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MINISTRY OF WATER RESOURCES
BANGLADESH WATER DEVELOPMENT BOARD

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MEGHNA ESTUARY STUDY

DRAFT DEVELOPMENT PLAN

VOLUME 5 : PRE-FEASIBILITY STUDIES LAND DEVELOPMENT
PART - 1: RANGABALI - CHAR BISWAS
PART - 2: HATIA - MANPURA
PART - 3: URIR CHAR - CHAR PIR BAKSH

March 1999

DHV CONSULTANTS BV

in association with

KAMPSAX INTERNATIONAL
DANISH HYDRAULIC INSTITUTE

DEVELOPMENT DESIGN CONSULTANTS
SURFACE WATER MODELLING CENTRE
AQUA CONSULTANTS AND ASS. LTD.

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PART 1

RANGABALI - CHAR BISWAS

TABLE OF CONTENTS

P1-1	INTRODUCTION	1
1.1	General description of the area	1
1.2	Rationale of the project	1
1.3	Project approach	1
1.4	Key assumptions	3
P1-2	MORPHOLOGICAL DEVELOPMENTS	3
2.1	Introduction	3
2.2	Objectives of the morphological study	3
2.3	Physical features	4
2.3.1	Tide	4
2.3.2	Bathymetry	4
2.3.3	Coastline migration	4
2.3.4	Waves	5
2.3.5	Tidal flow and sediment concentration and volume	5
2.4	Expected morphological developments	5
P1-3	PRESENT SITUATION	11
3.1	Physical setting	11
3.1.1	Topography	11
3.1.2	Climate	11
3.1.3	Soils	11
3.1.4	Land use	11
3.1.5	Flooding	11
3.1.6	Cyclones	12
3.2	Socio-economic setting	12
3.2.1	Demography	12
3.2.2	Land ownership	12
3.2.3	Credit and indebtedness	12
3.2.4	Income and sources of income	12
3.2.5	Communications	12
3.2.6	Education and literacy	12
3.2.7	Health	13
3.3	Hydraulic Infrastructure	13
3.4	Water Management	13
3.4.1	Polder Management	13
3.4.2	Operation	13
3.4.3	Maintenance	13
3.4.4	Drainage	15
3.4.5	Salinity	15
3.5	Agriculture	15
3.6	Livestock	16
3.7	Fisheries	16
3.8	Forestry	17
3.8.1	Background	17
3.8.2	Existing forest	17
P1-4	FUTURE WITHOUT PROJECT	18
4.1	Land accretion and land development	18
4.2	Physical and social infrastructure	19
4.3	Water management	19
4.3.1	Unprotected land	19
4.3.2	Flood protection	19
4.3.3	Drainage	19
4.3.4	Desalinisation	19

4.4	Agriculture	19
4.5	Livestock	20
4.6	Fisheries	20
4.7	Forestry	20
P1-5	PROPOSED INTERVENTIONS	21
5.1	Cross dams	21
5.1.1	Basic data	21
5.1.2	Cross dam design	22
5.1.3	Proposed cross dams	24
5.1.4	Implementation of the cross dams	24
5.1.5	Cost estimates of the cross dams	24
5.2	Empoldering of char land	26
5.2.1	Empoldering of Bara Baishdia, Polder 50/51, Year 1 and 2	26
5.2.2	Empoldering of Char Halim and Char Ganga, Compartment BB-2, Years 6 and 7	29
P1-6	DEVELOPMENT FOR THE PROJECT AREA	31
6.1	Development concept	31
6.2	Land accretion	31
6.3	Land development	34
6.4	Needs assessment	34
6.5	Project interventions	34
6.5.1	Safety of the population	34
6.5.2	Roads and transport	34
6.5.3	Settlements	35
6.5.4	Agriculture	35
6.5.5	Fisheries	36
6.5.6	Livestock	37
6.5.7	Forestry	38
6.6	Integrated water management	38
6.6.1	Project formulation and planning	38
6.6.2	Participation in water management	39
P1-7	IMPACT OF THE PROJECT	39
7.1	Physical infrastructure	39
7.2	Social infrastructure	39
7.3	Water management	39
7.4	Agriculture	40
7.5	Livestock	40
7.6	Fisheries	41
7.7	Forestry	41
P1-8	ENVIRONMENTAL ASPECTS	41
8.1	Aims and objectives of the environmental assessment	41
8.2	Proposed interventions	42
8.3	Baseline environmental conditions and future trends	42
8.4	Impact identification, quantification and valuation	42
8.4.1	Identified positive impacts	43
8.4.2	Identified negative impacts	44
8.4.3	External impacts and constraints	45
8.5	Environmental mitigation	45
8.5.1	Ghat relocation	45
8.5.2	In-shore marine habitats	46
8.5.3	Fisheries	46
8.5.4	Cholera	46
8.5.5	Direct construction impacts	46
8.6	Residual impacts	46
8.7	Environmental risk	46
8.8	Environmental monitoring and management	47

8.9	Conclusions of the environmental assessment	47
8.10	Future environmental work programme	47
P1-9	PRELIMINARY ECONOMIC ASSESSMENT	48
9.1	Project costs	48
9.2	Project benefits	49
9.3	Preliminary economic analysis	49
9.4	Conclusions	50
REFERENCES		63

LIST OF TABLES

Table P1-3.1:	Showing plantation area and growing stock	18
Table P1-5.1:	Tidal levels at Khepupara	22
Table P1-5.2:	Details of proposed cross dams	24
Table P1-5.3:	Cost estimate for cross dams	25
Table P1-5.4:	Features of the primary embankments	27
Table P1-5.5:	Estimated cost of primary embankments	27
Table P1-5.6:	Future drainage situation polder 50/51	28
Table P1-5.7:	Cost of new sluices	28
Table P1-5.8:	Excavation and re-excavation of drains	28
Table P1-5.9:	Investment physical intervention cost Bara Baishdia	28
Table P1-5.10:	Estimated cost of primary embankments	29
Table P1-5.11:	Future drainage situation polder 50/51	29
Table P1-5.12:	Cost of new sluices	30
Table P1-5.13:	Excavation and re-excavation of drains	30
Table P1-5.14:	Investment physical intervention cost Char Halim and Char Ganga	30
Table P1-6.1:	Present and potential aquaculture yields	36
Table 9.1:	Cost estimate for empolderment of North Char and Kasher Char	49
Table 9.3:	Results of preliminary analysis for Rangabali - Char Biswas	49
Table 9.2:	Summary of project costs	51

LIST OF FIGURES

Figure P1-1.1:	Location of the project area	2
Figure P1-2.1:	Potential sites for cross dams	6
Figure P1-2.2:	Frequency curves of daily high water levels at Khepupara	7
Figure P1-2.3:	Frequency curves of daily low water levels at Khepupara	8
Figure P1-2.4:	Exceedance frequency curve at Khepupara	9
Figure P1-2.5:	Coastline development of the Rangabali-Char Biswas area	10
Figure P1-3.1:	Situation of project area in February 1996	14
Figure P1-5.1:	Section and side view of cross dams	23
Figure P1-6.1:	Future accretion without intervention	32
Figure P1-6.2:	Future accretion with intervention	33

APPENDICES

Appendix I	52
Appendix II	57
Appendix III	61

P1-1 INTRODUCTION

1.1 General description of the area

The project area (Figure P1-1.1) is located in Galachipa thana of Patuakhali district at the outfall of the Tetulia River.

The main chars (islands) in the project area are Rangabali, Bara and Chota Baishdia, Char Biswas and Char Kajal. Rangabali-Baishdia islands are separated from the Char Biswas-Char Kajal islands by the Bura Gauranga River.

This river runs in an almost north-south direction between the Rangabali and Char Biswas. The Bura Gauranga river also bounds the project area on the eastern and south-eastern side and the Danrchhira river bounds it to the west.

There are other small creeks inside the islands. Satellite images show that the creek named Rangabali 'Done' located between Chota Baishdia and Rangabali is silting up.

Inspection of satellite images for the period 1973-96 reveal that land areas of the islands are increasing through siltation on their leeward sides and also by sedimentation of the channels inside the islands. Land formation activities are still continuing in the south, south-east and south-west of the project area. The elevation of natural levees along channel banks is higher than the land located away from channel banks.

1.2 Rationale of the project

The socio-economic and agricultural development in the project area are hampered by

- flooding from the Tetulia River and from the tidal creeks
- increase in soil salinity in the dry season due to intrusion of saline water
- drainage congestion during high tide

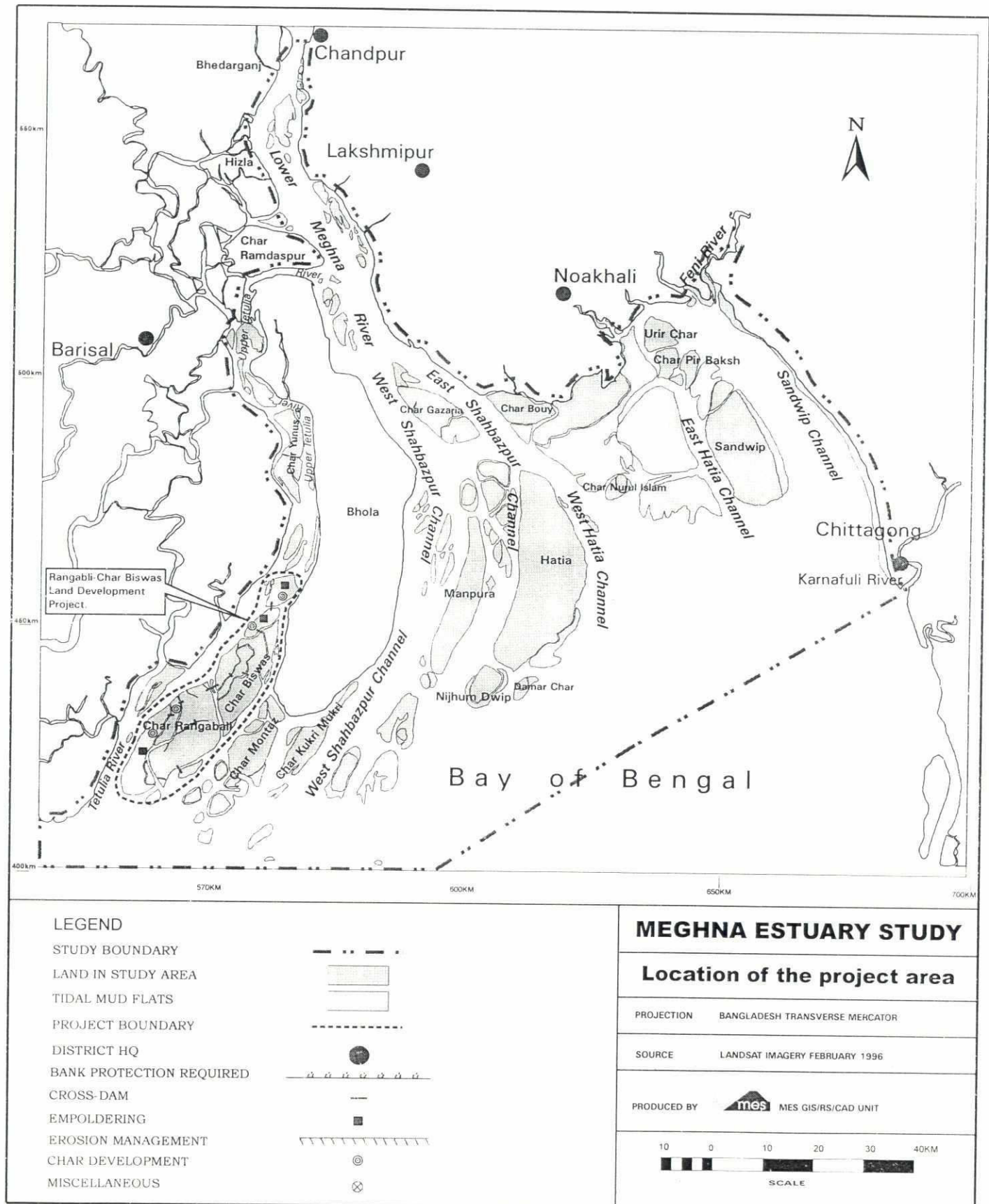
This pre-feasibility study is for a project that would aim to enhance land accretion by the construction of cross dams, control flooding, reduce salinity and improve drainage and water management over the next 5 to 10 years through a multidisciplinary and integrated development approach. The overall objective is to enhance security for the population in the area and improve socio-economic conditions.

1.3 Project approach

Interventions, such as cross dams, which accelerate the accretion of new land, present a dilemma from the economic point of view. Newly accreted land is saline, subject to tidal intrusions and low in fertility. For land to accrete to a sufficient level so that it can be successfully embanked and so that effective drainage and water management can gradually eliminate soil salinity takes a considerable number of years. The organic matter content of the soils is initially very low and increases only slowly. As long as these soil conditions prevail, agricultural yields are low. There is thus a long delay between investment in a cross dam and the commencement of a significant flow of benefits.

For these reasons it is appropriate to adopt an integrated development approach to the proposed development activities for chars in the Meghna estuary. By combining land accretion with land development and designing projects that incorporate cross dams, embankments, drainage and water management together with measures to increase the productivity and production of agriculture, livestock and aquaculture and other activities it is possible to design feasible development projects for these areas.

Figure P1-1.1: Location of the project area.



1.4 Key assumptions

The preparation of a pre-feasibility report requires the making of assumptions, especially with regard to the reliability and processing of data. For this study, the critical assumptions refer to the sequence of land development on newly accreted land and the role of mangrove forests on the estuarine chars. In particular, it is assumed that:

- new land reaching the level of +0.4 m PWD will be planted in mangroves
- mangrove forest which has reached the age of 15 years may be cleared for agriculture and other uses provided that a minimum depth of 1 km of forest is maintained all along the future coast at all times as an essential part of the protective barrier providing security against storms to the population
- existing forest which will be inside the proposed new polders will be cleared for agriculture after construction of the embankments.

P1-2 MORPHOLOGICAL DEVELOPMENTS

2.1 Introduction

Within the framework of the Meghna Estuary Study, the possibility of implementing cross dams in the project area has been studied. The potential sites for cross dams within the project area are shown in Figure P1-2.1. The cross dams will accelerate accretion because flow velocities in the closed channel section will be drastically reduced. Bank erosion due to the current will also stop in the channels.

To reduce the construction costs of such dams, the MES proposes to use geotextiles. Geotextiles will be spread out along the bottom across the channel and the space under the geotextile is filled with sand. This geotextile with sand acts as a base for the cross dam, to protect the bed against erosion during construction.

As a part of the pre-feasibility study of the Rangabali-Char Biswas Development Project, a morphological study has been carried out to ascertain the effects of cross dam construction on the morphological development of the area. Four options have been studied.

2.2 Objectives of the morphological study

The objectives of the present morphological study, carried out as a part of the pre-feasibility study, are as follows:

- to draw up an inventory of relevant reports, bathymetric maps, aerial photographs, satellite imagery, cross-sectional soundings, water levels, flow velocities, discharges, sediment concentration and grain size distribution
- to describe the morphological development of the study area during the last decades (in terms of accretion and erosion and land levels)
- to improve the understanding of the morphological phenomena in the area with the aid of satellite imagery as well as other historical data on bathymetry and land formation
- to assess long term changes of land formation and char development
- to make a preliminary assessment of the morphological impact of cross dam construction.

2.3 Physical features

There are old and emerging islands, tidal channels and creeks and mangrove forests in the area.

The low lying areas inside the islands are connected by numerous creeks. These creeks drain the individual drainage areas into the surrounding channels. The land levels in and around Rangabali and Char Biswas have reached Mean Higher High Water (MHHW) level and the area is flat.

Mangroves were planted in the newly accreted land situated at the south of Rangabali and Char Biswas.

2.3.1 Tide

As the area is located at the outfall of the Tetulia River close to the landward periphery of the Bay of Bengal, the tidal levels in the Bay affect the area, specially during high tide.

The tidal motion inside and around the project area dominates during both the pre-monsoon and post-monsoon. During the months of November through April, the high tide enters the project area but mostly remains within the channels, except during storms and cyclones.

From April onward, high tides start inundating the low lying areas and increase to their peaks in August. The tide is semi-diurnal with M2 and S2 as the major tidal constituents. At Khepupara, the high water levels and low water levels vary from +2.0 to +4.5 m CD and 0.0 to +2.5 m CD, respectively (conversion factor PWD = CD - 1.96 m). The seasonal variation of mean high water level at Khepupara is about 1 m (Figure P1-2.2) and that of mean low water level is about 0.75 m (Figure P1-2.3).

A frequency exceedance curve (Figure P1-2.4) has been prepared for the water levels of Khepupara, located close to the project area, which shows for how much of the time in a year a particular level remains under water. For example, -0.7m PWD remains under water for about 90 per cent of the time.

Saline water enters the project area during December to May. The Tetulia River supplies the major portion of upland fresh water flow into the area but as it does not carry as much fresh water as the other channels in the estuary, the tidal flow dominates even during the monsoon. This is evident from the difference of seasonal variation of mean high and low water levels.

2.3.2 Bathymetry

The channels inside and around the project are shallow in comparison with other channels (e.g., Shahbazpur Channel, Hatia Channel, Lower Meghna) in the estuary. Bathymetric data of 1997 shows that the maximum localised depth in the Bura Gauranga River between Rangabali and Char Biswas is about 6 m but the average depth varies between 3 and 4 m. This channel between these two islands is shallow at its northern end and relatively deep at the southern end. It is an important navigation route between the area around Galachipa and Char Montaz-Char Fasson (South Bhola) but it seems that it is silting up.

2.3.3 Coastline migration

The islands and chars increase or decrease in size through the migration of their coastlines. Satellite images of 1957, 1973 and 1996 (Figure P1-2.5) show that the project area did not increase significantly between 1957 and 1973 but it increased significantly between 1973 and 1996.

At the northern tip of the project, Kasher Char and the small island south of it developed between 1973 and 1976. Between 1973 and 1996, Rangabali island gained most in area among all the existing islands with its area in 1957, 1973 and 1996 being about 90.6, 95.2

and 130.6 km², respectively. Between 1973 and 1996, Rangabali grew by almost 37 per cent while Bara Baishdia grew by about 20 per cent.

2.3.4 Waves

Waves bring sediment into suspension which is then transported by the current. Dominant wave directions are S and SE. The influence of other wave directions on sediment transport is almost nil. Representative wind speeds are about 8-12 m/sec for the S and SE directions. Significant wave height can be about 0.8 m with a wind speed of 11-16 knots (6 to 8 m/sec) from these directions.

2.3.5 Tidal flow and sediment concentration and volume

Flow and sediment concentration was measured twice in October 1989, during a spring and a neap tide, at the northern end of the Bura Gauranga River located Rangabali and Char Biswas. Although these data are relatively old and not representative, but they give some indication of the situation. Of the two measurements, average spring tide velocity was higher than the average neap tide velocity with maximum recorded velocity during spring and neap tides being 1.2 m/sec and 0.5 m/sec, respectively.

Average sediment concentrations during spring and neap tides were 0.6 gm/litre and 0.25 gm/litre, respectively. The maximum concentration was 0.8 gm/litre.

The direction of net flow of water and sediment during spring and neap tides was towards north and south, respectively. During the only measurement on a neap tide, there was no flood flow.

2.4 Expected morphological developments

As a result of the gradual siltation of the Tetulia outfall, the land area is also increasing.

In the past, the project area has been raised by sedimentation of silts from the adjoining rivers and this will continue. The Danrhhira and Bura Gauranga Rivers and the small tidal creeks are expected to reduce in size by siltation. The incoming and outgoing tidal volume will be reduced, flow velocity will decrease and consequently, sedimentation will occur. The area will increase in size. As the Bura Gauranga River shows a tendency to silt up, tidal water and sediment volume during flood and ebb will decrease in future.

New islands will emerge in the channels encircling the project area and the existing islands will increase in size by enlarging their coastlines in the south and south-west directions. Because the fresh water flow from the Tetulia River into the project area does not cause significant erosion in the north around Kasher Char, these increases in area will not be at the cost of erosion elsewhere.



Figure P1-2.1: Potential sites for cross-dams

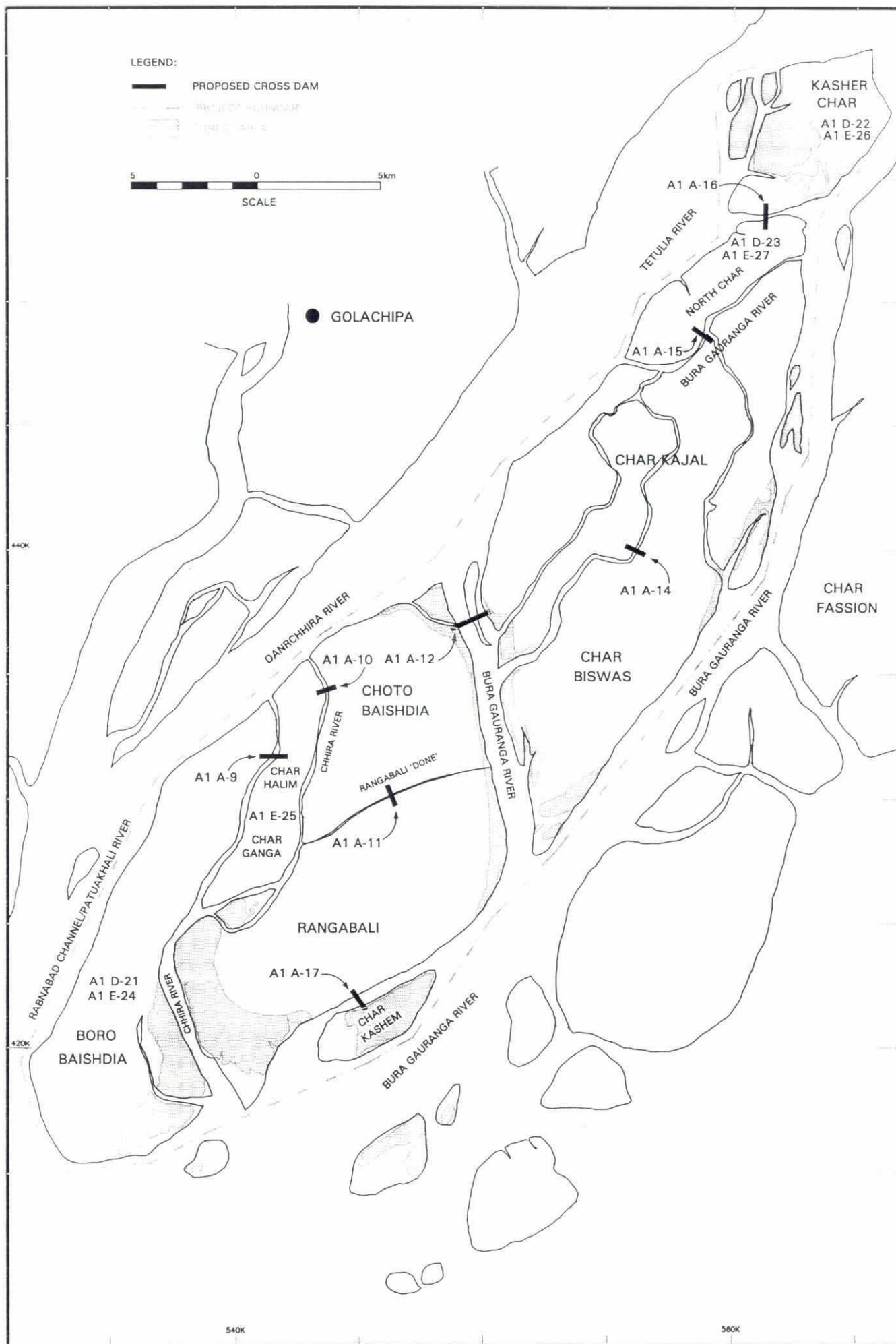


Figure P1-2.2 Frequency Curves of Daily High Water Levels at Khepupara (Apr 1986 to Dec 1997)

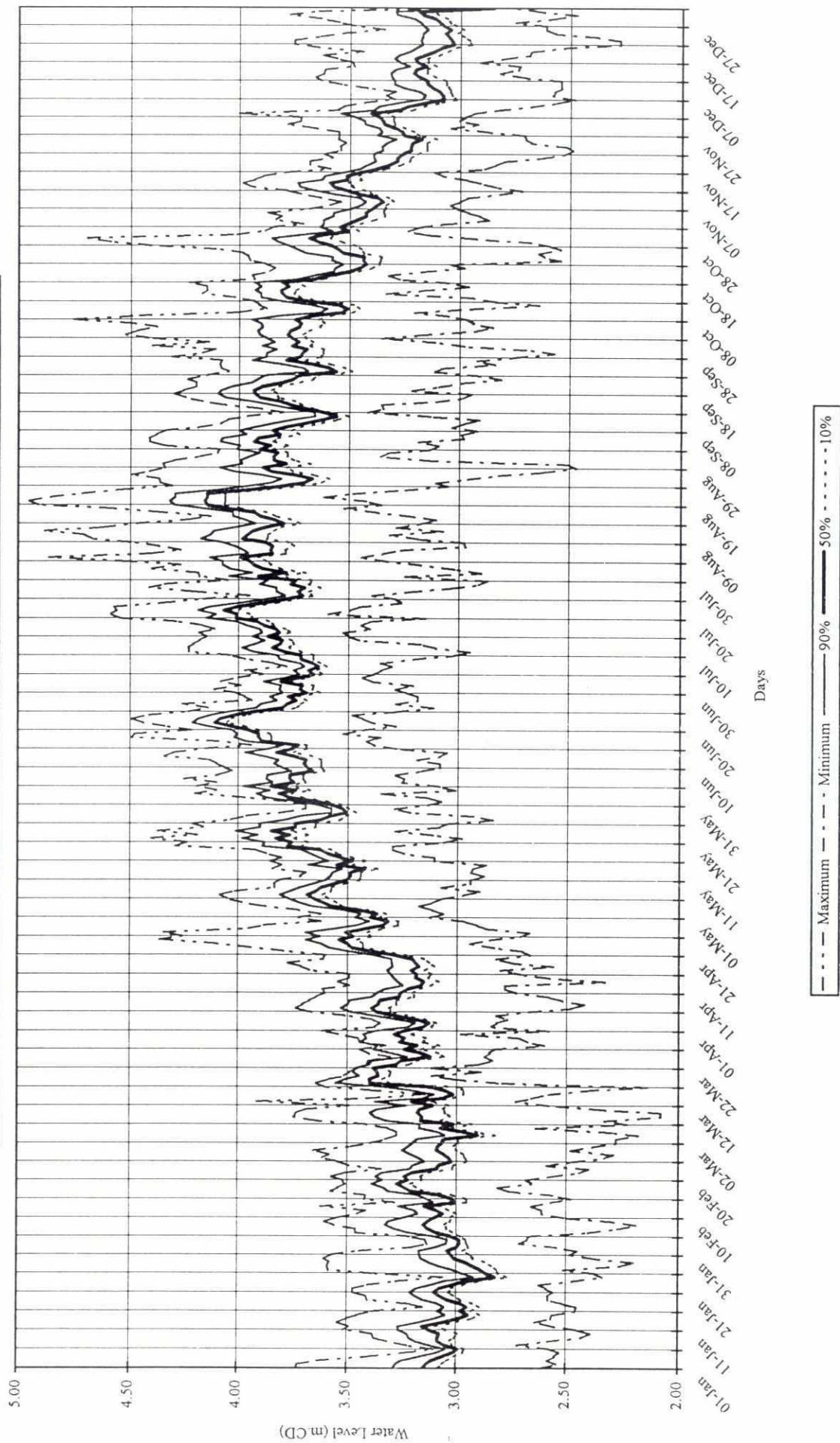
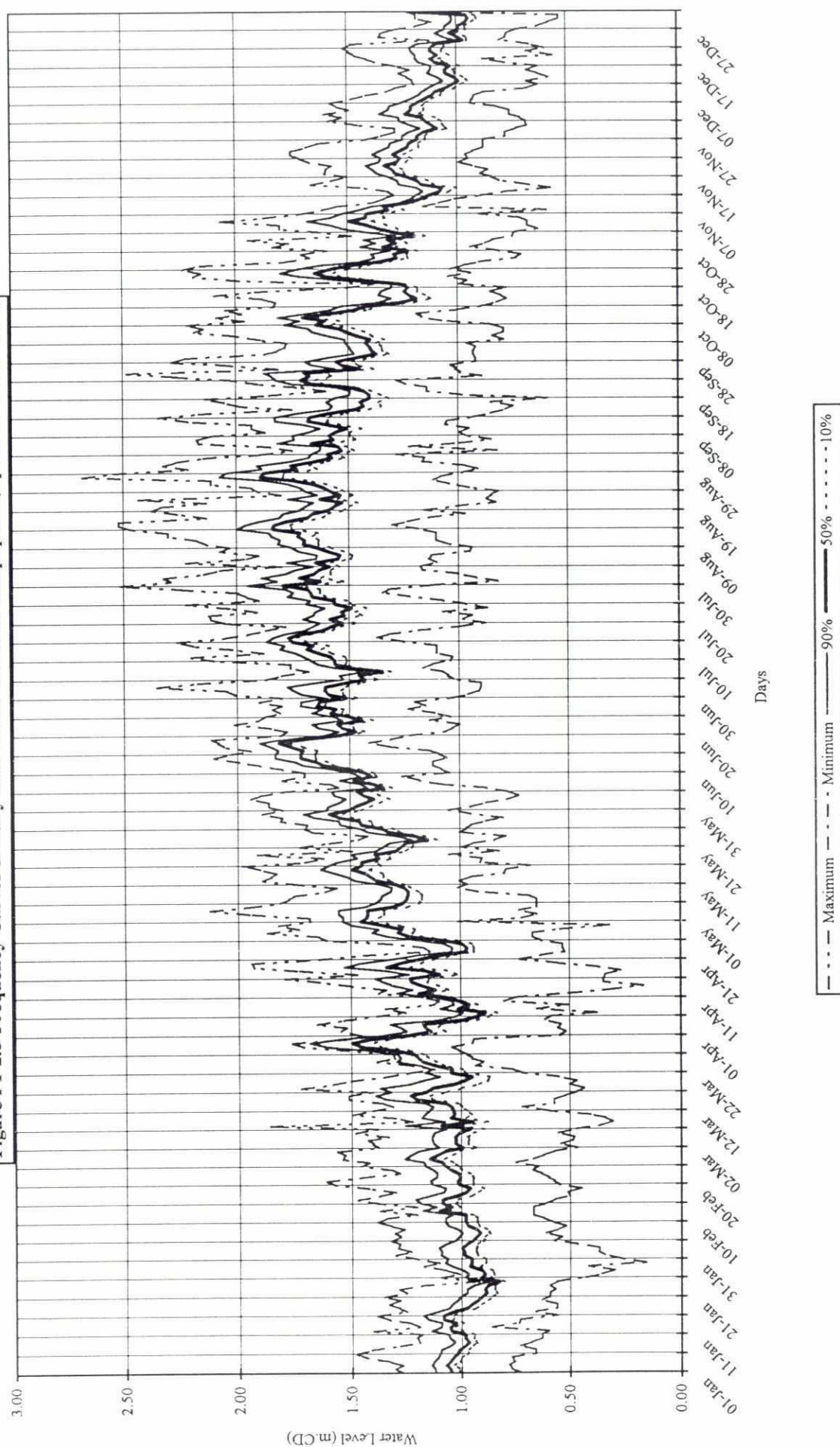
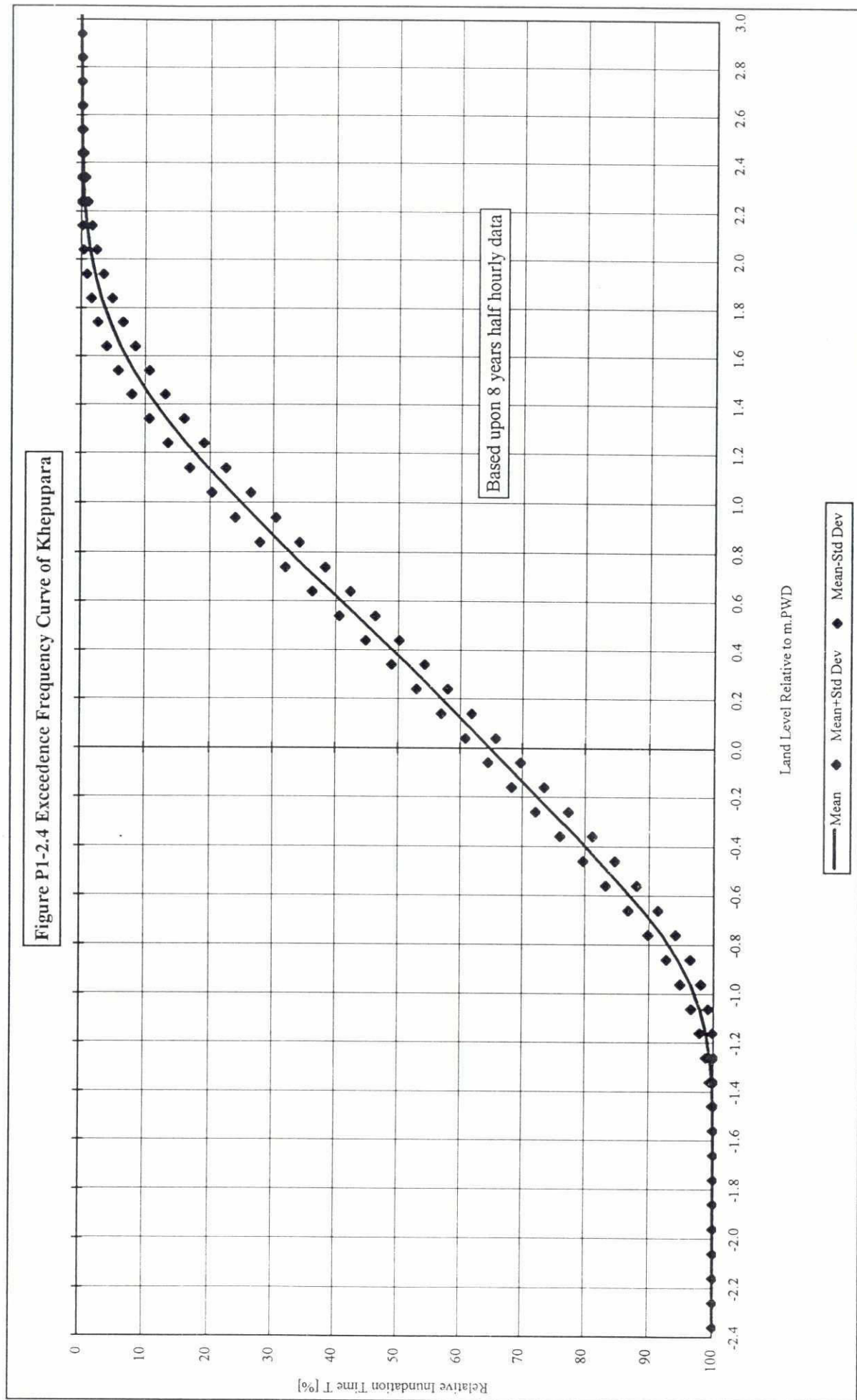


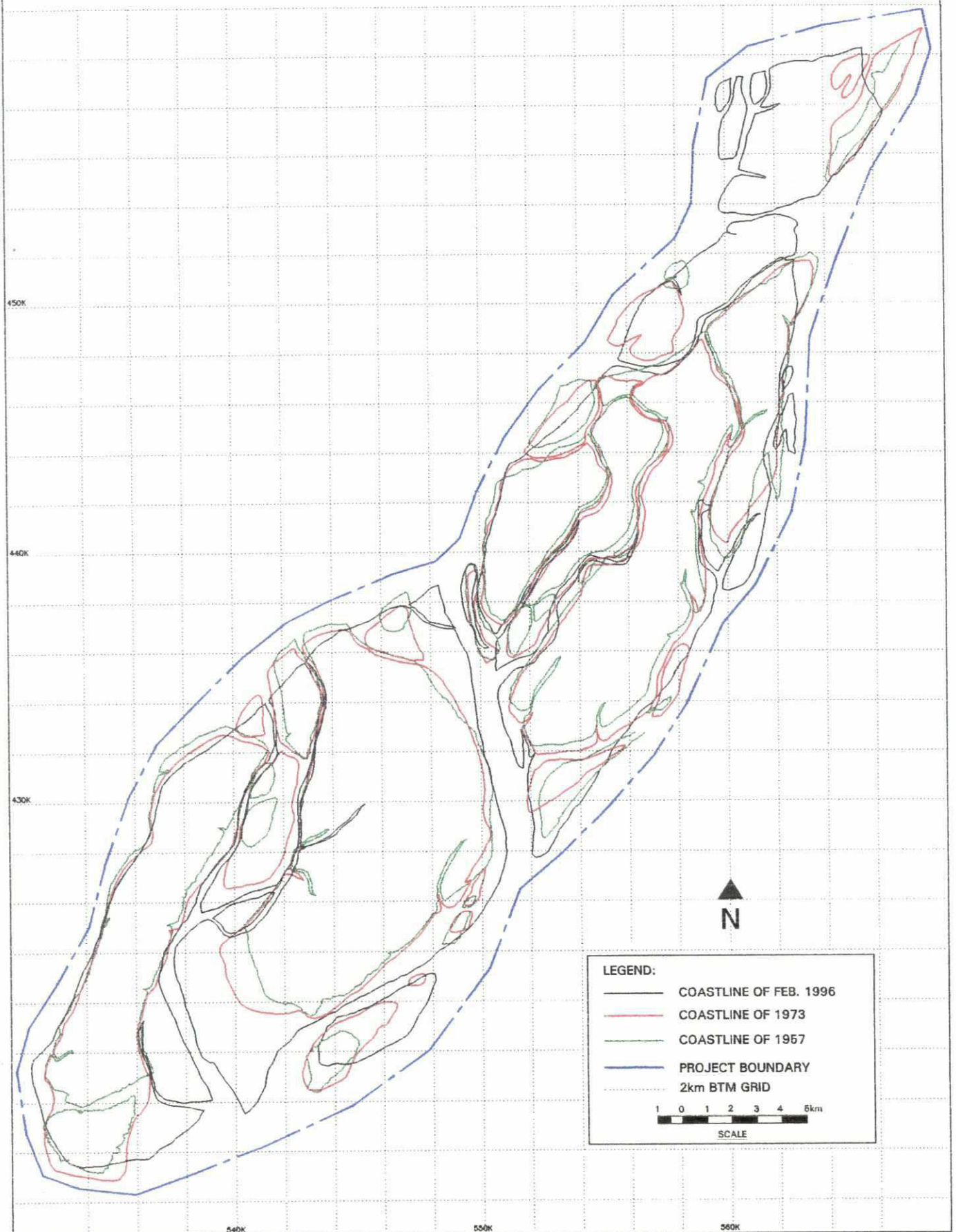
Figure P1-2.3 Frequency Curves of Daily Low Water Levels at Khepupara (Apr 1986 to Dec 1997)





23

Figure P1-2.5: Coastline development of Rangabali-Char Biswas area



P1-3 PRESENT SITUATION

3.1 Physical setting

3.1.1 Topography

The most recent mapping for the project area are the preliminary drafts of Finmap sheets, dated 1992/94. Most of the area has a level of above +1.2 m PWD. In general, land should only be empoldered in this area when it reaches a level of about +1.5 m PWD.

3.1.2 Climate

The mean annual rainfall at Rangabali and Char Biswas is about 3,000 mm, with June and July receiving the highest rainfall. However, annual variations can be significant. The hottest month is May when the mean average temperature is 29°C and the coolest month is January, when the mean average temperature is about 20°C. Monthly evapotranspiration is highest in April and May and lowest is in January and February.

3.1.3 Soils

The project area is part of the young lower Meghna estuarine flood plain. In general, the soils are seasonally flooded, poorly drained and have developed from moderately fine textured silt loams.

Salinity levels are still relatively high, at least in some areas. Analysis of the samples also indicated that pH levels are higher in some areas that is recommended for agriculture. As in other, similar areas, the levels of organic matter in the soils are generally low. Soil development on the estuarine chars is a long a slow process, even after the construction of embankments provides the opportunity for the gradual reduction of salinity levels.

3.1.4 Land use

Of the total of 42,400 ha at present in the project area, 17,480 are already protected by embankments. Base on recent satellite images it is estimated that some 5,400 ha (12.7 per cent of the total area) outside existing embankments is forested. The remainder is either cultivated, in fish ponds or is low lying mudflat and grassland used for the grazing of cattle and goats.

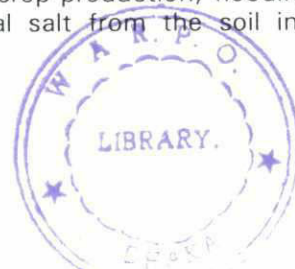
Crop production on Rangabali and Char Biswas can be limited by flooding and storm surges during the monsoon which can damage standing crops. Salinity and lack of water for irrigation in the dry season are limiting factors for cultivation, especially of Aus and Rabi crops. A single crop of the local salt resistant T. Aman is usual in most of the area and on about 20 per cent of the area, the rice crop is followed by rabi crops such as keshari, chilli, sweet potato and groundnut.

3.1.5 Flooding

There has only been limited data on land levels on Rangabali and Char Biswas available to MES. Land levels are generally assumed to be around mean high water level.

Peak tides inundate land outside the existing embankments and also sometimes inside through the drainage system which is not always managed effectively to stop saline intrusion. Even higher areas will be flooded during cyclones which are generally accompanied by tidal surges.

The large river discharge in the monsoon period dilutes the salinity of the sea water in the estuary, but in the dry season the sea water remains sufficiently saline for its intrusion to cause more serious damage to crops than in the monsoon. For successful crop production, flooding by saline water during the dry season requires rain to leach residual salt from the soil in the following monsoon.



3.1.6 Cyclones

The area is in one of the most cyclone hazard prone parts of the Bay of Bengal. In the past, major cyclones have taken a large toll of both human life and livestock. Except on Bara Baishdia, Char Halim and Char Ganga in the south and the chars at the northern end of the project area, most of the population is already protected by embankments.

3.2 Socio-economic setting

The socio-economic setting of the project area is profoundly influenced by the dynamic physical environment in which communities are living. The tides, flooding, storms and processes of erosion and accretion are major parameters of existence.

Socio-economic surveys were carried out during MES, including on Bara Baishdia, to provide background information on the socio-economic setting of the project area and information for three aspects of project formulation: economic viability, social desirability and possible development strategies. The survey investigated settlement patterns, demography, occupations, land ownership, credit and indebtedness, income and sources of income, communications, literacy, education and health.

The results of these surveys are presented in the Draft Master Plan, Volume 4 : Rural Development

3.2.1 Demography

At the time of the 1991 census, the population of the mauzas constituting the project area was about 110,000 with an average household size of about 6.

3.2.2 Land ownership

According to the survey data, about 10 per cent of households on Bara Baishdia are functionally landless. Another 60 per cent have less than one hectare.

Throughout the project area, many landless, marginal and small farmers operate land of absentee land owners who live outside the area. Usually the crop is distributed 50:50 between the landowner and sharecropper.

3.2.3 Credit and indebtedness

The most common source of credit for households in the area are money lenders. Credit appears to be used principally for income related purposes - either agriculture, fishing or trade - but a significant number of loans appear to have a social purpose.

3.2.4 Income and sources of income

Households typically have cash income from a number of different sources. Of the various sources, fishing is, on average, the most important. Agriculture and fishing are the principal occupations in the project area and some households have income from both sources. Livestock also play an important role in the household economy, although the contribution from this source to cash income is relatively small. Other significant sources of income include remittances from family members working outside the area.

3.2.5 Communications

Communications to and from both Rangabali and Char Biswas are entirely by water transport. The principal routes are towards Galachipa and Patuakhali. The restricted nature of the communications system hampers transport for goods both into and out of the area. Improved accessibility would have a beneficial effect on production as well as on services available to the population.

3.2.6 Education and literacy

The illiteracy rate in Bara Baishdia appears to be quite low, 30 - 35 percent according to the MES survey. The rate will be higher in the less developed parts of the project area. However,

the MES survey gave generally higher literacy rates than the official data for the corresponding areas.

3.2.7 Health

The thana health complex for the project area is at Galachipa on the mainland and is the only available source of health data for the area. This data reflects the health situation in the urban and surrounding areas of the thana headquarters and is not directly applicable to the project area. However, it indicates that the most commonly reported diseases in the area are diarrhoea, intestinal parasites, peptic ulcers, respiratory tract infections and malaria and other fevers.

3.3 Hydraulic Infrastructure

The pre-feasibility study area is formed by eight chars south-west of Bhola named from north to south: Kasher Char (2,590 ha), North Char (1,785 ha), Char Kasem (820 ha), Char Kajal-Biswas (14,856 ha), Char Chota Baishdia - Char Rangabali (13,370 ha), Char Halim and Ganga (1,850 ha) and Char Bara Baishdia (7,140 ha). A map of the study area is presented in Figure P1-3.1, which shows the existing situation.

The three larger chars are already protected against flood and the intrusion of saline water. These are Char Kajal-Biswas with polder 55/3 protecting 9,450 ha, Char Chota Baishdia with polder 52/53-A protecting 3,090 ha and Rangabali, polder 52/53-B, with 4,940 ha protected. Polder 55/3 was completed in 1991 and the other two were completed in 1992.

3.4 Water Management

Water management, comprising the use of embankments, sluices and drains to improve the control over water levels and water salinity, is only possible inside the two polders 55/3 and 52/53 A and B. For unprotected land within the pre-feasibility study area, water management is virtually impossible.

3.4.1 Polder Management

Overall polder management is the responsibility of BWDB. Two polders, 52/53 A and B, fall under the Khepupara O&M Sub-Division, and polder 55/3 comes under Galachipa O&M Sub-Division. Both Sub-Divisions fall under the Patuakhali O&M Division. The Ministry of Water Resources issued guidelines for People's Participation (GPP) in August 1994. These guidelines prescribe the involvement of water users in the water management of FCD schemes of BWDB (such as polders). The GPP guidelines have not yet been implemented in these polders.

A lack of O&M, in particular maintenance, has been observed in all three polders. One of the constraints of BWDB is a lack of O&M funds. O&M are financed by an Annual Development Plan (ADP) or through the National Revenue Budget. Since these polders are considered completed, an ADP is no longer prepared. Hence, only the revenue budget of BWDB can be used for O&M. Occasionally O&M is carried out under the food for work programme as has happened elsewhere. However, due to insufficient revenue funds only minor emergency maintenance works are carried out. Even in case of an emergency, it is not unusual that maintenance is delayed due to shortage of funds.

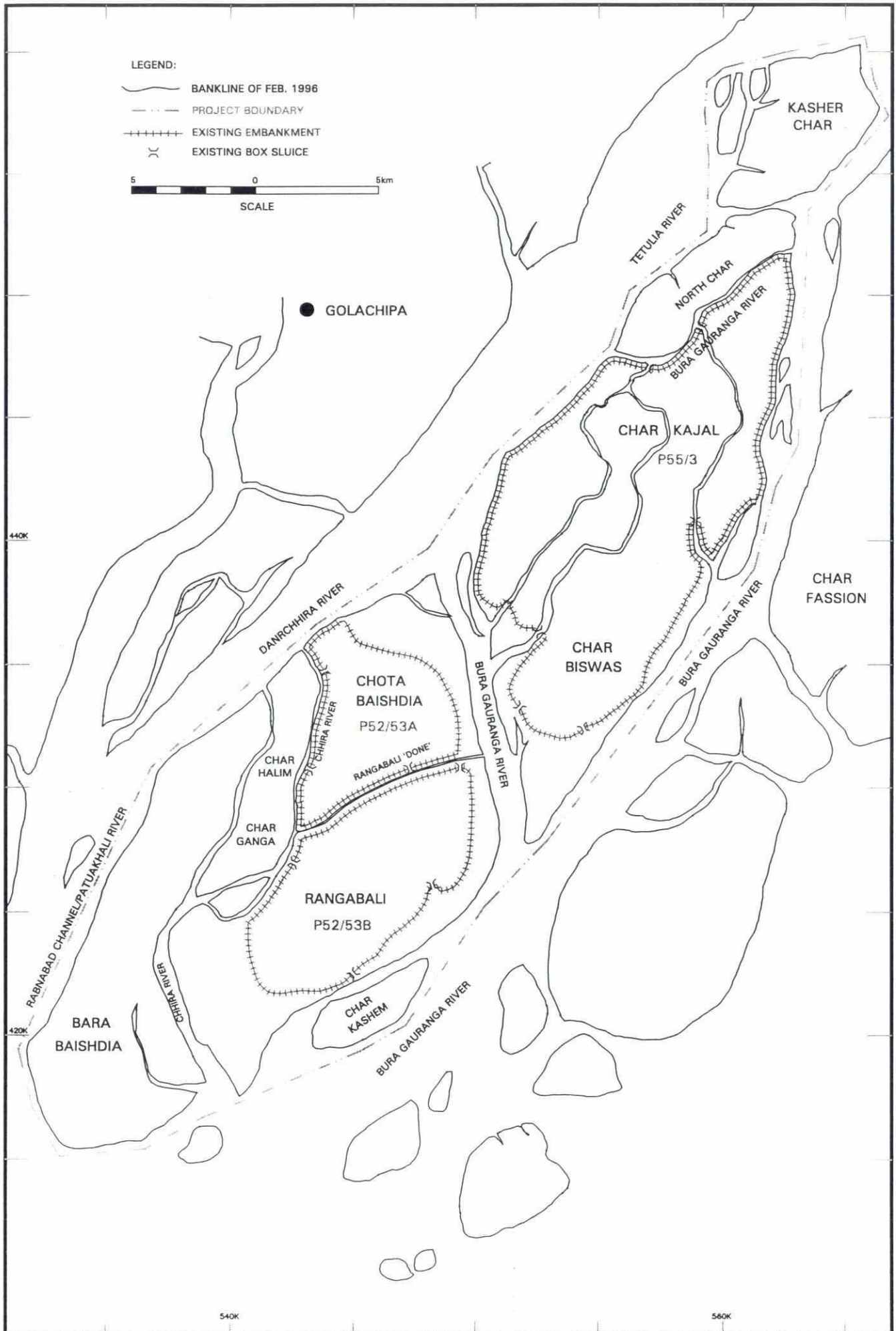
3.4.2 Operation

No BWDB staff is present in polder 55/3 and 52/53 A&B for the operation of sluices or to supervise the use of main drains and embankments. Operation is done by the local population. Sluice committees do exist but little is known about their functioning.

3.4.3 Maintenance

No regular systematic inspections and surveys of the infrastructure are at present made by BWDB. Hence, no routine or periodic maintenance plans are prepared or implemented (which is not surprising if no maintenance funds are available). Emergency maintenance works may be proposed by the SDE and based on field inspection reports of the Sectional Officer (SO).

Figure P1-3.1: Situation of project area in February 1996



3.4.4 Drainage

The occurrence of severe drainage congestion during the monsoon affects crop production, mainly Aman rice, at various places. No O&M monitoring is carried out by BWDB, which means that no water levels are measured inside the polder to verify the drainage congestion. The ADC-Land leases drains at the district level (Patuakhali) to influential persons of the local community. Leaseholders consider these drains their property. Therefore, they feel that they have the right to install bamboo piling and nets, which block the free flow in drains, or even to construct cross dams in the drains.

The presence of a large number of footpaths and rural roads without sufficient culverts or bridges is known to be a serious cause of drainage congestion in polders. At the same time, in the absence of sufficient rural roads, drains continue to fulfil a need for transport and small boats are frequently used throughout the polder.

3.4.5 Salinity

Since the construction of the primary ring embankment, saline floods no longer occur inside the existing polder. It seems that soil salinity levels initially increased after completion of the polder, but were neutralised in the following years by letting water in from April onwards. When water salinity has dropped (expected in June), water levels in the drains are raised to flood and soak the fields.

The soil salinity is now decreasing and Aus cultivation on a large scale may be possible within a few years. Outside the empoldered area the salinity levels remain high.

3.5 Agriculture

Information on agricultural and other production specific to the project area is limited. The only part of the area included in the MES surveys was Bara Baishdia. However, production conditions in the project area are generally similar to those of other islands and chars in the estuary, in particular to nearby Char Montaz and Kukri Mukri which were also included in MES surveys.

Agriculture in these areas is typified by low yields and low cropping intensities. To a large extent, these are the result of soil salinity and a low level of soil fertility combined with damage from flooding and pests. Crop losses can be as high as 50 per cent or more and in extreme cases, in unprotected areas, a whole crop may be lost.

In the unprotected areas the intrusion of saline water at certain times cannot be prevented. In the dry season, the salinity of the water in the surrounding channels is relatively high and spring high tides can lead to the intrusion of salt water in agricultural areas. Also in the dry season, the salinity of surface soils in both protected and unprotected areas can increase due to the capillary rise of saline ground water. The rains of the next monsoon season are required to leach this salt from the soil. Salinity is not such a serious problem during the monsoon season, but flooding from tides or storm surges can damage crops.

The potential for irrigation in the project is limited to supplementary irrigation by LLP from khals inside the embanked area. Usable ground water sources may be found at a depth of about 300 metres. The extent of this resource, which is used for domestic water supply, is unknown. Given the conditions in the project area, pumping from this depth would not be viable for crop production.

On Bara Baishdia, about 70 per cent of households involved in agriculture have holdings of 1 ha. or less. The situation is similar on Char Montaz and Kukri Mukri and may be assumed to pertain throughout the project area. Only about 10 per cent of households have more than 3 ha.

The major constraints to production are soil salinity, the low fertility of the soil, the lack of water in the dry season and insect and other pests. Yields are low and, barring flood or tide damage, may not differ much between protected and unprotected areas, at least at present.

Average yields actually achieved for rice are about 1 mt/ha. Rabi crops grown typically include chilli, groundnut, keshari, mung, and sweet potato.

Among the constraints to production in the project area are the lack of extension services and the lack of access to markets, either local markets or to wider, regional markets. Both of these constraints are linked to the isolation of the area and the poor transportation links to outside areas. The limited transportation links also make agricultural inputs difficult to obtain and relatively expensive (compared to areas with better and cheaper transportation links) and tend to reduce the prices that can be obtained for any surpluses farmers produce.

3.6 Livestock

Livestock are an integral part of the household economy throughout the estuarine chars, being kept for draft purposes, to provide food and as a source of income. The first plant species to establish itself on newly accreted is usually uri grass which provides the natural basis for supporting cattle, goats and sheep.

The cattle in the area are usually of the zebu type, fairly well adapted to the local climate and environment, but with low productivity. The average cow produces only about 1-2 litres of milk per day during lactation. The buffaloes are the Indian water buffalo type and are preferred by farmers as tough draft animals that can survive on the coarser roughage available on chars and in forest undergrowth. The milch buffaloes produce a little more milk than cows.

The cattle and buffaloes of large and medium farmers usually graze on the newly accreted chars and in the forests or in the fields after harvest. Cattle owning landless and marginal farmers, who have less access to land and less crop residues, face more difficulty in obtaining fodder. The availability of fodder may be especially a problem during July to November when the fields are in crops and during the dry season from November to March when weed production is at a minimum. Marginal farmers typically tether their animals on the river banks, fallow lands and pond dykes or stall feed them to avoid the risks of theft or loss on the chars or in the forest.

The chicken and ducks of the deshi type, are raised around the homestead and are usually the responsibility of the women. The chickens typically produce 40-45 eggs and the ducks 60-80 eggs per year.

Livestock productivity is low and spending on feed supplements or veterinary care is virtually zero. However, the household survey indicated that on Bara Baishdia, as well as on Char Montaz and Kukri Mukri, that around 10 per cent of average household cash income is generated from the sale of livestock and livestock products. Household consumption of livestock products and the use of draft animals in crop production provide additional benefits.

3.7 Fisheries

Fisheries is an important activity in the project area and plays a vital role in nutrition and income generation. Among households surveyed on Bara Baishdia, 20 per cent named fishing as their principal occupation and for another 20 per cent it was the secondary occupation. This is somewhat more than on Char Montaz and Kukri Mukri, but significantly less than in Nijhum Dwip.

Capture fisheries, carried out in the inshore and offshore waters and in inland water bodies such as beels, khals, rivers are by far the most important in the project area. By contrast, aquaculture, which comprises the pond raising of carp and shrimp plays only a very minor role at present. An estimate of the area of existing ponds is not available, but in common with other similar areas is unlikely to be more than about 2 per cent of net agricultural area.

In common with other areas of the estuary, four main types of gear are being used by fishermen. These are:

- push nets which are operated for seed fishing (e.g. shrimp seed) by part-time fishermen

- drift gill nets which are placed in the river to catch Hilsha, pomfret, Spanish mackerel, croaker, and snapper
- estuarine set bag nets (behundi) which is a traditional gear for catching a wide variety of species but which is rather destructive as it catches a large number of juvenile fish and shrimp
- marine set bag nets which are an enlarged version of the estuarine set bag net and is operated offshore in areas with a depth of 10 to 30 metres.

Fish marketing is poorly developed in the area and transport costs to major market centres are relatively high. These factors depress prices and those received by fishermen are generally low.

Some fishing is carried out in the inland water bodies of the study area during the monsoon, i.e. in the khals and flooded land. The principal species caught are taki, shing, puti and chingri.

3.8 Forestry

3.8.1 Background

Mangrove afforestation was initiated by the Forest Department in 1965 in response to a recognised need for coastal afforestation to establish a protective shelter belt along the coast. Afforested areas include some in and around Rangabali and Char Biswas and some other, smaller chars within the project area. Afforestation of newly accreted land, especially for foreshore protection, remains an important aspect of development for the area.

3.8.2 Existing forest

FD records show that some 4,300 ha of mangrove plantation has been established on 14 chars in the project area during the period 1974-75 to 1997-98. Table P1-3.1 shows annual plantation areas and an estimate of present total volume based on a rapid assessment of the mangrove forest resources in the MES area made by the MES forestry specialists in December 1997 and January 1998. According to this assessment, the total growing stock within the project area stands at 0.6 million m³. The species planted in the accreted land are mostly Keora (about 90 per cent), Baen, Gewa and others (the rest 10 per cent).

Management of these forests previously included thinning operations, which were carried out during the fiscal years 1988-89 and 1989-90 in all these plantations up to 9 years of age. Because of the high cost of thinning and relatively lower returns, thinning was considered to be uneconomic and thenceforth no regular thinning is being carried out in these plantations.

Table P1-3.1: Showing plantation area and growing stock

Year of Plantation	Area (hectares)	Sum of Every Five years	Volume/ha (in m ³)	Total Volume (in m ³)
1974 - 75	0	0	227	0
1975 - 76	263	979	207	202,476
1976 - 77	69			
1977 - 78	109			
1978 - 79	289			
1979 - 80	249			
1980 - 81	281	1,359	190	257,585
1981 - 82	220			
1982 - 83	249			
1983 - 84	265			
1984 - 85	344			
1985 - 86	283	994	133	132,202
1986 - 87	202			
1987 - 88	191			
1988 - 89	71			
1989 - 90	247			
1990 - 91	172	757	40	30,083
1991 - 92	184			
1992 - 93	227			
1993 - 94	105			
1994 - 95	69			
1995 - 96	103	193	2.5	485
1996 - 97	90			
1997 - 98	0			
Total	4,282	4,282		622,830 Say 0.6 million

P1-4 FUTURE WITHOUT PROJECT

4.1 Land accretion and land development

With no intervention, land area will continue to accrete at a rate similar to the past. Based on a study of land formation and char development between 1973/74 and 1996, it is estimated that with no intervention the accretion of new land in the whole project area over the period to 2025 will be about 4,850 ha or about 167 ha per year.

The general land development sequence recommended by MES for newly accreted land is for it first to be planted in mangroves. This helps to stabilise the land, promotes further accretion and the development of the soils and provides protection from tides and cyclones. After 15 years, forest may, in principle, be cleared for agriculture provided a coastal protection belt is retained.

However, in the future without project, the development of newly accreted land in the project area, without the project, is expected to proceed as follows:

- 50 per cent of land reaching the level of +0.4 m PWD will be planted in mangrove
- there will be no clearing of mangrove forest after 15 years
- remaining land will be used for the grazing of livestock.

4.2 Physical and social infrastructure

Without the project, physical infrastructure in the project area will develop only slowly. Embankments will not be constructed on Bara Baishdia, Char Halim or Char Ganga in the immediate future but may be built eventually.

Improvements in transport and communications will be slow to materialise. There are no official BIWTA routes in the area and none are expected, but there are regular private sector services connecting the area with the mainland. Rangabali and Char Biswas will continue to depend on boats for all communications. There may be a gradual improvement in the frequency and regularity of private boat services to the mainland.

The safety and security of the population is a relatively high priority. The construction of additional killas and cyclone shelters in unprotected areas is likely to continue under either regular government or NGO programmes in the coming years.

Other social infrastructure in the area will continue to expand gradually in accordance with Government's regular programmes. The area is relatively well provided with primary schools, but there is a shortage of high schools. Health services in the area are also very limited.

4.3 Water management

4.3.1 Unprotected land

Without intervention, the situation of unprotected land will remain unchanged from a water management or drainage perspective. Agriculture will be limited to only one, low yielding rice crop during the monsoon and a large and increasing number of people and property will remain exposed to harmful floods.

4.3.2 Flood protection

The flood protection embankments of the existing polders will continue to degrade. Gradually the embankment will lose its strength and capability to stop saline flooding, increasing the risk of inundation. Infrastructure inside the polder such as roads, ponds and homesteads may be damaged and standing crops may be lost. Agricultural production will be hampered in subsequent years due to raised soil salinity level (re-salinisation). Continuing deterioration of the hydraulic infrastructure may eventually lead to a costly rehabilitation programme.

4.3.3 Drainage

As has happened in older polders, drainage is expected to worsen as more rural roads and footpaths are constructed without sufficient bridges and culverts. Population density is still low in these rather new polders, but is increasing rapidly. Urbanisation and the creation of homesteads and fish ponds may lead to increasing obstruction of drains. Roads will affect the catchment areas of sluices and areas may be deprived of proper drainage.

4.3.4 Desalinisation

In case saline floods re-enter the polder area through broken sluices or breached embankments, desalinisation will be slowed down and may even reverse into a process of resalinisation.

4.4 Agriculture

Agriculture in the project area is constrained by soil salinity, low soil fertility and a lack of inputs and extension support and also by exposure to high tides and storms in unprotected areas. Without project interventions and unless new embankments are built, salinity would decline only very slowly or not at all, since the land would remain vulnerable to saline intrusion from high tides. The risk of damage to crops from tides and floods would be unchanged. Fertility may

gradually rise as the organic content of soil rises. Farmers' access to information and technical support would improve only slowly although the possibility of gradually improving communications may provide some stimulus to production through better access to markets.

Overall, it is unlikely that yields or cropping intensities would increase significantly from those obtained at present. In particular, expansion of Rabi crops would continue to be inhibited by the saline conditions. Even inside the embankments, production conditions will only improve if adequate O&M is implemented.

The land accreting naturally in the project area will be used for mangrove forestry or grazing rather than for agriculture.

4.5 Livestock

Although livestock and poultry at present contribute only modest amounts to household cash income they are nevertheless an important component of the household economy, contributing draft power and dietary supplements in the form of milk, eggs and meat.

As new land accretes, the land available for the grazing of large and small ruminants will increase. The livestock population of the project area is already relatively large and the average number of livestock owned per household is not expected to increase in the future. Increases in livestock population will be related to the increasing numbers of households in the area. Successful livestock production in the project area depends on the safety of the animals, especially during cyclones. Unless the number of kills in the area is increased to adequate numbers, then it is unlikely that livestock populations would increase very significantly, or at least that investments will be made to improve livestock productivity.

Gradually improving communications with the area and better access to markets may act as a stimulus for livestock production in the area. However, the lack of veterinary and extension services are not likely to change significantly in the near term without the project and this will inhibit livestock production.

Overall, without project interventions, livestock populations will increase, but current levels of productivity are not expected to change significantly. Per household ownership of livestock will not change significantly in the future. Future growth in livestock populations is therefore dependent on the future number of households. The carrying capacity of the area is also a factor that will impose restrictions on total livestock numbers

4.6 Fisheries

Marine fisheries are at present an important source of income for households in the project area. There are early signs, however, that the resource is being over fished and that total output will fall, possibly leading to falling incomes. If this occurs, agriculture and livestock will assume relatively more important roles in the local economy.

It is estimated that there are 200 - 300 ha of fish and shrimp ponds in the project area. Some fish ponds are located outside the embankment and these face the same risk from floods, tides and storms as other crops, but a production cycle is possible between the end of October and May or June when the risk of damage is low. Development of additional fish ponds would proceed only slowly without improved infrastructure and technical support.

4.7 Forestry

Without specific project intervention, afforestation of newly accreted areas will continue only under other Forest Department projects and programmes. Existing forest areas will be maintained. Not all newly accreting areas will be planted in mangroves: for the purpose of this study the proportion afforested is assumed to be 50 per cent.

P1-5 PROPOSED INTERVENTIONS

To develop the project area, as many as 12 engineering and 4 development interventions have been considered:

- 8 cross-dams
A1A-9, A1A-10, A1A-11, A1A-12, A1A-14, A1A-15, A1A-16, A1A-17
- 3 empolderings
A1D-21, A1D-22, A1D-23,
- 4 char development projects
A1E-24, A1E-25, A1E-26, A1E-27

Their locations can be seen in Figure P1-2.1.

5.1 Cross dams

The objective of the proposed cross dams is to block the tidal currents in the channels between the chars. These dams will stop the tidal flow between the islands and thus enhance accretion on both sides of the dams, eventually creating one united land mass.

5.1.1 Basic data

Basic data required for the design of the closure dams are very limited.

Reference levels

The following reference levels have adopted in this study:

Public Works Department Datum (PWD)

General horizontal reference datum defined by the Public Works Department. This datum is applied in the whole of Bangladesh.

Chart Datum (CD)

A local datum used as reference for tide levels. Chart datum is a plane below which tide seldom falls. The relationship between the Chart datum used at Khepupara for Rangabali and Char Biswas the Public Works datum is : $CD = PWD - 1.96 \text{ m}$

Topographic data

Existing topographic data have been retrieved and used for the preparation of the pre-feasibility study.

Bathymetric data

Various bathymetric surveys have been carried out in the Rangabali and Char Biswas area. The most recent surveys were carried out in February 1997. It is expected that after the heavy 1998 flooding the cross section will have changed, fresh surveys will be done during the 1998/1999 winter season at the alignments of the proposed cross dams.

Water levels

Tidal information is obtained from the Bangladesh Tide Tables 1997, published by the Department of Hydrography of the Bangladesh Inland Water Transport Authority. The tidal station relevant for the area is Khepupara. The tidal levels for this station are given in the table.

Table P1-5.1: Tidal levels at Khepupara

	Levels with respect to:	
	CD	PWD
Lowest Astronomical Tide	- 0.323	-2.28
Mean Low Water Spring	0.195	- 1.76
Mean Low Water Neap	1.025	- 0.93
Mean Low Water	2.060	0.10
Mean High Water Neap	3.096	1.14
Mean High Water Spring	3.925	1.96
Highest Astronomical Tide	4.445	2.45

Currents

Information on currents prevailing in the channel at Rangabali and Char Biswas are not yet available because the detailed 2-D model has not been prepared due to lack of data in the shallow areas. However, since natural siltation in recent years has been considerable, currents in the channels will be moderate.

After detailed surveys of the shallow area have been completed, the detailed 2-D model with 200 metre grid spacing will be calibrated and the effect of the proposed interventions on water levels and currents will be simulated.

Soils

Geotechnical survey data for the cross dam alignments in the Rangabali and Char Biswas project area are not available. For the time being it has been assumed that the soil conditions will be similar to the conditions for the Nijhum Dwip cross dam. In general the survey indicated:

- densities around 1.9 mt/m³
- moderate SPT values and results of unconfined compression tests which agree with the classification of "stiff silt".
- consolidation Cc values are normal but the shear test values are lower than expected.

Construction materials

In the project area the only available construction material is earth. For construction of an earthen dam one should preferably use clayey soil, with 15 percent clay particles. This requirement would qualify the soil as a medium plasticity clay, a lower boundary of 10 percent could be accepted.

"Hard" materials, such as rock or boulders are not available near the closure site would, if required, have to be imported from elsewhere. Local sand (with the required grain size) and sylhet sand to be used for filling synthetic bags and geobags, have to be brought from elsewhere.

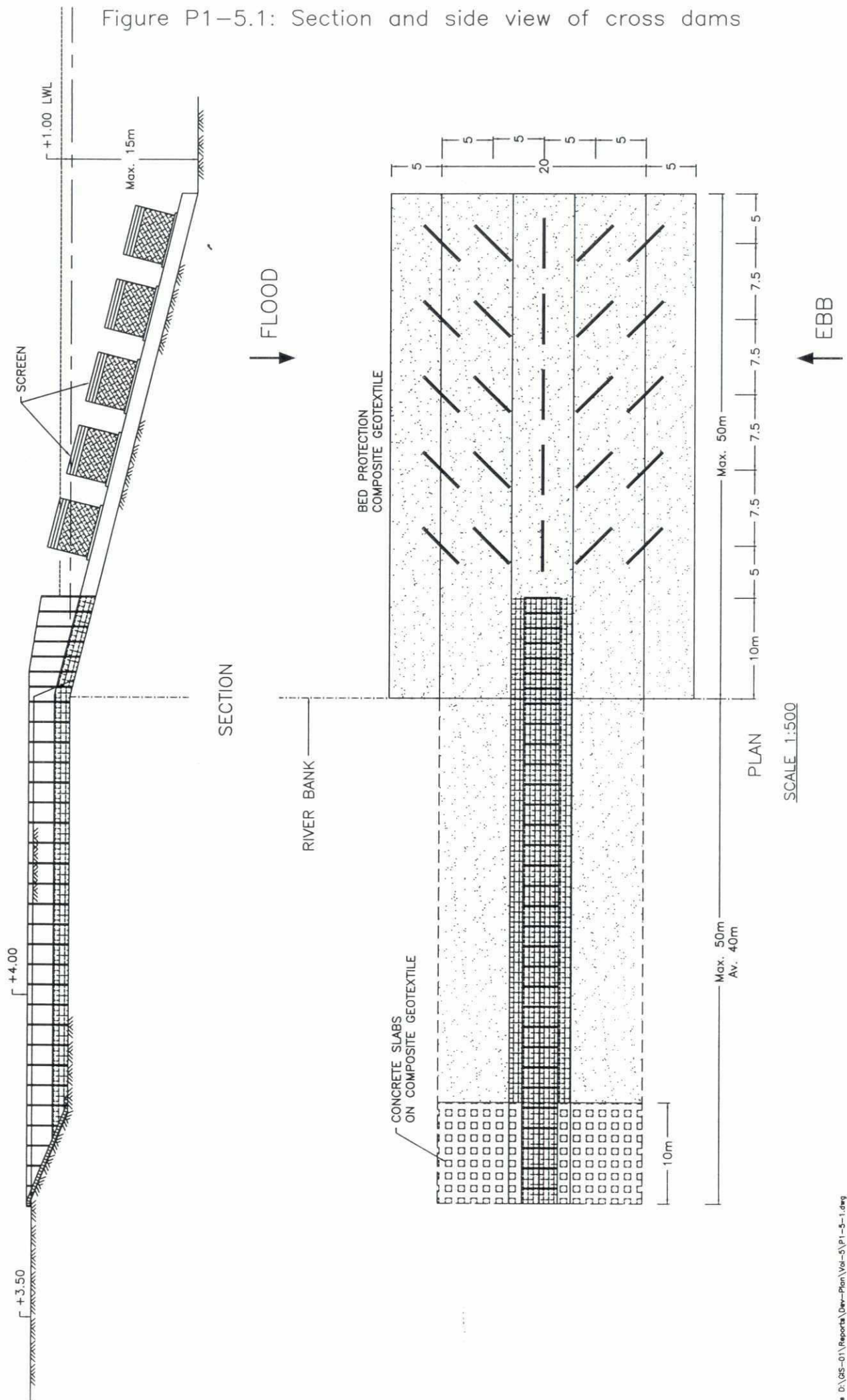
Bamboo and bullah poles, which may be used for cross dam elements or for temporary works.

5.1.2 Cross dam design

An alternative design and construction method for cross dams has been developed under the Meghna Estuary Study. This type of cross dam differs from conventional methods by the use of geotextile materials and construction methods using prefabricated elements. Based on the findings and lessons learned during implementation and monitoring of Haimchar and Khorki erosion control pilot schemes,

MES has developed the concept of a permeable cross dam consisting of a geotextile bed protection, a low under water dam of concrete blocks or synthetic bags filled with stabilised earth, A-frames made of GI pipe, anchored in the low dam and geotextile screens, fixed to the A-frames, for partial closure of the cross section of the channel. Further details are provided in the Feasibility Study reports for Nijhum Dwip as well as Char Montaz/Kukri Mukri.

A section and side view of the permeable cross dam is indicated in Figure P1-5.1.



5.1.3 Proposed cross dams

The area south and southwest of Bhola has been accreting rapidly in the past 25 years. At present a number of channels between Bhola and the chars south of Bhola have more or less stabilised. Without intervention these channels would gradually lose more and more discharge capacity and will eventually be filled up completely. It is not possible to predict when the channels will be closed naturally.

By constructing cross dams the flow velocities in the channels between the chars will be reduced substantially; this will accelerate accretion and cause these channels to silt up much earlier than would be the case without interventions. The smaller channels can be closed by conventional earth cross dams, while permeable dams can be used for the two larger channels. The flow through the permeable cross dams may be reduced gradually by enlarging the screens and dumping more ballast blocks on the under water dam.

The cross dams that may be implemented over time are indicated in Table P1-5.2.

Table P1-5.2: Details of proposed cross dams

Cross Dam	Location	Length and type of dam	
		Earth dam	Permeable dam
A1 A-9	Bara Baishdia - Char Halim	200	1,200
A1 A-10	Char Halim - Chota Baishdia	150	
A1 A-11	Rangabali - Chota Baishdia	120	
A1 A-12	Chota Baishdia - Char Biswas		
A1 A-14	Char Kajal - Char Biswas	130	
A1 A-15	Char Kajal - North Char	140	600
A1 A-16	North Char - Kaser Char	300	
A1 A-17	Rangabali - Char Kashem		

5.1.4 Implementation of the cross dams

The schedule for implementation of the cross dams cannot be given unless more basic data are available. In any case the works will not be implemented during the Development Plan period.

The actual requirements for execution of the works depend on the channel depth prior to the start of the works. Some of the smaller channels may be closed by traditional methods using earth fill embankment and gunny bags filled with earth.

Waterborne equipment like a Twin Hull Pontoon, an auxiliary pontoon, tug boats etc. will be required for installation of the bed protection and A-frames in the large channels.

5.1.5 Cost estimates of the cross dams

The layout, design and the estimate of quantities of work of the cross dams have been based on surveys during MES. During the 1998 extreme flooding substantial changes may have occurred along the proposed alignments of the cross dams. In the period before the start of implementation the situation will change again. A fresh estimate of quantities will be required at the time the amount involved for a construction loan has to be determined. The unit rates are based on current rates of the BWDB O&M circle of Bhola. These unit rates will also have to be adjusted at a later stage.

Table P1-5.3 provides the detailed cost estimate for cross dams A1 A-9, A-10, A-11, A-12, A-13, A-14, A-15, A-16, A-17.

Table P1-5.3: Cost estimate for cross dams

Cross dam	Approximate location		Type of dam	Length in m				Total length m
	Easting	Northing		Earth dam height (m)		Permeable cross dam height (m)		
				2	3	4	4	
A1-A9	540900	431000	Earth dam	100	50	50		200
A1-A10	542900	430600	Earth dam	50	50	50		150
A1-A11	545100	429900	Earth dam	50	50	20		120
A1-A12	549900	436800	Permeable dam		100		400	700
A1-A14	556400	440500	Earth dam	50	50	30		130
A1-A15	558600	448100	Earth dam	50	50	40		140
A1-A16	561400	453400	Earth dam	150	100	50		300
A1-A17	545400	421700	Permeable dam		100		200	300

Quantities per unit length of dam			
Work item	Earth dam height (m)		
Earth fill (m3/m)	2	3	4
Synthetic bags (nos/m)	20	39	21
			1,707

Work item	Unit	Unit cost Taka
Earth fill	m3	150
Synthetic bags	no	40
Permeable cross dam, A-frames 6 m, complete	m1	75000
Permeable cross dam, A-frames 4 m, complete	m1	60000

Cost of cross dams					
Cross dam	Earth dam height (m)		Permeable cross dam height (m)		Total cost Tk. '000
	2	3	4	5	
A1-A9	300	293	3,573		4,166
A1-A10	150	293	3,573		4,016
A1-A11	150	293	1,429		1,872
A1-A12		585		24,000	77,085
A1-A14	150	293	2,144		2,587
A1-A15	150	293	2,859		3,301
A1-A16	450	585	3,573		4,608
A1-A17		585		12,000	35,085
				22,500	
				Total cost	132,720

5.2 Empoldering of char land

The interventions mentioned below will contribute to a) improving primary and secondary protection and b) reducing the present drainage congestion. These engineering interventions do not stand on their own, but are part of a water management component described under 6.6.

This component of the study focuses on the possibility of further improving physical protection through the empoldering of the existing chars Bara Baishdia and Chars Halim and Ganga and eventually new accreted land induced by cross dams. The preliminary needs assessment indicated a strong wish of the local population for the empolderment of Bara Baishdia and to some extent the construction of a cross dam between Bara Baishdia and Char Halim and Ganga. BWDB¹ has already planned for this area to become polder 50/51.

There remains a question whether Chars Halim and Ganga can be included polder 50/51. A topographical survey will be required to assess the land level of Halim and Ganga. This char has been formed gradually during the last 25 years and the average ground level seems to be 0.20 to 0.30 metre below that of Bara Baishdia. Char Bara Baishdia has existed for more than 30 years in its present form and its ground level is comparable to that of the adjacent polder 52/53 A and B.

The construction of cross dam A1 A-9 in the khal between Char Bara Baishdia and Char Halim and Ganga is expected to stimulate the ongoing accretion. The same can be said for cross dam A1 A-10 in the khal between Char Halim and Ganga and Char Chota Baishdia. The result will mean a merging of polder 50/51 and 52/53 A and B. The construction of these cross dams, in particular cross dam A1 A-10, requires a more intensive and structured consultation involving all stakeholders and local organisations, including boat owners. It is likely that navigation will be adversely affected by the closure realised by cross dam A1 A-10.

The following options are possible:

- Option A. Empoldering of Bara Baishdia in year 1 and 2.
- Option B. Empoldering of Bara Baishdia and the construction of cross dam A1 A-9 in year 1 and A1 A-10 followed by the empoldering of Char Halim and Char Ganga in years 6 and 7. The two chars will form one polder comprising two compartments.
- Option C. Same as B, but with the construction of both cross-dams A1 A-9 and A1 A-10 in years 1 and 2.

So far option B seems to be the most desired by the local population, local organisations (Bara Baishdia and Chars Halim and Ganga form one union) and BWDB. Option B will be worked out in further detail. Options A and C are possible modifications of option B. The empoldering of Bara Baishdia forms the core intervention in all cases.

5.2.1 Empoldering of Bara Baishdia, Polder 50/51, Year 1 and 2

The interventions required for empoldering are:

- construction of primary protection embankments
- construction of new sluices
- modification of the existing drainage network

A remark need to be made here concerning the location of the cross dam A1 A-9 (and eventually cross dam A1 A-10). From the point of view of empoldering, the optimal location of the cross dam would be the location of a future closure, which will be required to join Char Halim and Char Ganga with Bara Baishdia. Therefore a location of the cross dam A1 A-9 in the north of the khal between these two areas is preferred.

¹ Project Concept Paper (PCP) for Polder 50/51, BWDB, Patuakhali Q&M division, October 1996

Construction of primary embankments

Empoldering of the area of char Bara Baishdia will be realised by the construction of two primary embankments, a sea-facing and an interior primary embankment. The total protected area is estimated at 3,800 ha. Anticipating the joining with char Halim and Ganga, the protected area of char Bara Baishdia will form a separate compartment, named BB-1 of Polder 50/51. The sea-facing primary embankment will have to cope with a much greater wave action and will have a riverside slope of 1:7 and a freeboard of 1.22 m. The crest width of the interior primary embankment will differ from place to place, since a large part of this embankment will be used to accommodate a paved R-1 road.

Table P1-5.4: Features of the primary embankments

Type	Crest Level (m PWD)	Freeboard (m)	Crest Width (m)	Slope R/S	Slope C/S
Primary embankment, sea-facing	4.92	1.22	4.25	1:7	1:2
Primary embankment, interior	4.61	0.91	4.25	1:3	1:2
Primary embankment, interior cum R-1 road	4.61	0.91	4.90	1:3	1:2

The length of the sea-facing primary embankment will be 23.5 km and 9.1 km for the interior primary embankment with a crest width of 4.90 m and 8.0 km with a crest width of 4.25 m.

Table P1-5.5: Estimated cost of primary embankments

Compartment	Embankment Type	Length (Km)	Rate (Tk '000 per Km)	Cost (Tk '000)
BB-1	Primary embankment, sea-facing	23.5	2,869	67,422
BB-1	Primary embankment, interior	8.0	1,658	13,264
BB-1	Primary embankment, interior cum R-1 road	9.1	1,728	15,725
Total				96,411

To further improve the flood protection, a green forest belt will be created around the entire polder 50/51 and 52/53 A and B. The width of the foreshore (forest area) may vary from 100 m to 1000 m. A minimum width of 100 m is recommended only when no erosion is expected. The combination of sufficient foreshore with forest followed by an embankment is expected to provide a better flood protection.

In case of erosion, the combination of forest and a wider foreshore is preferred and will delay, but not prevent, an eventual retirement of the primary embankment. Only adequate bank protection works can bring erosion to a halt.

Construction of new sluices

Excess rainfall will leave the empoldered land through drainage sluices and smaller additional surface sluices. For the purpose of this study a ratio of 150 ha/m² drainage sluice cross section (a maximum) will be taken for an estimation of the required drainage sluice capacity. Drainage sluices will be equipped with vertical gates for water retention. Compartment BB-1 will be provided with 4 standard box-culvert drainage sluices with a total of 10 vents. The drainage ratio will be 140 ha/m².

Three surface sluices are planned in every 10 km of primary embankment. The construction of surface sluices and the construction of a minor drain along the primary embankment will mitigate local drainage congestion.

Table P1-5.6: Future drainage situation polder 50/51

Compartment	Sluice Code	Nos. Vents	Cross section (m ²)	Catchment (ha)	Capacity (ha/m ²)
BB-1	D/S-1	4	11.12	3,800	137
	D/S-2	3	8.34	-	-
	D/S-3	3	8.34	-	-

Table P1-5.7: Cost of new sluices

Compartment Code	Additional New Sluices	Qty.	Cost (Tk '000)
BB-1	D/S 1, Box Culvert (1.52x1.83m) Sluice, 4 vents	1	12,000
	D/S 2, Box Culvert (1.52x1.83m) Sluice, 3 vents	1	9,000
	D/S 3, Box Culvert (1.52x1.83m) Sluice, 3 vents	2	9,000
	Surface Sluices	12	9,264
Total			39,264

Improvement of drainage network of newly empoldered land

A natural network of khals will form the basis of a future drainage network. A detailed drainage study and field survey will define the need for upgrading khals, which will function as primary and secondary drain. A minor drain will be constructed along the primary embankment as mentioned earlier. In addition, provision has been made for re-excavation of 6 km of primary drain, 12 km of secondary drain and 2 km of new primary drain (linkage) per 1,000 ha.

Table P1-5.8: Excavation and re-excavation of drains

Compartment Code	Catchment Area (ha)	LS Cost ² (Tk '000)
BB-1	3,800	5,335
Total		5,335

The total investment for the above described physical intervention, the empoldering of Bara Baishdia, is estimated at:

Table P1-5.9: Investment physical intervention cost Bara Baishdia

Sl. No	Description	Total Cost (Tk '000)	Cost/ha (Tk)
1	Construction of primary embankment	96,411	25,371
2	New drainage sluices	39,264	10,332
3	Improvement of drainage channels	5,335	1,404
Total		140,847	37,107

² Drainage improvement costs new land, 1,361,000 Tk/1000 ha (see annex WM/MK)

5.2.2 Empoldering of Char Halim and Char Ganga, Compartment BB-2, Years 6 and 7

The interventions required for empoldering of this adjacent char are:

- construction of primary protection embankments
- construction of a closure
- construction of new sluices
- modification of the existing drainage network
- construction of a paved r-1 road.

Construction of primary embankments

Empoldering of the area of char Halim and Ganga will be realised by the construction of a similar set of embankments as for Bara Baishdia: a short sea primary embankment in the north (2.5 km), an interior primary embankment in the east (5.9 km) and an interior primary embankment cum R-1 road in the south (4.4 km). The total protected area is estimated at 1,500 ha and will form compartment BB-2 of polder 50/51.

Table P1-5.10: Estimated cost of primary embankments

Compartment	Embankment Type	Length (Km)	Rate (Tk '000 per Km)	Cost (Tk '000)
BB-2	Primary embankment, sea-facing	2.5	2,869	7,172
BB-2	Primary embankment, interior	5.9	1,658	9,782
BB-2	Primary embankment, interior cum R-1 road	4.4	1,728	7,840
Total				24,794

Construction of closure

The khal between Bara Baishdia and Chars Halim and Ganga needs to be closed in the south. It is expected that the cross section has been reduced as a result of sedimentation after the construction of a cross dam in the north of this khal, five years earlier. The cost of the closure are estimated at Tk 1,050,000.

Construction of new sluices.

Excess rainfall will leave the empoldered land through drainage sluices and smaller additional surface sluices. Also in this case, drainage sluices will be equipped with vertical gates to allow for water retention. Compartment BB-2 will be provided with 2 standard box-culvert drainage sluices with a total of 4 vents. The drainage ratio will be 135 ha/m².

Three surface sluices are planned in every 10 km of primary embankment. The construction of surface sluices and the construction of a minor drain along the primary embankment will mitigate local drainage congestion.

Table P1-5.11: Future drainage situation polder 50/51

Compartment	Sluice Code	Vents	Cross section (m ²)	Catchment (ha)	Capacity (ha/m ²)
BB-2	D/S-4	2	5.56	1,500	135
	D/S-5	2	5.56		

Table P1-5.12: Cost of new sluices

Compartment Code	Additional New Sluices	Qty.	Cost (Tk '000)
BB-2	D/S 4, Box Culvert (1.52x1.83m) Sluice, 2 vents	1	6,000
	D/S 5, Box Culvert (1.52x1.83m) Sluice, 2 vents	1	6,000
	Surface Sluices	3	2,316
Total			14,316

Improvement of drainage network of newly empoldered land

A natural network of khals will form the basis of a future drainage network. A detailed drainage study and field survey will define the need for upgrading khals, which will function as primary and secondary drains. A minor drain will be constructed along the primary embankment as mentioned earlier. Provision has also been made for re-excavation of 6 km of primary drain, 12 km of secondary drain and 2 km of new primary drain (linkage) per 1,000 ha.

Table P1-5.13: Excavation and re-excavation of drains

Compartment Code	Catchment Area (Ha)	LS Cost ³ (Tk '000)
BB-2	1,550	2,176
Total		2,176

Construction of roads

No dedicated roads will be constructed at this stage. Existing (interior) embankments will be used for road construction. The only additional cost in this case is a pavement of 13.5 km for the R-1 road on top of the interior primary embankment of the compartments BB-1 and BB-2. However, construction will be taken up in the future because this road will only have a function if it is linked by a bridge with a paved R-1 road in the north of Rangabali polder 52/53-B. The latter is not yet planned.

The total investment for the empoldering of Char Halim and Char Ganga is estimated at Table P1-5.14

Table P1-5.14: Investment physical intervention cost Char Halim and Char Ganga

Sl. No	Description	Total Cost (Tk '000)	Cost/ha (Tk)
1	Construction of primary embankments	24,794	15,996
2	Closure	1,050	677
3	New drainage sluices	14,316	9,236
4	Improvement of drainage channels	2,176	1,404
Total		42,336	27,314

³ Drainage improvement costs new land, 1,361,000 Tk/1000 ha (see annex WM/MK)

P1-6 DEVELOPMENT FOR THE PROJECT AREA

6.1 Development concept

Interventions to promote land accretion, such as the cross dams proposed in this project, generally cannot be shown to be economically feasible because of the long lapse between the intervention (and the investment) and the start of the flow of benefits. Furthermore, because of such problems as soil salinity, low soil fertility and flooding from tides and storms, levels of production initially achieved in newly accreted areas are low.

For this reason, interventions to promote accretion must be included as one component of an integrated package of development measures for a project area. An integrated approach to development, in this context, will aim to maximise the benefits that can be achieved from land accretion. This will be done by such measures as:

- promoting the safety of the population (including the providing of cyclone shelters and killas where appropriate)
- embanking areas to protect against tides and storms when the land has reached an appropriate level
- providing adequate infrastructure for drainage and water management
- providing appropriate infrastructure for transport and communications
- establishing coastal forests as part of the protection system for the local population and to promote the stability of the land
- promoting measures to reduce soil salinity and increase agricultural production
- promoting improved aquaculture and livestock production systems
- supporting the development of settlements and village infrastructure
- improving the access of the population to education and health services, where necessary.

For the Rangabali and Char Biswas project area, such an integrated approach will have to be followed in order to maximise benefits from the expected land accretion and from the area as a whole.

6.2 Land accretion

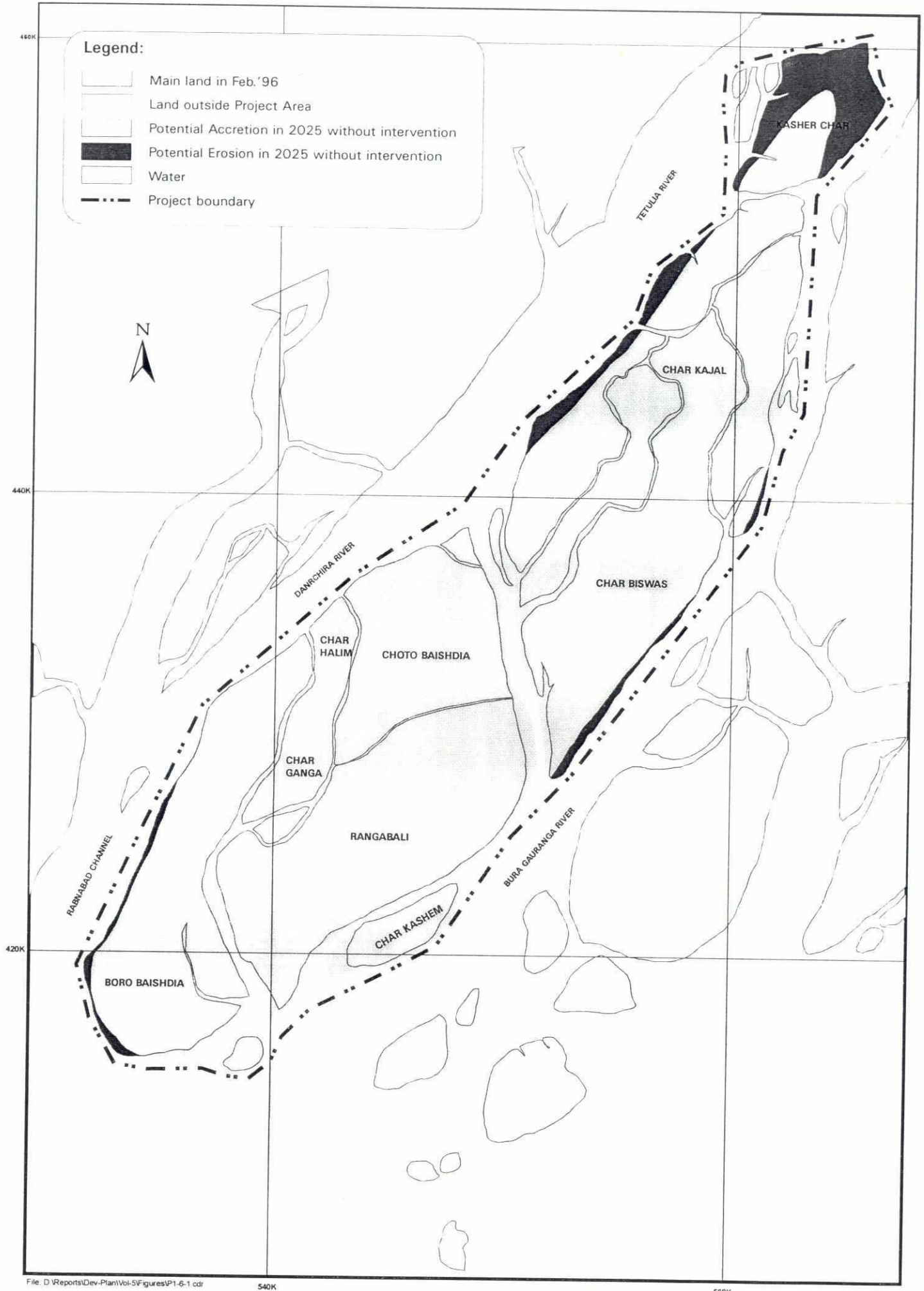
The accretion of land with and without the proposed cross dams is discussed in Chapter 2. Within the frame work of the Master Plan, the development of the Rangabali and Char Biswas areas have been planned for the medium term, 7 – 8 years from the present. In the intermediate period natural accretion will continue; in particular several of the smaller channels still active at present may be silted up before the integrated development of the area will be taken up.

It is also recommended that the smaller active channels that do not require special technology be closed through the Food For Work programme. Closure of these channels will not only accelerate the accretion of new land but also enhance internal communications within the area.

The areas expected to accrete in the area in the future with no intervention and with interventions have been indicated in Figures P1-6.1 and P1-6.2.

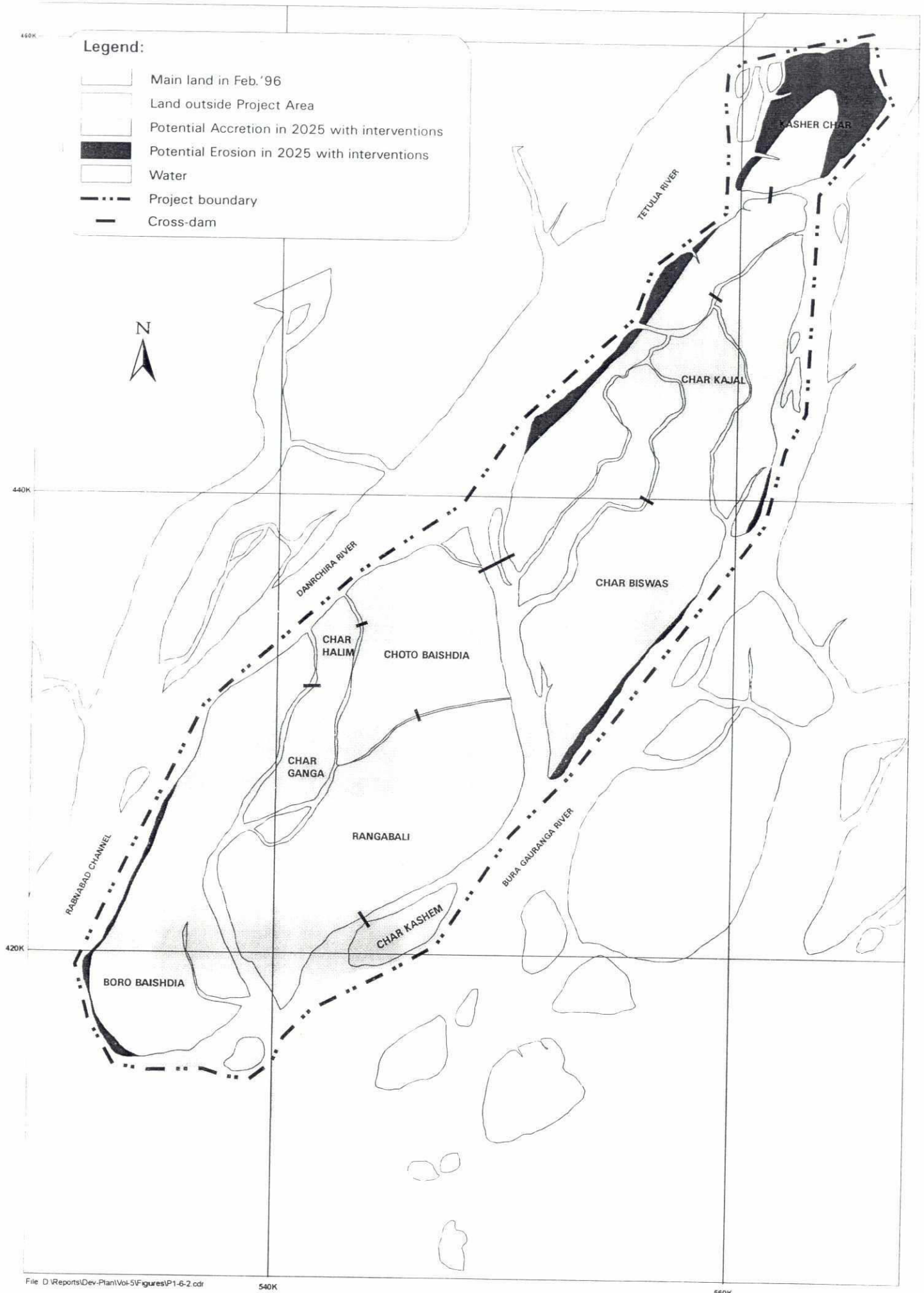
64

Figure P1-6.1: Potential Accretion and Erosion of Rangabali-Char Biswas area in 2025 without interventions



67

Figure P1-6.2: Potential Accretion and Erosion of Rangabali-Char Biswas area in 2025 with interventions



6.3 Land development

Newly accreted land is saline, generally of low fertility and usually still subject to frequent flooding from tides and storms. In the MES area, it is recommended that all newly accreted land be planted in mangroves for an initial 15 year period. Placing the land under forest cover helps to increase stability, promotes further accretion and helps to increase the organic matter content of the soils, apart from providing essential protection from cyclones.

Thus, the principal sequence for land development which should be followed for newly accreted land in the Rangabali and Char Biswas area, with the project, is as follows:

- all newly accreted land reaching the level of +0.4 m PWD is planted in mangroves as it accretes and is left in forest for 15 years
- starting in year 16, new land that has been in forest for 15 years may be cleared
- 1 km depth of mangrove forest is retained outside embankments along all coasts at all times as an important element in the cyclone protection system
- land not in forest and not under cultivation may be used for the grazing of livestock - this includes cultivated land when it is not under crops
- fish ponds are assumed to occupy 2.5 per cent of gross agricultural area.

6.4 Needs assessment

A needs assessment has not yet been carried out for the Rangabali and Char Biswas area. However, it is expected that as in other parts of the MES study area, the accretion of more land and the construction of embankments to increase safety and reduce saline water intrusion will have a high priority.

6.5 Project interventions

In addition to the physical interventions described in Chapter 5, a number of other interventions are proposed to support productive activities in the project area. These activities would be implemented throughout all the chars in the project area and not just those newly empoldered.

6.5.1 Safety of the population

The improved safety and security of the population is a major objective of the MES project. The rehabilitation of embankments as well as the construction of new embankments proposed for the Rangabali and Char Biswas area will enhance the safety of the population in that area.

It is not proposed to construct more cyclone shelters or killas under the project as any additional requirements for these are expected to be met from other government and NGO projects.

6.5.2 Roads and transport

Provision should be made for all embankments constructed or rehabilitated under the project to have the capacity to carry roads along their crests. The embankments will then become part of the road network in the project area. This road network will have a positive impact, not only the safety and security of the population, but also on all types of economic activity. By improving access to markets for inputs and outputs, roads will especially benefit agricultural production.

With successful implementation of the major cross dam A1 A-12 the Rangabali area will be joined with Char Biswas and road access between these char will be possible.

6.5.3 Settlements

New agricultural land in the project area, whether from newly accreted land or from the clearing of existing forest would first be allocated to landless families already in the area. These households, although they have no land, do have homesteads and it is therefore assumed that settlements are not required for these households. Settlements are required for households moved into the area from outside to settle on surplus land. The estimate of the number of households for which land would be available may be based on the following assumptions:

- existing cultivated land in the project area is all occupied and not available for redistribution
- cultivated area is estimated at 70 per cent of gross non-forested area
- land available for allocation to households goes first to landless households already living in the project area
- available land is allocated at the rate of 0.8 ha of cultivable land per household
- settlements are only constructed on land allocated inside embankments.

Furthermore, only land available inside the existing and proposed polders is considered for inclusion in possible settlements under the project. Cluster settlements will be constructed for these new settler households, including housing, ponds, water supply and sanitation and access roads, if needed. The exact location of settlements and the precise model to be used for their development can be decided by year 5 of the project.

6.5.4 Agriculture

The most important project interventions aimed at improving agricultural production would be the rehabilitation and construction of embankments and the associated drainage infrastructure. The main impact of these works would be to protect land from flooding and high tides. After establishment or rehabilitation of the embankment and the drainage system the main benefits for the empoldered area will be:

- reduced risk of damage from saline intrusion
- gradual reduction in salinity as monsoon rains leach salt from the soil
- reduced risk of damage from flooding during high tides or cyclones
- improved water management.

As in the case of the feasibility studies prepared under MES, specific support for the improvement of agricultural production is not proposed for the present project. Rather as salinity declines over the years it will be possible for the farmers to grow higher yielding less salt tolerant varieties of paddy crops and to gradually expand the area of Rabi crops. Rehabilitation and construction of embankments and the improved drainage system will reduce the frequent crop losses due to checking up saline intrusion or water logging. Improved water management, by retaining water in khals at the end of the monsoon season, might also provide some water for irrigation during the Rabi season.

Although soil salinity and cyclone damage are the major problems for farming development, attention might also be given in the final project design to other constraints for farming. At present the availability of seed, fertiliser and pesticides is low and the extension service is inadequate with too few, poorly trained extension officers. Due to the remoteness of the area there is limited access to markets or larger trade centres. Problems of crop losses caused by pests, loss of animals due to diseases and low health status, lack of appropriate credit facilities, land use conflicts, secure land tenure and market access are problems that have been reported in surveys and observations from the field. Integrated Pest Management, homestead development and programmes for women, micro-credit support, income generating activities, livestock fodder

development and specially focused agricultural research to address problems identified during the MES surveys could be relevant components of an integrated char development project.

While establishment and rehabilitation of embankments and drainage systems provides the basis for the development of the farming system, farmers will benefit from the improvements to the extent that their resources allow. An integrated farming system development programme focused on the needs of the farm household and improved management of resources will enable farmers to benefit more from the improved farming conditions. Such an approach may address some or all of the specific issues mentioned above. Co-ordination of such a programme for the project area might be considered as a component of the final project and should be within the responsibility of the relevant ministries.

6.5.5 Fisheries

Project interventions in the fisheries sector would be restricted to the promotion and upgrading of production in existing and new ponds. There would be no activities for the marine fisheries sector.

Experience elsewhere in Bangladesh has indicated that a major bottleneck for the development of carp rearing and the overcoming of the relatively low production rates is poor management, caused by lack of knowledge on the part of the pond owners and operators. A carp rearing development programme and extension programme should include the existing cultured, culturable ponds as well as any new ponds in the accreted land.

The present production rate in the area of around 825 kg/ha/year for cultured ponds can be increased to an average of about 2,000 kg/ha/year if proper husbandry techniques are applied. This production rate will be less than the average of 2,200 kg/ha/year obtained elsewhere in Bangladesh due to the physical properties of soil and water in the coastal area. Increasing the production of existing ponds and introduction of carp rearing in the newly accreted land can only be achieved if an aquaculture extension programme is carried out in the project area. The present and future yields that can be achieved as a result of the proposed aquaculture extension programme are summarised in Table P1-6.1

Table P1-6.1: Present and potential aquaculture yields

	Carp		Shrimp
	Culturable Ponds	Cultured Ponds	
Present and without project	250	800 -825	130
With project	-	2,000	400

The basis of an aquaculture development programme is the transfer of knowledge through extension officers. Experience in FAP 20 indicates that the availability of credit is not a prerequisite for a successful programme. Interested pond owners and operators are given basic training after which the extension officer visits each pond operator once a month at the pond site and provides further on site training. Experience with similar programmes in Bangladesh (FAP 20, MAEP) indicate that one extension officer can cover 60 ponds (12 ha) per year and that it takes two years to bring the pond to the proposed production level of 2,000 kg/ha/year.

There are shrimp ponds in the project chars but the area of these ponds is not known at present. These have very low yields. A major bottleneck of shrimp farming at present is the ravaging impact of the white spot disease which has reduced production levels and the average size of shrimps produced. Future development of shrimp production will only be possible when the present non-sustainability of shrimp farming is overcome through the production of pathogen free post-larvae. Nevertheless, it is proposed to include shrimp production in the aquaculture programme, although for only a limited number of ponds. Provided the current disease problem is overcome, yields can be increased from 130 kg/ha to 400 kg/ha.

6.5.6 Livestock

The project area has good potential for livestock development, for cattle and goats as well as for poultry. The further development of livestock production in the area, however, will depend upon improved safety and security for animals, in the form of killas or embankments where livestock can be kept during floods and cyclones, as well as on improved access to markets as the remoteness of the area is a serious constraint to the development of production. Without these, the risks of loss may outweigh any incentives to invest in this sector.

To promote livestock development in the area, a two part programme is proposed that will:

- provide general training for livestock owners in improved husbandry methods, improved animal health and other topics
- provide intensive training and credit for selected farmers wishing to adopt a more intensive approach to livestock production.

The second part of this programme will provide for the development of more intensive methods of raising and managing draft cattle, milch cows, beef cattle, goats and chickens (either for egg or broiler production). The programme should be implemented by a suitably qualified and experienced NGO working in co-operation with DLS.

Service delivery for the livestock sector would be improved through a participatory approach. Interested youths, nominated by their communities, would be trained as Livestock Field Workers (LFW). The LFW would reside in his own community and would earn his livelihood through selling his services to the community and maintaining liaison with DLS and other input suppliers. The LFW would also act as a model livestock operator, would assist with demonstrations and support livestock activities taken up by the farmers with credit support. The LFW in co-operation with DLS field staff would vaccinate animals against prevalent diseases and offer basic veterinary services.

Similarly, for poultry development, Women Poultry Workers would be trained to work within their communities, offering a comparable range of services to that of the LFW.

The implementing NGO would arrange training and support for the LFWs and the WPWs in co-operation with DLS. The DLS would support with continuous training facilities in the Thana Veterinary Hospital to improve skills and with inputs free of cost or at cost price as made available by the Government on a priority basis.

The project would assist in the establishment of demonstration farms with improved animals and chickens. The farmers participating in project activities will be expected to bear the cost of inputs and the services of LFW and WPW so as to avoid any dependency culture for free inputs and services.

The LFW and WPW will be trained so that they are able to provide advice on feeds and feeding, preservation of crop residues, green grass and crop by-products for fodder during lean months and inclement periods. They are also expected to maintain close collaboration with the DLS for routine disease surveillance, preservation and dispatch of samples for laboratory diagnosis and to call on expert services needed from the DLS from time to time by the farmers of the area.

The NGO, together with the LFWs and WPWs will also explore the opportunities in the area for feasible activities such as mini-milk processing and marketing and the marketing of eggs, chicken and other livestock products.

In addition to the training and demonstration activities aimed at all livestock operators, the programme would provide specific training and support to men and women interested in taking up more intensive livestock and poultry production activities with credit support. Training on improved management and health care should be provided to the selected farmers prior to the provision of credit. Monitoring and follow up support would be provide through the

implementing NGO and its staff. Liaison with the local Livestock Officer would be maintained for speedy and effective solution of any problems of general importance.

6.5.7 Forestry

Forestry, particularly mangrove forestry, will be an important component of the Rangabali - Char Biswas Development Project, especially for increasing the protection of the life and property of the people against cyclones and tidal surges.

With the project, all newly accreted land along the coast will be planted initially in mangroves. Appropriate management of these areas and the existing 5,400 ha of mangrove plantation should be possible on a (long term) self-financing basis. Once established, a coastal protection belt of at least 1 km of forest should be maintained at all times along the whole coastline of the chars.

Afforestation activities should be implemented by the Forest Department which has the necessary infrastructure, manpower and experience to implement these activities. A participatory approach should be used, involving local people in the establishment and management of the forested areas.

6.6 Integrated water management

6.6.1 Project formulation and planning

In the case of major interventions such as cross dams and empoldering, the participation of the local population and local organisations is a pre-requisite. In project planning, the following steps are distinguished; a) needs assessment, b) preliminary design, c) impact assessment and d) (pre-) feasibility study and e) detailed design.

Empoldering of new land will create possibilities to manipulate water levels and water salinity inside the flood protected area. To assure that the infrastructure fulfils the needs expressed and to assure sustainability and proper use of the infrastructure, participation of the local population and organisations is required. SRP developed in 1997-1998 a methodology named Rapid Water Management Appraisal (RWMA).

The MES team has carried out needs assessment during the study. Preliminary designs have been made along with a preliminary impact assessment and its pre-feasibility has been studied. During the next stage, the feasibility study, it is therefore recommended to undertake consultation and a RWMA before final and detailed design studies are carried out.

During the planning process for cross dams and polders, the following representatives and organisations must be consulted:

- Thana Development Co-ordination Committee (TDCC) of Galachipa Thana.
Possible conflicts with existing land and water use plans and practices, potential inter-agency conflicts and co-ordination will be discussed in this committee. The TDCC and the DDCC of Patuakhali should be kept informed about the progress of the feasibility study.
- Project Committee (PC).
It is recommended to establish a PC to assist further studies. The PC will comprise representatives locally elected persons such as the union Parishad members and Chairmen, who represent the interest of all stakeholders. The PC should ensure that all stakeholders are heard and incorporated in the final needs assessments and RWMA. The PC will decide for or against ("Go or No Go") a final plan for the construction of cross dams and empolderment. This PC will continue to function during project implementation and will form the Water Management Committee (WMC) of polder 50/51.
- Stakeholders.
After the identification of stakeholders, consultation of stakeholders can take place at Parishad or Gram level. The main function is to hear the opinion of the various stakeholders

such as farmers, fishermen, boat owners, traders, town dwellers etc. about their needs and comments on proposed interventions.

6.6.2 Participation in water management

For effective planning, management, operation and maintenance of water management infrastructure, it is necessary that all affected parties, including stakeholders, central and local government organisations, NGOs and others be involved. A description of institutional arrangements for the involvement of these groups in the management and O&M of polders is given in Appendix II.

P1-7 IMPACT OF THE PROJECT

7.1 Physical infrastructure

The major impacts of the project will result directly from the physical infrastructure to be constructed or rehabilitated. The cross dams will result in the accretion of new land which can be used for forestry, agriculture and grazing.

The proposed embankments will increase the security of the population living in the area and will lead to improved conditions for agriculture and the raising of livestock as well as other possible economic activities.

Although designed eventually to carry roads, there will be no hard surface roads constructed on the embankments by the project. Nevertheless, access along the embankments will contribute to productive activities by facilitating access to local markets and boat ghats. Access to education, health and other government services will also be facilitated and people will be able to move more easily to safety when there are cyclones.

7.2 Social infrastructure

The project will construct cluster settlements for households from outside the project area who will be settled on land that is surplus after landless households already living in the area have been allocated land.

There will be no other direct impact on social infrastructure, except that by facilitating the development of a basic road network the project will also facilitate access to social services for all households living in the area.

7.3 Water management

The expected impact of the water management interventions and development activities is an improved and more sustainable physical safety by applying the prevailing design standards for primary and secondary protection of polder areas.

A second impact is the reduction of drainage congestion. This will create the conditions required for further improvement of crop production, like the eventual introduction of HYV Aman rice varieties and higher cropping intensities from the introduction of a second, Aus, rice crop and Rabi crops.

Proper operation of drainage sluices and improved protection against re-salinisation by intrusion of saline floods will allow, although slowly, a further reduction of soil salinity levels in the polder.

A third impact is an increased accessibility of the polder area. Compartment bunds and embankments form flood free roads and main and secondary drains, provided with low cost

bridges (steel structure) will form a reliable and cheap opportunity for transport of farm inputs and produce.

7.4 Agriculture

Implementation of the project will lead to an increase in the land available for agriculture in the project area and over time there will be gradually rising yields and cropping intensities as salinity declines and security from storm and other damage increases.

The existing land available for agriculture in the project area is estimated at between 70 and 80 per cent of the gross non-forested land above +1.5 m PWD. The proportion not included covers homestead areas, khals, drainage canals and other non-cultivated areas. With the project, existing forest areas inside new polders will be cleared for agriculture and some newly accreted land also becomes available.

With no intervention, only a small amount of land will accrue and it is assumed that this will either be planted in forest or used as grazing land. When the cross dams are constructed, all the land in channels between the existing chars that is projected for inclusion in future polders will not be forested, but remaining newly accreted land will all be forested. Some of this may be cleared for agriculture after 15 years, but the proportion that can be cleared for agriculture is limited by the requirement to maintain a 1 km coastal forest margin at all times.

Crops yields in the project area are low because of the saline conditions and low nitrogen levels. With improved conditions as a result of project implementation, yields will rise slowly, partly as a result of changes to non-salt tolerant varieties and partly as a result of more secure conditions.

Cropping intensities would also increase gradually from the present average of about 110 per cent - 120 per cent for areas outside embankments and around 130 per cent - 140 per cent for areas inside the existing embankment. It is expected that for areas inside embankments, cropping intensity would rise slowly to an average 165 per cent and for areas outside embankments to about 135 per cent in the 15 to 20 years after project implementation.

For newly accreted areas, both yields and cropping intensities will initially be at much lower levels than those currently achieved for existing land. Yields are expected to start at about 50 per cent of present levels and the initial cropping intensity at about 75 per cent. Rabi crops (usually just keshari to begin with) are started on a small scale after about 5 or 6 years. The transition from present production conditions or initial conditions on new land to those expected with implementation of the project is expected to take about 20 years.

7.5 Livestock

With some additional areas available for grazing and fodder production and greater security from flooding and cyclones, livestock populations will increase although the total number will be constrained by the carrying capacity of the available grazing land. The proposed Livestock Improvement Programme, although it will directly affect only a minority of livestock owners, is expected to have an impact on livestock production in the area, gradually improving production methods and raising productivity.

Livestock populations are projected to increase in line with increases in the number of households in the project area. Average livestock ownership per household is not expected to increase greatly.

Changes in livestock productivity will be reflected in declining mortality rates, increasing average size of animals due to more and better fodder and better animal health and increased output of milk and eggs.

With project implementation, the transition from the present to the future situation is assumed to occur over 10 to 12 years. These changes, combined with increasing populations, have a significant impact on livestock production.

7.6 Fisheries

The project would lead to a small increase in the area of fish ponds and to significant improvements in productivity.

The area of ponds currently in the project area is not known with certainty but is assumed to be about 300 ha. In new areas, it is assumed that 2.5 per cent of the gross new agricultural land area will be converted to ponds. A high proportion of these ponds will be in borrow pits created by the construction of new embankments.

At present, there is almost no shrimp cultivated in the project area. This will change in the future and it is assumed that one third of new ponds will be devoted to shrimp.

The fisheries development programme will increase productivity of fish ponds, with average annual yield in properly managed cultured fish ponds rising to 2,000 kg/ha from the average of about 800 kg/ha under present operating systems. Shrimp yields will depend on resolving the White Spot disease issue, but this is expected in the medium to long run. Yields are expected to rise from about 130 kg/ha currently achieved in the MES area to about 400 kg/ha without the disease and with improved technology and management. Full transition to with project productivity levels may take up to 10 years.

7.7 Forestry

Afforestation of the newly accreted land will have positive environmental impact because forestry operation generally starts at accretion levels which are much below the levels required for agriculture or settlement. Besides, forestry will encourage the process of soil formation in terms of accretion and structuring the newly accreted soil. This will also provide valuable organic matter, will offer grazing facilities to livestock which in turn will supply processed organic matter in the form of animal dung.

Forestry will also supply valuable biomass as fuel and construction materials. The tree-rim will offer resistance against salt spray entering the agricultural crops and will act as powerful barriers against cyclone damage.

The forestry operation will create employment opportunities. It will also supply timber, pole wood and firewood for various end uses.

P1-8 ENVIRONMENTAL ASPECTS

8.1 Aims and objectives of the environmental assessment

The Rangabali and Char Biswas Development Project is one of the three selected projects of the Meghna Estuary Study to be taken to pre-feasibility study. The aim of the environmental assessment component of the Study is to ensure environmentally sound project planning and implementation takes place.

It must be remembered that the primary aim of the intervention is to speed up the natural accretion process that will happen even without human intervention, working with natural trends rather than against them.

The delineated project area for the pre-feasibility study is given in Figure P1-1.1 and includes the embanked and unembanked parts of Rangabali and Char Biswas and the associated clustered islands.

8.2 Proposed interventions

The nature of the proposed intervention has been outlined in chapters 5 and 6 above. Environmental considerations have also been incorporated into project design to minimise possible negative impacts and reduce the need for specific mitigation programmes.

8.3 Baseline environmental conditions and future trends

To a limited extent baseline data collection for both the natural and human environment has been carried out for the area. The data allow identification of the existing environmental constraints and also likely future trends so that an appropriate set of interventions can be drawn up for the area, as well as for assessing impacts in with and without intervention conditions. This baseline data provides the framework for identifying likely impacts due to the proposed interventions, assessing their importance and then setting up data collection programmes to allow quantification, valuation and also monitoring of Important Environmental Components (IEC's) and variables.

The main processes that have been identified are erosion and accretion patterns, with the primary risks and constraints being cyclones (causing loss of life and disruption), saline water intrusion and soil salinity, including problems of capillary rise in the dry season. The principal environmental conditions and constraints to economic development in the area have been identified and include the following issues with respect to the proposed cross dams and utilisation of their predicted benefits:

- the nature of the system for allocating land rights and managing land use on newly accreted land
- the present pattern of surface water quality, particularly soil salinity, caused by saline inflow and how this changes as land accretes
- groundwater quality and availability for drinking water
- rainfall drainage in embanked areas
- low agricultural yields and poor marketing systems for agricultural production as well as fisheries, primarily due to poor communications
- crop losses due to pest attack
- large areas of unembanked land which support a significant number of grazing animals
- over-exploitation of the in-shore fisheries which may be at an unsustainably high level
- human food intake and nutrition levels which are relatively good at present, probably because limited marketing opportunities mean a high proportion of what is produced is consumed rather than sold
- poor health facility provision, a lack of sanitation facilities and recent low primary and secondary schooling availability in the area
- relatively high levels of diarrhoeal disease, probably due to poor water supply
- monitoring of dolphin movement through the channels in which the cross dams are located
- as it is not a conservation area, sustainable management of planted mangrove forest.

8.4 Impact identification, quantification and valuation

A comparative assessment would allow the significant impacts of the proposed intervention, (both positive and negative) to be identified. In addition, the comparison with a without project situation would allow the impacts of the project to be separated from future trends. The need for mitigation could also be identified and the effectiveness of mitigation could be assessed. Of concern are those residual impacts which are negative, i.e. those impacts for which mitigation is either impossible or unable to prevent the post project situation being worse off than that before it caused as a result of the intervention.

The primary conclusions regarding positive and negative impacts are given below. The direction of the impact is viewed from the perspective of long term sustainable human use of resources and where significant and possible these have been quantified.

8.4.1 Identified positive impacts

Land accretion

The construction of cross dams will ensure that land accretion is accelerated. However, before the implementation of the project accretion will continue at a natural pace. Meanwhile, implementation of small cross dams under a Food For Work programme would also accelerate accretion. A programme for implementation of the remaining cross dams will be finalised when the development of the Rangabali and Char Biswas area is taken up. The extrapolation of accretion with and without the project is based on this schedule.

Embanking of land for agricultural use and human settlement

The additional accreted land will allow embankments to be constructed earlier and to enclose a larger area of land. In turn this new land allows those households then resident in the area, who have no agricultural land, to be allocated a cultivable plot. Households may also be settled in the area from outside if land is available.

Reduction in cyclone damage

The effects of cyclone surges will be reduced in the new embankment locations as the waves are dissipated by the kilometre wide forest belt and also by the seaward side run-up slope. Analysis carried out by the CPP project indicated that such planting can dissipate 2 metres of wave energy in a 1991 type cyclone.

Reduction in soil salinity

Soil salinity inside the rehabilitated and new embankments will be reduced as there will be less saline intrusion and the drainage system should allow flushing of the soils with monsoon rainfall fresh water. However, capillary rise of saline ground water in the dry season is still likely to remain a significant problem for many years.

Improvement in terrestrial bio-diversity

The use of the new embankments for multiple uses, including possible linear settlements and social forestry, is likely to improve bio-diversity of terrestrial flora and fauna. The overall area of forestry outside the embankments will be significantly greater than without the project (although it will be in a corridor strip rather than a concentrated block), with benefits for terrestrial ecology.

Increase in agricultural production

Increased agricultural production is likely to occur as a result of accreted land being embanked and used for all year cropping within the constraints of salinity and irrigation water availability. In addition some land which will be forested and lies more than one kilometre from the sea could be cleared for seasonal agricultural use and grazing, after it has risen to the appropriate level. In addition it is proposed to try and introduce an integrated pest management programme in an attempt to address the serious problem of losses from pest crop attack.

Increase in homestead production

The allocation of cultivable land to landless households and increased physical security are likely to induce increased homestead production at the household level.

***Increase in livestock production***

The accreted land available outside the embankments and either not forested or cleared of forest after 16 years would allow additional large and small livestock to be reared. In addition the proposed livestock extension programme would increase the quality of the livestock.

Increased forestry area

The area that could be put under forestry with a sustainable management system could be increased substantially in the with project case, compared to the without project case, assuming the Forest Department were to continue planting all newly accreted land.

Increased aquaculture production

As part of the targeted aquaculture programme using the borrow pits from embankment construction and also bringing the presently under-used ponds into full production, the area of ponds could be increased substantially by year 30. There would also be a targeted shrimp aquaculture programme.

Income generation opportunities

Homestead production would be further increased as a result of income generation programme for women implemented under an NGO.

Improved access

As a direct result of cross dam and embankment construction there would be significantly better road access within the project area. This would allow better marketing with secondary benefits to agricultural production. These benefits could be significant.

8.4.2 Identified negative impacts***Changes in in-shore marine habitats***

There are likely to be some changes in the extent and location of in-shore marine habitats in the area, some of which are likely to happen despite the intervention. However, there is little doubt that this process would be accelerated by the construction of cross dams and in particular movement through the channels in which the cross dams are located would cease. From the sedimentation analysis is also apparent that similar new habitats will appear away from the cross dams. The crucial question is whether the fauna (including fish) using the present tidal mudflats will move to the new locations as replacement habitats.

Like fish resources and wading birds, monitoring is required to see if the dolphin populations will move to the natural replacement habitats that are likely to emerge.

Fisheries

The predicted trend is that fisheries in the area are now likely to decline in the future, irrespective of the project, due to over-fishing. It is not possible to quantify this trend without a significant data collection programme, which is considered an urgent priority. The proposed cross dams are likely to cause a further change in fish habitat and an additional reduction in fisheries catch but this cannot be quantified without a baseline catch assessment and monitoring over a significant period of study to investigate long term trends rather than seasonal fluctuations. In addition there is likely to be some temporary disruption to fishing operations by the closure of channels between islands.

Human nutrition

The declining fish resources, a trend which will happen irrespective of the project, when combined with increasing human populations and a possible change in fish marketing patterns, is likely to result in a reduction in human protein intake. Improved access to the area could cause more fish to be sold rather than directly consumed. It is not possible to quantify this impact and there could be complex two-way trends with some households improving their nutrition and others suffering a reduction. A monitoring programme for human nutrition will be required to identify and quantify any change.

Navigation

The closing of the channels between islands will obviously prevent navigation through them and may also require some ghats to be relocated. The biggest disruption would be likely to occur when cross dam A1 A-12 is constructed. A detailed navigation survey and analysis would be required to address this issue, taking into account that the rivers in the area are gradually silting up naturally.

Changes in access

Whilst the improved internal access that is likely to result from the construction of a road on top of the cross dams and connecting embankments will be considered a benefit, there are also likely to be some simultaneous negative impacts. These include additional induced in-migration which would put more pressure on existing resources and facilities. There may also be a risk of more social conflict as a result. Careful management, including fair and transparent procedures for new land allocation are critical in handling such conditions.

Direct construction impacts

There are likely to be few problems with land acquisition, compensation and involuntary resettlement. There are likely to be direct construction issues which if well managed can be overcome and may increase potential benefits, particularly employment opportunities. There are also likely to be issues linked to the collection and handling of construction materials.

8.4.3 External impacts and constraints

There are no obvious upstream impacts created by the proposed intervention, however any future upstream development, particularly that in the Bhola area (which lies outside the remit of the MES) and the planning unit east of Char Montaz and Kukri Mukri, would need to bear in mind possible induced impacts on the project area. Cumulative impact analysis would be needed if all MES planning units and programmes are actually constructed.

As discussed above, the outputs of the sedimentation analysis indicated that in the with project situation, accretion of tidal mudflats is likely to occur to the south of Rangabali and Char Biswas. Whilst this may provide replacement in-shore marine habitats, the ability of species to quickly colonise these areas is unknown, although the past morphological development of the area has followed these trends, if at a slower rate.

8.5 Environmental mitigation

Due to the fact that the interventions will have been carefully designed there is little need for specific targeted mitigation programmes. These are indicated below.

8.5.1 Ghat relocation

It may be necessary to relocate any ghats presently found adjacent to channels that would become accreted. Relocation should involve negotiations with the affected parties to come to acceptable alternative locations. Consideration could be given to establishing a boat centres at new sites based upon the ideas recommended by BIWTA.

8.5.2 In-shore marine habitats

It is expected that replacement in-shore marine habitats will be naturally formed, but monitoring of this will be required and in particular the extent to which dolphins, fish and wading birds are able to relocate to these areas. The degree to which this natural habitat replacement mitigates the negative impacts of the intervention will also need to be monitored, along with investigations to identify the locations of fish spawning and breeding sites, specifically to discover if these are on tidal mudflats or in the deeper inter-island channels.

8.5.3 Fisheries

Irrespective of the project there is a need for fisheries management programme aimed at keeping fish catch levels within sustainable limits to prevent serious future decline. A detailed baseline catch assessment is needed together with studies into fish ecology to improve understanding of the present situation, followed by a monitoring programme to see the effects of sedimentation on fish habitat change and how this affects fisheries production. Once this is done then the need for and nature of a specific mitigation programme for in-shore fisheries can be decided.

The proposed aquaculture intervention may act as partial mitigation for some fish dependant households, however the techniques and experience required are very different from open water fisheries.

8.5.4 Cholera

The region is now the habitat of classic cholera, probably as a result of ecological changes occurring in the country. The feasibility study should address this issue.

8.5.5 Direct construction impacts

An environmental management component for construction operations will need to be set in place so that potential problems can be identified in advance and steps taken to avoid or minimise negative impacts.

8.6 Residual impacts

The possible positive residual impacts far outweigh the negative. However, there are some negative impacts which are unlikely to be fully mitigated for:

- reduction in in-shore marine habitats, particularly for fish and a lesser extent Gangetic dolphins, with implications for common good fishing and professional fishing household livelihoods
- the human nutrition implications of the change in fish availability are uncertain at present but the negative impacts on nutrition from changes in fish consumption patterns could outweigh the benefits from greater agricultural production.

8.7 Environmental risk

The following basic assumptions have been made when assessing the proposed intervention:

- the procedures for land allocation will be improved to ensure that they are systematic, fair, equitable and timely. If this is not done then full potential benefits of the intervention are unlikely to be attained. The experience of the CDSP with this problem should be borne in mind
- the proposed drainage systems will be fully effective in preventing saline intrusion and also disposing of monsoon rainfall flooding.

It is assumed that if the project goes ahead then it will be as an integrated development project. If a more limited intervention of just cross dam construction were to be implemented, then specific mitigation measures (at present incorporated in the many components of the integrated programme), may need to be implemented.

Evidence from the 1991 cyclone indicates that the overall risk of cyclone damage will be reduced by forest and suitably designed embankments dissipating waves. In addition there would also be a reduction in loss of human lives and livestock, although this would be greatly enhanced by construction of suitable cyclone shelters and killas.

8.8 Environmental monitoring and management

Assuming that the project goes ahead then the following items will need to be monitored:

- accretion and erosion patterns using time series satellite imagery; such work will indicate the effectiveness of the intervention and also any induced impacts on in-shore marine habitats and navigation
- in-shore fish catch assessment, a study of fish ecology (specifically on spawning and breeding grounds) and assessment of stocks, as well as monitoring of the impacts of changed accretion patterns on fish habitats and stocks
- incidence of malaria, water borne disease and cholera
- human nutrition levels in relation to fish consumption
- household socio-economics related to predicted project benefits
- external issues, particularly induced accretion and any proposed upstream developments.

The main mitigation step would be relocation of any ghats. Other mitigation measures may be necessary depending upon the results of monitoring programmes.

The implementation of the monitoring programmes could be carried out by the locally based project management. Alternatively, the Environmental Cell that is being established at WARPO, as part of the National Water Management Plan, could take responsibility for the work within the framework of the proposed coastal area management unit at WARPO.

The Department of Fisheries already have plans to carry out a major fish resource assessment for the area which with appropriate institutional liaison could carry out the required fisheries monitoring for the proposed intervention.

8.9 Conclusions of the environmental assessment

Under the Department of the Environment environmental classification the proposed intervention would appear to be in the highest Class D (Red) under Section 66 (flood control embankment, polder, dike etc.). Before the project can go ahead the DoE will need to review and approve the EIA and grant a Site Clearance Certificate. Before a full Environmental Clearance Certificate can be granted a No Objection Certificate will be required from the Local Authority. As there is little experience in the implementation of these procedures so far in Bangladesh it is considered unwise to embark upon this process until agreed arrangements are in place for the funding of the project.

Under World Bank Operational Directive 4:01 the proposed intervention would probably be classified as Class A (the highest), although it could possibly be down graded to Class B, as the extent of the effected area is relatively small by international standards.

The fundamental problem with the proposed intervention is that whilst the cross dams significantly speed up land accretion, the predicted positive economic impacts of utilising such land are long term (between 15 and 30 years) and the construction costs are relatively high per beneficiary household. A case could be made on social benefit grounds for going ahead with the project, but this would need to be considered against other development priorities in the country.

8.10 Future environmental work programme

TOR for full feasibility study, detailed baseline and needs assessment are required before any detailed design. In addition a suitable, locally based inter-disciplinary and decentralised institutional structure will need to be established for detailed project planning and implementation. The

procedures for allocation of new land through the Ministry of Land will also need to be streamlined to be operational in a transparent, fair, equitable and timely manner at local level.

The monitoring programmes established under the project need to be continued:

- monitoring of erosion and accretion from satellite imagery
- water and soil salinity monitoring at least two times a year and preferably increased to four times
- studies of in-shore marine habitats, fish ecology (particularly the fish spawning and breeding grounds), along with a baseline survey of fisheries catch and a stock assessment
- monitoring of the incidence of malaria and waterborne disease in the area.

P1-9 PRELIMINARY ECONOMIC ASSESSMENT

A brief preliminary economic assessment of the proposed project has been made. This assessment, which is based on the same assumptions and parameters used for the economic analysis for the feasibility studies for Nijhum Dwip and Char Montaz - Kukri Mukri⁴, is broadly indicative only. In particular, costs have been estimated based only on preliminary designs and benefits have been estimated on the assumption that conditions (yields, cropping intensities, etc.) are the same as in the other locations, without out adjustment for any specific conditions in the Rangabali - Char Biswas area. This assessment includes the following costs and benefits:

- costs of 8 cross dams (see Table P1-5.3)
- empoldering and water management facilities for Bara Baishdia (Table P1-5.9) and Chars Halim and Ganga (Table P1-5.14)
- empoldering of North Char and Kasher Char, with costs pro-rated from the costs for Bara Baishdia and Chars Halim and Ganga
- costs of aquacultural and livestock programmes at the same annual cost as for Char Montaz - Kukri Mukri Integrated Development Project
- agricultural, aquacultural and livestock benefits for the four empoldered areas.

9.1 Project costs

The costs of engineering interventions are taken from chapter 5. All cross dams are assumed to be implemented during the first two years of the project. Polders are constructed in years 1 and 2 (Bara Baishdia) and years 6 and 7 (Halim Char and Char Ganga).

For this analysis, the empoldering of North Char and Kasher Char has been added, although this is not discussed in chapter 5. For convenience, it is assumed that these two chars are empoldered in years 4 and 5 of the project. Because no investigation has been made of the actual requirements of these two chars, the costs (see Table 9.1) have been derived by assuming:

- embankments are 50:50 sea facing and interior
- sluice costs per ha are the average for Bara Baishdia plus Chars Halim and Ganga
- drainage costs per ha are the same as for the other chars.

⁴ See volumes 3 & 4 of this Report, respectively.

Table 9.1: Cost estimate for empolderment of North Char and Kasher Char

	North Char	Kasher Char	Total
Area of char (ha)	1,785	2,590	4,375
Estimated area embanked (ha)	1,340	1,890	3,230
Perimeter of char (km)	22.8	25.1	47.9
Est. embankment length (km)	18.5	17.9	36.4
COST (Tk '000)			
Embankments	41,884	40,525	82,409
Water management/sluices	13,132	18,522	31,654
Drainage channels	1,881	2,654	7,535
Total estimated cost	56,897	61,701	121,598

Project costs are summarised in Table 9.2. Contingencies are included at 10 per cent of base costs and project management costs of BWDB are included at 10 per cent of civil works base costs.

No costs are included for new settlements it is not possible to estimate the requirement for this component at this stage.

9.2 Project benefits

Project benefits are estimated on the same basis as they have been calculated in the feasibility studies for Nijhum Dwip and Char Montaz - Kukri Mukri. There studies may be referred to for a detailed discussion of the assumptions and approach used.

Non-quantified benefits will be similar to those at the other two sites.

9.3 Preliminary economic analysis

EIRRs were estimated for several options. Firstly, an estimate was made for all the proposed new empoldered areas and secondly for Bara Baishdia and Chars Halim and Ganga only. In each case, EIRRs were estimated for the scenario where the costs of all cross dams are included and then for the scenario when only those cross dams directly affecting the areas to be empoldered were counted. There is significant difference between the results because the two largest and most expensive proposed cross dams (A-12 and A-17) do not directly affect the areas under consideration. The results are in Table 9.3. No sensitivity analysis of these results has been carried out.

Table 9.3: Results of preliminary analysis for Rangabali - Char Biswas

Areas	Cross dam costs included	EIRR (%)
Bara Baishdia, Char Halim, Char Ganga, North Char, Kasher Char	A1-A9, A1-A10, A1-A11, A1-A12, A1-A14, A1-A15, A1-A16, A1-A17	7.2
	A1-A9, A1-A10, A1-A15, A1-A16	10.1
Bara Baishdia, Char Halim, Char Ganga	A1-A9, A1-A10, A1-A11, A1-A12, A1-A14, A1-A15, A1-A16, A1-A17	7.3
	A1-A9, A1-A10	11.5

This assessment does not take into consideration development activities on Chars Rangabali, Choto Baishdia, Biswas and Kajal which should be included in any feasibility study for a project in the area. Such activities would probably have a significant impact on total project benefits.

These are positive indications of the potential viability of a project in this area. More detailed and extensive investigation is needed during the feasibility study. The following points are noted:

- any project for this area will include development activities for the already empoldered areas on chars Rangabali, Choto Baishdia, Biswas and Kajal, which together constitute about two thirds of the total project area
- development activities for these areas focusing on rehabilitation and improvement of operation of the water management infrastructure and improving the productivity of agriculture, livestock and aquaculture could add significantly to total project benefits
- the proposed new polders have relatively low ratios of area empoldered to length of embankment - e.g. 72 ha/km for North Char and about 94 ha/km for Bara Baishdia compared with about 120 ha/km for Kukri Mukri; alternative polder configurations, which may be possible after the channels between the chars have accreted, should be investigated during the feasibility study.

9.4 Conclusions

There are good prospects that a useful and viable project can be designed for implementation in the Rangabali - Char Biswas area. This should be further investigated, in greater detail, during a feasibility study.

Table 9.2: Summary of project costs (financial prices)

Unit: Tk '000

Component	Project Year							Total
	1	2	3	4	5	6	7	
Cross dams	87,139	45,581						132,720
Embankments	48,206	48,205	48,790	48,790		12,397	12,397	218,785
Water management	19,632	19,632	17,150	17,150		7,683	7,683	88,930
Drainage channels	2,667	2,667	2,455	2,455		1,088	1,088	11,333
Sub-total civil works (A)	157,644	116,085	68,395	68,395	0	21,168	20,081	451,768
Livestock development	900	900	900	900	900	900	900	6,300
Livestock line of credit	350	350	350	350	350	350	350	2,450
Aquaculture development	1,250	1,250	1,250	1,250	1,250	1,250	1,250	8,750
Sub-total development (B)	2,500	2,500	2,500	2,500	2,500	2,500	2,500	17,500
Project management (10% A)	15,764	11,609	6,834	6,834	0	2,117	2,008	45,166
Contingencies (10% A + B)	16,014	11,859	7,084	7,084	250	2,367	2,258	46,916
TOTAL COSTS	191,922	142,053	84,813	84,813	2,750	28,152	26,847	561,350

4

Appendix I

DESIGN CRITERIA AND BASIC COST DATA

1. Land level for empoldering

After a many years of accretion most of the old char land will have reached a land level which is near to the mean higher high water level (MHHWL). In cases where accretion is stimulated, for example by a cross dam, a land level near to MHHWL may be reached after 5 years. Land levels are still inundated approximately 10 per cent of the time. Older char land that has reached MHHWL is characterised by a more or less flat surface.

The minimum land level considered for empoldering is important from a drainage point of view. The lower the land, the more problematic drainage by gravity will be. Technically land levels below MHHWL can be empoldered too, but with land levels equal to or above MHHWL it is expected that flood protection is still economically feasible. In other words, the height of the embankment, the sluice capacity to be installed and the modifications required to improve the natural drainage network of creeks, as defined in detailed design studies, are expected to be affordable in economic terms. The final decision for empolderment is an economical rather than a technical decision.

MHHWL varies from place to place in the estuary and is influenced by seasonal effects, overall wind and sea current directions, location of land bodies and differences in gravity. Hence, there is no absolute PWD land level for empoldering, which is valid for the entire estuary. The level for empoldering is always linked to the local MHWL. In case of char Bara Baishdia and char Halim and Ganga, the land level of +1.5 m PWD is approximately MHWL and is considered a minimum level for empoldering for this study.

2. Flood protection embankments

Primary (sea) embankments

Height

Only agricultural damage is most likely and it is assumed that sufficient facilities are available for the local population in case of cyclone storm surge, such as an early warning system, cyclone shelters and killas for livestock. In line with CPP-II (FAP-7) and SRP (EC) a 1:20 years flood frequency is considered the design height of embankments, increased with a freeboard of 1.22 m in case of a sea-facing embankment. In case the embankment is located along a minor tidal khal, a freeboard of 0.91 m is considered sufficient.

Side slopes

Unless stability considerations indicate otherwise, a side slope of 1:2 is adopted for the countryside and 1:7 for the seaside. In case the embankment does not face the sea, but a minor khal, a slope of 1:3 has been selected.

Crest width

In case of sea facing embankments, inspection roads (also used during emergency repairs) are considered a necessity. A minimum crest width of 4.25 m is therefore maintained. This width is also sufficient to use primary embankments as fair weather R-2 rural roads, which require a crest width of only 3.6 m.

The crest width of the embankment will be increased to 4.90 m in case a paved R-1 rural road is planned on a primary embankment.

Physical features of primary embankments

Type	Crest Level ⁵ (m PWD)	Freeboard (m)	Crest Width (m)	Slope R/S	Slope C/S
Primary embankment, sea-facing	4.92	1.22	4.25	1:7	1:2
Primary embankment, interior	4.61	0.91	4.25	1:3	1:2
Primary embankment, interior cum paved R-1 road	4.61	0.91	4.90	1:3	1:2

Based on the above criteria and the BWDB standard schedule of rates the costs of embankments have been calculated.

Estimated costs per kilometre embankment

Type	Volume (m ³)	Rate ⁶ (Tk/m ³)	Construction Costs/Km (Tk '000)	Land Acquisition ⁷ Cost (Tk '000)	Turfing Costs ² (Tk '000)	Total Costs (Tk '000)
Primary embankment, sea-facing New Construction	67,170	30.9	2,076	519	274	2,869
Primary embankment, interior	37,360	30.9	1,154	345	159	1,658
Primary embankment cum R-1 road	39,210	30.9	1,212	352	164	1,728

Drainage sluices

Final detailed drainage design studies can be carried out when accretion has been completed. For the purpose of this study, historical data have been used to define the required sluice capacity with a so called drainage ratio. The drainage ratio is defined as the inverse of the available drainage sluice cross section for a given catchment area, expressed in ha/m².

Drainage ratio of existing polders

Polder	Name	Total Catchment Area (Ha)	Total Sluice Cross Section (m ²)	Average Drainage Ratio (Ha/m ²)
55/1	Galachipa	10,900	85.3	129
55/3	Char Biswas-Kajal	9,850	61.2	161
58/1	Manpura Hazirhat	3050	18.0	170
58/2	Shakuchia-Manpura	3250	25.0	130
72	Sandwip	18,700	87.3	214
73/2	South Hatia	12,300	73.2	168
Average				162

In comparing existing and recently rehabilitated polders in the study area, it was found that the average drainage ratio is 162 ha/m². Given the problematic drainage situation in a number of these polders, and for purpose of planning in this study only, the design drainage ratio is set slightly higher, at 150 ha/m².

⁵ Based on present design of primary embankments for Char Montaz.

⁶ Standard Schedule of Rates, 1995, prices converted to 1998 prices.

⁷ A land cost of 114,000 Tk/ha is assumed for this region.

Drainage sluice

Like in most polders, the standard BWDB box culvert drainage sluice has been selected with a cross section of 2.78 m² (1.52 m x 1.83 m) per vent. In most cases such drainage sluices comprise one to five vents.

Surface sluice

The purpose of a surface sluice is to solve local drainage congestion along the flood protection embankment. Land near the coastline of chars may be slightly lower and at the same time a number of minor creeks are blocked by the primary embankment. Therefore a provision of 3 minor drainage sluices per 10 km of primary embankment has been made⁸ with a pipe diameter of 1.22 m. On both sides of the sluice a flap gate will be provided. This sluice may also be used to flush water into the polder, if required. Where required, a minor drain will be constructed along the primary embankment, on the country side, separated by a berm of 2 m.

The cost of a standard drainage sluice varies from Tk 4.5 million⁹ to Tk 8.3 million¹⁰. The need for pile foundations can increase the cost of a sluice considerably, as do the requirement for improved flap gates and vertical lift gates, which last longer and have a better performance. For this study an average provision has been taken for pile foundations.

Costs of drainage and surface sluices

Type of Sluice	LS Costs (Tk)
Surface Sluice Diameter 1.22 m provided with two flap gates (c/s and r/s). 1 vent	772,000
Box Culvert Sluice Dimensions 1.52x1.83m provided with vertical lift gate (c/s) and improved flap gate (r/s). 2 vent	6,000,000
3 vent	9,000,000

Drainage channels

Starting point is the natural creek system formed during accretion. It is expected that primary drains can be selected at an interval of 2 to 3 km and secondary drains with spacing between 1 and 2 km, resulting in average secondary drainage areas of 30 to 40 ha. Additional tertiary drains may be selected or constructed to drain isolated low pockets.

The existing drains are considered sufficient to meet the drainage requirements. Nevertheless, several rehabilitation design studies show costs for improving the drainage network varying from 85 to 643 Tk/ha catchment area¹¹. These costs cover, in most cases, the re-excavation of a few primary drain sections in a rehabilitated polder. In the case of new polders these cost may be much higher (SRP-EC). The current practice of BWDB is not to modify the existing drainage network.

For this study, a provision of re-excavation of 30 per cent of primary drains and a lump sum for the excavation of connecting drains (between primary drains and primary drains and sluices) have been taken, based on an average density of drains and historical re-excavation costs. In the case of existing polder land, no provision for connecting drains has been made. Re-excavation of primary drains is expected to maintain a depth of around 2 m, recommended for the stimulation of deep drainage, which plays a major role in the desalinisation of the subsoil.

⁸ Average found in rehabilitated Polder 55/1

⁹ BWDB, 1998, Patuakhali O&M Division.

¹⁰ CDSP, 1996, Char Bhatir Tek.

¹¹ SRP-EC, 1992-4, polder 73/1AB, 58/3, 73/2 and 35/1.

Costs for improvement of drains per 1,000 ha.

Description	Length (Km)	Volume ¹² (m ³)	Rate ¹³ (Tk/m ³)	Cost (Tk '000)
Re-excavation Primary Drains (30%)	2.4	26,400	21.8	576
Excavation of Drains	n.a.	38,000	21.8	828
Total				1,404

Bridges and culverts

In the case of Bara Baishdia, it is assumed that all required bridges and culverts are in place and where new bridges and culverts are required that these will be provided under regular development plans (ADP) of the local Government and LGED.

¹² An average volume of 6000 m³ per km was found for re-excavation of primary drains in polder 73/2, SRP 1994.

¹³ Based on 1995 Standard Schedule of Rates.

Appendix II



INTEGRATED WATER MANAGEMENT

1. Participation in water management

Effective drainage, operation and maintenance programmes require the involvement and co-operation of stakeholders and other relevant organisations. For example: What will be considered a primary or secondary drain? What will be the policy regarding fishing in main drains and near sluices? Which drainage channels should remain accessible for country boats, when should sluices be opened and closed? What are the target water levels for drains? What will be the yearly routine and periodic maintenance programme, what will be the amount for a flood protection fee (local cost recovery)? All these questions related to water management, but can not be answered by BWDB only. The involvement of stakeholders, local Government bodies like DOF, LGED, but also NGOs are required.

To involve stakeholders and to ensure representation of the interest groups, the organisation of stakeholders, such as farmers, fishermen, boat owners, traders etc. is needed. Experiences with the present GPP, which focuses more on irrigation projects, are not always successful. Recent national workshops on people's participation in water management revealed a number of shortcomings of the present GPP concerning FCD schemes like polders. A revision of the GPP is under preparation. Anticipating expected changes; it is envisaged that there should be three important parties involved in water management, BWDB, the so-called Water Management Committee and the Stakeholder's Organisation.

The role of BWDB will be mainly limited to planning and implementation of *periodic maintenance* of embankments and sluices, involving stakeholders and local Government Representatives. Further, BWDB will participate in a thana and district level Co-ordination Committee to discuss issues related to maintenance in the context of overall land and water use.

The new Water Management Committee (WMC) comprises local politicians and advisers from Bara Baishdia Union. The role of the WMC is mainly that of planning and decision making in operation and maintenance. Also arbitration in water management conflicts, cost recovery, formulation of an annual and seasonal water management plan for the polder and defining the function of infrastructure in the context of a land and water use plan will be handled by the WMC.

The Stakeholders will be organised in two tiers only. The bottom tier will be at compartment level, named Water Management Block and a second tier will comprise the two compartments BB-1 and BB-2, named Water Management Board (WM-Board). The members of this board are proposed by the Blocks, but are subject to approval and appointment by the WMC. The members of the WM-Board are the chief executives of O&M and must receive remuneration and a (modest) office facility from the Local Government for their (time consuming) efforts.

WMC, BWDB, WM-Blocks and the local WM-Board will meet at least twice, seasonally (pre-monsoon) and annually (post-monsoon). O&M plans and budgets will be prepared and finalised by WMC and BWDB with participation of the stakeholders. Implementation is done by the BWDB and local WM-Board.

It is expected that the present GPP idea of a "Project Council" or "Polder Council" will be discontinued under the new GPP. The already existing TDCC is the most appropriate platform to co-ordinate the inter-linked activities of BWDB, LGED, DOF and DAE and other GOs and NGOs. In the TDCC, a water management plan will be presented by the WMC. After discussion eventual consequences of the plan will be endorsed by the TDCC of Galachipa and the organisations involved in the TDCC (All Government Organisations).

In the case of the creation of compartments BB-1 and BB-2 that form polder 50/51, the WMC will cover both compartments. Polder 52/53 A and B, being in different unions, will have their own WMCs.

The institutional framework for water management as described above will be subject to a final version of a revised GPP, which is expected to become effective in 1999. In the absence of a revised GPP, the chances for improved water management are limited. WUCs and WUA depend too much on BWDB and have no formal power and are therefore rather inactive. Polder Councils depend on the willingness and resources of TNOs and other GOB officials, which is very limited. The BWDB's role under the current GPP, which is regarded as the motor of people's participation in water management, is far from their traditional engineering role. The new GPP should provide the stakeholders with a formal say, through the WMC, formed and chaired by elected people's representatives. Besides, these WMC will have the means to implement a water management plan. A local budget is raised through the collection of a local water tax (collected through the Union Council) and implementation is assured by a local WM-Board with the backing of the WMC and Union Councils.

2. Management, operation and maintenance

The WMC will formulate an operation plan that describes water level targets to be met in drainage channels on a monthly basis and a set of instructions for the operation of sluices. The WM-Board will appoint a sluice operator and ensure the daily operation of sluices and monitor the water levels in the drainage channels through gauge readers.

BWDB has to build-up skills and experience in preparing a sound periodic maintenance plan. Based on an inventory of the hydraulic infrastructure and period maintenance criteria, a periodic maintenance plan can be prepared and implemented. Periodic maintenance plans are based on actual field inspections, surveys and needs expressed by the WM-Blocks and WM-Board. The periodic maintenance plan requires approval from the WMC.

Based on the operation plan and formulated targets, financial and physical indicators need to be identified and data will be collected and used to evaluate the yearly performance of the two compartments BB-1 and BB-2. This will be a task of the WMC.

The implementation of an O&M programme requires the regular presence of a Sub-Divisional Engineer of BWDB based at Khepupara, trained in periodic maintenance planning, budgeting, implementation and monitoring.

3. Water management and O&M budget

One of the conditions for successful implementation is the availability of sufficient periodic maintenance funds under the heading "works" of the revenue budget allocated to BWDB. The height of the O&M budget will depend on the maintenance standards applied but will be at least near to 1 to 2 per cent of the estimated new price of the infrastructure. BWDB will provide funds for periodic and emergency maintenance of embankments and sluices as well as their own establishment.

Stakeholders such as landowners, farmers, fishermen, house-owners, shopkeepers and traders will pay a local polder tax. Polder tax revenue should cover the budget requirement for the implementation of a routine maintenance plan for sluices and embankments, but also the routine and periodic maintenance plan for drains. It should also cover establishment costs such as the remuneration of the local WM-Board members and their employees such as sluice operators and gauge readers. The Union Council through their local tax system will be entitled to collect the polder tax.

4. Involvement of landless and destitute women

Routine maintenance should be carried out by Embankment Maintenance Groups (EMG) and Channel Maintenance Groups (CMG) consisting of destitute women and landless, eventually supported by NGOs. Funds will be provided by the Union Council.

For periodic maintenance of embankments, BWDB will employ local Labour Contracting Societies (LCS) for earth works (status of D-Class contractor). Both groups will consist of landless and destitute women and will be trained by BWDB.

There is no guarantee that with the above described institutional set-up O&M will improve. However, transparency and accountability are clearly increased. Moreover, the physical safety has now become the shared responsibility of the local population, local institutions like Union Councils, WMC and a local WM-Board, and a national institute, BWDB.

Appendix III

IDENTIFICATION OF FURTHER INVESTIGATIONS IN MORPHOLOGY

Objectives

Within the framework of MES development, the options of implementing the cross dams have been described for the prefeasibility study areas of Rangabali - Char Biswas, Hatia - Manpura and Urir Char - Pir Baksh. For each of these study areas the expected morphological changes were delineated.

With respect to the implementation of the development schemes, in the feasibility stage, the following morphological studies and investigations can be identified:

1. data collection and field surveys,
 - 1A. topography and bathymetry
 - 1B. hydraulic and morphological data
2. data processing and data analysis,
3. mathematical model investigations,
4. morphological interpretation.

Results

The outcome of the hydraulic and morphological study should be:

- a quantitative assessment of the accretion and erosion rate of the areas during and after the implementation of the cross-dam.
- an assessment of the closure method and procedures during various construction stages.
- improved knowledge and understanding of land formation and char development due to implementation of cross-dams

Task description

1. Data collection and field surveys

The morphological and hydraulic impact due to closure and implementation of the cross-dam requires data on:

A. Topography and bathymetry for the whole project area

This gives an indication of the sediment budget. All bathymetric data and levelling data should be defined with reference to PWD. New information (coastline, land use, infrastructure) derived from recent remote sensing images should be incorporated.

B. Hydraulic and morphological data

1. land level data along the channel and adjacent islands.
2. water level, flow velocities and discharge measurements along the channel
3. waves
4. cross-sectional profiles
5. sediment concentrations and grain sizes of suspended sediment, grain sizes of bed sediment

2. *Data processing and data analysis*

Data processing and data analysis concern:

1. laboratory analysis of sediment data
2. analysis of current velocities, water levels and bathymetry
3. calculation of the discharge and sediment transport
4. assessment of the accretion and erosion rate along the channel and adjacent islands during and after implementation of the cross-dam
5. analysis of the accretion and erosion rate using bathymetric information.

3. *Mathematical model investigations*

A 2D mathematical model investigation programme should be executed for the pre-feasibility study areas to gain insight into the hydrodynamic and morphodynamic behaviour of the tidal channels under various hydraulic conditions during and after implementation of the cross-dam. The mathematical model investigation should be carried out by the Surface Water Modelling Centre (SWMC).

4. *Morphological analysis and interpretation*

Based on the data analysis and the results of the mathematical investigations, the future morphodynamic behaviour has to be studied and the prediction for accretion and erosion in the channels and intertidal zones have to be updated and corrected where necessary.

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PART 2
HATIA - MANPURA

TABLE OF CONTENTS

P2-1	INTRODUCTION	1
1.1	General description of the project area	1
1.2	Project rationale	1
1.3	Project approach	1
1.4	Key assumptions	1
P2-2	MORPHOLOGICAL DEVELOPMENTS	3
2.1	Introduction	3
2.2	Objectives of the morphological study	3
2.3	Physical features	3
2.3.1	Tide	3
2.3.2	Bathymetry	4
2.3.3	Coastline migration	4
2.3.4	Waves	4
2.3.5	Tidal flow and sediment concentration	4
2.4	Expected morphological developments	5
P2-3	PRESENT SITUATION	11
3.1	Physical setting	11
3.1.1	Topography	11
3.1.2	Climate	11
3.1.3	Soils	11
3.1.4	Land use	11
3.1.5	Flooding	11
3.1.6	Cyclones	11
3.2	Socio-economic setting	11
3.3	Hydraulic infrastructure and water management	12
3.4	Agriculture	12
3.5	Livestock	12
3.6	Fisheries	13
3.7	Forestry	13
3.7.1	Background	13
3.7.2	Existing forest	13
P2-4	FUTURE WITHOUT PROJECT	16
4.1	Land accretion and land development	16
4.2	Physical and social infrastructure	16
4.3	Water management	16
4.4	Agriculture	16
4.5	Livestock	17
4.6	Fisheries	17
4.7	Forestry	17
P2-5	PROPOSED INTERVENTIONS	17
5.1	Cross dams	17
5.1.1	Basic data	17
5.1.2	Cross dam design	19
5.1.3	Proposed cross dams	21
5.1.4	Implementation of the cross dams	21
5.1.5	Cost estimates of the cross dams	21
5.2	Development of char land	21
P2-6	DEVELOPMENT FOR THE PROJECT AREA	21
6.1	Development concept	21
6.2	Land accretion	22
6.3	Land development	22

6.4	Needs assessment	25
6.5	Project interventions	25
6.5.1	Safety of the population	25
6.5.2	Roads and transport	25
6.5.3	Settlements	25
6.5.4	Agriculture	26
6.5.5	Fisheries	26
6.5.6	Livestock	26
6.5.7	Forestry	26
P2-7	IMPACT OF THE PROJECT	27
7.1	Physical infrastructure	27
7.2	Social infrastructure	27
7.3	Agriculture	27
7.4	Livestock	27
7.5	Fisheries	28
7.6	Forestry	28
P2-8	ENVIRONMENTAL ASPECTS	28
8.1	Aims and objectives of the environmental assessment	28
8.2	Proposed interventions	28
8.3	Baseline environmental conditions and future trends	28
8.4	Impact identification, quantification and valuation	29
8.4.1	Identified positive impacts	29
8.4.2	Identified negative impacts	31
8.4.3	External impacts and constraints	31
8.5	Environmental mitigation	32
8.5.2	Ghat relocation	32
8.5.2	In-shore marine habitats	32
8.5.3	Fisheries	32
8.5.4	Direct construction impacts	32
8.6	Residual impacts	32
8.7	Environmental risk	32
8.8	Environmental monitoring and management	33
8.9	Conclusions of the environmental assessment	33
8.10	Future environmental work programme	34
	REFERENCES	37
	LIST OF TABLES	
	Table P2-3.1: Showing plantation area and growing stock	14
	Table P2-5.1: Tidal levels at Char Chenga	18
	LIST OF FIGURES	
	Figure P2-1.1: Location of the project area	2
	Figure P2-2.1: Potential sites for cross dams	6
	Figure P2-2.2: Frequency curves of daily high water levels at Char Chenga	7
	Figure P2-2.3: Frequency curves of daily low water levels at Char Chenga	8
	Figure P2-2.4: Exceedance frequency curve Char Chenga	9
	Figure P2-2.5: Coast line development of Hatia - Manpura 1957, 1973 and 1996	10
	Figure P2-3.1: Situation of project area in February 1996	15
	Figure P2-5.1: Section and side view of cross dam	20
	Figure P2-6.1: Future accretion and erosion in Hatia - Manpura area without intervention	23
	Figure P2-6.2: Future accretion and erosion in Hatia - Manpura area with intervention	24
	Appendix I	35

P2-1 INTRODUCTION

1.1 General description of the project area

The project area is located in the Hatia thana of Noakhali district, see Figure P2-1.1. It covers the islands in the East Shahbazpur Channel between northern Manpura and northern Hatia. The principal chars (islands) in the project area are Moulavir Char and Dhal Char.

This is a very dynamic part of the estuary. Inspection of satellite images of 1957, 1973 and 1996 show that the north and north-eastern parts of Hatia and the northern tip of Manpura are continuously being eroded. Land formation activities continue in the East Shahbazpur Channel to the west of north Hatia but the newly accreted chars are mobile.

1.2 Project rationale

The socio-economic and agricultural development in the project area are hampered by :

- erosion of the northern Hatia and the migration of chars
- soil salinity, especially in the dry season due to the intrusion of saline water
- drainage congestion during high tide in the newly accreted chars.

This pre-feasibility study is for a project that would aim to enhance land accretion by the construction of cross dams and to promote char development through a multidisciplinary and integrated development approach. The project would also include afforestation of newly accreted land to promote land stabilisation and for foreshore protection.

1.3 Project approach

Interventions, such as cross dams, which accelerate the accretion of new land, present a dilemma from the economic point of view. Newly accreted land is saline, subject to tidal intrusions and low in fertility. For land to accrete to a sufficient level so that it can be successfully embanked and so that effective drainage and water management can gradually eliminate soil salinity takes a considerable number of years. The organic matter content of the soils is initially very low and increases only slowly. As long as these soil conditions prevail, agricultural yields are low. There is thus a long delay between investment in a cross dam and the commencement of a significant flow of benefits.

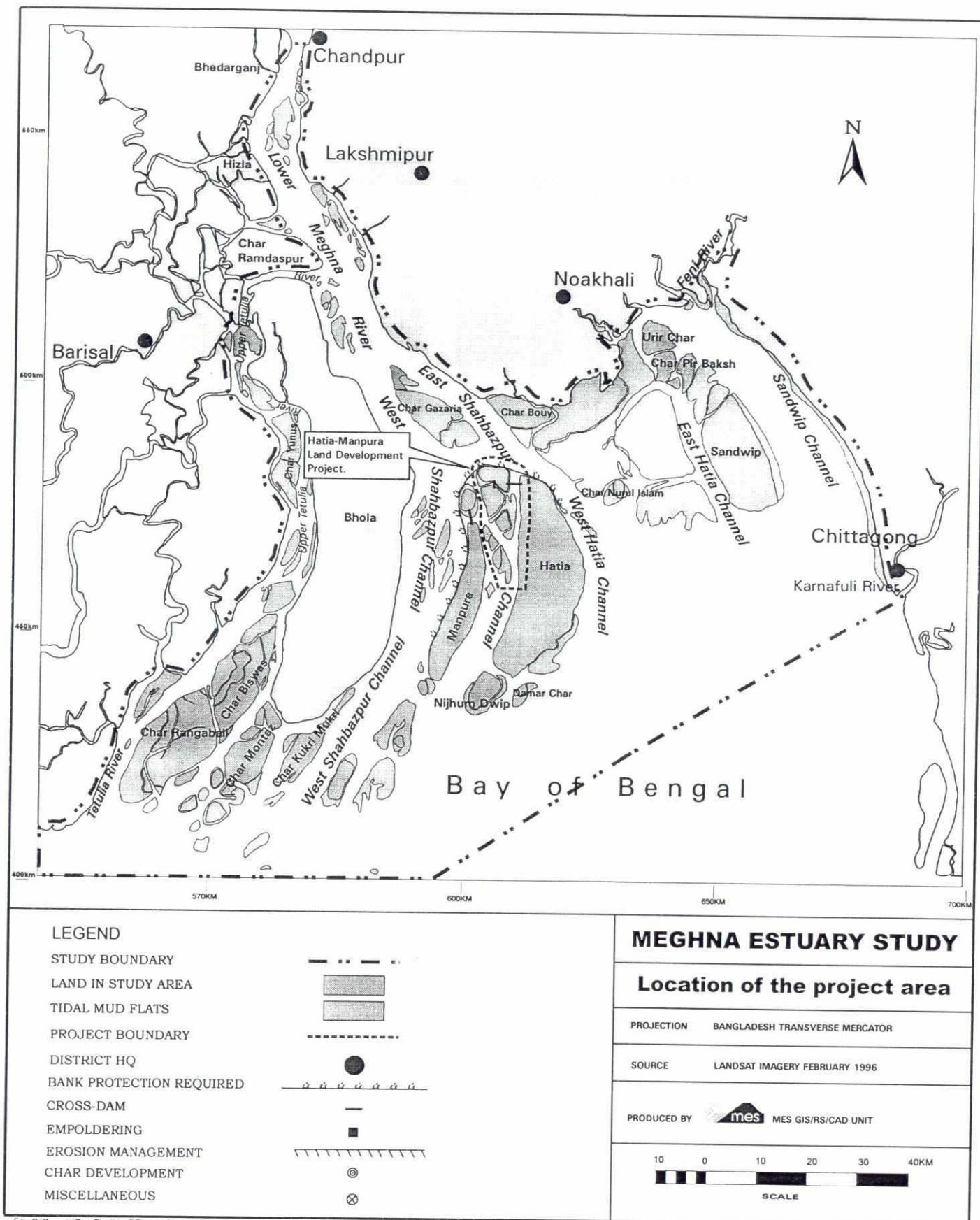
For these reasons it is appropriate to adopt an integrated development approach to the proposed development activities for chars in the Meghna estuary. By combining land accretion with land development and designing projects with components that may include cross dams, embankments, drainage and water management together with measures to increase the productivity and production of agriculture, livestock and aquaculture and other activities it is possible to design feasible development projects for these areas.

1.4 Key assumptions

The emphasis of this proposed project is on land accretion. Char development activities would focus on improving infrastructure and production, but at this stage no empoldering of unprotected areas is proposed. Critical assumptions for the study refer to the sequence of land development on newly accreted land and the role of mangrove forests on the estuarine chars. It is assumed that:

- new land reaching the level of +1.1 m PWD will be planted in mangroves
- mangrove forest which has reached the age of 15 years may be cleared for agriculture and other uses provided that a minimum depth of 1 km of forest is maintained all along the future coast at all times as an essential part of the protective barrier providing security against storms to the population.

Figure P2-1.1: Location of the project area.



P2-2 MORPHOLOGICAL DEVELOPMENTS

2.1 Introduction

Within the framework of the Meghna Estuary Study, the possibility of implementing cross dams in the project area has been studied. The potential sites for cross dams within the project area are shown in Figure P2-2.1. The cross dams will accelerate accretion because flow velocities in the closed channel section will be drastically reduced. Bank erosion due to the current will also stop in these channels.

To reduce the construction costs of such dams, the MES proposes to use geotextiles. Geotextiles will be spread out along the bottom across the channel and the space under the geotextile is filled with sand. This geotextile with sand act as a base for the cross dam to protect the bed against erosion during construction.

As a part of the pre-feasibility study for the Hatia-Manpura Development Project, a morphological study has been carried out to ascertain the effects of cross dam construction on the morphological development of the area.

2.2 Objectives of the morphological study

The objectives of the present morphological study are as follows:

- to draw up an inventory of relevant reports, bathymetric maps, aerial photographs, satellite imagery, cross-sectional soundings, water levels, flow velocities, discharges, sediment concentration and grain size distribution
- to describe the morphological development of the study area during the last decades (in terms of accretion and erosion and land levels)
- to improve the understanding of the morphological phenomena in the area with the aid of satellite imagery as well as other historical data on bathymetry and land formation
- to assess long term changes of land formation and char development
- to predict the preliminary morphological impact of cross dam construction for an intermediate time period (10-30 years).

2.3 Physical features

There are old and emerging islands, tidal channels and creeks and mangrove forests in the area. The islands located to the west of north-west Hatia and to the north-east of Manpura are dynamic. Land levels on Hatia island are above the Mean Higher High Water (MHHW) level. Mangroves have been planted in the newly accreted chars.

2.3.1 Tide

The tidal motion inside and around the project area dominates during pre-monsoon and post-monsoon. From April to October, high tides start inundating the low-lying areas and increase to their peaks in August. The tide is semi-diurnal with M2 and S2 as the major tidal constituents.

At Char Chenga, the high water levels and low water levels vary between 2.0 and 5.0 m CD and 0.0 and 2.0 m CD, respectively (Conversion factor: PWD = CD - 1.18 m). The seasonal variation of mean high water level at Char Chenga is about 1.5 m (Figure P2-2.2) and that of mean low water level is about 0.9 m (Figure P2-2.3).

A frequency exceedance curve (Figure P2-2.4) of water levels was prepared for Char Chenga, located south of the project area on the west coast of Hatia, which shows for how much of the time in a year a particular level remains under water. For example, +0.7 to +0.9 m PWD remains under water for about 50 per cent of the time. The lower levels remain under water for most of the time than the higher levels.

2.3.2 Bathymetry

The East Shahbazpur Channel located between Northwest Hatia and Moulavir Char on the north-east side of Manpura inside the project area is shallow in comparison with other channels (e.g., West Shahbazpur Channel Hatia Channel, Lower Meghna) in the estuary.

Bathymetric data of 1997 shows that the maximum localised depth in this area is about 4.5 m below MSL but the average depth seems to be less than 4.5 m. In comparison, the channel located west of the project area (West Shahbazpur Channel) is deeper, specially on the north-eastern Bhola side where erosion is continuing. This is the navigation route between Nijhum Dwip, Char Alexander and Char Jabbar.

The shallow channels around Moulavir Char and Dhal Char show a tendency to silt up. The cross-sectional area of the West Hatia Channel at the tip of Hatia island shows a decreasing tendency during the last ten years. The maximum channel depth increased slightly over time and the thalweg is migrating towards the south by eroding North Hatia but the thalweg was always on the North Hatia side.

2.3.3 Coastline migration

Aerial photographs of 1956-1957 and satellite images from 1973 to 1996 (Figure P2-2.5) show that north and north-eastern Hatia has been eroding since late 1950s and the rate is about 30 to 60 m/year. North Manpura eroded between 1973 and 1996. Dhal Char increased significantly in size between 1973 and 1996. Between 1973 and 1996, the east and west coastlines of Char Faizuddin (northern part of Manpura) accreted and eroded, respectively.

Manpura increased in size between 1973 and 1996 by the infilling of channels between small chars and also by enlargement of its coastline around Goalia (southern Manpura). The islands and chars increase or decrease in size by the migration of their coastlines. The whole west coastline of Hatia retreated, i.e. eroded, between 1973 and 1996.

2.3.4 Waves

Waves bring sediment into suspension which is then transported by the current. The results of a 2D wave model indicate that under the prevailing wind conditions, wave height can be about 0.2 to 0.6 m.

2.3.5 Tidal flow and sediment concentration

Flow and sediment concentration were measured in February and March 1987 and also in August 1997 during spring and neap tides in the East Shahbazpur Channel between Northeast Hatia, Moulavir Char and Dhal Char and between Dhal Char and Manpura. Although the data of 1987 are relatively old and not representative, they give some indication of the situation.

Among these measurements, average spring tide velocity was higher than the average neap tide velocity. Maximum recorded velocity during spring and neap tides were 2.3 m/sec and 1.5 m/sec, respectively.

Average sediment concentration during spring and neap tides varied between 2.1 and 1.3 gm/lit and between 0.4 and 0.5 gm/lit respectively. The maximum concentration was 3.75 gm/lit. Average concentration of 1987 samples is almost twice that of 1997 samples.

The concentration of sediment shows spatial and temporal variation. Measurements indicate that sometimes the shape of the concentration profile in a vertical is uniform and sometimes it is logarithmic. The difference in shape of the concentration profile may be due to density difference and the salinity gradient.

The direction of net flow of water and net sediment transport during spring and neap tides were towards the north and south, respectively. This indicates that the area is sensitive to changes in tide and river outflow.

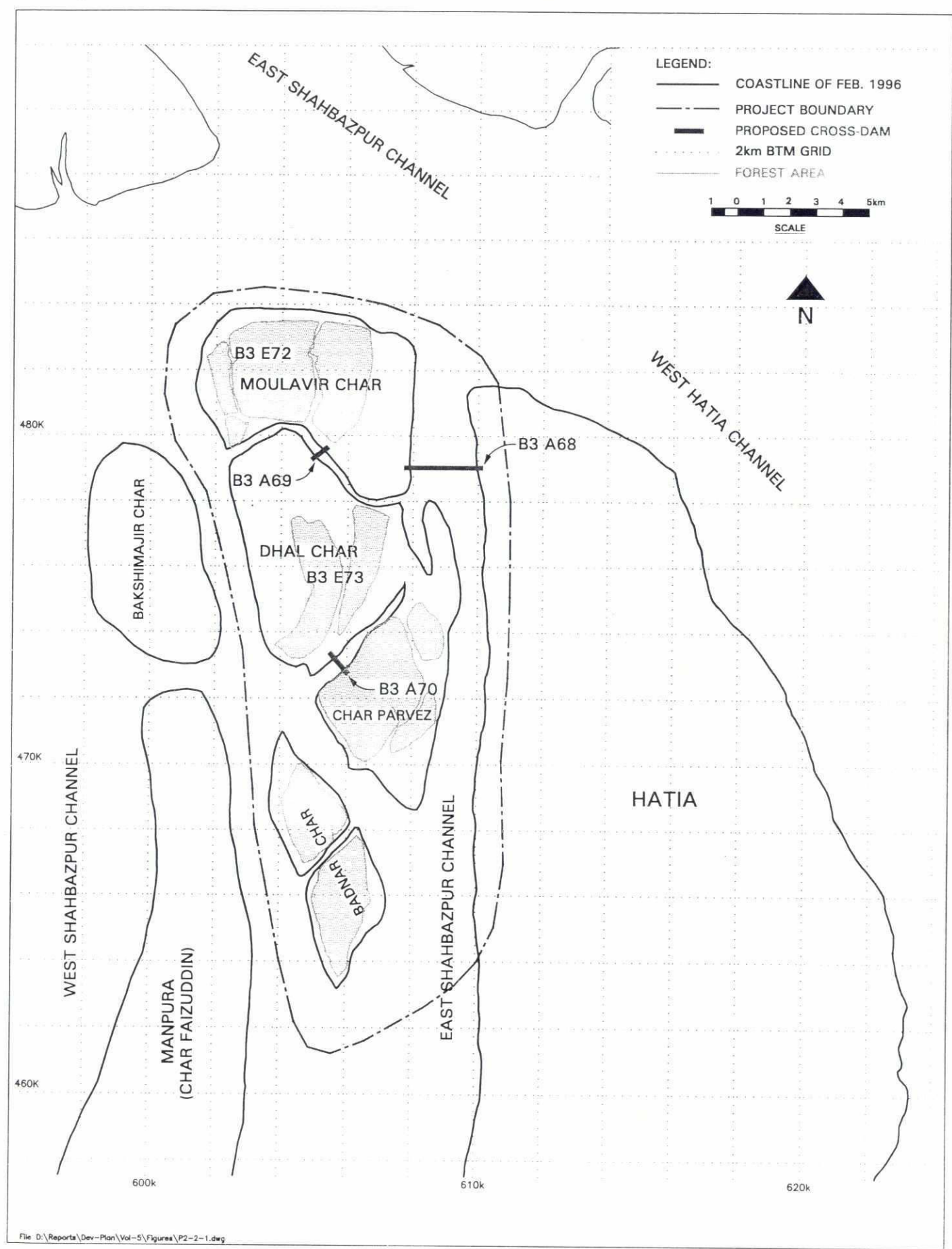
2.4 Expected morphological developments

The islands and chars in the project area have developed by the interaction of river borne and tide driven sediments. The Dhal Char and the Moulavir Char islands are expected to grow in size in the western and southern directions. If no bank protection work is executed along the east coast of Bhola, located to the west of project area, it will erode due to the implementation of this project.

The incoming and outgoing tidal volume will be reduced in the East Shahbazpur Channel inside the project area, flow velocity will decrease and consequently, sedimentation will occur. The area will increase in size. So tidal water and sediment volume during flood and ebb will decrease in future.

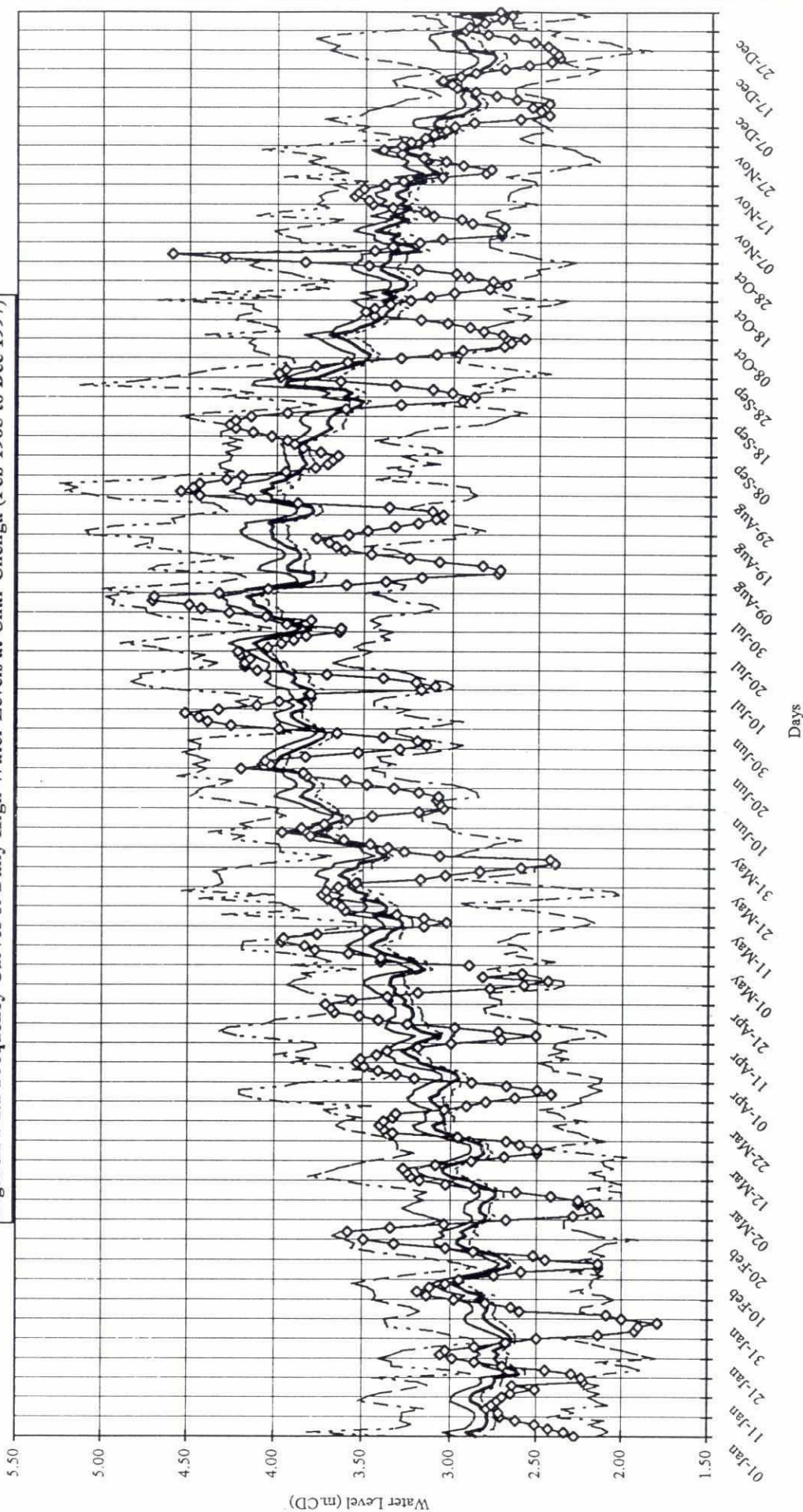
From a morphological point of view, it is expected that the relatively small tidal channels will silt up rapidly due to the construction of the cross dams. The total increase in area by 2025, as a result of these interventions, is estimated at 2,110 ha. This should be studied in detail during the feasibility study.

Figure P2-2.1: Potential sites for cross-dams



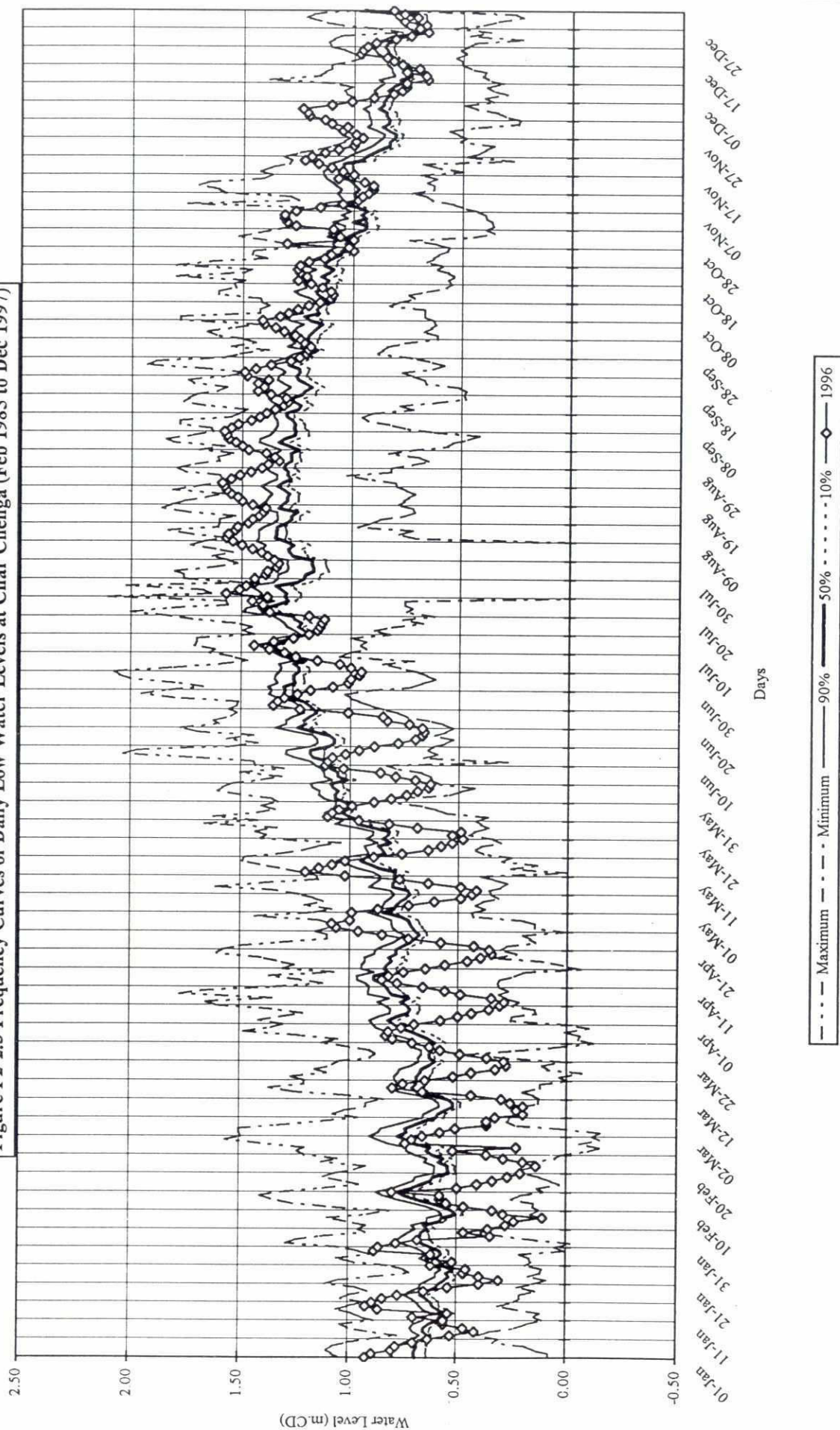
92

Figure P2-2.2 Frequency Curves of Daily High Water Levels at Char Chenga (Feb 1985 to Dec 1997)



--- Maximum - - - Minimum - . - . 50% — 1996

Figure P2-2.3 Frequency Curves of Daily Low Water Levels at Char Chenga (Feb 1985 to Dec 1997)



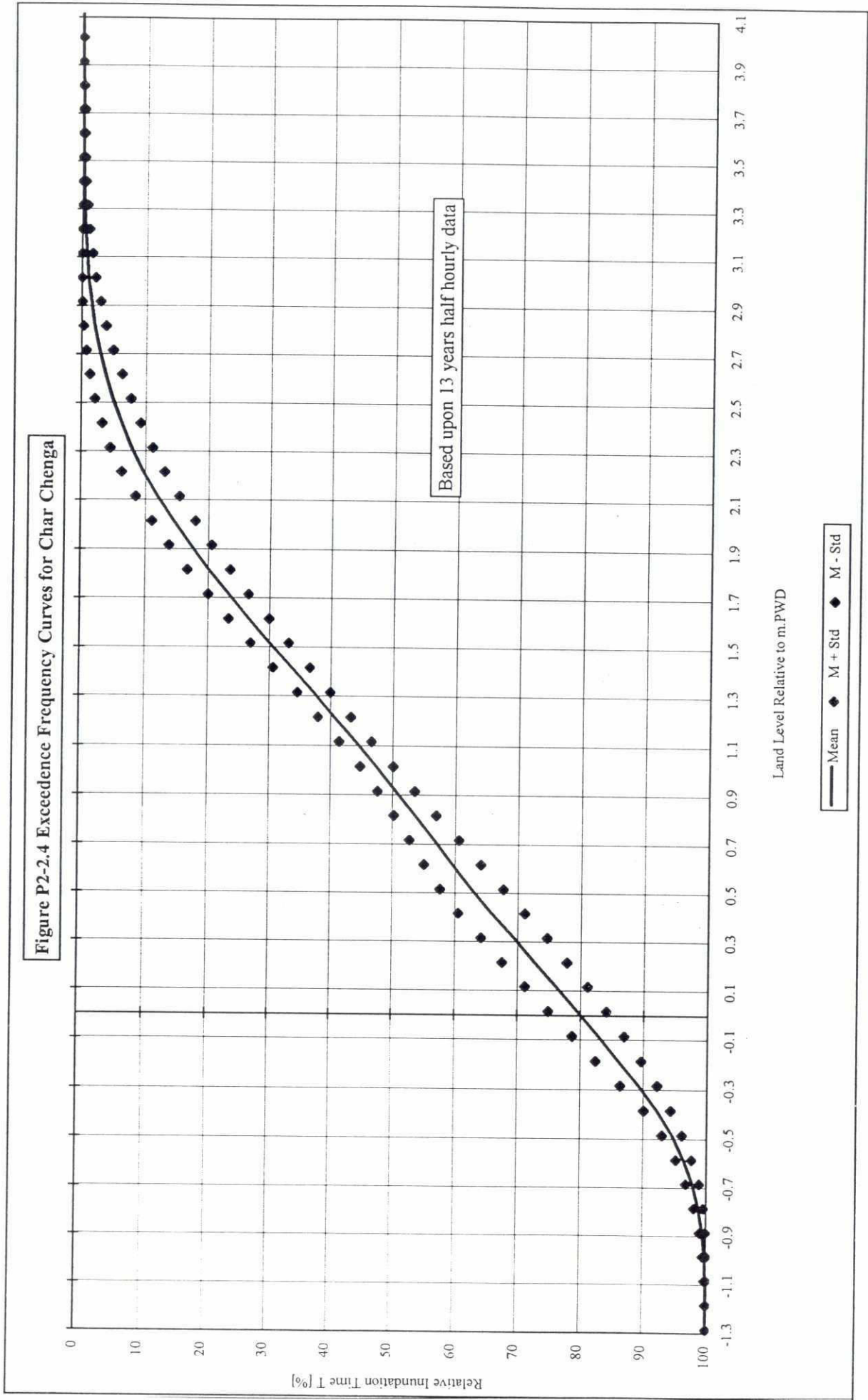
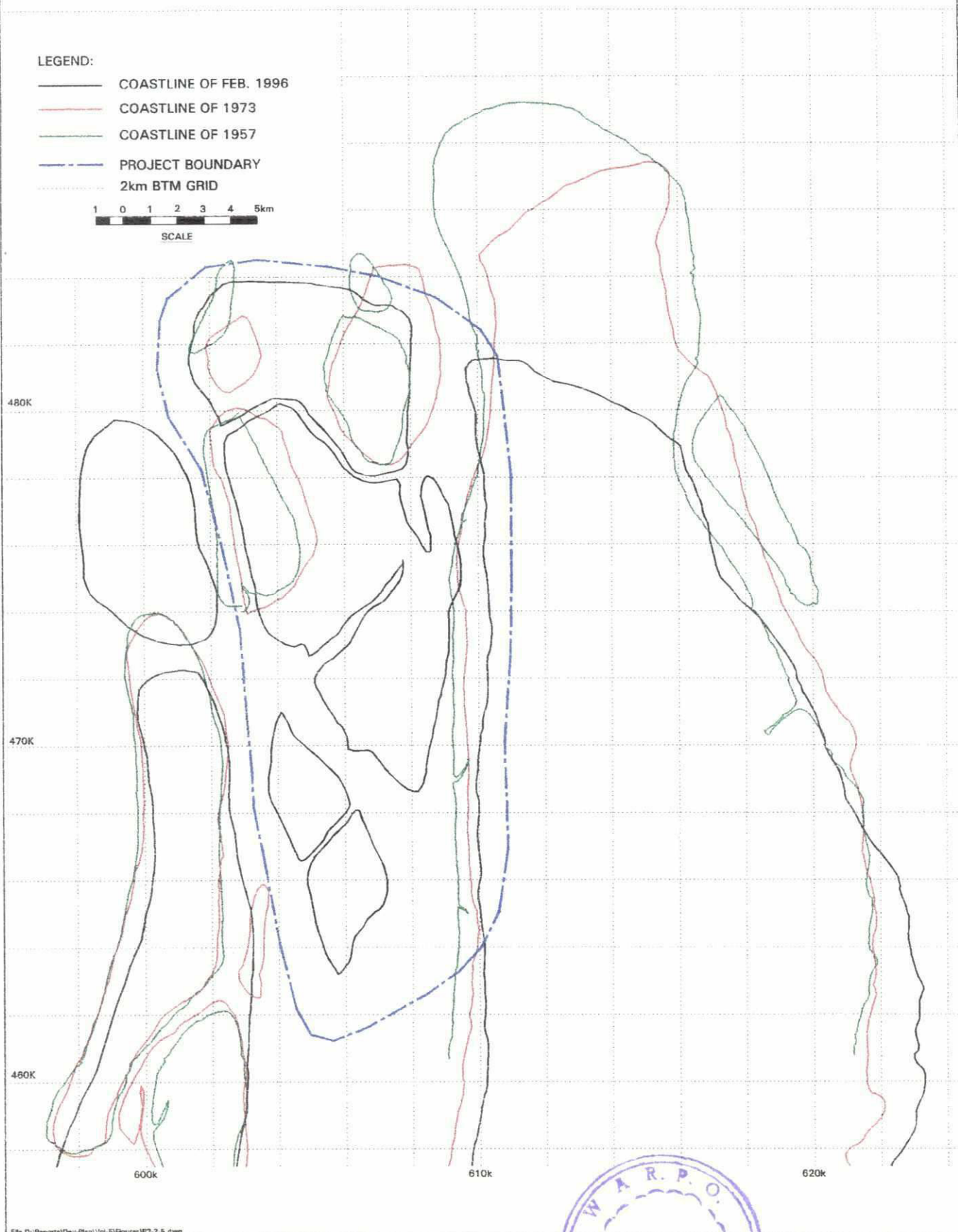


Figure P2-2.5: Coastline development of Hatia-Manpura 1957, 1973 and 1996



P2-3 PRESENT SITUATION

3.1 Physical setting

3.1.1 Topography

The most recent mapping for the project area are the preliminary drafts of Finmap sheets, dated 1992/94.

3.1.2 Climate

The mean annual rainfall at Hatia and Manpura is about 2,500 mm, with June and July receiving the highest rainfall. However, annual variations can be significant. The hottest month is May when the mean average temperature is 29° C and the coolest month is January, when the mean average temperature is about 20° C. Monthly evapotranspiration is highest in April and May and lowest is in January and February.

3.1.3 Soils

The project area is part of the young lower Meghna estuarine flood plain. In general, the soils are seasonally flooded, poorly drained and have developed from moderately fine textured silt loams.

Salinity levels are still relatively high. In some similar areas, soil samples have indicated that pH levels are sometimes higher than is recommended for agriculture. The levels of organic matter in these soils is generally low. Soil development on the estuarine chars is a long and slow process, even when the construction of embankments provides the opportunity for the gradual reduction of salinity levels.

3.1.4 Land use

Of the total of 8,480 ha at present in the project area, some 3,940 ha (46 per cent) is forested. The remainder is either cultivated or is grassland used for the grazing of cattle and goats.

3.1.5 Flooding

Only been limited data on land levels in the area has been available to MES. Land levels are generally assumed to be around mean high water level. Peak tides inundate land, even higher areas will be flooded during cyclones which are generally accompanied by tidal surges.

The large river discharge in the monsoon period dilutes the salinity of the sea water in the estuary, but in winter the sea water remains sufficiently serious damage to crops than in the monsoon. For successful crop production, flooding by saline water during the dry season requires rain to leach residual salt from the soil in the following monsoon.

3.1.6 Cyclones

The area is at risk from cyclones, as are other parts of the Bay of Bengal. The project area is not protected by embankments, leaving the people without protection against storm surges.

3.2 Socio-economic setting

The socio-economic setting of the project area is profoundly influenced by the dynamic physical environment in which communities live. The tides, flooding, storms and processes of erosion and accretion are major parameters of existence.

Socio-economic surveys were carried out during MES to provide background information on the socio-economic setting and information for three aspects of project formulation: economic viability, social desirability and possible development strategies.

The survey investigated settlement patterns, demography, occupations, land ownership, credit and indebtedness, income and sources of income, communications, literacy, education and health for a number of areas, which did not include the Hatia - Manpura area. Nevertheless, the survey results gave broadly similar results for all areas and thus a general view of the situation throughout the MES study area.

Communications to and from both Hatia and Manpura are entirely by water transport. The restricted nature of the communications system hampers transport for goods both into and out of the area. Improved accessibility would have a beneficial effect on production as well as on services available to the population.

3.3 Hydraulic infrastructure and water management

There is no existing hydraulic infrastructure in the project area and consequently no facilities for water management.

3.4 Agriculture

Agriculture in the project area is very limited in scale. A single crop of salt tolerant rice is probably the norm. To a large extent the agricultural situation is the result of soil salinity and a low level of soil fertility combined with damage from flooding and pests. Crop losses can be as high as 50 per cent or more and in unprotected areas a whole crop may be lost to flooding.

In the unprotected areas the intrusion of saline water at certain times cannot be prevented. In the dry season, the salinity of the water in the surrounding channels is relatively high and spring high tides can lead to the intrusion of salt water in agricultural areas. Also in the dry season, the salinity of surface soils can increase due to the capillary rise of saline ground water. The rains of the next monsoon season are required to leach this salt from the soil. During the monsoon season, flooding from tides or storm surges will damage crops.

The constraints to production on the chars and islands such as the project area include the lack of extension services and the lack of access to either local or regional markets. In the project area, agricultural surpluses must be very small, at best, but these constraints will affect the future expansion of production. Both of these constraints are linked to the isolation of the area and the poor transportation links to outside areas. The limited transportation links also make agricultural inputs difficult to obtain and relatively expensive (compared to areas with better and cheaper transportation links) and tend to reduce the prices that can be obtained for any surpluses farmers produce.

3.5 Livestock

The grazing of livestock is a relatively important activity for households living on the chars in the project area. Livestock provide food, draft power and a source of income. On newly accreted land, the first plant species to establish itself is usually uri grass. This provides fodder and the basis for supporting cattle, goats and sheep.

The cattle in the area are usually of the zebu type, fairly well adapted to the local climate and environment, but with low productivity. The average cow produces only about 1-2 litres of milk per day during lactation.

The buffaloes are the Indian water buffalo can survive on the coarser roughage available on chars and in forest undergrowth available in the project area.

3.6 Fisheries

Fishing is normally an important activity on the chars, but in this case little information is available. In common with other chars, fishing will play an important role in the nutrition of households in the project area and it will also provide some cash income, but the extent to which it does so and its relative importance among other sources of cash income is not known.

Fish marketed from the area most probably go to the population centres on north Hatia, which are relatively nearby. In general, however, fish marketing is poorly developed and transport costs are usually relatively high. These factors depress the prices and those received by fishermen are generally low.

Some fishing may be carried out in the inland water bodies of the study area during the monsoon, i.e. in the khals and flooded land.

3.7 Forestry

3.7.1 Background

Mangrove afforestation was initiated by the Forest Department in 1965 in response to a recognised need for coastal afforestation to establish a protective shelter belt along the coast. Afforested areas include some in and around Manpura, northern Hatia and the chars within the project area. Afforestation of newly accreted land, especially for foreshore protection, remains an important aspect of development in the area.

3.7.2 Existing forest

Over 7,500 ha of mangrove plantation have been established on the islands and chars north of Manpura and between Manpura and northern Hatia, including those in the project area during the period 1974 to 1998. Table P2-3.1 shows annual plantation areas and an estimate of present total volume on these chars based on a rapid assessment of the mangrove forest resources in the MES area made by the MES forestry specialists in December 1997 and January 1998. According to this assessment, the total growing stock in this area is about 0.9 million m³. The species planted in the accreted land are mostly Keora (about 90 per cent), Baen, Gewa and others (the rest 10 per cent).

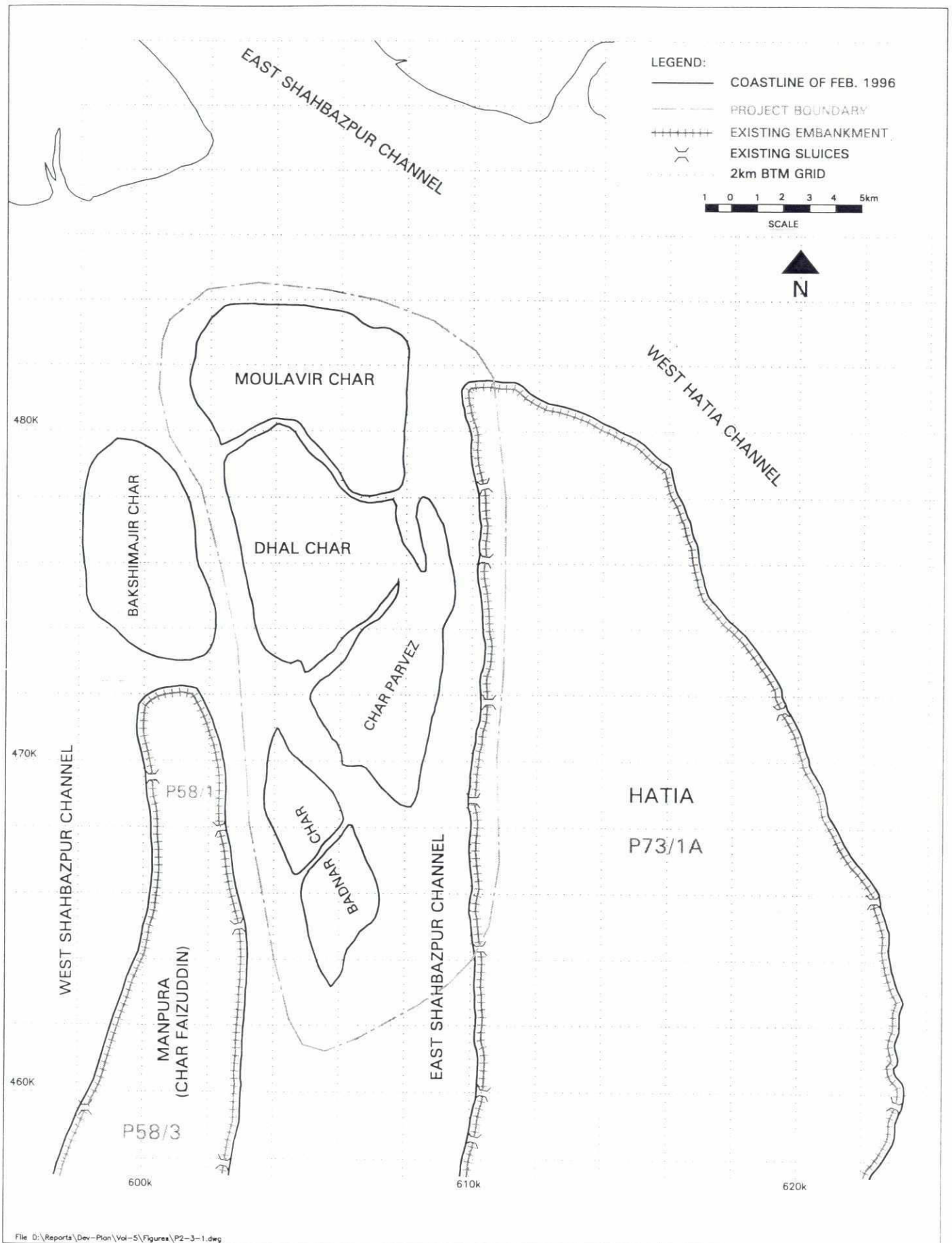
The present area of forest on the chars within the project area is only 3,940 ha.

Management of these forests previously included thinning operations, which were carried out during the fiscal years 1988-89 and 1989-90 in all these plantations up to 9 years of age. Because of the high cost of thinning and relatively lower returns, thinning was considered to be uneconomic and thenceforth no regular thinning is being carried out in these plantations.

Table P2-3.1: Showing plantation area and growing stock

Year of plantation	Area of Hatia North (ha)	Area of Manpura (ha)	Total area (ha)	Total of every 5 years plantation (ha)	Volume in m ³ /ha	Total volume in m ³
1974	12	0	12	68	227	15,434
1975	56	0	56			
1976	12	0	12			
1977	324	0	324	1,466	207	303,198
1978	202	0	202			
1979	141	366	507			
1980	40	381	421			
1981	40	0	40			
1982	30	171	201			
1983	0	245	245	1,342	190	254,362
1984	141	275	416			
1985	283	157	440			
1986	445	267	712			
1987	364	171	535			
1988	60	164	224	2,036	133	270,788
1989	404	0	404			
1990	161	0	161			
1991	200	0	200			
1992	0	135	135			
1993	0	205	205	1,690	40	67,160
1994	410	150	560			
1995	250	340	590			
1996	159	300	459			
1997	0	200	200			
1998	0	300	300	959	2.5	2,407
Total	3,734	3,827	7,561	7,561		913,351 Say 900,000

Figure P2-3.1: Situation of project area in February 1996



P2-4 FUTURE WITHOUT PROJECT

4.1 Land accretion and land development

With no intervention, land area will continue to accrete at a rate similar to the past. Based on a study of land formation and char development between 1973/74 and 1996, it is estimated that with no intervention the accretion of new land in the whole project area over the next 30 years will be almost 3,800 ha or about 130 ha per year.

The general land development sequence recommended by MES for newly accreted land is for it first to be planted in mangroves. This helps to stabilise the land, promotes further accretion and the development of the soils and provides protection from tides and cyclones. After 15 years, forest may be cleared for agriculture provided a 1 km coastal belt is retained for protective purposes.

Given the recent history of mangrove planting in this area, it is likely that without the project a relatively high proportion of newly accreting land will be planted in mangrove. The development of newly accreted land, without intervention, is expected to proceed as follows:

- a high proportion of land reaching the level of +1.1 m PWD will be planted in mangrove
- there will be no clearing of mangrove forest after 15 years
- remaining land will be used for the grazing of livestock.

4.2 Physical and social infrastructure

Without the project, physical infrastructure in the project area will develop only slowly. Embanking of the chars between Hatia and Manpura is not planned as part of this project, but may occur eventually.

Improvements in transport and communications will be slow to materialise. There is regular ferry service between north Hatia and Noakhali, but communications from the project area to north Hatia are by country boat. The project area will continue to be dependent on boats for all communications.

The safety and security of the population in the project area, including new migrants, should have a relatively high priority. Without intervention, a large and increasing number of people and their property will remain exposed to floods and cyclones. The construction of additional killas and cyclone shelters may be necessary but is likely to be continued under either regular government or NGO programmes in the coming years.

Other social infrastructure in the area will have to be provided in accordance with Government's regular programmes.

4.3 Water management

There is at present no water management infrastructure in the project area and without intervention, the situation will remain unchanged. Drainage will continue to be through natural khals and channels.

4.4 Agriculture

Agriculture in the project area is constrained by exposure to high tides and storms in unprotected areas and to soil salinity, low soil fertility and a lack of inputs and extension support. Without project interventions, soil salinity would decline only very slowly or not at all, since the land would remain vulnerable to saline intrusion from high tides. The risk of damage to crops from tides and floods would be unchanged. Fertility may gradually rise as the organic content of soil rises.

Agriculture will be limited to only one, low yielding rice crop during the monsoon and small areas of salt tolerant crops such as keshari during the dry season.

The land accreting naturally in the project area will be relatively small and will be used for mangrove forestry or grazing and rather than for agriculture.

4.5 Livestock

As new land accretes, the land available for the grazing of large and small ruminants will increase. Increases in livestock population will be related to the increasing numbers of households in the area. Successful livestock production in the project area depends on the safety of the animals, especially during cyclones. Unless the number of killas in the area is increased to adequate numbers, then it is unlikely that livestock populations would increase very significantly, or at least that investments will be made to improve livestock productivity.

Gradually improving communications with the area and better access to markets may act as a stimulus for livestock production in the area. However, the lack of veterinary and extension services are not likely to change significantly in the near term without the project and this will inhibit livestock production.

4.6 Fisheries

As on other chars in the estuary, marine fisheries are likely to be an important source of nutrition and cash income for those living in the area. However, there are early signs that the resource is being over fished and that total output will fall. If this occurs, agriculture and livestock can be expected to assume relatively more important roles in the economy of the project area.

4.7 Forestry

Without specific project intervention, afforestation of newly accreted areas will continue only under other Forest Department projects and programmes. Existing forest areas will be maintained. New plantations will be established on a high proportion of the areas rising to about the level of +1.1m PWD.

P2-5 PROPOSED INTERVENTIONS

To develop the project area, 5 engineering interventions have been considered:

- 3 cross-dams
B3 A-68, B3 A-69, B3 A-70
- 2 char development projects
B3 E- 72, B3 E-73

Their locations are shown in Figure P2-2.1.

5.1 Cross dams

The objective of the proposed cross dams is to block the tidal currents in the channels between the chars. These dams will stop the tidal flow between the islands and thus enhance accretion at both sides of the dams eventually creating one united land mass.

5.1.1 Basic data

Basic data required for the design of the closure dams are very limited.

Reference levels

The following reference levels have adopted in this study:

Public Works Department Datum (PWD)

General horizontal reference datum defined by the Public Works Department. This datum is applied in the whole of Bangladesh.

Chart Datum (CD)

A local datum used as reference for tide levels. Chart datum is a plane below which tide seldom falls. The relationship between the Chart datum used for Hatia and Manpura and the Public Works datum is as follows: $PWD = CD - 1.18 \text{ m}$

Topographic data

Existing topographic data are not available.

Bathymetric data

Various bathymetric surveys have been carried out in the Hatia and Manpura area. The most recent surveys were carried out in February 1997. It is expected that after the heavy 1998 flooding the cross section will have changed, fresh surveys will be done during the 1998/1999 winter season at the alignment of the proposed cross dams.

Water levels

Tidal information is obtained from the Bangladesh Tide Tables 1997, published by the Department of Hydrography of the Bangladesh Inland Water Transport Authority. The tidal station relevant for the area is Char Chenga. The tidal levels for this station are given in the table.

Table P2-5.1: Tidal levels at Char Chenga

	Levels with respect to:	
	CD	PWD
Lowest Astronomical Tide	- 0.375	-1.55
Mean Low Water Spring	0.256	- 0.91
Mean Low Water Neap	1.060	- 0.11
Mean Low Water	2.037	0.87
Mean High Water Neap	3.014	1.85
Mean High Water Spring	3.818	2.65
Highest Astronomical Tide	4.449	3.28

Currents

Information on currents prevailing in the channel at Hatia and Manpura are not yet available because the detailed 2-D model has not been prepared due to lack of data in the shallow areas. However, since in recent years natural siltation has been considerable, currents in the channels will be moderate.

After detailed surveys of the shallow area have been completed, the detailed 2-D model with 200 metre grid spacing will be calibrated and the effect of the proposed interventions on water levels and currents will be simulated.

Soils

Geotechnical survey data for the cross dam alignments in the Hatia and Manpura project area are not available. For the time being it has been assumed that the soil conditions will be similar to the conditions for the Nijhum Dwip cross dam. In general the survey indicated:

- densities around 1.9 mt/m^3
- moderate SPT values and results of unconfined compression tests which agree with the classification of "stiff silt"
- consolidation C_c values are normal but the shear test values are lower than expected.

Construction materials

In the project area the only available construction material is earth. For construction of an earthen dam one should preferably use clayey soil, with 15 percent clay particles. This requirement would qualify the soil as a medium plasticity clay, a lower boundary of 10 percent could be accepted.

"Hard" materials, such as rock or boulders are not available near the closure site and would, if required, have to be imported from elsewhere. Local sand (with the required grain size) and sylhet sand to be used for filling synthetic bags and geobags also have to be brought from elsewhere.

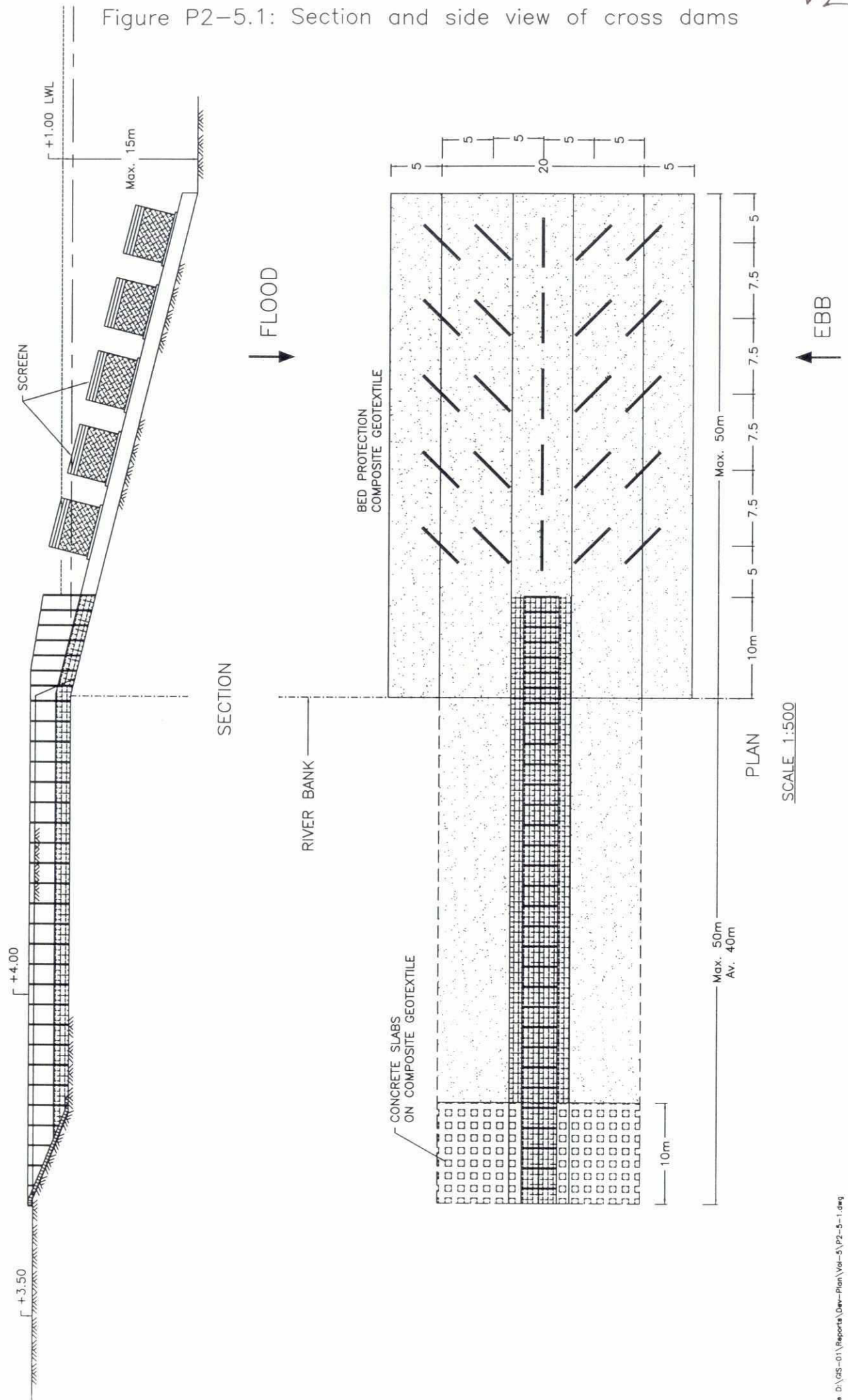
Bamboo and bullah poles, which may be used for cross dam elements or for temporary works.

5.1.2 Cross dam design

An alternative design and construction method for cross dams has been developed under the Meghna Estuary Study. This type of cross dam differs from conventional methods by the use of geotextile materials and construction methods using prefabricated elements. Based on the findings and lessons learned during implementation and monitoring of Haimchar and Khorki erosion control pilot schemes, MES has developed the concept of a permeable cross dam consisting of a geotextile bed protection, a low under water dam of concrete blocks or synthetic bags filled with stabilised earth, A-frames made of GI pipe, anchored in the low dam and geotextile screens, fixed to the A-frames, for partial closure of the cross section of the channel. A section and side view of the permeable cross dam is indicated in Figure P2-5.1.

Further details are provided in the Feasibility Study reports for Nijhum Dwip as well as Char Montaz - Kukri Mukri.

Figure P2-5.1: Section and side view of cross dams



5.1.3 Proposed cross dams

The area between North Hatia and North Manpura has been accreting rapidly in the past 25 years. At present a number of channels have more or less stabilised. Without intervention these channels would gradually lose more and more discharge capacity and will eventually be completely filled up. It is not possible to predict when the channels will close naturally.

By constructing permeable cross dams the flow velocities in the channels between the chars will be reduced substantially; this will accelerate accretion and cause these channels to silt up much earlier than would be the case without interventions. The flow through the permeable cross dams may be reduced gradually by enlarging the screens and dumping more ballast blocks on the under water dam.

5.1.4 Implementation of the cross dams

The schedule for implementation of the cross dams cannot be given until more basic data are available. In any case, these works will not be implemented during the Development Plan period.

The actual requirements for execution of the works depend on the channel depth prior to the start of the works. Some of the smaller channels may be closed by traditional methods using earth filled embankment and gunny bags filled with earth.

Waterborne equipment such as a Twin Hull Pontoon, an auxiliary pontoon, tug boats etc. will be required for installation of the bed protection and A-frames in the large channels.

5.1.5 Cost estimates of the cross dams

The layout, design and the estimate of quantities of work of the cross dams have been based on surveys during MES. During the 1998 extreme flooding substantial changes may have occurred along the proposed alignments of the two cross dams. In the period before start of the implementation the situation will change again.

A fresh estimate of quantities based on the then existing situation will be required at the time the amount involved for a construction loan has to be determined. The unit rates are based on current rates of the BWDB O&M circle of Bhola. These unit rates will also have to be adjusted at a later stage.

5.2 Development of char land

The proposed project involves char development activities for Moulavir Char, Dhal Char and Char Parvez. These activities are for unprotected land only as the construction of embankments and water management infrastructure is not included as part of this project. Embanking this area should only be considered later in the Master Plan period.

P2-6 DEVELOPMENT FOR THE PROJECT AREA

6.1 Development concept

The project area is adjacent to the northern end of Hatia which has been experiencing extensive erosion for many years. During the Master Plan period, further erosion has been projected at 2,000 to 4,000 ha in this area. Erosion of such an area could directly affect as many as 3,500 to 4,500 households. Promoting accretion in the project area, to connect the existing chars between Hatia and Manpura with Hatia island itself will provide alternative areas for the (eventual) resettlement of at least some of those displaced by the erosion of Hatia. Therefore, this proposed project focuses on land accretion.

Newly accreted land is not, however, equivalent to old land that is eroded away as it is affected by salinity for many years and initially has low organic matter content and consequent poor productive potential.

A high proportion of the existing areas of the chars is forested and for the remainder grazing is the main use. There is little agriculture. Furthermore, because of the need to retain much of the existing forest as part of the 1 km coastal protection belt, reasonably extensive areas with the potential, ultimately, for embanking, will only emerge after the areas between the chars and between the chars and Hatia have accreted.

In the meantime, the project proposes to include only some limited char development activities on the islands for the existing population. This might include measures to improve livestock, homestead production of vegetables and minor crops, some support for tree growing around homesteads and other income generating measures. An adequate number of cyclone shelters and killas should also be provided.

The process by which newly accreted land gradually becomes more productive is a slow one and the potential for integrated development in the area is at present limited. Therefore the economic benefits accruing to the interventions will only occur some considerable time in the future. (Perhaps not before 8 to 10 years after implementation of the cross dams.) In addition, estimating the costs of the project involves a number of significant unknowns.

The purpose of this project is to provide land for the future settlement of households displaced by erosion in adjacent areas. Preliminary economic assessment of the project is not possible at this stage.

6.2 Land accretion

The accretion of land with and without the proposed cross dams is discussed in Chapter 2. Within the frame work of the Master Plan, the development of the Hatia and Manpura areas have been planned for the medium term, 8 to 9 years from the present. In the intermediate period natural accretion will continue; in particular several of the smaller channels still active at present may silt up before the integrated development of the area is taken up.

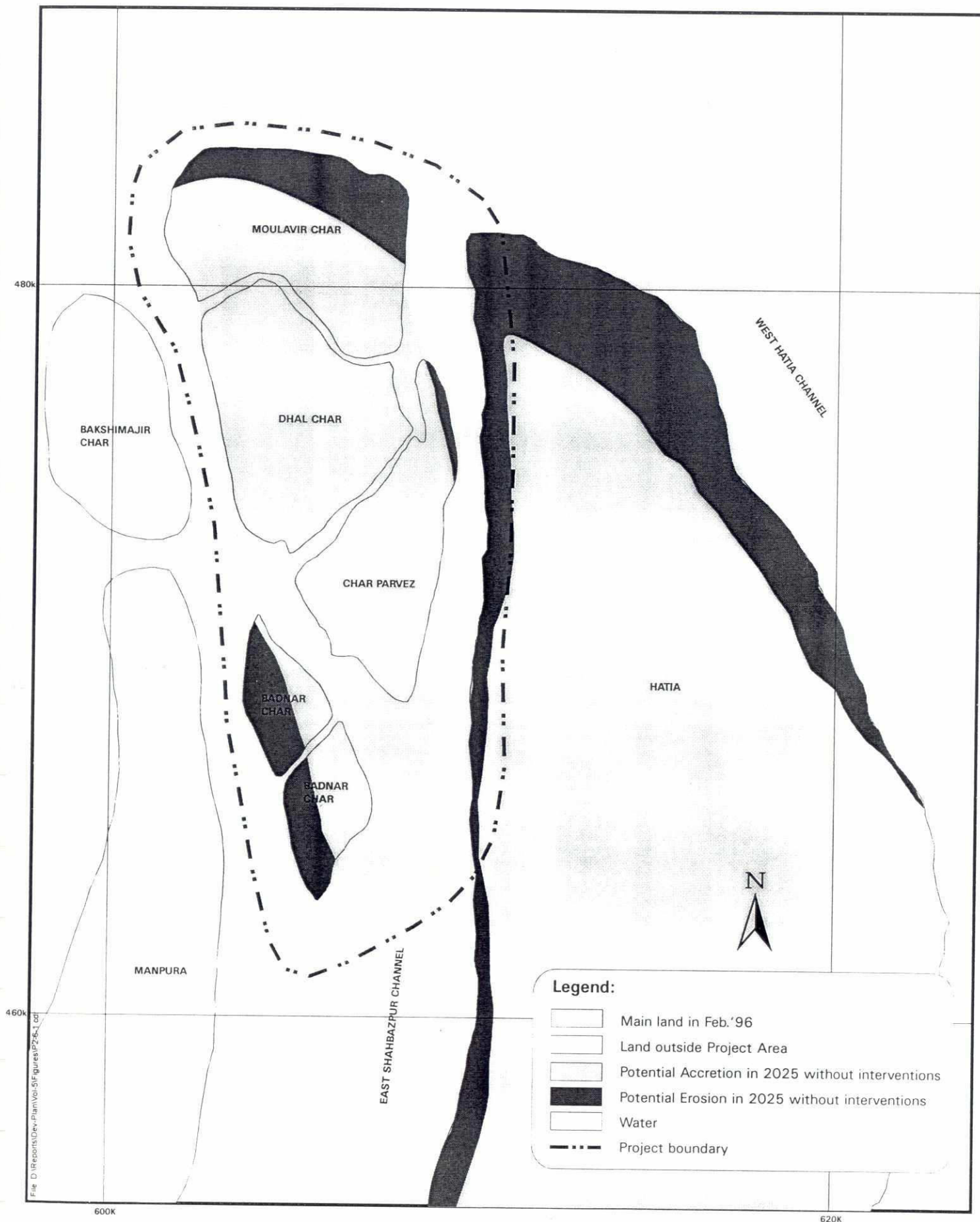
The areas expected to accrete in the area in the future without intervention and with interventions have been indicated in Figure P2-6.1.

6.3 Land development

Newly accreted land is saline, generally of low fertility and usually still subject to frequent flooding from tides and storms. In the MES area, it is recommended that all newly accreted land be planted in mangroves for an initial 15 year period. Placing the land under forest cover helps to increase stability, promotes further accretion and helps to increase the organic matter content of the soils, apart from providing essential protection from cyclones.

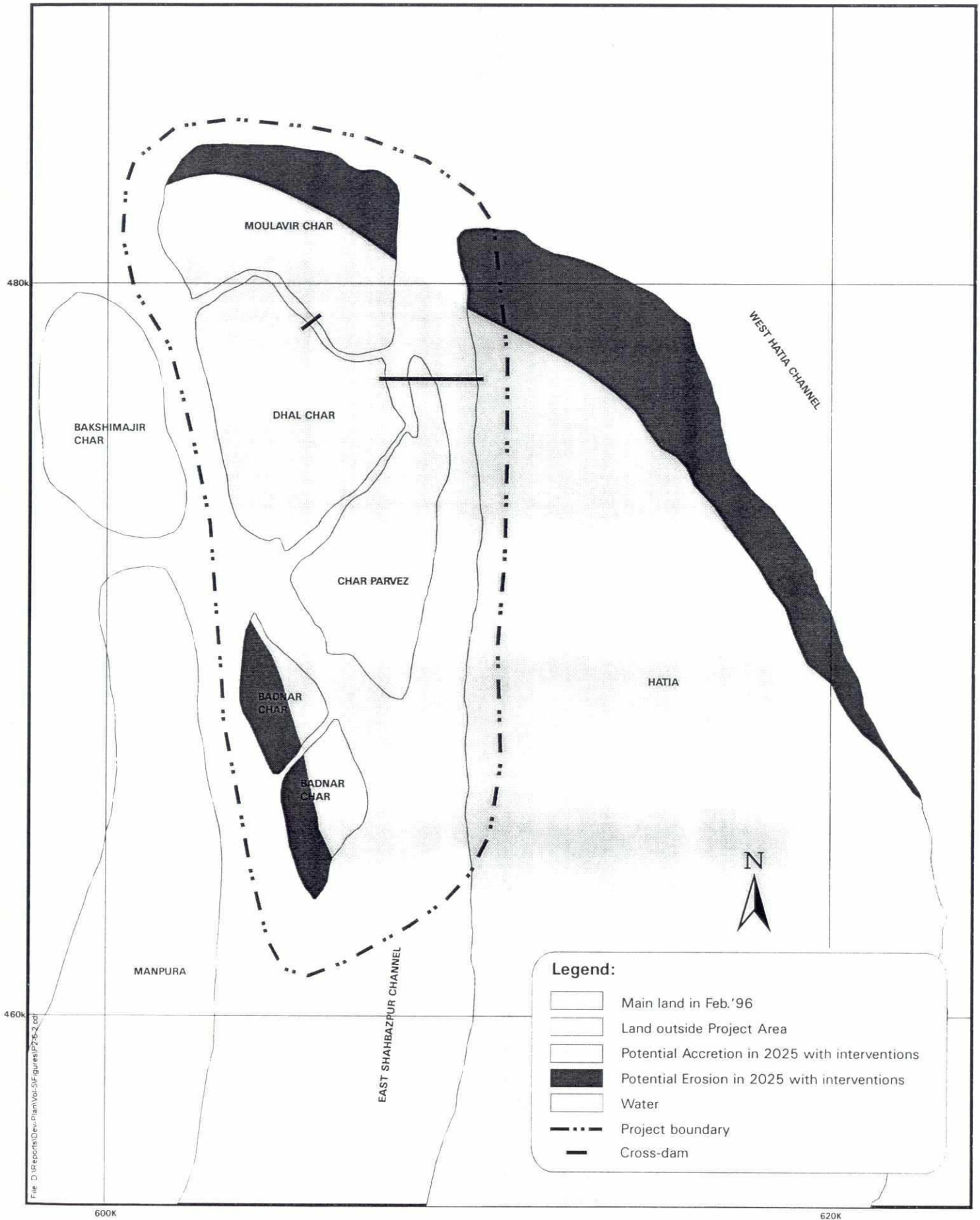
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Figure P2-6.1: Potential Accretion and Erosion of North Hatia area in 2025 without interventions



23

Figure P2-6.2: Potential Accretion and Erosion of North Hatia area in 2025 with interventions



Thus, the principal sequence for land development which should be followed for newly accreted land in the project area, with the project, is as follows:

- all newly accreted land reaching the level of +1.1m PWD is planted in mangroves as it accretes and is left in forest for 15 years
- starting in year 16, new land that has been in forest for 15 years may be cleared
- 1 km depth of mangrove forest is retained along all coasts at all times as an important element in the cyclone protection system
- land not in forest and not under cultivation may be used for the grazing of livestock - this includes cultivated land when it is not under crops

In this area, embankments should only be constructed when the land is above +2.2 m PWD. Only land above this level is relatively safe for agriculture and for permanent settlement.

6.4 Needs assessment

A needs assessment has not yet been carried out for the Hatia and Manpura area. However, as elsewhere in the MES study area, it is expected that the accretion of more land and the construction of cyclone shelters and killas will have high priority. The construction of embankments is also usually seen as a high priority in most areas.

6.5 Project interventions

In addition to the physical interventions described in Chapter 5, a number of other interventions are proposed to support productive activities in the project area.

6.5.1 Safety of the population

The improved safety and security of the population is a major objective of the MES project. Because the construction of embankments is not proposed for project area at this stage, additional cyclone shelters and killas should be built as an interim measure to enhance the safety of the population and its livestock. This need could be met by the project or from other government and NGO projects.

6.5.2 Roads and transport

There will be no formal development of the road network in the area under the project. Boats can be expected to remain an important component of the transport system in the area.

However, once the chars have been joined to Hatia island by accretion of the channel separated them, it will be possible to establish land and road access to the project area. Improvements in access will especially benefit agricultural production.

6.5.3 Settlements

It is intended that ultimately, land will be available in the project area for the resettlement of households from outside the area, especially households that are displaced by erosion on adjacent north Hatia.

However, available land should be allocated first to landless households living in the area at the time of allocation. These households, although they have no land, will probably have homesteads and it is therefore assumed that specific settlement activities will not be required for them. Settlements will be required for households moved into the area from outside to settle.

Cluster settlements will be constructed for these new settler households, but these settlements should normally only be established on the protected land inside future embankments

6.5.4 Agriculture

Until embankments are eventually constructed the scope for improving agriculture in the project area will be limited. Farming systems in the chars and islands of MES area are adapted to the high risk of crop damage by flooding, salinity and pest attack and the general low level of resources. These conditions are unlikely to change.

Nevertheless, some measures should be included to improve agricultural production in the area. These might include support for improving production of vegetables and minor crops around homesteads (especially when these are constructed on raised areas) and on killas where soil salinity and the risk of saline flooding will be less than for other areas. Support could also be given for salt tolerant crops such as keshari and sweet potato in the Rabi season, when the risk of loss from flooding is much reduced.

A programme for integrated pest management could be introduced to farmers in the area.

6.5.5 Fisheries

There will be no fisheries (aquaculture) development activities under the project. The scope for development of this sector on unprotected land is limited.

6.5.6 Livestock

Accretion of land will provide additional grazing areas for livestock. The project area has good potential for livestock development, for cattle, goats and poultry in the long term, especially once land access to Hatia has developed. Further development of livestock production in the area, however, will depend upon improved safety and security for animals. The lack of killas or embankments, where livestock can be kept during floods and cyclones, is a serious constraint to the development of production. Without these, the risks of loss may outweigh any incentives to invest in this sector.

To promote livestock development in the area, a programme similar to those proposed in the feasibility studies for Nijhum Dwip and Char Montaz - Kukri Mukri could be established to:

- provide general training for livestock owners in improved husbandry methods, improved animal health and other topics
- provide intensive training and credit for selected farmers wishing to adopt a more intensive approach to livestock production.

The second part of this programme will provide for the development of more intensive methods of raising and managing draft cattle, milch cows, beef cattle, goats and chickens.

In addition to the training and demonstration activities aimed at all livestock operators, the programme would provide specific training and support to men and women interested in taking up more intensive livestock and poultry production activities with credit support. Training for improved management and health care should be provided to the selected farmers prior to the provision of credit. Monitoring and follow up support would be provided through the implementing NGO and its staff.

6.5.7 Forestry

Forestry, particularly mangrove forestry, will be an important component of the Hatia - Manpura Development Project, especially for increasing the protection of the life and property of the people against cyclones and tidal surges.

With the project, it is expected that a high proportion of newly accreted land reaching the level of +1.1 m PWD will be planted in mangroves. Appropriate management of these and the existing areas of mangrove plantation should be possible on a (long term) self-financing basis.

Mangrove afforestation activities should be implemented by the Forest Department which has the necessary infrastructure, manpower and experience to implement these activities. A participatory approach should be used, involving local people in the establishment and management of the forested areas.

A social forestry programme should also be implemented for households living on the chars. This would focus on planting species such as coconut and areca palms around homesteads.

P2-7 IMPACT OF THE PROJECT

7.1 Physical infrastructure

The major impact of the project will result directly from the construction of the cross dams and the accretion of new land which can be used for forestry, agriculture and grazing.

The construction of cyclone shelters and killas under the project will enhance for the safety of the population in the project area. Furthermore, once the area between the chars and Hatia has accreted, it will be possible for people and livestock to move inside the embankments on Hatia for safety in times of danger.

7.2 Social infrastructure

Cluster settlements may be constructed for households displaced from Hatia and resettled in the area on surplus land. The project is not expected to have any other direct impact on social infrastructure.

Schools and health services will be provided by the responsible government departments in line with their regular programmes for the area.

7.3 Agriculture

Most of the land accruing under the project will be used either for forestry or the grazing of livestock.

Under the proposed char development activities, some increases in the production of crops and vegetables are expected, but this will be achieved from increased areas planted rather than increases in yields on existing areas. Because the basic conditions for agriculture on the chars will not change under this project, yields will remain low.

At some point in the future, it is expected that land that has reached the required level will be embanked, after which improvements in agricultural production would be expected. This, however, is beyond the scope of the present project scope.

7.4 Livestock

With some additional areas available for grazing and fodder production and greater security from flooding and cyclones provided by killas, livestock populations will increase although the total number will be constrained by the carrying capacity of the available grazing land. The proposed Livestock Improvement Programme, although it will directly affect only a minority of livestock owners, is expected to have an impact on livestock production in the area generally, gradually improving production methods and raising productivity.

Livestock populations are projected to increase in line with increases in the number of households in the project area but average livestock ownership per household is likely to be similar both with and without the project.

Changes in livestock productivity will be reflected in declining mortality rates, increasing average size of animals due to more and better fodder and better animal health and increased output of milk and eggs. These changes are likely to occur over a relatively long period, but will have a significant impact on livestock production.

Once land has accreted so that there is a land connection with Hatia, the marketing of livestock products will be facilitated, which will further support improvements in productivity.

7.5 Fisheries

The project does not include provision for promoting aquaculture production. Significant development of fish ponds is unlikely before the area can be embanked.

7.6 Forestry

The project would promote the expansion of the forest on the chars in the project area, especially as an essential component in the protective system for increasing the security of the population. Although beyond the scope of the project as proposed here, some of this forest will eventually be cut to make way for agriculture and the settlement of households. However, retention of a coastal protection forest around the future perimeter of the area implies maintaining a permanent forest of at least some 3,000 ha.

The mangrove forests will also provide benefits to the population in the form of fuel, construction materials and fodder for livestock as well as contributing to the stabilisation of the land and increasing the organic matter content of the newly accreted land on which they are planted.

There will also be an increase in tree cover from the planting of palms, and perhaps other trees, around homesteads. These will provide households with a direct benefit in terms of food and cash income.

P2-8 ENVIRONMENTAL ASPECTS

At some point in the future, it is expected that land that has reached the required level will be embanked, after which improvements in agricultural production would be expected. This, however, is beyond the scope of the present project scope.

8.1 Aims and objectives of the environmental assessment

The Hatia - Manpura Development Project is one of the three selected projects of the Meghna Estuary Study to be studied at pre-feasibility level. The aim of the environmental assessment is to ensure environmentally sound project planning and implementation takes place. The primary aim of the intervention is to speed up the natural accretion process that will happen even without human intervention, working with natural trends rather than against them.

The delineated project area for the pre-feasibility study is given in Figure P2-1.1.

8.2 Proposed interventions

The nature of the proposed intervention has been outlined in chapters 5 and 6 above. Environmental considerations have also been incorporated into project design to minimise possible negative impacts and reduce the need for specific mitigation programmes.

8.3 Baseline environmental conditions and future trends

To a limited extent baseline data collection for both the natural and human environment has been carried out for the area. The data allow identification of the existing environmental constraints and also likely future trends so that an appropriate set of interventions can be drawn up for the area. This baseline data provides the framework to identify likely impacts due to the proposed intervention, assess their importance and then set up data collection programmes to allow quantification, valuation and also monitoring of Important Environmental Components (IEC's) and variables.

The main processes that have been identified are erosion and accretion patterns, with the primary risks and constraints being cyclones (causing loss of life and disruption), saline water intrusion and soil salinity, including problems of capillary rise of saline ground water in the dry season. The principal environmental conditions and constraints to economic development in the area have been identified and include the following issues with respect to the proposed cross dams and utilisation of their predicted benefits:

- complex flow pattern, require more data
- need sustainable management for newly accreted area
- the present pattern of surface water quality, and particularly soil salinity, caused by saline inflow and how this changes as land accretes
- ground water quality and availability for drinking water
- rainfall drainage
- low agricultural yields and poor marketing systems for agriculture and fisheries, primarily due to poor communications
- crop losses due to pest attack
- over-exploitation of the in-shore fisheries which is at an unsustainably high level
- poor health facility provision, a lack of sanitation facilities and schooling availability in the area

The feasibility study should investigate all the above issues carefully.

8.4 Impact identification, quantification and valuation

A comparative assessment would allow the significant impacts of the proposed intervention, (both positive and negative) to be identified. In addition, the comparison with a without project situation would allow the impacts of the project to be separated from future trends. The need for mitigation could also be identified and the effectiveness of mitigation could be assessed.

Of concern are those residual impacts which are negative, i.e. those impacts for which mitigation is either impossible or unable to prevent the post project situation being worse off than that before it caused as a result of the intervention.

The primary conclusions regarding positive and negative impacts are given below. The direction of the impact is viewed from the perspective of long term sustainable human use of resources and where significant and possible these have been quantified.

8.4.1 Identified positive impacts

Land accretion

The construction of cross dams will ensure that land accretion is accelerated. However, before the implementation of the project, accretion will continue at a natural pace. A programme for implementation of the cross dams will be prepared when the project is taken up.

Land for agricultural use and human settlement

The additional accreted land will allow those households resident in the area, (and also the predicted increase based upon past trends), who have no agricultural land to be allocated a cultivable plot. In addition, more households may eventually be settled into the area, with both a house plot and an agricultural land allocation.

Reduction in cyclone damage

The effects of cyclone surges will be reduced in the new embankment locations as the waves are dissipated by the kilometre wide forestry belt and also by the seaward side run-up slope. Analysis carried out by the CPP project indicated that such planting can dissipate 2 metres of wave energy in a 1991 type cyclone.

Reduction in soil salinity

Soil salinity- will probably remain high until embankments are constructed at some future time. Annual flushing of the soils with monsoon rainfall will allow some agricultural production to continue. Capillary rise will also remain a significant problem for many years.

Improvement in terrestrial bio-diversity

The establishment of settlements is likely to improve bio-diversity of terrestrial flora and fauna. The overall area of forestry will be significantly greater than without the project with benefits for terrestrial ecology.

Increase in agricultural production

Some additional land will be available for grazing, and for seasonal agricultural use after it has risen above + 2.2 m PWD. This may lead to small increases in agricultural production.

In addition it is proposed to try and introduce an integrated pest management programme in an attempt to address the serious problem of losses from pest crop attack.

Increase in homestead production

Increase in homestead crop and poultry production at the household level should occur. However it is difficult to quantify this at present. Socio-economic monitoring at household level would be required to quantify and value this benefit.

Increase in livestock production

The accreted land available that is not forested would allow additional large and small livestock to be reared. In addition the proposed livestock extension programme would increase the quality of the livestock.

Increased forestry area

The area that could be put under forestry with a sustainable management system would be increased substantially in the with project case, compared to the without project case, assuming the Forest Department continues planting a high proportion of newly accreted land.

Improved access

As a direct result of cross dam construction there would be land access to the project area from Hatia and track and road networks within the area may also develop. This would allow better marketing with secondary benefits to livestock and agricultural production. The benefits that this creates cannot be easily quantified but may be significant.

8.4.2 Identified negative impacts

Changes in in-shore marine habitats

There are likely to be changes in the extent and location of in-shore marine habitats in the area, some of which are likely to happen despite the intervention. However there is little doubt that this process would be accelerated by the construction of cross dams and in particular movement through the channels in which the cross dams are located would cease. From the sedimentation analysis is also apparent that similar new habitats will appear away from the cross dams.

Fisheries

The predicted trend is that fisheries in the area are now likely to decline in the future, irrespective of the project, due to over-fishing. It is not possible to quantify this trend without a significant data collection programme, which is considered an urgent priority if the project were to go ahead. The proposed cross dams are likely to cause a further change in fish habitat and an additional reduction in fisheries catch. Again it is not possible to quantify this without a baseline catch assessment and monitoring. In addition there is likely to be some temporary disruption to fishing operations by the closure of channels between islands.

Human nutrition

The declining fish resources, a trend which will happen irrespective of the project, when combined with increasing human populations and a possible change in fish marketing patterns, is likely to result in a reduction in human protein intake. Improved access to the area could cause more fish to be sold rather than directly consumed. It is not possible to quantify this impact and there could be complex two-way trends with some households improving their nutrition and others suffering a reduction. A monitoring programme for human nutrition will be required to identify and quantify any change.

Navigation

The closing of the channels between islands will disrupt navigation through them. This is, however, only local traffic.

Changes in access

Whilst the improved internal access that is likely to result from the construction of the cross dams will be considered a benefit, there are also likely to be some simultaneous negative impacts. These include additional induced in-migration which would put more pressure on existing resources and facilities. There may also be a risk of more social conflict as a result. Careful management, including fair and transparent procedures for new land allocation are critical in handling such conditions.

Direct construction impacts

Construction of the cross dams does not require any land acquisition. Any direct construction issues, if well managed, can be overcome and in many cases increase potential benefits, particularly employment opportunities. There may also be issues linked to the collection and handling of construction materials.

8.4.3 External impacts and constraints

There are no obvious upstream impacts created by the proposed intervention. However, any future upstream development, would need to bear in mind possible induced impacts on the project area. Cumulative impact analysis needed if all MES planning units and programmes are actually constructed.

The outputs of the sedimentation analysis indicated that in the with project situation, accretion of tidal mudflats is likely to occur to the south of the project area. Whilst this may provide replacement in-shore marine habitats, the ability of species to quickly colonise these areas is unknown, although the past morphological development of the area has followed these trends, if at a slower rate.

8.5 Environmental mitigation

Due to the fact that the interventions will have been carefully designed there is little need for specific targeted mitigation programmes. These are indicated below.

8.5.2 Ghat relocation

It may be necessary to relocate any ghats at present adjacent to channels that will be closed and will silt up. Relocation should be done with careful negotiation with the affected parties in order to decide on an acceptable alternative location.

8.5.2 In-shore marine habitats

It is expected that replacement in-shore marine habitats will be naturally formed, but monitoring of this will be required and in particular the extent to which dolphins, fish and wading birds are able to relocate to these areas. The degree to which this natural habitat replacement mitigates the negative impacts of the intervention will also need to be monitored.

8.5.3 Fisheries

Irrespective of the project there is a need for fisheries management programme aimed at keeping fish catch levels within sustainable limits to prevent serious future decline. A detailed baseline catch assessment is needed plus studies into fish ecology to fully understand the present situation, followed by a monitoring programme to see the effects of sedimentation on fish habitat change and how this effects fisheries production. Once this is done then the need for and nature of a specific mitigation programme for in-shore fisheries can be decided.

8.5.4 Direct construction impacts

An environmental management component for construction operations will be needed to be set in place so that potential problems can be identified in advance and steps taken to avoid or minimise negative impacts. With care a well-implemented construction management plan can provide additional benefits.

8.6 Residual impacts

The possible positive residual impacts far outweigh the negative, but there are some negative impacts which are unlikely to be fully mitigated for:

- reduction in in-shore marine habitats, particularly for fish and a lesser extent Gangetic dolphins, with implications for common good fishing and professional fishing household livelihoods
- the human nutrition implications of the change in fish availability are uncertain at present but the negative impacts on nutrition from changes in fish consumption patterns could outweigh the benefits from greater agricultural production.

8.7 Environmental risk

The following basic assumption has been made when assessing the proposed intervention:

- the procedures for land allocation will be improved to ensure that they are systematic, fair, equitable and timely. If this is not done then full potential benefits of the intervention are

unlikely to be attained. The experience of the CDSP with this problem should be borne in mind.

Since a limited intervention of just cross dam construction and char development is to be implemented, more specific mitigation measures (normally incorporated in the many components of the fully integrated programme), may need to be implemented.

Evidence from the 1991 cyclone indicates that the overall risk of cyclone damage will be reduced by dissipation of waves due to suitably designed embankments and forestry planting. In addition there would likely to be a reduction in loss of human lives and livestock, although this would be greatly enhanced by construction of suitable cyclone shelters and raised earthworks platforms (killas).

8.8 Environmental monitoring and management

Assuming that the project goes ahead then the following items will need to be monitored:

- accretion and erosion patterns using time series satellite imagery; such work will indicate the effectiveness of the intervention and also any induced impacts on in-shore marine habitats and navigation.
- in-shore fish catch assessment, a study of fish ecology (specifically on spawning and breeding grounds) and assessment of stocks, as well as monitoring of the impacts of changed accretion patterns on fish habitats and stocks.
- incidence of malaria, waterborne disease and cholera
- human nutrition levels in relation to fish consumption
- household socio-economics related to predicted project benefits
- external issues, particularly induced accretion and any proposed upstream developments.

The main mitigation step would be relocation of any ghats, if needed. Other mitigation measures may be necessary depending upon the results of monitoring programmes.

The Department of Fisheries already has plans to carry out a major fish resource assessment for the area, which with appropriate institutional liaison could carry out the required fisheries monitoring for the proposed intervention.

8.9 Conclusions of the environmental assessment

Under the Department of the Environment environmental classification the proposed intervention would appear to be in the highest Class D (Red) under Section 66 (flood control embankment, polder, dike etc). Before the project can go ahead the DoE will need to review and approve the EIA before they can grant a Site Clearance Certificate. Before a full Environmental Clearance Certificate can be granted a No Objection Certificate will be required from the Local Authority. As there is so far little experience in the implementation of these procedures, it is considered unwise to embark upon this process until agreed arrangements are in place for the funding of the project.

Under World Bank Operational Directive 4:01 the proposed intervention would probably be classified as Class A (the highest), although it could possibly be down graded to Class B, as the extent of the effected area is relatively small by international standards.

The fundamental problem with the proposed intervention is that whilst the cross dams significantly speed up land accretion, the predicted positive economic impacts of utilising such land are long term (between 15 and 30 years) and the construction costs are relatively high per beneficiary household. A case could be made on social benefit grounds for going ahead with the project, but this would need to be considered against other development priorities in the country.

8.10 Future environmental work programme

TOR for a full feasibility study, detailed baseline and needs assessment are required before any detailed design. In addition a suitable, locally based inter-disciplinary and decentralised institutional structure will need to be established for detailed project planning and implementation. The procedures for allocation of new land through the Ministry of Land will also need to be streamlined to be operational in a transparent, fair, equitable and timely manner at local level.

The monitoring programmes established under the project need to be continued:

- monitoring of erosion and accretion from satellite imagery
- regular bathymetric surveys of the channels between the islands and assessment of cross sectional areas as well as flow distribution in the channels through computer calculations

In addition the following new monitoring will need to be established:

- studies of in-shore marine habitats, fish ecology (particularly the fish spawning and breeding grounds), along with a baseline survey of fisheries catch and a stock assessment.
- monitoring of the incidence of malaria in the area.

Appendix I

IDENTIFICATION OF FURTHER INVESTIGATIONS IN MORPHOLOGY

Objectives

Within the framework of MES development, the options of implementing the cross dams, have been described for the prefeasibility study areas of Rangabali - Char Biswas, Hatia - Manpura and Urir Char - Pir Baksh. For each of these study areas the expected morphological changes were delineated.

With respect to the implementation of the development schemes, in the feasibility stage, the following morphological studies and investigations can be identified:

1. data collection and field surveys,
 - 1A. topography and bathymetry
 - 1B. hydraulic and morphological data
2. data processing and data analysis,
3. mathematical model investigations,
4. morphological interpretation.

Results

The outcome of the hydraulic and morphological study should be:

- a quantitative assessment of the accretion and erosion rate of the areas during and after the implementation of the cross-dam.
- an assessment of the closure method and procedures during various construction stages.
- improved knowledge and understanding of land formation and char development due to implementation of cross-dams

Task description

1. *Data collection and field surveys*

The morphological and hydraulic impact due to closure and implementation of the cross-dam requires data on:

A. *Topography and bathymetry for the whole project area*

This gives an indication of the sediment budget. All bathymetric data and levelling data should be defined with reference to PWD. New information (coastline, land use, infrastructure) derived from recent remote sensing images should be incorporated.

B. *Hydraulic and morphological data*

1. land level data along the channel and adjacent islands.
2. water level, flow velocities and discharge measurements along the channel
3. waves
4. cross-sectional profiles
5. sediment concentrations and grain sizes of suspended sediment, grain sizes of bed sediment

2. *Data processing and data analysis*

Data processing and data analysis concern:

1. laboratory analysis of sediment data
2. analysis of current velocities, water levels and bathymetry
3. calculation of the discharge and sediment transport
4. assessment of the accretion and erosion rate along the channel and adjacent islands during and after implementation of the cross-dam
5. analysis of the accretion and erosion rate using bathymetric information.

3. *Mathematical model investigations*

A 2D mathematical model investigation programme should be executed for the pre-feasibility study areas to gain insight into the hydrodynamic and morphodynamic behaviour of the tidal channels under various hydraulic conditions during and after implementation of the cross-dam. The mathematical model investigation should be carried out by the Surface Water Modelling Centre (SWMC).

4. *Morphological analysis and interpretation*

Based on the data analysis and the results of the mathematical investigations, the future morphodynamic behaviour has to be studied and the prediction for accretion and erosion in the channels and intertidal zones have to be updated and corrected where necessary.

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PART 3

URIR CHAR - CHAR PIR BAKSH

TABLE OF CONTENTS

P3.1	INTRODUCTION	1
1.1	General description of the area	1
1.2	Rationale of the project	1
1.3	Project approach	1
1.4	Key assumptions	1
P3.2	MORPHOLOGICAL DEVELOPMENTS	4
2.1	Introduction	4
2.2	Objectives of the morphological study	4
2.3	Physical Features	4
2.3.1	Tide	5
2.3.2	Bathymetry	5
2.3.3	Coastline migration	5
2.3.4	Waves	5
2.3.5	Tidal flow and sediment concentration and volume	5
2.4	Expected morphological developments	6
P3.3	PRESENT SITUATION	12
3.1	Physical setting	12
3.1.1	Topography	12
3.1.2	Climate	12
3.1.3	Soils	12
3.1.4	Land use	12
3.1.5	Flooding	12
3.1.6	Cyclones	12
3.2	Socio-economic setting	13
3.2.1	Demography	13
3.2.2	Land ownership	13
3.2.3	Credit and indebtedness	13
3.2.4	Income and sources of income	13
3.2.5	Communications	13
3.2.6	Education and literacy	14
3.2.7	Health	14
3.3	Hydraulic Infrastructure	14
3.4	Water Management	14
3.5	Agriculture	14
3.6	Livestock	15
3.7	Fisheries	15
3.8	Forestry	16
P3.4	FUTURE WITHOUT PROJECT	18
4.1	Land accretion and land development	18
4.2	Physical and social infrastructure	18
4.3	Water management	18
4.4	Agriculture	18
4.5	Livestock	19
4.6	Fisheries	19
4.7	Forestry	19
P3.5	PROPOSED INTERVENTIONS	19
5.1	Cross dams	20
5.1.1	Basic data	20
5.1.2	Cross dam design	21
5.1.3	Proposed cross dam	21
5.1.4	Implementation of the cross dam	22
5.1.5	Cost estimates of the cross dam	22

5.2	Empoldering	22
P3.6	DEVELOPMENT FOR THE PROJECT AREA	26
6.1	Development concept	26
6.2	Land accretion	26
6.3	Land development	30
6.4	Needs assessment	30
6.5	Project interventions	30
6.5.1	Safety of the population	30
6.5.2	Roads and transport	30
6.5.3	Settlements	30
6.5.4	Agriculture	31
6.5.5	Fisheries	32
6.5.6	Livestock	32
6.5.7	Forestry	33
6.6	Integrated water management	33
6.6.1	Project formulation and planning	33
6.6.2	Participation in water management	34
P3.7	IMPACT OF THE PROJECT	34
7.1	Physical infrastructure	34
7.2	Social infrastructure	34
7.4	Water management	35
7.5	Agriculture	35
7.6	Livestock	35
7.7	Fisheries	36
7.8	Forestry	36
P3.8	ENVIRONMENTAL ASPECTS	36
8.1	Aims and objectives of the environmental assessment	36
8.2	Proposed interventions	36
8.3	Baseline environmental conditions and future trends	37
8.4	Impact identification, quantification and valuation	37
8.4.1	Identified positive impacts	37
8.4.2	Identified negative impacts	39
8.4.3	External impacts and constraints	40
8.5	Environmental mitigation	40
8.5.1	Ghat relocation	40
8.5.2	In-shore marine habitats	40
8.5.3	Fisheries	40
8.5.4	Direct construction impacts	40
8.6	Residual impacts	41
8.7	Environmental risk	41
8.8	Environmental monitoring and management	41
8.9	Conclusions of the environmental assessment	42
8.10	Future environmental work programme	42
P3.9	PRELIMINARY ECONOMIC ASSESSMENT	42
9.1	Project costs	43
9.2	Project benefits	43
9.3	Preliminary economic analysis	43
	REFERENCES	54

LIST OF TABLES

Table P3-3.1: Showing plantation area and growing stock	16
Table P3-5.1: Tidal levels at Sandwip	20
Table P3-5.2: Features of the primary embankments	24
Table P3-5.3: Estimated cost of primary embankments	24
Table P3-5.4: Future drainage situation	25
Table P3-5.5: Cost of new sluices	25
Table P3-5.6: Excavation and re-excavation of drains	25
Table P3-5.7: Investment cost	26
Table P3-9.1: Summary of project costs (financial prices)	43

LIST OF FIGURES

Figure P3-1.1: Location of the project area	3
Figure P3-2.1: Potential sites for cross dams	7
Figure P3-2.2: Frequency curves of daily high water levels at Sandwip	8
Figure P3-2.3: Frequency curves of daily low water levels at Sandwip	9
Figure P3-2.4: Exceedance frequency curve Sandwip	10
Figure P3-2.5: Coast line development of Urir Char - Char Pir Baksh 1957, 1973 and 1996	11
Figure P3-3.1: Situation of project area in February 1996	17
Figure P3-6.1: Future accretion and erosion in the Urir Char area without interventions	28
Figure P3-6.2: Future accretion and erosion in the Urir Char area with interventions	29

APPENDICES

Appendix I	44
Appendix II	49
Appendix III	52

P3.1 INTRODUCTION

1.1 General description of the area

The project area (Figure P3-1.1) is located in the Sandwip Thana of Chittagong district at the northern end of Sandwip Channel. The area is located between the Sandwip island and Char Balua (Noakhali mainland). Urir Char began to emerge in the late fifties as a result of gradual siltation of the left arm of the Lower Meghna River. This area is located in a channel system which connects the two different tidal hydraulic systems, namely, the Sandwip Channel and the Hatia Channel with water level difference and time lag between the parts.

The main chars (islands) in the project area are Urir Char to the northwest and Char Pir Baksh to south between Urir Char and Sandwip. Some channels between the chars/islands dry up during low water.

Inspection of satellite images for the period 1957, 1973, and 1996 shows that the areas of the islands have increased significantly between 1973 and 1996. Land formation continues around the project area.

1.2 Rationale of the project

The socio-economic and agricultural development in the project area are hampered by

- erosion at the north of Urir Char and on the west of Char Pir Baksh
- soil salinity due to intrusion of saline water
- drainage congestion during high tide.

This pre-feasibility study is for a project that would aim to enhance land accretion by the construction of cross dams, control flooding, reduce salinity and improve drainage and water management over 5 to 10 years through a multidisciplinary and integrated development approach. The overall objective is to enhance security for the population in the area and improve socio-economic conditions.

1.3 Project approach

Interventions, such as cross dams, which accelerate the accretion of new land, present a dilemma from the economic point of view. Newly accreted land is saline, subject to tidal intrusions and low in fertility. For land to accrete to a sufficient level so that it can be successfully embanked and so that effective drainage and water management can gradually eliminate soil salinity takes a considerable number of years. The organic matter content of the soils is initially very low and increases only slowly. As long as these soil conditions prevail, agricultural yields are low. There is thus a long delay between investment in a cross dam and the commencement of a significant flow of benefits.

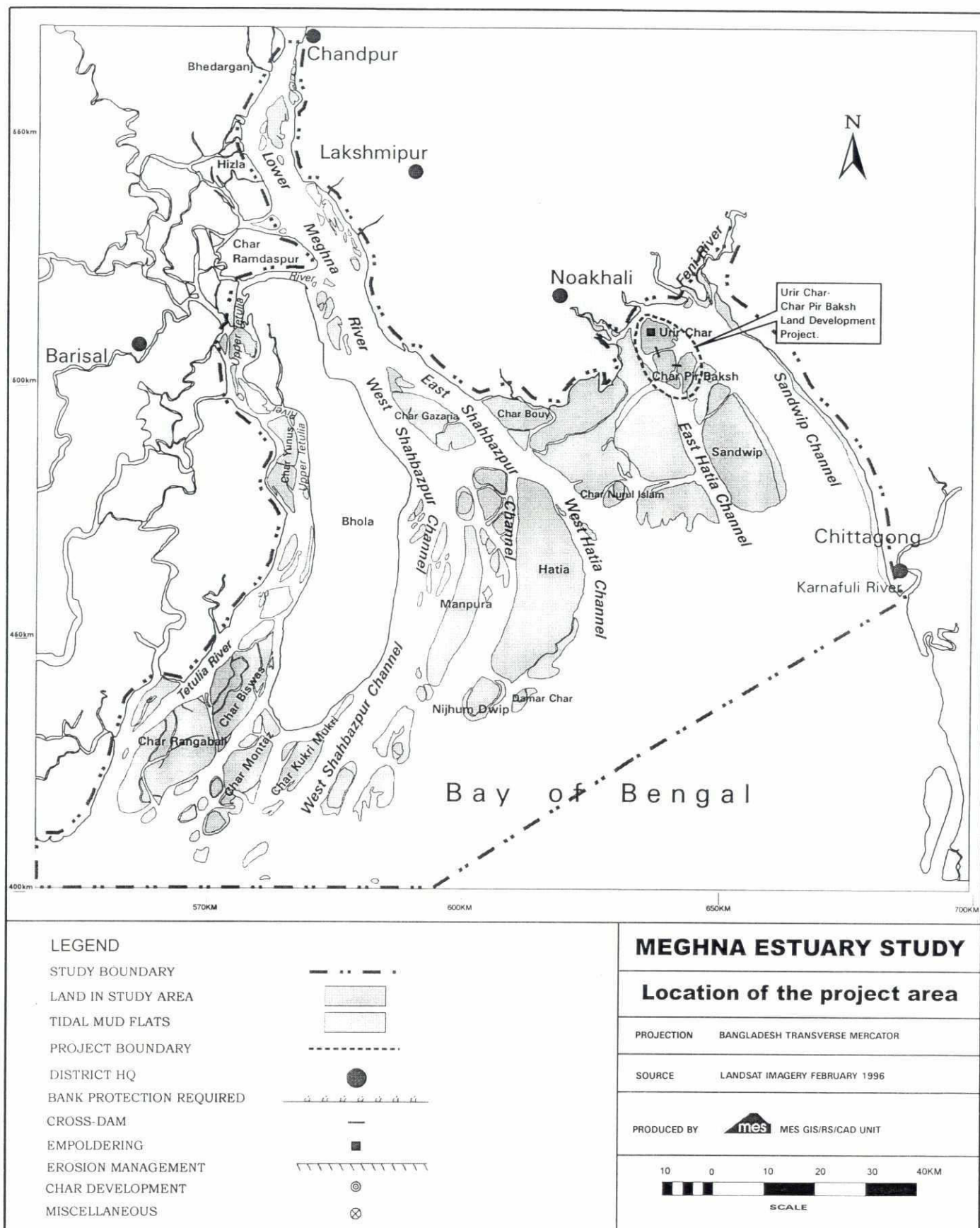
For these reasons it is appropriate to adopt an integrated development approach to the proposed development activities for chars in the Meghna estuary. By combining land accretion with land development and designing projects that incorporate cross dams, embankments, drainage and water management together with measures to increase the productivity and production of agriculture, livestock and aquaculture and other activities it is possible to design feasible development projects for these areas.

1.4 Key assumptions

The preparation of a pre-feasibility report requires some assumptions, often with regard to the reliability and processing of data. For this study, critical assumptions refer to the sequence of land development on newly accreted land and the role of mangrove forests on the estuarine chars. In particular, it is assumed that:

- new land reaching the level of + 1.7m PWD will be planted in mangroves
- mangrove forest which has reached the age of 15 years may be cleared for agriculture and other uses provided that a minimum depth of 1 km of forest is maintained all along the future coast at all times as an essential part of the protective barrier providing security against storms to the population
- existing forest which will be inside the proposed new polders will be cleared for agriculture after construction of the embankments.

Figure P3-1.1: Location of the project area.



P3.2 MORPHOLOGICAL DEVELOPMENTS

2.1 Introduction

Within the framework of the Meghna Estuary Study, the possibility of implementing cross dams in the project area has been studied. The potential sites for cross dams within the project area are shown in Figure P3-2.1. The cross dams will accelerate accretion because flow velocities in the closed channel section will be drastically reduced. Bank erosion due to the current will also stop in the channels.

To reduce the construction costs of such dams, the MES proposes to use geotextiles. Geotextiles will be spread out along the bottom across the channel and the space under the geotextile is filled with sand. This geotextile with sand acts as a base for the cross dam, to protect the bed against erosion during construction.

As a part of the pre-feasibility study of the Urir Char and Char Pir Baksh Development Project, a morphological study has been carried out to ascertain the effects of cross dam construction on the morphological development of the area.

2.2 Objectives of the morphological study

The objectives of the present morphological study, carried out as a part of the pre-feasibility study, are as follows:

- to draw up an inventory of relevant reports, bathymetric maps, aerial photographs, satellite imagery, cross-sectional soundings, water levels, flow velocities, discharges, sediment concentration and grain size distribution
- to describe the morphological development of the study area during the last decades (in terms of accretion and erosion and land levels)
- to improve the understanding of the morphological phenomena in the area with the aid of satellite imagery as well as other historical data on bathymetry and land formation
- to assess long term changes of land formation and char development
- to predict the preliminary morphological impact of cross dam construction for an intermediate time period (10-30 years).

2.3 Physical Features

There are tidal channels and creeks and mangrove forests in the area.

The area is located on the outskirts of the Feni estuary but fresh water input to the area is negligible when compared with the tidal inflow and outflow to and from the Sandwip and Hatia Channels. It is reported that tidal bores occur in the area during spring tide. The low lying areas inside the islands are connected by creeks. These creeks drain the individual drainage areas into the surrounding channels.

Mangroves have been planted at the southern side of Char Pir Baksh and act as foreshore protection. The area shows a gradual tendency of sedimentation. During a reconnaissance flight in 1997, huge intertidal mudflats, i.e. emerging islands, were identified on the periphery of chars in the area at low tide. The area is morphologically dynamic.

Mangroves were planted in the newly accreted land situated at the southeast of Urir Char and Char Pir Baksh.

2.3.1 Tide

The tidal motion dominates the project area round the year. The tide is semi-diurnal with M2 and S2 as the major tidal constituents. A statistical analysis of water levels has been made for the years 1996 and 1997. Although the quantity of data was inadequate to make good judgements, the results of the analysis give some indication of variations in water levels, but this might not be representative. The analysis indicates that the high water and low water levels vary from 4.0 to 7.75 m CD and -0.5 to 2.25 m CD, respectively. The seasonal variation of mean high water level at Sandwip is about 2.8 m (Figure P3-2.2) and that of mean low water level is about 2.0 m (Figure P3-2.3). Conversion factor for water levels: m PWD = CD 1.706m.

A frequency exceedence curve (Figure P3-2.4) of water levels has been prepared for the Sandwip gauge which shows for how much of the time a particular level remains under water. For example, +2.0 m PWD remains under water for about 40 per cent of the time. Lower levels remain under water longer than higher levels.

2.3.2 Bathymetry

The Sandwip Channel and the East Hatia Channel encircles the project area on the east and west. The Sandwip and Hatia Channels are connected by at least three channels, the widest of which is the channel between North Sandwip and Char Pir Baksh. One set of bathymetric data of 1997 shows that the maximum depths in the channels between Urir Char and Char Balua (Noakhali mainland) and between Sandwip and Char Pir Baksh are about -10 m PWD and -7 m PWD, respectively. These two channels are located outside the project area.

When the thalweg of channels migrates towards land, it erodes the bank. The movement of the thalweg of the channels encircling the project area was determined. The thalweg of the channel between North Sandwip and Char Pir Baksh shows a tendency to move towards the Char Pir Baksh bankline. The thalweg of the channel between Urir Char and Char Balua is moving towards Char Balua, i.e. the Char Balua side on the Noakhali mainland is experiencing erosion. The thalweg of the channel between Char Pir Baksh and Char Lakhi (on the Noakhali mainland to the west of the project) has a tendency to move towards the Char Pir Baksh coastline.

Launches and steamers cannot pass through the channel between Sandwip island and Char Pir Baksh during low tides. The channels and creeks inside the project area are shallow in comparison with the channels encircling the project area.

2.3.3 Coastline migration

Satellite images of 1957, 1973, and 1996 (Figure P3-2.5) show that the project area increased in size significantly over the period. The islands and chars increase or decrease in size by the migration of their coastlines. The satellite image of 1973 shows that Char Pir Baksh was then a small isolated emerging island located between Sandwip and Char Lakhi of Noakhali. In 1957 Pir Baksh was a tiny char.

2.3.4 Waves

Waves bring sediment into suspension for which current is the transporting agent. Dominant wave directions are south and southeast. The influence of other wave directions on sediment transport is almost nil.

2.3.5 Tidal flow and sediment concentration and volume

Flow and sediment concentration data of November 1997 are available in two channels encircling the project area - in the channel between North Sandwip and Char Pir Baksh and between Urir Char and Char Balua. The data of 1994 are also available for these cross-sections.

These measurements show that the average spring tide velocity is higher than the average neap tide velocity with maximum recorded velocity during spring and neap tides being 2.6 m/sec and 1.6 m/sec, respectively.

Average sediment concentration during spring and neap tides varied between 2.2 and 3.4 gm/litre and between 0.2 and 1.0 gm/litre, respectively.

The concentration of sediment around the project area shows that in general, there is a concentration gradient. Concentration increases from the surface to the bottom. The concentration also shows spatial and temporal variation. Measurements indicate that sometimes the shape of the concentration profile in a vertical is uniform and sometimes it is logarithmic. The difference in shape of the concentration profile may be due to density differences and the salinity gradient.

The directions of net flow of water and sediment transport during spring and neap tides in the channels between North Sandwip and Char Pir Baksh and between Char Pir Baksh and Char Lakhi were towards southwest and south respectively.

2.4 Expected morphological developments

The islands and chars will increase in size by enlarging their coastlines and also by the sedimentation of channels and creeks located in between the islands and chars. Char Pir Baksh will increase in size in the south and southeast directions.

Mangroves might halt erosion at the southeast of Char Pir Baksh and will act as foreshore protection.

As a result of cross-dam construction, the incoming and outgoing tidal volume will be reduced in the channels inside and encircling the project area, flow velocity will decrease and consequently, sedimentation will occur. The area will increase in size. Tidal water and sediment volume during flood and ebb will therefore decrease in future.

From a morphological point of view, it is expected that the relatively small tidal channels will silt up rapidly due to the construction of the cross dams. The additional area expected to accrete by 2025 as a result of the cross dams is 344 ha. This should be studied in detail during the feasibility study.

Figure P3-2.1: Potential site for cross-dam

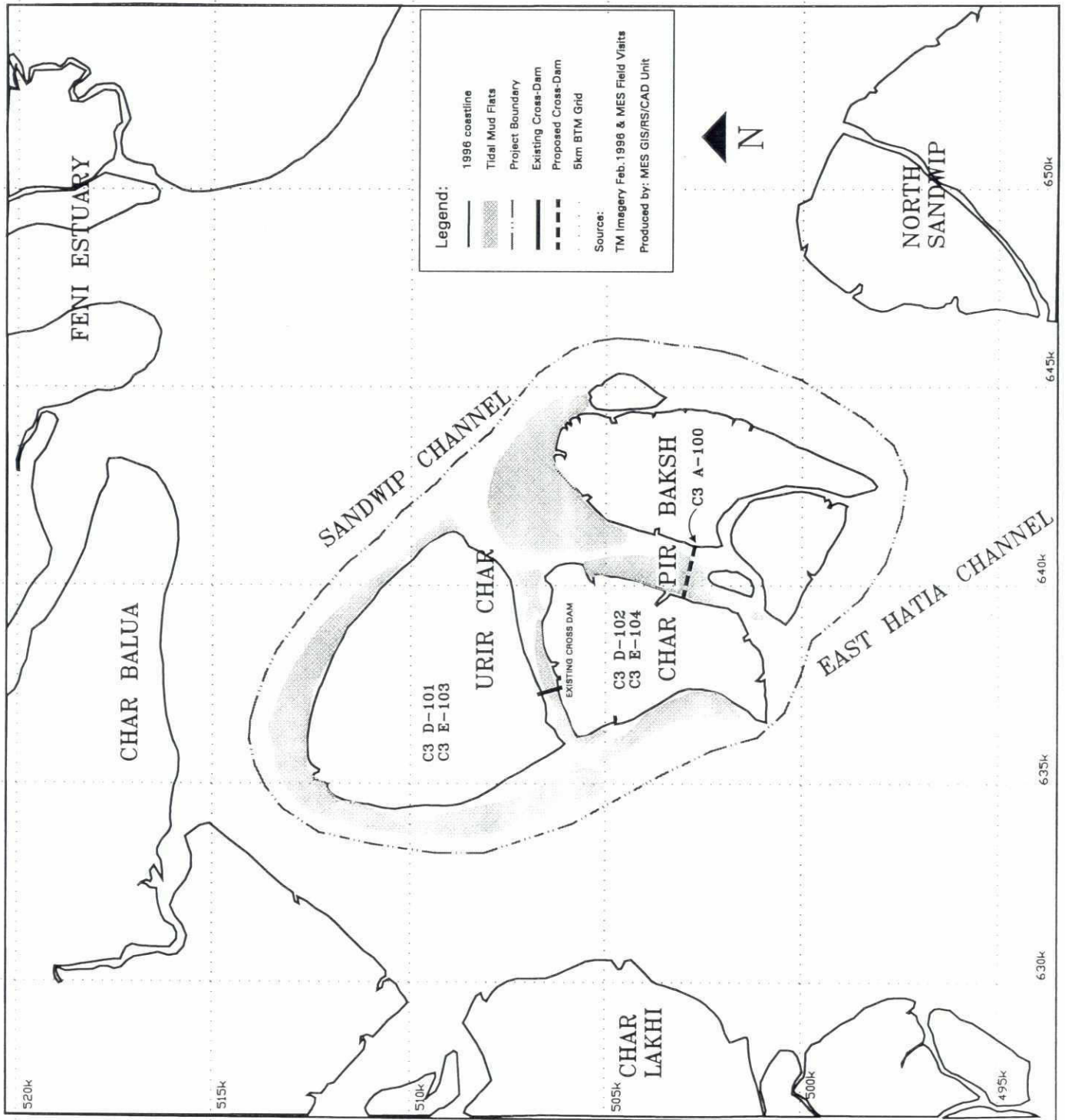


Figure P3-2.2 Frequency Curves of Daily High Water Levels at Sandwip (01 Jan 1996 to 31 Dec 1997)

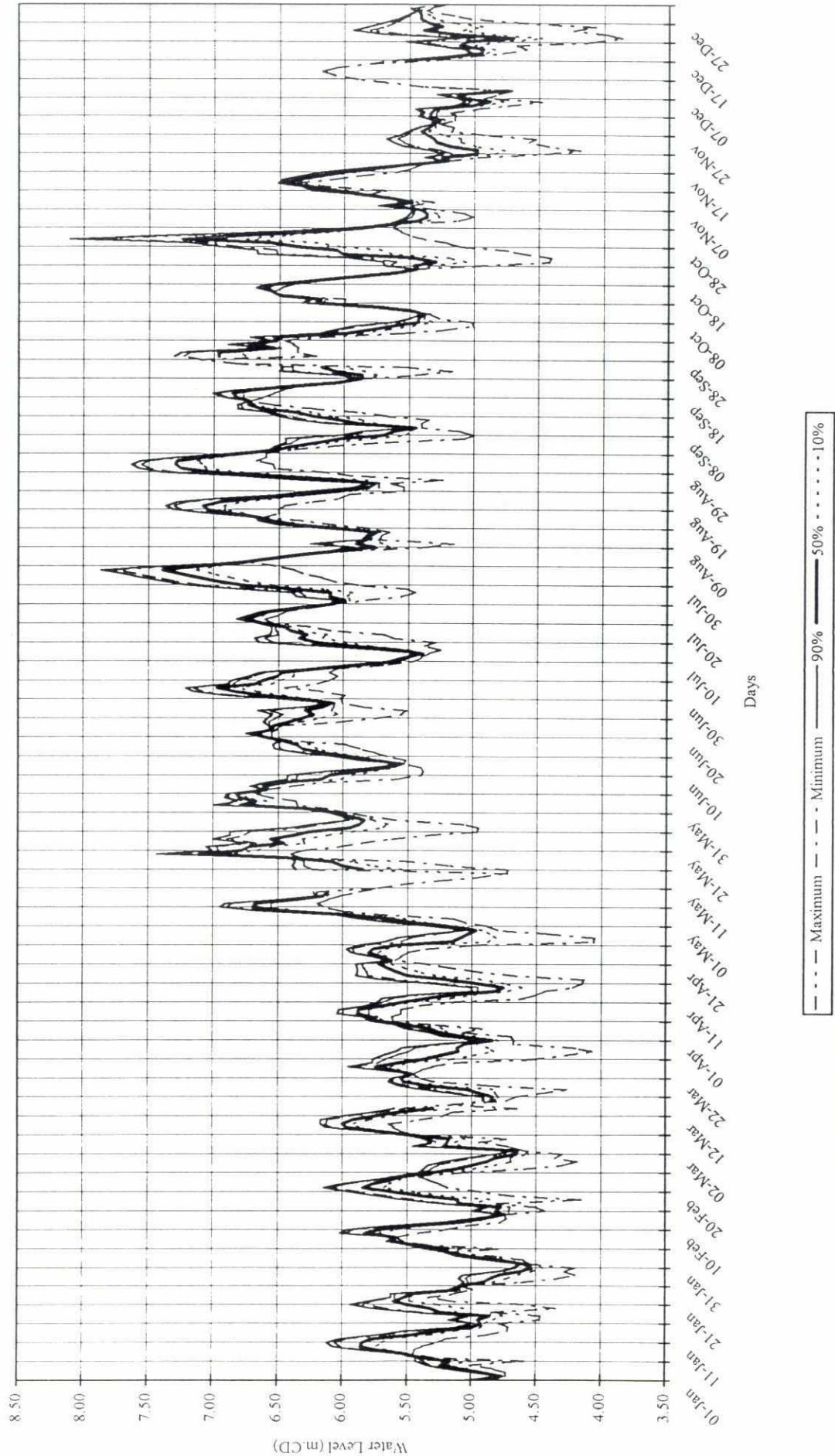
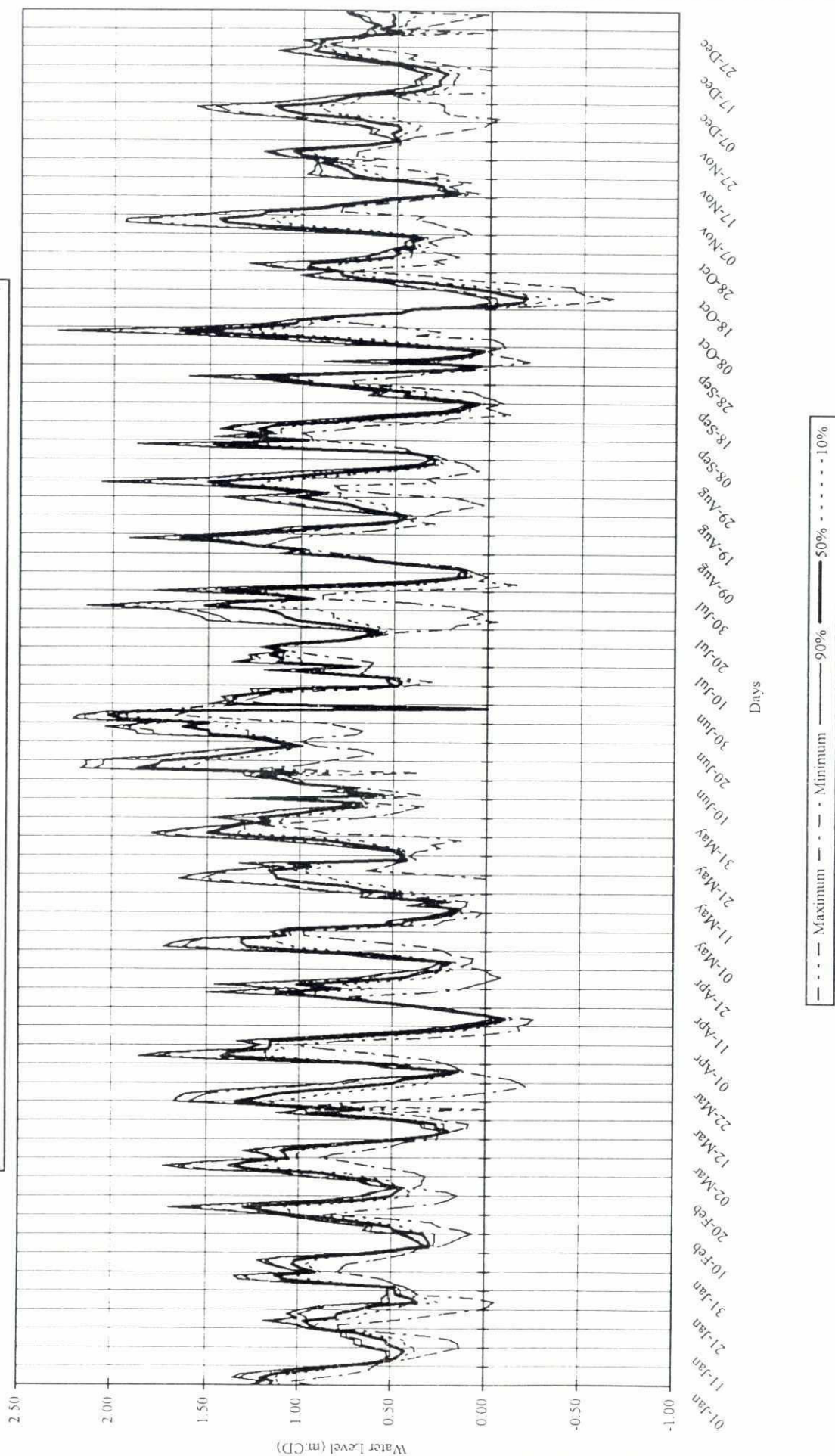


Figure P3-2.3 Frequency Curves of Daily Low Water Levels at Sandwip (01 Jan 1996 to 31 Dec 1997)



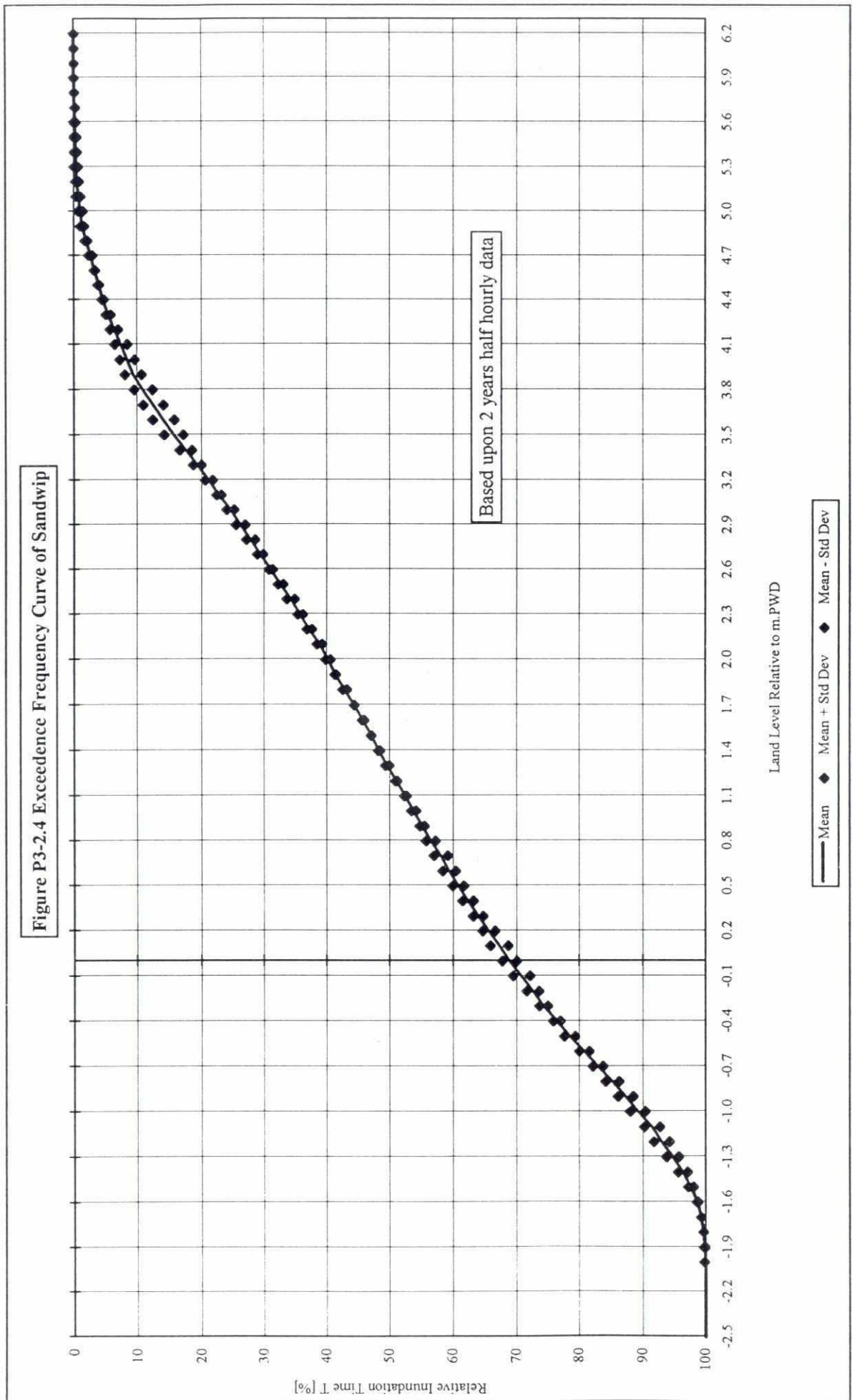
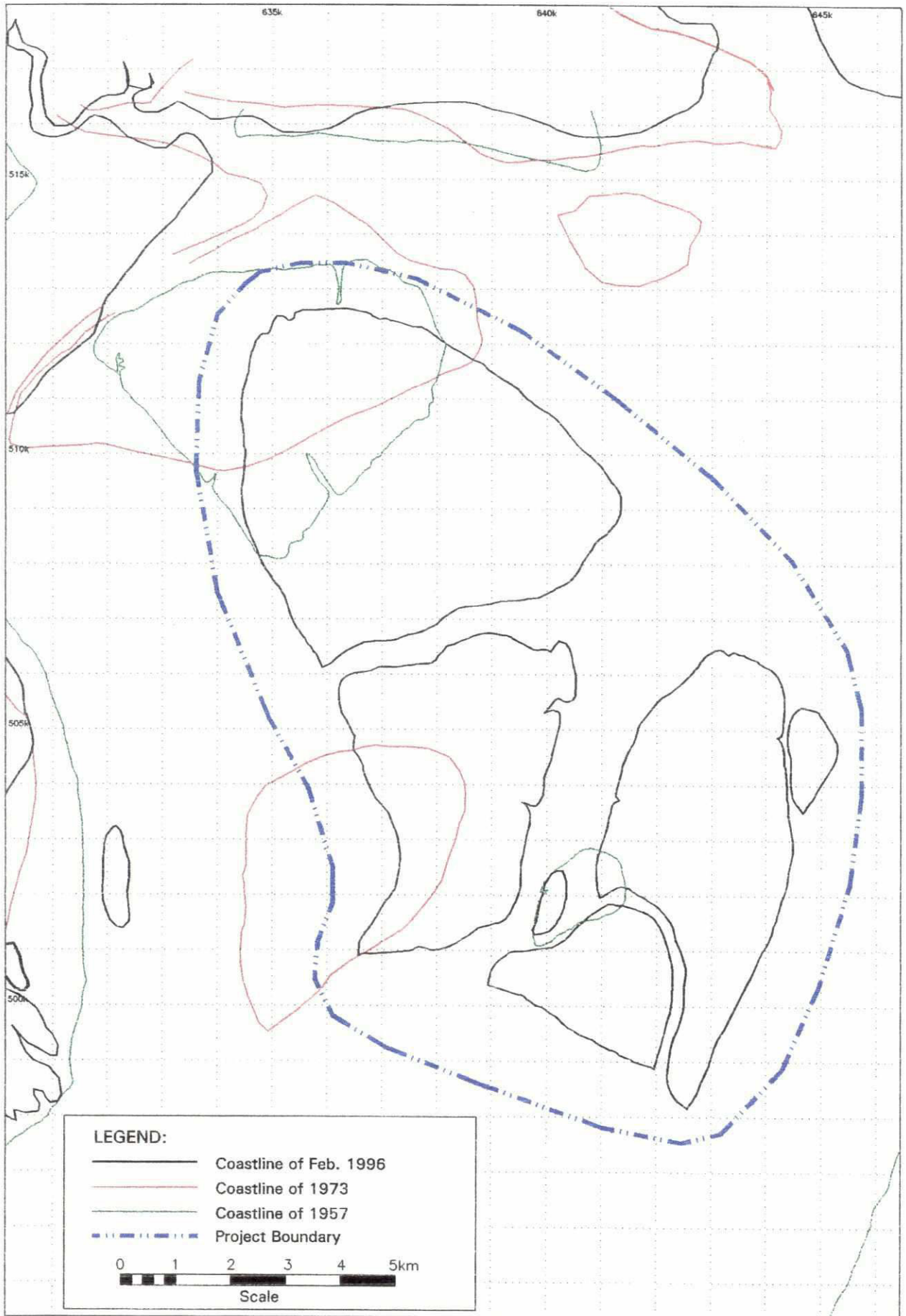


Figure P3-2.5: Coastline development of Urir Char-Char Pir Baksh
1957, 1973 and 1996



P3.3 PRESENT SITUATION

3.1 Physical setting

3.1.1 Topography

The most recent mapping for the project area are the preliminary drafts of Finmap sheets, dated 1992/94. Most of the area has a level of about +2.8 m to +3.0 m PWD. In this area, land may need to reach a level of about +4.0 m PWD before being empoldered.

3.1.2 Climate

The mean annual rainfall at Urir Char and Char Pir Baksh is about 3,500 mm, with June and July receiving the highest rainfall. However, annual variations can be significant. The hottest month is May when the mean average temperature is 29° C and the coolest month is January, when the mean average temperature is about 20° C. Monthly evapotranspiration is highest in April and May and lowest is in January and February.

3.1.3 Soils

The project area is part of the young lower Meghna estuarine flood plain. In general, the soils are seasonally flooded, poorly drained and have developed from moderately fine textured silt loams.

Salinity levels are still relatively high, at least in some areas. As in other, similar areas, the levels of organic matter in the soils are generally low. Soil development on the estuarine chars is a long a slow process, even after the construction of embankments provides the opportunity for the gradual reduction of salinity levels.

3.1.4 Land use

Of the total of 7,000 ha at present in the project area, about 4,000 ha or 57 per cent is forested. The remainder is either cultivated, in fish ponds or is low lying mud flat and grassland used for the grazing of cattle and goats.

Crop production on Urir Char and Char Pir Baksh can be limited by flooding and storm surges during the monsoon which can damage standing crops. Salinity and lack of water for irrigation in the dry season are limiting factors for cultivation, especially of Aus and Rabi crops. A single crop of the local salt resistant T. Aman is usual in most of the area and on about 30 per cent of the cultivated area, the rice crop is followed by rabi crops such as khesari, sweet potato and beans.

3.1.5 Flooding

There has only been limited data on land levels on Urir Char and Char Pir Baksh available to MES. Land levels are generally assumed to be around mean high water level. Peak tides may inundate land and even higher areas will be flooded during cyclones, which are generally accompanied by tidal surges.

The large river discharge in the monsoon period dilutes the salinity of the sea water in the estuary, but in winter the sea water remains sufficiently saline for the intrusion of sea water in this season to cause more serious damage to crops than in the monsoon. For successful crop production, flooding by saline water during the dry season requires rain to leach residual salt from the soil in the following monsoon.

3.1.6 Cyclones

The area is in one of the most cyclone hazard prone parts of the Bay of Bengal.

In the past, major cyclones have taken a large toll of both human life and livestock. Although some cyclone shelters were previously constructed some have already been destroyed by erosion. Protection for the population is limited.

3.2 Socio-economic setting

The socio-economic setting of the project area is profoundly influenced by the dynamic physical environment in which communities live. The tides, flooding, storms and processes of erosion and accretion are major parameters of existence.

Socio-economic surveys were carried out during MES in several areas, including Urir Char, to provide background information on the socio-economic setting of the project area and information for three aspects of project formulation: economic viability, social desirability and possible development strategies. The survey investigated settlement patterns, demography, occupations, land ownership, credit and indebtedness, income and sources of income, communications, literacy, education and health.

The results of these surveys are presented in the Draft Master Plan, Volume 4: Rural Development

3.2.1 Demography

The population of the mauzas constituting the project area is about 17,000 with an average household size of about 6.

3.2.2 Land ownership

According to the survey data, almost 30 per cent of households in the project area are functionally landless. Another 60 per cent have less than one hectare.

Throughout the project area, many landless, marginal and small farmers operate land of absentee land owners who live outside the area. Usually the crop is distributed 50:50 between the landowner and sharecropper.

3.2.3 Credit and indebtedness

The most common sources of credit are the Bangladesh Krishi Bank and money lenders. Credit is principally used for agriculture and related purposes.

3.2.4 Income and sources of income

Average household cash incomes in Urir Char are lower than in other areas surveyed. As elsewhere, households typically have income from a number of different sources. Agriculture and livestock are the principal occupations in this area, with the latter making a larger contribution to average household cash income. Unlike other parts of the MES study area, fishing is relatively unimportant in Urir Char with only 25 per cent of households having any income from this source. Other significant sources of income include remittances from family members working outside the area.

3.2.5 Communications

Communications to and from both Urir Char and Char Pir Baksh are entirely by water transport. The principal routes are towards Sandwip, the thana headquarters, and the Noakhali mainland. The restricted nature of the communications system hampers transport for goods both into and out of the area. Improved accessibility would have a beneficial effect on production as well as on services available to the population.

3.2.6 Education and literacy

The illiteracy rate in Urir Char appears to be quite low, about 50 percent according to the MES survey. The rate will be higher in the less developed parts of the project area. However, the MES survey gave generally higher literacy rates than the official data for the corresponding areas.

3.2.7 Health

The thana health complex for the project area is at Sandwip thana headquarters and is the only available source of health data for the area. This data reflects the health situation in the surrounding areas of the thana headquarters and is not directly applicable to the project area. However, it indicates that the most commonly reported diseases in the area are diarrhoea, intestinal parasites, peptic ulcers, respiratory tract infections and malaria and other fevers.

3.3 Hydraulic Infrastructure

No embankments or other hydraulic infrastructure has so far been constructed in the project area.

3.4 Water Management

There are no facilities for water management with the exception of natural drainage khals and channels.

3.5 Agriculture

Agriculture in the project area is typified by low yields and low cropping intensities. To a large extent, these are the result of soil salinity and a low level of soil fertility combined with damage from flooding and pests. Crop losses can be as high as 50 per cent or more. In extreme cases, in unprotected areas, a whole crop may be lost.

The whole area is unprotected and the intrusion of saline water at certain times cannot be prevented. In the dry season, the salinity of the water in the surrounding channels is relatively high and spring high tides can lead to the intrusion of salt water in agricultural areas. Also in the dry season, the salinity of surface soils can increase due to the capillary rise of saline ground water. The rains of the next monsoon season are required to leach this salt from the soil. Salinity is not such a serious problem during the monsoon season, but flooding from tides or storm surges can damage crops.

Ground water, pumped from depths of about 300 m, is only used for domestic water supply. The extent of the resource is not known. The pumping of ground water for irrigation, given the conditions in the project area, would not be viable for crop production.

About 90 per cent of households involved in agriculture have holdings of 1 ha. or less. The major constraints to production are soil salinity, the low fertility of the soil, the lack of water in the dry season and pest damage to crops.

Rabi crops grown typically include chilli, groundnut, khesari, mung, and sweet potato. The conditions in the chars and frequent damage usually result in low crop yields. Yields actually achieved for rice, for example, may often be below 1 mt/ha.

Among other constraints to production in the project area are the lack of extension services and the lack of access to local or regional markets. Both of these constraints are linked to the relative isolation of the area and the transportation links to outside areas. The limited transportation links also make agricultural inputs difficult to obtain and relatively expensive (compared to areas with better and cheaper transportation links) and tend to reduce the prices that can be obtained for any surpluses farmers produce.

3.6 Livestock

Livestock are a relatively important part of the household economy in the project area, being kept for draft purposes, to provide food and as a source of income. On newly accreted land, the first plant species to establish itself is usually uri grass. This provides fodder and the basis for supporting cattle, goats and sheep.

The cattle in the area are usually of the zebu type, fairly well adapted to the local climate and environment, but with low productivity. The average cow produces only about 1-2 litres of milk per day during lactation.

The buffaloes are the Indian water buffalo type and are preferred by farmers as tough draft animals that can survive on the coarser roughage available on chars and in forest undergrowth. The milch buffaloes produce a little more milk than cows.

The cattle and buffaloes of large and medium farmers are usually grazed on the newly accreted chars and in the forests or in the fields after harvest. Cattle owning landless and marginal farmers, who have less access to land and less crop residues, face more difficulty in obtaining fodder. The availability of fodder may be especially a problem during July to November when the fields are in crops and during the dry season from November to March when weed production is at a minimum. Marginal farmers typically tether their animals on the river banks, fallow lands and pond dykes or stall feed them to avoid the risks of theft or loss on the chars or in the forest.

The chicken and ducks are of the deshi type, are raised around the homestead and are usually the responsibility of the women. The chickens typically produce 40-45 eggs and the ducks 60-80 eggs per year.

Usually, spending on feed supplements or veterinary care for livestock is virtually zero. However, the household survey on Urir Char indicated that between 30 and 40 per cent of household cash income is generated from the sale of livestock and livestock products. This is much higher than in other areas surveyed. Household consumption of livestock products and the use of draft animals in crop production provide additional benefits.

3.7 Fisheries

Fisheries is an important activity in the project area and has a significant role in nutrition and provides about 30 per cent of average household cash income. Approximately 25 per cent of the households in the area depend on fishing for a part of their livelihood. There are two types of fisheries in the project area:

- Capture fisheries: carried out at sea in the inshore and offshore waters and in inland water bodies such as beels, khals, rivers and the flood plain.
- Aquaculture: which comprises the pond raising of carp and shrimp in ponds

Some data from the project area suggests that there are about 1,000 small fish ponds with a total area of around 80 ha yielding around 400 to 500 kg/ha/year. Fish marketing is poorly developed in the area and transport costs to major market centres are relatively high. These factors depress the prices and those received by fishermen are generally low.

Limited fishing is carried out in the inland water bodies of the study area during the monsoon, i.e. in the khals and flooded land. The principal species caught are taki, shing, puti and chingri.

The most common aquaculture practices in Bangladesh are the rearing of Indian carp in fresh water ponds and the raising of tiger shrimp in brackish water ponds.

3.8 Forestry

Some 4,800 ha of mangrove plantation has been established on chars in the project between 1981 and 1998. Of this only about 4,000 ha remain. Table P3-3.1 shows annual plantation areas and an estimate of present total volume based on a rapid assessment of the mangrove forest resources in the MES area made by the MES forestry specialists in December 1997 and January 1998. According to this assessment, the total growing stock within the project area stands at 0.16 million m³. The species planted in the accreted land are mostly Keora (about 90 per cent), Baen, Gewa and others (the rest 10 per cent).

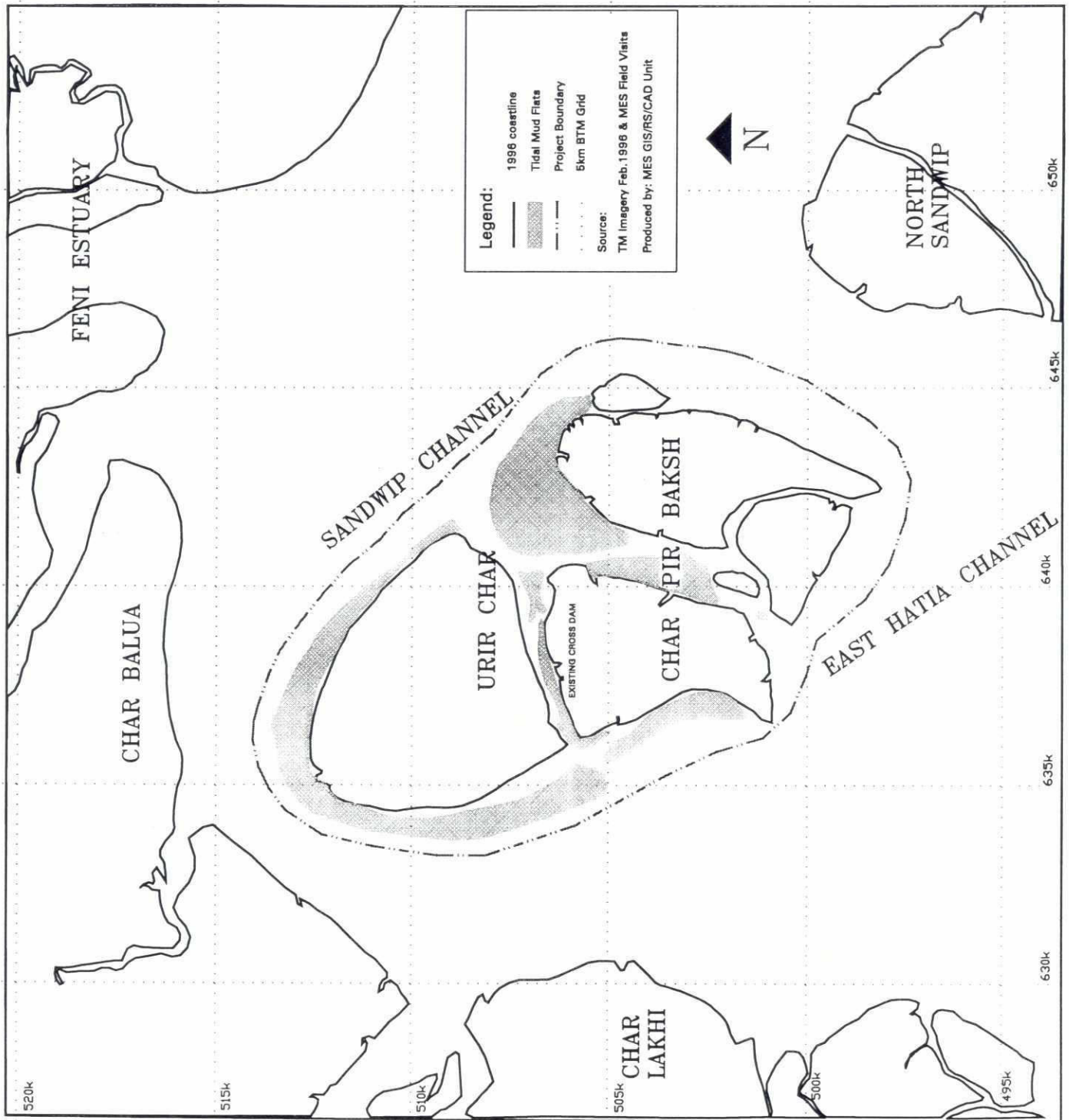
Management of these forests previously included thinning operations, which were carried out during the fiscal years 1988-89 and 1989-90 in all these plantations up to 9 years of age. Because of the high cost of thinning and relatively lower returns, thinning was considered to be uneconomic and thenceforth no regular thinning is being carried out in these plantations.

According to MES estimates, there are more than 3,700 ha of submerged area (mudflats) in the project area which could be included in an afforestation programme as soon as levels have risen sufficiently for it to be colonised by uri grass.

Table P3-3.1: Showing plantation area and growing stock

Planting year	Area (ha)	Sum of every 5 years plantation (ha)	Average volume (m ³ /ha)	Total volume (m ³)
1981	91	1,613	57	91,722
1982	16			
1983	30			
1984	951			
1985	525			
1986	583	1,156	40	46,113
1987	223			
1988	145			
1989	205			
1990	0			
1991	243	1,560	12	18,641
1992	273			
1993	438			
1994	229			
1995	377			
1996	170	550	0.8	413
1997	180			
1998	200			
Total	4,879	4,879		156,852 Say 157,000

Figure P3-3.1: Situation of project area in February 1996



P3.4 FUTURE WITHOUT PROJECT

4.1 Land accretion and land development

With no intervention, the land area will continue to accrete at a rate similar to the past. Based on a study of land formation and char development between 1973/74 and 1996, it is estimated that with no intervention the accretion of new land in the whole project area over the period to 2025 will be about 2,600 ha or about 90 ha per year.

The general land development sequence recommended by MES for newly accreted land is for it first to be planted in mangroves. This helps to stabilise the land, promotes further accretion and the development of the soils and provides protection from tides and cyclones. After 15 years, forest may be cleared for agriculture provided a coastal belt is retained for protective purposes.

Given the recent history of mangrove planting in this area, it is likely that without the project a relatively high proportion of newly accreting land will be planted in mangrove. The development of newly accreted land around Urir Char and Char Pir Baksh, without any intervention, is expected to proceed as follows:

- a high proportion of land reaching the level of + 1.7 m PWD will be planted in mangrove
- there will be no clearing of mangrove forest before 15 years
- remaining land will be mostly used for the grazing of livestock.

4.2 Physical and social infrastructure

Without the project, physical infrastructure in the project area will develop only slowly. Embanking on Urir Char and Char Pir Baksh will not occur in the foreseeable future but may occur eventually.

Improvements in transport and communications will be slow to materialise. There are no official BIWTA routes in the area and none are expected, but there are regular private sector services connecting the area with the mainland. Urir Char and Char Pir Baksh will continue to be dependent on boats for all communications. There may be a gradual improvement in the frequency and regularity of private boat services to the mainland.

The safety and security of the population is a relatively high priority. The construction of additional killas and cyclone shelters is likely to be continued under either regular government or NGO programmes in the coming years.

Other social infrastructure in the area will continue to expand gradually in accordance with Government's regular programmes. The area has 4 primary schools, but there is no high school. Health services in the area are also very limited.

4.3 Water management

Without intervention, the situation of unprotected land will remain unchanged from a water management or drainage perspective. Local farmers may gradually improve the natural drainage networks.

4.4 Agriculture

Agriculture in the project area is constrained by exposure to high tides and storms in unprotected areas and to soil salinity, low soil fertility and a lack of inputs and extension support. Without project interventions (and embankments), salinity would decline only very slowly or not at all, since the land would remain vulnerable to saline intrusion from high tides. The risk of damage to crops from tides and floods would be unchanged. Fertility may gradually rise as the organic content of soil rises. Farmers' access to information and technical support would improve only slowly although the possibility of gradually improving communications may

provide some stimulus to production through better access to markets.

Agriculture will be limited to one low yielding rice crop during the monsoon and a much smaller area (at present reported at about 20 to 30 per cent of cultivated area) of relatively salt tolerant rabi crops in the dry season.

Overall, it is unlikely that yields or cropping intensities would increase significantly from those obtained at present. In particular, expansion of Rabi crops would continue to be inhibited by the saline conditions.

New land accreting naturally will initially be used for mangrove forestry or grazing rather than agriculture.

4.5 Livestock

Although livestock and poultry at present contribute only modest amounts to household cash income they are nevertheless an important component of the household economy, contributing draft power and dietary supplements in the form of milk, eggs and meat.

As new land accretes, the land available for the grazing of large and small ruminants will increase. However, the average number of livestock owned per household is not expected to increase in the future. Increases in livestock population will be related to the increasing numbers of households in the area. Successful livestock production in the project area depends on the safety of the animals, especially during cyclones. Unless the number of kills in the area is increased to adequate numbers, it is unlikely that livestock populations would increase very significantly, or that investments will be made to improve livestock productivity. Furthermore, although gradually improving communications with the area and better access to markets may act as a stimulus for production in the area, the lack of veterinary and extension support will also inhibit livestock production.

Overall, without the project, livestock populations will increase, but current levels of productivity are expected not to change significantly. Per household ownership of livestock will not change significantly. Future growth in livestock populations will probably depend the carrying capacity of the area and the future number of households.

4.6 Fisheries

Fisheries are at present a relatively minor source of income for households in this area. Without implementation of the project, the relative importance of fisheries is not expected to change. In particular, investments in expanding or upgrading aquaculture activities are most unlikely because of the lack of protection against flooding from tides and storm surges.

4.7 Forestry

Without specific project intervention, afforestation of newly accreted areas will continue only under regular Forest Department projects and programmes. Existing forest areas will be maintained. Not all newly accreting areas will be planted in mangroves but for the purpose of this study the proportion afforested is assumed to be about 50 per cent of land reaching +1.7 m PWD.

P3.5 PROPOSED INTERVENTIONS

To develop the project area, as many as 5 engineering interventions have been considered:

- 1 cross-dam
C3 A-100
- 2 empolderings
C3 D-101 C3 D-102

- 2 char development projects
C3 E-103, C3 E-104

Their locations are shown in Figure P3-2.1.

5.1 Cross dams

The objective of the proposed cross dam is to block the tidal currents in the channel between Urir Char and Char Pir Baksh. This dam will stop the tidal flow between these islands and thus enhance accretion on both sides of the dam, eventually creating one united land mass.

5.1.1 Basic data

Basic data required for the design of the closure dams are very limited.

Reference levels

The following reference levels have adopted in this study:

Public Works Department Datum (PWD)

General horizontal reference datum defined by the Public Works Department. This datum is applied in the whole of Bangladesh.

Chart Datum (CD)

A local datum used as reference for tide levels. Chart datum is a plane below which tide seldom falls. The relationship between the Chart datum used at Sandwip for Urir Char and Char Pir Baksh the Public Works datum is: $PWD = CD - 1.71 \text{ m}$

Topographic data

Existing topographic data have been retrieved and used for the preparation of the pre-feasibility study.

Bathymetric data

Various bathymetric surveys have been carried out in the Urir Char and Char Pir Baksh area. The most recent surveys were carried out in February 1997. It is expected that after the heavy 1998 flooding the cross section will have changed. Fresh surveys will be done during the 1998/1999 winter season at the alignment of the proposed cross dam.

Water levels

Tidal information is obtained from the Bangladesh Tide Tables 1997, published by the Department of Hydrography of the Bangladesh Inland Water Transport Authority. The tidal station relevant for the area is Sandwip. The tidal levels for this station are given in the table.

Table P3-5.1: Tidal levels at Sandwip

	Levels with respect to:	
	CD	PWD
Lowest Astronomical Tide	-0.583	-2.293
Mean Low Water Spring	0.238	-1.472
Mean Low Water Neap	1.634	-0.076
Mean Low Water	3.243	1.533
Mean High Water Neap	4.851	3.141
Mean High Water Spring	6.248	4.538
Highest Astronomical Tide	7.070	5.360

Source: BIWTA, 1999 Tide Tables

Currents

Information on currents prevailing in the channel at Urir Char and Char Pir Baksh is not yet available because the detailed 2-D model has not been prepared due to lack of data in the shallow areas. However since in recent years natural siltation was considerable, currents in the channels will be moderate.

After detailed surveys of the shallow area have been completed, the detailed 2-D model with 200 metre grid spacing will be calibrated and the effect of the proposed interventions on water levels and currents will be simulated.

Soils

Geotechnical survey data for the cross dam alignments in the Urir Char and Char Pir Baksh project area are not available. For the time being it has been assumed that the soil conditions will be similar to the conditions for the Sandwip cross dam. In general the survey indicated:

- densities around 1.9 mt/m^3
- moderate SPT values and results of unconfined compression tests which agree with the classification of "stiff silt".
- consolidation C_c values are normal but the shear test values are lower than expected.

Construction materials

In the project area the only available construction material is earth. For construction of an earthen dam one should preferably use clayey soil, with 15 percent clay particles. This requirement would qualify the soil as a medium plasticity clay. A lower boundary of 10 percent could be accepted.

"Hard" materials, such as rock or boulders are not available near the closure site would, if required, have to be imported from elsewhere. Local sand (with the required grain size) and sylhet sand to be used for filling synthetic bags and geobags would also have to be brought from elsewhere.

Bamboo and bullah poles, which may be used for cross dam elements or for temporary works would have to be brought from elsewhere.

5.1.2 Cross dam design

The design and construction method for the proposed cross dam will be of the traditional type. In the winter season the channel will be virtually dry and can easily be closed by traditional methods. Recently LGED has completed construction of a cross dam connecting Urir Char and Char Pir Baksh I using the traditional method under a Food For Work Programme. (See photographs).

5.1.3 Proposed cross dam

LGED plans to implement another cross dam in between Char Pir Baksh I & II in the near future.

The ongoing erosion has been taken into account in selecting the location of the cross dam. In recent years the south-west coast line of Char Pir Baksh has been eroded considerably; therefore the alignment of the proposed cross dam should be located as far to the north as possible.

5.1.4 Implementation of the cross dam

The schedule for implementation of the cross dam will be prepared by LGED when the required funds are available. The most important issue is the timing of the final closure of the channel and completion of the dam; optimum use has to be made of the winter season for completion of the works.

The actual requirements for execution of the works depend on the channel depth prior to the start of the works. Since the traditional method of cross dam construction will be followed, mostly earth works by labour force will be involved.

5.1.5 Cost estimates of the cross dam

The layout, design and the estimate of quantities of work of the cross dam will be prepared after a fresh survey of the channel has been completed.

5.2 Empoldering

The interventions mentioned below will contribute to a) improve primary protection and secondary protection and b) reduce the present drainage congestion. These engineering interventions do not stand on their own, but are part of the water management component described in section 6.5 and Appendix II.

This study focuses on the possibility to further improve the physical protection through empoldering of Urir Char and Char Pir Baksh. The preliminary needs assessment indicated a strong wish of the local population for empolderment

The interventions required for empoldering are:

- construction of primary protection embankments
- construction of new sluices
- modification of the existing drainage network

Construction of primary embankments

Empoldering of the area will be realised by the construction of two primary embankments, a sea-facing and an interior primary embankment. The total protected area is estimated at 5,150 ha. The sea facing primary embankment will have to cope with a much greater wave action and will have a riverside slope of 1:7 and a freeboard of 1.22 m. The crest width of the interior primary embankment will differ from place to place, since a large part of this embankment will be used to accommodate a paved R-1 road.

Urir Char cross dam, showing slope erosion



Rapid accretion along side Urir Char cross dam



Table P3-5.2: Features of the primary embankments

Type	Crest Level (m PWD)	Freeboard (m)	Crest Width (m)	Slope R/S	Slope C/S
Primary embankment, sea-facing	7.88	1.22	4.25	1:7	1:2
Primary embankment, interior	7.57	0.91	4.25	1:3	1:2
Primary embankment, interior cum R-1 road	7.57	0.91	4.90	1:3	1:2

The length of the sea-facing primary embankment will be 41.8 km and 26.96 km for the interior primary embankment in Urir Char compartment (UC) and Char Pir Baksh compartment (PB I & PB II).

Table P3-5.3: Estimated cost of primary embankments

Compartment	Embankment Type	Length (km)	Rate (Tk '000/km)	Cost (Tk '000)
Urur Char	Primary embankment, sea-facing	12.4	3,788	46,970
Pir Baksh I & Pir Baksh II	Primary embankment, sea-facing	16.3	3,788	61,740
Urur Char	Primary embankment, interior	5.9	1,689	9,965
Pir Baksh I & Pir Baksh II	Primary embankment, interior	11.3	1,689	19,085
Total				137,760

To further improve the flood protection, a green forest belt will be created around the entire polder. The width of the foreshore (forest area) may vary from 200 m to 1,000 m. A minimum width of 200 m is acceptable only when no wave action is expected. The combination of sufficient foreshore with forest followed by an embankment is expected to provide a better flood protection.

In case of erosion, the combination of forest and a wider foreshore is preferred and will delay, but not prevent, an eventual retirement of the primary embankment. Only adequate bank protection works can bring erosion to a halt.

Construction of new sluices.

Excess rainfall will leave the empoldered land through drainage sluices and smaller additional surface sluices.

For the purpose of this study a ratio of about 155 ha/m² drainage sluice cross section (a maximum) will be taken for an estimation of the required drainage sluice capacity. Drainage sluices will be equipped with vertical gates for water retention. The new polder (UC) will be provided with 3 standard box-culvert drainage sluices with a total of 8 vents. The drainage ratio will be 157 ha/m².

Three surface sluices are planned in every 10 km of primary embankment. The construction of surface sluices and the construction of a minor drain along the primary embankment will mitigate local drainage congestion.



Table P3-5.4: Future drainage situation

Compartment	Sluice Code	Vents	Cross section (m ²)	Catchment (ha)	Capacity (ha/m ²)
UC	DS ₁	3	8.34	2,690	138
	DS ₂	2	5.56		
	DS ₃	2	5.56		
PB-1	DS ₁	1	2.78	1,560	140
	DS ₂	2	5.56		
	DS ₃	1	2.78		
PB-2	DS ₁	1	2.78	1,760	158
	DS ₂	2	5.56		
	DS ₃	1	2.78		

Table P3-5.5: Cost of new sluices

Compartment	Additional New Sluices	Qty.	Cost (Tk '000)
UC	D/S 1, Box Culvert (1.52x1.83m) Sluice, 3 vents	1	9,000
	D/S 2, Box Culvert (1.52x1.83m) Sluice, 2 vents	1	6,000
	D/S 3, Box Culvert (1.52x1.83m) Sluice, 2 vents	1	6,000
	Surface Sluices	7	5,400
Sub-total			26,400
PB-1	DS ₁ Box Culvert (1.52 x 1.83 m) Sluice 1 Vent	1	3,000
	DS ₂ Box Culvert (1.52 x 1.53m) Sluice 2 Vents	1	6,000
	DS ₃ Box Culvert (1.52 x 1.83 m) Sluice 1 Vents	1	3,000
	Surface Sluices	5	3,860
Sub-total			15,860
PB-2	DS ₁ Box Culvert (1.52 x 1.83 m) Sluice 1 Vents	1	3,000
	DS ₂ Box Culvert (1.52 x 1.83m) Sluice 2 Vents	1	6,000
	DS ₃ Box Culvert (1.52 x 1.83 m) Sluice 1 Vent	1	3,000
	Surface Sluices	8	6,180
Sub-total			18,180
Total			60,440

Improvement of drainage network of newly empoldered land

A natural network of khals will form the basis of a future drainage network. A detailed drainage study and field survey will define the need for upgrading khals, which will function as primary and secondary drains. A minor drain will be constructed along the primary embankment as mentioned earlier. Provision has also been made for re-excavation of 6 km of primary drain, 12 km of secondary drain and 2 km of new primary drain (linkage) per 1,000 ha.

Table P3-5.6: Excavation and re-excavation of drains

Compartment	Catchment Area (ha)	LS Cost ¹ (Tk '000)
UC	2,300	3,128
PB-1	1,340	1,822
PB-2	1,510	2,054
Total		7,004

¹ Drainage improvement costs new land, 1,361,000 Tk/1000 ha (see Appendix)

The total investment for the above described physical intervention, the empoldering of Urir Char and Char Pir Baksh, is estimated at:

Table P3-5.7: Investment cost

Sl. No	Description	Total Cost (Tk '000)	Cost/ha (Tk)
1	Construction of primary embankment	137,760	26,287
2	New drainage sluices	60,440	10,053
3	Improvement of drainage channels	7,004	1,360
Total		205,204	37,700

P3.6 DEVELOPMENT FOR THE PROJECT AREA

6.1 Development concept

Interventions to promote land accretion, such as the cross dams proposed in this project, generally cannot be shown to be economically feasible because of the long lapse between the intervention (and the investment) and the start of the flow of benefits. Furthermore, because of such problems as soil salinity, low soil fertility and flooding from tides and storms, levels of production initially achieved in newly accreted areas are low.

For this reason, interventions to promote accretion must be included as one component of an integrated package of development measures for a project area. An integrated approach to development, in this context, will aim to maximise the benefits that can be achieved from land accretion. This will be done by such measures as:

- promoting the safety of the population (including the providing of cyclone shelters and killas where appropriate)
- embanking areas to protect against tides and storms when the land has reached an appropriate level
- providing adequate infrastructure for drainage and water management
- providing appropriate infrastructure for transport and communications
- establishing coastal forests as part of the protection system for the local population and to promote the stability of the land
- promoting measures to reduce soil salinity and increase agricultural production
- promoting improved aquaculture and livestock production systems
- supporting the development of settlements and village infrastructure
- improving the access of the population to education and health services, where necessary.

For the Urir Char and Char Pir Baksh project area, this integrated approach will have to be followed in order to maximise benefits from the expected land accretion and from the area as a whole.

6.2 Land accretion

The accretion of land with and without the proposed cross dams is discussed in Chapter 2. Within the framework of the Master Plan, the development of the Urir Char and Char Pir Baksh

areas have been planned implementation during the development plan period. In the intervening period natural accretion will continue; in particular several of the smaller channels still active at present may silt up before the integrated development is started.

It is also recommended to close the smaller active channels, that do not require special technology, through the Food For Work programme. Closure of these channels will not only accelerate the accretion of new land but also enhance internal communications within the area.

The areas expected to accrete in the area in the future with no intervention and with interventions have been indicated in Figures P3-6.1 and P3-6.2.

Figure P3-6.1: Potential Accretion and Erosion of Urir Char-Char Pir Baksh area in 2025 without interventions

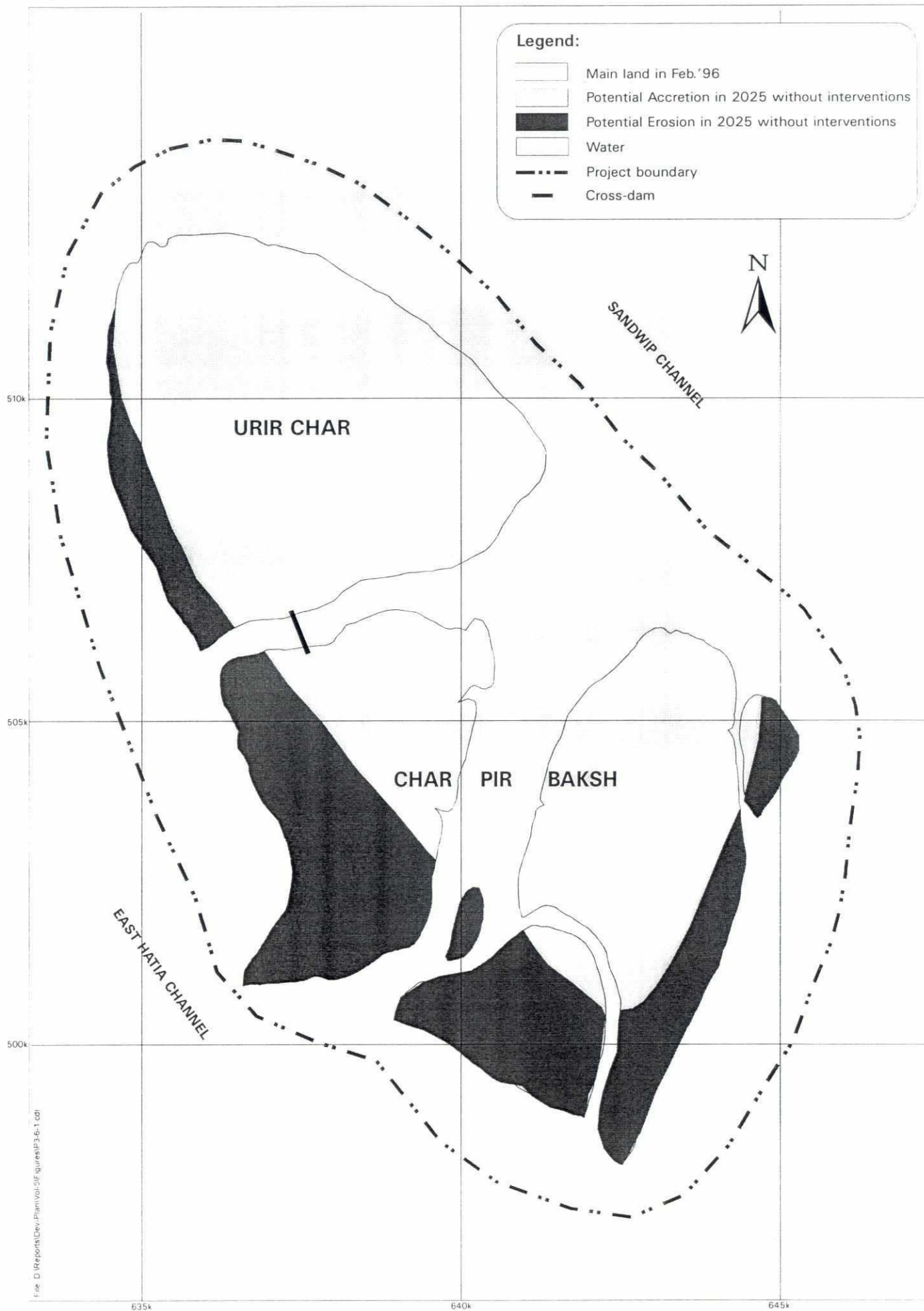
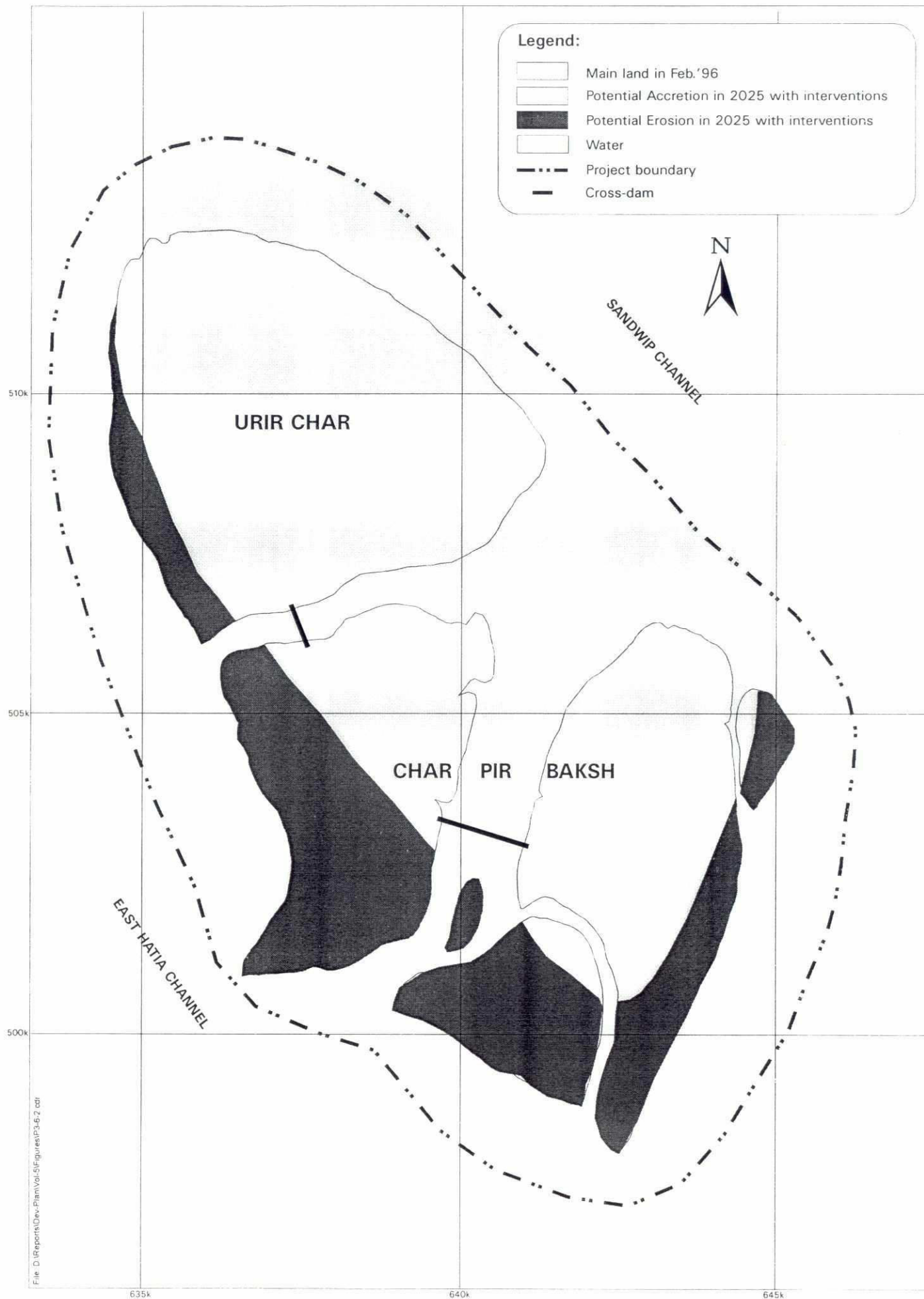


Figure P3-6.2: Potential Accretion and Erosion of Urir Char-Char Pir Baksh area in 2025 with interventions



6.3 Land development

Newly accreted land is saline, generally of low fertility and usually still subject to frequent flooding from tides and storms. In the MES area, it is recommended that all newly accreted land be planted in mangroves for an initial 15 year period. Placing the land under forest cover helps to increase stability, promotes further accretion and helps to increase the organic matter content of the soils, apart from providing essential protection from cyclones.

Thus, the principal sequence for land development which should be followed for newly accreted land in the Urir Char and Char Pir Baksh area, with the project, is as follows:

- all newly accreted land reaching the level of +1.7 m PWD is planted in mangroves as it accretes and is left in forest for 15 years
- starting in year 16, new land that has been in forest for 15 years may be cleared
- 1 km depth of mangrove forest is retained outside embankments along all exposed coasts at all times as an important element in the cyclone protection system
- land not in forest and not under cultivation may be used for the grazing of livestock - this includes cultivated land when it is not under crops
- fish ponds are assumed to occupy 2.5 per cent of gross agricultural area.

6.4 Needs assessment

A detailed needs assessment has not yet been carried out for the Urir Char and Char Pir Baksh area. However, it is expected that the construction of embankments to reduce saline water intrusion will have a high priority. Other high priorities are usually the accretion of more land and the construction of embankments.

6.5 Project interventions

In addition to the physical interventions described in Chapter 5, a number of other interventions are proposed to support productive activities in the project area.

6.5.1 Safety of the population

The improved safety and security of the population is a major objective of the MES project. The rehabilitation of embankments as well as the construction of new embankments proposed for the Urir Char and Char Pir Baksh area will enhance the safety of the population in that area. It is not proposed to construct more cyclone shelters or killas under the project as any additional requirements for are expected to be met from other government and NGO projects.

6.5.2 Roads and transport

Provision has been made for all embankments constructed under the project to have the capacity to carry roads along their crests. The embankments will then become part of the road network in the project area. This road network will have a positive impact, not only the safety and security of the population, but also on all types of economic activity. By improving access to markets for inputs and outputs, roads will especially benefit agricultural production.

6.5.3 Settlements

New agricultural land in the project area, whether from newly accreted land or from the clearing of existing forest will first be allocated to landless families already in the area. These households usually have homesteads and therefore settlement activities will not be required for them.

The availability of surplus land, after allocation to landless families, will depend upon the population living in the area at the time embankments are constructed and the area actually protected. Surplus land may be allocated to households from outside the area, for whom cluster settlements would be established. The criteria for allocating land are:

- existing cultivated land in the project area is all occupied and not available for redistribution
- land available for allocation to households goes first to landless households already living in the project area
- available land is allocated at the rate of 0.8 ha of cultivable land per household (in accordance with present government norms)
- settlements are only established on land allocated inside embankments.

Settlements established under the project for new settler households would include housing, ponds, water supply and sanitation and access roads.

6.5.4 Agriculture

The most important project interventions aimed at improving agricultural production would be the rehabilitation and construction of embankments and the associated drainage infrastructure. The main impact of these works would be to protect land from flooding and high tides. After construction of the embankment and the drainage system the main benefits for the empoldered area will be:

- reduced risk of damage from saline intrusion
- gradual reduction in salinity as monsoon rains leach salt from the soil
- reduced risk of damage from flooding during high tides or cyclones
- improved water management.

As in the case of the feasibility studies prepared under MES, specific support for the improvement of agricultural production is not proposed for the present project. Rather as salinity declines over the years it will be possible for the farmers to grow higher yielding less salt tolerant varieties of paddy crops and to gradually expand the area of Rabi crops. Rehabilitation and construction of embankments and the improved drainage system will reduce the frequent crop losses due to checking up saline intrusion or water logging. Improved water management, by retaining water in khals at the end of the monsoon season, might also provide some water for irrigation during the Rabi season.

Although soil salinity and cyclone damage are the major problems for farming development, attention might also be given in the final project design to other constraints for farming. At present the availability of seed, fertiliser and pesticides is low and the extension service is inadequate with too few, poorly trained extension officers. Due to the remoteness of the area there is limited access to markets or larger trade centres. Problems of crop losses caused by pests, loss of animals due to diseases and low health status, lack of appropriate credit facilities, land use conflicts, secure land tenure and market access are problems that have been reported in surveys and observations from the field. Integrated Pest Management, homestead development and programmes for women, micro-credit support, income generating activities, livestock fodder development and specially focused agricultural research to address problems identified during the MES surveys could be relevant components of an integrated char development project.

While establishment and rehabilitation of embankments and drainage systems provides the basis for the development of the farming system, farmers will benefit from the improvements to the extent that their resources allow. An integrated farming system development programme focused on the needs of the farm household and improved management of resources will enable farmers to benefit more from the improved farming conditions. Such an approach may address some or all of the specific issues mentioned above. Co-ordination of such a programme for the project area might be considered as a component of the final project and should be within the responsibility of the relevant ministries.

6.5.5 Fisheries

Project interventions in the fisheries sector would be restricted to the promotion and upgrading of production in existing and new ponds. There would be no activities for the marine fisheries sector.

Experience elsewhere in Bangladesh has indicated that a major bottleneck for the development of carp rearing and the overcoming of the relatively low production rates is the poor management, caused by lack of knowledge on the part of the pond owners and operators. A carp rearing development programme and extension programme should include the existing cultured, culturable ponds as well as any new ponds in the accreted land.

The present production rate in the area of around 400 - 500 kg/ha/year could be increased to an average of about 2,000 kg/ha/year if proper husbandry techniques are applied. This production rate will be less than the average of 2,200 kg/ha/year obtained elsewhere in Bangladesh due to the physical properties of soil and water in the coastal area. Increasing the production of existing ponds and introduction of carp rearing in the newly accreted land can only be achieved if an aquaculture extension programme is carried out in the project area.

There is no information about current shrimp production on the chars, although it could be introduced. A major bottleneck of shrimp farming at present is the ravaging impact of the white spot disease which has reduced production levels and the average size of shrimps produced. Future development of shrimp production will only be possible when the present non-sustainability of shrimp farming is overcome through the production of pathogen free post-larvae. Nevertheless, shrimp production could be included in the aquaculture programme, although for only a limited number of ponds. Provided the current disease problem is overcome, yields can be increased from 130 kg/ha to 400 kg/ha.

6.5.6 Livestock

Livestock production is a relatively important activity for households on Urir Char and Char Pir Baksh. The area has good potential for livestock development, for cattle and goats and perhaps for poultry. The further development of livestock production in the area, however, will depend upon improved safety and security for animals which would be provided by killas or embankments where livestock can be kept during floods and cyclones. Improved access to markets would also need to be addressed. Without these, the risks of loss may outweigh any incentives to invest in this sector.

To promote livestock development in the area, a two part programme is proposed that would:

- provide general training for livestock owners in improved husbandry methods, improved animal health and other topics
- provide intensive training and credit for selected farmers wishing to adopt a more intensive approach to livestock production.

The second part of this programme would provide for the development of more intensive methods of raising and managing draft cattle, milch cows, beef cattle, goats and chickens (either for egg or broiler production). The programme should be implemented by a suitably qualified and experienced NGO working in co-operation with DLS.

Service delivery for the livestock sector would be improved through a participatory approach, with selected individuals, nominated by their communities, being trained as Livestock Field Workers (LFW). The LFW would reside in his own community, act as a model livestock operator and would earn his livelihood through selling his services to the community and maintaining liaison with DLS and other input suppliers. The LFW would assist with demonstrations and support livestock activities and offer basic veterinary services.

Similarly, for poultry development, Women Poultry Workers would be trained to work within their communities, offering a comparable range of services to the LFW.

The implementing NGO would arrange training and support for the LFWs and the WPWs in co-operation with DLS. The DLS would support with continuous training facilities in the Thana Veterinary Hospital to improve skills. The farmers participating in project activities would be expected to bear the cost of inputs and the services of LFW and WPW so as to avoid any dependency culture for free inputs and services.

The NGO, together with the LFWs and WPWs would also explore the opportunities in the area for feasible activities such as mini-milk processing and marketing and the marketing of eggs, chicken and other livestock products.

In addition to the training and demonstration activities aimed at all livestock operators, the programme would provide specific training and support to individuals interested in taking up more intensive livestock and poultry production activities with credit support. Relevant training should be provided to the selected farmers prior to the provision of credit. Monitoring and follow up support would be provided through the implementing NGO and its staff. Liaison with the local Livestock Officer would be maintained for speedy and effective solution of any problems of general importance.

6.5.7 Forestry

Mangrove forestry will be an important component of the Urir Char - Char Pir Baksh Development Project, especially for increasing the protection of the life and property of the people against cyclones and tidal surges.

With the project, all newly accreted land will be planted in mangroves. Appropriate management of these areas and the existing 4,000 ha of mangrove plantation should be possible on a (long term) self-financing basis. Once established, a coastal protection belt of at least 1 km of forest should be maintained at all times along the whole coastline of the chars.

Afforestation activities should be implemented by the Forest Department which has the necessary infrastructure, manpower and experience to implement these activities. A participatory approach should be used, involving local people in the establishment and management of the forested areas.

6.6 Integrated water management

6.6.1 Project formulation and planning

In the case of major interventions such as cross dams and empoldering, the participation of the local population and local organisations is a pre-requisite. In project planning, the following steps are distinguished; a) needs assessment, b) preliminary design, c) impact assessment and d) (pre-) feasibility study and e) detailed design.

Empoldering of new land will create possibilities to manipulate water levels and water salinity inside the flood protected area. To assure that the infrastructure fulfils the needs expressed and to assure sustainability and proper use of the infrastructure, participation of the local population and organisations is required. SRP developed in 1997-1998 a methodology named Rapid Water Management Appraisal (RWMA).

The MES team has carried out needs assessment during the study. Preliminary designs have been made along with a preliminary impact assessment and its feasibility has been studied. During the next stage, the feasibility study, it is therefore recommended to undertake consultation and a RWMA before final and detailed design studies are carried out.

During the planning process for cross dams and polders, the following representatives and organisations must be consulted:

- Thana Development Co-ordination Committee (TDCC) of Sandwip thana.
Possible conflicts with existing land and water use plans and practices, potential inter-agency conflicts and co-ordination will be discussed in this committee. The TDCC and the DDCC of Chittagong should be kept informed about the progress of the feasibility study.
- A Project Committee (PC) (to be established)
It is recommended to establish a PC to assist further studies. The PC will comprise representatives locally elected persons such as the Union Parishad members and Chairmen, who represent the interest of all stakeholders. The PC should ensure that all stakeholders are heard and their views incorporated in the final needs assessments and RWMA. The PC will decide for or against ("Go or No Go") a final plan for the construction of empolderment. This PC will continue to function during project implementation and will form the Water Management Committee.
- Stakeholders.
After the identification of stakeholders, consultation of stakeholders can take place at Parishad or Gram level. The main function is to hear the opinion of the various stakeholders such as farmers, fishermen, boat owners, traders, town dwellers etc. about their needs and comments on proposed interventions.

6.6.2 Participation in water management

For effective planning, management, operation and maintenance of water management infrastructure, it is necessary that all affected parties, including stakeholders, central and local government organisations, NGOs and others be involved. A description of institutional arrangements for the involvement of these groups in the management and O&M of polders is given in Appendix II.

P3.7 IMPACT OF THE PROJECT

7.1 Physical infrastructure

The major impacts of the project will result directly from the physical infrastructure to be constructed or rehabilitated. The cross dams will result in the accretion of new land which can be used for forestry, agriculture and grazing.

The proposed embankments will increase the security of the population living in the area and will lead to improved conditions for agriculture and the raising of livestock as well as other possible economic activities.

Although designed eventually to carry roads, there will be no hard surface roads constructed on the embankments by the project. Nevertheless, access along the embankments will contribute to productive activities by facilitating access to local markets and boat ghats. Access to education, health and other government services will also be facilitated and people will be able to move more easily to safety when there are cyclones.

7.2 Social infrastructure

If surplus land is available within the embankments after landless households already living in the area have been allocated land, the project will construct cluster settlements for households from outside the project area.

The project would be no other direct impact on social infrastructure, except that by facilitating the development of a basic road network the project will also facilitate access to social services for all households living in the area.

7.4 Water management

The expected impact of the interventions and development activities implemented under water management is improved and more sustainable physical safety by applying the prevailing design standards for primary and secondary protection of polder areas.

A second impact is the reduction of drainage congestion. This will create the conditions required for further improvement of crop production, such as the introduction of HYV Aman, the introduction of a second, Aus, rice crop and the expansion of Rabi crops.

Proper operation of drainage sluices and improved protection against re-salinisation by intrusion of saline floods will allow, although slowly, a further reduction of soil salinity levels in the polder.

A third impact is an increased accessibility of the polder area. Compartment bunds and embankments form flood free roads and main and secondary drains, provided with low cost bridges (steel structure) will form a reliable and cheap opportunity for transport of farm inputs and produce.

7.5 Agriculture

Implementation of the project will lead to an increase in the land available for agriculture by promoting accretion and protecting existing land from flooding and saline intrusion.

The land available for agriculture in the project area is estimated at 70 - 80 per cent of the gross non-forested land above about +4.0 m PWD. The proportion not included covers homestead areas, khals, drainage canals and other non-cultivated areas. With the project, existing forest areas inside new polders will be cleared for agriculture and some newly accreted land also becomes available.

Crops yields in the project area are low because of the saline conditions and low nitrogen levels. With improved conditions as a result of project implementation, yields will rise slowly, partly as a result of changes to non-salt tolerant varieties and partly as a result of more secure conditions.

Cropping intensities will also increase gradually from the present average of about 120 per cent. For areas inside future embankments, cropping intensity would rise slowly to perhaps 160 - 170 per cent and for areas outside embankments perhaps to 130 per cent over the coming 15 to 20 years.

For newly accreted areas, both yields and cropping intensities will initially be at much lower levels than those currently achieved for existing land. Yields may start at only about 50 per cent of present levels and the initial cropping intensity would be less than 100 per cent. Rabi crops (usually just keshari to begin with) are started on a small scale a few years after rice. The transition from present conditions or initial conditions on new land to those expected with implementation of the project would be long and slow and could take as long as 15 or 20 years.

7.6 Livestock

The development of new polders would cause the loss of some grazing areas to agriculture, but this would be compensated by increased crop residues and newly accreted land. With new areas available for grazing and fodder production and greater security from flooding and cyclones, livestock populations would probably increase, but constrained by the carrying capacity of the available grazing land.

Any increase in the number of households on the chars would be associated with an increase in livestock numbers.

The proposed Livestock Improvement Programme, although it would directly affect only a minority of livestock owners, would have an impact on livestock production in the area generally, gradually improving production methods and raising productivity.

Changes in livestock productivity will be reflected in declining mortality rates, increasing average size of animals due to more and better fodder and better animal health and increased output of milk and eggs. These changes would occur relatively slowly but ultimately have a significant impact on total production.

7.7 Fisheries

Implementation of a programme to improve aquaculture would lead to an increase in the area of fish ponds and to significant improvements in productivity.

Fish ponds could occupy between 2 and 3 per cent of the gross agricultural land area, with most being in the protected areas within the embankments. A high proportion of these ponds will be in borrow pits created by the construction of new embankments.

At present, there is almost no shrimp cultivated in the project area. This will change in the future and it is assumed that one third of new ponds will be devoted to shrimp.

The fisheries development programme would aim to increase productivity of fish ponds, with the average annual yield in properly managed cultured fish ponds rising to 2,000 kg/ha from the average of about 800 kg/ha under present operating systems. Yields for shrimp ponds could reach about 400 kg/ha provided the white spot disease problem is solved and with improved technology and management.

7.8 Forestry

Afforestation of the newly accreted land will have positive environmental impact because mangroves help promote accretion and stabilisation of the land, improve the organic matter content of the soils and can play an important role in protecting the population from storms and tidal surges. Forests will also supply valuable biomass for fodder and fuel as well as construction materials. Especially if operated on a community participation basis, forestry will create employment opportunities for local people.

P3.8 ENVIRONMENTAL ASPECTS

8.1 Aims and objectives of the environmental assessment

The Urir Char and Char Pir Baksh Development Project is one of the three selected projects of the Meghna Estuary Study to be taken to pre-feasibility study. The aim of the environmental assessment component of the Study is to ensure environmentally sound project planning and implementation takes place. The primary aim of the intervention is to speed up the natural accretion process that will happen even without human intervention, working with natural trends rather than against them. The delineated project area is given in Figure P3-1.1.

8.2 Proposed interventions

The nature of the proposed intervention has been outlined in chapters 5 and 6 above. Environmental considerations have also been incorporated into project design to minimise possible negative impacts and reduce the need for specific mitigation programmes.

8.3 Baseline environmental conditions and future trends

To a limited extent baseline data collection for both the natural and human environment has been carried out for the area. The data allow identification of the existing environmental constraints and also likely future trends so that an appropriate set of interventions can be drawn up for the area, as well as for assessing impacts in with and without intervention conditions. This baseline data provides the framework for identifying likely impacts due to the proposed intervention, assess their importance and then set up data collection programmes to allow quantification, valuation and also monitoring of Important Environmental Components (IEC's) and variables.

The main processes that have been identified are erosion and accretion patterns, with the primary risks and constraints being cyclones (causing loss of life and disruption), saline water intrusion and soil salinity. The principal environmental conditions and constraints to economic development in the area have been identified and include the following issues:

- erosion is very complex and needs modelling
- big tidal range, intervention may be larger
- cross dams induced impact and constraints (erosion, accretion and tidal range)
- a high risk area for cyclones
- land grabbing
- the nature of the system for allocating land rights and managing land use on accreted land
- the present pattern of surface water quality, and particularly soil salinity, caused by saline inflow and how this changes as land accretes
- ground water quality and availability for drinking water
- low agricultural yields and poor marketing systems for agricultural production and fisheries
- crop losses due to pest attack
- large areas of unembanked land which support a significant number of grazing animals; grazing is therefore a significant issue - forest vs. uri grass land
- over-exploitation of the in-shore fisheries which are at an unsustainably high level
- poor health care provision, lack of sanitation facilities and limited schooling availability

8.4 Impact identification, quantification and valuation

A comparative assessment would allow the significant impacts of the proposed intervention, (both positive and negative) to be identified. In addition, the comparison to a without project situation would allow the impacts of the project to be separated from future trends. The need for mitigation could also be identified and the effectiveness of mitigation could be assessed. Of concern are those residual impacts which are negative, i.e. those impacts for which mitigation is either impossible or unable to prevent the post project situation being worse off than that before it caused as a result of the intervention.

The primary conclusions regarding positive and negative impacts are given below. The direction of the impact is viewed from the perspective of long term sustainable human use of resources and where significant and possible these have been quantified.

8.4.1 Identified positive impacts

Land accretion

The construction of the cross dam will ensure that land accretion is accelerated. However before the implementation of the project accretion will continue at a natural pace. Meanwhile implementation of cross dams under a Food For Work programme would also accelerate accretion. A programme for implementation of the remaining cross dam will be prepared when the development of the Urir Char and Char Pir Baksh area is taken up. Based on this implementation schedule, prediction with regard to accretion in the without and with project cases will be prepared.

Embanking of land for agricultural use and human settlement

The additional accreted land will allow embankments to be constructed earlier and to enclose a larger area of land. In turn this new land allows those households then resident in the area, who have no agricultural land to be allocated a cultivable plot.

Reduction in cyclone damage

The effects of cyclone surges will be reduced in the new embankment locations as the waves are dissipated by the proposed 1 km wide forest belt and also by the seaward side run-up slope. Analysis carried out by the CPP project indicated that such planting can dissipate 2 metres of wave energy in a 1991 type cyclone.

Reduction in surface water salinity

Surface water salinity inside the rehabilitated and new embankments will be reduced, as the embankments and appropriate operation of the drainage system will prevent sea water intrusion.

Reduction in soil salinity

Soil salinity inside the rehabilitated and new embankments will be reduced, as there will be less saline intrusion and the drainage system should allow flushing of the soils with monsoon rainfall. However capillary rise is still likely to remain a significant problem for many years.

Improvement in terrestrial bio-diversity

The use of the new embankments for settlements and social forestry is likely to improve bio-diversity of terrestrial flora and fauna. The area of forest outside the embankments will have benefits for terrestrial ecology.

Increase in agricultural production

Increased agricultural production is likely to occur as a result of accreted land being embanked and cropped more intensively. In addition some land which will be forested and lies more than one kilometre from the sea could be cleared for seasonal agricultural use and grazing, after it has been raised to +4.0 m PWD. It is also proposed to try and introduce an integrated pest management programme in an attempt to address the serious problem of losses from pest crop attack.

Increase in homestead production

Security from flooding may produce a significant increase in homestead crop and poultry production at the household level. Socio-economic monitoring at household level would be required to quantify and value this benefit.

Increase in livestock production

The accreted land available outside the new embankments and either not forested or cleared of forest after 16 years would allow additional livestock to be reared. In addition the proposed livestock extension programme would increase the quality of the livestock.

Increased forestry area

The area of forest under a sustainable management system could be increased substantially in the with project case, compared to the without project case, assuming the Forest Department were to continue planting all newly accreted land.

Increased aquaculture production

As part of the targeted aquaculture programme using the borrow pits from embankment construction and also bringing the presently under-used ponds into full production, the area of ponds could be increased substantially by year 30. There would also be a targeted shrimp aquaculture programme.

Improved access

As a direct result of cross dam and embankment construction there would be significantly better road access within the project area. This would allow better marketing with secondary benefits to agricultural production and fisheries. The benefits could be significant.

8.4.2 Identified negative impacts

Changes in in-shore marine habitats

There are likely to be minor changes in the extent and location of in-shore marine habitats in the area, some of which are likely to happen despite the intervention. From the sedimentation analysis is also apparent that similar new habitats will appear away from the cross dams. The crucial question is if the fauna (including fish) using the present tidal mudflats will move to the new locations as replacement habitats.

Fisheries

The predicted trend is that fisheries in the area are now likely to decline in the future, irrespective of the project, due to over-fishing. It is not possible to quantify this trend without a significant data collection programme, which is considered an urgent priority. The proposed cross dam is likely to cause a very limited change in fish habitat but this cannot be quantified without a baseline catch assessment and monitoring. In addition there may be some temporary disruption to fishing operations by the closure of channels between islands.

Human nutrition

The declining fish resources, a trend which will happen irrespective of the project, when combined with increasing human populations and a possible change in fish marketing patterns, may result in a reduction in human protein intake. Improved access to the area could cause more fish to be sold rather than directly consumed. It is not possible to quantify this impact and there could be complex two-way trends with some households improving their nutrition and others suffering a reduction. A monitoring programme for human nutrition will be required to identify and quantify any change.

Navigation

The closing of the channels between islands will obviously prevent waterborne navigation through them and may also require some ghats to be relocated. Negotiations would have to take place to arrange a suitable re-location site for any ghat that requires moving. The new sites must be seen to be an acceptable replacement.

Changes in access

Whilst the improved internal access that is likely to result from the construction of a road on top of the cross dams and connecting embankments will be considered a benefit, there are also likely to be some simultaneous negative impacts. These include additional induced in-migration which would put more pressure on existing resources and facilities. There may also be a risk of more social conflict as a result. Careful management, including fair and transparent procedures for new land allocation are critical in handling such conditions.

Direct construction impacts

There are likely to be few problems with land acquisition, compensation and involuntary resettlement. There may be direct construction issues which if well managed can be overcome and increase potential benefits, particularly employment opportunities. There are also likely to be issues linked to the collection and handling of construction materials.

8.4.3 External impacts and constraints

There are no obvious upstream impacts created by the proposed intervention, however any future development in the area, particularly the implementation of the Sandwip cross dam, would need to bear in mind possible induced impacts on the project area. Cumulative impact analysis would be needed if all MES planning units and programmes are actually constructed.

As discussed above the results of the morphological studies indicate that along the south-west and south-east coast lines erosion will continue. This retreat of the coast line has to be taken into account in planning and design of the proposed interventions.

The outputs of the sedimentation analysis indicated that in the with project situation, accretion of tidal mudflats is likely to occur to the north of Urir Char and Char Pir Baksh. Whilst this may provide replacement in-shore marine habitats, the ability of species to quickly colonise these areas is unknown, although the past morphological development of the area has followed these trends, if at a slower rate.

8.5 Environmental mitigation

Due to the fact that the interventions will have been carefully designed there is little need for specific targeted mitigation programmes. These are indicated below.

8.5.1 Ghat relocation

It may be necessary to relocate any ghats at present found adjacent to channels that would become accreted. Relocation could be done with negotiation with the affected parties to come to an acceptable alternative location. Consideration could be given to establishing a boat centres at new sites based upon the ideas recommended by BIWTA.

8.5.2 In-shore marine habitats

It is expected that replacement in-shore marine habitats will be naturally formed, but monitoring of this will be required and in particular the extent to which dolphins, fish and wading birds are able to relocate to these areas. The degree to which this natural habitat replacement mitigates the negative impacts of the intervention will need to be monitored, along with investigations to identify the locations of fish spawning and breeding sites, specifically to discover if these are on tidal mudflats or in the deeper inter-island channels.

8.5.3 Fisheries

Irrespective of the project there is a need for fisheries management programme aimed at keeping fish catch levels within sustainable limits to prevent serious future decline. A detailed baseline catch assessment is needed plus studies into fish ecology to fully understand the present situation, followed by a monitoring programme to see the effects of sedimentation on fish habitat change and how this effects fisheries production. Once this is done then the need for and nature of a specific mitigation programme for in-shore fisheries can be decided.

8.5.4 Direct construction impacts

An environmental management component for construction operations will need to be set in place so that potential problems can be identified in advance and steps taken to avoid or minimise negative impacts.

8.6 Residual impacts

The possible positive residual impacts far outweigh the negative. However, there are some negative impacts which are unlikely to be fully mitigated for:

- reduction in in-shore marine fisheries with implications for common good fishing and professional fishing household livelihoods
- human nutrition implications of the change in fish availability are uncertain at present but the negative impacts on nutrition from changes in fish consumption patterns could outweigh the benefits from greater agricultural production.

8.7 Environmental risk

The following basic assumptions have been made when assessing the proposed intervention:

- the procedures for land allocation will be improved to ensure that they are systematic, fair, equitable and timely. If this is not done then full potential benefits of the intervention are unlikely to be attained. The experience of the CDSP with this problem should be borne in mind.
- the proposed drainage systems will be fully effective in preventing saline intrusion and monsoon rainfall flooding.

It is assumed that if the project goes ahead then it will be in the fully integrated form as proposed. However if a more limited intervention of just cross dam construction were to be implemented then specific mitigation measures (presently incorporated in the many components of the integrated programme), may need to be implemented.

Evidence from the 1991 cyclone indicates that the overall risk of cyclone damage will be reduced by forest and suitably designed embankments dissipating waves. In addition, there would also be a reduction in loss of human lives and livestock, although this would be greatly enhanced by construction of suitable cyclone shelters and killas.

8.8 Environmental monitoring and management

Assuming that the project goes ahead then the following items will need to be monitored:

- accretion and erosion patterns using time series satellite imagery; such work will indicate the effectiveness of the intervention and also any induced impacts on in-shore marine habitats and navigation
- in-shore fish catch assessment, a study of fish ecology (specifically on spawning and breeding grounds) and assessment of stocks, as well as monitoring of the impacts of changed accretion patterns on fish habitats and stocks
- incidence of malaria, waterborne disease and cholera
- human nutrition levels in relation to fish consumption
- household socio-economics related to predicted project benefits
- external issues, particularly induced accretion and any proposed developments near the project area.

The main mitigation step would be relocation of any ghats. Other mitigation measures may be necessary depending upon the results of monitoring programmes.

The implementation of the monitoring programmes could be carried out by the locally based project management unit. Alternatively the Environmental Cell that is presently being established at WARPO, as part of the National Water Management Plan, could take responsibility for the work within the framework of the proposed coastal area management unit at WARPO.

The Department of Fisheries already have plans to carry out a major fish resource assessment for the area, which with appropriate institutional liaison could carry out the required fisheries monitoring for the proposed intervention.

8.9 Conclusions of the environmental assessment

Under the Department of the Environment environmental classification the proposed intervention would appear to be in the highest Class D (Red) under Section 66 (flood control embankment, polder, dike etc.). Before the project can go ahead the DoE will need to review and approve the EIA and grant a Site Clearance Certificate. Before a full Environmental Clearance Certificate can be granted a No Objection Certificate will be required from the Local Authority. As there is little experience in the implementation of these procedures so far, it is considered unwise to embark upon this process until agreed arrangements are in place for the funding of the project.

Under World Bank Operational Directive 4.01 the proposed intervention would probably be classified as Class A (the highest), although it could possibly be down graded to Class B, as the extent of the effected area is relatively small by international standards.

The fundamental problem with the proposed intervention is that whilst the cross dams significantly speed up land accretion, the predicted positive economic impacts of utilising such land are long term (between 15 and 30 years) and the construction costs are relatively high per beneficiary household. A case could be made on social benefit grounds for going ahead with the project, but this would need to be considered against other development priorities in the country.

8.10 Future environmental work programme

TOR for full feasibility study, detailed baseline and needs assessment are required before any detailed design. In addition a suitable, locally based inter-disciplinary and decentralised institutional structure will need to be established for detailed project planning and implementation. The procedures for allocation of new land through the Ministry of Land will also need to be streamlined to be operational in a transparent, fair, equitable and timely manner at local level.

The monitoring programmes established under the project need to be continued:

- monitoring of erosion and accretion from satellite imagery
- water and soil salinity monitoring at least two times a year and preferably four times.
- studies of in-shore marine habitats, fish ecology (particularly the fish spawning and breeding grounds), along with a baseline survey of fisheries catch and a stock assessment.
- monitoring of the incidence of waterborne disease in the area.

P3-9 PRELIMINARY ECONOMIC ASSESSMENT

A brief preliminary economic assessment of the proposed project has been made. This assessment, which is based on the same assumptions and parameters used for the economic analysis for the feasibility studies for Nijhum Dwip and Char Montaz - Kukri Mukri², is broadly indicative only. In particular, costs have been estimated based only on preliminary designs and benefits have been estimated on the assumption that conditions (yields, cropping intensities, etc.) are the same as in the other locations, without out adjustment for any specific conditions in the Urir Char - Char Pri Baksh area. This assessment includes the following costs and benefits:

- the costs of cross dams, which are build by LGED in this case, have been treated as sunk costs
- empoldering and water management facilities (Table P3-5.7)
- costs of aquacultural and livestock programmes at the same annual cost as for Char

² See volumes 3 & 4 of this Report, respectively.

Montaz - Kukri Mukri Integrated Development Project

- agricultural, aquacultural and livestock benefits for the empoldered areas.

9.1 Project costs

The costs of engineering interventions are taken from chapter 5. The cross dams will have been built before the start of the project. Polders are assumed to be constructed in years 1 and 2.

Project costs are summarised in Table 9.1. Contingencies are included at 10 per cent of base costs and project management costs of BWDB are included at 10 per cent of civil works base costs.

No costs are included for new settlements it is not possible to estimate the requirement for this component at this stage.

Table P3-9.1: Summary of project costs (financial prices)

Unit: Tk '000

Component	Project Year					Total
	1	2	3	4	5	
Cross dams						
Embankments	59,935	80,825				140,760
Water management	26,400	34,040				60,440
Drainage channels	3,128	3,879				7,007
Sub-total civil works (A)	89,463	118,744	0	0	0	208,207
Livestock development	900	900	900	900	900	4,500
Livestock line of credit	350	350	350	350	350	1,750
Aquaculture development	1,250	1,250	1,250	1,250	1,250	6,250
Sub-total development (B)	2,500	2,500	2,500	2,500	2,500	12,500
Project management (10% A)	8,946	11,874	0	0	0	20,820
Contingencies (10% A + B)	9,196	12,124	250	250	250	22,070
TOTAL COSTS	110,105	145,242	2,750	2,750	2,750	263,597

9.2 Project benefits

Project benefits are estimated on the same basis as they have been calculated in the feasibility studies for Nijhum Dwip and Char Montaz - Kukri Mukri. There studies may be referred to for a detailed discussion of the assumptions and approach used.

Non-quantified benefits will be similar to those at these other sites.

9.3 Preliminary economic analysis

The EIRR is estimated to be about 16 per cent - relatively high because no cross dam costs are included. No sensitivity of this result has been carried out. Because the estimate is based closely on the analysis for the feasibility studies, the sensitivity of the result will be broadly similar to those cases.

This analysis indicated that there are good prospects that a useful and viable project can be designed for implementation in the Urir Char - Char Pir Baksh area. This should be further investigated, in greater detail, during a feasibility study.

289

Appendix I



DESIGN CRITERIA AND BASIC COST DATA FOR URIR CHAR AND CHAR PIR BAKSH

1. Land Level for Empoldering

After a many years of accretion most of the old char land will have reached a land level which is near to the mean higher high water level (MHHWL). In cases where accretion is stimulated, for example by a cross dam, a land level near to MHHWL may be reached after 5 years. Land levels are still inundated approximately 10 per cent of the time. Older char land that has reached MHHWL is characterised by a more or less flat surface.

The minimum land level considered for empoldering is important from a drainage point of view. The lower the land, the more problematic drainage by gravity will be. Technically land levels below MHHWL can be empoldered too, but with land levels equal to or above MHHWL it is expected that flood protection is still economically feasible. In other words, the height of the embankment, the sluice capacity to be installed and the modifications required to improve the natural drainage network of creeks, as defined in detailed design studies, are expected to be affordable in economic terms. The final decision for empolderment is an economical rather than a technical decision.

MHHWL varies from place to place in the estuary and is influenced by seasonal effects, overall wind and sea current directions, location of land bodies and differences in gravity. Hence, there is no absolute PWD land level for empoldering, which is valid for the entire estuary. The level for empoldering is always linked to the local MHWL. In case of char Urir Char and Char Pir Baksh the land level of +3.8 m PWD is approximately MHHWL and is considered a minimum level for empoldering for this study.

2. Flood Protection Embankments

Primary (Sea) Embankments

Height

Only agricultural damage is most likely and it is assumed that sufficient facilities are available for the local population in case of cyclone storm surge, such as an early warning system, cyclone shelters and killas for livestock. In line with CPP-II (FAP-7) and SRP (EC) a 1:20 years flood frequency is considered the design height of embankments, increased with a freeboard of 1.22 m in case of a sea-facing embankment. In case the embankment is located along a minor tidal khal, a freeboard of 0.91 m is considered sufficient.

Side Slopes

Unless stability considerations indicate otherwise, a side slope of 1:2 is adopted for the countryside and 1:7 for the seaside. In case the embankment does not face the sea, but a minor khal, a slope of 1:3 has been selected.

Crest Width

In case of sea facing embankments, inspection roads (also used during emergency repairs) are considered a necessity. A minimum crest width of 4.25 m is therefore maintained. This width is also sufficient to use primary embankments as fair weather R-2 rural roads, which require a crest width of 3.6 m only.

The crest width of the embankment will be increased to 4.90 m in case a paved R-1 rural road is planned on a primary embankment.

Physical features of primary embankments

Type	Crest Level ³ (m PWD)	Freeboard (m)	Crest Width (m)	Slope R/S	Slope C/S
Primary embankment, sea-facing	7.88	1.22	4.25	1:7	1:2
Primary embankment, interior	7.57	0.91	4.25	1:3	1:2
Primary embankment, interior cum paved R-1 road	7.57	0.91	4.90	1:3	1:2

Based on the above criteria and the BWDB standard schedule of rates the costs of embankments have been calculated.

Estimated costs per kilometre of embankment

Type	Volume (m ³)	Rate ⁴ (Tk/m ³)	Construction Costs/km (Tk '000)	Land Acquisition ⁵ Cost (Tk'000)	Turfing Cost ² (Tk'000)	Total Costs (Tk '000)
Primary embankment, sea-facing new construction	93,000	30.9	2,874	593	321	3,788
Primary embankment, interior	42,600	30.9	1,316	217	156	1,689
Primary embankment cum R-1 road	55,860	30.9	1,726	285	196	2,207

3. Drainage

Final detailed drainage design studies can be carried out when accretion has been completed. For the purpose of this study, historical data have been used to define the required sluice capacity with a so called drainage ratio. The drainage ratio is defined as the inverse of the available drainage sluice cross section for a given catchment area, expressed in ha/m².

Drainage ratio of existing polders

Polder	Name	Total Catchment Area (ha)	Total Sluice Cross Section (m ²)	Average Drainage Ratio (ha/m ²)
55/1	Galachipa	10,900	85.3	129
55/3	Char Biswas-Kajal	9,850	61.2	161
58/1	Manpura Hazirhat	3050	18.0	170
58/2	Shakuchia-Manpura	3250	25.0	130
72	Sandwip	18,700	87.3	214
73/2	South Hatia	12,300	73.2	168
Average				162

In comparing existing and recently rehabilitated polders in the study area, it was found that the average drainage ratio is 162 ha/m². Seen the problematic drainage situation in a number of these polders, and for purpose of planning in this study only, the design drainage ratio is set on a slightly higher side, around at 155 ha/m².

³ Based on present design of primary embankments for Char Montaz.

⁴ Standard Schedule of Rates, 1995, prices converted to 1998 prices.

⁵ A land cost of 114,000 Tk/ha is assumed for this region.

Drainage Sluice

Like in most polders, the standard BWDB box-culvert drainage sluice has been selected with a cross section of 2.78 m² (1.52 m x 1.83 m) per vent. In most cases such drainage sluices comprise one to five vents.

Surface Sluice

The purpose of a surface sluice is to solve local drainage congestion along the flood protection embankment. Land near the coast line of chars may be slightly lower and at the same time a number of minor creeks are blocked by the primary embankment. Therefore a provision of 3 minor drainage sluices per 10 km primary embankment has been made⁶ with a pipe diameter of 1.22 m. On both sides of the sluice a flap gate will be provided. This sluice may also be used to flush water in the polder if required. Where required, a minor drain will be constructed along the primary embankment, on the country side, separated by a berm of 2 m.

The cost of a standard drainage sluice varies from Tk 4.5 million⁷ to Tk 8.3 million⁸. A need for pile foundations can increase the cost of a sluice considerably, but also the requirement of improved flap gates and vertical lift gates, which last longer and have a better performance. For this study an average provision has been taken for pile foundation

Costs of drainage and surface sluices

Type of Sluice	LS Costs (Tk)
Surface Sluice Diameter 1.22 m provided with two flap gates (c/s and r/s). 1 vent	772,000
Box Culvert Sluice Dimensions 1.52x1.83m provided with vertical lift gate (c/s) and improved flap gate (r/s). 1 vent 2 vent 3 vent	3,000,000 6,000,000 9,000,000

Drainage Channels

Starting point is the natural creek system formed during accretion. It is expected that primary drains can be selected at an interval of 2 to 3 km and secondary drains with spacing between 1 and 2 km, resulting in average secondary drainage areas of 30 to 40 ha. Additional tertiary drains may be selected or constructed to drain isolated low pockets.

The existing drains are considered sufficient to meet the drainage requirements. Nevertheless, several rehabilitation design studies show costs to improve the drainage network, varying from 85 to 643 Tk/ha catchment area⁹. These costs cover in most cases the re-excitation of a few primary drain sections in a rehabilitated polder. In the case of new polders these cost may be much higher (SRP-EC). The current practice of BWDB is not to modify the existing drainage network.

For this study, a provision of re-excitation of 30 per cent of primary drains and a lump sum for the excavation of connecting drains (between primary drains and primary drains and sluices) have been taken, based on an average density of drains and historical re-excitation costs. In the case of existing polder land, no provision for connecting drains has been made. Re-

⁶ Average found in rehabilitated Polder 55/1

⁷ BWDB, 1998, Patuakhali O&M Division.

⁸ CDSP, 1996, Char Bhatir Tek.

⁹ SRP-EC, 1992-4, polder 73/1AB, 58/3, 73/2 and 35/1.

excavation of primary drains is expected to maintain a depth of around 2 m, recommended for the stimulation of deep drainage, which plays a major role in the desalinisation of the subsoil.

Costs for improvement of drains per 1,000 ha.

Description	Length (km)	Volume ¹⁰ (m ³)	Rate ¹¹ (Tk/m ³)	Cost (Tk '000)
Re-excavation primary drains (30%)	2.4	26,400	21.8	576
Excavation of drains	n.a.	38,000	21.8	785
Total				1,361

4. Bridges and Culverts

It is assumed that all required bridges and culverts are in place and where new bridges and culverts are required, that these will be provided under regular development plans (ADP) of the local Government and LGED.

¹⁰ An average volume of 6000 m³ per km was found for re-excavation of primary drains in polder 73/2, SRP 1994.

¹¹ Based on 1995 Standard Schedule of Rates.

Appendix II

INTEGRATED WATER MANAGEMENT

1. Participation in water management

Effective drainage, operation and maintenance programmes require the involvement and co-operation of stakeholders and other relevant organisations. For example: What will be considered a primary or secondary drain? What will be the policy regarding fishing in main drains and near sluices? Which drainage channels should remain accessible for country boats, when should sluices be opened and closed? What are the target water levels for drains? What will be the yearly routine and periodic maintenance programme, what will be the amount for a flood protection fee (local cost recovery)? All these questions related to water management, but can not be answered by BWDB only. The involvement of stakeholders, local Government bodies like DOF, LGED, but also NGOs are required. Figure wm/bb-4 shows an institutional framework, which makes use of the already existing organisations. This set-up, which is subject to approval of new GPP, may prove to be workable and capable to deal with issues related to water management.

To involve stakeholders and to ensure representation of the interest groups, the organisation of stakeholders, such as farmers, fishermen, boat owners, traders etc. is needed. Experiences with the present GPP, which focuses more on irrigation projects, are not always successful. Recent national workshops on people's participation in water management revealed a number of shortcomings of the present GPP concerning FCD schemes like polders. A revision of the GPP is under preparation. Anticipating expected changes; it is envisaged that there should be three important parties involved in water management, BWDB, the so-called Water Management Committee and the Stakeholder's Organisation.

The role of BWDB will be mainly limited to planning and implementation of *periodic maintenance* of embankments and sluices, involving stakeholders and local Government Representatives. Further, BWDB will participate in a Thana and District level Co-ordination Committee to discuss issues related to maintenance in the context of overall land and water use.

The new Water Management Committee (WMC) comprises local politicians and advisers from Urir Char Union. The role of the WMC is mainly that of planning and decision making in operation and maintenance. Also arbitration in water management conflicts, cost recovery, formulation of an annual and seasonal water management plan for the polder and defining the function of infrastructure in the context of a land and water use plan will be handled by the WMC.

The Stakeholders will be organised in two tiers only. The bottom tier will be at compartment level, named Water Management Block (WM-Block) and a second tier at polder level, named Water Management Board (WM-Board). The members of this board are proposed by the Blocks, but are subject to approval and appointment by the WMC. The members of the WM-Board are the chief executives of O&M and must receive remuneration and a (modest) office facility from the Local Government (UC).

WMC, BWDB, WM-Blocks and the local WM-Board will meet at least twice, seasonally (pre-monsoon) and annually (post-monsoon). O&M plans and budgets will be prepared and finalised by WMC and BWDB with participation of the stakeholders. Implementation is done by the BWDB and local WM-Board.

It is expected that the present GPP idea of a "Project Council" or "Polder Council" will be discontinued under the new GPP. The already existing TDCC is the most appropriate platform to co-ordinate the inter-linked activities of BWDB, LGED, DOF and DAE and other GOs and NGOs. In the TDCC, a water management plan will be presented by the WMC. After discussion eventual consequences of the plan will be endorsed by the TDCC of Sandwip and the organisations involved in the TDCC (All Government Organisations).

The institutional framework for water management as described above will be subject to a final version of a revised GPP, which is expected to become effective in 1999. In the absence of a revised GPP, the chances for improved water management are limited. WUCs and WUA depend too much on BWDB and have no formal power and are therefore rather inactive. Polder Councils

depend on the willingness and resources of TNOs and other GOB officials, which is very limited. The BWDB's role under the current GPP, which is regarded as the motor of people's participation in water management, is far from their traditional engineering role. The new GPP should provide the stakeholders with a formal say, through the WMC, formed and chaired by elected people's representatives. Besides, these WMC will have the means to implement a water management plan. A local budget is raised through the collection of a local water tax (collected through the Union Council) and implementation is assured by a local WM-Board with the backing of the WMC and Union Councils.

2. Management, operation and maintenance

The WMC will formulate an operation plan that describes water level targets to be met in drainage channels on a monthly basis and a set of instructions for the operation of sluices. The WM-Board will appoint a sluice operator and ensure the daily operation of sluices and monitor the water levels in the drainage channels through gauge readers.

BWDB has to build-up skills and experience in preparing a sound periodic maintenance plan. Based on an inventory of the hydraulic infrastructure and period maintenance criteria, a periodic maintenance plan can be prepared and implemented. Periodic maintenance plans are based on actual field inspections, surveys and needs expressed by the WM-Blocks and WM-Board. The periodic maintenance plan requires approval from the WMC.

Based on the operation plan and formulated targets, financial and physical indicators need to be identified and data will be collected and used to evaluate the yearly performance of the compartments. This will be a task of the WMC.

The implementation of an O&M programme requires the regular presence of a Sub-Divisional Engineer of BWDB based at Sandwip, trained in periodic maintenance planning, budgeting, implementation and monitoring.

3. Water management and O&M budget

One of the conditions for successful implementation is the availability of sufficient periodic maintenance funds under the heading "works" of the revenue budget allocated to BWDB. The height of the O&M budget will depend on the maintenance standards applied but will be at least near to 1 to 2 per cent of the estimated new price of the infrastructure. BWDB will provide funds for periodic and emergency maintenance of embankments and sluices as well as their own establishment.

Stakeholders such as landowners, farmers, fishermen, house-owners, shopkeepers and traders will pay a local polder tax. Polder tax revenue should cover the budget requirement for the implementation of a routine maintenance plan for sluices and embankments, but also the routine and periodic maintenance plan for drains. It should also cover establishment costs such as the remuneration of the local WM-Board members and their employees such as sluice operators and gauge readers. The Union Council through their local tax system will be entitled to collect the polder tax.

4. Involvement of landless and destitute women

Routine maintenance should be carried out by Embankment Maintenance Groups (EMG) and Channel Maintenance Groups (CMG) consisting of destitute women and landless, eventually supported by NGOs. Funds will be provided by the Union Council.

For periodic maintenance of embankments, BWDB will employ local Labour Contracting Societies (LCS) for earth works (status of D-Class contractor). Both groups will consist of landless and destitute women and will be trained by BWDB.

There is no guarantee that with the above described institutional set-up O&M will improve. However, transparency and accountability are clearly increased. Moreover, the physical safety has now become the shared responsibility of the local population, local institutions like Union Councils, WMC and a local WM-Board, and a national institute, BWDB.

Appendix III

IDENTIFICATION OF FURTHER INVESTIGATIONS IN MORPHOLOGY

Objectives

Within the framework of MES development, the options of implementing the cross dams have been described for the prefeasibility study areas of Rangabali - Char Biswas, Hatia - Manpura and Urir Char - Pir Baksh. For each of these study areas the expected morphological changes were delineated.

With respect to the implementation of the development schemes, in the feasibility stage, the following morphological studies and investigations can be identified:

1. data collection and field surveys,
 - 1A. topography and bathymetry
 - 1B. hydraulic and morphological data
2. data processing and data analysis,
3. mathematical model investigations,
4. morphological interpretation.

Results

The outcome of the hydraulic and morphological study should be:

- a quantitative assessment of the accretion and erosion rate of the areas during and after the implementation of the cross-dam.
- an assessment of the closure method and procedures during various construction stages.
- improved knowledge and understanding of land formation and char development due to implementation of cross-dams

Task description

1. *Data collection and field surveys*

The morphological and hydraulic impact due to closure and implementation of the cross-dam requires data on:

A. *Topography and bathymetry for the whole project area*

This gives an indication of the sediment budget. All bathymetric data and levelling data should be defined with reference to PWD. New information (coastline, land use, infrastructure) derived from recent remote sensing images should be incorporated.

B. *Hydraulic and morphological data*

1. land level data along the channel and adjacent islands.
2. water level, flow velocities and discharge measurements along the channel
3. waves
4. cross-sectional profiles
5. sediment concentrations and grain sizes of suspended sediment, grain sizes of bed sediment

2. *Data processing and data analysis*

Data processing and data analysis concern:

1. laboratory analysis of sediment data
2. analysis of current velocities, water levels and bathymetry
3. calculation of the discharge and sediment transport
4. assessment of the accretion and erosion rate along the channel and adjacent islands during and after implementation of the cross-dam
5. analysis of the accretion and erosion rate using bathymetric information.

3. *Mathematical model investigations*

A 2D mathematical model investigation programme should be executed for the pre-feasibility study areas to gain insight into the hydrodynamic and morphodynamic behaviour of the tidal channels under various hydraulic conditions during and after implementation of the cross-dam. The mathematical model investigation should be carried out by the Surface Water Modelling Centre (SWMC).

4. *Morphological analysis and interpretation*

Based on the data analysis and the results of the mathematical investigations, the future morphodynamic behaviour has to be studied and the prediction for accretion and erosion in the channels and intertidal zones have to be updated and corrected where necessary.

REFERENCES

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