UNITED NATIONS
Economic and Social Commission for Asia and the Pacific

POLDERS IN ASIA

Bangladesh, China, Indonesia, Malaysia, Philippines, Thailand, Viet Nam

ATLAS OF URBAN GEOLOGY

Volume 6

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FOREWORD

The construction of polders was recognized as a potential method of developing coastal lowlands, river valleys, marshes and swamp ground, as well as tidal embayments and gulf areas. Inasmuch as the largest populations in Asia are located in coastal areas it was agreed by ESCAP that the application of polder technology would be of value to many ESCAP member states in need of new land in areas which were at present flooded or partially flooded because of poor drainage. ESCAP countries noted that there was a need to provide a forum for exchange of experience and information relevant to polders. Consequently, the Government of the Netherlands agreed to share its well known expertise in this field with developing countries of Asia. A study tour of polderised areas of the Netherlands in November of 1989 was arranged by ESCAP in cooperation with the Geological Survey of the Netherlands, the International Institute of Hydrological and Environmental Engineering (IHE), the Flevoland Directorate, and an expert from South Holland Province. At the conclusion of the study tour a number of papers were presented by ESCAP participants. Those papers are presented herein for the use of developing countries in Asia which may wish to review the progress made in the development of polders in seven countries of the region, i.e. Bangladesh, China, Indonesia, Malaysia, Philippines, Thailand and Viet Nam.

In a number of these countries the use of dyke systems and the application of polder technology has resulted in the drainage of areas which normally would have been inundated by sea water. In other areas coastal embankments have been important in mitigating the impact of flooding as well as in enabling new land to be brought into agricultural production. Thousands of square kilometres of land have been reclaimed in Asia as a result of the proper application of the polder concept. It is now recognized that polder technology, if properly applied, can result in an improvement in the development of coastal lowlands resulting in new rice lands, fish culture, salt culture and other innovative economic activities such as cultured pearls, crocodile farming, production of sea foods, and so on. Especially notable progress has been made in a number of ESCAP countries as indicated by the papers presented in this volume which is one of a series devoted to the application of geology to problems of development.

ESCAP would like to express its appreciation to those organizations of the Government of the Netherlands which took part in organising the Study Tour as well as the Government of the Netherlands for funding the Study Tour and the follow-up technical missions. Finally, ESCAP expresses its appreciation to the participating countries and to the experts which presented the results of their work on polders during the Study Tour.

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CURRENT STATUS OF LAND RECLAMATION AND POLDER DEVELOPMENT IN COASTAL LOWLANDS OF BANGLADESH

by
M.A. Bari Talukder[1]

1. Introduction

Bangladesh emerged on the world map as an independent and sovereign country on 16 December 1971. It lies in the north-eastern part of South Asia between 20° 34' and 26° 38' north latitude and 28° 01' and 92° 41' east longitude. It is bounded by India on the west, east and north; partly by Burma in the southeast and in the south by the Bay of Bengal (Fig. la). It is an irregularly flat-surfaced and low-lying country with a total area of 143,998 sq. km. and its population as of March 1989 (estimated) is 110 million and is estimated to reach 140 million by the year 2000. The annual growth rate of population is 2.17 per cent.

For administrative purposes, the country is divided into four (4) divisions, 21 regions (former districts), 64 districts (former sub-divisions), 460 Upazilas (newly reconstituted sub-district by converting former Thanas as a part of administrative decentralized process), 4,472 unions, 60,215 mouzas and 85,650 villages. Nearly 85 per cent of its population live in villages with an average size of 7.44 persons per household totalling 14,785,000 households. The literacy rate is only 23.8 per cent (male 31 per cent and female 16 per cent). The density of population, possibly highest in the world, is 764 persons per sq. km. The average per capita annual income is US$130 only (1).

2. The Economy of Bangladesh

Agriculture is the backbone of the Bangladesh economy. Agriculture sector (also includes fisheries, livestock and forestry) accounts for nearly 60 per cent of the Gross Domestic Product (GDP), gives employment to 75 per cent of the rural workforce and provides the base for more than 90 per cent of the country's export earnings. In rural Bangladesh, 81 per cent of the male and 55 per cent of the female population are employed to work directly on agriculture while another 10 per cent of men and 28 per cent of women are employed in production and transport which are largely related to agriculture. Agriculture, however, directly and indirectly accounts for employment to about 90 per cent of rural male and 80 per cent of rural female labour force (2).

Of Bangladesh's 110 million people, nearly 85 per cent are rural and 50 per cent are functionally landless and underemployed. One-fifth of the total area (14.40 million hectares) remains under water at all times and one-third to one-half during the monsoon season. Natural calamities such as floods, cyclonic storms, and droughts during the dry season occur periodically, causing serious disruption of agricultural production. Rice is by far the main dominant crop occupying about 80 per cent of the total cultivated area followed by jute, 6 per cent; wheat, 4 per cent, and a variety of other crops like pulses, oilseeds, sugarcane and vegetables for the remaining 10 per cent. But the per unit productivity of rice, for the above factors and other reasons, remains among the lowest in the world and it is still well below the Asian average, although efforts are being intensified to increase use of HYV seeds and fertilizers, and expansion of irrigation and credit facilities to reach the desired goals.

The current major concern and development thrust of the government policy is to attain self-sufficiency in foodgrain production by the year 1992 by producing 20 million tons. The population growth rate has surpassed that of food production in recent years which necessitates the annual import of more than 1.6 million tons of grains to meet the shortfall. Against this backdrop, the Government of Bangladesh has required that the development intervention should focus more on irrigation and flood control investments with immediate impact of foodgrain self-sufficiency.

The total land in production (including fallow land) has slightly increased from 9.12 million hectares (MHA or 22.42 million acres in 1973 to 9.13 MHA (22.55 million acres) in 1983. During the same period, the total cropped area, however rose from 12.23 MHA (30.21 million acres) to 13.33 MHA (32.91 million acres) mainly due to increased cropping intensity. Total area under rice cultivation has also increased from 9.31 MHA (23 million acres) in 1972 to a little over 10.53 MHA (26 million acres) in 1983. Apart from these measures, the current thinking of the government policy options is to increase the per unit productivity vertically rather than horizontally. However, the industrial productivity in the country is very meager. It contributes only 10 per cent to the GDP (3).

3. Physical Features and Climate of Bangladesh

The flat alluvial plain of Bangladesh, very often known as the largest delta in the world, lies between the Indian foothills of the Himalayan mountains on the north and the Bay of Bengal on the south. The mean elevations are usually between 0-30 m above sea level but the maximum altitude never exceeds 40 m above sea level.

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It has a tropical monsoon climate with annual temperature varying from 10 to 36 degrees Centigrade and annual rainfall from a minimum of 1400 mm in the northwest region (Rajshahi district) to the maximum of 4000 mm in the northeast region (Sylhet district) with an average rainfall of 2134 mm (4).

There are three distinct climatic seasons in Bangladesh. The monsoon (rainy) season from May to October experiences more than 90 per cent of the total annual rainfall. It is characterized by high temperature, high humidity and low solar radiation. The dry, cool season (winter season) from November to February receives negligible amount of rainfall, and is characterized by low temperature, low humidity and high solar radiation. The pre-monsoon, hot summer season from March to April receives some rainfall in occasional heavy thunderstorms and hailstorms and is characterized by the highest temperature and evaporation rates. Following the monsoon, the availability of soil moisture declines and falls short of the crop demand during the Rabi season (winter months). Then during the pre-monsoon, scanty and erratic distribution of rainfall also causes soil-moisture deficits for crops. Potential soil moisture deficiencies over 6-7 months seriously limit crop production in Bangladesh. Similarly, crop environment during the monsoon (Kharif) season is not favourable for achieving full potential yields due to uneven distribution of rainfall, flooding at variable depths, low solar radiation, and high temperature and humidity during this season. This necessitates the development of drainage and irrigation for increased crop production (5).

4. Land and Land Occupancy

Land is the main productive asset which presents both social and economic status in rural Bangladesh. Land distribution is, however, highly skewed, more in some districts than in others. Table I presents the country-wide pattern of land ownership. Fifty per cent of rural households can be termed as landless if those having less than half an acre of land are included. This further reveals that the percentage of land owned in various farm sizes is strongly skewed towards the richer farmers. This can be better represented in an "inverted Pyramid" (Table II). The 2.5 per cent rich farmers own 25.2 per cent of land, the larger middle farmers own another 22.7 and the smaller middle farmers 31.4 per cent. The functionally landless and subsistence households making up 76 per cent of the rural population own only 21.7 per cent of the land (6).

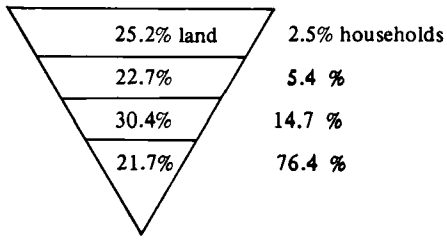
Land is a scarce and limited natural resource in Bangladesh. It is the key to crop production. There is little or no scope of bringing any new land for production purposes except for limited natural man-made accretion of new lands in the coastal area. Landlessness is increasing at an alarming rate of more than five (5) per cent per year. There already exists an unfavourable man-land ratio in rural Bangladesh. It has almost doubled over the decades and will continue to rise inexorably (7).

Table I. The Pattern of Land Ownership in Rural Bangladesh as in 1978*

Category of Farmers	*% Rural Households*	*% Land-owned*
1. Functionally landless		
a) households having no land or homestead only – 28.7%		
b) households owning under 0.5 acre of land (excluding a) – 21.3%	50.0	21.7
2. Subsistence Holdings (0.5-2.0 acres)	26.4	
3. Middle Farmers		
a) 2- 5 acres	15.7	30.4
b) 5-10 acres	5.4	22.7
4. Rich Farmers (Above 10 acres)	2.5	25.2
	100.	100.

* Rehman Sobhan. The Crisis of External Dependence, 1982.

Table II. An Inverted Pyramid showing the Land Ownership Pattern in Rural Bangladesh.



The same report further shows that about 23 per cent of the land, particularly the absentee landlord (rich farmers) is put out on rent or share cropping. The usual share-cropping pattern provides one-half of the crop to the landowner and the balance half to the tiller, who has to bear all the inputs and cultivation costs. However, the declining trend of land-man ratio over the last three decades is presented in Table II.

Table III. Per Person Availability of Cropped Area (1950-1985)*

Year	*Per Person Cropped Area (ha)*
1944-50	0.23
1969-70	0.19
1978-79	0.15
1984-85	0.13

**Source:* Northwest Hydraulic Consultants Report 1987 on Field Workshop on Small Scale Water Control Structures.

The total land area of Bangladesh is about 14.3 million hectares (MHA) of which 67 per cent are net cultivable. The current land utilization is shown in Table III.

Table IV. Land Utilization Pattern in Bangladesh (1984-1985)*

	Type of Land	*Area (in M. Ha)*	*Area by Percentage*
1.	Total Land Area	14.27	100
2.	Not available for Cultivation	2.41	17
3.	Forest	2.07	14
4.	Cultivable Waste	0.23	2
5.	Current Fallow	0.51	4
6.	Net Cropped area	9.05	63
7.	Net Cultivable area	9.56	67

**Source:* MPO, BBS (1983-1984) and ASR, 1989 (Vol. II, March 1989)

The landscape of Bangladesh is characterized by some 36 physiographic units which may be broadly grouped into three landforms such as hill areas accounting for 12 per cent, terrace areas covering 8 per cent, and flood plain areas covering 80 per cent of the country. Five million hectares are subject to annual inundation ranging from 30 cm to more than 2 m. The depth, timing, rate and duration of flooding largely determine the choice and timing of crops to be grown in Rabi and Kharif seasons. Based on the seasonal flooding, the land resources of Bangladesh have been classified into five land types (Table V).

5. Cropping Patterns

Each of the five land categories (F0 to F4) as shown in Table V has a unique cropping system, principally determined by land level relating to flooding, soil drainage and soil moisture storage capacity. Availability of irrigation, population pressure and market factors largely determine the crop intensification as well as diversification. The current cropping intensity in Bangladesh is around 154 per cent.

6. Emergence of Bangladesh Water Development Board

Bangladesh Water Development Board (BWDB) has had a long story to its credit and had to crawl a series of steps before it has come to its present shape.

Bangladesh has been suffering from the chronic twin problems of 'floods and droughts' for the centuries past since it is a country of rivers and rivulets. Until the partitioning of India in 1947, the region had been neglected and no substantial amount of water resources development work was undertaken. When the country had suffered from the unprecedented floods in two consecutive years in 1954 and 1955, a 'Flood Commission' was constituted in December 1955 by the government to look into the problems and to advise remedial measures. Subsequently, they obtained the services of a team of experts on water resources management known as 'Krug Mission' – a United Nations Technical Assistance Mission in 1956. This Mission submitted its report in 1957 after detailed review of the gigantic problems associated with it. Based on the recommendation of the Krug Mission, an authority known as East Pakistan Water and Power Development Authority (EPWAPDA) was created in 1959 for the unified and coordinated development of the water and power resources in Bangladesh.

It was a turning point in the history of BWDB when it came into being on May 31, 1972 through the bifurcation of the then EPWAPDA into two Boards – one for water and the other for power under the Presidential Order No. 59 of 1972. The Board, among others, was entrusted with the following responsibilities: (8)

- Construction of dams, barrages, reservoirs, and other original works, irrigation, embankment and drainage, bulk water supply to communities and recreational use of water resources;

Table V. Land Types Defined on the Basis of Flood Depth

Land Type	*Description*	*Flood depth (in cm.)*	*Nature of flooding*	*Cultivable areas covered by each type (in M. Ha)*	*Choice of crops to be grown*
F0	High Land	0-30	Intermittent	3.27 (36)	HYV rice
F1	Medium High	30-90	Seasonal	3.15 (35)	Local Au & T. Ama
F2	Medium low land	90-180	Seasonal	1.43 (16)	B. Aman
F3	Low land	greater than 180 cm	Seasonal	1.10 (12)	B. Aman
F4	Very low land	greater than 180 cm	Seasonal/ perennial	0.08 (1)	Unsuitable for growing even B. Am
	Total			9.03 (100)*	

Source: Northwest Hydraulic Consultants Report (1987) and MPO (1986).

* Figures within parenthesis indicate the Percentage Distribution of Cultivable Area.

- Flood control including watershed management;
- Prevention of salinity, water congestion and reclamation of land; and
- Regulation of channels to concentrate river flow for more efficient movement of water, silt and sand, excluding all such operations as in the opinion of the government, may be carried out by any other agency.

Thus, in line with the national policy of water resources development and management, the BWDB is aimed at the optimum development of the available water resources in the country, their proper use in order to attain self-sufficiency in foodgrain production (by the year 1992), improve the socio-economic conditions and raise the overall standard of living of the people.

Self-sufficiency in food production is the ultimate goal of Water Board projects. With this aim in mind, BWDB has completed, so far, a total of 138 projects, including some major projects, namely, Karnafuli Multipurpose Project; G.K. Project (Phase I and II), Brahmaputra Flood Embankment Project, Dhaka-Narayanganj-Demra Project (DND) Irrigation Project, Tubewell and Low-lift Pump Irrigation project in northern districts, Coastal Embankment Project (Phase I), Barisal Irrigation Project (Phase I), Chandpur Irrigation Project, Comprehensive Drainage Schemes for Noakhali and Manu River Projects, as well as recently completed Moheshkhali Jetty in southern district of Cox's Bazar.

Records of BWDB further reveal that it has completed (as of June 1983 since its inception) 5,541.40 Km (3,444 miles) of embankment; 3,320.98 Km (2,064 miles) of irrigation canals; 2,786.79 Km (1,732 miles) of draiange channels; 2,396 hydraulic structures; 1,209 drainage sluices; 740 flushing sluices; 3,368 bridges and culverts and 950 closures. Besides, flood protection and drainage facilities have been provided to 2.40 million hectares (59.36 lakh acres), and irrigation facilities provided to 0.26 million hectares (6.42 lakh acres) of land. The total area so far reclaimed from the sea is 563.15 sq.km (350 sq. miles) (9).

7. Land Reclamation and Polder Development in Coastal Areas of Bangladesh

BWDB is a semi-autonomous agency under the Ministry of Irrigation, Water Development and Flood Control, and is responsible for planning, design, implementation and operation and maintenance of all water development projects undertaken by it.

Historically, Bangladesh is a land of rivers. It has within its territorial boundary the confluence of the three great river systems of which two international rivers – the Ganges and the Bramaputra merge together to form Padma and in turn join with another big river – the Meghna and all of them flow into the Bay of Bengal. The combined drainage area of the three river systems lie in four countries, namely: China, Nepal, India and Bangladesh, out of this drainage area only eight per cent lies in Bangladesh.

Most parts of Bangladesh are within the flood plain of these three river systems and is drained through the lower Meghna Estuary (Fig. 2) except the southeastern part of the country comprising the greater districts of Chittagong and Chittagong Hill Tracts which are drained independently into the Bay of Bengal through a number of hill streams such as Feni, Karnaphuli, Sangu, Matamuhuri, Bogkhali and the Naf river.

In order to protect the rich agricultural land on the seashore islands and coastal areas comprising the greater districts of Khulna, Barisal, Patuakhali, Noakhali and Chittagong, an extensive land reclamation project of polderisation has been completed in those districts. There are as many as 18 polders covering an area of 480 sq. km. in the greater Chittagong district alone. A number of large, medium and smaller projects of Flood Control, Irrigation, Drainage and River Training work have also been completed in this area. Some of the most important projects are:

1. Karnaphuli Irrigation Project
2. Fatikchari FCD and Irrigation Project
3. Dhurang Khal Irrigation Project
4. Sea Front Protective Works at
   i) Pattenga
   ii) Latifpur – Kumira
5. Town Protection Works at
   i) Ramgarh
   ii) Bandarban
6. Moheshkhali Jetty Construction for Coastal transportation facilities to Urban Centres in the district of Cox's Bazar.
7. Shrimp Culture Project being implemented to boost more foreign exchange earnings.

8. Concept of Polder Development

Polder – as an engineering concept of flood management – is a part of the complex process of the Coastal Embankment Project (CEP). The Dutch term "Polder" has been extensively used in Bangladesh since the sixties to designate the reclaimed bodies of land in the coastal regions. The primary purpose of Polderisation is to increase agricultural production and productivity and reduction of flood damages by protecting the land from saline water inundation and tidal flooding from the Bay of Bengal by constructing embankment and drainage sluices. This is not an entirely new concept to the people of this country. Evidences show that from time immemorial marginal and small earthen dykes were constructed by the feudal lords and farmers to protect their crops from salinity and flooding. But these nominal dykes were inadequate in section and were not maintained properly. As a result, every year extensive damages were caused to standing crops in the coastal areas.

The CEP was conceived and initiated by the then EPWAPDA in early sixties. Subsequently, it was proposed in 1967 that the project be divided into two phases and that the first be expedited as part of the "Grow More Food" Programme. Thus, the first phase (Phase I) was approved in April 1968. Phase I consists of 92 polders with about 2,500 miles (4,022.5 km) of embankment and 780 drainage sluices. The gross area to be protected under Phase I Polder was estimated to be nearly one million (1.01 million) hectares (2.5 million acres). Phase I was completed by June 1971 at a total cost of Rs. 1,145 million.

Polders under Phase II were classified as deferred in the revised programme and final project evaluation study. Phase II includes three categories of land areas such as:

a) relatively non-saline areas,

b) off-shore islands presently unsuitable due to erosion and sediment deposition,

c) partially reclaimed/unreclaimed areas of new land resulting from construction of the Meghna Cross-Dams.

The Phase I included plans to construct 86 Polders of which about 60 per cent (60%) were completed by 1968 and the rest by mid-seventies. Phase II, which included a further 16 Polders, has not yet been formally initiated, although between 1958 and 1983, there had been some area-specific development of polders that fit more or less within the development framework of both phases of the CEP. Phase I provided protection to 1.01 million hectares through construction of 3,620.25 km. (2,250 miles) of embankment and 800 sluices.

A summary statement of *projects undertaken by BWDB as of June 1987-88:*

No. of projects completed	:	415
Projects completed before liberation	:	87
Projects completed after liberation	:	328
On-going projects during 1987-88	:	36

9. Prospects & Potential of Polder Development

The coastal areas of Bangladesh have a vast potential for land reclamation, fish culture, salt culture and other innovative economic activities such as cultured pearls, crocodile farming, production of seafoods, and so on. The gliterring coastline and the fertile delta have received enthusiastic mention in the accounts of many ancient travellers, and attracted traders and plunderers throughout the centuries.

The coastal area covers almost a fourth of the total area of the country stretching over 90 upazilas and accomodates nearly 250 million people. The off-shore islands of Cox's Bazar and Saint Martin are characterized by long sandy beaches providing ideal environment for promotion of tourism and immense opportunities for commercially exportable items or commodities.

Some of the on-going projects and identification of future projects for implementation are discussed below (11):

1. *Polders* Over 70 coastal polders built in the sixties gave protection against salinity and tidal bores and produced 1.5 million additional tons of foodgrains. They also provided the foundation for large scale expansion of shrimp/salt culture. Some of these polders need further rehabilitation for their smooth functioning in addition to new polder development.

2. *Land Reclamation* It is possible to reclaim in phases an estimated 5-10 thousand square miles from the Bay of Bengal. The on-going land reclamation project under BWDB has resulted in designing the Sandwip Cross-Dam which will yield more than 200 square miles of land.

3. *Shrimp Culture* A rapid expansion of shrimp farming seems to be viable even without jeopardising the area ecological balance. Moreover, studies carried out by experts indicate that through improved methods, shrimp productivity could be raised from the existing level of 68 kg/ha to about 250 kg/ha, thus increasing production from 3,500 tons to 30,000 tons of shrimps annually.

4. *Mangroves* The mangrove forests of Sundarbans and Chakoria have been seriously depleted through management lapses and unauthorized felling. This is a direct threatening to ecological imbalance and serious shortages of materials for industries in the southwest region and extinction of the famous Royal Bengal Tigers. There is a scope for integrated management of the Sundarbans forests and crocodile farming in this area.

5. *Wind Mills* Availability of strong winds along the coasts round the year suggests the feasibility of wind mills for running mills, cold storages, hydro-electric projects, and so on.

6. *Prospects for Hydrocarbons and Minerals* It is generally believed that Bangladesh is floating on gas and possibly on oil. A search for exploration of hydrocarbons and minerals could be intensified in the coastal regions.

10. Socio-Economic Impacts of Polderisation

Coastal Polderisation may have some positive as well as negative impacts on the life of the farming community of the project area. From the positive impacts, many kinds of tangible and intangible benefits may be accrued. Tangible benefits are those that can be expressed in monetary terms and may be classified as either primary or secondary. Intangible benefits, on the other hand, are those that (satisfy the human needs and desires) are not fully measured in monetary terms. These include such benefits as improvement of health and living conditions, general welfare and agro-socio-economic improvement, recreational and tourist opportunities (12).

Primary Benefits

These benefits are the increased value of goods and services directly resulting from the project such as:

a) Increase in net agricultural income from the additional reclaimed land and productivity

b) Net income from the increased fish outputs

c) Net income from the salt production.

d) Net income from plantation crops like coconut products and by-products as well as coastal mangrove afforestation programme to be carried out along the sides of embankments. This may provide ecological balance and thus reduce green house effect.

Secondary Benefits

Secondary benefits are the increased value of goods and services indirectly resulting from the project such as

(a) Use of embankments as roads

(b) Increase in profits to agri-business

(c) Providing employment to unemployed labour force and landless farm workers,

(d) More earnings or savings in foreign exchange

(e) Reduction of cyclonic damage, soil erosion and sedimentation

(f) Value of new land or reclaimed land added by the polder project

(g) Increased use of inputs (HYV seeds, credit, fertilizer, pesticides, irrigation water) and the corresponding level of crop yields.

(h) Scope of intensification and diversification of the existing cropping pattern and cropping intensity.

(i) Production of more feeds and fodders for improvement of livestock resources which ensures supply of draft animals for ploughing, marketing and also production of milk, meat and manures.

(j) Supply of pure drinking water free from salinity for preservation of both human and animal health.

(k) Resettlement of landless population made by river erosion in "cluster villages", popularly known as "guccha gram", a project under taken by the Government.

Negative Benefits

Implementation of polder projects may cause some tangible and intangible adverse effects. These are:

(a) Withdrawal of crop land for construction of embankments

(b) Impairment of direct waterways transportation to main land

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7. World Bank Sector Report, 1984. World Bank HQ, Washington D.C., USA.

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9. See BWDB Brochure

10. See Northwest Hydraulic Consultants Report (1987) on Field Workshop on Small Scale Water Control Structures.

11. See Hasna Moudud's Proposal of Informal Parliamentary Group on Coastal Area Resource Development and Management of Bangladesh, October 1987 (Mimeo).

12. See EPWAPDA's Coastal Embankment Project: Engineering and Economic Evaluation Report, Volume I, December 1968.

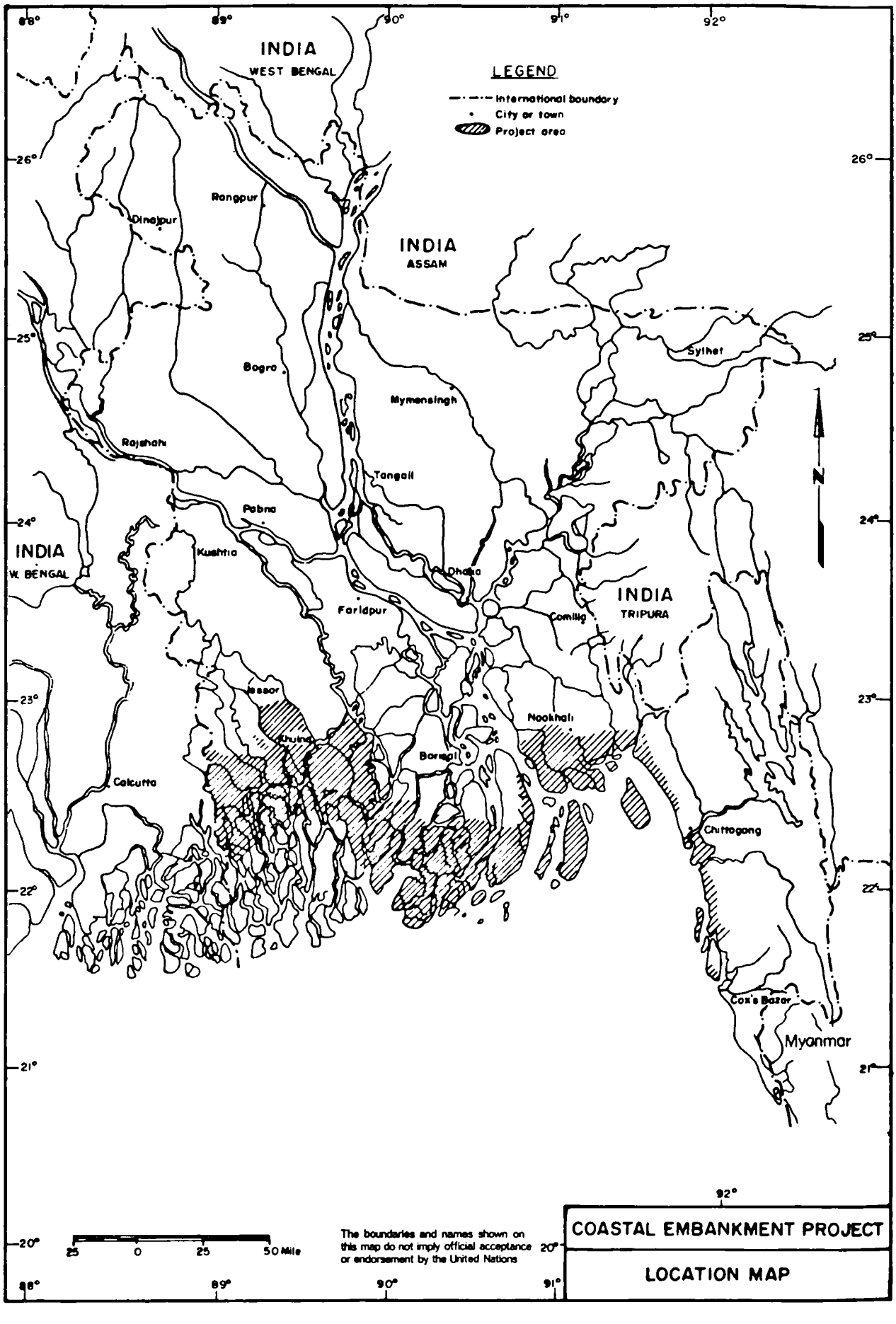

Figure 1. Location map of the Coastal Embankment Project

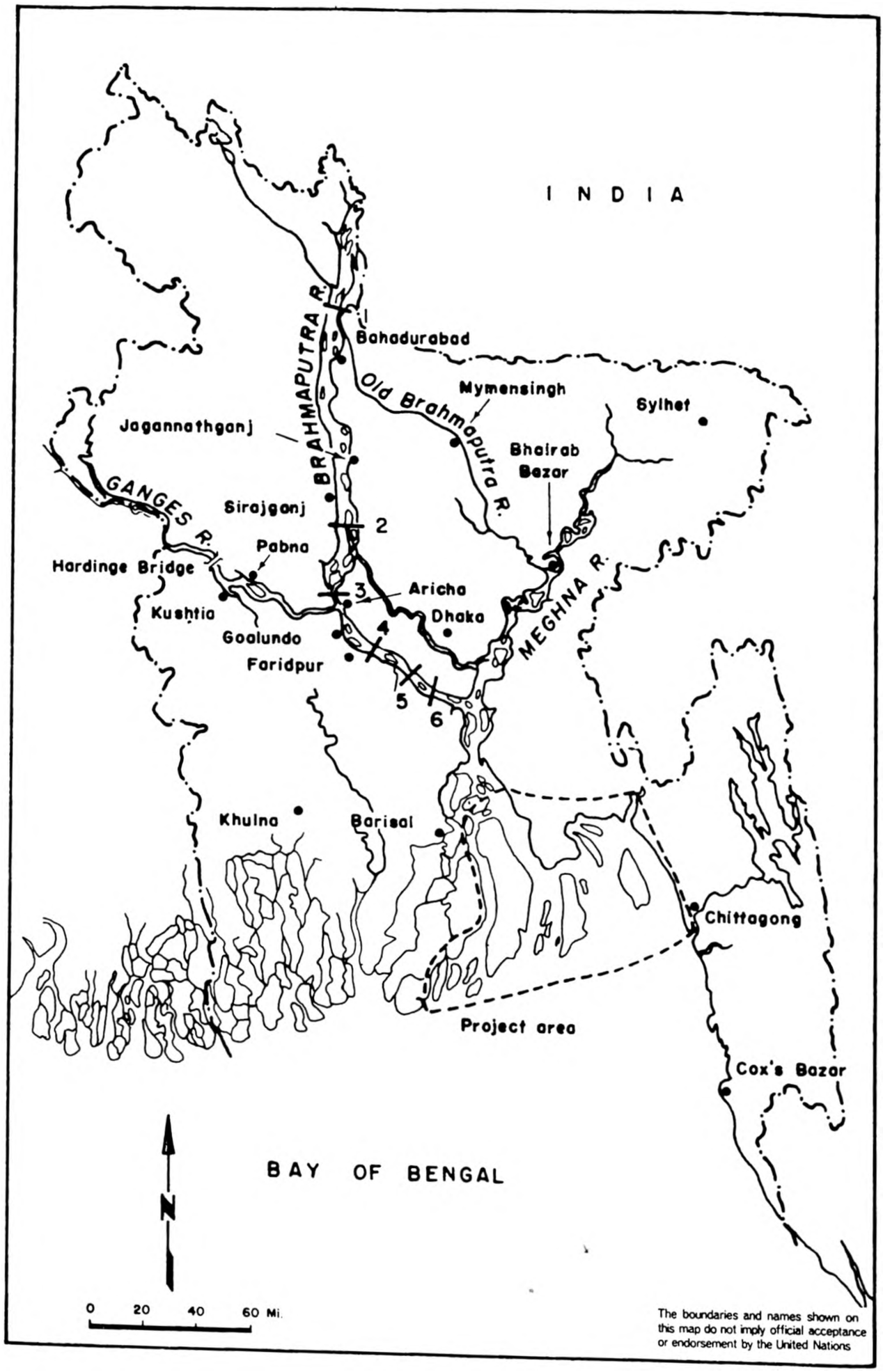

Figure 2. Location map of the Land Reclamation Project

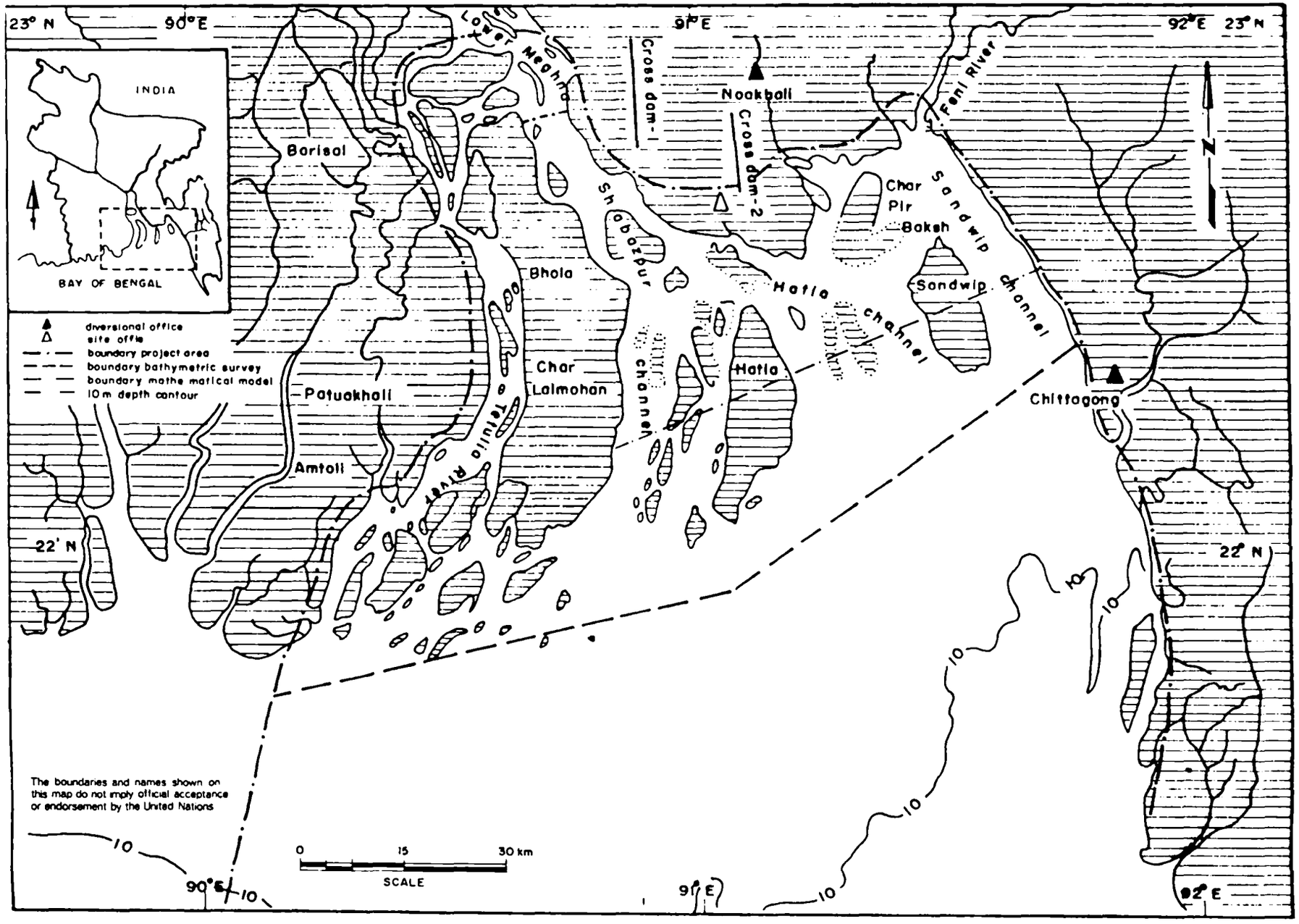

Figure 3. Location map of the Land Reclamation Project

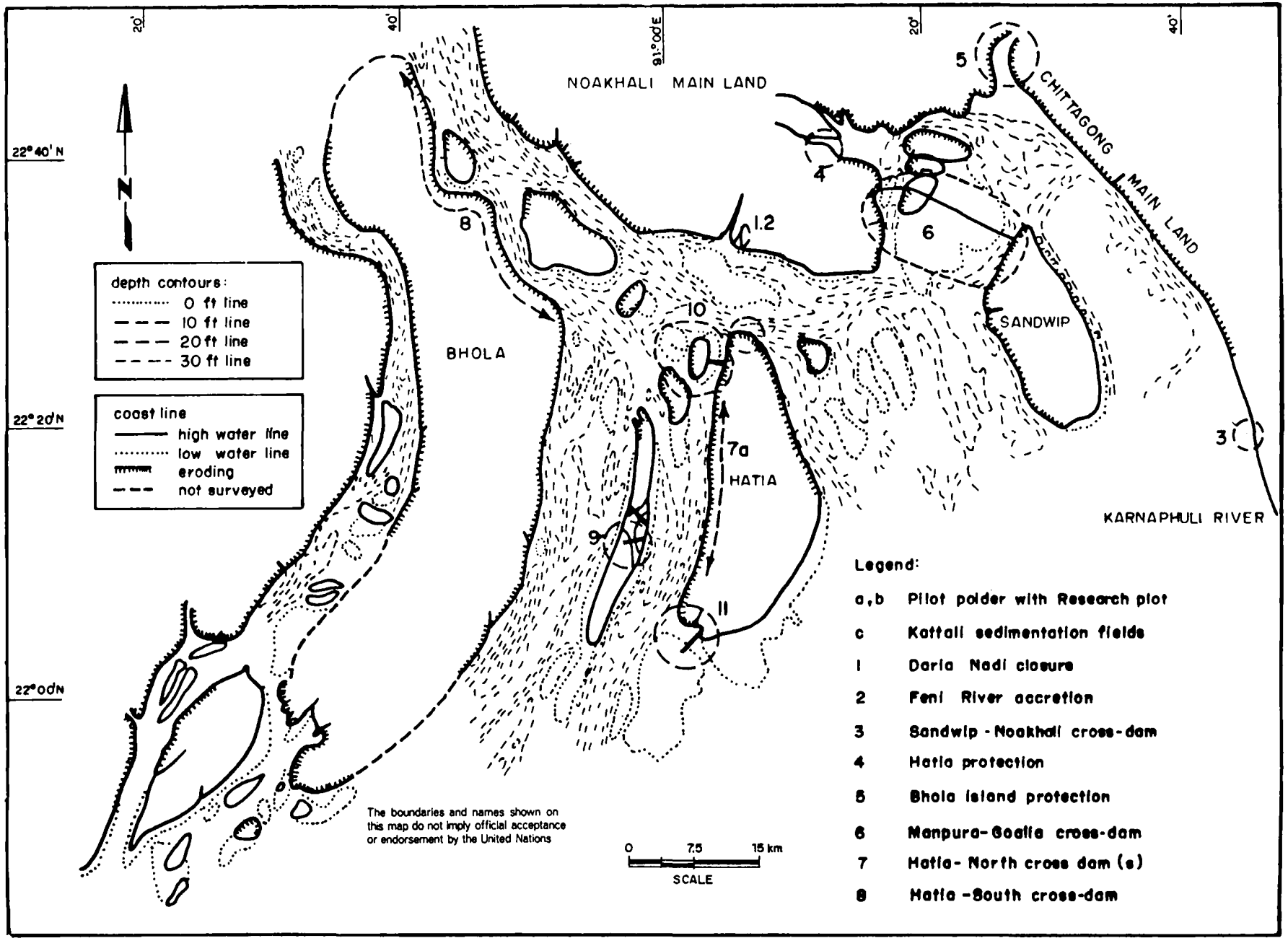

Figure 4. Location map of the projects proposed for the long-term plan of the Land Reclamation Project

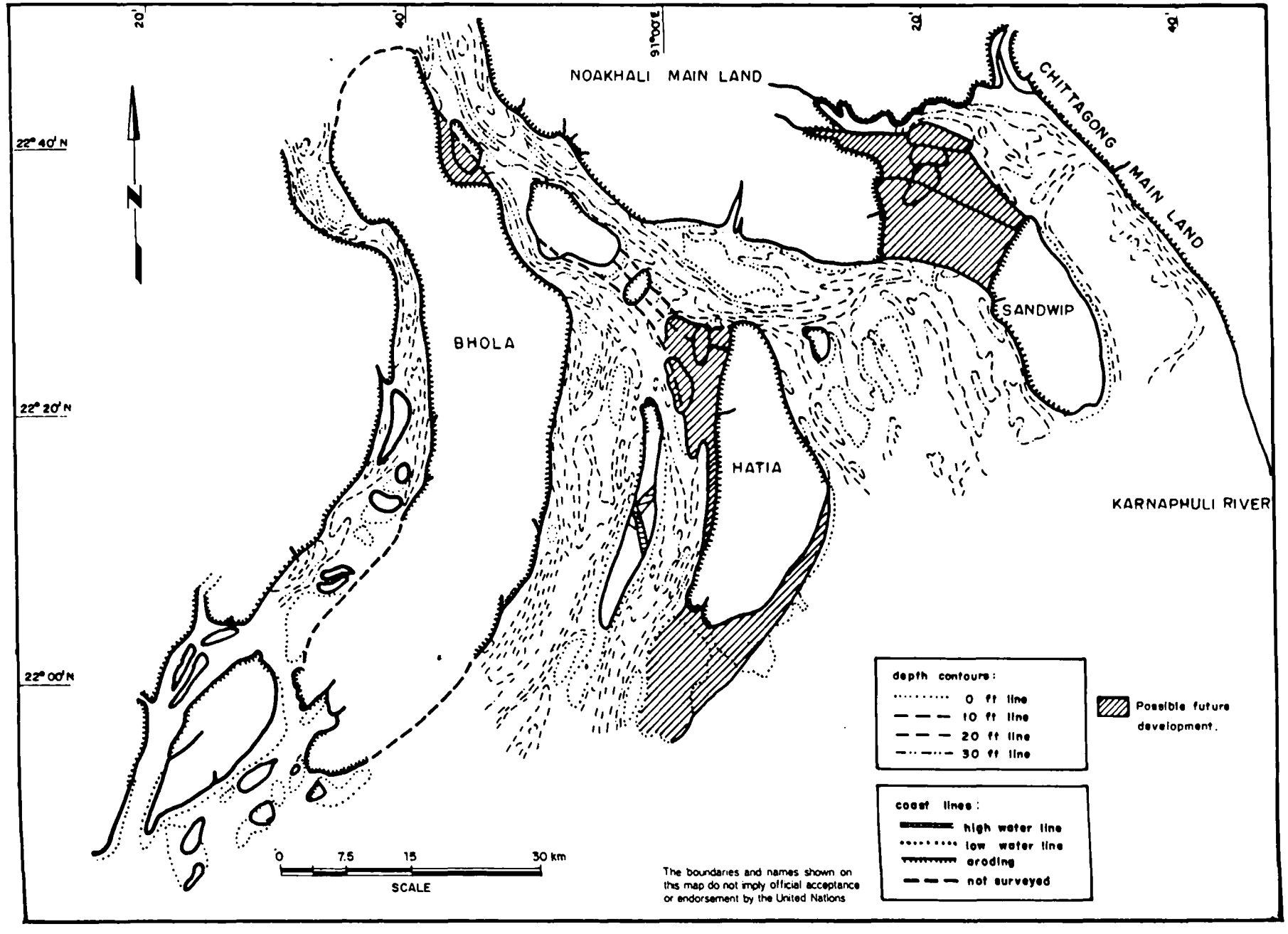

Figure 5. Possible future land development areas of the Land Reclamation Project

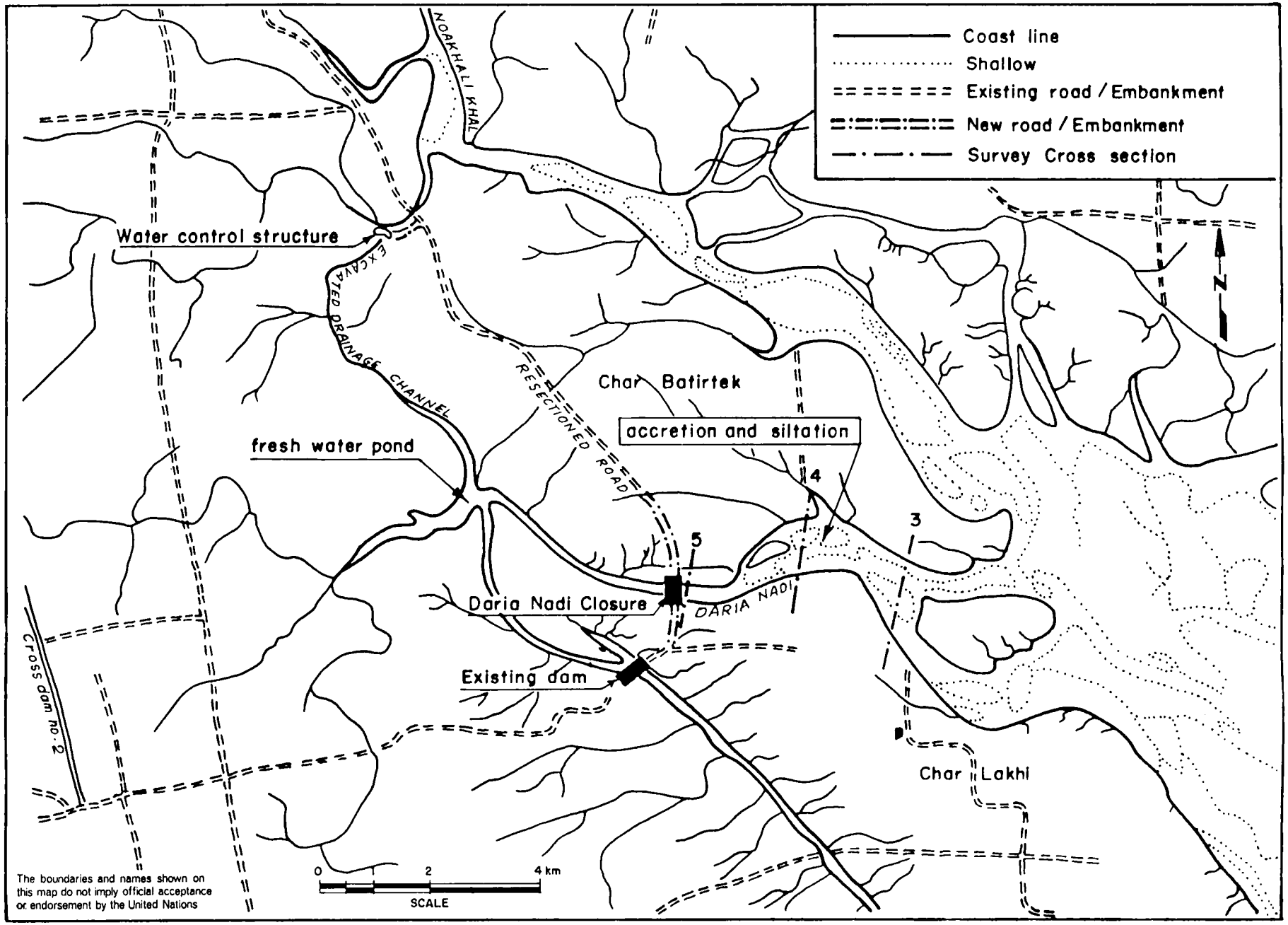

Figure 6. Map showing Daria Nadi Closure and related works

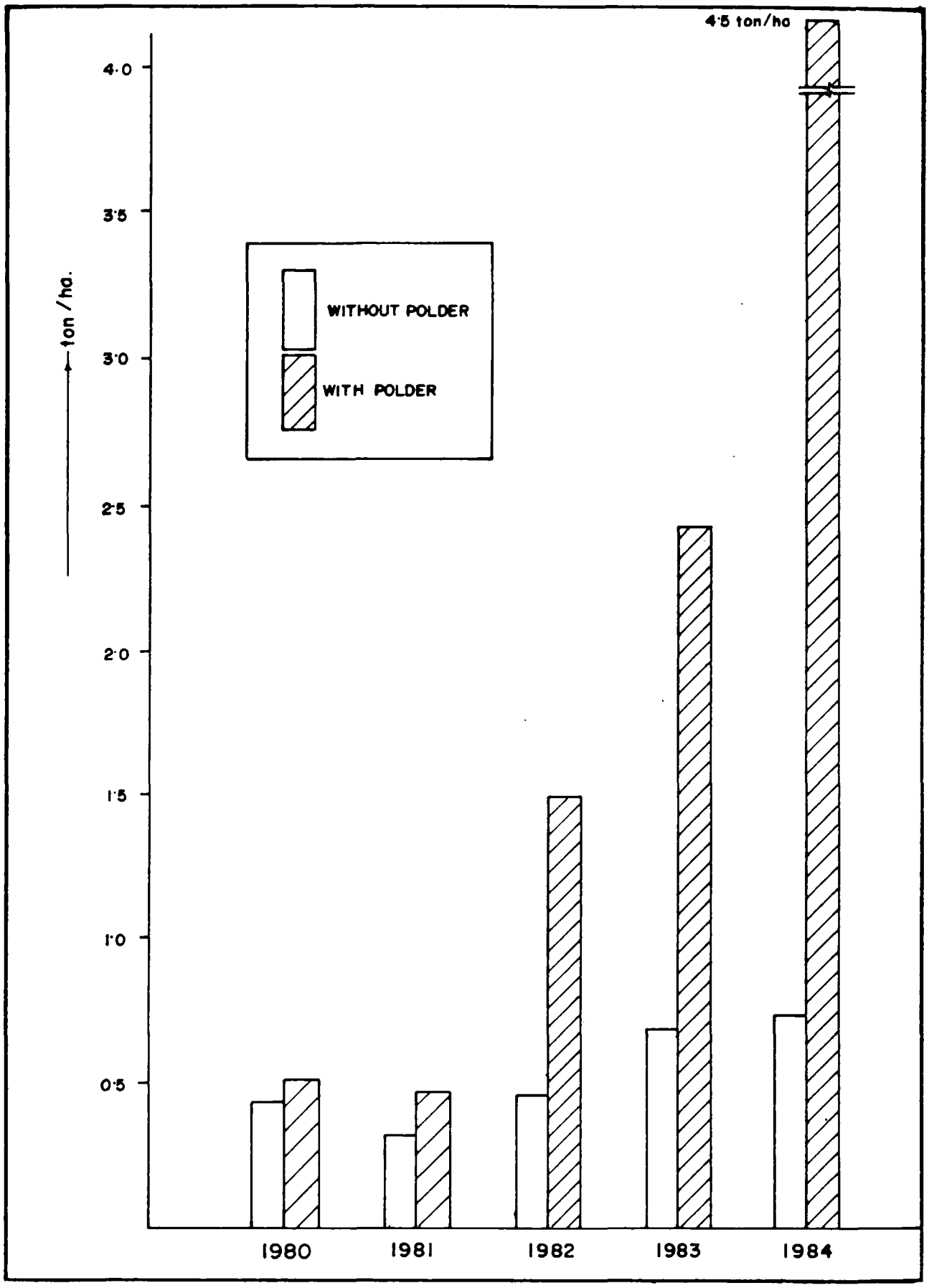

Figure 7. Sediment yields of Char Baggar Dona with and without polders

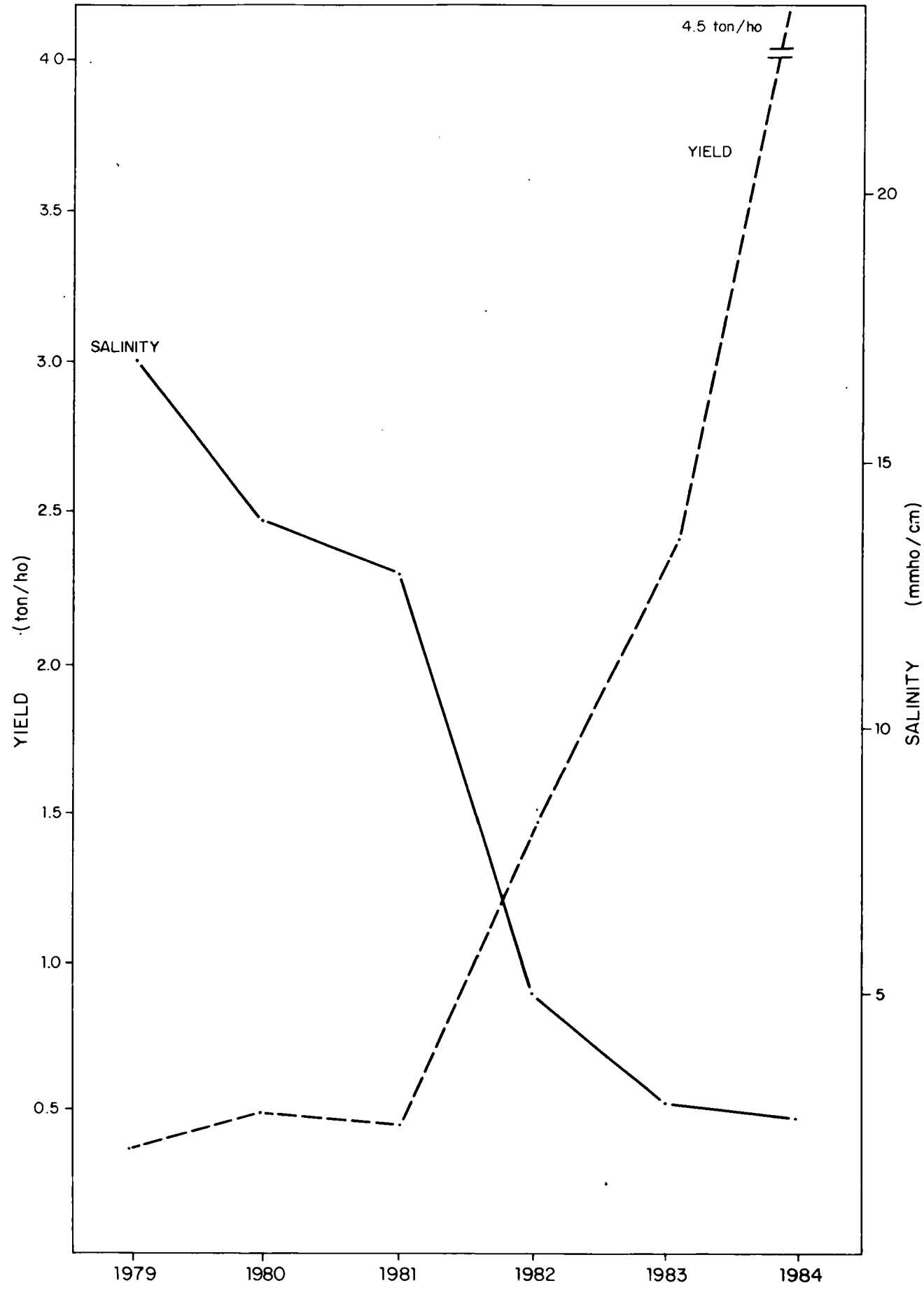

Figure 8. Salinity versus yield inside the Char Baggar Dona polder

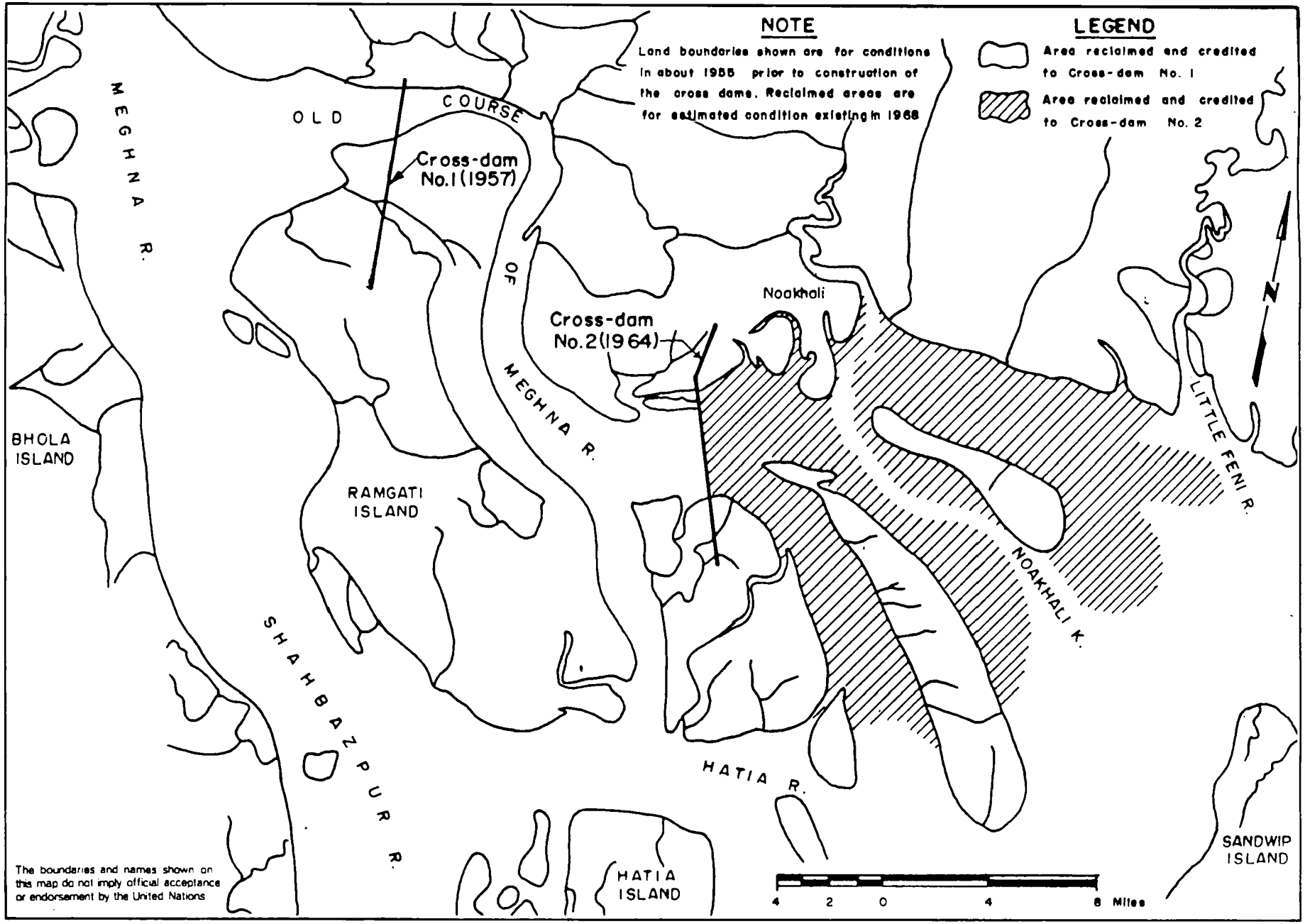

Figure 9. Reclaimed area in the old course of the Lower Meghna river

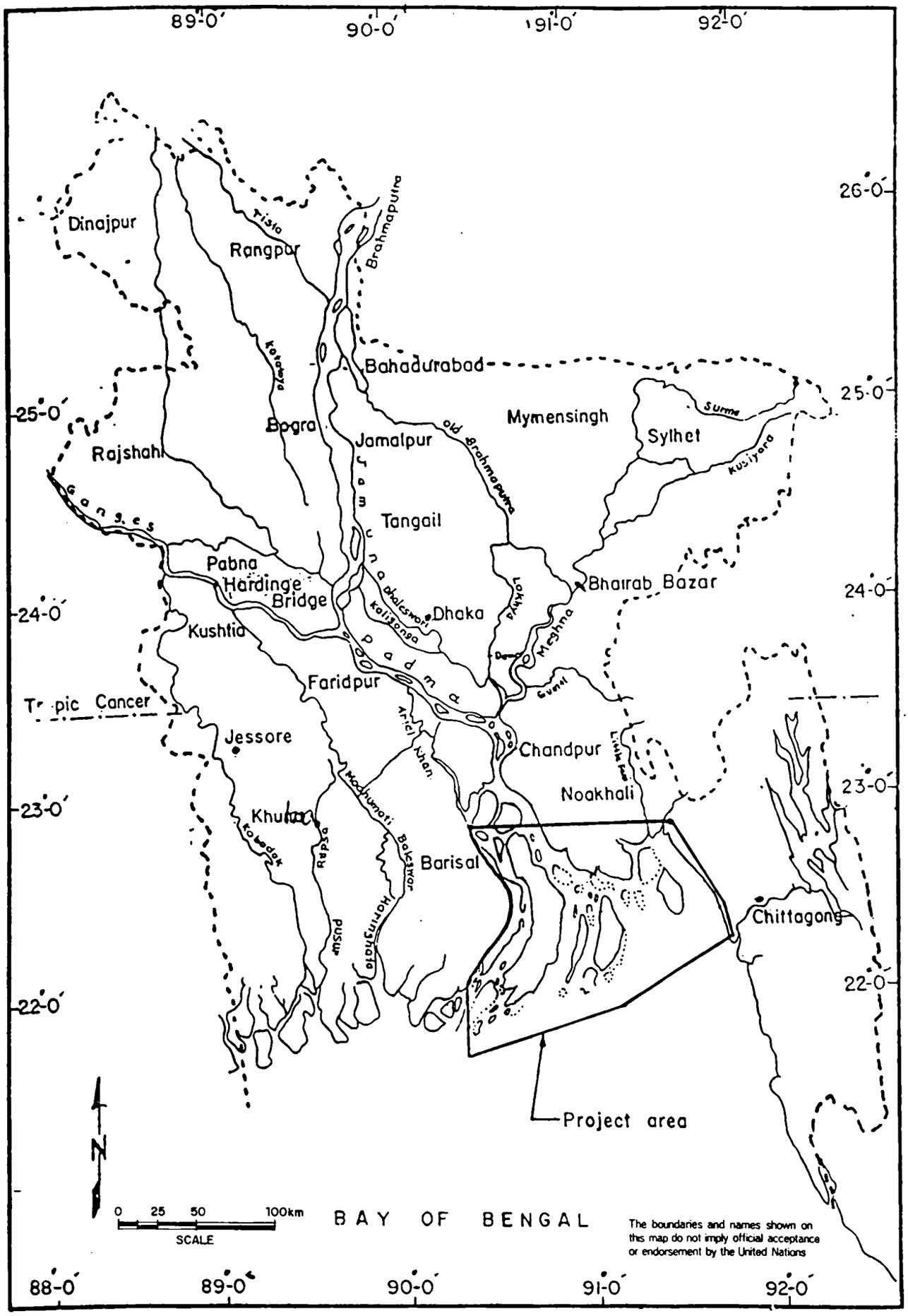

Figure 10. Map of Land Reclamation Project at a scale of 1:3,000,000

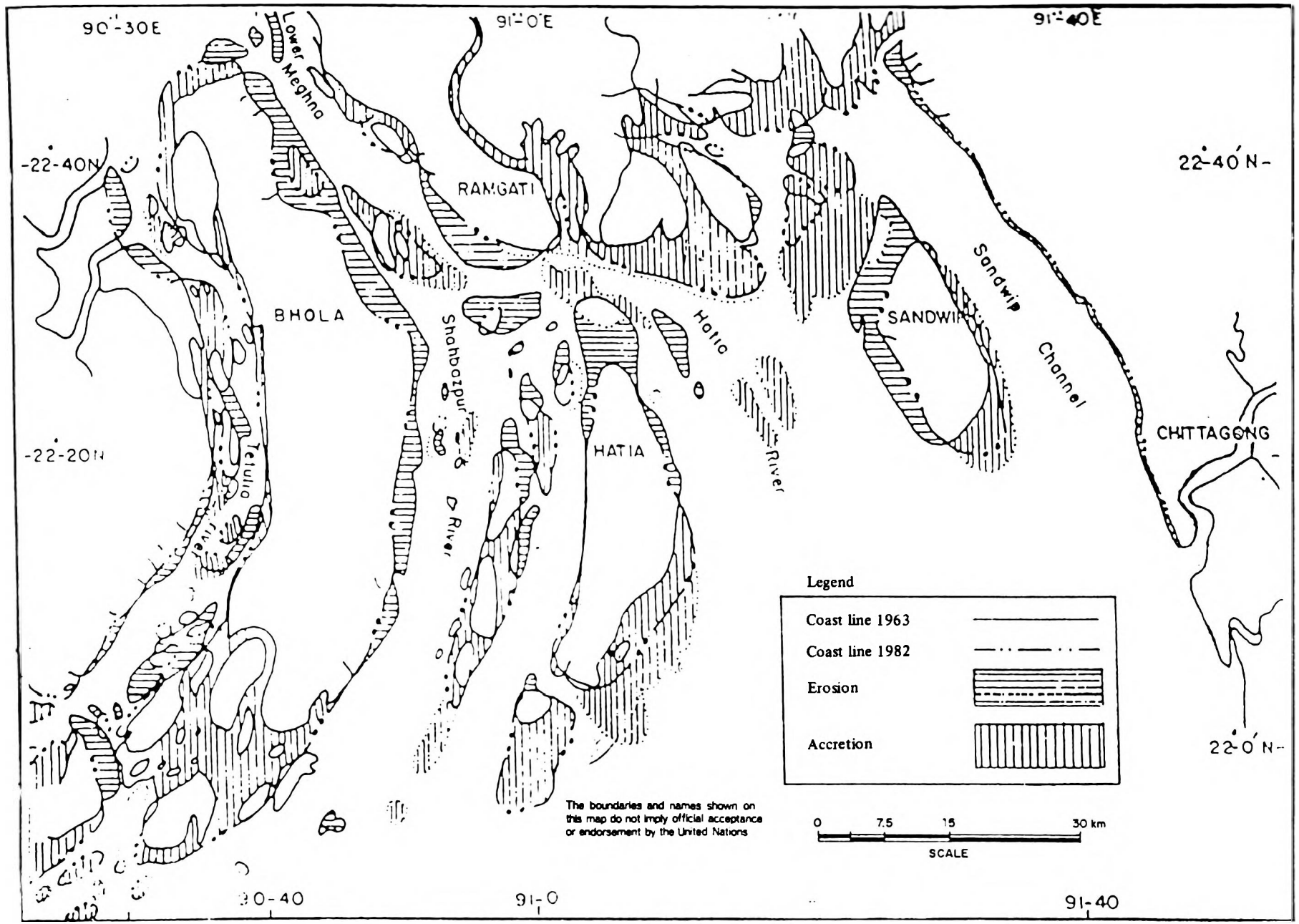

Figure 11. Coastline changes from 1963 to 1982 in the Land Reclamation Project area

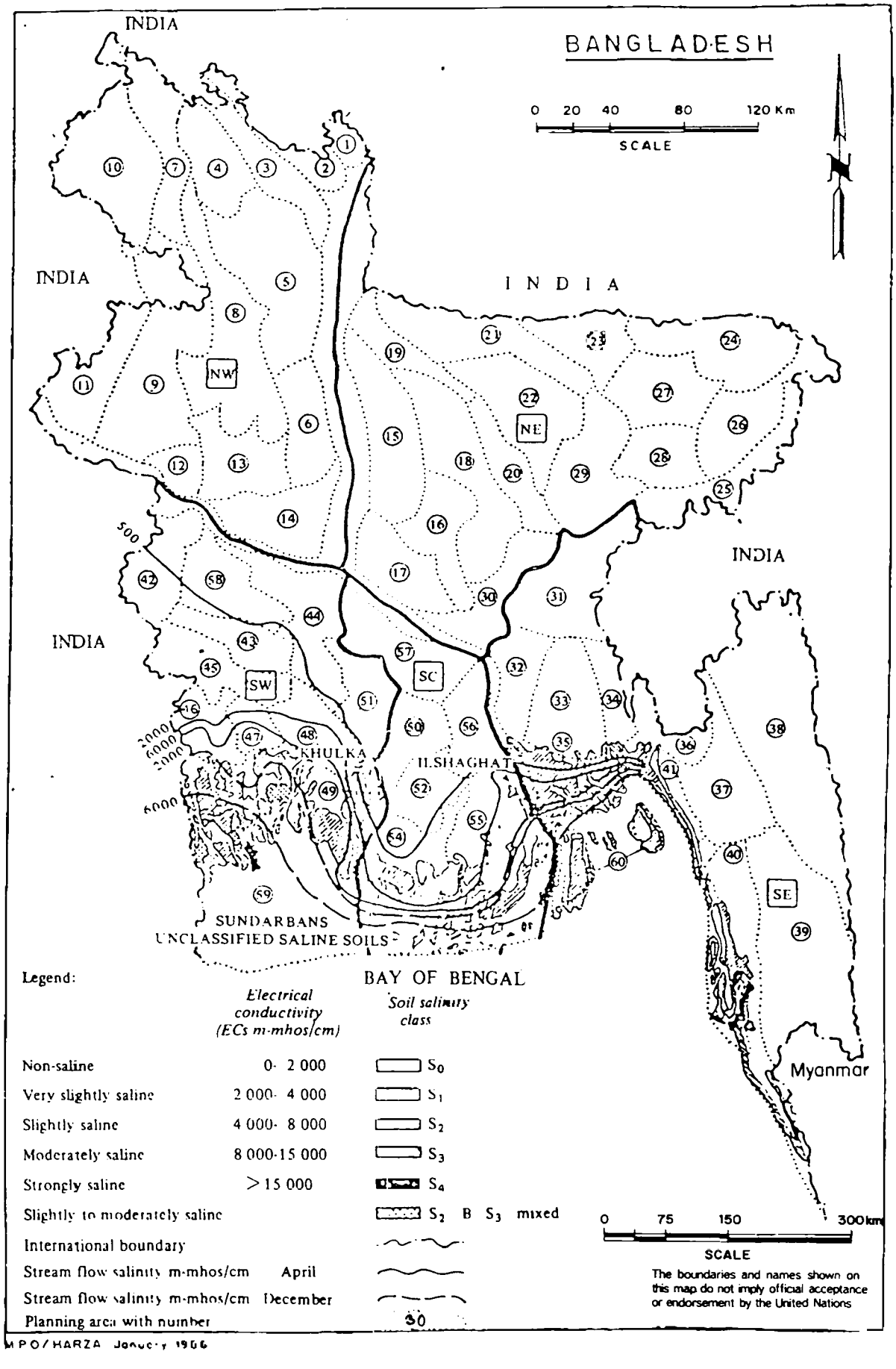

Figure 12. Soil salinity and river-water salinity conditions from December to April in Bangladesh

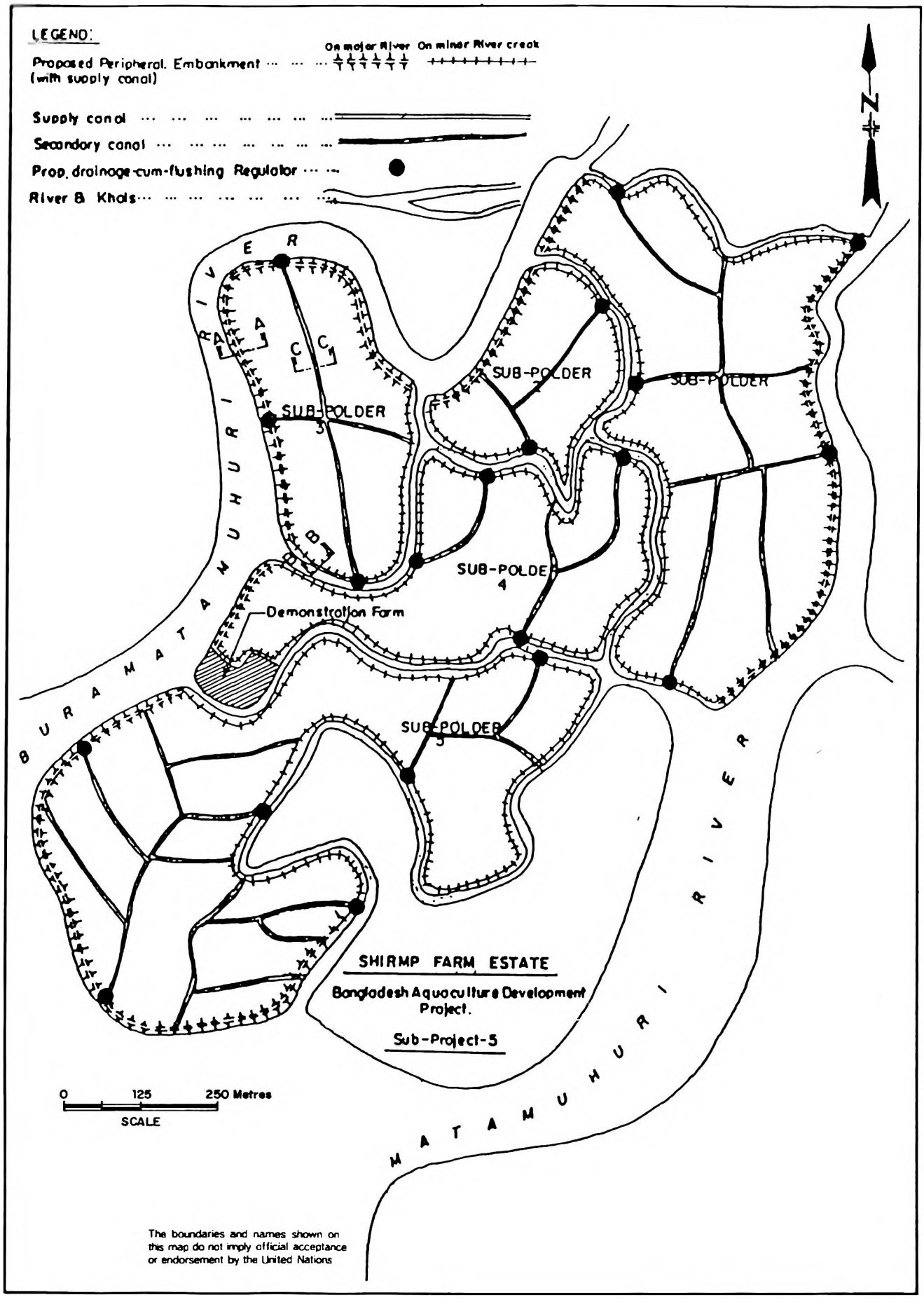

Figure 13. Map of Rampur area showing the location of the shrimp culture project.

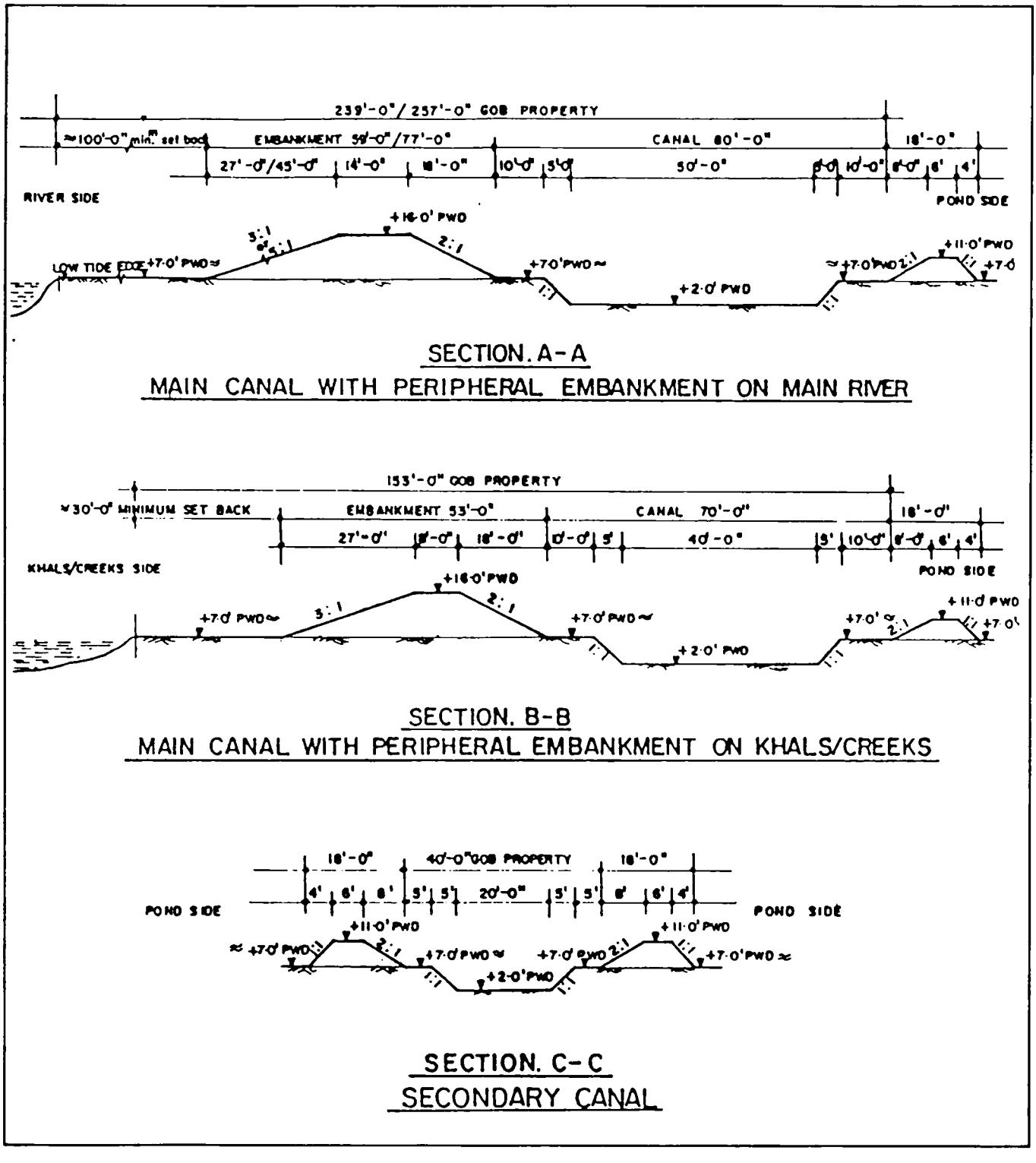

Figure 14. Cross-sections of main canals for peripheral embankments on the main river, khals/creeks and secondary canals

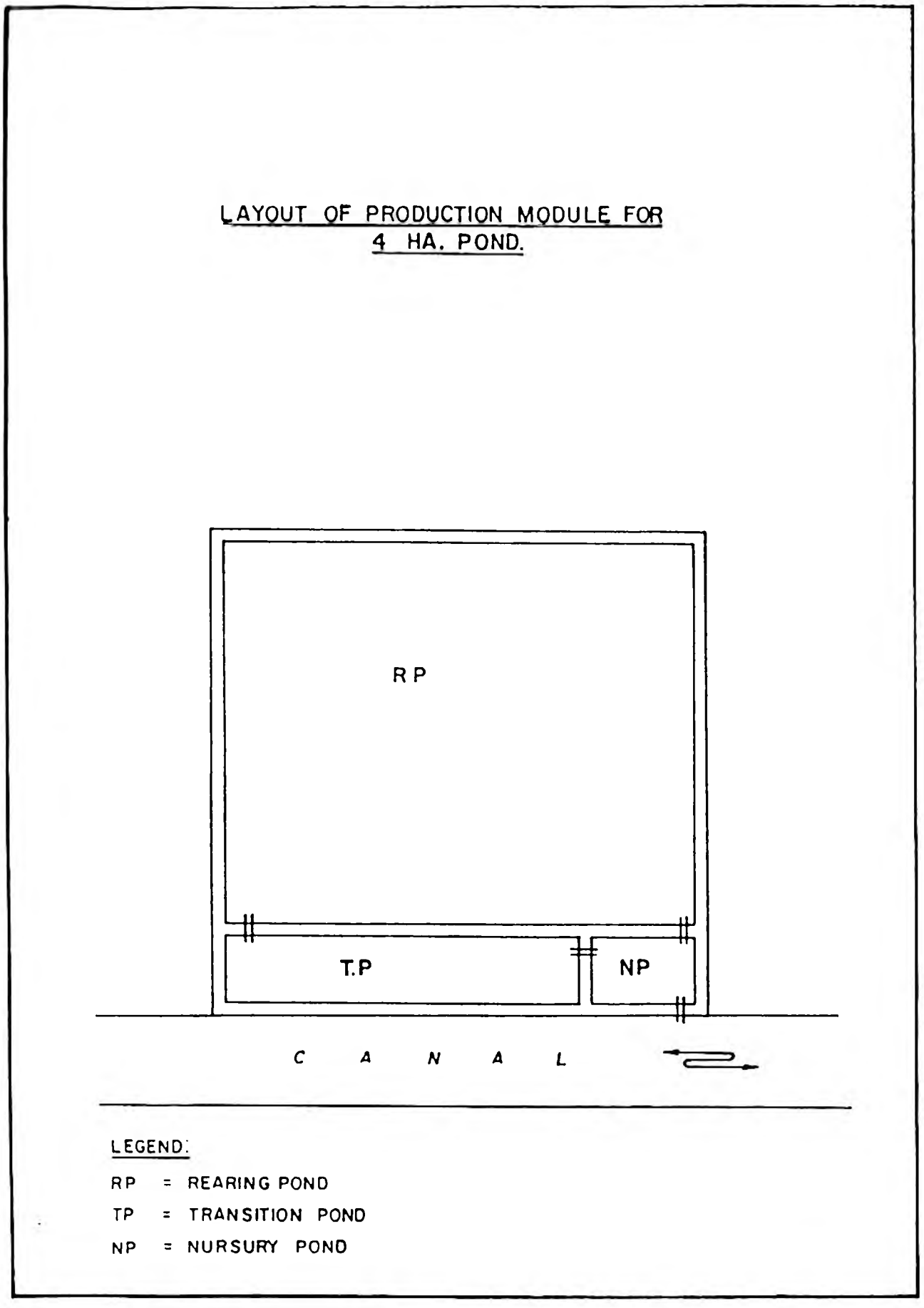

Figure 15. Layout of production module for a four hectare pond

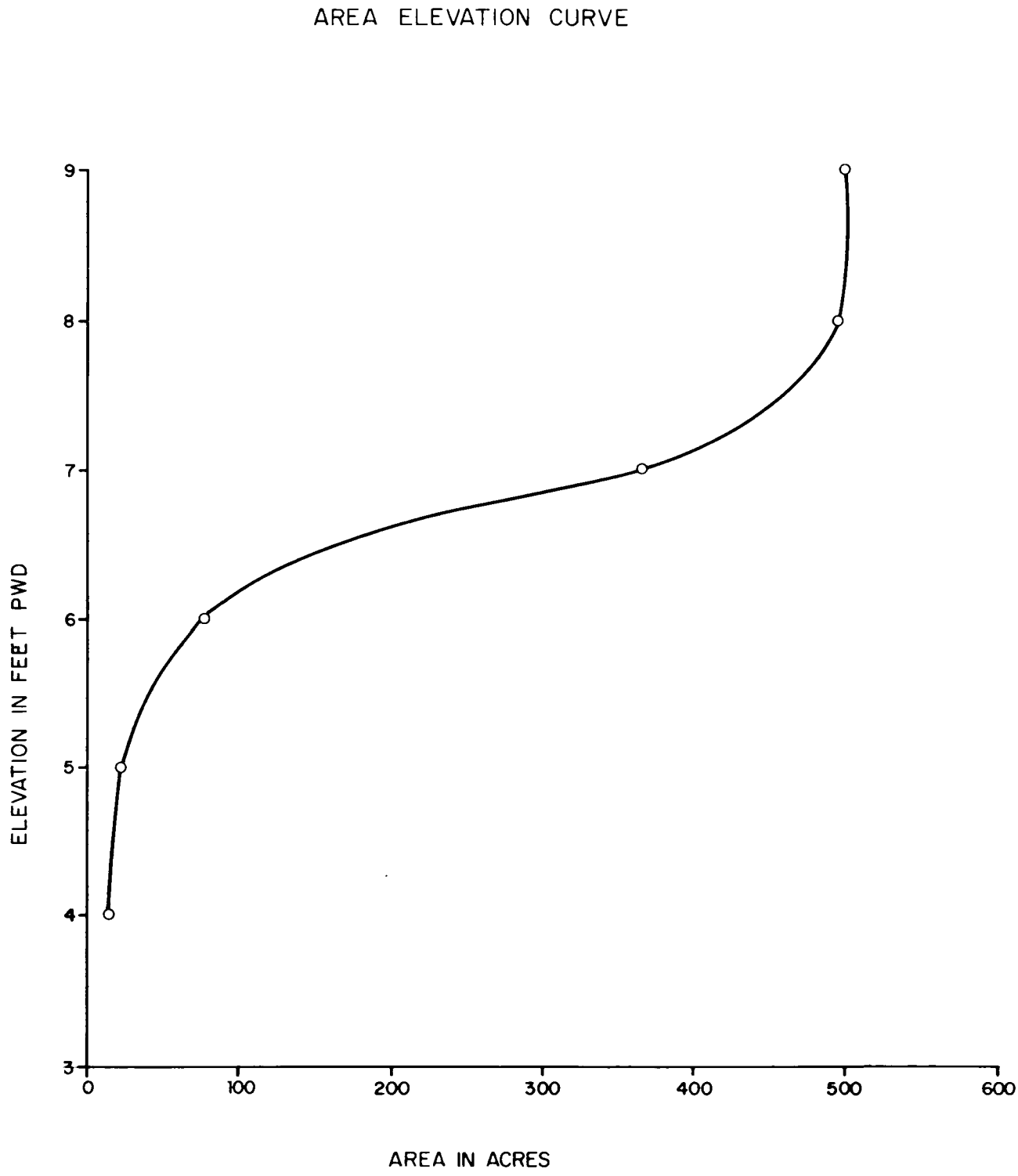

Figure 16. Area elevation curve for the Land Reclamation Project

DEVELOPMENT OF COASTAL LOWLANDS IN BANGLADESH FOR SHRIMP CULTURE. A CASE STUDY

by
M.A. Bari Talukder[1]

1. Introduction

General

The coastal area is the area where the sea meets with the land. It is the site of complex natural systems where intense interactions occur between land, sea, and atmosphere. These systems consist of sets of interacting components under the influence of related physical and biological processes. The physical processes involve mixing of fresh water with sea water, tidal and wave actions, sedimentation, variations of temperature and salinity etc. While the biological processes are associated with flora and fauna including fish resources, mangrove ecosystem etc. These processes act in a complicated way and have great influence on the coastal environment and marine resources.

The understanding of the complexity of any coastal area depends on the detailed information and knowledge of the major components of the river and delta system of the region i.e. the drainage basin, alluvial valley, deltaic plain, receiving basin etc. (Coleman and Wright 1971). These deltas are the gifts of rivers resulting from interacting alluvial and marine forces. Since ancient times river deltas and coastal areas have been the site of economic and commercial activities and were of fundamental importance to civilization. As a result the study of deltaic/coastal regions received considerable attention from ancient scholars. The deltaic accumulations play an important role even today in accommodating the world's energy because the deltaic sediments provide source beds and reservoirs for a large fraction of the known petroleum reserve of marine origin.

Coastal zone

The coastal zone where the land and sea meet is composed of a variety of complex environments. The zone includes bays, estuaries, deltas, marshes, dunes and beaches. A broad range of conditions is represented in these environments. They vary from coast to coast. A thorough study of different phenomena and processes will provide information for understanding coastal dynamics. The coastal areas of the world contain a large percentage of its population and areas of extreme economic importance. The economic and related activities include industrial, residential, recreational, transportation, defence etc. For the development infrastructure and other facilities, scientific and technologically based studies are essential. In addition, overall information and knowledge on the physical and biological processes of the coastal region are required for exploration and exploitation of the resources of the seas. The world population is increasing in a tremendous way so the salvation of the future generation lies to a great extent in the exploration of the sea/marine resources and coastal areas particularly for the developing countries.

Bangladesh has a vast coastal area full of resources in the South where the land meets the Bay of Bengal. The coastal region of the country which includes the old districts of Chittagong, Noakhali, Barisal and Khulna is the complex interacting zone of a) the discharges from Ganges, Brahmaputra and Meghna river systems b) tidal waves originating in the Indian ocean and c) wind action generated mainly by cyclones and south west monsoon. These actions lead to constant changes in the coastal geomorphology of Bangladesh. The result is accretion in some place and erosion in other places.

For socioeconomic development planning, for exploration and exploitation of the resources of the coastal areas, seas and also for political reasons, it is essential that the accretion and erosion problems be monitored on a regular basin.

Characteristics of Bengal Basin and the Bay of Bengal

The Bengal Basin is one of the largest geosynclinal (a large depression or trough in the earth's crust) basins of the world. It is located in the eastern side of the South Asian Sub-continent. The Basin is bordered on the north by the lofty Tertiary Himalayas, on the north-east and east by the late Tertiary Shillong plateau, Tripura hills of lesser elevation and Naga Lusai folded belt, and on the west by peninsular shield of India (geologically ancient Chotanagpur plateau of moderate height). The southern fringe of the basin is not distinct, but the geophysical evidence indicates that it is open towards the Bay of Bengal for a considerable distance. The formation and growth of the Bengal Basin are directly related to the origin and morphology of the Indo-Gangetic plain which itself is overlain and filled by sediments thousands of meters thick.

The Bay of Bengal is situated in the northeastern corner of the Indian Ocean. This is bounded between latitude 5°-22° N and Longitudes 80°-95° E. It occupies an area of 2,173,010 sq. km. and is bordered by India and Sri Lanka to the west, Bangladesh to the north, and Burma and the northern part of Malayan Peninsula to the east. According to the definition of the International Hydrographic Bureau, the southern boundary extends from Dondra Head at the southern end of Sri Lanka to the northern tip of Sumatra. The Bay is about 1,609 km. wide, with an average depth of more than 792.5 m. Maximum depth is 4,500 m (Encyclopaedia Brittanica, 1980). A

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number of large rivers namely, the Ganges and the Brahmaputra on the north, the Irrawaddy on the east, and the Godavari, Mahanandi, Krishna, Kaberi on the west flow into the Bay of Bengal. The Andaman and Nicobar groups are the important islands. In addition, the rivers Karnafully, Sangu, Matamuhuri and Naaf drain the Chittagong region and flow into the Bay of Bengal. Sandwip, Hatia, Bhola and a number of small islands are located at the apex of the Bay.

The floor of the Bay of Bengal is characterized by a number of topographical features including the Ninety-East Ridge, the Bengal Deep Sea Fan, the Nicobar Fan, the Swatch of No Ground, the Burma trench and the Chagos-East coast trench. The Ninety-East Ridge is situated in the mid part of the Bay and runs north south almost along the 90° E Longitude. This Ridge stretches for about 5,000 km from 15° N to 30° N latitude. To the west of the Ninety-East Ridge lies the Bengal deepsea Fan and east of it is the Nicobar fan. The Bengal deep sea Fan extends from 20°N to 7°S a total length of about 3,000 km. with a width of 1,000 km. (Curray and Moore 1974). The eastern margin of the Nicobar Fan is the Andaman-Sunda trench. The most prominent physiographical and morphological feature of the Bay of Bengal is the Swatch of No Ground. It is a submarine canyon or elongated steep walled cliff running partially across the continental shelf about 24 km. south of the flat mangrove islands of the delta of the Ganges and the Brahmaputra. Another morphological feature of interest is the Burma trench, a long but narrow depression of the sea floor having a relatively steep rise. It is situated in the eastern part of the Bay along the Chittagong, Cox's Bazar, Burma coast. The East coast trench extends from near the mouth of the Passur river to Sri Lanka and further south.

Coastal region of Bangladesh

Bangladesh having an area of about 144,000 sq. km. with population of about 100 million is situated in the north eastern part of the South-Asian sub-continent and has a vast sea area to the south in the Bay of Bengal. The country is drained by the Ganges, Brahmaputra and Meghna river system which is one of the largest in the world. This system has its origin in the Himalayas and the Khashijaintia hills to the north of the country. This river system while flowing through Nepal, India and Bangladesh carries an estimated annual sediment load of about 2.4 billion tons (Coleman 1969). These sediments are subjected to coastal dynamic processes generated mainly by river flow, tide and wind actions leading to accretion and erosion in the coastal region of Bangladesh. The dynamic process in the Bay of Bengal are greatly influenced by its various topographical and morphological features.

The coastal morphology of Bangladesh is characterized mainly by:

- a vast network of rivers.
- an enormous discharge of river water heavily laden with sediments, both suspended and bed load.
- a large number of islands in between the channels.
- the Swatch of No Ground (a submarine canyon) running NE-SE partially across the continental shelf about 24 km. south of the Bangladesh coast.
- a funnel shaped and shallow northern Bay of Bengal at the north of which the coastal area of Bangladesh is located.
- strong tidal and wind actions.
- tropical cyclones and the associated storm seas.

These factors act in complicated ways to bring about geomorphological changes in the Bangladesh coast.

Morphologically the coast line of Bangladesh from the Feni river to Badar Mokam (south tip of mainland) along Chittagong can be classified as a "Pacific type" coast running parallel to the young fold mountain ranges. The east coast is regular and unbroken and is protected along the sea coast by mud flats and submerged sands. A continuous strip of sand lies from Cox's Bazar to Badar Mokam and forms a long sea beach of about 145 km. The smaller rivers of the east (Karnafuli, Sangu, Matamuburi) also contribute to the active nature of the area.

Soils of the coast

More than 85 per cent of the area of Bangladesh is flat alluvial plain criss-crossed by an intricate system of rivers and their tributaries. The network of rivers numbering about 23,024,000 km in length and covering an area of 9,380 sq. km. (6.5 per cent of the total area of Bangladesh) is responsible for the deposition of silts on the alluvial soil during the rainy season. This increases soil fertility. In the coastal area, this is off-set by saline intrusion and cyclonic storms. Coastal soils primarily consist of fine sands, silts, silty sands, sandy silts and clayey silts. The soil characteristics of Chittagong area are formed of recent and sub-recent alluvial sediments of tidal and river flood plains and of piedmont alluvial plains and valleys. They are dominantly silty and comprise silt loam to silty clay loams on ridges and slightly clayey soils in the basin. They are slightly to moderately saline along the coast.

Climate of the coastal area

The coastal area of Bangladesh is within the tropical zone between 21 and 23 degrees north latitude. Like the climate of the country, there are four distinct seasonal weather patterns governed mostly by two monsoons, namely the south-west monsoon and the north-east monsoon. These are catagorized as follows.

The dry winter season from December to February – Rainfall is infrequent under the influence of the dry air circulation of land originated mostly from the north-east monsoon. The wind flows from a north-easterly direction at the beginning of the season, changes to northerly and at the end of the season becomes north westerly or westerly. Temperatures in the low twenties during the day and in the low tens at night are common during this season. The humidity gradually decreases during this season. The skies are generally clear.

The transition period from March to May – This period is termed the pre-monsoon season and is characterized by short duration thunder storms of land origin, often associated with violent squally winds. This is the general pattern in the months of March and April. The climate in May is characterized by severe cyclonic storms originating over the Bay of Bengal. This is the hottest month of the year and the day-time temperature may rise to about 40°C in the north western part of the coastal area.

The monsoon season from June to September – This season is characterized by heavy rainfall under the influence of the south-west monsoon with 75 per cent of the total annual rainfall occuring in this period. Monsoon depressions are usually of several days duration and rainfall is steady at moderate rates. Mean temperatures are above 20°C and humidity averages about 85 per cent. The skies are normally cloudy to overcast.

The second transition period from October to November – This transition period is termed post-monsoon since it follows the monsoon season. This season is characterized by violent tropical cyclonic storms which form and develop over the Bay of Bengal. More than 75 per cent of the cyclonic storms which strike the coastal area occur during this season and in the month of May. The storms of this season are, however, more severe and destructive than those which occur in May.

The mean annual rainfall varies from approximately 150 cm. in the north west portion of the Khulna region to over 380 cm. south of Cox's Bazar. The heaviest rainfall occurs in July and ranges from about 36 cm during that month near Khulna to over 90 cm. at Cox's Bazar. There is practically no rain during the dry winter months of December through February.

Geology of the coastal area

The coastal area, except in the Chittagong region, has been formed by Quaternary sediments deposited by the Ganges-Brahmaputra-Meghna river system. These sediments are thought to be as thick as 3,000 m (Morgan and McIntire, 1959). Logs of tube wells in the project area indicate little change in the character of the sediments to depths of 400 m. Soils in the delta show that some have localized variations, both areally and stratigraphically, but consist primarily of fine, sands, silts, silty sands, sandy silts and clayey silts. Remnants of swamps and forests appear in the form of peat layers particularly in the Khulna region. The excavation here of wood, trees or other vegetation at depths of upto 30 cm. below ground surface provides evidence of large scale subsidence caused by compaction of recent sediments and possibly by structural downwarping.

Geologically, the Bengal basin is an active tectionic region. Morgan and McIntire (1959) suggested that the land in Noakhali region (The Pippera surface) has been uplifted by some 150 cm. in recent times.

In Chittagong region, the agricultural lands in the project area have been formed by predominant alluvial deposits transported from the Chittagong hills by local streams and rivers, although some lands were formed by beach and tidal flat deposits. The soils in this district are generally younger and coarser textured but show similar variations of sands, silts and occasional clays.

2. The Fisheries Sector

General

Bangladesh since its emergence as an independent nation, is faced with serious long term problems. Population density of 680 inhabitants per, square kilometer and a population growth rate of about 2.6 per cent per annum exacerbate problems of food supply and employment. With export earnings covering less than one third of the country's import bill, the economy faces continuing structural deficits and is heavily dependent on foreign aid. The GOB policies emphasize measures to control population growth, increase food production and improve nutrition and curtail the external trade deficit.

The Bangladesh agricultural sector, including fisheries, contributes about 50 per cent of GDP and provides about 75 per cent of employment and exports. Rice is the staple food grain of the country and paddy covers 80 per cent of the cropped area and the cropping intensity is about 140 per cent. With the average farm holding being only 1.4 ha in a context of highly fragmented holdings and a majority of the rural population in dire poverty, investment in agricultural inputs and on farm development is limited. Given the relative scarcity of land, significant increase in production can only occur through crop intensification and diversification. Such as planting high yielding varieties (HYV), increased use of inputs, expanded and improved irrigation and by increasing cropping intensity through measures such as better utilisation of the available lands during the off-season.

Role of the economy

Fisheries is important in Bangladesh in terms of income, employment, nutrition and foreign exchange earnings. The basic meal consists of rice with fish which traditionally provides 80 per cent of the animal protein in the diet. The fisheries sector accounts for 3.5 per cent of the total and 7 per cent of the agricultural GDP. Fisheries provides full time employment for about 2 million people, equivalent to about 7 per cent of total employment, about 1.3 million people are in fishing and fish farming, while the rest work in distribution and processing. The number of full-time fisherman who are mostly landless, rose at the rate of about 3 per cent per year in the past fifteen years and it can be assumed that this trend continues. Part-time fisherman are estimated at about 10 million with a peak in the flood season from June through October. With the population growing and production having gone through a phase of decline, per capita

fish consumption has declined from 11.3 kg. in 1972 to 7.6 kg. in 1988. Seafood exports, about 85 per cent of it is shrimp grown mainly in brackish-water ponds of coastal polders, totalled 22,000 MT in 1988 and realized close to US$ 140 million in foreign exchange, equivalent to 11 per cent of the country's total export earnings. The shrimp industry grew annually by about 22 per cent in the past ten years and ranks third among all export commodities behind jute, jute products and leather. In the next year, shrimp exports will most likely move to second rank.

Production

Bangladesh is a major producer of inland fish and per unit of land, it is the world's leader in fresh water fish production with 4,076 kg/sq.km (China 411 kg, India 391 kg, world average 90 kg). Even the per capita production of 5.5 kg. demonstrates Bangladesh's lead compared to other major fresh water producers (China 4.2 kg, India 1.8 kg). In 1988, fish production rose again to the 1972 level of 824,000 MT, after having declined to 646,000 MT in 1980. The decline occured in inland rivers and flood lands which provide for over 50 per cent of all fish landings and over 70 per cent of the inland fish catch. The major species caught are small indigeneous fish, Hilsa, snake heads and catfish. At present inland fisheries (including ponds and lakes) provide 570,000 MT, a 73 per cent of total production, against almost 90 per cent earlier. The decline was due to (i) the adverse effect of flood control structures on the fish habitat, (ii) over exploitation of fish resources with increasing population pressure, and (iii) inadequate fisheries development efforts. Production started to grow again during the '80s as a result of increased fishing efforts in coastal artisanal fisheries, which provide 25 per cent of total production and from fish and shrimp ponds. Most of the production from fisheries is consumed domestically but exports mainly of cultured shrimp, is developing fast. Seasonal peaks are June-July, flood plain fish, (28 per cent) December-February; coastal and marine fish without Hilsa (14 per cent) October-February; river fish without Hilsa (13 per cent), April-May, and pond fish (18 per cent), October-March.

Shrimp production is of particular importance for Bangladesh due to its contribution to exports, inspite of a relatively small share of about 2.5 per cent in the world market. In 1987, total shrimp production was estimated at 73,000 MT of live weight, head on shrimp, corresponding to about 40,000 MT of processed head-on shrimp, that constitutes the bulk of the exports. Out of the 73,000 MT, of shrimp, fresh water shrimp accounted for 43,000 MT. They are caught in rivers and impoundments of low lands. Of the fresh-water shrimp, 95 per cent are small sized shrimp and prawn, mostly consumed locally; some 1,500 to 2,000 MT are annually exported. Of the 1987 production about 30,000 MT (head-on equivalent to about 16,500 MT head-off) were brackish-water or marine shrimps culture accounted for about 50 per cent, artisanal coastal and estaurine fisheries for about 37 per cent and trawler based marine fishery for the remaining 13 per cent. Coastal and Marine catch peaks in December-April, brackish-water shrimp culture peaks twice in the western Bangladesh the peak harvesting season is May-July, in the east October-November.

Objectives for development

GOB's principal objectives for the fisheries sectors area:–

- to improve the nutritional level of the population through increased fish production and consumption (supplementing the agricultural development objective to increase food grains production to the level of self sufficiency).
- to expand employment opportunities and improve socio-economic conditions among those engaged in the fisheries sectors, and
- to increase export earnings from fisheries, including shrimp increases in production, and employment opportunities are mainly experted from inland fisheries, with aquaculture having the best potential for rapid growth. The proposed would particularly address the export earnings objectives through the shrimp culture.

The World Bank in 1983 recommended development in three areas of aquaculture based fisheries:

(i) Culture-based fisheries (mainly for carp) in larger inland water bodies, such as in low-lying depressions within drainage and flood control schemes. Annual production could increase from 150 kg/ha/year to about 450 kg/ha/year. Some 200,000 ha of low-lying land have such development potential.

(ii) Shrimp culture development in coastal areas. Conversion of current low yielding trapping methods into higher yielding "extensive" and "semi-extensive" operations could increase annual production of export quality of shrimp from its current level of about 68 kg/ha to 250 kg/ha. Production on the 52000 ha currently exploited could increase from 3,500 tons head-on shrimp to 13,000 tons. An additional 42,000 ha of coastal lowlands have been identified as technically suitable for shrimp-farming development.

(iii) Intensification of carp culture in ponds where water control conditions are appropriate. The adoption of "extensive" technology by fish farmers would allow annual production to increase from 115 kg/ha to 500 kg/ha.

3. Shrimp Culture for Development

Area and production

As demand and prices for shrimp in the international market rose, extensive shrimp culture developed mostly

within polders. The area under shrimp culture has expanded rapidly over the past years, on the order of 40 per cent per year, since 1980/81. In 1984 shrimp was cultivated over an area of about 52,000 ha in coastal areas, of which 61 per cent were in the Khulna division in the west, 36 per cent in Cox's Bazar district in the east, and 3 per cent in more central coastal areas. Production in 1984 was at some 3,500 tons of head-on exportable shrimp and 5,200 tons of miscellaneous small fish and shrimp consumed or sold locally. The 3,500 tons of head-on exportable shrimp are equivalent to 2,200 tons of headless shrimp of 19 per cent of Bangladesh's shrimp exports in 1982/83 (11,500 tons), the balance coming from marine trawling as well as coastal and reverine small scale fishing.

Shrimp farming

Shrimp farms are generally developed by building a small peripheral dike around low-lying land areas inside polders built by Bangladesh Water Development Board. Average land holding size in the polders is 1.0 ha and plots are fragmented on average 0.24 ha. The enclosed pond ranges in size from 10 ha to 150 ha, depending on topographical features and local practices in shrimp farming. Typically, the land owners lease the pond area for about half a year to persons interested in shrimp farming, while using it for paddy or salt production during the other half of the year. Water levels in the ponds, range between 0.3 m and 1.0 m. Pond salinity varies with changes of salinity in adjacent rivers and tidal canals. The changes, in turn, depend on such factors as land elevation and location, volume and seasonal flactuation of the rivers, upland flow. In the semi-saline zone of Khulna Division in the west, river salinity rises steadily from October to June/July, then it decreases with the monsoon rains. In the eastern coastal area around Cox's Bazar, the shorter and wider rivers and coastal channels respond to the influence of the sea, and to more intense rainfall, giving rise to a less stable and generally more saline regime.

The majority of shrimp is cultivated in rotation with paddy in Khulna division and with salt production in the Cox's Bazar district. In the shrimp/paddy rotation, shrimp grow from January to May in the shrimp/salt retation shrimp grow from June to November. In both cases. Land is left fallow for half a year if it is not used for shrimp cultivation. Juvenile shrimp are entrapped in the pond with the influx of spring tides at the beginning of the shrimp growing season and depend for their growth mainly on the detritus of decomposing micro organism. Current yields of export quality shrimp range from 50 kg/ha to 150 kg/ha with an annual average yield of nearly 70 kg/ha/year. Yields have gradually improved in recent years, particularly in Khulna division where some shrimp farmers have stocked their ponds with juvenile shrimp that were collected by fisherman in estuaries, and have reached yields of 150 kg/ha.

Marketing and processing

The local system for collecting, transporting, processing and shipping frozen shrimp is, in general, adequate and would accommodate the incremental output envisaged by the proposed project. In 1984, 45 processing plants were in operation, of which 15 were in the Khulna, 28 in the Chittagong, and 2 in the Cox's Bazar area. Their combined annual processing capacity is esimated to be about 60,000 tons of frozen headless shrimp. However, annual throughput is a mere 20 per cent of installed capacity.

This low utilization is due to lack of raw materials even though processors offer competitive prices to attract shrimp to their plants or collection centres in shrimp producing areas. Thus, there is adequate processing capacity to deal with the project output and adequate price incentive for project producers. Most of the processing plants operate under a tax holiday system that exempts processors from payment of income tax for five years or more, depending on location. In addition, processors benefit from other measures of industrial or export promotion, among which the Export Performance License system is the most important. It provides exporters of frozen shrimp with import Enlistment Certificates equivalent to 80 per cent of the value of their exports. These certificates can be sold in the open market and, thus, improve business profitability.

4. The Project

Location

A main project area of about 7,000 ha of low lying coastal lands is already selected for improvement under shrimp culture. Out of this 1,400 ha will be in Khulna district and 5,600 ha will be in the Cox's Bazar district. An area of 1,700 ha on former mangrove land in Rampur (study area) which is already leased out to private shrimp farmers will be developed.

Criteria for selection

The project area includes lands where three modes of shrimp cultivation currently in use are being practiced. The criteria for selection take into account numerous physical requirements and the location's suitability for intensive or semi-intensive shrimp-farming without adverse effects on existing land-use patterns.

The existing peripheral embankments of the selected polders must be of good standard to assure that shrimp culture and agricultural activities are safe from flooding.

A fundamental requirement is a sufficient supply of saline water that can be controlled and easily provided to shrimp fields. Locations must therefore be close to waterways having adequate salinity levels in the shrimp farming season. The tidal characteristics of the waterway and the elevation of the proposed land for development must be such that the land can be flooded by gravity flow during

the relatively short and intermittent periods of high spring tides which increase in level in the early part of the shrimp-farming season. Rapid filling is desirable. Ponds should be capable of filling to an average depth of 2 feet in less than 45 days and should reach to a depth of 3 feet by mid-season. Besides dimension, the control structure which regulates the quality of water is also a critical factor for rapid filling of the pond.

Rapid and complete drainage of shrimp fields are required for a number of reasons: namely to facilitate speed of transition from one mode to another, allow the effective flushing away of saline water in shrimp/paddy modes, and to allow the ground to be drained, dried and exposed to the atmosphere as a conditioning treatment necessary for enhanced shrimp production. The topography of the selected areas must be suitable for drainage and lay out of shrimp farming blocks.

Enclosing embankments of a shrimp farming area are subjected to exposure to severe wave action. This situation should be avoided as the cost for providing protective measures are significant.

Shrimp farming area should be so selected that it has no adverse effects to neighboring areas. The possibility of seepage of saline waters into agricultural land must be avoided and where shrimp lands are developed along the tidal margins of land areas under other uses, provision must be retained for the latter to be fully drained independent of the water management requirements in the shrimp farming blocks.

In planning the development of shrimp-farming areas, existing communications must be preserved and the requirements of home-steads, drinking water supply and areas for livestock grazing must be taken into account.

The area to be selected must be under shrimp cultivation for the preceeding two years.

The financial rate of return on total investment should be above 25 per cent.

Project component

The purpose of the project is to intensify the production of high value shrimp from tidal lands currently being used for low-yielding shrimp trapping in order to generate income and foreign exchange in response to demand for such shrimp on international markets. The project would complement the GOB's current efforts and create the basis for future programme to develop coastal lowland through aquaculture.

To achieve the above objectives the project will provide for:

i) infrastructure (embankments and water control structures and shrimp hatcheries) which would permit more efficient water management in the project area and supply high quality shrimp seed.

ii) supply of medium term credit to shrimp farmers, traders and hatchery operators for financing on-farm investment, marketing equipment and private hatchery investments.

iii) institutional support through financing of building, equipment incremental staff salaries and incremental operating costs for DOF & BWDB in order to strengthen their ability to implement and monitor the project and

iv) technical assistance consisting of (a) consulting services to assist a project implementation unit (b) training of shrimp farmers.

5. Engineering Studies

General

Present study has been directed for modification of the earlier study to make an appropriate water management system so that farms of 10 acres can be developed with requirements fulfilling the criteria set forth for shrimp culture.

The invert level of the pond regulator has been set at 5.5 ft PWD. It is seen that about 10 per cent of the area is below the invert level. It has therefore been proposed that the pond bottom shall be levelled to at least 5.50 ft PWD. So as to achieve total drainage and uniform distribution of depth.

Each 10 acre farm will draw tidal flow from the main canal through a regulator 4'-0" wide and invert level set at 5.50 ft PWD.

Design criteria

In general, design practice followed by Bangladesh Water Development Board in coastal embankment projects have been followed.

The project area in Rampur is encircled by the river Matamaburi, Baro Matamahuri and Mahesh Khali river and by link canals between Baro Matamaburi and Matamaburi. Numerous tidal creeks originating from the peripheral river traverses the project area.

The land topography does not permit innudation to desired depth even during spring tide in the early months of the year. Month of January has the lowest tide level. during this month the pond will be drained, dried and leached out. From February the pond will be filled up and the shrimp culture will proceed continuously till December with intermediate leaching and drainage during and at the end of each culture period. Available tidal head will not allow filling the fish ponds to the desired depth round the year. In order to allow round the year culture, pumps will be needed by each farm in addition to flushing-cum-drainage structure. Pumps will be operated only when the tidal head does not permit gravity flow either to fill up the pond or for water exchange. Regulators will provide

drainage and tidal flushing by gravity whenever tidal head permits. A flushing canal leading from the regulator will run along the periphery of the sub-polders and supply waters to individual farms. A drainage canal will run along one side the individual ponds and lead the drainage to the regulator for disposal. The outlet of the drainage canal of the individual farm will remain closed during flushing. These drainage canals will also serve to dispose of the leaching drainage at the end of each culture season.

Flood levels of different frequency for Cox's Bazar area have determined the crest level of the embankment which was computed by adding 3 ft as free board according to existing practice followed by BWDB. The computed crest levels have been compared with existing BWDB embankment crest levels and fixed at 16.00 PWD. The following section has been adopted.

Embankment section

	On major river	*On other khals*
River side slope	1:3 (For Maheskhali 1:5)	1:3
Pond side slope	1:2	1:2
Crest width	14-0"	8-0"

Project costs

The project cost features include water control structures, embankments for flood protection and supply or drainage canals.

Cost estimates of these features have been prepared on detailed design and on the basis of 1987 schedule of Chittagong O & M circle of BWDB. A summary of cost for development of off farm facilities in Rampur area is furnished below:–

Total cost of estimate for embankment, water control structure and other off-farm structure RAMPUR area.

Sl no	*Item of work*	*Total unit*	*Cost in million Tk*
1.	Flood protection embankment with canal &	33 miles.	
	other off farm canal	19 „	
		52 miles.	61.80
2.	Water control structures.	20 nos.	77.70
		Total cost Tk.	139.50
		Say Tk. 140.00 million.	

6. Benefits

The major quantifiable benefits would be the annual incremental production of about 1,500 tons of head-on exportable shrimp and about 1,800 tons of miscellaneous shrimp and fish on the main project area of about 7,000 ha. Other tangible benefits that were taken into account in the financial and economic analysis are the production of Juvenile shrimp in the project hatcheries and the incremental production of some paddy. These benefits would result in increased net income to farmers and would be brought about by improved water management and shrimp-farming technology disseminated by the shrimp culture extension services.

Financial benefits

Financial analysis was undertaken for the three shrimp production needs for a typical 30 ha group of farms practicing the shrimp/paddy or shrimp/salt rotation and a 40 ha farm for shrimp mono-culture. For the purpose of calculating financial rate of return only, on-farm investments are treated as investment cost. The financial rate of return of the three models exceeds 50 per cent. They are very high because the major infrastructure is financed with public finance and the effects of the cost recovery scheme in FRR calculations are mitigated.

Economic analysis

The economic rate of return (ERR) of the project is estimated at 27 per cent. At a discount rate of 12 per cent the estimated, opportunity cost of capital in Bangladesh, the projects discounted benefits would be US$41 million and the discounted costs US$23 million, leading to net present value in economic terms of US$18 million.

In the economic analysis, it has been assumed that the project life is 20 years, with full production development reached in year eight unless otherwise stated, residual values are 100 per cent of the cost of land and 20 per cent of the cost of civil works. Except for the cost of additional project areas all project cost items, including the physical contingencies are included in the economic analysis. Taxes and duties and price contingencies have been excluded. Sensitivity analysis indicate that the project remain viable under a variety of assumptions regarding costs and benefits.

Environment effects

The project would not have any detrimental effect on the environment. Intensification of shrimp culture under the project would only take place in areas where it is already practiced. Neither the existing land use pattern nor the present ecological balance would be changed. Positive effects would be achieved through (i) elimination of salt water seepage into adjacent agricultural land by construction of appropriate boundary embankments, and (ii) efficient and timely water exchanged to leach-out salt from soils for paddy cultivation. The further spread of extensive shrimp operation into agricultural and forest land would be counteracted by (i) the projects contribution to realize GOB policies on salt water intake and lease of public land; and (ii) demonstrating the financial rewards of intensified shrimp culture. The project would not harm other riparian states

nor would it be harmed by the use of water by such other riparian states.

7. Discussion

The salinity range within which brackish-water shrimp grow best lies between 12 ppt and 30 ppt; for comparison the salinity of fresh-water is 0 ppt and sea water around 30 ppt. Salinity levels vary seasonally in the project area and create a variety of combinations of brackish-water shrimp culture, agriculture and fish culture. Brackish-water shrimp culture is limited to areas that can provide water to the required salinity range for a minimum of 5-6 months. Below that threshhold, shrimp will not grow to sizes that are exportable and command a good price, and the cost of water infrastructure and operation become too high. The land area lying above that threshhold, contained within the project area is of the order of some 210,000 ha.

Intensified shrimp culture requires an adequate and cost supply of saline water. Water supply costs are low when the shrimp culture land is within the tidal range. Most of the present or potential shrimp culture land lies within the range of the tide. The project area has excellent assets and a comparative advantage of location that will allow its shrimp culture to survive price slumps on the world market, water supply and drainage problems for shrimp culture, due to inadequate water infrastructures, are however, found everywhere in the project area and are most marked in the coastal polders. This may sound paradoxical because shrimp culture has developed on some 50,000 ha out of existing 80,000 ha of land behind the shelter of the embankments. Within the polders, the previously dense net work of natural tidal water supply and drainage channels has been interupted. Shrimp culturists near the embankment achieve adequate water exchange only through tampering with the peripheral polder embankments in a hazardous manner which endanger the flood protection needs of others, while those further to the centre of the polder cannot improve water exchange. Water exchange, which improves shrimp culture on a substantial scale and at the same time guarantees the safety and respects the requirements of agriculture, requires modifications to the existing public water infrastructure. These improvements must be delivered by the public sector, because it owns the basic infrastructure and only it can assure that a reasonable balance between the agriculture, shrimp culture and other interests is maintained.

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PRESENT SITUATION AND PROSPECTS OF NATURAL RESOURCES DEVELOPMENT IN THE COASTAL ZONE OF CHINA

by
Ha Chengyou and Xie Jianfei[1]

1. General Description of the Coastal Coastal Zone of China

China is both a continental and an oceanic country which has a vast sea area, with a coast line as long as 18,000 km. There are 6,536 islands, each having an area of over 500 m^2, making a total area of 72,850 km^2 and a coast line of 14,000 km. The Bohai Sea of China is an epicontinental sea, while the Yellow Sea, East China Sea and South China Sea of China are marginal seas of the Pacific Ocean. Along the coast line are located more than ten provinces and municipalities, one autonomous region and 156 towns. They are from north to south the Liaoning Province, Hebei Province, Tianjin Municipality, Shandong Province, Jiangsu Province, Shanghai Municipality, Zhejiang Province, Fujian Province, Guangdong Province and Guangxi Autonomous Region, except the towns.

The coastal zone of China under alternating actions of natural agents from land and sea includes coastal lands, intertidal flats and submerged shore slopes, which are all being formed and developed under interactions of marine dynamic force and seashore geological processes. The coastal zone extends across four different climatic zones, i.e., the frigid-temperate, temperate, subtropical and tropical zones, where conditions of hydrology, soil, vegetation, landform, geomorphology and geology are quite different. The evolution of the coast line reflects the influence of geological and climatic changes, the actions of river flow, typhoon, seawave, tide, epicontinental current and sea level fluctuations.

The coastal zone of China can be identified as two types: the plain type and the bedrock type. The former is mainly formed by sedimentation of silts transported by rivers towards the sea under the action of seawaves and currents along the shore. The constituent materials are fine and extremely fine sand and clay. The beach of the coastal plain is smooth and flat. The latter type is the result of tectonic activities and seawave erosion, featured by a zigzagged beach, with numerous scarps, narrow flats, irregular capes, gulfs and isles along the deep-water coastal zone. Bedrock outcrops can often be seen over the upper tidal zone, whereas in the lower tidal zone are generally gravels and coarse sand.

Each of the two types may also have two sub-types: the river-mouth sub-type and the seashore sub-type. The former is influenced by the big rivers (the Yellow River, the Yangtze River and the Pearl River), and includes deltas and estuary geomorphologic features. The latter emphasizes the biotic type of seashore with coral reefs and mangroves.

The coastal zone of China consists of four areas: the Bohai Sea area, the Yellow Sea area, the East China Sea area, and the South China Sea area. The major islands along the zone from north to south are the Changshan Qundao, Miaodao Qundao, Chongming Dao, Zhoushan Qundao, Taiwan Dao, Wanshan Qundao, Hainan Dao and isles in the South China Sea.

Since 1980, the departments concerned have carried out multi-disciplinary investigations on natural resources in coastal areas and tidal flats. The results demonstrate that the coastal and nearshore areas are rich in biotic and non-biotic resources. Among those, mineral deposits, petroleum and natural gas are proved to have considerable reserves, and therefore a great potential exists in marine energy and resources are important for industry. With the development of the national economy of China, the coastal areas have been identified as productive forces and important bases for the prosperity of China and economic and technological interaction with foreign countries.

2. Development of Natural Resources in Coastal Areas and Its Problems

The coastal zone of China is the most developed and important economic zone of the country and economic development along the coast occupies a decisive position in China. There are more than 700 ports or harbours, of which over 70 handle an annual capacity of 100,000 tons of cargo. There are also 300 important fishing harbours. The Shanghai port is the largest and has a handling capacity per year of over a hundred million tons. Those having yearly capacity of a total of more than 20 million tons include Dalian, Qinghuangdao, Tianjin, Qingdao, Ningbo, Guangzhou and Shanjiang.

The rivers in China have poured into the sea a great quantity of silt which was deposited in the shallow sea area, forming 400,000-500,000 mu (1 mu = 1/15 hectare) of flats that have played an important role in alleviating the contradiction between the large population and less cultivated land, and in developing agriculture in coastal areas. For example, 2,000,000 mu of reed marshes provide yearly about several ten thousand tons of reed which is an excellent material for papermaking. This is an important factor for the development of the papermaking industry in coastal areas. Along the coast south of the Yangtze River where it

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is suitable for planting orange and sugarcane, there are at present 600,000 mu of sugarcane, producing 270,000 tons of sugar; and it is planned to expand the sugarcane fields up to 1,400,000 mu till the year of 2000, with an estimated production of 600,000 tons of sugar. Meanwhile, about 800,000-1,000,000 mu are planned to be used for orange plantations with a planned production of 800,000-1,000,000 tons of oranges till 2000. All these agricultural activities will make a considerable income for the country.

In addition to the growing of crops for economic purposes farmland for cereal crops will also be developed on the flats till 2000 for an average production of 700 jin (1 jin = 1/2 kg) per mu. This will make an increase in grain production of about 200,000 tons, which will make a significant contribution to the food production in China.

The continental shelf within the domain of China is the most promising off-shore oil-producing area. It is estimated that the potential of off-shore petroleum may reach 500-800 million tons. For instance, the high-yielding wells located within the broad river-mouth sectors of the Bohai Sea have produced 1,000 tons per day of crude oil and natural gas of 600,000 m^3. With the petroleum exploration and exploitation along the continental shelf, oil and gas supplied by the coastal zone will gradually increase to a greater proportion of the total yield of the country.

Moreover, the potential of tidal energy along the seashore is theoretically estimated to be of 11 billion kilowatts and the exploitable and usable installed capacity will be 20 million kilowatts concentrated in the coastal terrains of Fujian and Zhejiang provinces. There is also a considerable potential of wind energy for generating electricity. Such generation of electricity is now in an experimental stage and, if successful, will solve the problem of supplying electricity for housing and small scale industries.

The development programme for the coastal zone is still at its starting point though it has already shown its feasibility and brought some benefits to the people. A series of environmental geological problems have arisen which calls for an environmental awareness during the process of development. There problems are:—

1. Shortage of wager in coastal areas has affected further development. For example, the deficiency in water supply of Tianjin Municipality is estimated at about 430,000,000 ton/yr. In big cities such as Shanghai, Tianjin, Ningbo and Nantong, the lowering of the groundwater table caused by overpumping has resulted in cones of depressions in large areas and consequent land subsidence. The accumulative subsidence of Shanghai has reached 2.63 m, and the maximum accumulative subsidence of Tianjin up to 1.78 m. Till 1985, the subsiding rate of urban areas of Ningbo reached an average of 25-30 mm/yr. The deep groundwater in Nantong dropped from the water-level mark of 2 m in 1965 to that of −33 m in 1984, forming a cone of depression up to several ten square kilometres. In some areas along the coast, over-extraction of groundwater has induced seawater intrusion which resulted in the deterioration of the quality of fresh groundwater. In the case of the water supply to Dalian Municipality depending mainly on fissure water coming from karstified aquifers, intense exploitation of groundwater for industrial and agricultural use, caused seawater intrusion to expand from a naturally intruded area of 4.2 km^2 before 1969 to an artificially-induced intruded area of 83.9 km^2 in 1977. During the period from 1977 to 1981, the area of seawater intrusion in Dalian expanded to 173.5 km^2, the yearly average being 17.9 km^2. With the expansion of seawater-intruded area, water quality has been seriously deteriorated. The content of chloride ions in groundwater increasing from 200-600 mm/l (1970-1973) to 300-800 mm/l (1974-1978) indicates the growing seriousness of seawater intrusion and deterioration of the limited fresh water resources, which intensifies the contradication between water supply and demand.

2. The layout and distribution of engineering projects incompatible with natural environments and irrational development of mineral deposits, all have destroyed the ecologic balance of the environment and given rise to the silting of flats increasingly. For example, sluice gates being built at river mouths will affect development of harbours; tidal weirs at smaller river mouths will cut off runoff and decrease holding capacity of tidal current. This may cause serious upstream and downstream silting of the weirs and blocking of navigation channels. The medium- and small-size ports may finally lose their original function or even become abandoned. The city of Ningbo had been accessible via the Yongjiang River at high tide for ten-thousand-tonnage ships. However, since a sluice gate was built on the Yaojiang River upstream, the navigation channel became silted to such an extent that even an eight-thousand-tonnage ship had to wait for the tide to sail in. The deposition of mud and silts in the Yongjiang River has thus been accelerated and has to be dredged at times. Similarly, silting is also a very common problem on flats along the shore in Jiangsu Province where now a few sluice gates and dams are built at several locations there. Various harmful effects have been brought about by the above-mentioned inappropriate engineering projects.

3. As the coastal zone of China lies along the seismic belt of the circum-Pacific region, earthquakes of high frequency is also a factor that affects the development of the coastal areas. In 1975, the Haicheng earthquake of magnitude 7.3 on Richter scale in Liaoning Province destroyed a great number of buildings and structures and caused liquifaction of sand and soil over an extensive area. In 1976, the violent earthquake of magnitude 7.8 on Richter scale at Tangshan, with intensity at the epicenter up to 11°, caused sudden destruction of houses and death of several hundred thousand people. Over an area of several ten thousand square kilometers, many engineering structures collapsed because of the failure of solid foundations under the conditions of soil liquifaction, resulting in water gushing and sand oozing from underground. Apart from earthquakes, the muddy soft ground spreading widely over the coastal zone and the weathered red clay extensively distributed in the hilly terrains along the southeast coast of China, provide unfavourable engineering geological conditions for civil angineering construction. It is obvious that

geological processes, earthquakes and other possible geological hazards will be very harmful to engineering construction in the coastal zone.

4. China is one of the countries subjected to calamities caused by frequent occurrences of typhoons, which bring a great loss of life and property every year. The windstorm and tide at the Lianyun port where the Yellow River runs into the sea, killed 10,000 people in 1973, and at the Xingang port of Tianjin caused an economic loss about 100,000,000 yuan in 1985. Moreover, the tidal erosion may very often lead to the retreat of the coast line. Lianyun port is such an example. In 1979, people reclaimed land from the flats along the shore about 100,000 mu, but in 1980, the embankment was broken through by tidal waves and the seashore retreated 800 m, resulting in an extensive area of fertile farmland being destroyed. The global sea level fluctuations may also be attributed to oceanic calamities along the coastal zone. Therefore, the rapid development in coastal areas is under a greater challenge day by day due to the above average frequency of natural calamities.

3. Prospects for the Development of the Coastal Zone

1. Overall planning and a scheme for rational development

Since the development of the natural resources of the flats along the coastal zone of China require careful scientific planning by a multi-disciplinary group of researchers, a unified plan for such a development scheme should be drawn-up taking into account the economic development of the country. This plan should take into consideration ecological and environmental problems caused by development. For some important economic zone in this coastal belt the plan should be studied intensely by scientists of related disciplines before working out a unified implementation scheme. This is because, for example, in respect of the development of mineral resources, there are many cases of irresponsible and wanton digging of quartz sand and quarrying of building materials from the flats along the beach. These willful activities have led to changes of shore erosion and inbalance in sedimentation. The quarrying of building materials or mining of mineral deposits have even destroyed the local natural features originally favourable for the tourist industry. If an appropriate unified plan is not implemented the consequences would be serious and damaging to the human habitat.

2. Rational development and scientific management of groundwater resources.

It is important to take surface water and groundwater as an integrated system, so as to develop the two in a comprehensive way and thus make full use of water resources. It is also important to pay more attention to the monitoring and prediction of land subsidence so as to prevent further intrusion of seawater and alleviate the pressing situation of water insufficiency, and simultaneously reduce the loss caused by land subsidence. The reason for doing so is that deep fresh water-bearing systems, such as aquifers occurring in the Huang-Huai-Hai Plain and in the Yellow River and Yangtze River deltas, are practically not readily renewable once they are deteriorated.

3. Environmental geological studies on tidal flats

Tidal flats should be fully cultivated with crops in a planned way suited to local climate and soil for the benefit of improving living standards of the people in nearby areas. For some of the flats, priority should be given to fisheries and aquaculture. Regarding the establishment of centres for petroleum exploitation in the flat zone, restrictions should be placed towards heavy petrochemical industries which require high consumption of water and energy and cause serious contamination of the environment. The existing industries with serious problems of waste disposal should be gradually removed from coastal areas for the protection and amelioration of coastal ecology and the environment. In the mean time, seismologic observation should not be neglected, so as to reduce losses caused by earthquakes.

China is a developing country with a relatively low economic prosperity and for the long-time benefit of the country, various natural resources in the coastal zone should be developed and put to good use in a planned and a rational way under the unified leadership of the Government.

4. Acknowledgements

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LOWLAND DEVELOPMENT IN INDONESIA: EXPERIENCE, STRATEGY AND OPTIONS

by
Directorate of Swamps[1]

1. Lowland Resources

To ease the pressure on land in Java, Bali and Madura, and to meet the food requirements for its population, the Government of Indonesia opted in the 1960's for development of its vast lowland resources.

Gross area

The land area of the Indonesian archipelag has some 39,500,000 ha and about 17 per cent of total land area consist of inland and coastal swamplands, composed of young alluvial marine, riverine and peat deposits.

Suitable areas

A nationwide inventory of coastal and near coastal swampland in three main islands Sumatera, Kalimantan and Irian Jaya showed that from about 24,000,000 ha surveyed area 5,600,000 ha is suitable for food crops and agriculture development. (Euroconsult/BIEC, 1984) out of these suitable areas, 2,800,000 ha are located in Irian Jaya and the remaining distributed equally in Bumatera and Kalimantan.

Developed areas

From the above mentioned inventory it is also indicated that about 3,300,000 ha of the resources have been developed.

By 1988 about 850,000,000 ha has been recorded as reclaimed under Central Government Programme and 450,000 ha under Local Government Programme, and Non Government Programme. Such reclamation has been mainly directed to food crop production. The remaining 2,000,000 ha were developed by various agents for other purposes.

Remaining areas

The remaining area of 30,600,000 ha was temporarely classified as unsuitable for agricultural development and included forests for conservation, production forests, and protected mangrove areas along the coast line.

It is expected that during REPELITA V (Fifth Five year Development Plan) emphasis will be laid on the Second Stage Development of already developed areas, rather than on the reclamation of new areas.

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2. Development Strategy

Having considered several factors such as unstable soil conditions limited budget to cope with the target, the Government in developing the lowlands areas has opted to embark on a development strategy which will be implemented in stages.

First stage of development

The objectives of the first stage development are:

- To increase national food production, to achieve self sufficiency in rice.
- To promote regional development in outer Java island.
- To create employment.
- To utilize optimally the available resources.
- To develop Human Settlements.

In the first stage of development, the investment was mainly technical in nature, consisting of essential infrastructures and services to facilitate rainfed agriculture development and provision of about 2,5 Ha land for each farmer of which only 1,5 Ha was cleared.

Infrastructures identified are the uncontrolled drainage system, flood protection, simple houses, farm roads and bridges, and public facilities such as markets, schools, health centres, mosques, churchs etc.

During the first stage it was assumed that the farmers could obtain a subsistence income level and would generate sufficient additional income to further develop their farms. Optimal utilization of the production factors under this concept would end the period of this stage and the Government envisages a subsequent stage with an additional capital input to eliminate constraints for further development namely: 'Second Stage of Development'.

3. Constraints to First Stage of Development

A combination of technical and institutional constraints affected the lowland development and consequently led to lower farm incomes than originally anticipated.

Technical constraints

a. Soil management
   - Shallow potential acid sulphate clay (Low Ph's)
   - Soil Toxicity (Fe, Al, etc.)

- Deep peat
- Unconsolidated soils
- Soil fertility (locally)

b. Water Management

- Water-retention (porous soil)
- Over drainage (uncontrolled system)
- Salt intrusion (coastal areas)
- Decreasing drainage base

c. Crop Protection

- Rodent (contact with uncleared land)
- Pigs (contact with forest)
- Weed control
- Plant disease (Min. Extension Services)

Institutional aspects

a. Project Coordination

Swamp development up to now is a multi-agency activity coordinated at project, provincial and central level. Synchronisation of its activities is the main factor to the success of the project. Some decrees, regulation and procedures have been established for coordinating activities, but until now modification and improvement are still required.

b. Support Services

Support services amongst others are:

- Agricultural Inputs/Extension/Research
- Farmers Association/Cooperatives/Credit
- Health care (including drinking water)
- Marketing
- Security
- Monitoring and Evaluation

Most of those services were provided, but improvement of the system is still deemed necessary.

4. Second Stage of Development: Swamps

The objectives of the second stage of development in REPELITA V are:

- To increase farmers income.
- To maintain food self sufficiency.
- To stimulate equitable regional development.

The improvement of living standards of the population is a national committment in REPELITA V. In the existing swamp schemes many of the settlers come from the poorest areas and groups of Indonesia. Although they are frequently better off in the new schemes, poverty remains a major problem.

During REPELITA V food production should be able to cope with increasing population of about 2.2 per cent annually in order to maintain national food self sufficiency. Some study and figures have shown that the above rate is the limit which can be achieved through intensification programmes within the existing schemes. Some swamp schemes have comparative advantages in rice production.

Regional development should promote equity and unity in terms of politics, economics, socio-culture, and defence. The rural community should be encouraged to develop its human resources and be self reliant.

To achieve the above objectives the following activities will be undertaken under this second stage of development.

Improved drainage control facilities and accessibility

Reliable water management and efficient transportation of production are the key factors for the successfull development. In swamp areas both factors are specific characters. Soil and water conditions especially tidal effect and salt intrusion require an adequate control facilities. As the project sites are located in swamp areas transport will be by boats that require navigation channels operate for 24 hours of the day.

Crop diversification

Rice will only be promoted in the area and crop, diversification for the other areas will be implemented.

On a wider scale, diversification will not be limited in cropping systems, but will be excluded in food crops, estate crops, livestock, fisheries, services etc. which will be under sectoral development.

Agro-industries development

Compared with the upland area, transport costs in swamp areas are relatively expensive, and time consuming. Having this in mind, the potential for agro-industrial development in swamp areas will be considered.

Export oriented production

To date export oriented commodities in swamp lands have been neglected. However, given the potential of swamp areas for crops other than rice the promotion of export oriented crops is proposed. This will give a better opportunity for increasing incomes of farmers as well as other nationals.

Health and social services

Health and social services will receive special attention in swamps under the second stage development. These will include better health-care facilities, potable water, and development of a cohesive community.

Institutional improvement

To implement the second stage of development, institutional arrangements will be an important aspect of the

project, Therefore special arrangements involving all related agencies are urgently needed.

Extension services

One of the major problems faced by farmers in swamp areas is the new environmental conditions compared with the areas from where they come. To overcome this problem, the extension worker should be provided with adequate knowledge about the farming techniques and better incentives.

Sustainable environment

It is recognised that the first stage of development would have changed the environment to some extent and objectives of maintenance of the existing environment under the 2nd stage will be one of the main issues.

The environmental impacts resulting from development options will be considered and evaluated in terms of sustainability, benefit to nation and local community under this stage.

5. International Cooperation

A consensus has gradually evolved that the development of the tidal lowlands will be of importance to the future of Indonesia. From a global perspective, there is no doubt that South-East Asian countries, headed by Thailand and Malaysia, and followed by Indonesia and the Philippines will increasingly develop agro-industries that will contribute to economic advancement.

In order to keep a competitive edge, increases in productivity and production are essential. Opening up high potential land, like the tidal lowlands is an option that few countries outside Indonesia can claim to have. Also in Indonesia other initiatives would lead to development of increasingly marginal upland areas, where initial development costs may be relatively low but where sustainable and economically irrigable agricultural production would come at high costs due to the inherently lower fertility of the soil. From a global perspective it would then be of importance to develop the tidal lowlands.

Looking at it from the national perspective would lead to a similar conclusion. The agro-industry which is projected to contribute to an increase in a GDP growth rate of five per cent and more but will be insufficient to absorb the 2 million and more people a year who will join the labour force. Therefore agriculture will also have to absorb considerable numbers. If overpopulation in Java is also taken into account, it can be concluded that agricultural production in the tidal lowlands would help in offsetting the problems of such activity in areas that are said to contain infertile soil.

International assistance to support Indonesia in this task is critically important. Since 1976, the International Bank of Reconstruction and Development (IBRD) has assisted the Government of Indonesia in their lowland development programme. The IBRD initially provided funds for carrying out feasibility studies for planning and design and from 1981 through the Swamp Reclamation Project I, has assisted in implementation of a 9,000 ha scheme in Karang Agung, South Sumatera. The BRD also funded the Karang Agung II project which is comprised of 30,000 ha of lowland development.

In addition, the IBRD is assisting the Government in a number of supporting activities to lowland development such as agricultural research, establishment of monitoring and evaluation systems to support the management information on project performance, institutional strengthening and training of operation and maintenance staff including the introduction of an efficient O&M.

Also the Asian Development Bank has shown an interest in lowland development by financing the Telang Saleh feasibility study with co-financing from the Government of the Netherlands.

Moreover, the Dutch Government sponsors an acid clay research project in South Kalimantan.

The Government of Indonesia is interested in continuing international cooperation in the field of lowland development, in particular in the future stages of development of lowlands.

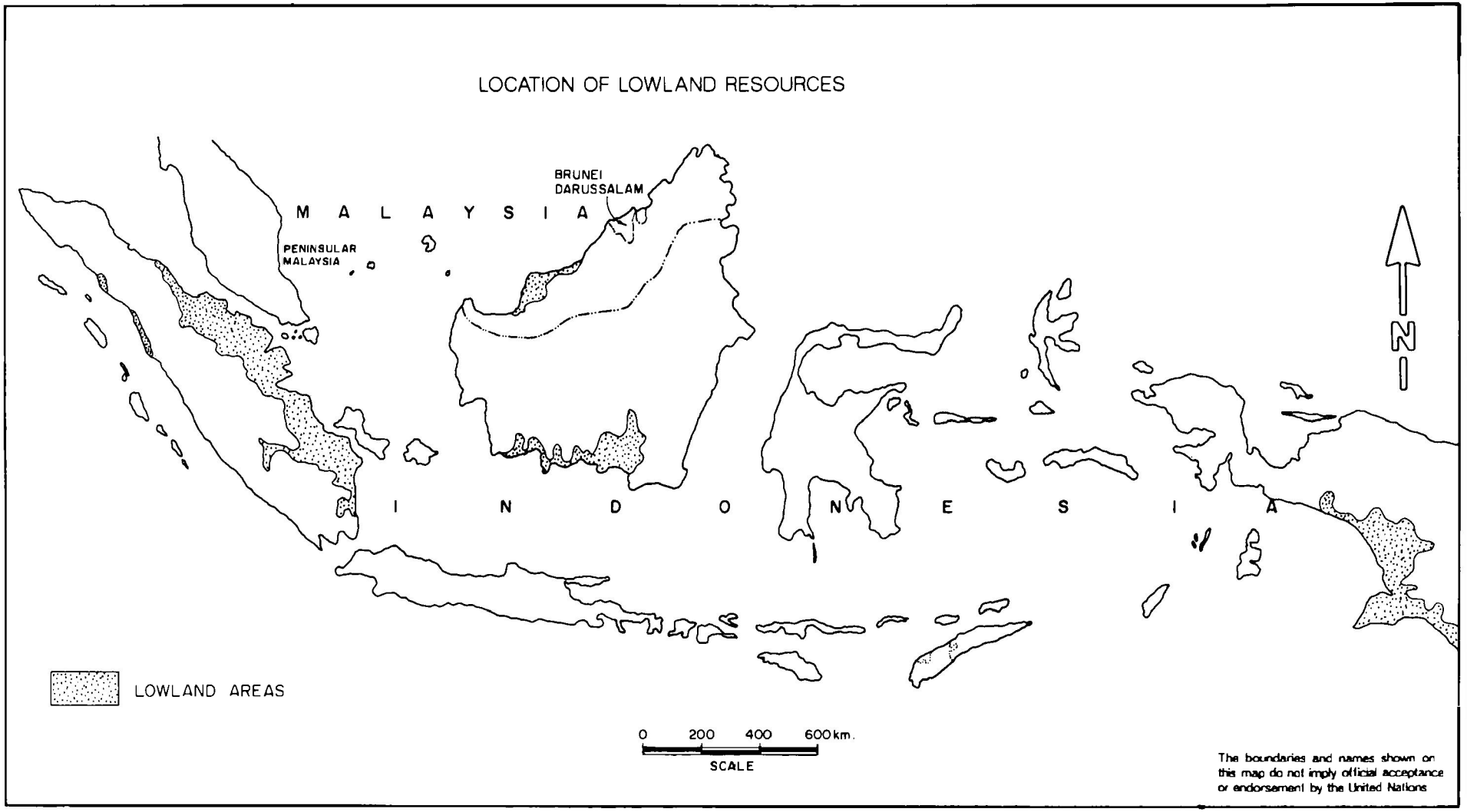
Presently, the Government in cooperation with IBRD, ADB and the Dutch Government are preparing extensive Second Stage Development programmes for swamps.

6. Programme for REPELITA V.

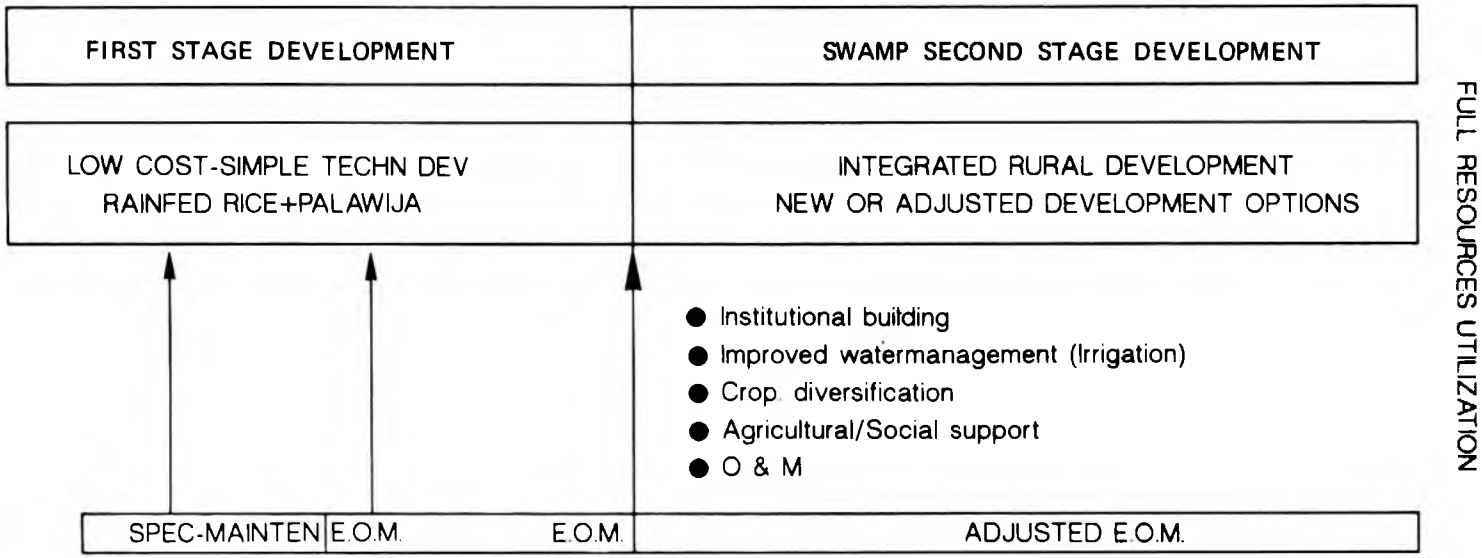
The overall Government objective for REPELITA V is among others, for continued economic growth with an equitable distribution of opportunity and benefits occuring to all the people of Indonesia. For agriculture and water resources sector, these have been formulated as to place priority on stabilising food self sufficiency, improving utilization, maintenance and rehabilitation of existing water resources infrastructure, and to reduce priority to reclaim new areas.

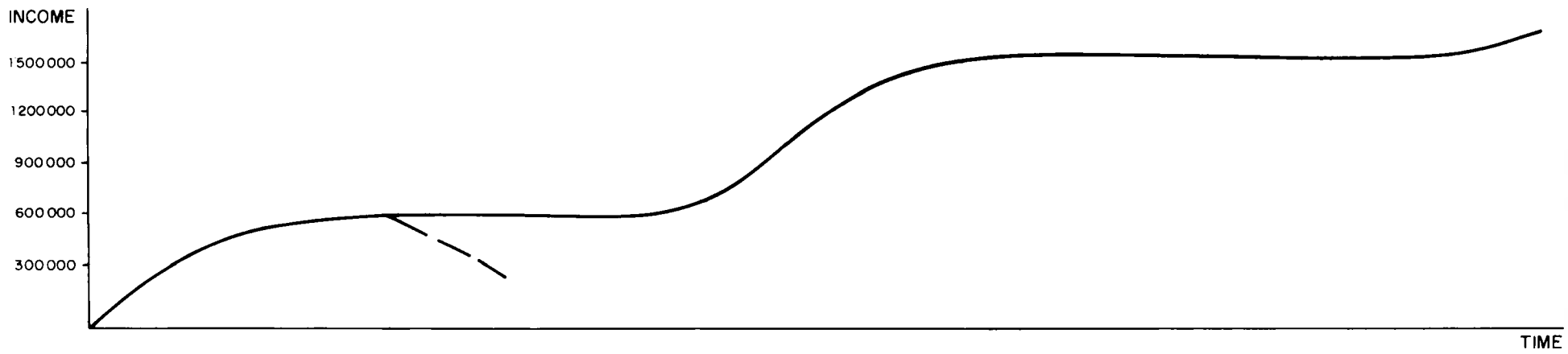
The above objectives have been translated to a lowlands development programme in the 'fifth five year development plan' (REPELITA V) and are as follows:

1. To efficiently operate and maintain the recently rehabilited or upgraded development schemes.
2. To improve the existing schemes used for agricultural purposes through second stage programme, of flood protection, navigation facility etc., covering areas of about 440,000 Ha.
3. To improve present lowland areas used traditionally for aquaculture purposes through rehabilitation and upgrading of the existing water supply to allow for shrimp cultivation, covering areas of about 60,000 Ha.
4. To develop the new fish ponds for shrimp culture, covering the areas of about 10,000 Ha.

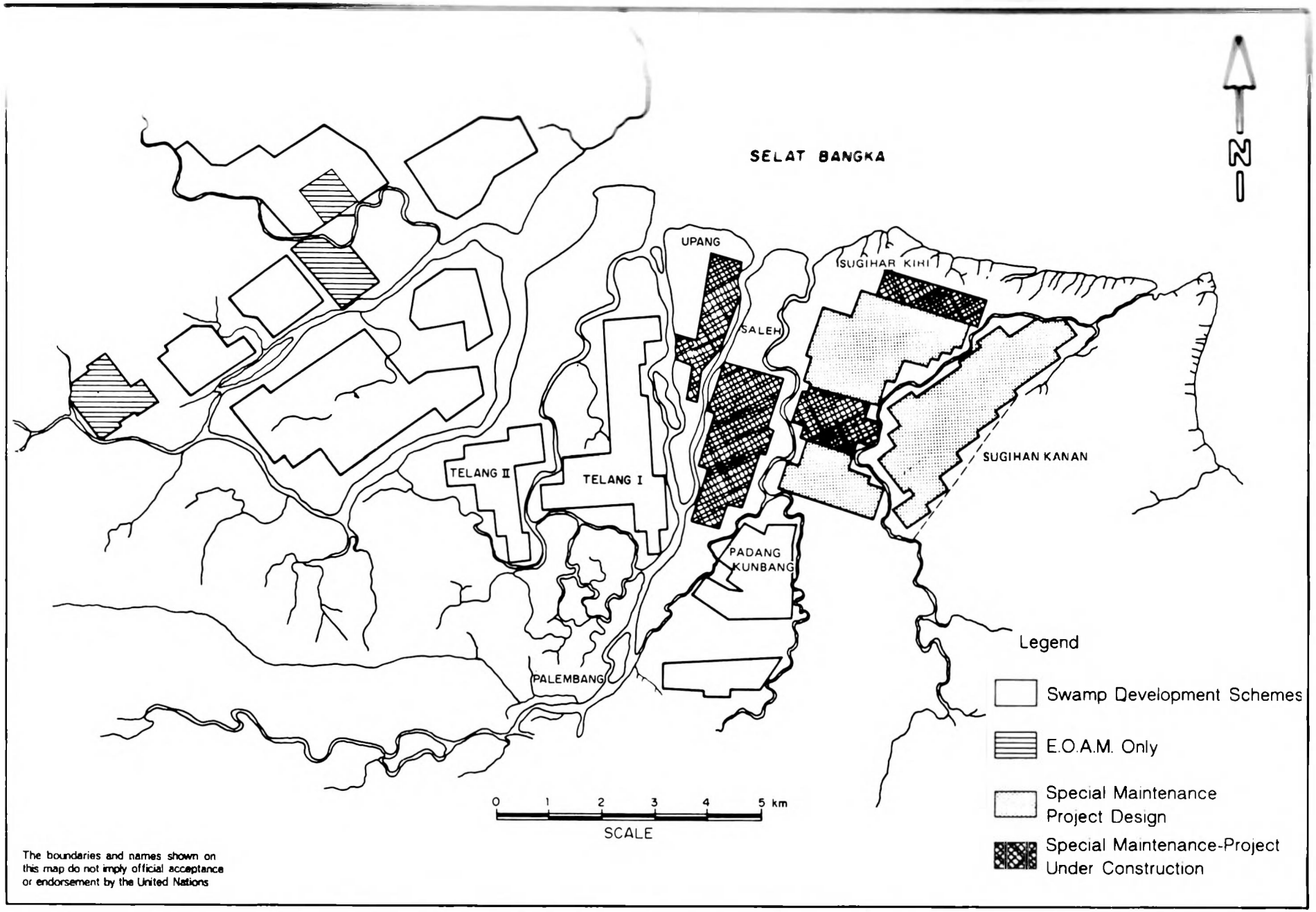


1. Location of lowland resources in Indonesia

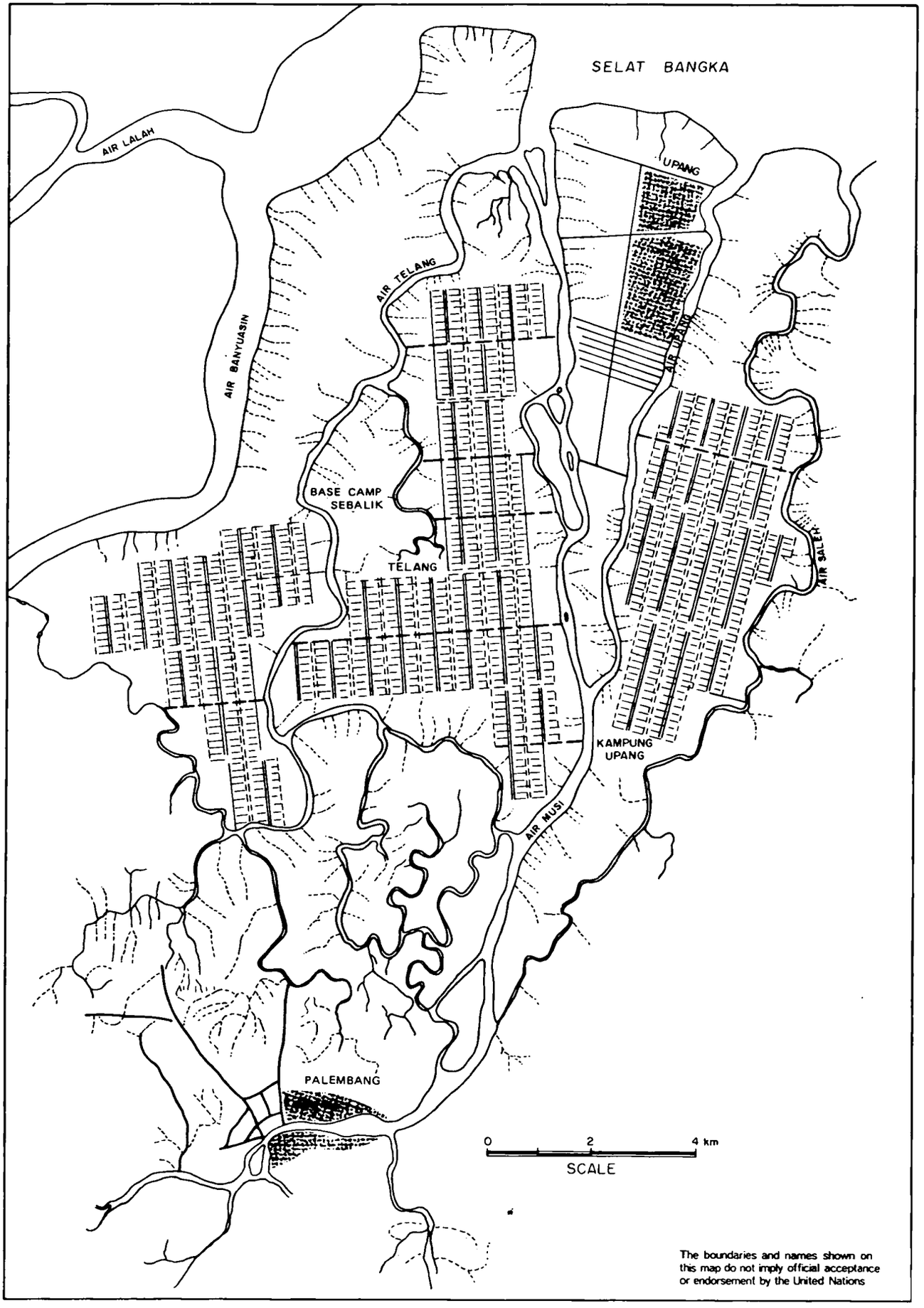




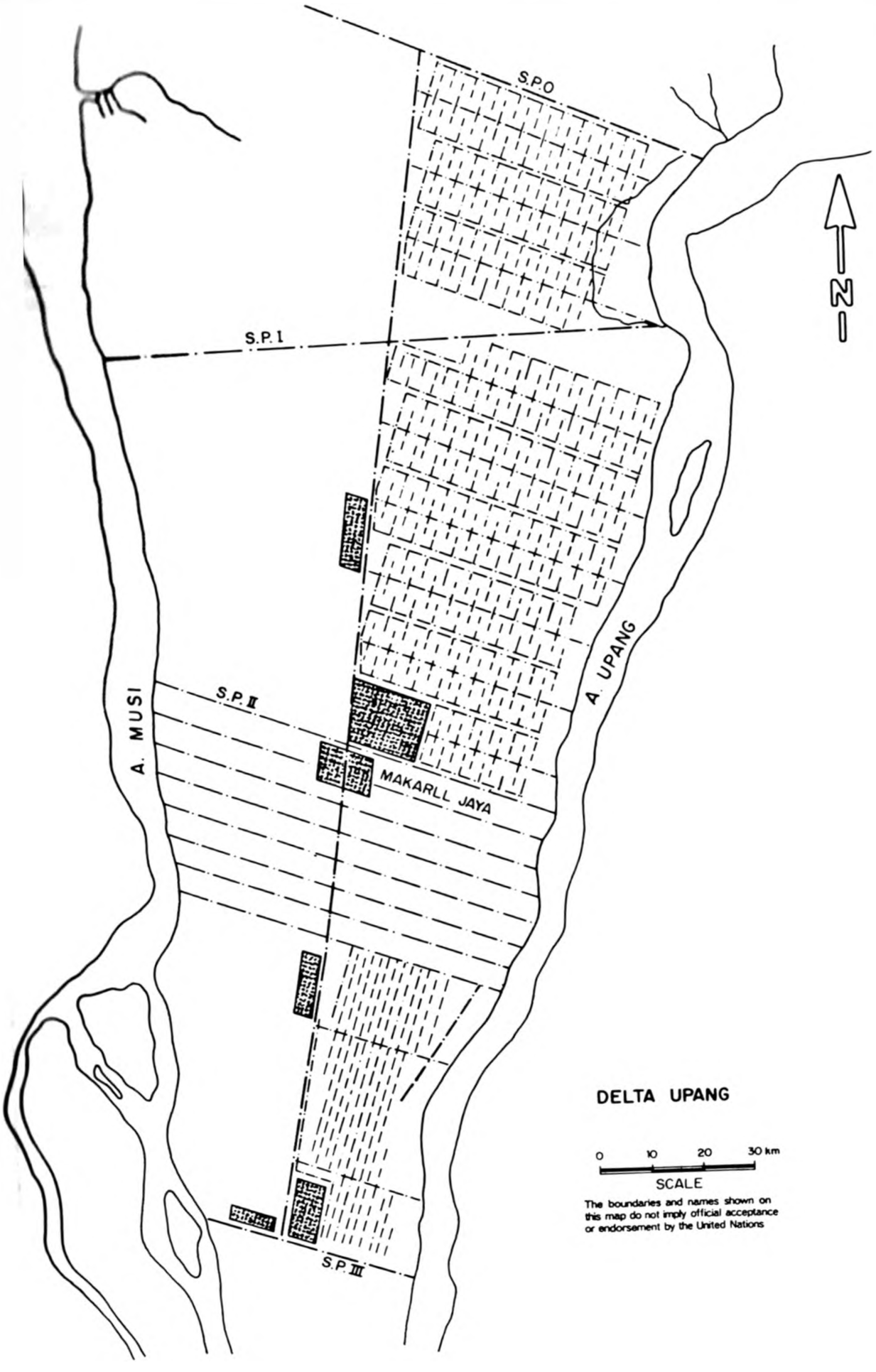
2. Sequence of events in staged swamp development



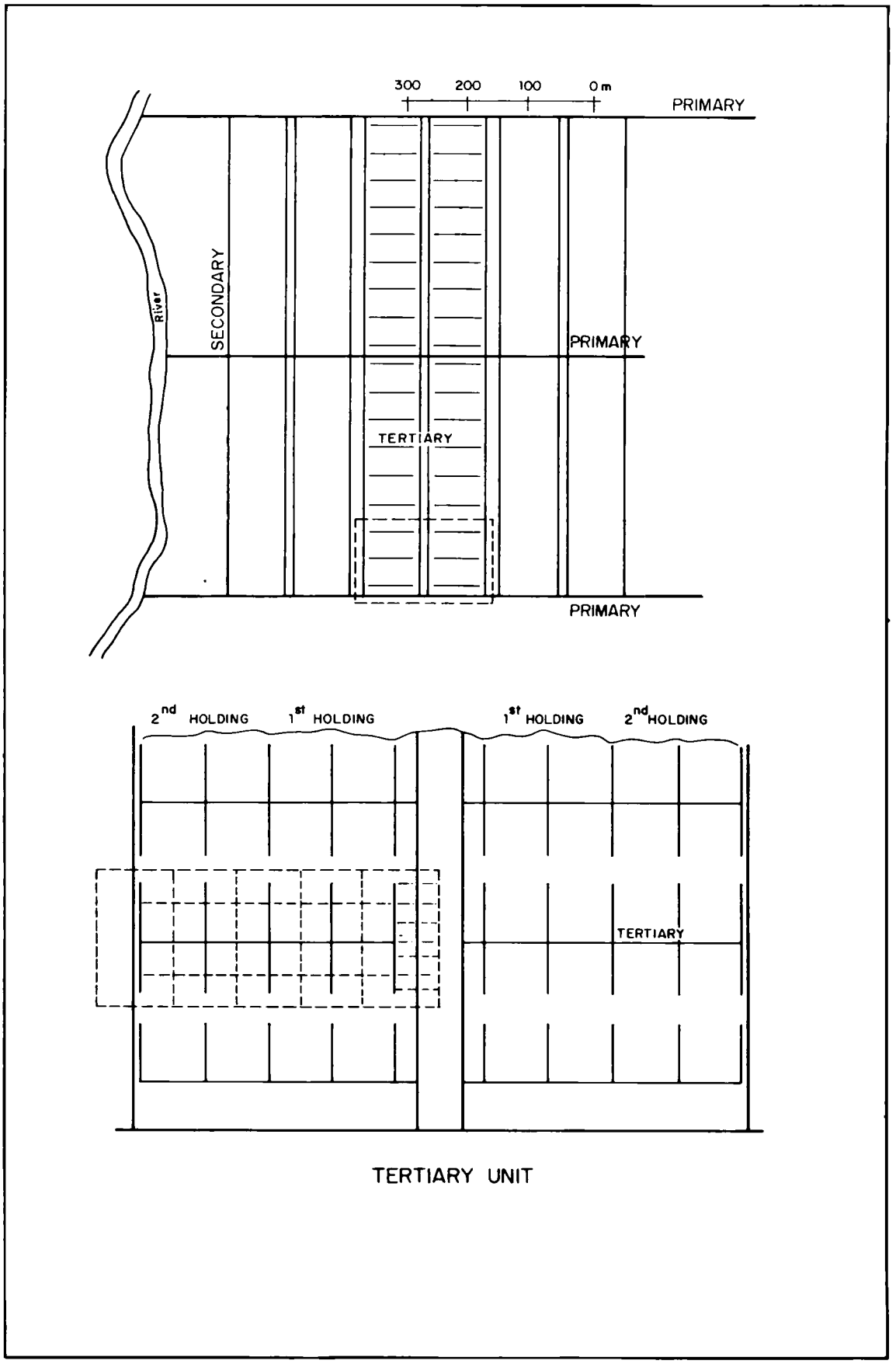
3. South Sumatera project areas



4. General layout of Telang I, II, Saleh and Upang.



5. General layout of Delta Upang



6. General layout of South Sumatera: Telang-Saleh-Sugihan

Table I. Developed Swamps in Indonesia

No.	Province	Central Government Programme			Local Government and non government			Total		
		PS (Ha)	Non PS (Ha)	Total (Ha)	PS (Ha)	Non PS (Ha)	Total (Ha)	PS (Ha)	Non PS (Ha)	Total (Ha)
1	2	3	4	5 = 3+4	6	7	8 = 6 + 7	9 = 3 + 4	10 = 4+7	11 = 5+8
	SUMATERA									
1	Aceh	0	4,600	4,600	0	0	0	0	4,600	4,600
2	Nort Sumatera	0	8,512	8,512	0	64,753	64,753	0	73,265	73,265
3	West Sumatera	0	15,656	15,656	0	4,481	4,481	0	20,137	20,137
4	Riau	92,704	4,216	96,920	59,460	6,198	65,658	152,164	10,414	162,578
5	Jambi	64,907	3,556	68,463	8,778	9,495	18,273	73,685	13,051	86,736
6	South Sumatera	352,671	14,650	367,321	6,577	97,552	104,129	359,248	112,202	471,450
7	Bengkulu	0	9,620	9,620	0	0	0	0	9,620	9,620
8	Lampung	0	27,550	27,550	0	0	0	0	27,550	27,550
	SUB TOTAL	510,282	88,360	598,642	74,815	182,479	257,294	585,097	270,839	855,936
	KALIMANTAN									
9	West Kalimantan.	80,963	16,498	97,461	12,740	19,048	31,788	93,703	35,546	129,249
10	Central Kalimantan	64,948	9,974	74,922	2,979	26,122	29,101	67,927	36,096	104,023
11	South Kalimantan	42,788	27,030	69,818	15,536	86,867	102,403	58,324	113,897	172,221
12	East Kalimantan	0	6,284	6,284	0	360	360	0	6,644	6,644
	SUB TOTAL	188,699	59,786	248,485	31,255	132,397	163,652	219,954	192,183	412,137
13	IRIAN	0	450	450	0	5,550	5,550	0	6,000	6,000
14	GULAWEBI	0	2,000	2,000	0	0	0	0	2,000	2,000
	TOTAL	698,901	150,596	849,577	106,070	320,426	426,496	805,051	471,022	1,276,073

PS : Tidal Swamps
Non PS : Non Tidal Swamps

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Annex

INFORMATION ON DELTA UPANG AND TELANG

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Information on the Development of Delta Upang and Telang

1. General

The Province of South Sumatra comprises vast low land areas north of Palembang. Over 300,000 ha of mostly tidal lands have been developed over the last 20 years (see Figure 2).

Based on expected high potential for agriculture, specially for rice production, development of the downstream sections of the larger alluvial plains has been a major activity since the late sixties. Table I shows the achievements of the First Phase (1969 – present).

Table I. First Phase Results in Lowland Reclamation Schemes in South Sumatra

Scheme	*Gross Size (ha)*	*Construction period*	*Number settled farmers families*
D. Upang	8,423	1969/76	2,138
Cintamanis	6,084	69/76	1,749
D. Telang I	26,680	1975/78	5,129
D. Telang II	13,800	76/78	3,772
D. Saleh	19,090	77/79	4,936
Sugihan Kiri	50,470	1978/83	13,013
Sugihan Kanan	31,140	79/83	8,835
Pulau Rimau	40,263	80/82	7,938
K Agung Hilir	20,317	81/82	2,960
Padang Sugihan	51,080	82/83	–
Padang Kumbang	14,226	83/85	–
K Agung I	9,000	1982/86	2,900
K Agung II	30,000	85/–	1,350
Total	320,573		54,720

The Telang and Upang areas which are located in the lower Musi basin between the Banyu Asin river and the Musi/Upang river are two of the Government sponsored lowland schemes (see Figure 3). On the fringes of these deltas human settlement dates back more than a hundred years. But only in 1969 was large scale development also of the central parts of the deltas initiated sponsored by the Government. This large scale development purposely avoided the areas with indigenous or spontaneous settlements and left their reclamation works untouched.

The morphologic landscape of the deltas is determined by a slightly higher ridge alongside the rivers traversed by several natural creeks. The centre part is generally a few decimeters lower causing long lasting inundation by stagnant rain water. In the central parts, soils are more clayey and have a higher organic matter content Sometimes peat domes have formed under a dense swamp vegetation. In part of the delta area under a topsoil of 25 to 75 cm acid sulfate soil is found.

The climate of the project area is classified as a tropical, rainy climate, with an average annual rainfall of about 2200 mm and temperatures averaging 27°C.

The deltas are situated in the tidal zone. Daily fluctuations of the water level in the rivers surrounding the deltas is in the range of 2 to 3.5 m. In the large navigation channels the tidal ranges are slightly less. Many of the navigation canals fall dry during low tide. In the rainy season average water levels may rise considerably and may be 0.5 m higher than during the dry season.

2. Agriculture and Current Land Use

The lay-out of the holdings comprise a home lot of 0,25 ha, a first holding of 1 ha developed by the project and a second holding of 1 ha which is supposed to be cleared by the settlers. The total holding amounts to 2.25 ha. The home lots and the first holdings are generally the most productive areas.

The annual cropping pattern consists mainly of a wetland rice crop in the wet season and a upland crop (palawtjn) usually grown on raised beds (sorjans) in the dry season.

Seeding of the wetland rice crop usually starts in October. The transplanting takes place in November – December. Harvest is from April to June for the local rice varieties and in March – April for high yielding varieties (HYV).

The upland crops are mainly corn, cassava, beans, peanuts and vegetables. During the rainy season these crops are successfully grown on bunds between rice fields, or on the sorjans. In better drained areas the crops can be sown directly on the fields. Several upland crops have a short growth sequence; often two or even three harvests may take place per year.

Yields are generally low. Present rice yields vary from 0.9 to 1.7 ton per harvest or even lower in poor areas. Yields of the upland crops are comparatively better. Areas planted with upland crops are generally small, not more than 0.3 ha/farm. Low production is mainly attributed to insufficiences in pest control, inadequate use of fertilizer inputs and labour shortages.

Apart from the above mentioned cropping patterns, also some tree cropping is practised. The main trees grown are coconuts, bananas, plantain, jackfruit and rambutan.

At present, almost no draft animals (kerbau, sapi) are in the schemes, owing to unripeness of the soils and hence low bearing capacity, but also because of shortage of buying capacity of farmers.

Preliminary surveys on farm income reveal large fluctuations with some alarming low levels. There appears to be a relation between income and physical conditions such as water management, elevation, soil type and marketing possibilities. Spontaneous settlers appear to obtain higher levels of income but this may be influenced by factors like earlier arrival and the possibility of selection of fertile lands.

3. Delta Upang

The Upang development scheme is located on the delta formed by the Musi and Upang rivers. On the northern side it borders the sea (Bangka strait). Delta Upang is the oldest scheme. Construction started in 1969 and it has served as a pilot project for swamp development. Three different layouts are applied in Delta Upang. The concepts orginated from the Institute of Technology in Bandung (see Figure 4).

Four primary channels intersect the Delta Upang island, running from the Musi to the Upang rivers. A centre channel connects the primary channels. This system of large channels serves as the main drains. They also have an important transportation function.

The cultivated area in Delta Upang is about 15,000 ha. From this, only 8,400 ha belong to the Government sponsored scheme. The remaining area is occupied by spontaneous settlers, mostly Buginese and Javanese people.

The situation in the Upang Delta is special because a spontaneously developed area is bordering a government sponsored area. An upgrading study in 1984 by Euroconsult/IDC mentioned the negation effect of this closeness where differences in cropping calendars resulted in heavy rat plagues.

The major part of the farming families live in 5 villages situated along the centre channel. The total population is estimated at 3000 kk (families). Most of them have lived 15 years or longer in the area.

The Delta Upang project is divided into blocks which are separated by the primary channels. The two northern blocks have tertiary drainage channels of 500 m long and 200 m apart serving farming blocks of 10 ha. Secondary drainage canals are connected via a collector drain with the centre channel or with the Musi River. The tertiary canals are 550 m long and 250 m apart, serving 14 ha each. Finally in the most southern block tertiary canals are 1,500 m long and 300 m apart, each serving 45 ha. Secondary canals discharge directly in the Upang river or via a collector into the contre channel.

At present a Special Maintenance Programme is underway in which the layouts are all changed from an open system to a closed system with flapgate structures on the secondary drains and protection dikes along the river banks, to improve water management.

A programme for efficient operation and maintenance was initiated last year (1988). However, it is not yet functioning properly, awaiting the accomplishment of the above mentioned Special Maintenance Programme.

4. The Telang I Scheme

The Telang I scheme is situated on one of the major central deltaic islands of the Musi Delta, situated just to the west of the main branch of the Musi River. On the fringes of this island, especially in the north-western corner, the first settlement dates back to the nineteenth century. In 1975 the Indonesian Government started opening large parts of the centre of this island. The government sponsored scheme comprises 27,000 ha.

The morphologic landscape on the Telang I deltaic island is characterised by a small ridge parallel in the eastern part at a short distance of, and parallel to the Musi River and, to its west, a relatively large area with a descending elevation, traversed by some natural creeks. The elevation of this ridge is just several decimeters above the wet season high water levels and the lower parts.

Due to a very low accessibility before opening, drainage of excess rainwater was limited in the wet season, causing long lasting temporary inundation of the centre-area. In the lower parts flooding was more pronouced. Soils on the ridge are predominantly silty with a low fertility and organic matter content while soils in the lower parts are more clayey higher in fertility and organic matter content.

In the early part of this century, a small community established itself at the mouth of the Telang creek, in and around the present village of *Muara Telang*. This communilty is a mixture of indigenous Malayu and sopontaneously settled Buginese. Main sources of income were logging and aquaculture while an extensive rice crop was grown in a limited part of the area entirely for local consumption. Other traces of settlement are obvious in the eastern part of the island, off the split of the Musi and Upang branches of the Musi River where a large local community had settled, at Kampung Upang. These people had opened some small areas for shifting cultivation and up to the present day claim large stretches of land here.

Review of Reclamation Activities

The present hydraulic infrastructure in Telang I scheme was constructed in the period 1975-1978. Settlement was implemented between 1977 and 1980.

The layout of the infrastructure is to be seen in Figure 5. The two basic elements are the navigation channels, interconnecting the tidal rivers Musi and Telang on both sides of the island, and the rectangular standard units with a size of 920 ha gross on both sides of the navigation channels. Measures for flood protection and/or water control (structures) were not included.

In total 29 of the 920 ha units were constructed, but several were not according to standard size. These units have a gross length of 4,000 m and a gross width of 2,300 m, and border a navigation channel. In the heart of these blocks a settlement and farm centre of 760 ha gross is situated accomodating 256 families. The fringes of the primary blocks are reserved for present and future infrastructure while for the time being they provide firewood for the settlers.

As a result of the environmental changes sparked off through the implementation of the first development round, average soil levels in the back-swamp central area have dropped in peak-level. Due to the lack of watercontrol measures and the extensiveness of the canal system shallow flooding is rampant in large parts of the lower areas in the western part in an above-average wet season (as 1986/87). Yet in the higher areas, in the eastern part of the island, the lack of water-retention measures results in extremely dry conditions in the dry season.

Cropping & Cropping Patterns

The farmers who originate from Java, concentrate their agricultural activities on a relatively diversified intercropping system. On their 0.25 ha home yards they have established a raised bed system (sorjan) with on the ridges predominantly tree culture; in the beds rice is grown, often year round. On their farmholdings they grow a rainfed rice culture. In a small percentage of the area a dry season supplementary tidal-irrigated rice crop is grown. Agricultural production in the northern part of the area is depressed by dry-season salt water intrusion.

In general, the level of intensification of thin riceculture depends prodominantly on the water management position of the area i.e. directly related to the distance to the navigation channels and the topographic elevation.

Another important factor is the marketing situation (a timely availability of reasonably priced agricultural inputs and a reasonably ensured market for outputs). Farmers close to the navigation channel are in this respect better off. Rat and pig infestations remain serious threats.

Farmers originating from Sumatera and Kalimantan, settled especially in the Northwesten part of Telang I. They comprise a large part of the farming population. They concentrate labour on areas with proper drainage possibilities and grow coconuts which are less rat susceptible. They grow a wet-season intensive rice crop on the lower areas. Sources of off-farm income (fishing) remain important.

RECLAMATION OF COASTAL LOWLANDS FOR AGRICULTURE ON THE WEST COAST OF PENINSULAR MALAYSIA

by
Ir. Neo Tong Lec[1]

1. Introduction

Geographically, Malaysia comprises two regions, Peninsular Malaysia and East Malaysia (namely, the state of Sabah and Sarawak on the northern part of the island of Borneo) separated by an expanse of water (South China Sea) with a distance of approximately 640 km. The country is situated between latitudes 1° and 7° north and longitudes 99° 35' and 119° east. (See Figure 1) and has total land area of 330,400 sq. kms.

Peninsular Malaysia lies between latitudes 1° 20' and 6° 40' north and longitudes 99° 35' and 104° 20'. Lengthwise, it runs in an approximately SSE direction being exposed on the east to the rough South China Sea and on the West it fringes the relatively calm Straits of Malacca. Geographically, it is dominated by a series of parallel mountain ranges running along its length and falling rather steeply towards the sea on the east and west. Consequently, highlands cover a major part of the country and out of its total area of 130,000 sq. km. more than half is over 150 meters above sea level.

The coastal lowlands along the west coast of Peninsular Malaysia measuring some 1,000 km in length and averaging about 30 km. in width have been formed by widespread sedimentation of alluvium brought down by the inland areas in recent times. The process of aggradation and gradual widening of the low lying coastal plains could be attributed to the relatively calm waters of the Straits of Malacca which create an ideal environment for the sediments to settle. This process is also being assisted by the presence of mangroves which proliferate along the west coast. The adventitious roots of the mangroves manage to trap a considerable amount of sediment which may otherwise be carried away by waves or tidal currents.

The soils along the west coast include mainly coastal marine clays and peat soil (See Figure 2). These coastal lowlands are generally inundated during high tides and need to be reclaimed and drained before any agricultural crops can be planted. The early settlers to the country came from the sea and settled along the river mouths and coastal lowlands. They discovered that these coastal lowlands could be made productive for agriculture when protected from tidal inundation. As such early rudimentary attempts at reclamation were made by constructing small bunds along the coast to exclude tidal intrusion and providing internal drainage through the bund by means of rudimentary tidal control gates. In time as the hinterland was being opened up for agriculture, these rudimentary bunds and gates caused frequent and intensive flooding of the lands behind it and were frequently breached thus destroying the cultivation.

2. Reclamation Strategy

Drainage Works

Around the turn of the century, agriculture development in Malaysia progressed rapidly with the cultivation of coconuts, rubber and oil palm on a commercial basis. There is a need therefore to rehabilitate and reclaim large areas of coastal lowlands for agriculture through properly planned drainage works designed to:

(i) protect against inundation by high tides

(ii) prevent saline intrusion

(iii) effectively drain the reclaimed lands, and

(iv) remove the heavy run-off from the large hinterland catchments.

The Government has, through one of its major engineering departments, namely the Drainage and Irrigation Department, embarked on the rehabilitation and reclamation of the coastal lowlands through the construction of various drainage schemes ever since the first scheme (Kapar Drainage Scheme in the State of Selangor) was constructed in the year 1910. To date, various drainage schemes totalling over 340,000 hectares have been developed for the cultivation of tree crops such as rubber, oil palm, cocoa, coconuts etc. On top of these areas, more than 300,000 hectares of the coastal lowlands have been reclaimed for the cultivation of paddy. The reclamation strategy adopted in the construction of the engineering works was to achieve maximum economy through the use of local materials and labour.

In general, the reclamation of coastal lowlands can be classified into two typical types, namely areas with narrow coastal strips and the other with comparatively wider lowlands. In the first case, coastal bunds are constructed running parallel to the coastline and tied up at the ends to local high grounds. Cross drains where necessary are constructed to divert heavy runoff from the hilly areas where it is discharged straight to the sea. The existing waterways are improved and new ones constructed if necessary to form the internal drains for the local drainage of the reclaimed lands where the water is being discharged through

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carefully located tidal control gates (sluices) (See Figure 3). On the other hand, in wide coastal lowlands, the drainage of the lands with ground elevation greater than H.W.O.S.T. are separated from the lower areas and discharged directly into the sea via a high level drain which is bunded on both banks. The lower areas are divided into distinct drainage compartments by cross-drains with bunds and the drainage of each compartment is diverted into the sea or main drains through its own tidal control gates which can then be much smaller in size. This arrangement also allows the compartments to be drained at different downstream water levels thereby taking greater advantage of the tides. Moreover, it avoids the excessive ponding of the low areas behind the coastal bunds. (See Figure 4).

Coastal Bunds.

Along the mangrove-fringed west coast, the coastal bunds are constructed from the local soft marine clays which are highly compressible in nature and are characterised by a low bulk density of between 1.3 to 1.6 gm/cu cm. with a liquid limit of up to 120 per cent. The undrained shear strength of the material displays low values varying from 0.6 to 12 kN/sq. m.

The coastal bunds are generally formed with a width of 3.3 m at the crest and a slope of 1 (vertical) in 3 (horizontal) using dragline excavators. A minimum free board of 0.6 metres above the highest high tide is provided. The reduced level at the top of the bund is normally at 3.0 metres above mean sea-level. The material for the bund construction is obtained from the borrowpit located inland from the bund with a berm-width of about 12 meters. The borrowpit serves as a drainage waterway and the berm acts as a maintenance path for future desilting of the borrow pit and topping up of the bund by excavators. (See Figure 5) The low shear strength of the material limits the height of the bund to about 2 metres and therefore the bund needs to be properly aligned and sited to avoid excessive low lying areas.

The normal departmental practice is to construct the coastal bund about 400 metres inland from the coastline along the mangrove-fringed areas. This will ensure that a buffer zone of untouched mangroves is maintained not only to protect the bund against erosion by the waves from the sea but also to preserve, to a certain extent, the natural habitat of the marine life and migratory birds which normally sojourn along the west coast of Peninsular Malaysia during their seasonal migration from the colder to warmer areas. For this latter reason alone, there are some mangrove swamps (such as those along the coastline of the state of Perak) which are gazetted as forest reserves and left undeveloped.

Creek Closures

The alignment of the coastal bund invariably requires it to be constructed across natural creeks which serve as drainage waterways for the low lying areas during low tides, and therefore need to be properly closed at these locations. At first, borrow areas are identified seaward of the creek closure site and dragline excavators are used to excavate and 'stock-pile' the spoil around the closure site. Rows of bakau piles are then driven across the creek, braced with areca nut palm wailings and lashed together with wire ropes. The closure operation itself is carried out during a neap tide cycle with a sufficient number of machines about 2 hours prior to the low tide and the spoil is dumped in between rows of piles previously driven in such a manner so as to ensure that the top of the filling is at all times maintained above the rising tide.

Tidal Gates

Tidal gates normally vary in size from 4 to 6-foot circular or square gated culverts to 12-foot single or multiple span open flumes equipped with guillotine-type aluminium gates, depending on the size of drainage areas required to be drained. Large tidal barrages (such as 7 bay – 45' x 20' gates with a shipping lock at Sg. Kedah) have also been constructed. As the outlet channels of tidal control gates do invariably silt up due to the reduction in the volume of the tidal prism and the insufficient upland water discharges during the dry season to flush out the outlets, it is good practice to locate the gate at an existing good outlet of a fairly large river. For this reason, it is desirable to have if possible, an indirect outlet to a large tidal estuary rather than a more direct outlet to the sea.

Tidal control gates are normally light weight construction (exerting contact pressures less than 300 lbs per square foot) as they are required to be built on the coastal clay having low bearing capacities. In spite of this, the construction is hydraulically stable as the uplift pressure developed is small due to the low permeability of the clayey soils. Heavier constructions are sited on friction-bearing bakau piles while for very heavy structures, it is necessary to use point bearing piles driven to set on a load-bearing underlying stratum.

3. Drainage and Irrigation Areas

The climate of Malaysia is characterised into two main monsoon periods, namely the North-East Monsoon (November to February) and the South-West Monsoon (May to August). While the North-East Monsoon brings with it heavy rainfall (along the whole length of the east coast of Peninsular Malaysia), the west coast, on the other hand is sheltered from its effects by the central mountain ranges. Moderately heavy rainfall occurs only at the beginning of this monsoonal period. The South-West Monsoon is comparatively milder and loses much of its moisture in orographic rainfall over the mountains of Sumatra. The major parts of the rainfall along the west coast occurs during the intermonsoonal periods where there is considerable convective activity and instability in the atmosphere, and intensive precipitation (up to 7.6 cm per hour) is experienced. The average annual rainfall is about 2,500 mm.

Drainage and irrigation schemes along the coastal lowlands are designed to remove the surface runoff and to protect the agricultural crops against flooding beyond their tolerable limits. The yield of certain tree crops such as rubber, cocoa and coffee is more susceptible to flooding and normally requires the water level to be brought down below its root zone within 72 hours. Oil palm, on the other hand, can withstand a higher water table for a longer duration with minor reduction in its yield. With rice crop in irrigated areas flooding of 72 hours duration may be acceptable except during certain periods of its growth. The coastal lowlands are normally designed to drain under gravity-flow during periods when the tide is low. As such the drainage channels are provided not only for conveyance but also to store the upland discharge during high tides. The coastal borrow pit inland of the bund serves mainly as a storage area.

While pumped drainage has been adopted for certain industrial areas, its use in agriculture development has not been considered justified (except under certain exceptional circumstances) owing to its high cost of operation and maintenance. Nevertheless, it is envisaged that as drainage areas become more developed in the future, pumped drainage may be required to play a supplementary role.

Irrigation areas can be classified into two main categories, namely, single cropping and double cropping areas. Irrigation areas were initially developed for cultivating a single crop of paddy during the wet period of the year through run-of-river irrigation schemes or controlled drainage schemes. The former diverts the run-of-river to supplement the rainfall while the latter holds back the rain falling within the area to inundate the paddy fields. With the passage of time, these irrigation areas were further improved, and double cropping made possible by exploiting the water resources in the hinterland. Major irrigation schemes for double cropping have since been developed either in the form of impounding schemes such as the Muda Irrigation Project (95,000 hectares) or by diversion of river flow from another catchment to augment the supply from the existing run-of-river schemes together with suitable supplementary pumped irrigation such as the North-West Selangor Irrigation Project (20,000 hectares) or a combination of both (as in the Kerian Irrigation Project-24,000 hectares).

4. Coastal Erosion

As stated earlier and shown in Figure 5, the coastal lowlands along the west coast have been reclaimed with the construction of a coastal bund located some 400 metres inland of the mangrove coastline. Since the early sixties, certain stretches of the mangrove buffer zone have vanished due to erosion thereby exposing the bund to direct wave attack. The wave overtopping and subsequent bund breach that occurred caused extensive damaged to the agricultural crops planted and various protection methods were carried out but with little success. These earlier attempts at bund protection using mainly local materials such as timber piles, tyre revetments, sand-bags and even rock filled gabions as revetments or groynes were constructed on an *ad hoc* basis in response to an emergency situation without proper understanding of the underlying problems. As erosion progressed these constructions collapsed and new retreat bunds had to be constructed further inland to protect the agricultural areas from saline inundation.

In the late seventies, a comprehensive study was undertaken to protect the coastal bund against erosion by using rock revetments on the seaward slope of the bund. This method known as rock-bund protection was implemented successfully in the Western Johore Agricultural Project and in the Muda Irrigation Project. In general, it has been found to function well although certain stretches have experienced minor settlement due to foundation failures and rectification works were subsequently instituted. Apart from this, another project for bund protection is presently being carried out by stabilising the eroding scarp seaward of the threatened bund by means of a revetment aligned approximately parallel to the bund. This escarpment protection allows the waves to break on it and any smaller secondary waves that pass over can be filtered off before they reach the bund by replanting mangroves in the space in between.

The National Coastal Erosion Study (EPU Malaysia, 1985) has identified 33 sections totalling 136.6 km along the entire length of the west coast which are subjected to critical erosion (defined as areas where the rates of erosion considered in conjunction with economic, agricultural, transportation, recreational and demographic values indicate that action to halt erosion may be justified) with some 177.8 km being identified as significant erosion areas. Works to arrest the erosion on some of these critical areas have been planned, designed and implemented.

5. Challenges Ahead

Since the sixties, rapid development has taken place on the reclaimed coastal lowlands. Industries have sprouted up in various industrial zones which have been planned and located within this area. Emphasis have been given by the Government to develop and intensify agriculture in this area through the implementation of Integrated Agricultural Development Projects (IADP) in order to increase agricultural production thereby raising the income of the farmers both from on-farm and off-farm activities. An integrated and co-ordinated approach to development has been adopted through the improvement of drainage and irrigation facilities, provision of credit facilities, high-yielding varieties and extension services as well as the promotion of organised group farming. The private sector has also contributed to the development of the land for the cultivation of rubber, oil palm, cocoa etc. on commercial basis.

Malaysia, at present has a population of 17.3 million and with an expected increase of 1 million in 3 years, it is anticipated that there may be a shortage of productive land in the future. It is timely that the Government has in

August this year announced a plan for a massive land reclamation scheme along the west coast of Peninsular Malaysia to reclaim some 3,200 square km of land from the Straits of Malacca.

This plan which is estimated to take 30 years to implement would surely provide a strong challenge to our local engineers in the years ahead in our attempt to turn the sea into useful and productive land.

6. Acknowledgement

The permission from the Director General, Drainage and Irrigation Department, Malaysia to publish this paper is gratefully acknowledged. Any opinion expressed are solely the writer's and do not necessarily reflect the views of the Department.

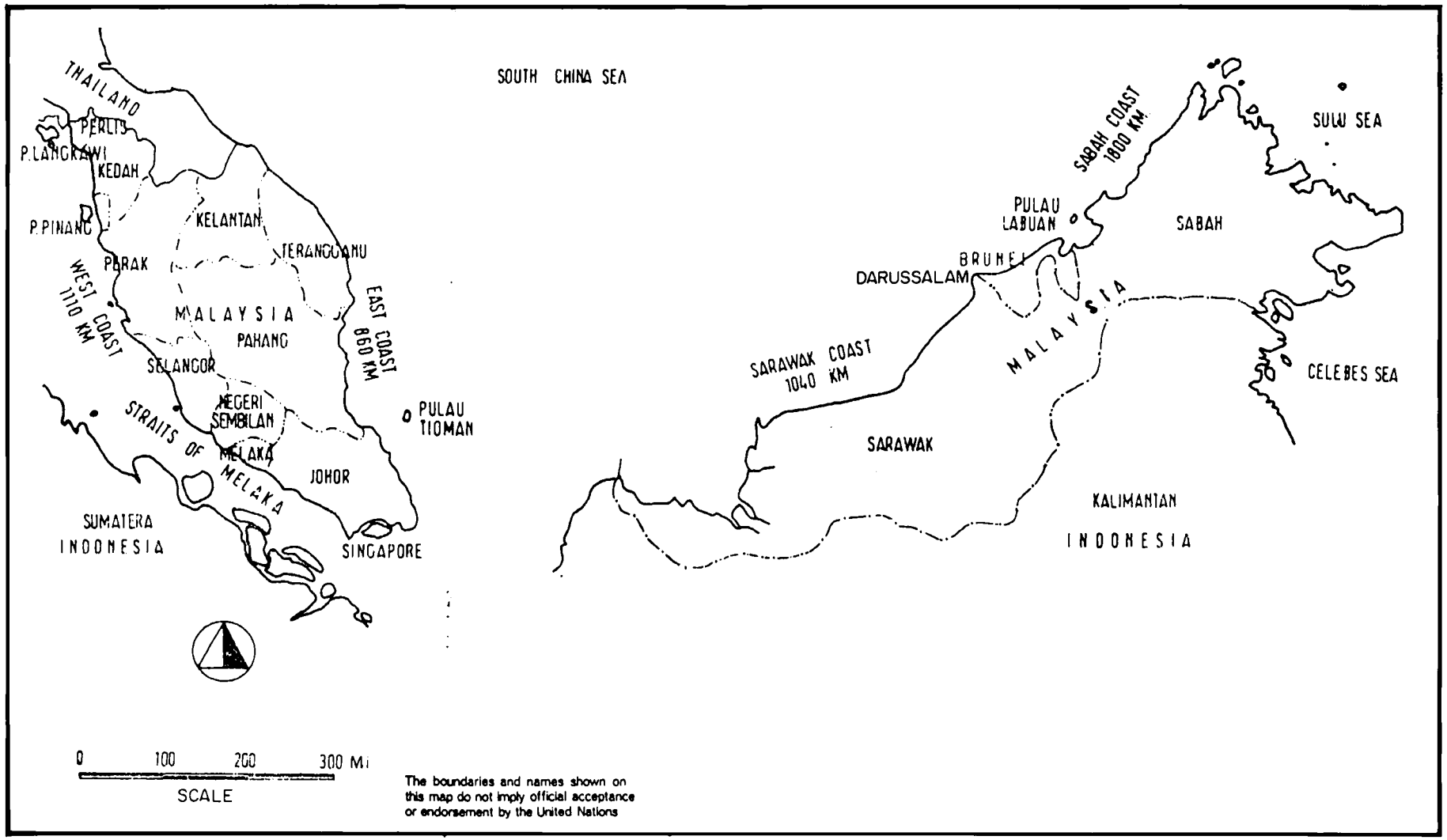

Figure 1. Map of Malaysia.

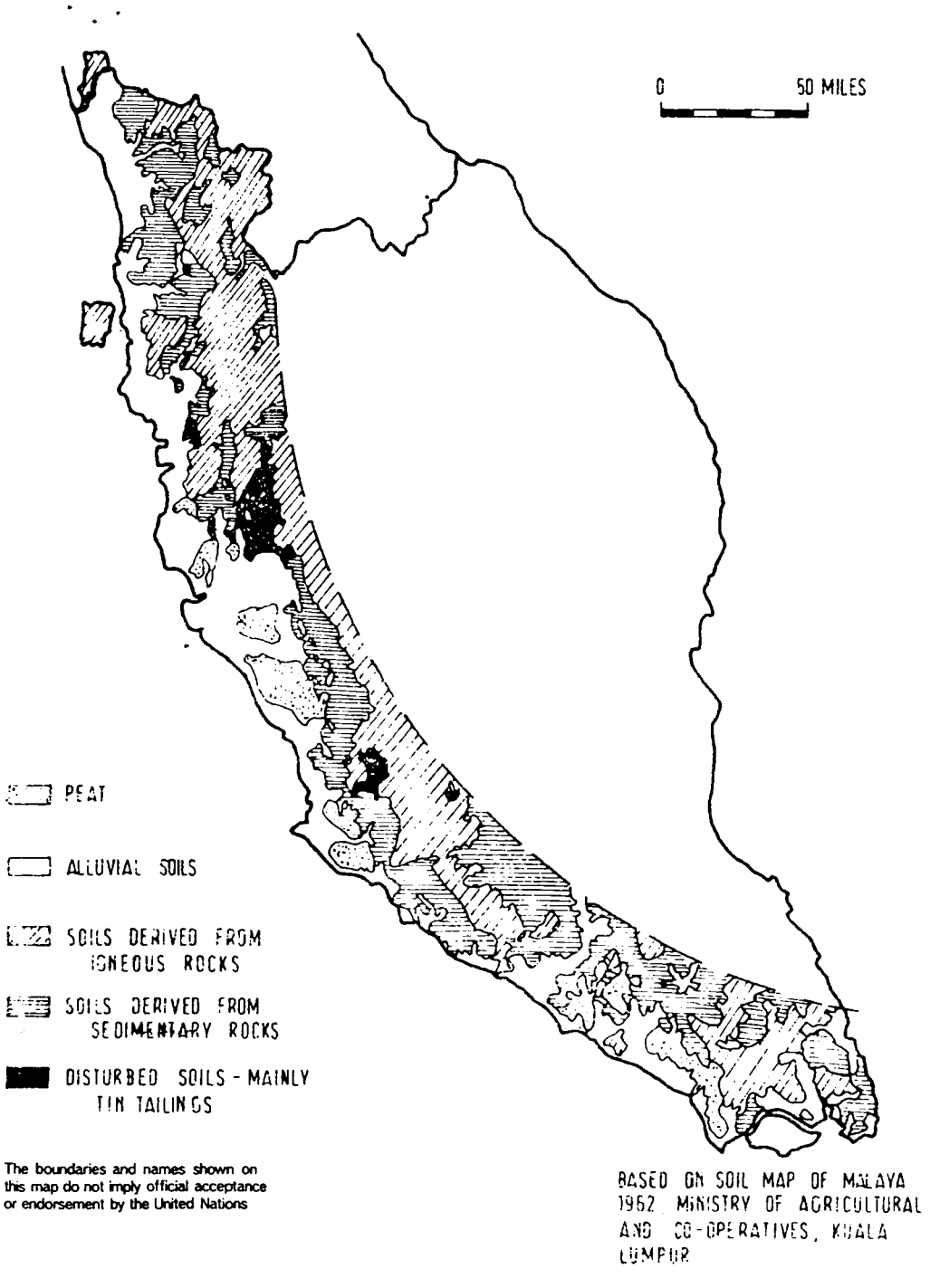

Figure 2. Soil map of the west coast of Peninsular Malaysia

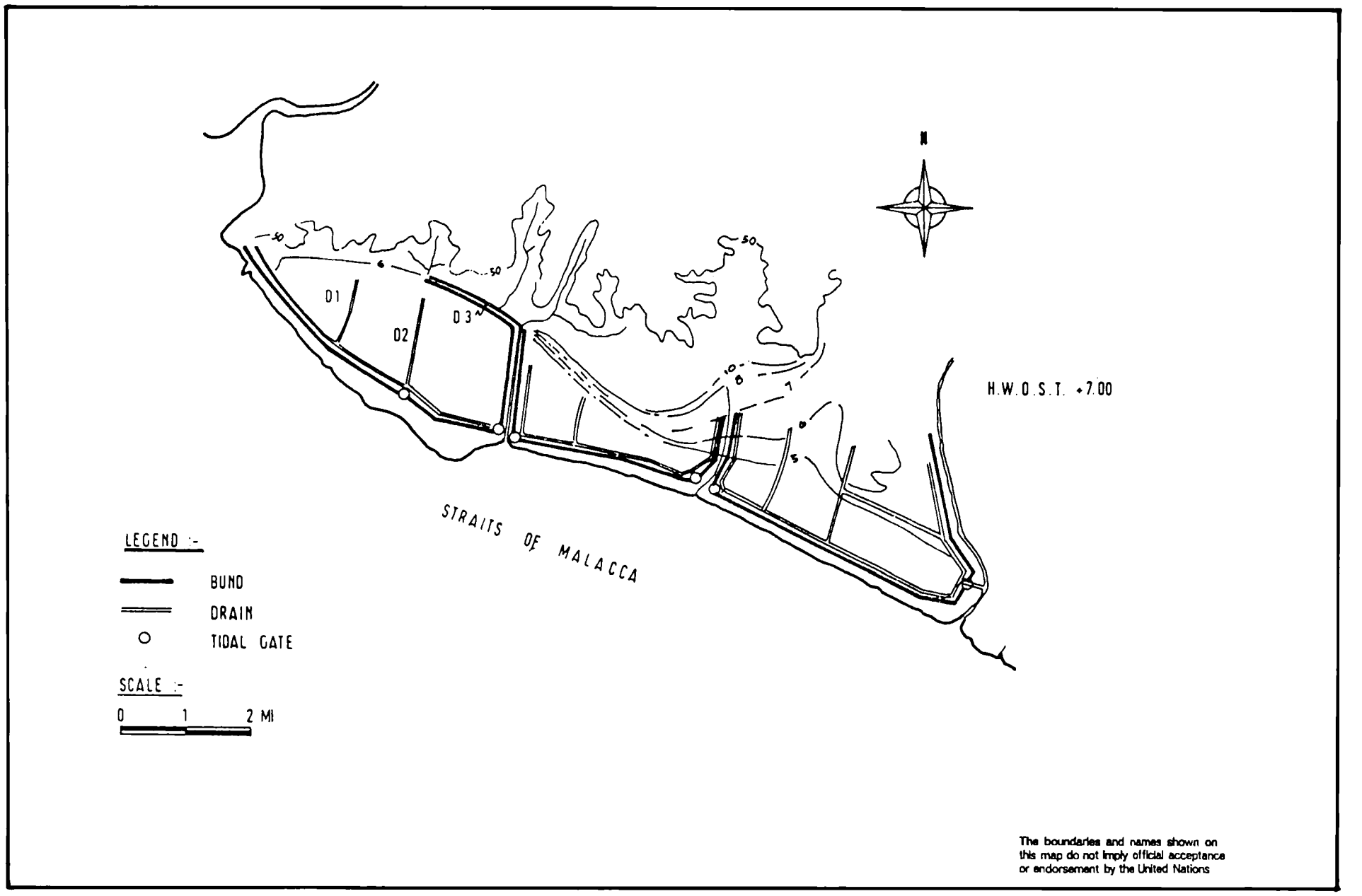

Figure 3. Typical drainage scheme for narrow coastal strip

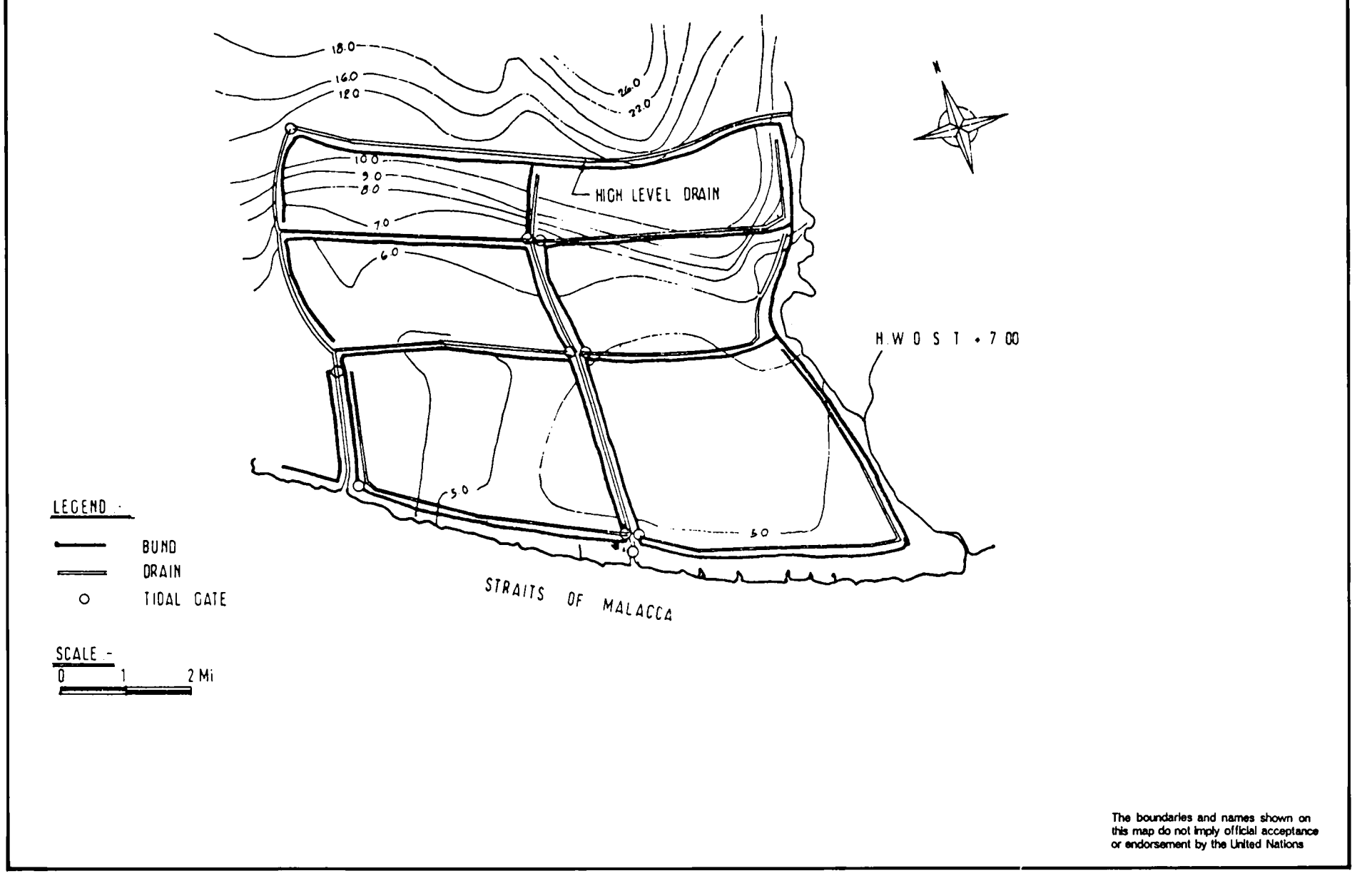

Figure 4. Typical drainage scheme for wide coastal strip

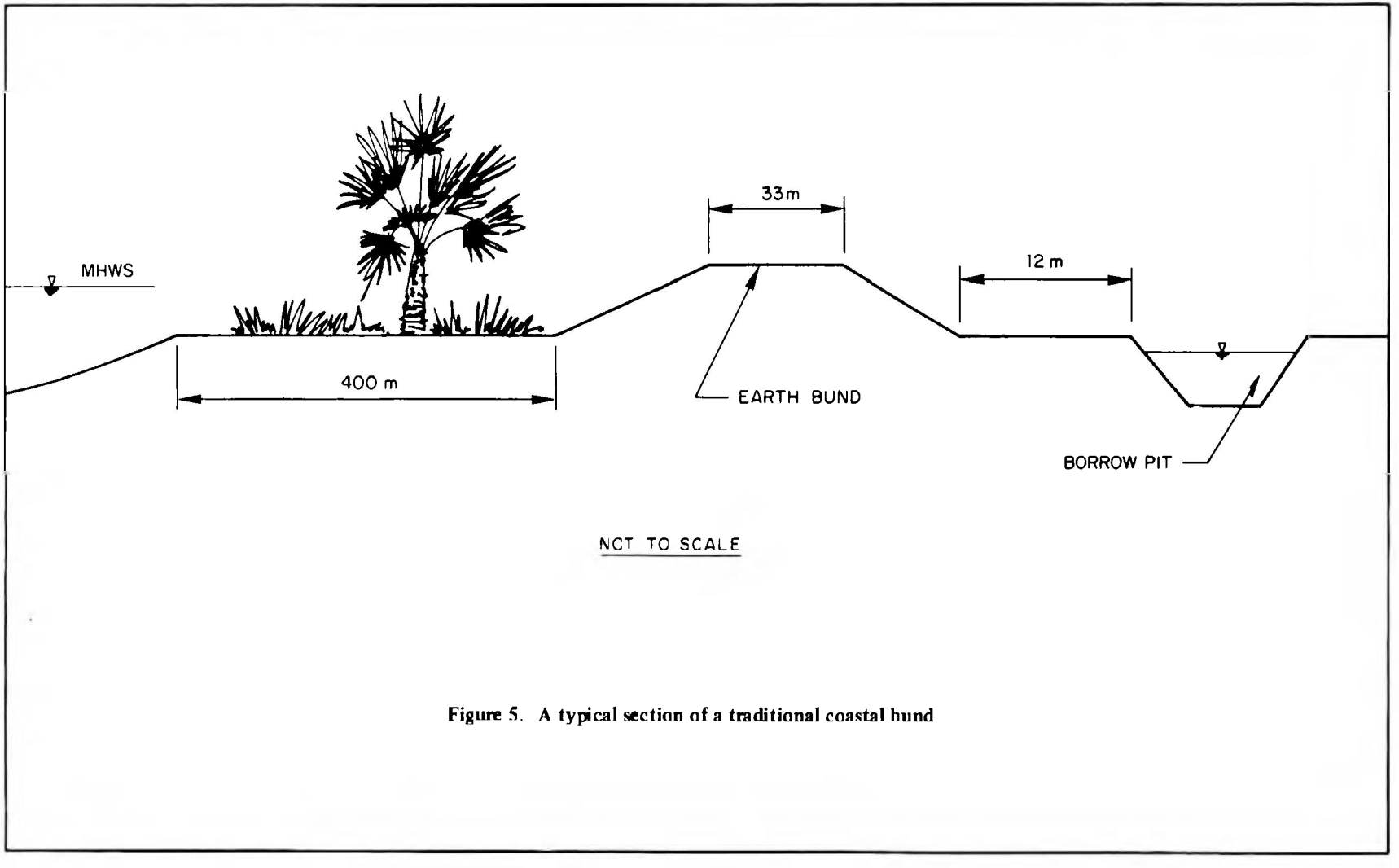

Figure 5. A typical section of a traditional coastal bund

LAND RECLAMATION AND DEVELOPMENT OF COASTAL AREAS IN THE PHILIPPINES: A CASE STUDY

by
Tito D. Fortes[1]

1. Introduction

The demands of growth and development as well as the increasing population in the Philippines especially in Metro Manila necessitate an expansion of the land area to accommodate various development projects. Hence, concerned governmental agencies like the Public Estates Authority, National Housing Authority, Philippine Ports Authority and the Department of Public Works and Highways in cooperation with the private sector, concerted their efforts in making possible a coordinated, economical and efficient reclamation of lands including their operation and management.

This study highlights the existing government policies on land reclamation, the proposed Navotas Bayshore Reclamation Project and the socio-economic impact of the completed Dagat-Dagatan Development Project.

2. Existing Policies on Land Reclamation

It is the declared policy of the Philippine Government to provide for a coordinated, economical and efficient reclamation of lands, and the administration and operation of lands belonging to, managed and/or operated by the government, with the object of maximizing their utilization and hastening their development consistent with the public interest.[2]

The Public Estates Authority (PEA) is the agency primarily responsible for integrating, directing and coordinating all reclamation projects. All reclamation projects are approved by the President upon recommendation of the PEA or through a proper contract executed by it with any person or entity.[3]

In addition, the PEA exercises the following powers and functions.[4]

1. Provide advice and assistance to the President in the formulation, implementation, and evaluation of plans or policies relative to all reclamation projects as would maximize their contribution to national development;

2. Issue such rules and regulations including the identification of such requirements as may be necessary for the evaluation and sound administration of all reclamation projects; and

3. Establish and implement a system of coordination with all concerned government agencies including monitoring of the progress of all reclamation projects.

Procedures in the Processing of Proposals for Reclamation Projects[5]

Before a proposed reclamation project is approved and implemented, the following procedures are observed:

1. *Submission of a Conceptual Study (Prefeasibility Study).* The conceptual study must provide the general overview of the project, sets down what it intends to accomplish and establish its over-all feasibility and viability.

The Conceptual Study shall then be endorsed to concerned government entities for comments, recommendations and satisfaction of agency requirements.

2. *Submission of a Feasibility Study.* When all referrals have been completed and favorable endorsement have been obtained by the project proposal, the Proponent shall be required to prepare and submit a formal feasibility study which shall contain a detailed presentation of the plans, studies and implementation aspects of the project.

Among others, the Feasibility Study should include socio-economic benefits study, reclamation and development plan, technical aspects, marketing aspects, financial aspects, operational aspects and cost-benefit analysis of the project.

3. *Evaluation By PEA of the Project Proposal.* The PEA shall evaluate the reclamation proposal (in consultation with other concerned agencies) to determine its consistency with the over-all development plan and objectives of the government, as well as its feasibility and viability.

4. *Submission by PEA of its Recommendation to the President.* This is done after full satisfaction of the feasibility and viability of the reclamation proposal and compliance by the Proponent with all of the requirements and conditions promulgated by the PEA and other concerned agencies.

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1 Chief Environment and Resource Specialist, Department of Environment and Natural Resources, Manila, Philippines

2 Section 2, Presidential Decree No. 1084

3 Section 1, Executive Order No. 525

4 *Ibid.*, Section 2, p. 2.

5 Details are contained in Annex 3

6 Information on the subject was provided by the Public Estates Authority

5. *Implementation of the Project.* Upon approval of the President, the PEA enters into a contract with the Proponent for the project's implementation.

3. The Proposed Navotas Bayshore Reclamation Project. A Case Study

Navotas, the maritime and fishing centre in the Northern section of Metro Manila encompasses 1,077 hectares distributed as follows:

Residential	–	396 hectares	–	36.71%
Commercial	–	77 hectares	–	7.15%
Industrial	–	81 hectares	–	7.54%
Institutional	–	11 hectares	–	1.04%
Open Space	–	57 hectares	–	5.49%
Fish Pond	–	453 hectares	–	42.07%
Total	–	1,077 hectares	–	100.00%

In 1987, it had an estimated population of 162,196 with an average growth rate of 2.69 between 1987-1992. The Municipal Development Planning Office (MDPO) of Navotas has calculated the population density to be 15,060 persons per hectare.

Initial studies and research made on the area revealed that there is an acute shortage of land for institutional, industrial and residential usages. At present, no large parcels of land in Navotas are available for commercial, industrial and planned residential expansion. It covers an aggregate area of 479.64 hectares. Hence, the proposed reclamation project is a welcome development.

Project Proposals

Land uses proposed to be located in the reclaimed area are as follows:

Industrial

Sea-related industrial usage is predominant along the coast line of Manila Bay from the South Harbor International Port to the Navotas Fish Port, immediately north of which is the project site. The northern section of the metropolitan region has rapidly industrialized.

A listing of possible industries that are best suited for the reclaimed land follows:

1. Petroleum-Oil-Lubricant Storage Area
2. Container Yard
3. Processing Industries
4. Ship-Building and Repair Facilities
5. Other industries

Establishment of Solid Waste Disposal Area

Presently, Metro Manila has eleven dump sites, the biggest of which is located in Tondo. However, this site is causing serious pollution problems to the surrounding urban and sea areas.

Sections of the proposed reclamation area offer space for solid waste disposal for the City using sanitary methods.

Residential

In the analysis of the densities of the different municipalities and cities of Metro Manila, Navotas, the region of the proposed reclamation project, has the highest population density. A study conducted revealed the unavailability of areas for additional residential usage.

The proposed relocation of industries within the reclamation project will entail support residential facilities which the town of Navotas can no longer accommodate.

Commercial

These are necessary support facilities for the residential needs of industrial workers. Among the proposed commercial facilities that may be provided within the reclamation area are:

- General merchandising, groceries
- Food shops, cafeterias
- Fresh fruits and vegetables market
- Wet market
- Department stores
- Home furnishings
- Gift shops, variety stores
- Textile and garment shops
- Dress shops, tailoring shops
- Service shops, repair shops
- Trading and merchandizing offices

Institutional and Recreational/Open Areas

These are necessary support facilities for the residential component of the reclamation area. Among the facilities that can be provided within the institutional/recreational zone are as follows:

- Police, fire, paramedic stations
- First stations, clinics
- Church, chapel, worship facilities
- Nurseries, day care centres
- Children's play areas
- Landscaping facilities, lagoon, park system
- Recreational facilities

Preliminary Engineering Analysis

4. Physical Conditions of the Reclamation Site

Hydrography

The shallow water depth of Manila Bay is due to the continuous sediment discharged from several rivers of which the most significant to the site is the Meycauayan River.

The general features of coastal deposits of Manila Bay are primarily due to the characteristics of the bay cur-

rent. The bay opens to the southwest facing the south China Sea and the eastward and northward currents are commonly observed in the vicinity of the proposed reclamation site.

In the case of Paranaque River which is located south of the Project site, major sediment does not form near its estuary because of the relatively strong velocity of the bay current.

On the other hand, heavy deposits are found in the estuary area of the Meycauayan River. The sea is shallow for a good distance from the shore due to the weak velocity of the bay current and the river is located in the inner part of Manila Bay.

Oceanography

The main tidal data are as follows:

Descriptions	*Values in meters*
Mean tidal range (MHW-MLW)	0.75
Diurnal tidal range (MHHW-MLLW)	1.01
Mean higher high water (MHHW)	+1.01 above MLLW
Mean high water (MHW)	+0.86 above MLLW
Mean sea level (MSL)	+0.47 above MLLW
Mean low water (MLW)	+0.10 above MLLW
Mean lower low water (MLLW)	0.00 above MLLW

Highest observed tide. . 1.77 above MLLW (July 23, 1911)
Lowest observed tide. . 0.67 below MLLW (Feb. 3, 1912)

The greatest tidal range usually occurs in June and December while the smallest range occurs in March and September.

No record of wave observations are available for the vicinity of the proposed reclamation site. However, in 1978, Salzgitter Consult GMBH estimated the waves with a probability of occurrence of once per year for each direction of attack using meteorological data. The results of the study made by Salzgitter are summarized as follows:

Direction of Attack	*Wave Height (m)*	*Design Wave Period (sec)*	*Wave Length (m)*
NW	0.7	5.0	37
WNW	1.1	6.5	55
W	1.5	5.5	47
WSW	1.7	6.0	56
SW	1.3	5.0	39

No official records concerning current observations are available of Manila Bay; however, a short survey was made some years ago and reported current velocities of around 0.05 m/sec. Even under the most adverse conditions, e.g. superposition of tidal currents and wind generated currents, no effective disturbance to navigation is expected.

Meteorology

Three major wind systems have been identified:

- NE monsoon (September – February)
- SE trade winds (February – May)
- SW monsoon (June – September)

Between 1955 and 1973, for the months of June to December, a total of 83 tropical cyclones (or more than 4 per year) approached Manila within 180 nautical miles. Thirty per cent of these typhoons caused winds in Manila of 40 km/h (Beaufort 6) and higher, only 8 per cent caused gales of 63 km/h (Beaufort 8) and higher. The average mean annual rainfall observed in Meycauayan and Navotas River systems ranges from 1,800 mm to 2,200 mm. Since the area has a tropical heavy rainfall, the type of rainfall is characterized by heavy showers. In such showers the rate of precipitation may reach to about 400 mm in lowland areas and 600 mm in mountain areas at maximum 24-hour rainfall of 25-year frequency.

Sub-surface Soils Conditions

Based on available secondary data and information gathered concerning subsurface soil conditions, the probable soil profiles and cross sections along the proposed routes show the general boundary between alluvial lowland plains (deltas) and diluvial upland formation (Guadalupe Tuff).

This tuff formation declines gradually westward to Manila Bay. There exist several valleys which were eroded and filled with deltaic sediments (alluvial deposits) by major streams i.e. Meycauayan and Navotas Rivers and their tributaries.

The deltaic deposits are intensively developed at variable depths of 10 to 25 m and are composed of silty clay, sandy and fine sand.

Deltaic deposits predominate, particularly in water-logged areas and fishponds. Representative soils properties of each layer are summarized as follows:

Unconfined Moisture Compressive

Epoch	*Name of Layer*	*N Value*	*Strength (gu) (kg/cm²)*	*Content (%)*	*Index (IP)*
Recent	Silty Clay	0- 3	0.1-0.3	40-50	15-20
Ditto	Silty Sand	0- 3	–	–	–
Recent/	Alternating	5-30	–	–	–
Pleistocene	Silty Sand/ Silt/ Clay	–	–	–	–
Pleistocene	Tuff	20-50	10-20	–	–

The stratification of sub-surface soils at the area to be filled is estimated as follows:

- Alluvium loose silt and clay with thin sand layers (from seabed to approximately 10 meters below seabed);

- Deluvium silty sand, sandy silt and clay layers (approximately 10 meters to 25 meters below seabed);
- Tertiary bedrock, tuff (approximately 20 to 30 meters below seabed).

Initial Environmental Examination

In compliance with the requirement of the Environmental Management Bureau (EMB), in order to obtain the approval and issuance of an Environmental Clearance Certificate for the implementation of this project, an initial environmental examination for the Navotas Reclamation Project will be conducted.

Favorable Environmental Impacts

Based on the preliminary physical survey conducted of the area supported by previous studies, it is projected that the Navotas Reclamation project will produce a large number of favorable effects outlined as follows:

Increase of Transport Mobility and Accessibility

The proposed reclamation project will provide the land required for the right-of-way for the Coastal Road. Hence, it could be said that the reclamation project will indirectly contribute to the increase of transport mobility and accessibility to the direct influence zone.

Creation of New Land

The proposed reclamation will provide about 500 hectares of land which can be utilized for land development purposes geared towards maximizing productive uses that will induce social and economic benefits to the National Capital Region with minimal adverse effects and conservation of the existing natural environment.

Realization of Land Use Potentiality

Land use potentiality in the direct influence zone, especially the district adjacent to the reclamation area, will be highly developed for industrial and housing land uses.

Promote Urban Renewal

The reclaimed land will be utilized for attainment of the socio-economic goals of the government whose present thrust is concerned with housing, traffic decongestion, provision of basic infrastructures, and in general, the enhancement of the quality of life. The project will offer various opportunities for providing solutions to pressing urban problems such as the solid waste disposal problem and the need for warehousing and processing industries, oil depots, container yard and commercial and housing space in the area.

Generation of Employment Opportunities

The proposed reclaimed area will absorb a sizeable number of workers when the area is developed by high priority projected industrial land uses.

Summary of Adverse Effects and Their Mitigation

Project elements reducing environmental quality and expected mitigation are summarized as follows:

Adverse Effect	*Mitigation*
1. Temporary Water	Spillways will be provided to minimize silting in the surrounding area during the construction.
2. Loss of bottom dwelling area for sea organisms	Sea beds will be stirred by the dredger, thereby changing the water quality temporarily in the surrounding area. The environmental effect of dredging is influenced by the characteristics of soils, oceanographic conditions, hydrographical conditions, type of dredger to be used and the size of borrow pit (area) planned. Therefore by adopting proper dredgers and proper construction management (i.e., concentrated dredging at good soil areas), the adverse effect will be significantly reduced.
3. Loss of Fishing grounds.	Offshore areas occupied by the reclamation will be sufficiently compensated. To facilitate the fishery and fish carrier boat the provision of approach ramp or nodal point areas will be planned at sufficient locations, since these facilities will mitigate fishermen's losses by increasing accessibility to consumer market.
4. Temporary air and water pollution during construction.	Nuisance and inconvenience during construction should be significantly reduced by introduction of proper construction management and supervision and adoption of proper construction equipment and methods.
5. Probable water and air pollution	Only light industries will be established, with provision for sewerage treatment plant. The siting of each type of industry has been determined by considering the labor-intensive (low energy consumption); therefore, air contamination will be minimal.
6. There will be possible pollution from tank cleaning and accidental oil spills	This can be minimized if the Petroleum Oil Lubricant (P.O.L.) storage area is properly designed, equipped and operated.

Project Costings

Detailed costing of the project including the cash flow and schedule of implementation are reflected in Fig. 1.

5. The Dagat-Dagatan Development Project – A Case Study on the Socio-Economic Impact of A Reclamation Project[6]

Dagat-Dagatan, a 410 hectares reclaimed area from a fishpond complex, is within the political jurisdiction of the Metroplitan Manila Commission. It is bounded by Kalookan City on the east, the town of Navotas on the west, Malabon on the north and Manila on the south.

The Dagat-Dagatan Development Project, an urban resettlement site, was implemented based on the sites and services development programme of the National Housing Authority (NHA). This new approach in resettlement of families in blighted areas promotes minimum displacement and avoids economic dislocation within an urban sphere. Dagat-Dagatan serves the primary purpose of a relocation centre for displaced families from the Tondo Foreshore Development Project in Manila, as well as families affected by the zonal infrastructure development in Manila.

The physical orientation of this urban resettlement project gives its residents equitable access to services and employment opportunities. The housing design was adapted to natural environment, size and characteristics of the population, available technology, social organization within the society, economic and political activities, and cultural values. The residential areas have provisions for essential community facilities, i.e., schools, barangay day care and livelihood centres, health centres, police and fire substations, and churches. Commercial and industrial centres are strategically situated along major transport routes, hence providing employment opportunities for the target population.

Population

Based on statistics compiled until September 1987, Dagat-Dagatan is inhabited by 11,317 families or approximately 102,000 individuals. It boasts of 68,807 registered voters and a labour force of 49,455.

Topography

Located along the flat coastline of Manila Bay, the reclaimed land of Dagat-Dagatan was raised to an average elevation of 2.50 meters above the mean low-low water (MLLW) level.

Geology

Since Dagat-Dagatan is a reclaimed area, its soil composition is generally sandy. Alluvial deposits are found in substrata soil while a mixture of different soil types and other inorganic matter comprise the top soil.

Accessibility

Passenger jeepneys plying the regular Navotas-Divisoria and Malabon-Divisoria routes provide transportation for commuters. Public utility buses sporting the Monumento-Letre route provide alternative means of commuting. At present, tricycles ply the route inside the project. Public transportation facilities pass through the major routes inside Dagat-Dagatan.

Land Use

Land use in Dagat-Dagatan is threefold, to wit: residential, commercial and industrial, and institutional and recreational. The major design reflects the wholistic approach in town planning – integrating environment, social and economic dimensions in community development.

Socio-Economic Development

An inter-agency approach towards socio-economic development is employed by the Authority to hasten the socio-economic upliftment of the residents. Social programmes such as: Health and Nutrition, Social Services and Family Planning, Environmental Sanitation, Sports and Recreation, and Peace and Order are well-provided for.

Organization of Homeowners' Association and Residents' Association was implemented to ensure the individual well-being of the residents. These are closely coordinated government programmes aimed to fully develop the human potentials and physical resources, establish educational and cultural activities conducive to the pursuit of sound social stability, and maintain the standards of a healthy and self-contained community.

The National Housing Authority, through the expertise of its Community Relations Officers, has continuously engaged the residents in on-going community organization and training programmes that will eventually ensure self-sufficiency among the residents. The implementation of such programmes taps the leadership potentials of every community member and elicits participation among the rest of the residents. This community-based structure scheme aims to identify and prioritize housing-related needs. The community relations arm of the Authority plan, implement and evaluate the effectivity of short-range programmes of actions, thus promoting unity within the various communities.

Close coordination with cause-oriented groups which makes the National Housing Authority become more aware of issues and concerns is maintained. Likewise, information motivation and dissemination regarding community development and policy formation is continuously followed-up. In this process a consensus of the reactions of the residents towards prevailing issues and concerns are gauged and carefully scrutinized.

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[6] Information on the subject was provided by the National Housing Authority

Community Facilities

In the light of the aforementioned purposes, an array of community facilities was provided to cater not only to the beneficiaries but also to a number of neighboring residents. Six (6) elementary schools and two (2) high schools were constructed to provide basic education. Three (3) health centres, one (1) of which has 20 bed-wards, operating and delivery rooms, were built for more efficient implementation of the health programmes. Barangay centres, parklands and recreational open spaces ensure interaction among residents from various communities in Dagat-Dagatan.

Livelihoood Assistance

To enhance the promotion of economic opportunities in the area, the Authority extends technical assistance to enterprising residents. They are encouraged to venture into small scale business and in the process, employment opportunities are made available to other residents.

Seminars on management and skills upgrading and training are held in order to tap individual capabilities of the residents. Once the capacity of the residents to perform tasks is gauged, possible placement in community-based economic institutions is facilitated. The livelihood programmes aim to make residents become more self-sufficient through self-help.

6. Conclusions

The need to expand land resources to cope with the demands brought about by industrialization and rapid rise in population has been clearly demonstrated in recent moves by the Philippine Government to intensify, an efficient and coordinated nationwide reclamation programme.

Specifically, development trends and influences in Metropolitan Manila have been strongly linked with the manner its coastal zones had been developed.

Despite efforts by the government to infuse larger capital investments in the region, government infrastructure programmes have not kept pace with the population and geographical development. The fast paced population growth has overshot allocated capital investments of the government. In less than 37 years, the urban population grew from 1.7 million to 7.3 million in 1986. Infrastructure projects, specifically roads, water supply, drainage and sewerage systems have not kept abreast with Metro Manila's expansion.

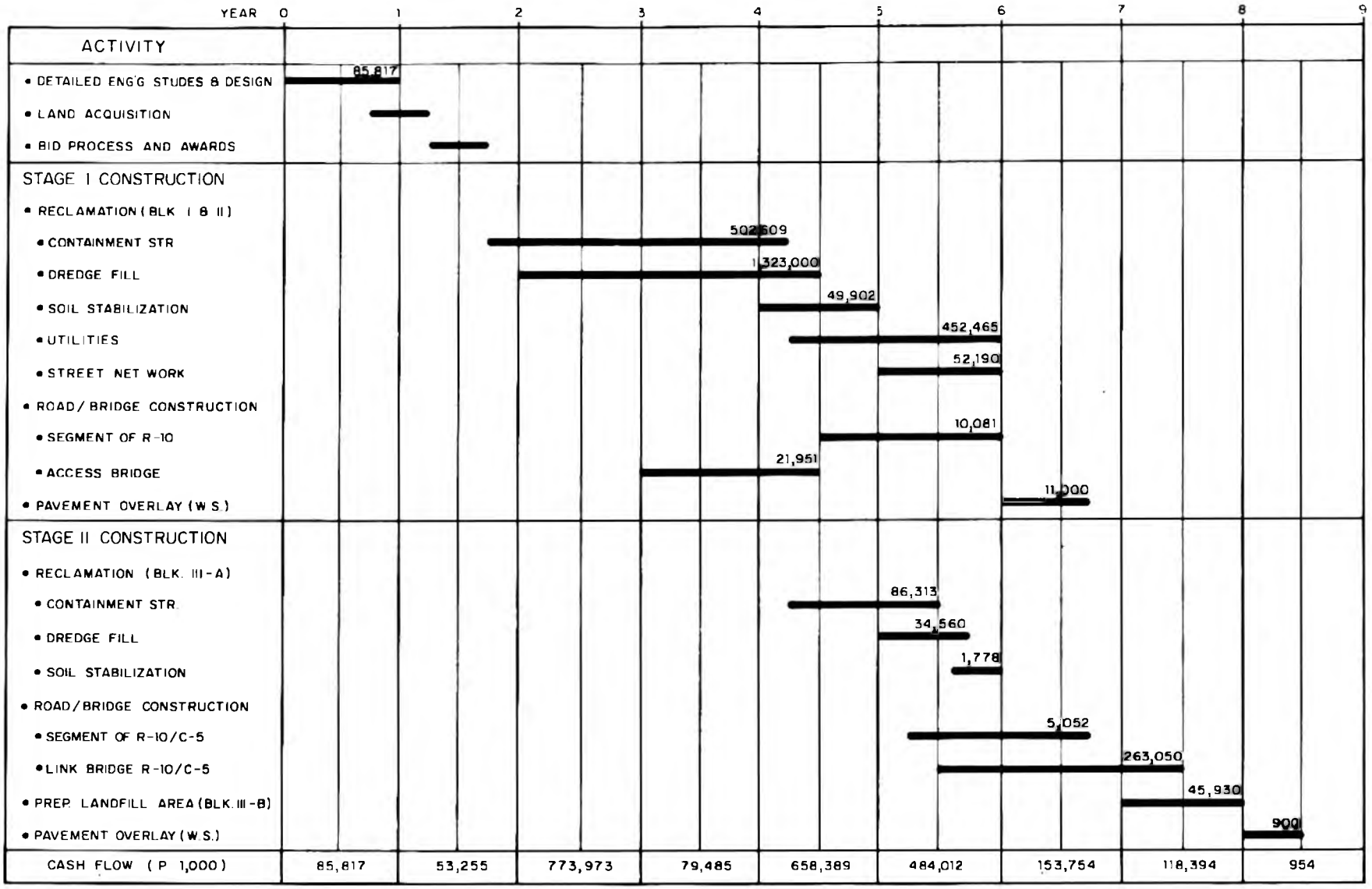
The proposed Navotas Bayshore Reclamation Project is a case in point. It is projected that it will produce many favorable effects such as an increase of transport many mobility and accessibility, creation of new land, realization of land use potentiality, promote urban renewal and generate employment opportunities.

Corollarily, the case of the Dagat-Dagatan Development Project demonstrates the socio-economic benefits that a reclamation project brings about such as equitable access to services and employment opportunities as well as social programmes like health and nutrition, social services and family planning, environmental sanitation, sports and recreation, peace and order and community development.

7. Acknowledgements

I would like to extend my sincere appreciation to Assistant General Theron Lacson and Engineer Gil Cabanting of the Public Estates Authority; Mr. Andy Lingan and Ms. Gloria Osmil of the National Housing Authority; Mr. Tomas Quintos and Mr. Bobby Aquino of the Philippine Ports Authority; and Assistant Secretary Manual Bonoan and Director Prudencio Baranda of the Department of Public Works and Highways for their unselfish cooperation in providing data and other information needed for the study.

CASH FLOW AND TIME SCHEDULE OF NAVOTAS RECLAMATION PROJECT & RELATED ROADS



NOTE • TOTAL COST = 3,118,033
• INCLUDING 6% CONSTRUCTION SUPERVISION
• EXCLUDING R.O.W & BID COST

Figure 1. Preliminaty Implementing Schedule

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Annexes

1. Presidential decree no. 1084
2. Executive order no. 525
3. Revised procedures in the processing of proposals for reclamation projects

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Annex 1

PRESIDENTIAL DECREE NO. 1084

CREATING THE PUBLIC ESTATES AUTHORITY, DEFINING ITS POWERS AND FUNCTIONS, PROVIDING FUNDS THEREFORE AND FOR OTHER PURPOSES

WHEREAS, there is a need to provide a coordinated, economical and efficient administration of lands and real estate, especially reclaimed lands, belonging to, managed and/or operated by the government;

WHEREAS, a government-owned and/or – controlled entity organized for the purpose is necessary;

NOW, THEREFORE, I, FERDINAND E. MARCOS, President of the Philippines, by virtue of the powers vested in me by the Constitution, do hereby decree and order:

SECTION 1. *Short title.* – This decree shall be known as the Charter of the Public Estates Authority.

SEC. 2. *Declaration of policy.* – It is declared policy of the State to provide for a coordinated, economical and efficient reclamation of lands, and the administration and operation of lands belonging to, managed and/or operated by the government, with the object of maximizing their utilization and hastening their development consistent with the public interest.

SEC. 3. *Creation, name, domicile and term.* – There is hereby created a body corporate to be known as the Public Estates Authority, hereinafter referred to as the "Authority" which shall have the attribute of perpetual succession and possessed of the powers of corporations, to be exercised in conformity with the provisions of this charter.

The principal office of the Authority shall be determined by its Board of Directors. It may establish such offices, agencies or branches in the Philippines as its business operations would require.

The Authority shall have a term of fifty (50) years from the issuance hereof, which shall be deemed for an equal period unless sooner dissolved by law.

SEC. 4. *Purposes.* – The Authority is hereby created for the following purposes:

a. To reclaim land, including foreshore and submerged areas, by dredging, filling or other means, to acquire reclaimed land;

b. To develop, improve, acquire, administer, deal in, subdivide, dispose, lease and sell any and all kinds of lands, buildings, estates and other forms of real property, owned, managed, controlled and/or operated by the government;

c. To provide for, operate or administer such services as may be necessary for the efficient, economical and beneficial utilization of the above properties.

SEC. 5. *Power and functions of the Authority* – The Authority shall, in carrying out the purposes for which it is created, have the following powers and functions:

a. To prescribe its by-laws.

b. To sue and be sued in its corporate name.

c. To adopt and use a seal and alter it at its pleasure.

d. To purchase, lease, build, alter, construct, erect, enlarge, occupy, manage, sell, mortgage, dispose of or otherwise deal in, buildings of every kind and character whatsoever, whether belonging to, or to be acquired by the Authority.

e. To construct, maintain and operate mains, pipes, machinery, water reservoirs, artesian wells as may be reasonably and necessarily required for the transaction of the lawful business of the Authority.

f. To own or operate railroads, tramways and other kinds of land transportation, vessels and pipelines, power house, hotels, restaurants, terminals, warehouses and to manufacture, produce, purchase, sell, dispose, encumber or otherwise deal in, rolling stock, equipment, tools and other appliances; to construct and operate in connection with its railroad lines toll viaducts, toll bridges and toll tunnels.

g. To construct, maintain and operate such systems of sanitary sewers as may be necessary for the proper sanitation of its areas of operation; to charge and collect such sums for construction and rates for this service as may be determined by the Board to be equitable and just; and to process waste materials obtained in the sewers for fertilizing purposes.

h. To construct, maintain and operate such storm drains as may be necessary.

i. To hold lands of the public domain in excess of area permitted to private corporations by statute.

j. To reclaim lands and to construct work across, or otherwise, any stream, watercourse, canal, ditch, flume, street, avenue, highway or railway of private or public ownership, as the location of said works may require provided that said works be con-

structed in such a manner as not to endanger life or property or in a manner not to impair unnecessarily their usefulness. Every person or entity whose property is crossed or intersected by said works shall not obstruct any such crossings or intersections and shall grant the Authority or its representatives, the proper authority for the execution of such work. The Authority is hereby given the right-of-way to locate, construct and maintain such works over the throughout the lands owned by the Republic of the Philippines or any of its branches and political subdivisions. The Authority or its representatives may also enter upon private property in the lawful performance or prosecution of its business and purposes; provided that the owner of such private property shall be indemnified for any actual damage caused thereby.

k. To issue such regulations as may be necessary for the proper use by private parties of any or all of the highways, roads, utilities, buildings and/or any of its properties and to impose or collect fees or tolls for their use provided that all receipts by the Authority from fees, tolls and other charges are automatically appropriated for its use.

l. To organize subsidiary companies to undertake any of the activities mentioned herein. The capital stock of such subsidiary companies shall be subscribed in whole or in part by the Authority.

m. To enter into, make, perform and carry out contracts of every class and description, including loan agreements, mortgages and other types of security arrangements, necessary or incidental to the realization of its purposes with any person, firm or corporation, private or public, and with any foreign government or entity.

n. To exercise the right of eminent domain in the name of the Republic of the Philippines, and in the acquisition of real estate by condemnation proceedings, the title to such real estate shall be taken in the name of the Republic of the Philippines, and thereupon all such real estate shall be entrusted to the Authority as the agent of the Republic of the Philippines to accomplish the aims and purposes of this decree.

o. To perform such acts and exercise such functions as may be necessary for the attainment of the purposes and objectives herein specified.

p. To premulgate such rules and regulations as may be necessary, to carry out its purposes and to provide penalties for the violation thereof which penalties shall be a fine of not more than five hundred pesos or imprisonment for not more than six months, or both such fine and imprisonment in the discretion of the court.

q. To perform such other functions as may be provided by law.

SEC. 6. *Governing Body.* – The Authority shall be governed by a Board of Directors, hereinafter referred to as the "Board" which shall be composed of a Chairman and four (4) members, to be appointed by the President of the Philippines. The Chairman and members of the Board shall serve for a term of three (3) years or until their successors shall have been appointed and qualified. In case of any vacancy in the Board the same shall be filled by the President of the Philippines for the unexpired term.

The Chief Executive of the Authority shall be a General Manager who shall be appointed by the President of the Philippines for the same term.

No person shall be appointed as Chairman or member of the Board; or as General Manager, unless he is a natural-born citizen of the Philippines, at least thirty (30) years of age and of established integrity.

SEC. 7. *Capital Stock.* – The Authority shall have an authorized capital stock divided into THREE MILLION (3,000,000) no par value shares to be subscribed and paid for as follows:

a. TWO MILLION (2,000,000) shares all be originally subscribed and paid for by the Republic of the Philippines by the transfer, conveyance and assignment of all the rights and interest of the Republic of the Philippines in that contract executed by and between the Construction and Development Corporation of the Philippines and the Bureau of Public Highways on November 20, 1973, the fair value of such rights and interests to be determined by the Board of Directors and approved by the President of the Philippines and the amount of FIVE MILLION (5,000,000) PESOS in cash;

b. The remaining ONE MILLION (1,000,000) shares of stock may be subscribed and paid for by the Republic of the Philippines or by government financial institutions at values to be determined by the Board and approved by the President of the Philippines.

The fair value of the interests hereby transferred shall, for all intents and purposes, be considered as paid-up capital pertaining to the government of the Republic of the Philippines in the Authority.

The voting power pertaining to the shares of stock subscribed by the government of the Republic of the Philippines shall be vested in the President of the Philippines or in such person or persons as he may designate.

SEC. 8. *Duties and Responsibilities of the General Manager* – The General Manager shall have the following duties and responsibilities:

a. To act as Chief Executive of the Authority.

b. To execute, administer and implement the policies and measures approved by the Board.

c. To direct and supervise the operations and administration of the Authority.

d. To represent the Authority in all dealings with offices, agencies and instrumentalities of the government and with all persons and other entities, public or private domestic or foreign.

e. To prepare the agenda for the meetings of the Board, and to submit for the consideration of the Board such policies and measures as he believes necessary to carry out the purposes and objectives of this Decree.

f. To exercise such other powers and perform such other duties provided in the by-laws and as may be vested in him by the Board.

SEC. 9. *Issuance of bonds.* – The Authority, upon the recommendation of the Secretary of Finance, the Monetary Board and the National Economic and Development Authority and with the approval of the President, is hereby authorized to issue bonds or other securities, whether tax-exempt or not, which may be guaranteed by the government, to finance its operations.

SEC. 10. *Auditor.* – The Commission on Audit shall appoint subject to the approval of the Board, a representative who shall be the Auditor of the Authority and such personnel as may be necessary to assist said representative in the performance of his duties.

SEC. 11. *Appointment, control and discipline of personnel.* – The Board, upon recommendation of the General Manager of the Authority, shall appoint the officers and employees of the Authority and its subsidiaries; fix their compensation, allowances and benefits, their working hours and such other conditions of employment as it may deem proper; grant them leaves of absence under such regulations as it may promulgate; discipline and/or remove them for cause; and establish and maintain a recruitment and merit system for the Authority and its affiliates and subsidiaries.

SEC. 12. *Loans.* – The Authority, as well as any affiliate corporation in which it holds, owns and/or controls by itself or jointly with one or more government-owned or-controlled corporations at least seventy-five per cent (75%) of the issued and outstanding shares of stock entitled to vote, when specifically authorized by the President of the Philippines, is hereby authorized to contract loans, credits, in any convertible foreign currency or capital goods, and indebtedness from time to time from foreign governments, or any international financial institutions or fund sources, or any entities, on such terms and conditions as it shall deem appropriate for the accomplishment of its purposes and to enter into and execute agreements and other documents specifying such terms and conditions.

SEC. 13. *Government financial institutions guarantee.* – The provision of any law to the contrary notwithstanding, any financial institution owned or controlled by the government of the Republic of the Philippines, other than the Central Bank, Government Service and Insurance System and the Social Security System, is hereby empowered to guarantee acceptance credits, loans, transactions, undertakings or obligations of any kind which may be incurred by the Authority, whether directly or indirectly, in favor of any person, association or entity, whether domestic or foreign.

SEC. 14. *Reports.* – The Authority shall, within three months after the end of every fiscal year submit its annual report to the President. It shall likewise submit such periodic or other reports as may be required of it from time to time.

SEC. 15. *Appropriation.* – The amount of FIVE MILLION (P5,000,000.00) PESOS which shall constitute partial payment of the subscription of the Republic of the Philippines in the capital stock of the corporation as provided in Section 7 of this charter is hereby appropriated out of any funds in the National Treasury not otherwise appropriated.

SEC. 16. *Separability clause.* – Should any provision of this Decree be held unconstitutional; no other provision here shall be affected thereby.

SEC. 17. *Repealing clause.* – All laws, decrees, executive orders, administrative orders, rules and regulations or parts thereof inconsistent herewith are hereby repealed, amended or modified accordingly.

SEC. 18. *Effectivity.* – This Decree shall take effect immediately.

Done in the City of Manila, this 4th day of February, in the year of Our Lord, nineteen hundred and seventy-seven.

(SGD.) FERDINAND E. MARCOS
President of the Philippines

Annex 2

EXECUTIVE ORDER NO. 525

DESIGNATING THE PUBLIC ESTATES AUTHORITY AS THE AGENCY PRIMARILLY RESPONSIBLE FOR ALL RECLAMATION PROJECTS.

WHEREAS, there are several reclamation projects which are on-going or being proposed to be undertaken in various parts of the country which need to be evaluated for consistency with national programmes;

WHEREAS, there is a need to give further institutional support to the Government's declared policy to provide for a coordinated, economical and efficient reclamation of lands;

WHEREAS, Presidential Decree No. 3-A requires that all reclamation of areas shall be limited to the National Government or any person authorized by it under a proper contract;

WHEREAS, a central authority is needed to act on behalf of the National Government which shall ensure a coordinated and integrated approach in the reclamation of lands;

WHEREAS, Presidential Decree No. 1084 creates the Public Estates Authority as a government corporation to undertake reclamation of lands and ensure their maximum utilization in promoting public welfare and interests; and

WHEREAS, Presidential Decree No. 1416 provides the President with cuntinuing authority to reorganize the national government including the transfer, abolition, or merger of functions and offices.

NOW, THEREFORE, I, FERDINAND E. MARCOS, President of the Philippines, by virtue of the powers vested in me by the Constitution and pursuant to Presidential Decree No. 1416, do hereby order and direct the following:

Section 1. – The Public Estates Authority (PEA) shall be primarily responsible for integrating; directing, and coordinating all reclamation projects for and on behalf of the National Government. All reclamation projects shall be approved by the President upon recommendation of the PEA, and shall be undertaken by the PEA or through a proper contract executed by it with any person or entity; Provided, that, reclamation projects of any national government agency or entity authorized under its charter shall be undertaken in consultation with the PEA upon approval of the President.

Sec. 2. – The PEA, in addition to the provisions of Presidential Decree No.1084, shall exercise the following powers and functions:

a. Provide advice and assistance to the President in the formulation, implementation, and evaluation of plans or policies relative to all reclamation projects as would maximize their contribution to national development;

b. Issue such rules and regulations including the identification of such requirements as may be necessary for the evaluation and sound administration of all reclamation projcts;

c. Establish and implement a system of coordination with all concerned government agencies including monitoring of the progress of all reclamation projects; and

d. Perform such other function as may be directed by the President.

Sec. 3. – All lands reclaimed by PEA shall belong to or be owned by the PEA which shall be responsible for its administration, development, utilization or disposition in accordance with the provisions of Presidential Decree No. 1084. Any and all income that the PEA may derive from the sale, lease or use of reclaimed lands shall be used in accordance with the provisions of Presidential Decree No. 1084.

DONE in the City of Manila, this 14th day of February, in the year of Our Lord, nineteen hundred and seventy-nine.

(SGD.) FERDINAND E. MARCOS
President of the Philippines

By the President:

JACOBO C. CLAVE
Presidential Executive Assistant

Annex 3

PUBLIC ESTATES AUTHORITY

REVISED PROCEDURES IN THE PROCESSING OF PROPOSALS FOR RECLAMATION PROJECTS

I. Conceptual Study (Pre-Feasibility Study)

A. Any entity, whether natural or juridical is qualified to undertake reclamation projects provided it shall first be authorized by the PEA pursuant to existing laws and regulations.

B. Any entity planning to undertake reclamation project shall write officially to PEA expressing its plans and intentions. The project shall be discussed by the PEA and the Proponent for further clarification of the project proposal and of the roles and responsibilities of the parties concerned including prescription of all requirements.

C. The Proponent shall be required to submit a Conceptual Study of the proposed reclamation project which shall contain the following general informations:

1. Project Title and name of proponent
2. Project objectives and conceptual framework
3. Location and size to include a vicinity map
4. Proposed land use to include land use map
5. Major design features
6. Estimated reclamation and development costs
7. General programme of work including timetable
8. Cost/benefit analysis of the Project

The conceptual study must provide the general overview of the project, sets down what it intends to accomplish and establish its over-all feasibility and viability. Additional informations/ data may be included at the option of the Proponent.

D. The Conceptual Study shall then be endorsed to the following government entities for comments, recommendations and satisfaction of agency requirements.

1. Local government authorities, i.e. city or town and province, where the proposed project is located. Public hearings shall be conducted when necessary for better appreciation of the project by the public and all concerned and for the resolution of all perceived problems.
2. NEDA Regional Office to determine its consistency or for incorporation with the regional development plan and objectives.
3. Housing and Land use Regulatory Board for locational clearance, environmental impact statement and guidelines governing land use and human settlements development.
4. When deemed necessary by any of the above agencies or by PEA, the project proposal may also be referred to:

4.1 The Philippine Ports Authority (PPA) where the project is adjacent to port facilities to avoid shipping related problems in the course of construction and upon completion, as well as to coordinate port use and satisfy PPA equirements.

4.2 The Department of Public Works and Highways (DPWH) to coordinate links to major road networks and to know public works requirements as prerequisite to construction.

4.3 The Bureau of Lands to coordinate land survey, titling and other Bureau requirements.

4.4 The Central Bank for reclamation projects with foreign financing component.

4.5 The Proponent shall submit additional data as may be required by any of the above prescribed agencies to support his study and shall comply with all other requirements.

II. Feasibility Study

When all referrals have been completed and favorable endorsement have been obtained by the project proposal, the Proponent shall be required to prepare and submit a formal feasibility study which shall contain a detailed presentation of the plans, studies and implementation aspects of the project.

The following are the suggested contents for the Feasibility Study which may be modified by the Proponent so long as the substantive aspects are retained.

1. Project Title
2. Name of Project Proponent, principal address and telephone number

3. Project objectives and conceptual framework
4. General Description of the Project (e.g., size, vicinity map, major design features, etc.)
5. *Socio-Economc Benefits*

   Indicates the magnitude of the project's constribution to socio-economic welfare of the concerned local government to regional as well as national development objectives. The socio-economic benefits should be weighed against social costs such as displacement or dislocation in livelihood of affected citizenry and environmental degradations, if any. This section should also indicate pertinent socio-economic data and the project's "positioning" or role relative to local, regional and national development objectives.

6. *Reclamation and Development Plan*

   a. General Development Concepts/Criteria

      Describes the development concepts/criteria or standard as well as policies that will be observed and adopted in the planning and construction of the project including those for parks, transportation, utility and waste disposal system.

   b. Land Use Allocation

      Describes breakdown of reclamined land into its various categories of uses which shall be analyzed relative to the project's goals, objectives, policies and constraints. In addition, each category of land use shall be described in terms of its specific components, objectives, location criteria, and development concept.

   c. Major Physical Design Proposal

      Describes essentially environmental considerations and land mass that will be formed resulting from the reclamation including its boundaries, and the factors whether environmental or economic, that influence its physical configurations.

   d. Reclamation and development costs schedule

      Describes breakdown of reclamation, construction, development and other incidental costs.

7. *Technical Aspects*

   Provides information among others, on the proposed reclamation/construction method to be adopted (as against other alternatives), technical, features, preliminary engineering including designs and technical standards adopted.

8. *Marketing Aspects*

   Concerns demand analysis of the need which the project intends to fill. This would include, among others, informations on the target market, price of land, estimates of sales, and the marketing programme and organization.

9. *Financial Aspects*

   a. Financing the Project

      Provides information among others, on funding requirements, sources of financing and terms, drawdown requirements and financial programme (cash flow).

   b. Estimate of Revenue from the Project

      Provides information among others, on the project's financial viability including assumptions of financial projections, and benefit/cost analysis.

10. *Operational :Aspects*

    a. Project Timetable for Reclamation and Development

    b. Project Implementation – Refers to adequacy of organizational and administrative arrangements or institutional requirements for the construction, installation, operation and maintenance of the project. This would include interface with appropriate government entities.

    c. Legal Considerations – Include among others, contracts for reclamation and other sub-contract documents if any, the territorial or juridical personality of reclaimed land, land titling and mode of disposition.

11. *Cost/benefit analysis of the Project*

    Resumé and conclusion on the over-all feasibility and viability of the project measuring benefits against costs and other considerations.

III. PEA Evaluation

PEA shall evaluate the reclamation proposal to determine its consistency with the over-all development plan and objectives of the government, its feasibility and viability. In the course of its evaluation, PEA shall be responsible for consulting with the appropriate government agencies as may be necessary. It shall require the Proponent to submit additional data or undertake further studies whenever necessary to support or clarify any aspects of the conceptual or feasibility study.

Cost of all studies shall be borne by the Project Proponent.

IV. Submission by PEA of its recommendation to the President

Upon full satisfaction of the feasibility and viability of the reclamation proposal and compliance by the Proponent with all of the requirements and conditions promulgated by the PEA and the other government agencies concerned, the PEA shall submit its recommendation to the President for approval.

V. Implementation of the Reclamation Project

As soon as the approval of the President is received by PEA, it shall enter into a contract with the Proponent for the Project's implementation.

SONGKHLA COASTAL CIRCULATION STUDY – THAILAND

by
Winai Sae-Chew[1]

Abstract

The Southern part of Thailand lies between the Gulf of Thailand and the Indian Ocean. It is located about latitude E 98° 30' to E 102°, longitude N 5° 45' to N 12°. The geological formations are the pre-Quaternary rocks in the middle of Peninsula. Geomorphologically there are high mountain ranges, swamp fields, alluvial plains, mud-rich strand plain and sand-bar/beach-ridges along the edge of the coast. Hypothetically, the alluvial plain and the mud-rich strand plain are suggestive of sedimentation derived from the second transgression of the sea about 6000 years ago. The processes of coastal movement, beach growth and land erosion have been recorded earlier (John Walker 1928, F.A. Neal 1940 and J Maccathy 1881). There is evidence to prove that processes of sedimentation, beach growth and land erosion were active in the Nakorn Srithammarat and Songkhla Districts. There are many development schemes located in these regions at present that affect the coastal environment. Human activities such as construction of coastal civil works, dumping of water in the sea, and fish farming have a direct impact on national development and affect this coastal environment. Therefore, the study was initiated by investigating and collecting essential physical data of Songkhla coast-line to understand the impact on the environment by such development. Many parameters such as geomorphology of the coast line and the sea bed, sedimentary petrology, sea-water quality (salinity, temperature, pH, turbidity), tidal circulation, and hydrologic conditions were analysed in the study. The results of the study will be of assistance to the relevant agencies of the government regarding regulatory measures for the protection of the coastal environment and resources.

1. Introduction

Due to rapid industrial and economic development suice 1985, Thailand has depleted its natural resources at a considerable pace. Such losses are mainly caused by human activities, for instance, river bank collapse from dredging, sea-water pollution from sewage systems, beach growth/beach erosion affected by the construction of coastal structures etc. Most of such development activities are taking place in the south of Thailand as compared to other regions. The regions of Songkhla and Nakorn Srithammaraj in the south are sensitive to the impact of changes in the natural ecosystem. Therefore, this study will specifically focus on the Songkhla coastal area rather than on other regions.

2. Objectives

The study would attain an understanding of the nature of interaction between sea and land, since such phenomena directly impact and affect the natural resources, coastal communities, and their development on a long term basis. The study embodies the application of GIS, hydrology, and oceanography. The collected data include the topography of the coastline, geology, properties of tidal circulation, sea-water data, wind velocity, etc. The collected data were evaluated with the objective of making a qualitative assessment of the environment degradation of the Songkhla coastal area.

3. General Topography of the Area

From Figure 1 it is apparent that the landscape is comprised of mountain ridges, trending from north to the south. The alluvial plain, mud-rich strand plain in the middle of the Peninsula and sand-bar/beach ridge complex along the coast form distinct geomorphic features and are composed of geological formations of pre-Quaternary age. The accumulation of sediments on alluvial plain and the mud-rich strand plain were studied to understand the sedimentary processes involved. The process of sedimentation in the area commenced from the event of the second transgression about 6000 years ago. This process of sedimentation is still continuing, particularly in the region of the Pakpanang estuary. Such processes of sedimentation had been recorded by John Walker in 1928, F.A. Neal in 1840 and J. Maccathy in 1881 who visited Siam during the reign of King Rama IV and observed beach growing processes in Pakpanang, Nakorn Srithammaraj and Songkhla lake. These records mention the shallowing of the rivers and growth of the beach in these areas. But in recent years this changed to become an erosional process in the Pakpanang estuary. High sedimentation rates in Songkhla lake and some parts of the coast have been recorded. (see Figures 2-5 after Prinya Nutalai, 1989).

4. Tidal Circulation of the Gulf of Thailand

From the satellite map of tidal circulation in the Gulf of Thailand (see Figure 6), it has been revealed that there are 2 major loops of tidal circulation. The first loop moves towards the south and turns it's direction into the Gulf

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again near Surat Thani and then moves north again. The second loop appears adjacent to the first moving from the south to the north and turns south again. It covers the area of Narathivat region up to Nakorn Srithammaraj region. Therefore, the sand in the south could be derived from two sources according to the circulation. The sedimentation in the Songkhla coastline is due to sediments derived from the estuaries in the eastern Malay Peninsula and is influenced by the second circulation loop as mentioned. The sedimentary particles in the Songkhla basin are different from the Surat Thani basin in size, colour and other features. For example, they are coarser, greyer and mixed with clay particles.

5. Investigation of the Songkhla Coastline

The study covered an area of 400 sq.kms. off the coast with a length of about 40 kms. and a width of 10 kms. Many parameters were studied such as tidal height, tidal-circulation, velocity, sea-water quality, sea bottom topography, wind velocity, contours of the seabed, etc. The average depth of the area studied is 6.5 m., temperature about 25.5 C., and the bottom features are sand, silt, clay and gravels. The average tidal height difference is around 1.80 m., with wind speed in both seasons, northeast and south-west monsoon, about 5.50 knots. The sedimentation rate is about 1.6 cm at the lake estuary, 0.65 cm. in the inner lake, and along the Samila coastal area is about 3.25 cm. Meanwhile, at the Sathing-pra coastline, north of Songkhla, erosion seems to be increasing. Each year the marine transgression is about 0.10 m. and from the observations made at the Pakpanang estuary, the problem of erosion is much greater there than in Sathing-pra which was not examined in detail. Therefore, it can be concluded that the marine transgression is due to erosion along the Songkhla coastline influenced by the construction of the deep sea port and bridge across the lake, dumping of waste at sea, fish farming and a fish processing factory. (Figures 7-18).

6. Acknowledgements

The writer would like to express his thanks to his helpful colleague, Dr. Somsak Baromtanarath, for his advice, Also the Department of Civil Engineering for facilitating the publishing of this paper. Without such assistance this work would not be possible. I would also like to extend my sincere thanks to ESCAP and the host country, the Netherlands, for their generosity in offering this opportunity for me to follow this programme.

7. Conclusions

Coastal development schemes are useful for strategies aimed at socio-economic development. But if there is no protection of the environment the environmental degradation will eventually lead to excessive costs for the mitigation of such negative effects. Therefore, the awareness and the protection of environmental changes are a vital prerequisite for any economic development strategy for the uplifting of the living conditions of the people.

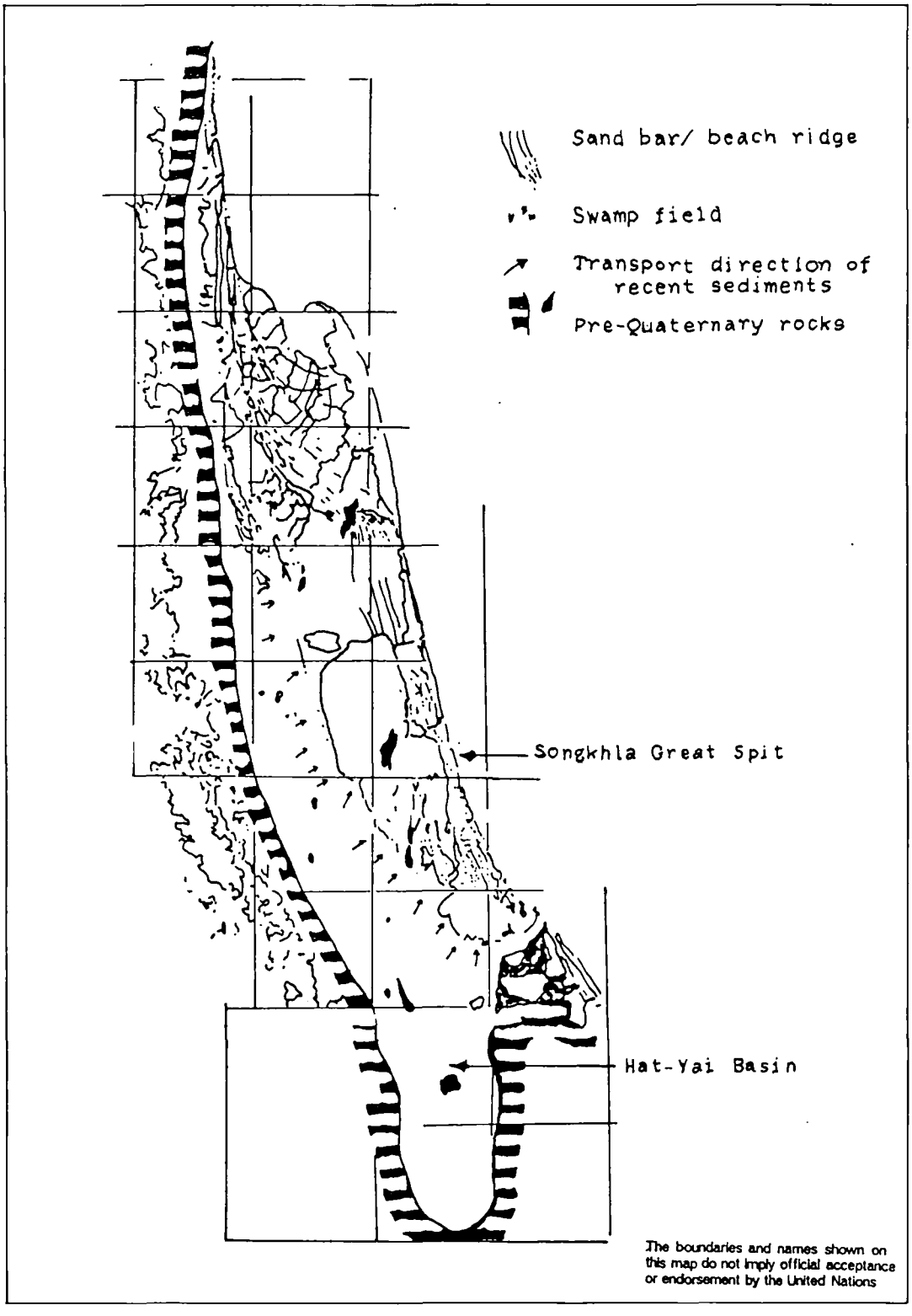

Figure 1. Sand bars/beach ridges in Songkhla – Nakorn Sri Thammarat Basin and the direction of sedimentation (after Sawata and others, 1982)

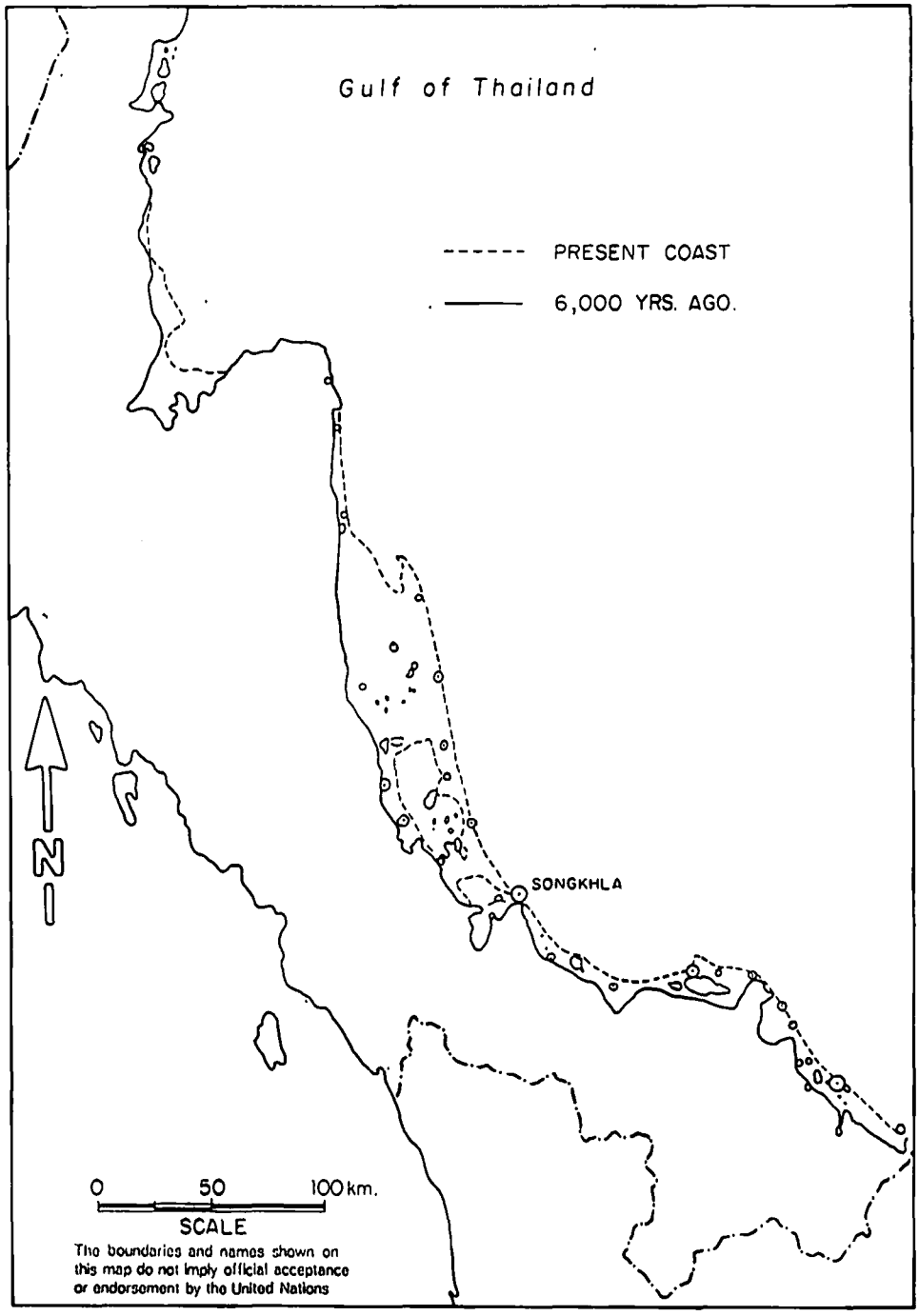

Figure 2. The Southeast coast 6,000 years ago (after Prinya Nutalai, 1989)

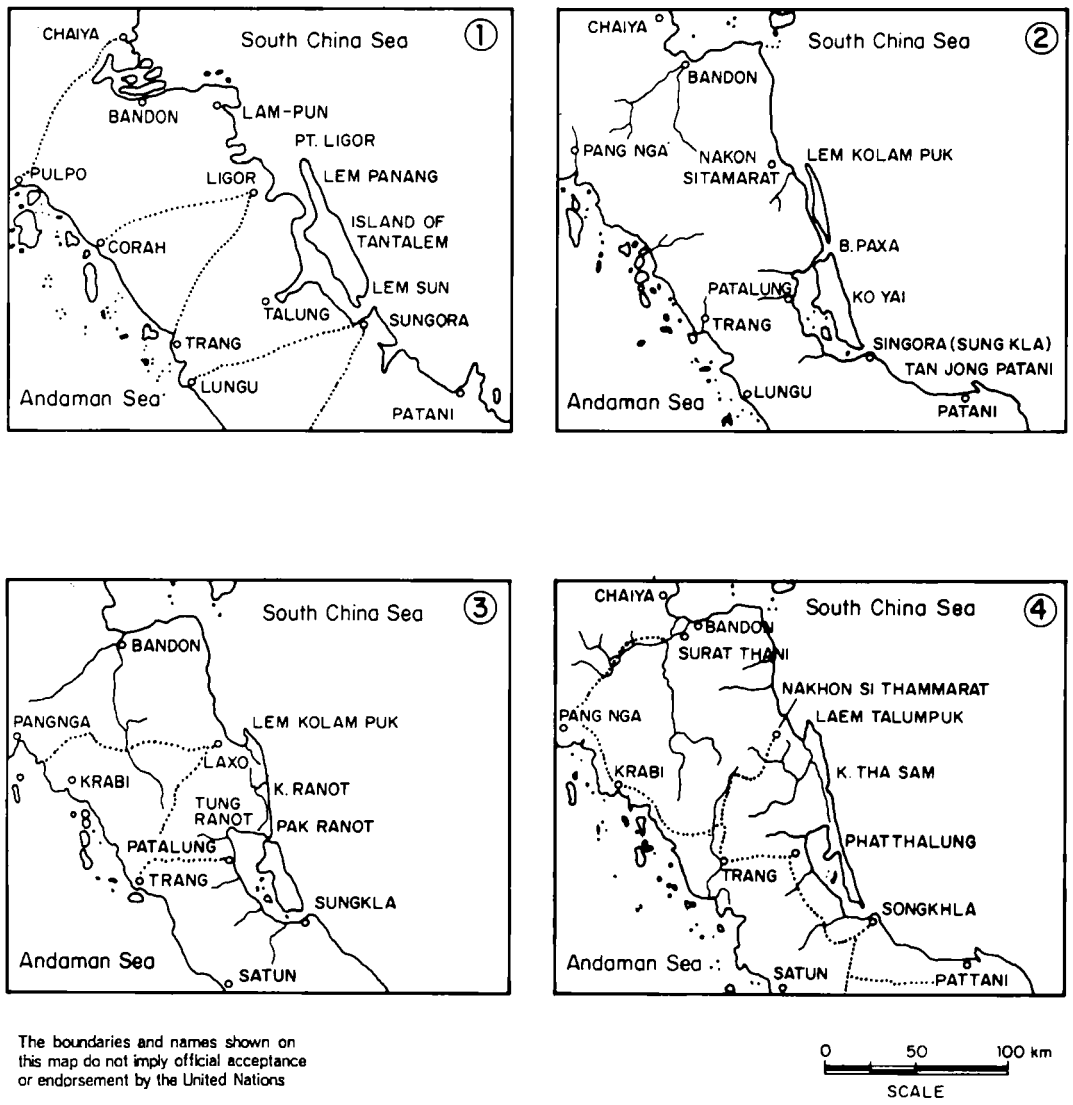

Figure 3. The beach growth phenomenon in the Southeast coast from 1728 to 1952 (after Prinya Nutalai, 1989)

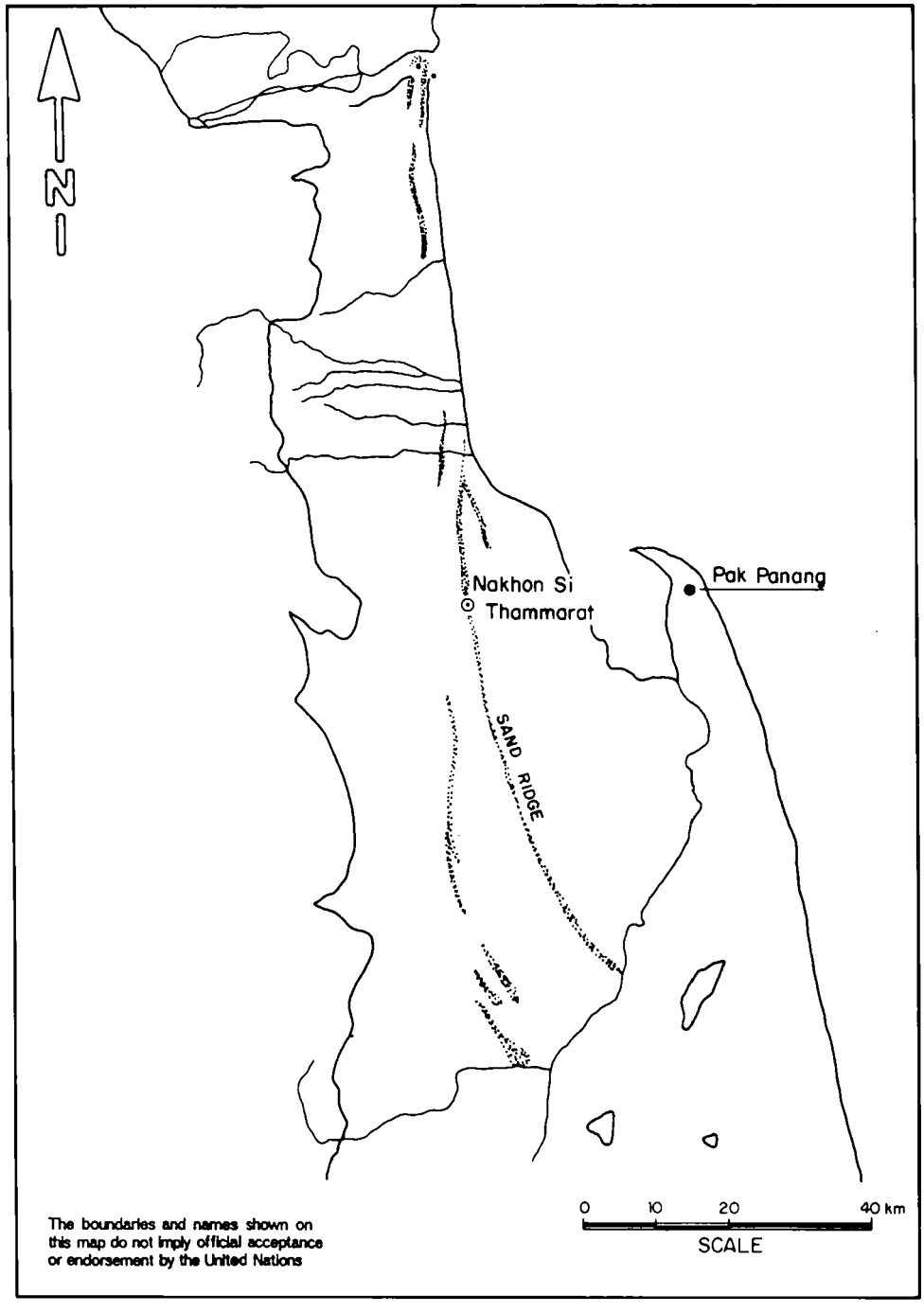

Figure 4. Topography of Nakorn Sri Thammarat: map scale is 1:1,000,000

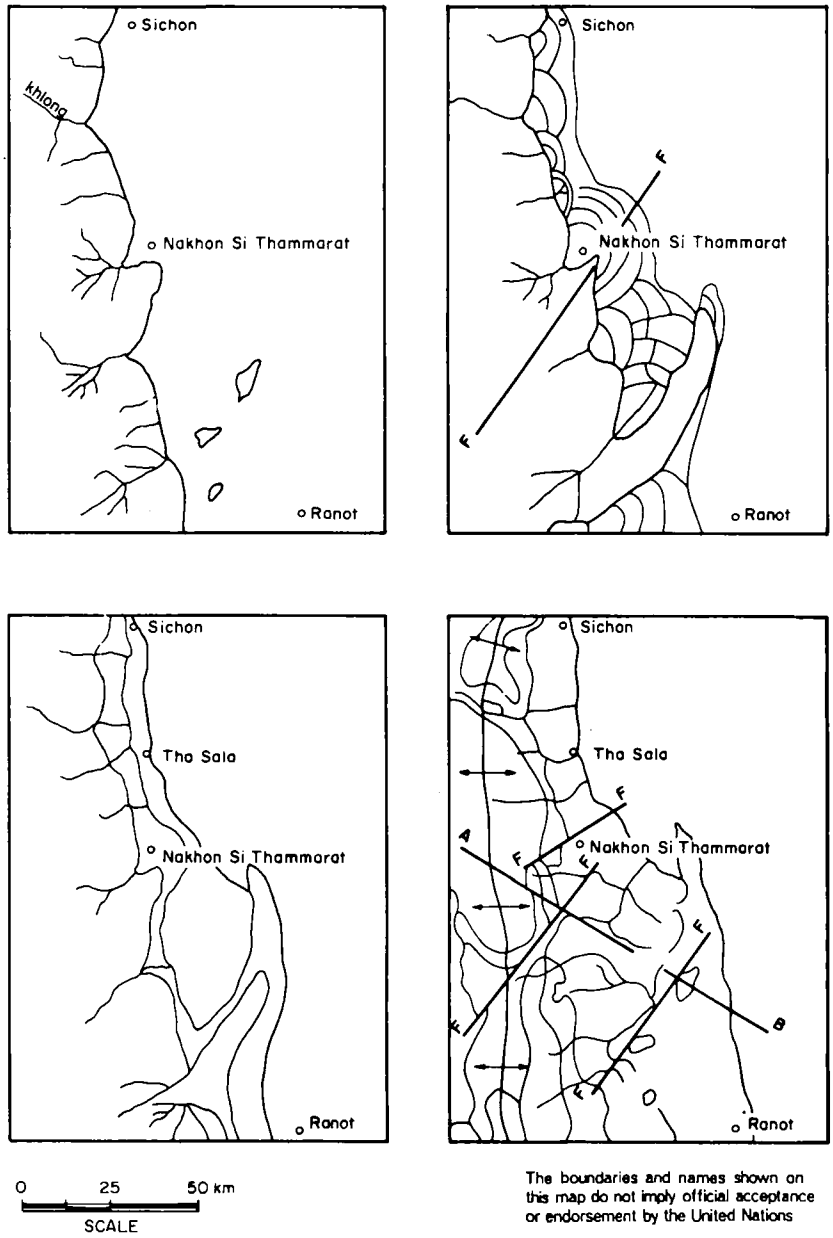

Figure 5. The land growth process (after Antara Team Study)

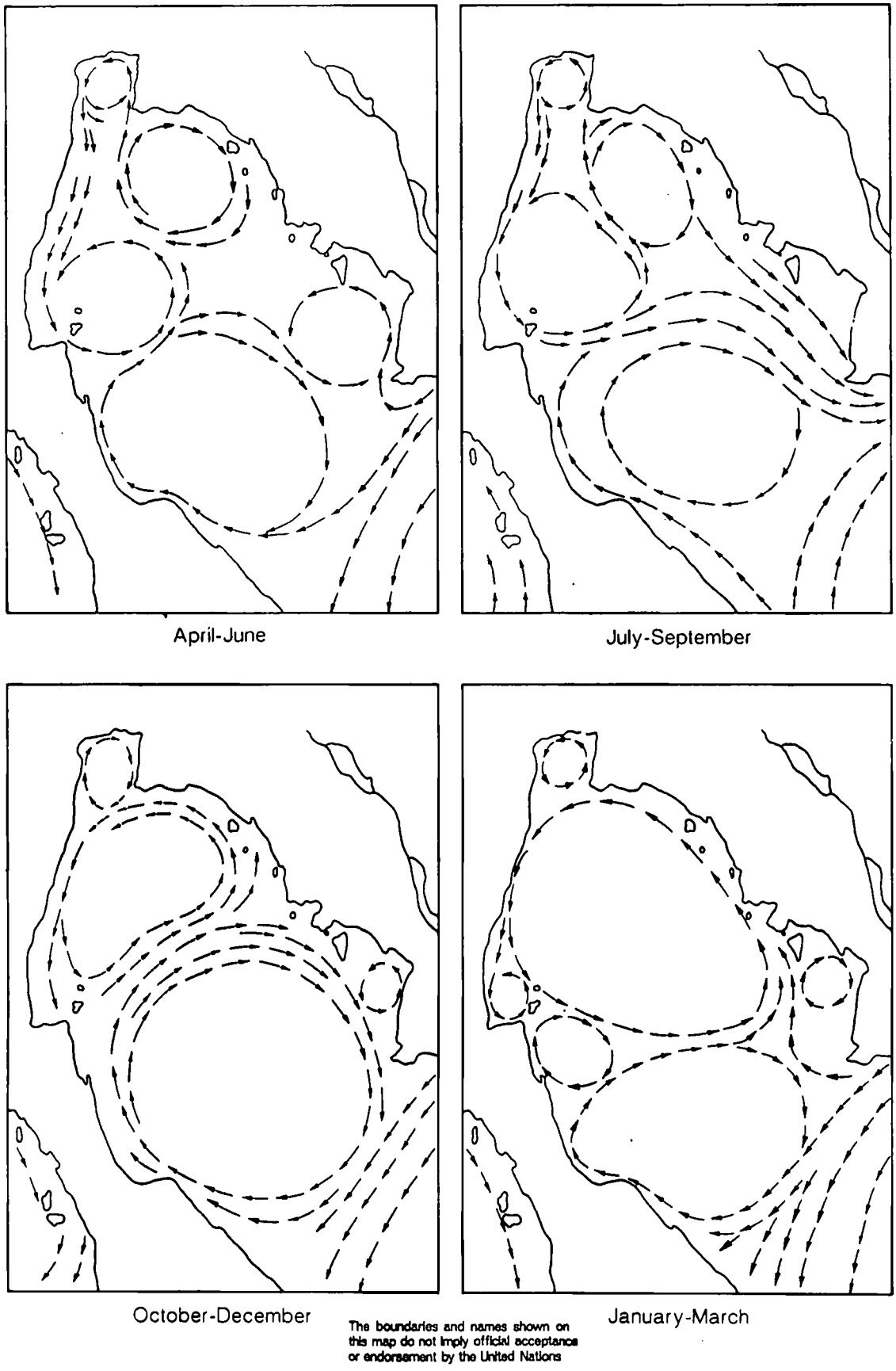

Figure 6. Tidal circulation in the Gulf of Thailand (Irrigation and Geology Dept., 1977)

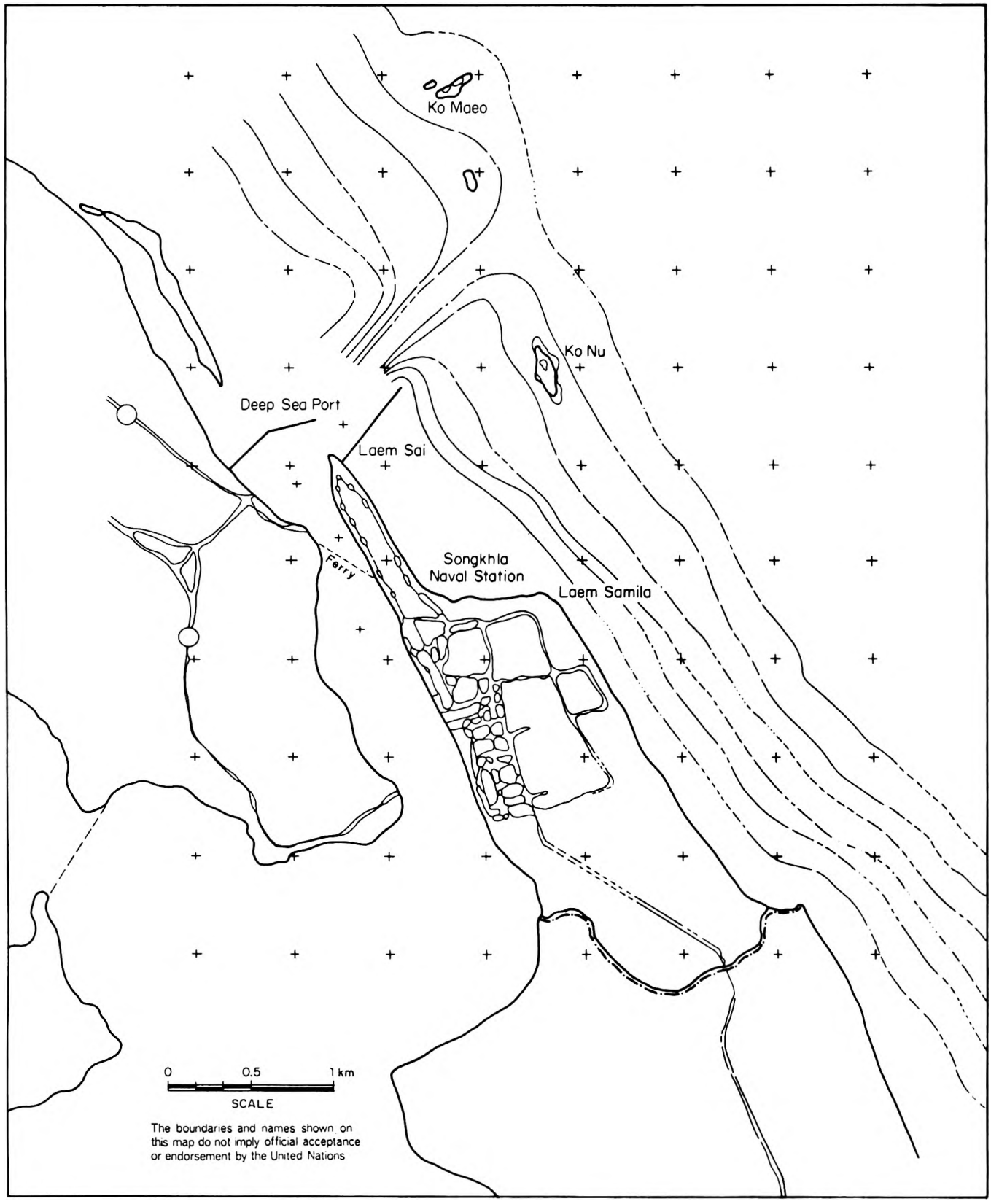

Figure 7. Contour of Songkhla sea-bottom

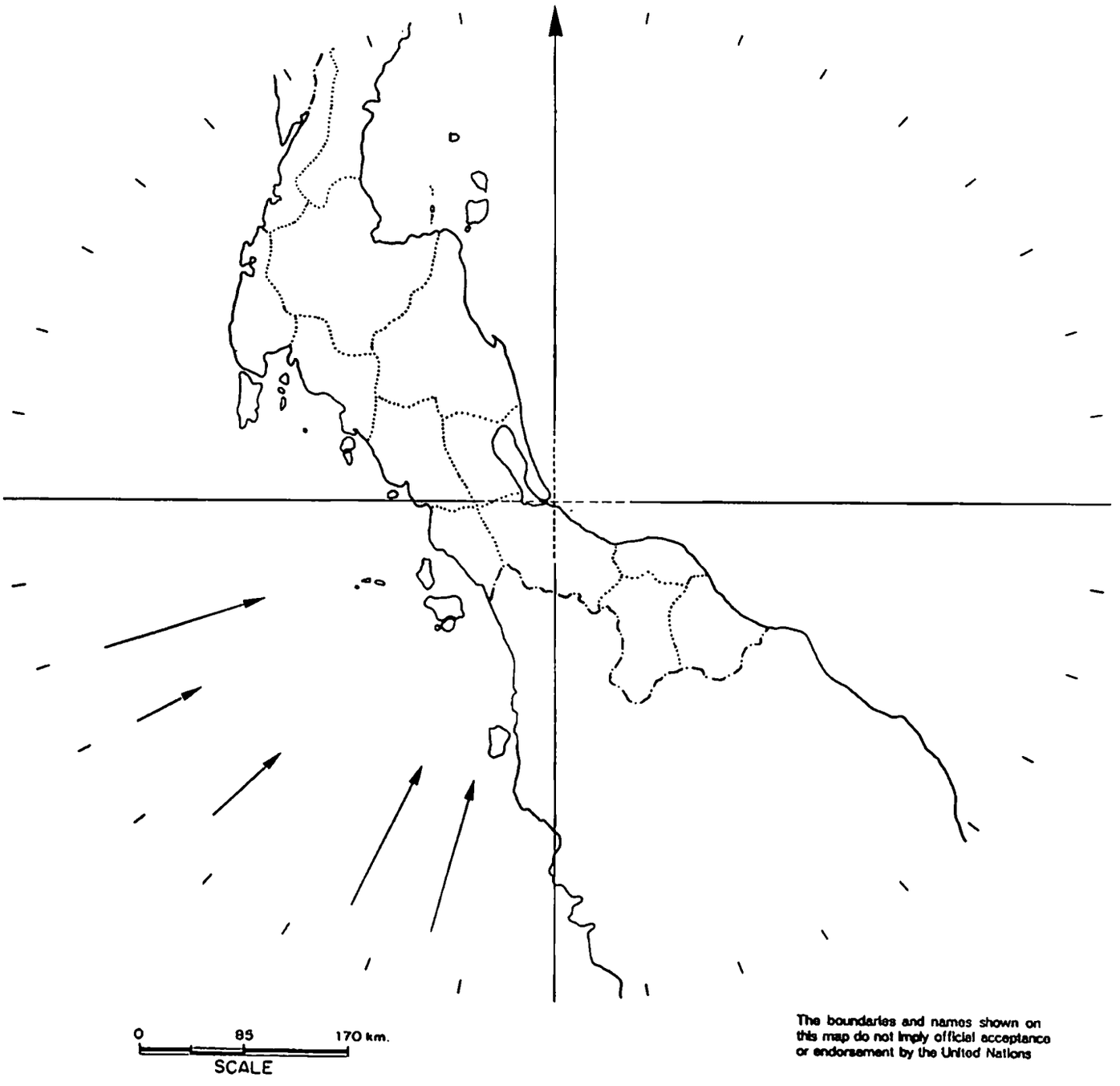

Figure 8. Wind direction during April-July

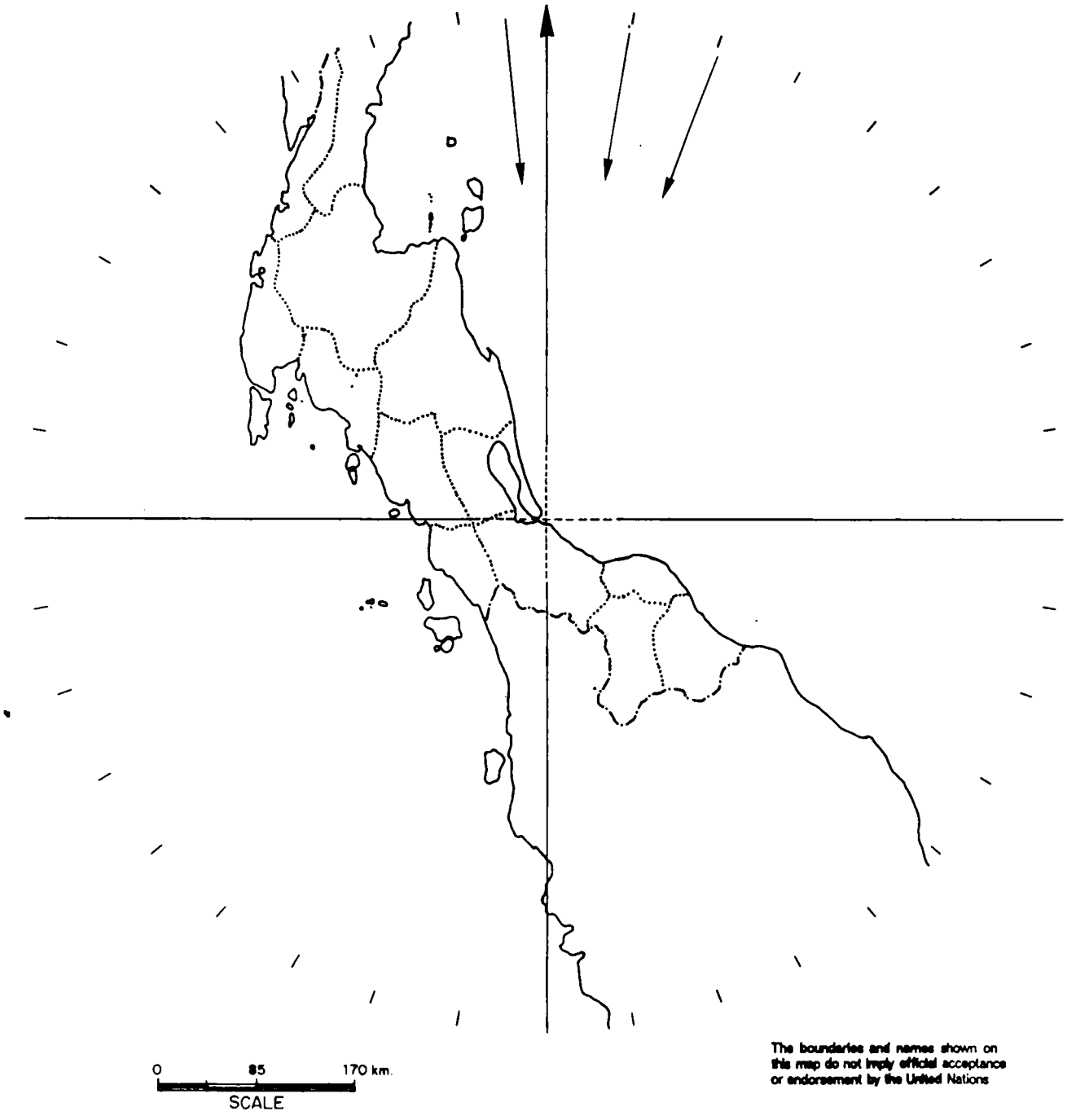

Figure 9. Wind direction during Sept -Jan.

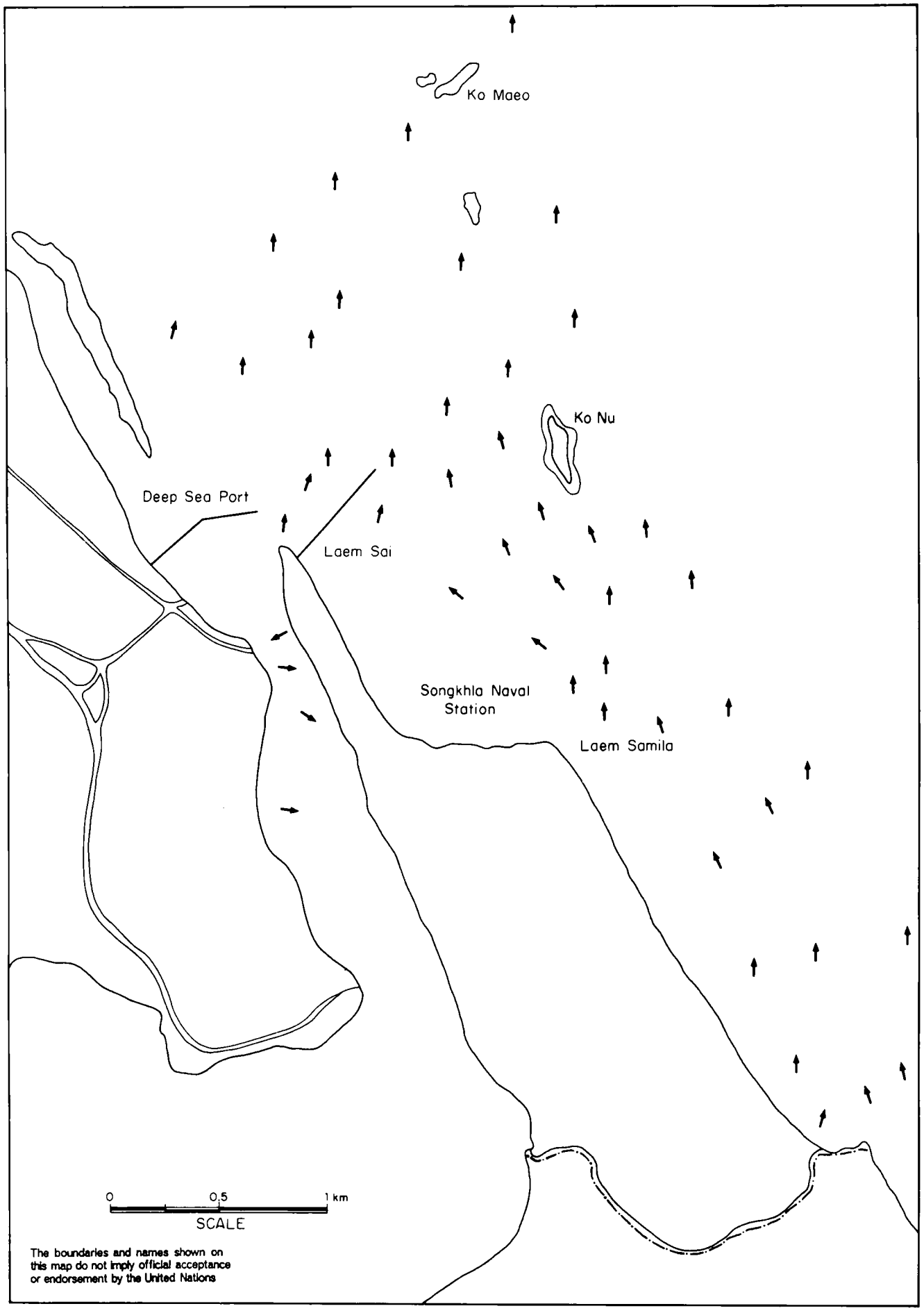

Figure 10. Current direction during April-July

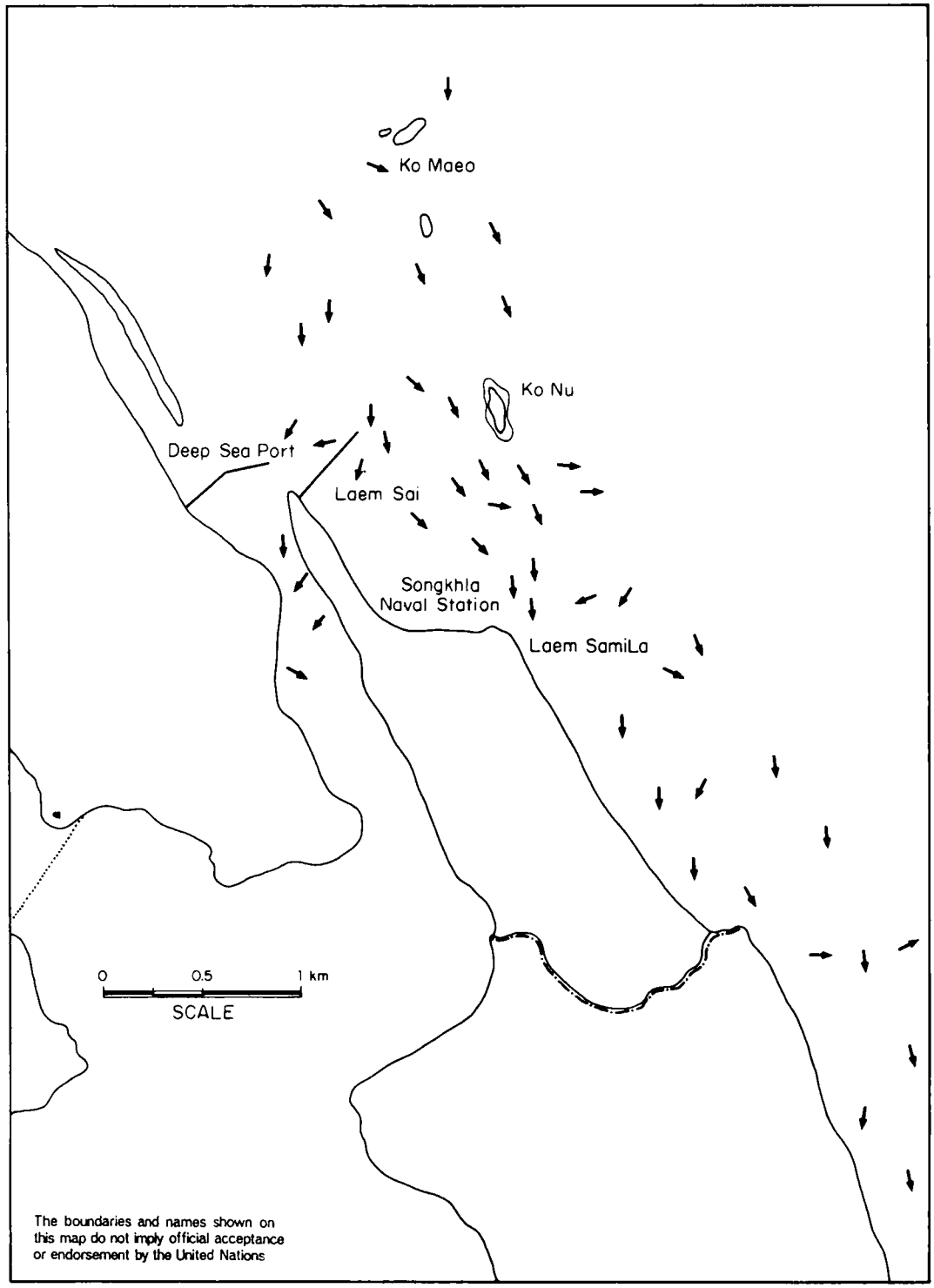

Figure 11. Current direction during Sept.-Jan.

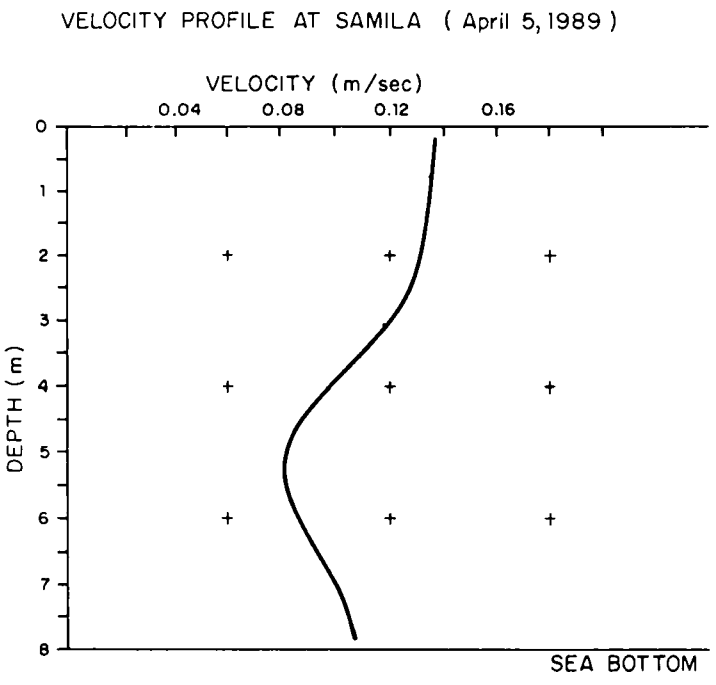

Figure 12. Velocity profile during April-July

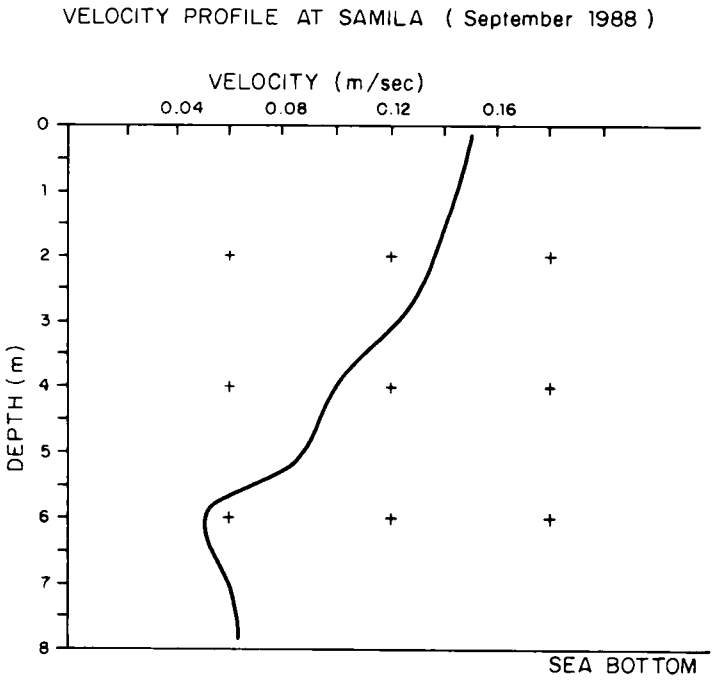

Figure 13. Velocity profile during Sept.-Jan.

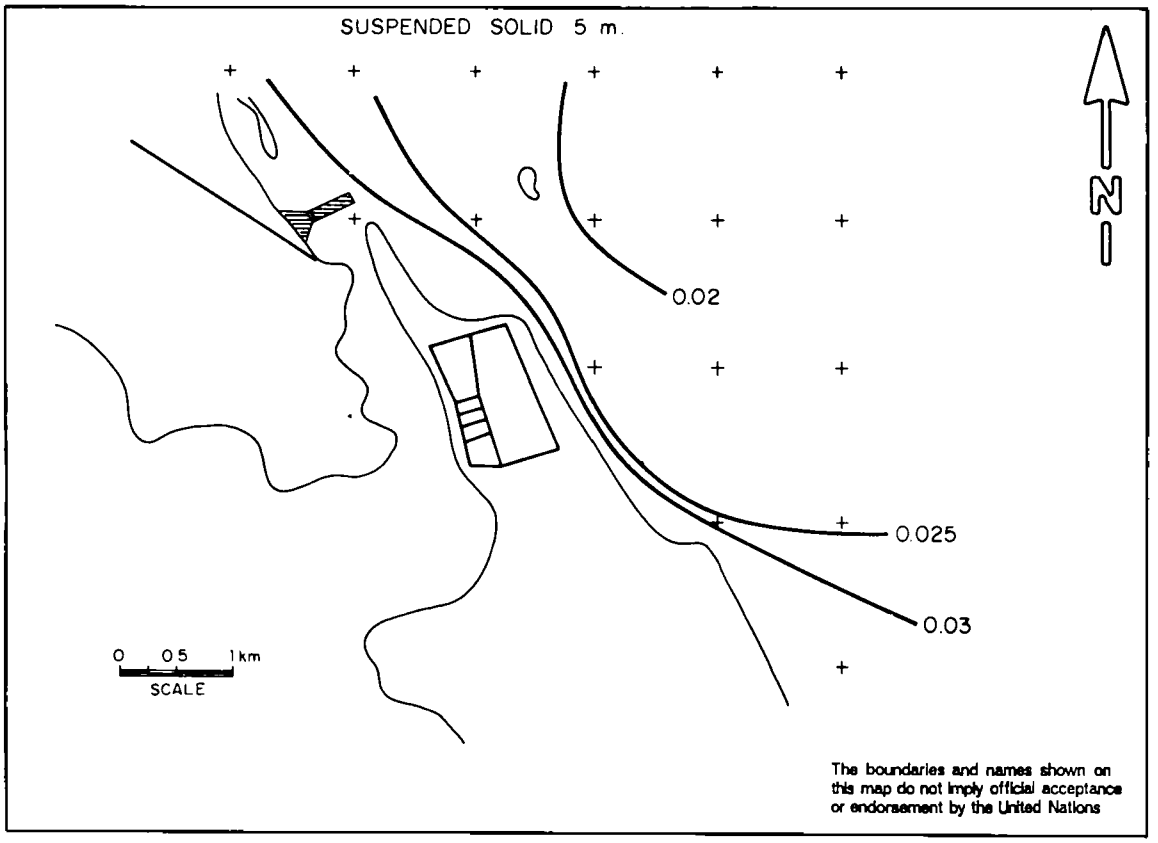

Figure 14. Suspended solids during April-July

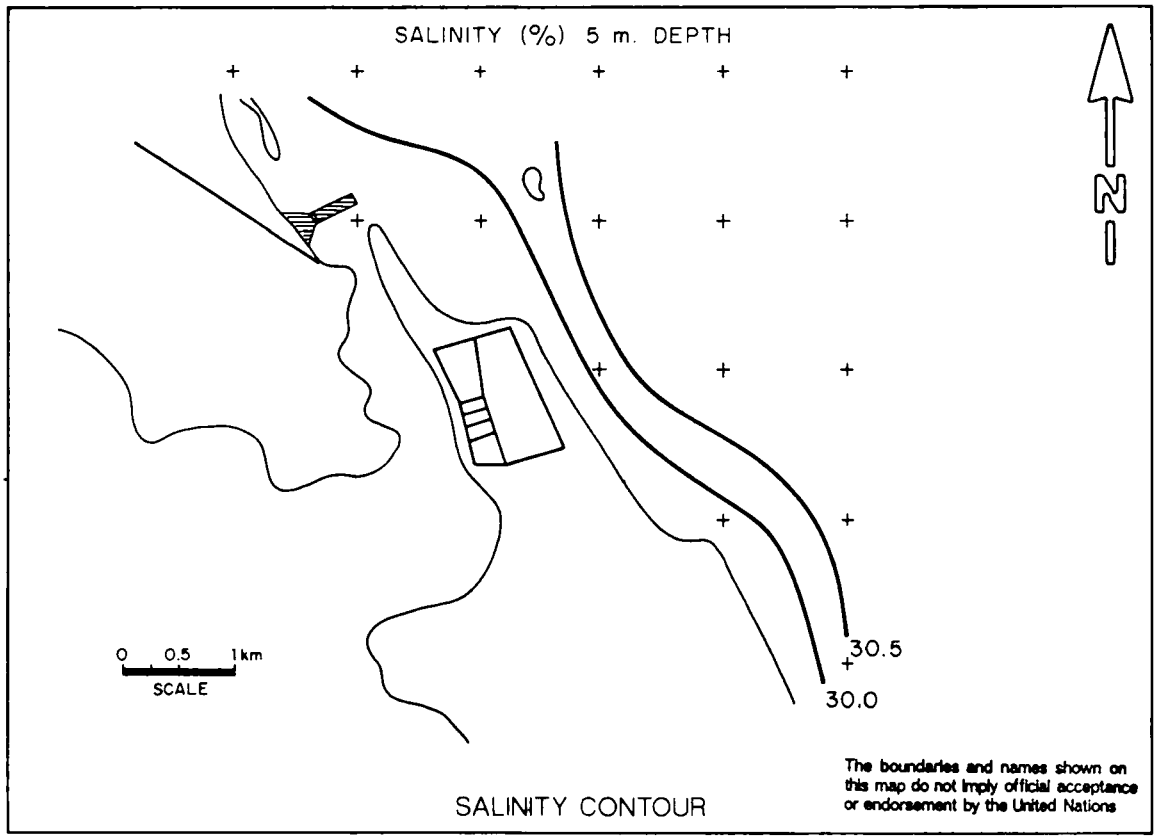

Figure 15. Salinity in Songkhla sea-water

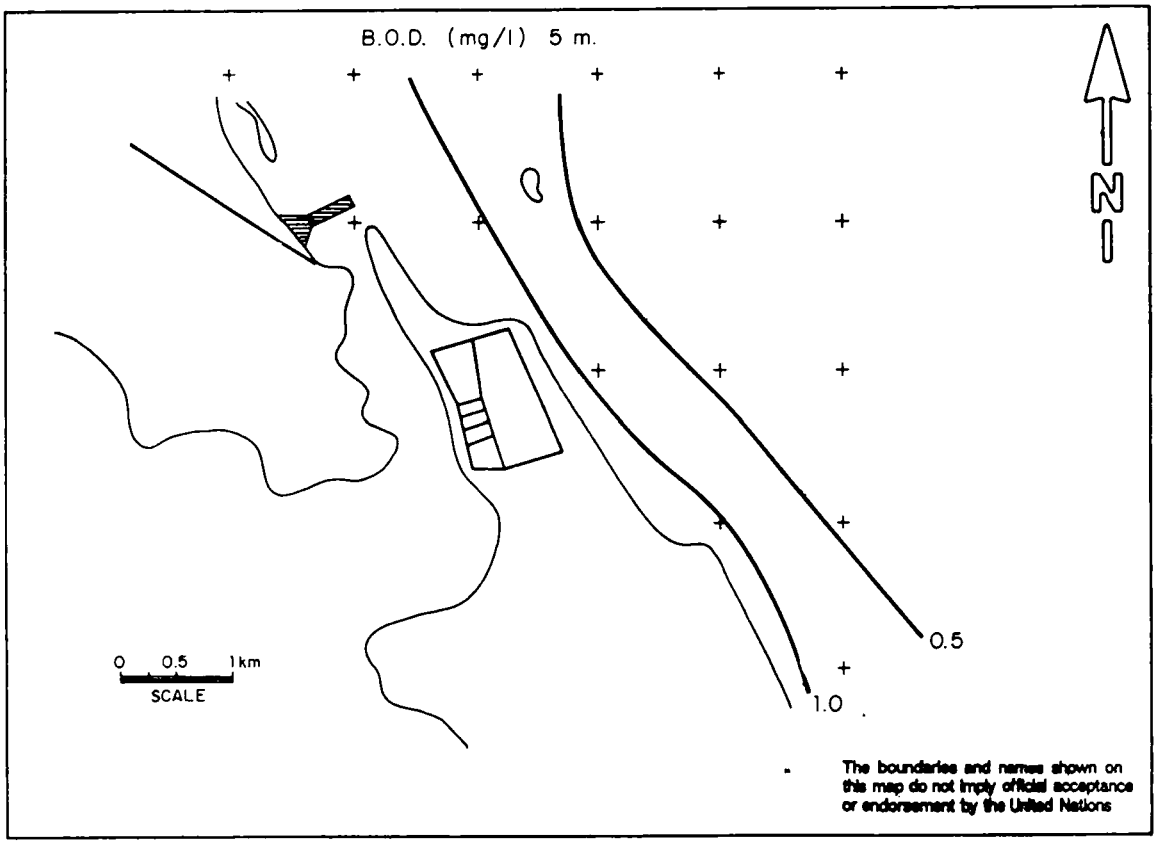

Figure 16. BOD contours of Songkhla sea-water

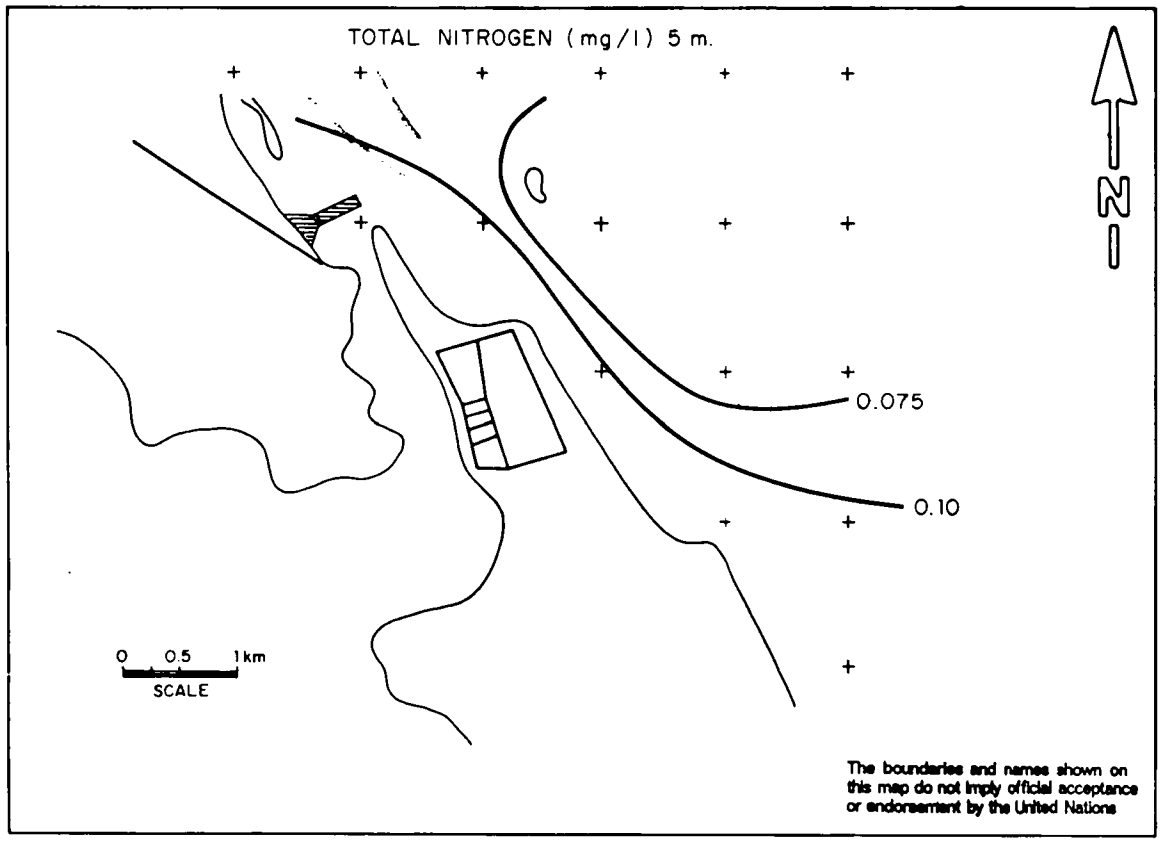

Figure 17. Total nitrogen contours of Songkhla sea-water

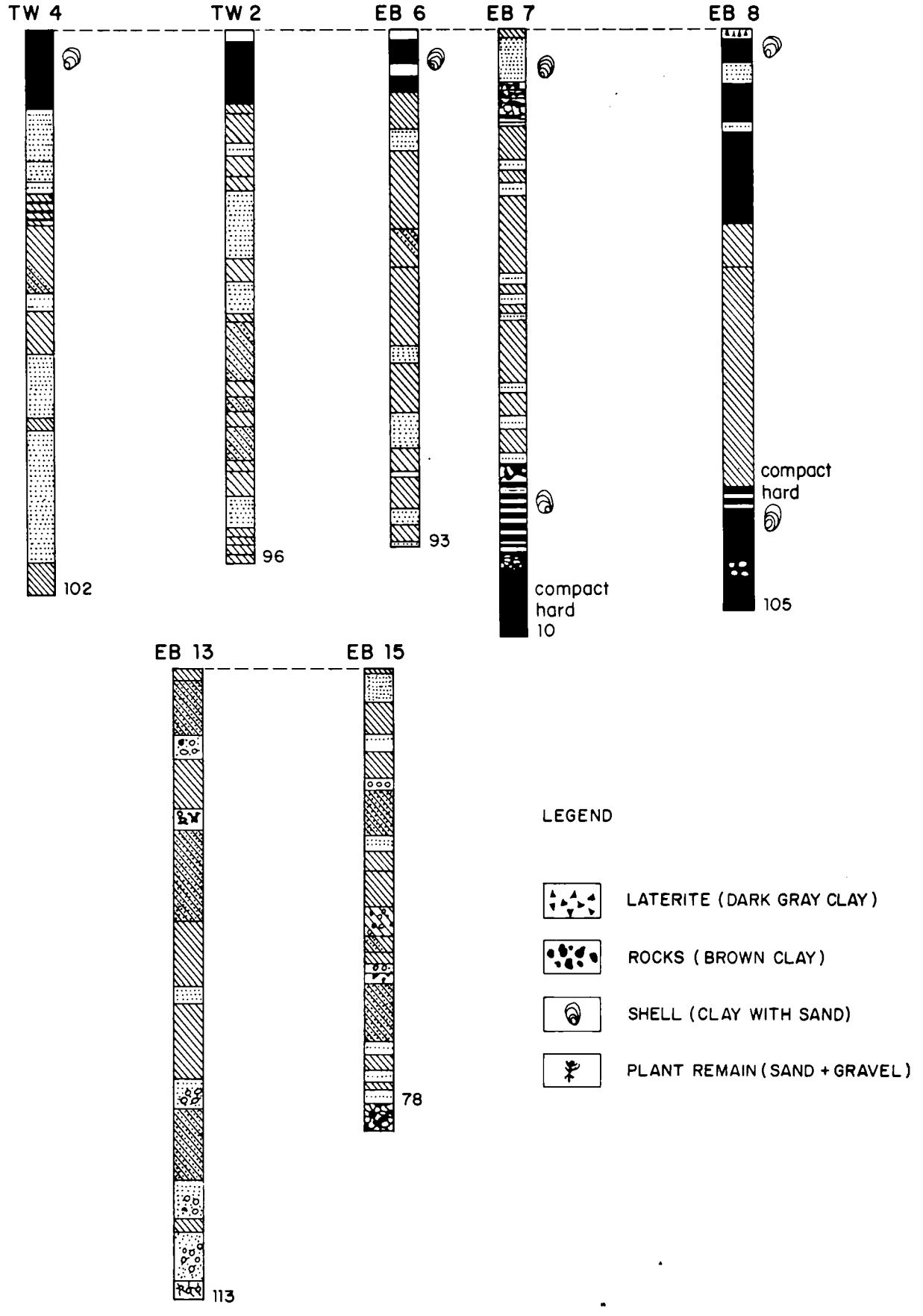

Figure 18. Geological sections of Songkhla seabed

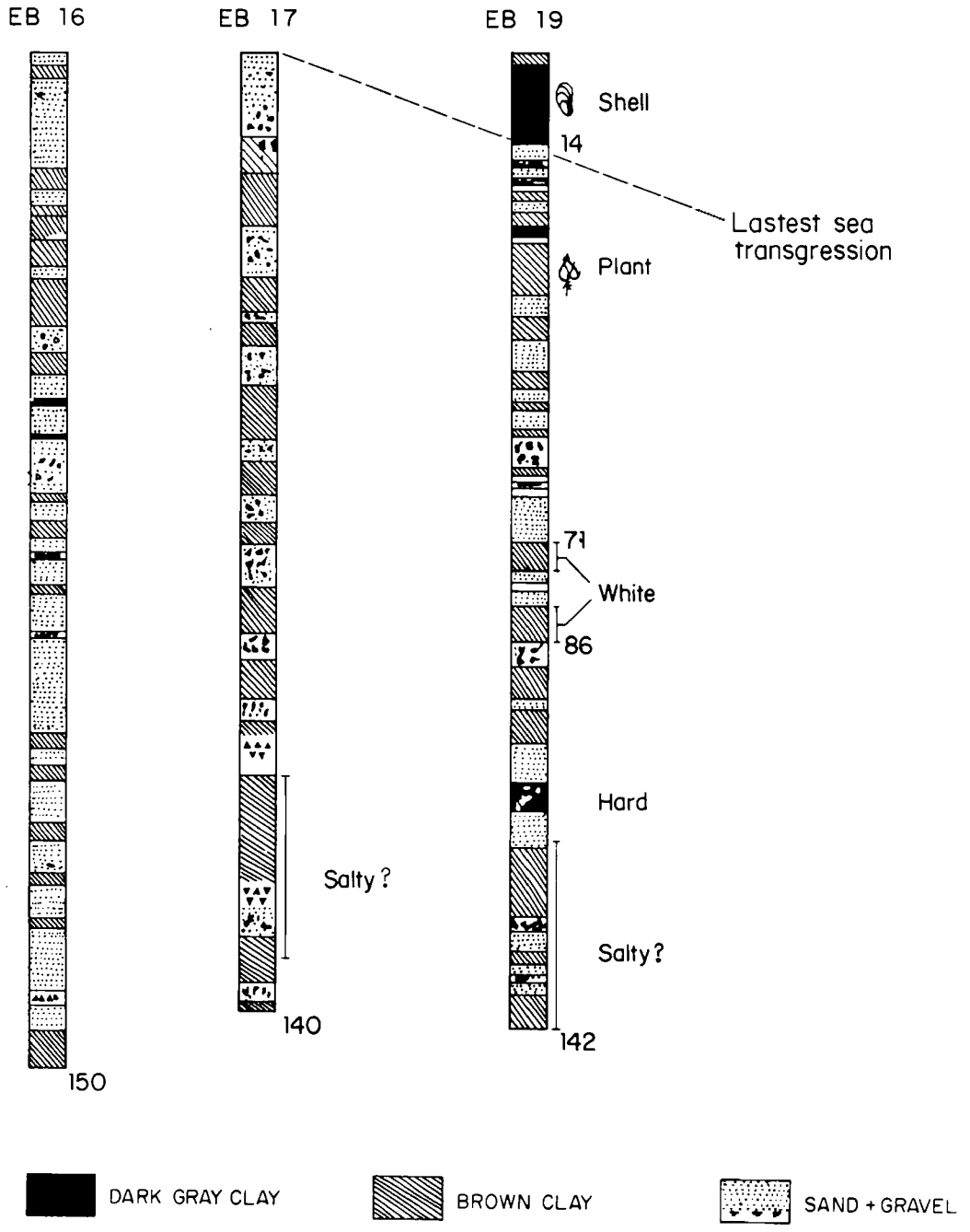

Figure 19. Geological sections of Songkhla seabed (continued from Figure 18)

SEADYKE AND LAND RECLAMATION IN VIET NAM

by
Pham Vu Dau[1] & Ngo Minh Huan[2]

Abstract

A 1,500 ha coastal lowland area of Quang Ninh province Vietnam was reclaimed and put into effective exploitation using local experience such as:

– Using soft clay with mangrove as reinforced element to place the dyke core.

– Construction of a drainage and irrigation system for irrigation and desalinisation.

– Planting of local species of rice which can grow in brackish water conditions but give a low productivity crop before planting high productivity species of rice.

As a result, a two agricultural cooperative commune with more than 7000 inhabitants live on an immense tidal flat which was once muddy and covered by wild vegetation.

1. Introduction

The Quang Ninh tidal land reclamation work lies on Northwestern part of Yen Hung district of Vietnam and it is 30 km from Hai Phong habour, in a North-East direction (see Fig 1).

The main purpose of the work is to prevent seawater from coming in and to reclaim the coastal lowland for agricultural use.

The main structures include:

+ A 4 km long seadyke with the following specifications:
  - Crest elevation : +4.5 m
  - Crest width : 3.0 m
  - Seaside slope : m = 1:5 with a stone revetment.
  - Inland slope : m = 1:2 with a berm 2 m wide at elevation +1.5 m.
+ A masonry sluice, reinforced concrete base, 5 gates, each gate 2.5 m wide. (Fig 7).

2. Topographical and Geological Conditions

The studied catchment is an almost round area with an average diameter of 5 km. The length from water divide to the dyke is 10 km. In the right bank are Na mountain (+ 229.00 m) and Vu Tuong Mountain (+165.00 m). In the left bank are low hills of Hiep Hoa and Cong Hoa villages with elevations of +20.0 m and +30.0 m respectively.

The area can be divided topographically into two distinctive terraces. The mountainous area, which includes mountains and hills, supplying water and the tidal flat which is now a 15 km^2 paddy land.

The tidal flat is about 6 km long and almost symmetrically divided by the river. The average ground elevation is +0.50 m, but at dyke section is about 0.0 m. The river bed is U-shaped. It is not deep but wide (river bed in the tidal plain section is relatively flat, i = 0.00067.).

The river flows from east to west and is influenced by diurnal tide. For P = 5 per cent the high tide is at elevation + 2.5 m and the neap tide at – 1.3 m. During high tide hours the flat was flooded and became a vast area with broken waves and violent wind, but at neap it became muddy and covered by mangrove and other wild vegetation which made it difficult for navigation by local inhabitants.

As regards to stratigraphy, the following soil layers are found:

– Recent mud (layer 2b) 0.30 m to 0.60 m thick in the tidal flat and 1.00 m thick in the river bed. It is brownish grey to blackish grey.

– Muddy silty clay (layer 2a), with organic matter such as decayed trees and shell, grey to blackish grey, saturated. The average thickness is 2 m. It was not possible to collect undistubed samples. This layer is widely distributed and was used as construction material.

– Brownish red clay with white mottlings, some gravel (layer 1), stiff, and a thickness not yet determined. There were some fine to medium sand seams found in the layer.

Some of the physical and mechanical properties are given in the following table:

Table I.

Soil layer	*Particle size*			*W*	*B*	*Atterberg limits*			*40*	*C*
	Clay	*Silt*	*Sand*	*(%)*		*WL*	*Wp*	*Ip*		
2a	33	57	10	60	2.1	41	23	18		
1	53	22	25	28	0.44	38	20	18	8	10	0.15

[1] Engineer, Deputy Director, Hydraulic Investigation & Design Institute.

[2] Engineer, Geologist Manager, Hydraulic Investigation & Design Institute.

3. Some Considerations on Stability of the Dyke.

The seadyke was constructed mainly based on the experience gained by provincial inhabitants during their enduring fight against nature.

It is well known that when an embankment of soft clay is placed on soft foundation, the cylindrical failure occurs. It usually starts with a vertical crack on the dyke crest then the soil mass slides.

In order to improve the stabilization potential of the dyke a combination of methods were employed so that the load can uniformly be distributed on the foundation, to increase bearing capacity of the foundation and to increase shearing strength of the dyke.

In order to meet the above requirements, mangroves were put in layers into soft clay as reinforced elements. The advantages of mangroves are:

Mangroves usually grow on tidal flats, where the soil is productive and grow very dense. It may reach the height of 1-2 m. Its shape is round with diameter of 2-3 cm (Fig. 11, 12) When fresh is very plastic and if submerged in water it would take a long time to decay. It is free from termite attack.

Layers of mangrove in clay behave as reinforced elements. Thanks to the high plasticity, these layers of mangrove can remarkably improve shear strength of the soil.

Layers of mangrove can act as horizontal-drain accelerating drainage and thus the consolidation process.

Layers of mangrove behave as bed layers and distribute load uniformly avoiding uneven settlement.

4. Construction Technique

The dyke was placed in 3 stages:

Stage 1:

* A dyke core was placed first to the high tide with the following specifications: (Fig. 3).

- Crest elevation : + 2.5 m
- Crest width : 2.0
- Slope : m = 1:5

Fill : soft clay, 2a layer and mangrove as reinforced element

* Spread a layer of mangrove 0.20-0.30 m on the entire area of the basement (9 m wide) then place a muddy soft clay layer 0.4-0.6 m, the layer of mangrove was proposed to reduce to 0.1-0.15 m.

* Continue placing in the same way until the design elevation was reached.

* When placing, mangrove layers should be put in such a way that they do not cross the whole cross section of the core so that it can prevent water from infiltrating through the mangrove layer.

* Dyke core must be raised above high tide (flux) of the day to prevent seawater from overflowing.

Stage 2:

After finishing stage 1 in a week, stage 2 began, the dyke has the following specifications:

- Crest elevation : + 3.5 m
- Crest width : 2.0 m
- Outside slope : m = 1:5
- Inside slope : m = 1:2

Fill : soft clay without mangrove.

Stage 3:

After finishing stage 2, a rest of 1 month was needed and then stage 3 began. In this stage the dyke was placed in the same way as it was done in stage 2 (Fig 4).

Finally the seaside slope was armoured by stone to prevent it from being eroded by action of waves (Fig 8).

5. Closure of the Final Gap

When placing an estuary dam or seadyke the following procedures were usually employed:

First, placing across channels, and waterways. The main river is left to discharge flood in rainy season and seawater. Placing from both sides and the main flow is closed finally at certain sections at a certain time of the day. This way of river closing has the advantage that the placed section serves as a pathway for transporting fill material from banks. However, this procedure usually gives rise to difficult problems as closure proceeds, the fall (i.e. the difference in water levels on both sides of the gap) will increase. This causes an increase in current velocity, necessitating the use of flow resistant dumping material during the entire closing procedure. That was why in this work the main flow was impounded before placing the last 2500 m section on the left bank. The original river bed had to be protected against scouring effects which are expected to occur. This was done by spreading a layer of boulders 2-3 m thick, and 10-15 m wide. The boulder jetty is advancing from A to B when it reached the length of 10 m. The main flow was diverted, soft clay was placed inside the jetty in the 3rd stage as shown in Figures 5 & 6.

First, part I was placed to the elevation of + 3.00 m at the crest and the slope was 1:2 on the inside and 1:3 on the outside. When the boulder jetty reached the river bed the same work began on the B side to prevent the encircling dyke and sluice from being eroded by action of flowing water. The final gap was about 50 m from B (Fig. 5).

6. Management and Operation

The work has been in effective operation since 1979. After 10 years of operation the following conclusions could be drawn:

– The dyke is stable, and no slides, nor boiling water point have been observed so far.

– The dyke subsides annually, the crest is eroded, and a regular replenishment is needed.

– Local material such as soft clay, which is widely distributed can be used in seadyke construction if treated using layers of mangroves, a wild vegetation which has no economic value, as a reinforcing element.

7. Land Reclamation and Crop Pattern

After placing the dyke, measures for land reclamation and intensive farming were employed:

– Conveying fresh water from Yen Lap reservoir 15 km away from the dyke.

– Construction of irrigation and drainage canals system (Fig. 10).

– Normally, on tidal flats rush is planted first and it would take 4 years for the land to be completely desalinized (Fig. 13). Then the local species of rice could be grown. However, thanks to fresh water, rice could be planted in the area.

8. Social and Economic Impact

As mentioned above, the area is a coastal lowland, which was muddy and covered by wild vegetation and influenced by duirnal tide and is now a productive paddy land of about 1500 ha. Due to proper measures of desalinization and intensive farming the rice productivity is increasing. In 1981 the rice productivity was 1500 kg/ha a year. In 1985 it rose to 2500 kg/ha and the last crop was more than 2700 kg/ha.

In the area, which was once deserted, a commune with two agricultural cooperatives and more than 7000 inhabitants was established with a general school and a medical centre. The living standards of the people were improved considerably. On the left bank, in agricultural cooperative 1, the landscape is animated and the people are constructing houses (Fig. 15). On the right bank the settlements are involved in cultivation, cattle breeding and fishing (Fig 16).

9. Conclusions

The paper has focused on 3 main problems:

– Firstly, soft clay can be used in seadyke construction using mangroves as a reinforcing element.

– Secondly, in estuary dams and seadyke construction, the river impoundment should be made prior to placing the last section on the tidal flat.

– Thirdly, irrigation by fresh water and introducing crop patterns are essential in coastal lowland reclamation.

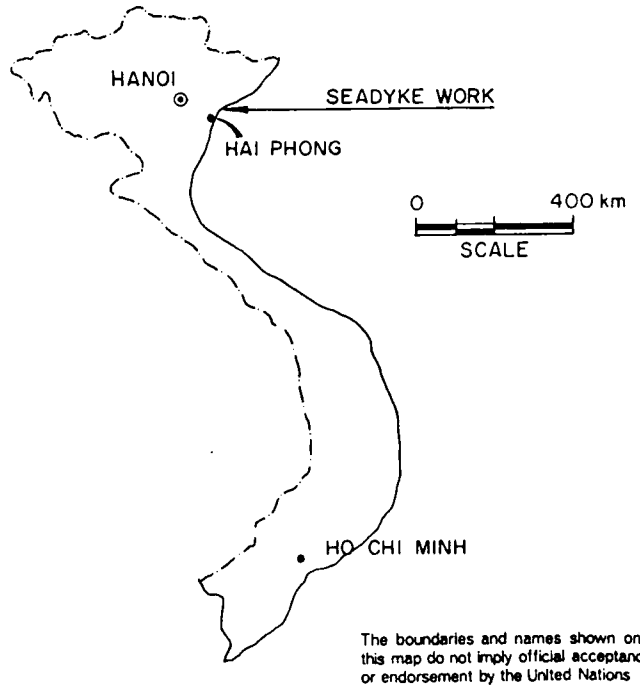

Figure 1. Location map

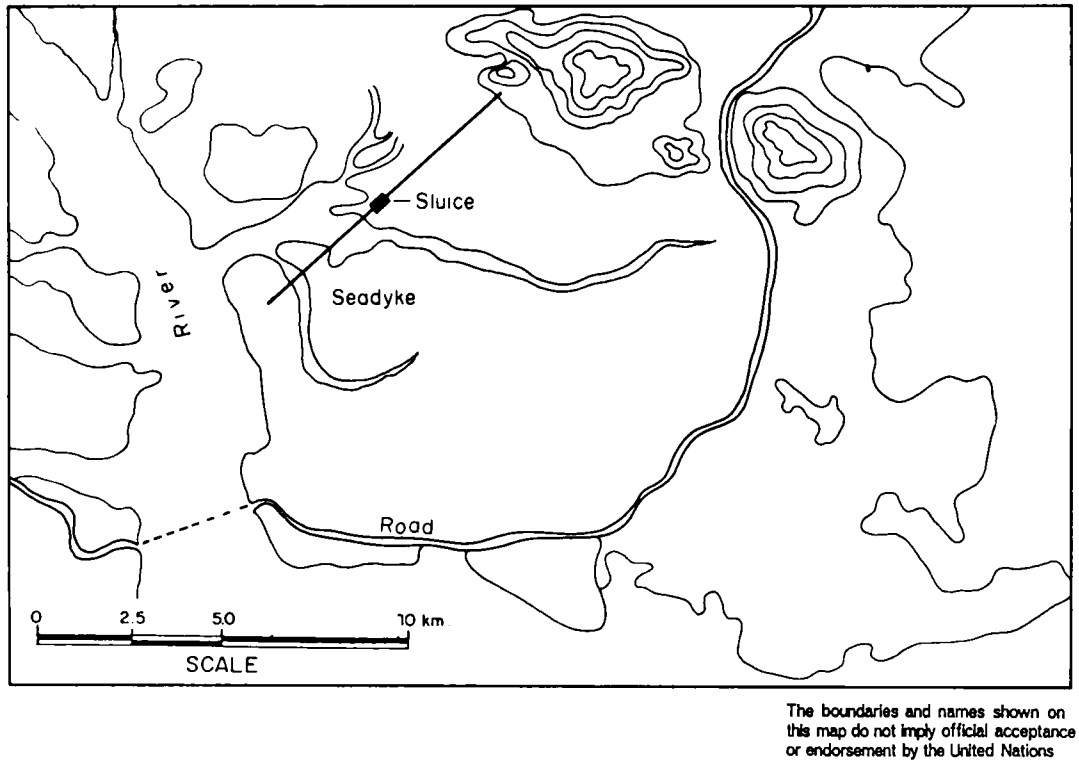

Figure 2. Headworks layout

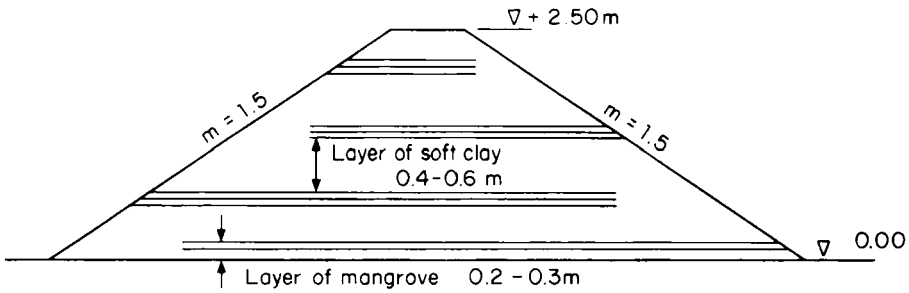

Figure 3. Dyke core

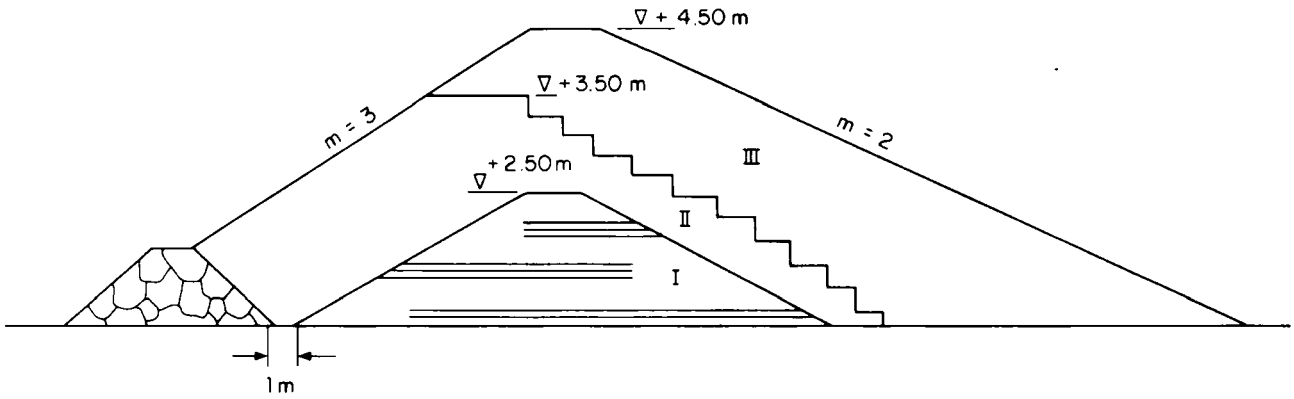

Figure 4. Cross-section at tidal flat section

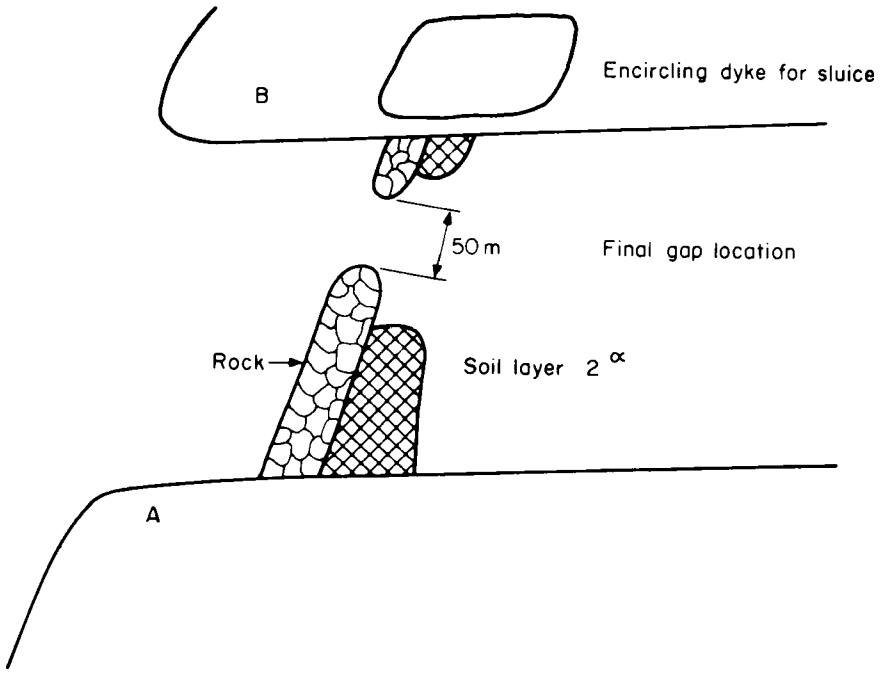

Figure 5. Closure of final gap

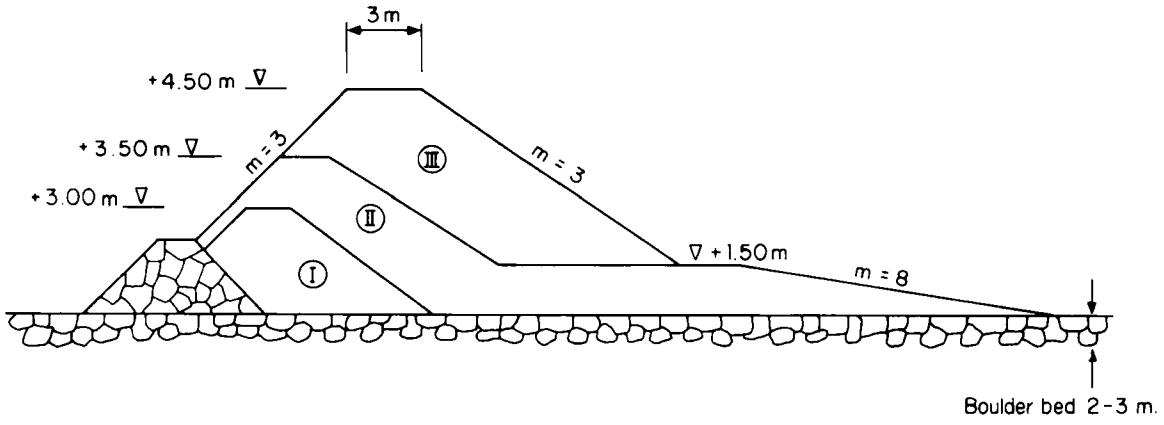

Figure 6. Cross section at river bed

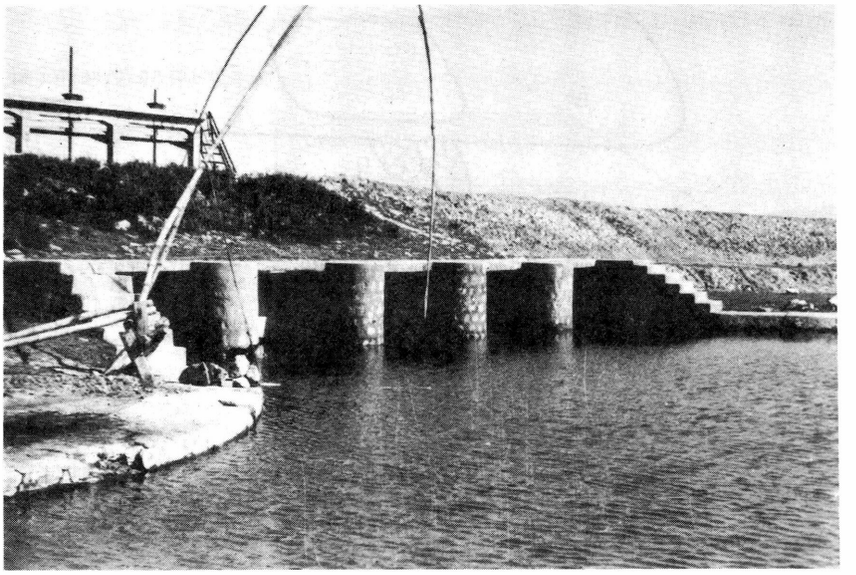

Figure 7. Gate 5 sluice

Figure 8. Armoured stone on seaside slope

Figure 9. View of the land side of the dyke showing the 2 m wide berm.

Figure 10. Drainage and irrigation canals

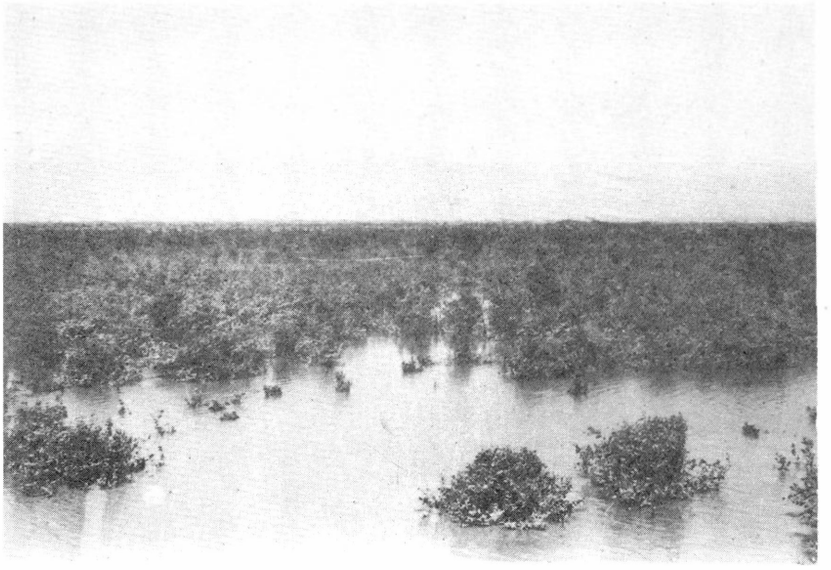

Figure 11. Mangrove

Figure 12. Mangrove

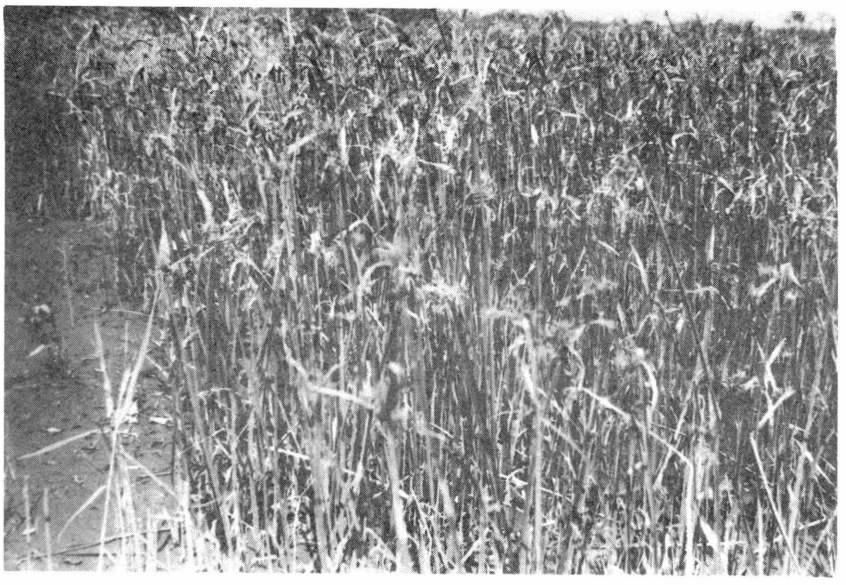

Figure 13. Rush field

Figure 14. Rice field

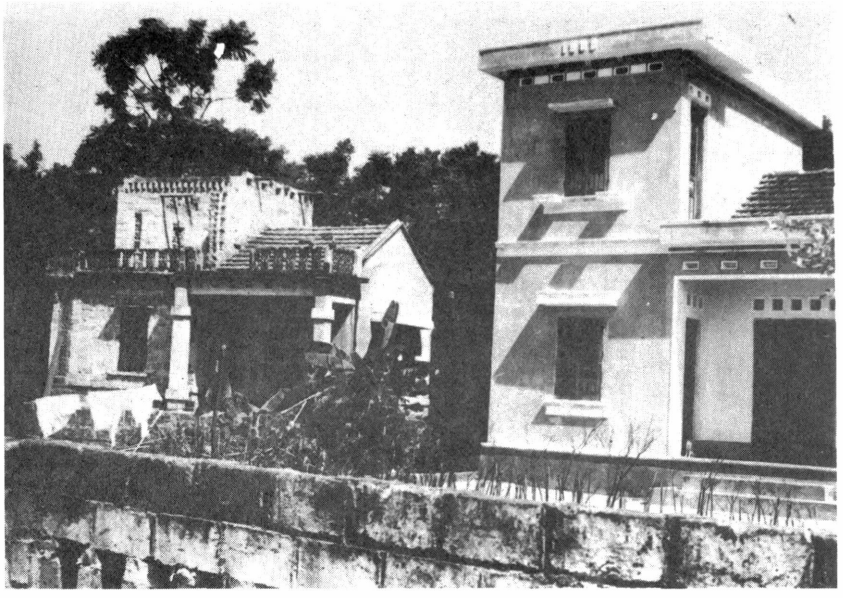

Figure 15. Two-storied house on the right bank

Figure 16. New human settlement