20,228	4.5	1.3
1) Town	736	0.2	1,695	0.4	2.3
2) Village	15,192	3.4	16,827	3.8	1.1
3) Office site	64	tr	1,559	0.3	24.4
4) Communication station	40	tr	124	tr	3.1
5) Mining	64	tr	-	-	-
5) Industry region	-	-	23	tr	+
2. Agricultural area	193,000	43.1	231,448	51.7	1.2
1) Orchard	1,336	0.3	820	0.2	0.6
2) Cash nut	-	-	56	tr	+
3) Ruber	130,624	29.2	176,452	39.4	1.4
4) Coconut	13,080	2.9	10,900	2.5	0.8
5) Banana	48	tr	-	-	-
6) Oil palm	-	-	23	tr	+
7) Sugarcane	32	tr	-	-	-
6) Paddy rice	47,880	10.7	43,163	9.6	0.9
7) Bamboo, etc	-	-	34	tr	+
3. Fowl farm	-	-	11	tr	+
4. Pasture and waste land	600	0.1	4,360	1.0	7.3
1) Natural pasture	600	0.1	545	0.1	0.9
2) Waste land	-	-	3,815	0.9	+
5. Forest area	229,903	51.4	158,288	35.4	0.7
1) Natural forest	180,642	40.4	142,345	31.8	0.8
2) Replant forest	-	-	927	0.2	+
3) Peat swamp forest	42,277	9.4	12,519	2.8	0.3
4) Destroy forest (Bush)	6,984	1.6	2,497	0.6	0.4
6. Other	7,944	1.8	31,909	7.1	4.0
1) Fail mine land	-	-	136	tr	+
2) Swampy land	-	-	18,930	4.3	+
3) Wet land	7,752	1.8	12,470	2.8	1.6
4) Beach	192	tr	373	tr	1.9
7. Water area	-	-	1,299	0.3	+
Total	447,543	100.0	447,543	100.0	1.0

Source : Land use survey; Land Development Department (1978, 1985)

Table-3 Land Utilization of Narathiwat Province, 1988

		Total Land	Forest Land	Farm Holding			Unclassified Land
				Farm Holding Land	Farm Size	Number of Farm	
Whole Kingdom	rai	320,696,888	89,877,182	147,800,656	28.08	5,244,643	83,019,050
	ha	51,311,502	14,380,349	23,648,105	4.49		13,283,048
Southern Region	rai	44,196,993	9,143,517	18,989,498	26.51	716,450	16,063,977
	ha	7,071,519	1,462,963	3,038,320	4.24		2,570,236
Narathiwat Province	rai	2,797,144	498,344	1,382,858	25.01	55,302	915,942
	ha	447,543	79,735	221,257	4.00		146,551

Source; Agricultural Statistics of Thailand, Crop Year 1990/91

Table-4 Type of Farm Holding Land of Narathiwat Province, 1988

		Farm Holding Land	Owend Land				Other				
			Owner	Mortgate out		Total	Rented	Mortgate in		Free of Charge	Total
				period unspecified	period specified			period unspecified	period specified		
Whole Kingdom	rai	147,800,656	117,896,388	3,544,885	31,251	121,472,524	18,748,049	567,028	20,562	6,992,493	26,328,132
	ha	23,648,105	18,863,422	567,182	5,000	19,435,604	2,999,688	90,724	3,290	1,118,799	4,212,501
Southern Region	rai	18,989,498	17,086,399	158,881	5,293	17,250,573	1,021,585	62,022	0	655,318	1,738,925
	ha	3,038,320	2,733,824	25,421	847	2,760,092	163,454	9,924	0	104,851	278,228
Narathiwat Province	rai	1,382,858	1,119,161	0	0	1,119,161	81,764	2,800	0	179,133	263,697
	ha	221,257	179,066	0	0	179,066	13,082	448	0	28,661	42,192

Source; Agricultural Statistics of Thailand, Crop Year 1990/91

Table - 5 Area of soil in peat swamps of coastal low land in Narathiwat province

Swamp	zone	Peat						Acid sulfate soil		Alluvial soil		Total	
		more than 1m		40 ~100cm		Total							
		ha	%	ha	%	ha	%	ha	%	ha	%	ha	%
Bacho	Dev.	2,812	6.71	1,054	2.52	3,866	9.23	1,374	3.28	617	1.47	5,857	13.98
	Con.	299	0.71	1,345	3.21	1,644	3.92	-	-	-	-	1,644	3.92
	Pre.	107	0.26	467	1.11	574	1.37	-	-	-	-	574	1.37
	Total	3,218	7.68	2,866	6.84	6,084	14.52	1,374	3.28	617	1.47	8,075	19.27
Kab Daeng	Dev.	191	0.46	537	1.28	728	1.74	2,384	5.69	182	0.44	3,294	7.87
	Total	191	0.46	537	1.28	728	1.74	2,384	5.69	182	0.44	3,294	7.87
To Daeng	Dev.	1,568	3.74	714	1.70	2,282	5.44	4,680	11.17	21	0.05	6,983	16.66
	Con.	1,196	2.86	8,893	21.23	10,089	24.09	5,221	12.46	35	0.08	15,345	36.63
	Pre.	-	-	8,064	19.25	8,064	19.25	136	0.32	-	-	8,200	19.57
	Total	2,764	6.60	17,671	42.18	20,435	48.78	10,037	23.95	56	0.13	30,528	72.86
Grand total		6,173	14.74	21,074	50.30	27,247	65.04	13,795	32.92	855	2.04	41,897	100.00

Remarks: Development zone- Most of the area has been disturbed. Project on development, reserch and other activities are allowed to be carried on within this zone.
Conservation zone- Partly disturbed area, reforestation is required for being retained in natural condition.
Preservation zone- Undisturbed area, has to be retained in the natural condition.

Reference:Commitee of the Pikul Thong Royal Development Study Center, 1986. Zoning of Peat land for Development Schemes, Dept. of land Development, Bangkok Thailand.
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