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MINISTRY OF WATER RESOURCES

BANGLADESH WATER DEVELOPMENT BOARD

MEGHNA ESTUARY STUDY

INTERIM MASTER PLAN

NOVEMBER 1997

DHV CONSULTANTS BV

in association with

KAMPSAX INTERNATIONAL
DANISH HYDRAULIC INSTITUTE

DEVELOPMENT DESIGN CONSULTANTS
SURFACE WATER MODELLING CENTRE
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INTERIM MASTER PLAN FOR THE MEGHNA ESTUARY

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1.0 INTRODUCTION

1.1 Background

The Meghna Estuary Study(MES) is a component of the Flood Action Plan(FAP) developed by the former Flood Plan Coordination Organization (FPCO) now merged with Water Resources Planning Organization(WARPO). WARPO is a wing of the Ministry of Water Resources, Government of Bangladesh. The FAP projects were formulated after the unprecedented floods in 1987 and 1988. The project is designated as FAP 5B.

The whole of Bangladesh has been the subject of respective FAP projects, the aim of which has been to improve standards of water management and enhance levels of protection against floods and erosion. Interventions proposed by respective projects have included: bank protection works, flood management, agriculture, fisheries, cyclone protection and institution development. Twenty six) such study projects are so far at the stage of completion.

The South East Regional Study (FAP-5) encompasses areas of Brahmanbaria, Comilla, Chandpur, Lakshmipur, Noakhali, Feni, coastal low lands of Chittagong and Cox's Bazaar. It does not, however, cover the lower Meghna river and its estuary.

The area under consideration comprises the lower Meghna estuary downstream of Chandpur, including set back lands, attached charlands and islands off the coast of Bangladesh, with the exception of the island of Bhola. (See Figure 1.1.1) The area also includes a 500 meter wide strip at either side of the estuary, from an arbitrary river bank or coast line extending from Kuakata in Kalapara Thana in the West to the northern side of the Karnafuli river in the East. The total area is approximately 11,000 sq km.

The area is characterized by high levels of hydro-dynamic activity. Erosion and accretion rates are high and the Area is periodically subject to severe storms and cyclones, these latter accompanied by tidal bores and storm surges. The sediment discharge from the Meghna river is the highest, the water discharge the third highest, of all river systems in the world. Lands are accreted as the river, its distributaries and tidal currents deposit sediment resulting from the erosion of river banks upstream and coastal islands.

Accretion can be accelerated by human interventions, such as the construction of cross-dams. Erosion and accretion are taking place concurrently with an overall annual net gain of land of around 1600 hectares between 1973 and 1996.

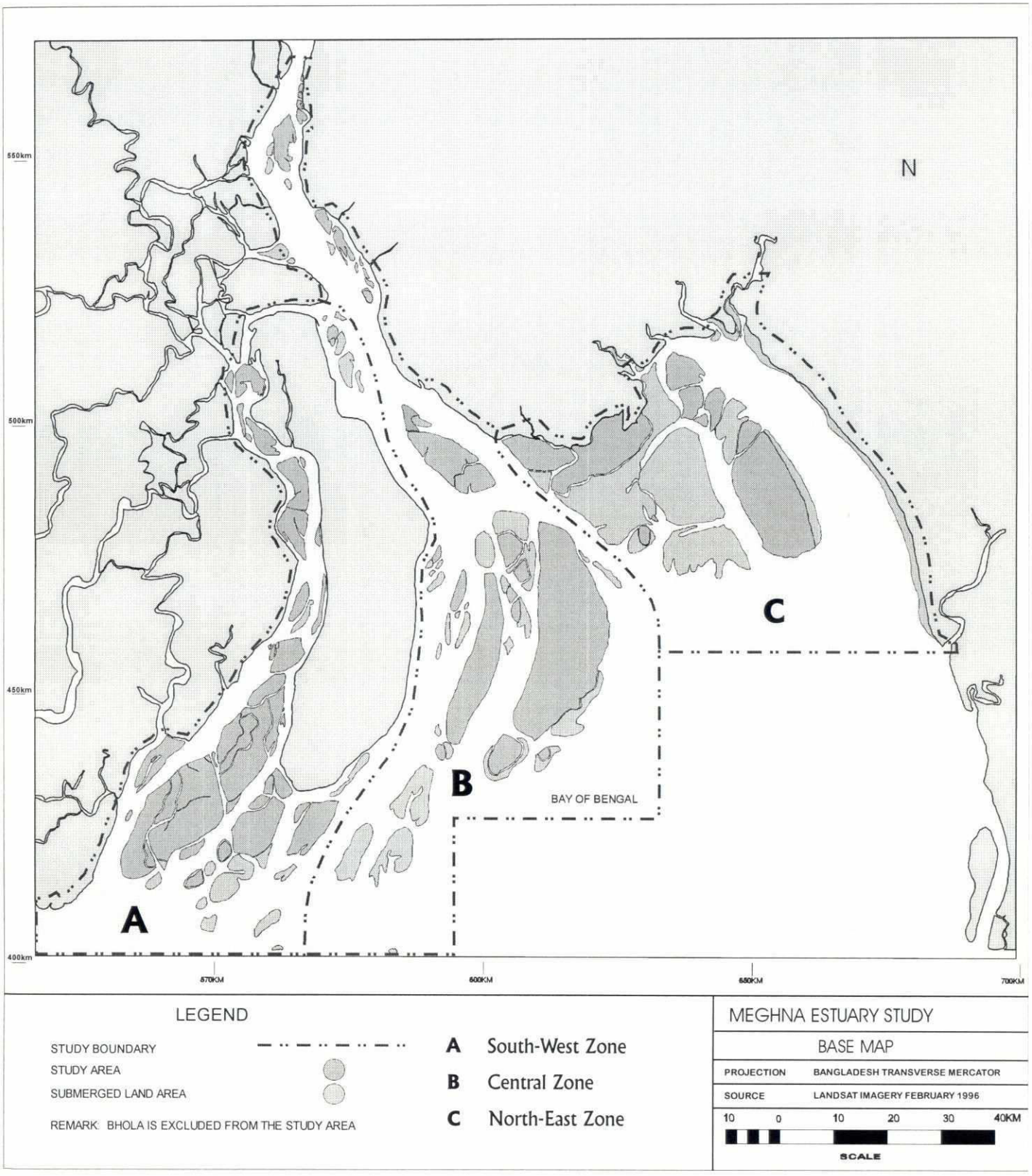
The safety of lives and properties of people living in the coastal areas and islands is of paramount concern to Government. There presently exist no planning criteria for the development of the estuarine areas within the given boundary. The Meghna Estuary Study is a special investigation in recognition of the extraordinary features of this area.

The Government of Bangladesh (GoB) objectives for the coastal and estuarine areas reflect two major concerns. Firstly, the need to provide communities living within these areas with the highest possible level of physical security against the cyclones and associated storm surges that periodically hit the area. Secondly, GoB is committed to the alleviation of poverty amongst the poorer sectors or society, a disproportionate percentage of which live on the coastal chars and lands adjacent to coastal and estuarine embankments.

1.2 Objectives of this Report

There are two principal objectives in preparing the Interim Master Plan. The first is to identify, describe and confirm a planning process which will inform and coordinate the preparation, conditions, purpose and sequence of all interventions initiated or implemented by concerned GoB authorities and agencies for the twenty five year period covered by the proposed Master Plan for the target area.

Figure 1.1.1 MES Base Map



The second objective of the Plan is to present a check list of principal issues it is anticipated must be considered when planning physical interventions/estuary development activities for the area. These activities and interventions will constitute the components of development projects.

Guidelines are provided for integrating environmental considerations into planning processes and for undertaking subsequent evaluations and assessments.

1.3 Expected Output

This Interim Master Plan provides the considerations to which people might refer when identifying development initiatives and components in the coastal and estuarine areas. It presents a brief description of the target area and a summary of GoB development policies for respective sectors. Further, it outlines a framework to guide the process of master planning for the lower Meghna river and estuary and indicates a possible development strategy.

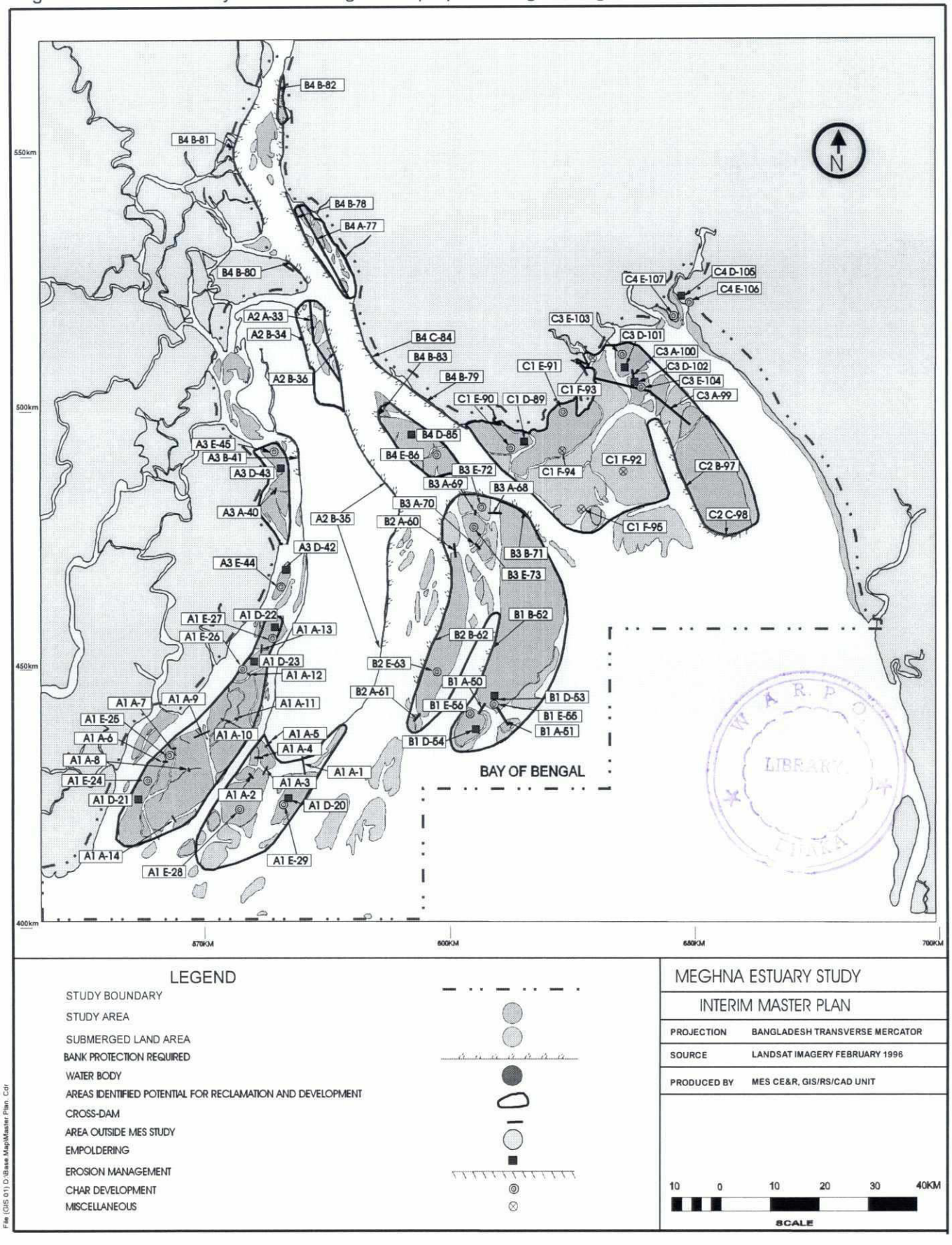
A map/blue print of the target area is attached (Figure 1.3.1) on which is marked the potential engineering interventions and brief description. An initial zoning of the Study Area and associated listing of engineering interventions is given in Table 1.3.1. These are predominantly concerned with development and accretion of charlands and islands, cross-dams linking islands and mainland, coastal and river bank protection works and stabilization of the existing/future developed situations. A list and brief description of these interventions is appended as Annex 1.

A corresponding list of associated components and physical inputs for the socio-economic development of these islands and accreted charlands is to be found in the contemporary Interim Development Plan.

INTERIM MASTER PLAN

Physical Interventions

Figure 1.3.1 MES Study Area showing site of proposed engineering interventions



Area (Area Code)	Type of Intervention (Project Code)		Potential Interventions	
			Sl. no.	Name
South Bhola A1	Cross Dam	A	1.	South Bhola - Char Kukri Mukri
			2.	Char Montaz 1
			3.	Char Montaz 2
			4.	Char Montaz 3
			5.	Char Montaz - Bhola
			6.	Rangabali 1
			7.	Rangabali 2
			8.	Rangabali 3
			9.	Rangabali - Char Biswas
			10.	Char Biswas 1
			11.	Char Biswas 2
			12.	Char Biswas 3
			13.	Char Biswas-Kachur char
			14.	Char Kashem-Rangabali
	Bank Protection	B		
	Erosion Management	C		
	Empoldering	D	20	Char Kukri Mukri
			21	Barabaishdia - Char Ganga
			22	Kachur Char
			23.	Char Biswas North Coast
	Char Development	E	24	Bara Baishdia
			25	Char Ganga
			26	Char Biswas North Coast
			27	Kachur Char
			28	Char Montaz
			29	Char Kukri Mukri
	Miscellaneous Measures	F		
Northeast Bhola A2	Cross Dam	A	33	Connecting Chars Opposite to Khorki
	Bank Protection	B	34	Khorki
			35	Chowkighata-Tazamuddin-Betua
			36	East Bank of Chars Opposite to Khorki
	Erosion Management	C		
	Empoldering	D		
	Char Development	E		
	Miscellaneous Measures	F		

Table 1.3.1 Proposed MES engineering interventions

West Bhola A3	Cross Dam	A	40	Connecting Char Yunus North and South
	Bank Protection	B	41	Gangapur in Borhanuddin Thana
	Erosion Management	C		
	Empoldering	D	42	Char Kushum
			43	Char Yunus
	Char Development	E	44	Char Kushum
			45	Char Yunus
	Miscellaneous Measures	F		

South Hatia B1	Cross Dam	A	50	Nijhum Dwip - South Hatia
			51	Damar Char - South Hatia
	Bank Protection	B	52	West Hatia Coast
	Erosion Management	C		
	Empoldering	D	53	South Hatia
			54	Nijhum Dwip
	Char Development	E	55	South Hatia
			56	Nijhum Dwip
	Miscellaneous Measures	F		

Manpura B2	Cross Dam	A	60	North Manpura to Bakshimajhir Char
			61	South Manpura to Char Nizam
	Bank Protection	B	62	West Monpura Coast
	Erosion Management	C		
	Empoldering	D		
	Char Development	E	63	Monpura
	Miscellaneous Measures	F		

North Hatia B3	Cross Dam	A	68	Moulvir Char - North Hatia
			69	Moulvir Char - Dhal Char
			70	Dhal Char - Char Parvez
	Bank Protection	B	71	North Hatia
	Erosion Management	C		
	Empoldering	D		
	Char Development	E	72	Moulvir Char
			73	Dhal Char
	Miscellaneous Measures	F		

Lower Meghna B4	Cross Dam	A	77	Connecting Chars along East Bank in Raipur-Lakshmipur
	Bank Protection	B	78	East Bank in Raipur - Lakshmipur
			79	Char Alexander
			80	Mehdiganj East Coast
			81	Hijla - Goshairhat
			82	Honar Char - Haimchar
			83	Northern Coast of Gazaria
	Erosion Management	C	84	Ramgati
	Empoldering	D	85	Char Gazaria
	Char Development	E	86	Char Gazaria
	Miscellaneous Measures	F		

South Noakhali C1	Cross Dam	A		
	Bank Protection	B		
	Erosion Management	C		
	Empoldering	D	89	Char Buoya
	Char Development	E	90	Char Buoya
			91	South of Char Clark
	Miscellaneous Measures	F	92	Tidal Mudflat Development
			93	Main Drain Outlets Noakhali Area
			94	Enhancing Accretion at the South of Char Clark
			95	Enhancing Accretion at the Northwest of Char Nurul Islam

Southwest Sandwip C2	Cross Dam	A		
	Bank Protection	B	97	West Sandwip
	Erosion Management	C	98	South Sandwip
	Empoldering	D		
	Char Development	E		
	Miscellaneous Measures	F		

North Sandwip C3	Cross Dam	A	99	Sandwip
			100	Connecting Urir Char North and South
	Bank protection	B		
	Erosion Management	C		
	Empoldering	D	101	Urir Char
			102	Char Pir Baksh
	Char Development	E	103	Urir Char
			104	Char Pir Baksh
	Miscellaneous Measures	F		

Feni River C4	Cross Dam	A		
	Bank Protection	B		
	Erosion Management	C		
	Empoldering	D	105	Muhuri Accretion
	Char Development	E	106	Muhuri Accretion
			107	Little Feni Accretion
	Miscellaneous Measures	F		

2.0 DESCRIPTION OF THE STUDY AREA

2.1 Natural Environment

Land Resources

The land area comprises the main islands of Sandwip, Hatia, Manpura, Kukri Mukri, Char Montaz, Char Biswas and Char Rangabali; the shallows and tidal mudflats along the coast of Noakhali and, finally, the many small islands lying within the indicated boundaries of the project area. Notably excluded are Bhola island and the landside areas of the Noakhali mainland.

As noted, above, the area is characterized by high levels of hydro-dynamic activity. Erosion and accretion rates are high and the area is periodically subject to severe storms and cyclones, these latter accompanied by tidal bores and storm surges. The safety of lives and properties of people living in the coastal areas and islands is of permanent concern to Government.

Soil, Plant Nutrients and Salinity

Most of the Meghna estuary study area is part of 'Young Meghna Estuarine Floodplain', according to FAO physiographic units. It consists of charlands of young and old ages. The following description of the soils, the content and salinity is based on FAO (1988) and Brammer, H. (1996).

The dominant soil textural classes that occur in the project area are silt loam and clay loam. New deposits and erosion are constantly taking place on the land margins, continuously altering the shape of the land areas. The sediments are deep silts which are finely stratified and slightly calcareous.

The soils in the coastal charland are calcareous alluvium. They are generally poor in organic matter content; most of them range from less than 1% to 1.5%. The low organic content indicates low fertility and a heavy and difficult soil. The pH values of the soil range from 6.0 - 8.4, mainly moderately alkaline, the pH values of the surface soil being lower than those of the subsoil.

In general total amount of nitrogen (N) is low in all soils of the estuary, around 0.1%, the available phosphor (P) is medium, most of the soils range from 15 to 25 ppm, and the level of potassium (K) is 1 to 5 ppm. Deficiencies of the micro-nutrients zinc and copper are widespread in the coastal region. Zn deficiency is much lower in the districts of saline belt like Noakhali. Boron toxicity sometimes occurs in coastal saline soils because of high B content in the intruding sea - water.

Some land near the coast is tidally flooded with salt water for part or all of the year. However, coastal embankments now protect many areas that were formerly regularly flooded with salt water. Flooding with salt water generally has had a limited effect on soil properties because most of the salt left in the soil is washed out by heavy rainfall or flooding with fresh river water in the monsoon season.

Soil salinity levels in most coastal regions fluctuate seasonally though are rarely high, that is, remaining below 8dS m(-1). High saturation of the exchange complex with sodium is harmful because this may destroy physical properties of the soil and offset plant nutrition. However sodium rarely exceeds 10-15 percent of the total exchangeable bases in any soil layer.

The Young Meghna Estuarine Floodplain soils are characteristically slightly or very slightly saline, that is, between 1 and 8dS m(-1). In many places, however, the soil surface becomes increasingly saline in the dry season.

Increased levels of soil salinity generally results from capillary movement of moisture to the surface from saline groundwater, which is present even in areas protected by embankments. Evaporation of this moisture concentrates salt on the surface. Heavy pre-monsoon and monsoon rainfall, however, quickly reduce the salinity. On affected soils, however, the salt concentration remains sufficient to prevent crop cultivation in the dry season or reduce the yields of *rabi* crops, except where irrigation can be provided.

In the Study Area floodwater is suitable for irrigation only around the northern tip of Bhola. In coastal regions the water becomes too saline during the *rabi* season. Very occasionally, yields of *kharif* crops are also reduced if dry spells during the rainy season allow salt to be drawn back to the soil surface. The distribution of saline soils is usually irregular. Salt concentrations vary considerably within small areas, even with in fields.

Salinity levels may also vary between years, depending on the dates of onset and ending of the dry season and whether or not rainfall occurs within the dry season.

Flooding with salt water during storm surges accompanying tropical cyclones may also increase ground water salinity and subsequent soil salinity levels in affected areas for a period of months or years after the event.

In the south-eastern part of the coastal islands the water remain saline also during the monsoon season and tidal flooding with salt water during the monsoon occurs frequently where there is no flood protection.

Natural Biological Environment

Since 1966, 1,35,000 hectares have been planted to mangrove in the Study Area. During the same period some 45,000 hectares have been lost. Losses have been largely due to erosion, though some plantings have failed to mature and a small area lost to encroachment. Most are single species plantations and of uniform age. Earlier plantations are now past their prime growth stage.

The greatest bio-diversity is normally found in the planted homestead vegetation and also along embankments. There is widespread abundance of wood available to the residents of the area and this fact contributes to the favourable rural energy balance.

Spotted deer ( ) are widespread throughout the area. Generally these have spread naturally though in some areas, such as Nijhum Dwip island and Kukri Mukri, they have been introduced by the Forestry Department during the mangrove planting programme. This reflected Department policy to establish new conservation areas.

The charlands in the northern part of the Bay of Bengal are internationally recognised as resting grounds for seasonally migrant water bird populations. Its importance is acknowledged in the Asian Wetlands Census (1989). At least 73 species are regularly sighted.

The Bay of Bengal is rich in fish fauna. Principal species include Hilsha/Indian Shad (*Tenulosa ilisha*), Fatty Catfish (*Pangasius pangasius*), Sea Bass (*Latis calcarifar*), Pomfret (Pampas sp.) in addition to Lobster (Panulirus polyphagus) and Tiger Shrimp (*Peneous monodon*).

The fisheries resource is generally under considerable pressure from both coastal and deep water fisheries.

In the area main threatened species is the Gangetic Dolphin (*Platanista gangetica*). Local people claim not to ever catch or kill it, there is known persecution in some localities. Its oil is sold in markets in Dhaka for medicinal purposes. There appears to be many habitats available for the Gangetic Dolphin. The most important threat to its survival is persecution rather than lack of suitable habitats. The Monitor Lizard (*Varanus bengalensis*) is another threatened species.

2.2 Human Environment

Demography

The total population of island and Chars within the Study Area is around 2.3 million. 1.60 million people live on the islands. The annual mean population growth rate is 1.75%.

The average household consists of 5.75 people, a figure which is little changed over the past decade. There is, however, a range of developments, with figures in some areas rising whilst in other areas there has been a fall. Overall though, as in Bangladesh in general, the average figure is showing a tendency to fall.

Land holding

Official figures show little change in the pattern of land holding. The number of households owning land either remains fixed or increases a little. However, when expressed as a percentage of the total number of households the number falls annually. These figures present a picture of a relentless rise in the number of landless households.

There are exceptions to this generally stable picture of land-holding, however. Over the 1981-91 decade Sandwip had a average annual population increase of only 0.36%. During the same period, however, the percentage of households registered as land owners fell by 10.7%.

A different picture is painted by official statistics as regards Manpura where during the same ten year period population grew at an average annual rate of 4.30% whilst land holding households as a percentage of total households fell by only 1.0% over the same decade.

Literacy

The recorded literacy rates vary across the Survey Area. They are generally low, are rising, but slowly.

Health services and drinking water

In all the *thana* with the study area there has been a substantial rise in the percentage of households with access to clean drinking water.
The percentage varies between areas and with few exceptions, is quite high, bearing in mind the dynamic and unstable nature of the estuary and riverine areas. *Thana* records for 1991 indicate a range from 57% (Lakshmipur: Ramgati) to 93% (Bhola: Daulatkan). In 30% of Study Area *thana* the figure is over 80%; a further 30% are below 70%.

Homestead production

Each village is normally divided into a number of raised homestead areas. These areas are generally occupied by more than one household group with their houses, ponds, and sometimes small upland cultivation fields. They are usually above normal flooding and therefore suitable for planting of tree species. Woody vegetation at homesteads has a positive effect on soil moisture through shading and increased mulching, for the benefit of other plants, e.g., vegetables.

Trees growing in homestead areas also provide easy access to fuelwood, fodder and other products. Homesteads provide about 70% of all wood consumption and about 90% of all fuelwood in Bangladesh (Khan and Alam 1996).

Although the planted homestead areas in recently accreted land are less rich and dense and therefore less productive the system remains similar. However, due to low levels of homestead production farmers on newly accreted land may supplement their fuelwood supply from mangrove plantations.

3.0 PLANNING PROCESS

3.1 Objectives and Planning Strategies

General

The GoB objectives for the Estuary and Coastal zone focus on two priorities:

- the **physical safety** of populations and communities resident and those who, in future, will migrate to and settle within the estuary and coastal zone;
- the **management** of both protected and accreted land as an **integrated rural development** programme, to enhance the **social security** of local communities.

As noted, above the area is characterized by continuous hydro-dynamic activities. Erosion and accretion rates are high and the area is periodically subject to severe storms and cyclone, the latter accompanied by tidal bores and storm surge.
The safety of lives and properties of people living in the coastal areas and islands is of permanent concern to Government.

In response to threats posed by the dynamic hydrology and the climatic environment GoB wishes to prepare a Master Plan for this region based upon an assessment of existing records and information, supplemented where necessary by additional survey material. The Master Plan will be for a period of 25 years.

The Plan will present an overview of prevailing physical, biological and sociological issues and contingencies of the target area. It will identify both principal obstacles to development and the most promising development opportunities.

Associated with the Master Plan will be a Land and Water Development Plan presenting a phased and realistic strategy for both overcoming those obstacles and of realizing identified opportunities.

As a prolegomena to the planning process this Interim Master Plan presents a catalogue of principal considerations and recommendations, both sectoral and non-sectoral, which must be elaborated in any subsequent prescriptions, either concerning formulation of policy or when planning practical interventions.

A corresponding Interim Development Plan will identify and outline a list of appropriate, mainly sectorally-based, development components/interventions which, in several combinations, will constitute the building blocks of area development. Selection of components from this list for implementation will reflect the ecological circumstances and development status of respective areas. The Master Plan will specify constraints and opportunities for development interventions. This will, of necessity, impose an order into the sequence of components/interventions.

The Interim Development Plan will identify conditions, or criteria, to which reference might be made in identifying/selecting components/interventions appropriate for respective areas. Hence, the conditions listed in the Interim Development Plan will supplement those *Planning Considerations for Estuary Development* referred to in the Interim Master Plan.

The entire planning process is prepared with reference towards meeting the Government's principal objectives of improving levels of physical safety for communities living in the coastal area and to alleviate poverty amongst these communities.

Reflecting these Government 'objectives' the 'conditions, criteria' and 'considerations' will be used to identify six priority projects, three of which will be prepared to Feasibility Level; three to Pre-feasibility.

Possible components might include constructions and/or plantations both to promote and to stabilize land accretion, char development, physical and social infrastructure provision, (re)settlement of households, sectoral extension services, erosion management and/or navigational channel development.

In identifying these components those two GoB objectives for the coastal region, noted above, will be taken into record. No potential activity will be considered where significant contribution to the achievement of either can not be achieved.

Physical safety

There is a clear need to enhance levels of **physical security** for people living in the Study Area; to provide **physical protection** against floods and cyclones that characterize the coastal zone.

Physical security will be enhanced by the construction of engineering works, including embankments, bank protections and cyclone shelters; also by establishing and maintaining mangrove plantations to the seaward side of human settlements. Security will similarly be improved by further improvements to cyclone warning and evacuation measures presently practiced in cyclone prone areas.

By necessity, physical interventions and constructions will be phased. For example, accreted land will be suitable for mangrove plantation only after a period of around five years. The same land may be suitable for embankment protection only after perhaps twenty years.

Prioritizing of areas for project interventions will also result in a phasing of development interventions. Prioritizing of project areas will be done bearing in mind relative levels of exposure to natural catastrophe, potential for accretion as well as potential for socio-economic development.

Protection works will be implemented for the benefit of communities occupying existing land and land accreted as a result of project interventions.

Socio-economic development in the Study Area will be a continuous process of change. Project interventions, however, will be in stages; they will be phased over the thirty years covered by the Master Plan.

Social Security and Integrated Rural development

Rural development initiatives and interventions will be for the benefit both of pre-project resident communities and settlers on newly accreting land.

The objective is to bring all districts within the Study Area, stable or newly accreted, under appropriate management for the sake of enhancing **rural development**.

To optimize benefits accruing from land accretion such project interventions must be associated with an adequately-financed settlement component. This will require technical and financial inputs in a series of stages, over a number of years, in addition to those invested in initial implementation of project works and infrastructure.

The single most important contribution to providing social security to respective households will be the issuing of certificates ensuring land tenure, thereby reducing greatly the probability of these households being evicted from their houses and lands.

Access to land is the most sensitive and hence the most important amongst rural development components. Several reports produced in connection with development projects of the coastal *char* lands have emphasised that rivalries between gangs representing and supporting influential and powerful elites present a significant problem to both settlement and subsequent development of these areas.

In addition to feelings of insecurity caused by the exposed nature of these coastal chars, settlers are largely at the mercy of the political and economic aspirations of these elites. The ready access to credit from these powerful people renders the settler households more dependent and enthralled.

Social security will be enhanced by the provision of physical inputs, such as adequately staffed and resourced schools, health centres and roads. The GoB Fifth Five Year Plan favours an integrated natural resource management strategy.

Households and communities will participate in deciding both details and overall strategy. They will subsequently be provided with the necessary physical inputs and associated extension services.

For the estuary and coastal areas, as in the country as a whole, poverty alleviation is a pre-requisite for socio-economic development.

Yields from agriculture on the *chars* are generally low and, with the constant danger of crop destruction from cyclones and salt water intrusion, household self-sufficiency in grain production cannot be achieved in the short run. It is unlikely that present or enhanced levels of agricultural production along will provide levels of income sufficient to alleviate poverty and thereby promote rural development.

Any development strategy for these areas that envisages an eventual agricultural use must, therefore, include aspects of management that address these constraints. Principal measures include the use of natural livestock manure and green manuring.

Management strategies will be developmental, changing over time, reflecting changes in local ecological circumstances. The aim will be a continued management of *char* lands through a series of integrated and diversified strategies utilizing a farming systems approach, supplemented as appropriate by fishing activities, both for home consumption and marketing.

The GoB Fifth Five Year Plan (1997-2002) acknowledges the need for productive employment generation in the rural areas and the development of rural infrastructure provision, including development of a marketing system to boost economic growth. Employment opportunities will likely be based on the processing of agricultural, livestock, tree growing or fishing products. The potential for such post-harvest processing should be considered when identifying appropriate land management strategies and farming systems for both settler and resident communities. Similarly, the potential for post-harvest processing and other small-scale industrial development should be considered when prioritizing amongst projects for implementation.

Project implementing agencies will maximize provision of income earning opportunities and employ local household members. Access to small scale credits will be provided, possibly through NGOs, to enable the establishment of small industrial developments and initiatives.

As elsewhere in the Fifth Five Year Plan, in their policy statements regarding the estuary and coastal zone GoB emphasizes the need to attract private sector investment if national resources are to be optimally exploited. It is unlikely, however, that private enterprises can be persuaded to invest heavily and, perhaps, over a long and relatively uncertain period of time in such isolated and unstable areas for uncertain rates of return. It is probable that donors will fund short term projects for the implementation of physical works.

Under these conditions, local households and communities must be encouraged and supported in initiating their own strategies for economic development. Much responsibility for facilitating these programmes will lie with NGOs.

3.2 Estuary Development

Agriculture

In their Fifth Five Year Development Plan the Government of Bangladesh sees agriculture continuing to play the main role in the growth and stability of the national economy.

The years 1997-2002 will be characterized by the development of a more integrated approach to agriculture including crops, livestock, fisheries and forestry through more efficient utilization of available land and water.

In principle, these strategies will be multi-sectoral. They will aim to exploit as wide as possible a range of resources and in an integrated way. Strategies will probably include crop production, large and small livestock husbandry, tree growing (for both wood and non wood products) and fishing.

Both subsistence and market oriented production opportunities will be sought. Opportunities for further processing of produce for marketing will be optimised, for example: fish drying and salting, leather curing and processing of non wood tree products. Opportunities for small ruminant and poultry development will be especially explored. Micro credits will be made available to facilitate such ventures.

All land based rural development strategies will reflect the characteristic successional nature of development in these areas. Hence, the combinations of resources to be exploited and the nature and/or intensity of that exploitation are likely to be modified during respective development periods. This will reflect changes in the *char*lands over time, changes which will include progressive desalination of soils, improved drainage and water management as well as higher levels of soil fertility, indicated by increasing levels of organic matter, falling pH levels and improving soil structure.

The Planning Considerations for Estuary Development (Chapter 4) and the associated Priorities for Component Selection (*Interim Development Plan*, Chapter 4) reflect the sequential nature of ecological development. These Considerations and Priorities must, however, be seen against the physical constraints and possibilities identified in the Master Plan and be guided by a need to contribute to meeting the Government objectives of increasing levels of physical safety and alleviating poverty as a pre-requisite to economic development in the estuary areas. (See below, Section 3.1)

The GoB Agricultural Development Plan identifies the Coastal Areas of Southern Bangladesh as a Special Agricultural Zone. Acknowledging the many cyclone related problems, associated with this zone, the Plan identifies the need to develop saline resistant varieties of rice, and proposing location specific research and extension.

Notably, the Plan recognizes several tree crops as principal cash crops in the coastal area, listing coconut, betel nut, palm and mangrove. Selection is limited by respective levels of soil salinity and exposure of respective sites to gale and storm damage.

Small and marginal farmers in *char*land areas will be provided with improved access to credit. More modern technologies will be made available to these farming households. NGO involvement in agricultural extension and service delivery will be increased in the coastal areas.

An effective marketing system will be developed in these coastal areas. The natural hazards of crop failure by flooding and salt water intrusion should be reduced by the construction of embankments and by drainage improvements.

Reference is made to the New Agricultural Extension Policy, which emphasizes the supportive and advisory nature of extension, of field officers working alongside farmers to identify problems and their solutions.

Fisheries

Both culture and capture fisheries are likely to make an important contribution to household incomes throughout the Master Plan period. An early opportunity might be the construction of household salt (or brackish) water shrimp rearing pools.

The Fifth Five Year Development Plan states that whilst fish production (marine, brackish water and inland) remains low, there is much scope for increasing the marine fisheries resource. The Plan does, however, acknowledge the need for judicious exploitation and scientific management of this resource.

Over the past twenty five years the share of marine fisheries in total national landing has risen from 10% to 22%. This represents a considerable increase in fishing pressure over interim years. The Plan endorses the observation made independently by ODA, BOBP and FAO that the continued and rapidly increasing use of traditional technology is causing serious over-exploitation of stocks, particularly by facilitating the capture of post-larvæ and juvenile fish.

The appropriate technology and equipment are not presently available in Bangladesh and the Plan calls for increased private sector involvement and investment to meet this shortfall.

With fish farmers' training and adequate levels of credit available it is claimed that further substantial increases in fish production will be possible whilst total catch will remain within the limits of Maximum Sustainable Yield.

GoB fisheries policy proposes an increased involvement of NGOs and private sector organizations in group formation, motivation, training and income generating activities in fishing communities and marginal farmers.

Livestock

Livestock is acknowledged as offering perhaps an effective means of improving the economic status of the more disadvantaged members of the community. Livestock husbandry will be an essential component in any envisaged integrated land management system for the coastal areas.

By constructed raised earth platforms and/or levees alongside drainage channels desalinization will be accelerated and areas become available for fodder production. Poultry and small ruminants can be supported on houselots.

Livestock are a source of milk, meat and eggs. In contemporary Bangladesh demand for these products far outstrips supply. Any local increase in availability of these products has the potential of improving nutritional levels of local households. In addition, large ruminants presently provide over 80% of traction power used by Bangladeshi agricultural producers. By targeting the landless, destitute women and unemployed youths livestock husbandry can also make a direct contribution to poverty alleviation through their sale of these products.

Amongst principal characteristics presently limiting livestock production are pests and diseases, inadequate levels of feed and fodder, non-intensive husbandry as well as the continued use of un-improved varieties of livestock. District livestock services will have to be improved.

Livestock husbandry can also offer opportunities for considerable improvement in the diets of poorer social groups. Private individuals, groups and NGOs have all shown positive results in livestock development activities.

NGOs will be encouraged to continue and expand their activities in implementing small livestock programmes amongst female-headed and/or landless households.

NGO programmes provide training and micro-credit facilities. This corresponds to GoB overall development policy which emphasizes the increased reliance of private sector during the coming years.

Killas

To provide safe havens for livestock at times of cyclones a number of generally rectangular earth mounds (termed *killas*) have been built. These vary in size from 30 x 30 meters to 90 x 90 meters, and 3 - 6 meters in height. Many of these have been built since the 1991 cyclone by community groups under the Local Government Engineering Department (LGED) managed Food For Work (FFW) programme. Most of the remaining *killas* were built in the early 1980s with initiative and support from NGOs.

Reports on their utilization are mixed. Around 70% of existing *killas* are located behind embankments. As such, they may be seen as offering little by way of additional protection to that otherwise provided by the embankment. Communities use the killas for cyclone protection both for themselves and for their livestock.

Killas are also used for non-cyclone related purposes, particularly for the cultivation of vegetables.

It has been recorded that people are disinclined to use killas because of a characteristic poor access and/or link road connecting the killas to the main road transport system. It is apparently the lack of road connection rather than the absolute distance from village to respective killas which is responsible for their irregular use. another criticism has been the lack of protection on the killas and the general absence of nearby deep tube wells.

There is sufficient evidence already gathered to encourage additional consideration of killas construction, outside of embankments and for both protection and development purposes.

Forestry

For the forestry sector the objectives of the Fifth Plan are to expand forest resources, make forests productive, develop institutional capabilities and encourage people's participation. The policy is to increase tree coverage in Bangladesh to 14% of the country's surface area. The limited remaining areas of natural forest will be protected and surrounded by buffer zones within which local people will have limited access to collect forest products.

Active participation of local people is seen as a pre-requisite to achieving a sustainable status of existing forest resources. Forest management is seen as presenting ample opportunities for improving the socio-economic status of poorer sections of society.

With regard to mangrove plantations Forestry Department policy anticipates three interventions:

- plantations will be monitored and, nine year after planting, a decision made regarding a possible initial thinning;

- subject to satisfactory growth rates, an additional thinning will take place after a further six years, in other words, fifteen years after planting, in which case 60% of standing mangrove poles will be removed;

- twenty years after planting the plantation will be visited by members of a specially constituted committee and a decision taken on whether the plantation area might be cut and converted into agricultural land.

It is noteworthy in this regard that, to date, there is little evidence of plantation management activities though the Forestry Department has records indicating that some mangrove plantations have had a first thinning.

What is certain, however, is that no mangrove plantations have been cut or converted into agricultural land, at least not with Forestry Department consent.
This is consistent with the Fifth Five Year Plan where it is stated that the existing coastal afforestation including mangrove will be continued, moreover proposing further that existing mature coastal plantations might be cut and replanted.

To limit the extent of damage by cyclones and tidal surges, the Forest Department is receiving donor assistance in raising plantations on embankments, along roadsides and on private lands in and along coastal regions.

Social forestry has now become a central feature in all forestry operations in Bangladesh. This policy will be continued and expanded in the coming years. Householders, residents or new settlers, will be encouraged to plant trees and woody herbaceous plants in their house gardens and on their agriculture land. NGOs will

provide technical advice and credit to individuals wishing to establish a commercial plant nursery and raising planting stock for sale.

3.3 Physical Interventions

For centuries accretion and erosion, both natural processes, have take place in a highly dynamic Meghna Estuary. This process continues today and constitutes a major obstacle and disincentive to capital investment in land management, whether at household or commercial level. Communities living in the estuary and coastal regions are also exposed to danger from periodic cyclones and their accompanying high winds and tidal surges. The Meghna Estuary Study focuses on an assessment of the potentials for minimizing the catastrophic effects of these natural processes and disasters on communities living in these areas. The Study will also focus on ensuring adequate stable lands as a pre-condition of land-based economic development.

The MES will assess the potentials for stabilizing and protecting existing accreted land. Similarly, "The Meghna Estuary Study focuses on an assessment of the potential for accretion."

In response to these two prescriptions and aided by a review of existing reports, MES studies so far, have enabled the compilation of a preliminary list of 79 possible engineering sub-projects, 26 of which are cross dams, the remaining 53 are various protection and char development measures.

A review of reports produced by other projects and studies, such as LRP, CDSP and FAP, will enable MES reports to include an outline of physical potentials and constraints to development throughout the estuary area.

"The Master Plan will also define (ensure) the stability of existing accretions for which priority projects are to be formulated."

To address this second prescription a series of possible engineering interventions are listed in the Interim Master Plan. A map showing these interventions, including: embankments, bank protection, erosion management, empoldering and char development measures is presented (See Figure 1.3.1.) A brief description of these sub-projects is presented below (Annex 2.)

There is apparently a huge potential for the accretion of new land in the Estuary area. The Lower Meghna River is heavily laden with sediment, most of which is presently washed out to sea by the strong river currents. The sediment will, however, be deposited anywhere conditions are favourable.

Such favourable conditions can be produced artificially, as demonstrated through the construction, in 1957 and 1963 respectively, of two cross dams across the Banmi Channel, once a channel of the Lower Meghna. Once constructed massive siltation occurred on both sides of the cross dams, giving some indication of the rates of siltation that could be expected in the area.

In 1977 the Land Reclamation Project (LRP) was started to undertake surveys and to make recommendations in the fields of land reclamation and estuary control. Under the terms of the LRP Project a number of channels across the coast of main land Noakhali were closed, the most significant of which was the 1982 Daria Nadi closure, resulting in the accretion of around 1,000 hectares.

Another major closure was the Feni Closure Dam, constructed in 1985. In both cases siltation occurred along the seaward face of the dams. The rate of siltation has been spectacular, providing further indication of the potential for land accretion.

Despite the potentially high rates of siltation it will still be some years before newly accreted land can be managed with a realistic expectation of positive financial (even economic) return.

It is regarded, therefore, as important that cross dam construction is identified as an activity to commence early in the life of the initial Master Plan. The proposed cross dam between Nijhum Dwip and Hatia is a priority project for which a feasibility study will be prepared.

Levels of physical safety are enhanced by the construction of embankments around accreted lands. Most of the islands in the MES Study Area, however, have already been provided with embankments, either under the original Coastal Embankment Project or under the Cyclone Protection Project (FAP7); others will be constructed under Phase 11 of the latter project. If, within the Study Area, additional embankments are needed than provided by these projects, they will be taken up in the Development Plan.

Whilst, in many cases, local communities would welcome such constructions, the associated issues concerning water management and drainage must be adequately researched prior to agreement on the large capital investments in embankment construction and subsequent maintenance.

The design height of embankments averages around 4.0 metres. The country side slope has a gradient of 1:3, resulting in a slope width of 12.6 metres. The outer slope has a gradient of 1:7 with a slope width of over 28 metres. Together, these slopes provide a combined width of around 40 metres, which can be planted to trees of appropriate species.

These trees will provide a valuable resource for households living nearby. Access to this resource will be in exchange for unpaid work on embankment maintenance. The Coastal Embankment Rehabilitation Project has developed models both for plantation activities and the participation of local people.

Bank protection works will be considered, using both existing and novel technologies. The costs of bank protection are very high and could normally be considered in the protection of densely populated, in other words urban areas. Particular interest is, therefore, being expressed in the relatively cheap technology that uses geo-textiles for deflecting flows of water from sites at greatest risk.

Some emphasis is placed on research leading to the preparation of water management and drainage schedules for respective char developments. Schedules will be prepared both for existing and stable lands and for proposed areas to be accreted following engineering interventions.

3.4 Environmental Considerations

Each project intervention in the Study Area will be prepared and presented in the form of an environmental management plan. The aim of this management plan will be to ensure the **continuity** of important environmental resources and services in an area, to maintain or to enhance levels of bio-diversity and hence to ensure the **sustainability** of the existing and future development programmes.

In the context of the Study Area, the goals of environmental management are to ensure the sustainability of agricultural and fisheries development, to ensure the integrity of the surrounding environment, to ensure social harmony both in and between communities and to ensure the health of settlements, through attention to proper sanitation and waste management.

Of principal concern will be the management of both erosion and accretion processes.

The physical, biological and social environment will be considered at each stage of the planning process to establish respective environmental scoping and bounding. Planning will follow the Guidelines, as outlined in Section 6.

4.0 PLANNING CONSIDERATIONS FOR ESTUARY DEVELOPMENT

4.1 Navigation

The primary navigation route in the Meghna Estuary is the bay-crossing passage connecting Chittagong sea port with inland river ports, as well as Mongla sea port. This passage is subject to constant change in response to changes in the coastal and/or estuarine morphology.

The route from Ilsa/Gazipur towards west through Goneshpur river (on the north of Bhola) and then towards the north-west through Sripur nullah or towards the south-west through Tentulia river to move round the southern part of Sripur for going to Barisal-Khulna or Patuakhali, also forms a part of primary waterways of the country.

Other navigational routes in the estuary, which do not come in the category of secondary or tertiary waterways and are also not chartered (not marked by BIWTA), are the channels in Shahbazpur river running by Bhola east coast from Tazumuddin down to the open sea, routes on east and west sides of Hatia, Sandwip channel (on eastern side of Sandwip) and waters on the north and north-west of Sandwip.

As mentioned above, the navigational route for the bay-crossing is unstable. This requires shifting of location and direction from time to time. It is not possible to maintain the route artificially, specially by dredging which is simply ineffective in the area. Therefore regular survey and searching of the position of deeper channel is required for marking the shipping lanes. The existing Hatia-Sandwip passage of around 30 km forms part of the bay-crossing route. At present, it is negotiated over very shallow patches of Bhasan Char observing tight tidal restrictions. A comparatively deep channel runs south-east from north Hatia that could be used as alternative to this latter route on way to Chittagong. Shippers are, however, reluctant to use this deeper channel, especially in monsoon, as it involves using the open sea which is more prone to rough water.

The proposed Hatia-Damar Char and Hatia-Nijhum Dwip cross dams are likely to develop a leeward seaboard on the eastern side of the islands for easier navigation in this part of bay-crossing. These dams are not expected to influence any other part of this trunk route but can be with reason expected to result in a better bay-crossing route.

4.2 Fisheries

Fisheries play a major role in nutrition, employment, foreign exchange earning and other areas of the economy of Bangladesh. Fisheries sub-sector contributes 3.5% of the country's GDP (World Bank 1991). Within the agriculture sector, fisheries accounts for about 10% of the gross value added. The sub-sector contributes about 80% percent to the nations animals protein intake. Around 1.2 million people are directly employed by this sub-sector. It is proposed that another 11 million people indirectly earn their livelihood out of activities related to fisheries.

Fish Ecology in the Meghna Estuary

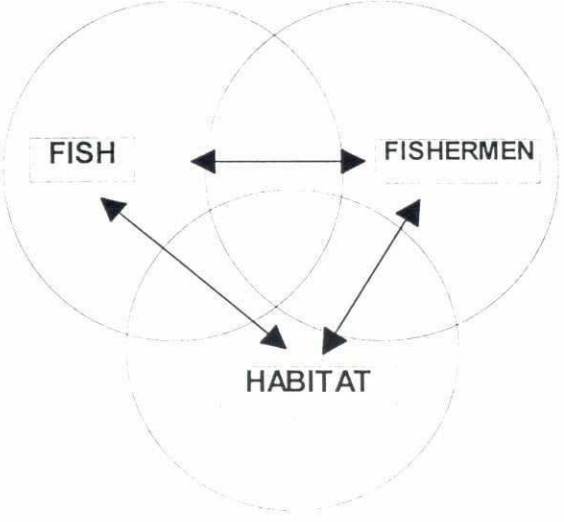
Biologically, the estuary provides spawning and nursery areas for a large number of fish and crustacean which spend the remainder of their life cycles at sea, or in fresh water. Further the estuary provide avenues of entry and exit for migration of anadromous and catadromous fishes.

Within the Meghna estuary species such as Ilish, Shrimps and fresh water prawn, are known as **estuarine dependent**, that is, passing a stage of their respective life cycles in the estuary is **obligatory** for the completion of their life cycles.

Future Developments

Fisheries in the Meghna estuary is a interactive process between ecological (the fish), Socio-economic (the fishermen) and physical (the estuary) factors. This process is visualized below. Any intervention or development in the MES area should encompass these three inter related elements. (See Figure 4.2.1)

Figure 4.2.1



The fish. The different species, with their respective ecologies and behaviours in the estuary is a given biological fact and will not change over time.

The fishermen. The total biomass of fish for each species in the estuary (the stock) is directly influenced by fishing activities. Over-exploitation of stocks will occur when the number of gears or fishermen is higher then the stocks can support.

The habitat. Between 60-80% of all fish and shrimp in the BOB are 'estuarine dependent.' Alteration of the habitat, for example, the estuary or intertidal area, will be to risk directly influence fish stocks and consequently the catch of the fishermen.

It is emphasized that a reduction of the estuarine area through land reclamation will have only a direct linear impact on fisheries production. Any reduction in spawning or nursery area of fish, however, will most likely have an exponential impact. This concern must be considered when identifying or preparing engineering and other physical components

Aquaculture

The last decade in Bangladesh has seen a rapid increase in aquaculture production. This has been primarily due to the introduction of improved husbandry techniques and the execution of large scale extension projects. The potential for such an aquaculture development within the MES area has not yet been realized though there is clear scope for further development in fresh or brackish water aquaculture.

Planning Considerations

Major considerations for long-term development of fisheries in the Meghna estuary are:

- Improvement of the socio-economic condition of the fisherfolk households, who are the poorest of the poor in the estuary. All intervention must be screened upon the impact upon this community, taking the overall picture of the whole estuary;
- The sustainable management of fisheries resources in the estuary based on catch and effort data and stock assessment analyses;
- Regulation of fishing effort through the creation of alternative income generating activities;
- Maintaining the recruitment of the economic important fish species such as; Ilish, Bagda, Golda and Pangash. This must be achieved trough fisheries regulations/cooperation with the fisheries communities and through protection of the actual spawning and nursery areas;
- There are opportunities to improve fresh water aquaculture, for example, the introduction of Indian carps and/or fresh water prawns;
- Introduction of the culture of brackish water, marine aquaculture, other then shrimp farming. The sustainability of further development of shrimp farming should be carefully studied, this in light of the recent disease outbreaks and the developments regarding the environmental impacts of shrimp farming.

4.3 Agriculture, Livestock and Homestead Production

Most farms in the Meghna estuary are complex systems where the individual components depend on and benefit from each other and all the farm-based activities are more or less integrated. Agricultural cropping, livestock production and the homestead production (trees for fruit, fodder and fuelwood, vegetables and other plants grown on the homestead area) are all contributing to the survival of the farm household. Land is the basic resource for agricultural crops and plants grown on the homestead, but also for livestock land is fundamental for fodder production and grazing.

When planning farming systems development in the coastal area, the preconditions for development, the technical constraints in coastal farming as well as the overall aspect of self-sufficiency and sustainability of the farm households should be considered.

The development of farming systems and improvement of the individual components will depend on the establishment of institutional structures that secure the farmers access to:

- land titling: to secure the long-term interest in improvements of the farm resources;
- protection of the land and user rights: to break the power of big land owners and 'landgrabbers';
- microcredit facilities: to enable the farmers to establish the production and improve the farming system;

- extension service: to support farmers in developing the farming system and integrate the different interest in the area.

Without such structures it is not possible to secure the farmers interests and a sustainable development.

The coastal area provides quite different farming conditions than what is found in the inland areas of Bangladesh. The main constraints are:

- Limited fresh water supply for irrigation during dry season. This affects most of the estuary except for the very northern part of the study area.

- Soil salinity. Whilst salinity levels vary in the study area, however there is a tendency for levels of soil salinity to increase from west to east, with salinity levels highest in the Sandwip area.

- Soil fertility. Fertility of the land varies according to land use, the general picture is that content of plant nutrients and organic matter is low and so are the CEC-levels.

The physical constraints are the main reasons for low yields and low cropping intensities. Farmers cannot profit from the three cropping seasons observed in many other parts of Bangladesh.

The limited market access in some parts of the study area restricts the supply of inputs as well as marketing of the production. Dependency of local tradesmen limits the farmers' possibilities for securing supply and sale of products as well as influencing timing and prices.

The physical constraints mentioned above are the reasons for the Meghna estuary study area being one of the more marginal agricultural areas in Bangladesh. It has been given low priority for agricultural development in the past.

The high risk of damage from storm surges, flooding, pests and animal diseases combined with the remoteness of the area has furthermore made it less attractive and accessible for development. Yet it has become the focus for resettling and settling of some of the most resource poor people of Bangladesh.

When considering settling of farmers in the area and development of the agriculture, livestock and homestead production, the potential for self-sufficiency and sustainability of the farming becomes an issue in itself. Most farmers cannot survive from the outcome of the farms with the present farming system and depend highly on fishing.

If the farmers are to be self-sufficient and sustain a living for the household based on the outcome of the land, planning of land use and development of farming, including all aspects, e.g., agriculture, livestock and homestead production, should be considered in a holistic perspective with a farming system approach based on needs assessments of the farm households.

A higher degree of integration between forestry, farming and development of the livestock sector combined with a larger focus on farm forestry or agroforestry to secure fodder and fuelwood supply should be prioritized.

Spatial conflicts may arise between forestry, livestock production, agricultural cropping and fish and shrimp cultivation as well as conflicts related to how different activities affect each other. The objective of a farming system approach is to combine these interests in the most profitable way. However, if larger scale production of one of the sectors is introduced planning and allocation of land for different purposes has to be considered.

- Forestry versus farming conflicts. Although most people in the coastal chars respect the existence of the mangrove forests for their own protection, an early integration of the settlers in the management and the use of the forest is needed to decrease the number of forestry/farming conflicts.

- Livestock/agricultural crops conflicts. Secured title to the land and allocation of community grassland, according to assessment of the village needs might solve the problem to a certain extend.

- Shrimp cultivation in the same polders as agricultural cropping creates conflicts because of the salt-water intake needed for the shrimps is damaging for the agricultural cropping and the desalinization of the protected areas. This conflict is necessary to consider when allocating land.

4.4 Forestry

Forestry issues should be considered in a wider context of environment and development, taking into consideration the multiple functions and uses of forests, including the potential for development offered by sustainable forest management, community and social forestry.

In order to accomplish this, a planned approach to development in the estuarine area must be followed:

Landuse classification and allocation of forest types is fundamental for development planning and forest management. Categories to be considered are protection forests, production forest, forest for conversion to agriculture, and forest for nature conservation;

It is necessary to consider the implications for planning arising from the multiple role of forestry and the objective of wood production in the development planning of the estuary;

A distinction should be made between the already established *existing resource* and the *newly created* plantations, with respect to forest management options for protection (including stabilization of mudflats and accretion enhancement) and socio-economic issues (satisfying the needs of people for forest goods and services and providing additional income and employment, agroforestry, cottage industry);

Land tenure issues and implications in the processing of developing newly accreted lands, including handover procedures and a practical division of responsibilities among the involved institutions have to be considered as well as overall resource assessment with current data on stand parameters like mangrove plantation area, stocking , growth and plantation quality.

A resource management strategy, which contemplates the successional nature both of the mangrove vegetation (i.e. it is assumed that the mangrove plantations would develop into a Sundarban like vegetation given sufficient time and stable conditions in the estuary), and development based on conversion of plantation land for integrated farming systems are also aspects to be taken into account.

The successional nature and the inter-relationship of these issues is best illustrated in Table 4.4.1.

Table 4.4.1. Planning matrix for forestry development in the Meghna Estuary

Ownership	Land category	Management objective	Possible Dev. Strategy	Other issues/ considerations
State land	Production mangrove plantation	Commercial wood production, sustainable mgmt.	Maintain as forest under FD mgmt.	Ensure compliance with GOB policies, mgmt. guidelines, etc
	Protection mangrove plantation	Cyclone protection	Convert to community or private land for agriculture, protection, conservation	Clear development strategies, institutional responsibilities, tenure regulations, handing-over procedures a precondition
	Conservation mangrove plantation/natural forest	Ecological stability	Maintain as conservation forest, no development	Ensure regulations, control & enforcement
	Newly accreted land	Stabilize +accrete + protect	Develop into protection forest and if desirable convert for other purposes later	Procedures and regulations in place for FD to acquire jurisdiction over land (from MLA)
Not applicable	Eroded land	Subtract from other categories	n.a.	Should be updated in natural resource registers
Community land	Production mangrove plantation	Satisfy wood product needs of community on sustainable basis	Sustainable mgmt. on basis of community needs assessment & management plans	Community participation , FD supervision/ control ensured
	Protection mangrove plantation	Grazing? Agroforestry?	No development, but introduce other tree species later	FD supervision/ control, community participation
	Conservation mangrove forest	Ecol. stability	No development	FD supervision/ control ensured
Private land	Homestead woodlot	Production of fuelwood, non wood products	Manage on sustainable basis	Value of forest products recognized by families, extension services available
	Agriculture	Agric. production	Agric. development	Agricultural potential ensured, extension services available

4.5 Secondary Protection Systems

The secondary protection system for the planned areas includes measures that provide additional protection to the beneficiaries. To understand the secondary protection better, the primary protection is briefly mentioned here.

Primary protection for example includes those infrastructural works which give first order of defence as cyclone proof embankments, flood proof embankments, regulators, drainage sluices, cyclone shelters, *killas* etc.

Other infrastructural like marginal embankments, drainage net works, boat shelters, feeder roads, pucca roads and houses, raised banks of ponds, water supply, sanitation, bridges, culverts, social forest and faster transport systems may be considered as secondary protection.

The coastal embankments are to be so planned and constructed that space for sufficient foreshore area is available for the development of forest. Normally specified set-back distances both for sea dykes and interior dykes are to be maintained where foreshore may develop through the process of siltation or accretion.

To increase the safety of the coastal on-shore and off-shore people and their properties, improvements may be possible though the development of secondary protection system.

One of the important components is the compartmental embankment, subdividing the polder into smaller units with hydrological boundary. Compartments can be considered as sub-polders of a large polder. In the event of failure of the main embankment, sub-embankments will stand at least for sometime as safety measure against flooding by saline water and salinization of soil by tidal waters.

Feeder roads, for faster movement of people; pucca houses, raised banks of ponds and others may also provide limited or temporary protection against cyclone and similar calamities. The design of such secondary protection system may be done following BWDB, LGED, DPHE and established specifications.

4.6 Non-structural and Other Protection Systems

Though the project area is out of devastating effect of severe floods that occur in mainland due to heavy rains and upland river discharge, it is subject to flooding from spring tides at many places and is always prone to inundation and damages by storm surges which accompany the cyclonic storms. The surges cause and extra rise of sea water level by 2-6 meter or more (9m in Nov. 1970) over normal tides. The frequent occurrence of cyclonic storms has made this area highly vulnerable to natural disasters.

Cyclones, are a feature of region's climate and cannot be avoided. But measures can be taken to evade or minimize the loss of lives and properties through both structural fortifications and non-structural precautionary steps in the way of reliable timely forecast and warning against the coming cyclone, dissemination of the warning at grass-root level and necessary evacuation of people from areas likely to be badly affected, before the cyclone strikes.

An early warning system against the cyclone in Bangladesh had been operating since long before and it was intensified in 1966 through a pre-disaster programme of works undertaken as a pilot project by joint collaboration between Red Cross & Red Crescent Societies in league with Swedish Red Cross Society.

This pre-disaster programme, though praiseworthy, failed to achieve its goal of protecting life and property of people in the coastal belt due to lack of village based organization, control, supervision and communication with top tiers of the government. The trail of destruction left behind by the cyclone of 12-13 Nov. 1970 demonstrated the ineffectiveness of the programme.

Bangladesh government after its inception therefore, examined the lacunae of the said programme and reorganized the early warning system for higher effectiveness, under the initiative of the United Nations and with co-operation of Red Cross and Red Crescent societies.

The Cyclone Preparedness Programme (CPP) was then established. Cyclone early warning system has two main components:

- The meteorological forecasting of the cyclone in Special Weather Bulletins issued by the Storm Warning Center of Meteorological Department in Dhaka.

- The communication system broadcasting and transmitting the Special Weather Bulletins all over the vulnerable areas operated under Cyclone Preparedness Programme (CPP).

Various measures have been formulated to minimize the loss of human life and property (including domestic animals). A 'National Co-ordination Committee' for cyclone emergency direct, co-ordinate and make overall supervision over pre and post cyclone activities carried out by the disaster committees at Divisional, District, Thana and Union levels. Standing orders are laid down for concerning ministries, divisions, departments and agencies to have their respective Action Plans and implement them speedily and systematically during the emergency period as well as in normal time as needed.

The action plans, under the standing orders, are meant for action towards infrastructural safety measures, watching and tracking of cyclone from depression stage, issue and wide dissemination of cyclone warning signals, training of volunteers, motivation of people for preparedness, necessary evacuation, relief operation, medical assistance & assessment of damage.

The actions normally fall under following stages:

	Maritime	River ports
i) Pre-disaster stage	off cyclone season	-
ii) Alert stage	signal no 1,2 and 3	signal no 1
iii) Warning stage	signal no 4	signal no 2
iv) Disaster stage	signal no 5,6 and 7 as danger signals; signal no 8,9 and 10 as great danger signals	signal no 3 signal no 4
v) Post-disaster stage	immediately after the cyclone until normalcy is attained	-

The depression and cyclones are classified as under:

Classification	Range of max. wind speed
i. Depression	45 - 50 Km/hr
ii. Deep depression	51 - 61 Km/hr
iii. Cyclonic storm	62 - 86 Km/hr
iv. Severe cyclonic storm	88 - 117 Km/hr
v. Severe cyclonic storm of hurricane intensity	118 and above Km/hr

The main departments and agencies who carry out their respective functions as laid in the standing orders, are;

i) Met Dept,
ii) Bangladesh SPARRSO,
iii) Ministry of R&R (renamed as Ministry of DMR),
iv) DG-R&R (renamed as DG-Relief),
v) Ministry of information,
vi) Radio Bangladesh
vii) Bangladesh Television,
viii) Ministry of Health & Population Control,
ix) Ministry of Food,
x) Ministry of Agriculture and
xi) Ministry, Fishery & Livestock, each of them has separate duties as to cyclone situation, consistent with its normal functioning.

At the Alert Stage the Storm Warning Center of Meteorological Department ensures that an early warning for cyclone is issued.

As mentioned earlier in the note of natural hazards, the project area is highly vulnerable to cyclones and storm surges. It is therefore badly in need of both structural fortification and non-structural systems of preparedness for minimizing the loss of human lives and properties.

A disaster preparedness programme essentially comprises an effective warning system and adequate infrastructures and institutional arrangements for door to door dissemination of danger message, motivation of people and necessary evacuation.

Bulletins are issued by Storm Warning Center as to depression, passage and intensity of storm, areas likely to be affected, etc. both for domestic awareness and international shipping and aviation. The Cyclone Preparedness Programme (CPP).

The sanitary conditions including drinking water in the project area are much below the requirement. Tubewells, which are the only source of drinking water, are very inadequate. That greatly tells upon the public health. An integrated programme involving health care, sanitation including drinking water supply, educational facilities, etc. is to be taken up for the settlers in the existing land and the expected new land in the project area (MES project).

The Initial Environmental Examination (IEE) over the trial area of Hatia-Nijhum Dwip cross-dam is being carried out by MES. After completion of the IEE the consultants will develop it into a full EIA (Environmental Impact Assessment). It will be then possible to make threadbare discussion over the environmental impacts including mitigation of negative factors if any, and propose necessary mitigation measures and enhancement programmes for that area and thereafter, an environmental profile for the whole MES area will be developed.

4.7 Water Management Systems

Accretion and land formation processes in the estuary differ considerably from place to place. These difference will influence opportunities for water management at a macro level.

Levels of agricultural production in coastal areas are less compared with other parts of Bangladesh. Drainage congestion, water logging accompanied with salinity and poor water management are considered main obstacles for agricultural development in flood protected areas situated in the Meghna Estuary.

Salinity levels of surrounding open water bodies show both regional and seasonable variations. Soil salinity is a major constraint in agricultural production in the study area. The salinity of surrounding open water will play an important role in defining the scope of water management.

An important water salinity level is 2 dS/m (deciSiemens per meter), near to 1.0 ppt (part per thousand). Soil moisture with a salinity level below this will support rice production and water can be used for surface water irrigation. The 2 dS/m salinity contours for May and October are shown in Figure 4.7.1. Serious crop damage occurs when standing crops are flooded by saline water.

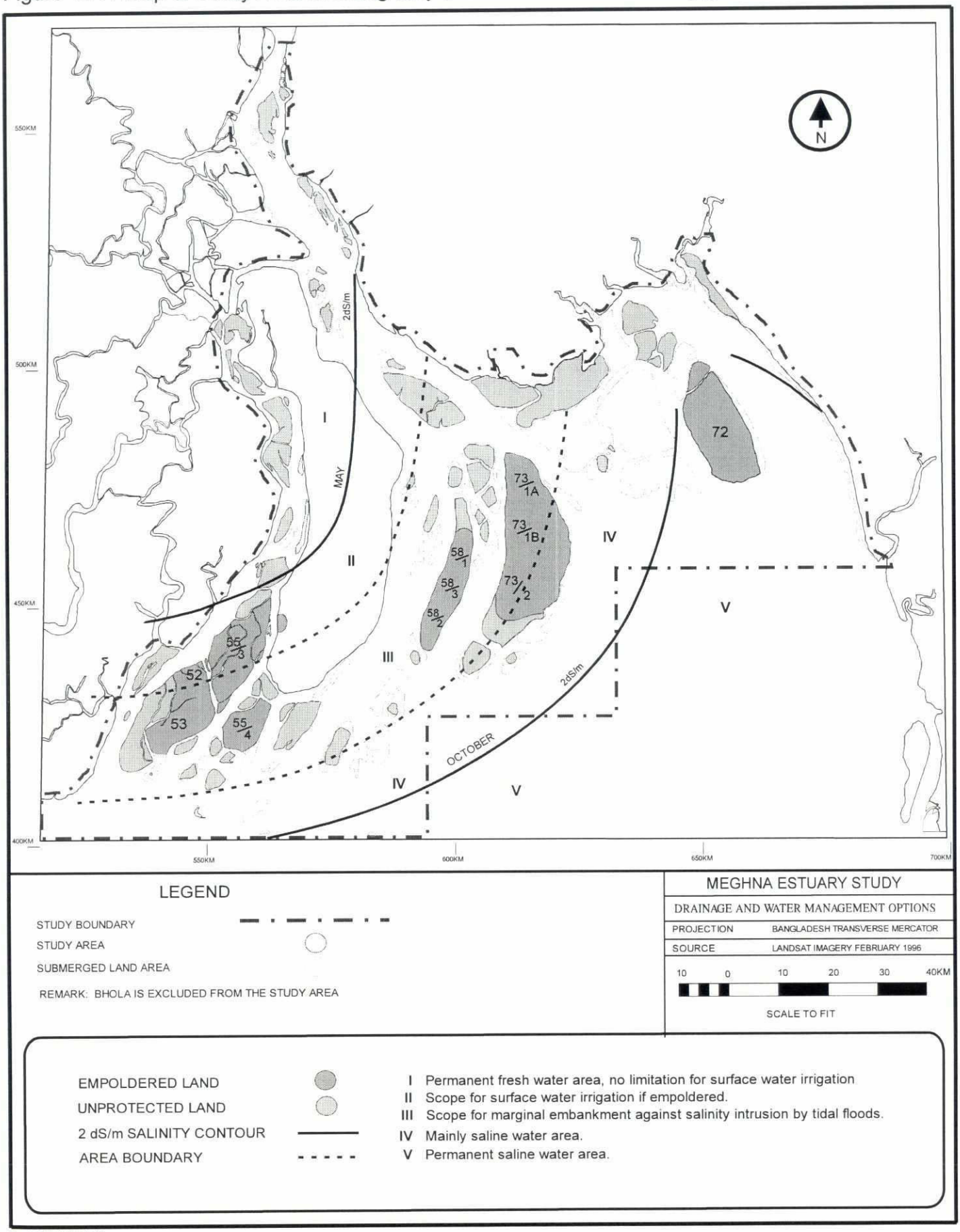
The opportunities for using (fresh) irrigation water and annual monsoon rains for accelerating reductions in soil salinity by leaching out surface salt deposits have to be considered.

Soils exhibit little variation throughout the estuary and the scope for desalinization should be widespread throughout the estuary and coastal zone.

Desalinization of polders is hampered by breaches in the flood protection embankment or damage to sluice gates. This results in saline tidal flooding and a resalination of soil moisture. Desalination will also be obstructed if drainage khals are not regularly maintained and re-excavated.

This situation is characterized in Polder 73/2 of South Hatia where soil salinity levels inside the polder are similar to those outside the embankment.

Figure 4.7.1 Map of Study Area showing May and October 2ds/m salinity gradient



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All efforts must be made to prevent resalinization of soils through flooding with sea water. Such flooding will damage standing and succeeding crops and delay the cultivation of Rabi crops followed by pre-monsoon (Aus) crops.

Consideration must be given to the possibility of using compartment embankments to reduce drainage congestion inside a poldered area. These embankments facilitate water management by proving control over water entering the main drainage system during periods of high rainfall.

Compartment embankments will also facilitate road communication inside the polder. This will prevent distortion of catchment areas of sluices by LGED/UP roads and footpaths. Appropriate planning will minimize expense on bridge and culvert construction.

Land reclamation and development will only be effective with adequate levels of competent institutional and technical support. Institutional development must ensure a capability to handle issues such as the selection and organization of settlers on the new land, organizing of supporting services and for the O and M of infrastructures.

For operation and maintenance of structures and other applied elements a two tiers water users organization has to be considered.

A first tier will be formed by a WUA (Water Users Association), which will participate in water management affairs concerning the entire polder. Co-ordination at between the water users and the various government departments (DAE, DoF, Forestry, BWDB) and NGOs will be arranged by the establishment of a polder council (PC) headed by TNO as its Chairman.

Water users do not form a homogeneous group but are formed by different interest groups or stakeholders such as farmers, fishermen, boatmen, landless women and eventually local traders, shopkeepers.

A second tier, will be formed by compartment committees or sluice committees. Water users committee will be responsible for the day to day operation of sluices and water levels in main and secondary drains.

Participation of water users should result in better identification of maintenance needs, planning, implementation and better operation. The practice of today is that sluices are operated by influential persons or fishermen who take lease of khals for fisheries. The interests of these stakeholders are in most cases conflicting. Transparent rules need to be formulated with the users to describe the primary and secondary functions and the use of infrastructure. Public supported enforcement of these rules will be required for its implementation.

Reliable and regular up dated scheme data, reflecting the actual status of the scheme are necessary for any planning. The over all objective of collection and processing of basic scheme data is to optimize the performance of the scheme.

At present, O&M operations are hampered by inadequate levels and poor quality of field level information and an inefficient planning procedure. Administrative procedures are too centralized, resulting in a lack of transparency and accountability in budget provision.

In estuary development processes, these features will be acknowledged and appropriate accommodations made to expedite implementation.

The most important role of beneficiary participation is in planning (water management plans, maintenance work plans and maintenance time schedules), monitoring and implementation (feed back from the field, supervision of works). Beneficiary participation will also include cost recovery (financial accountability of BWDB), participation in operation (of small structures) and maintenance (of small canals and structures).

In future planning of operation, all stakeholders will be heard and their demands will be forged together into a coherent plan. It is here that the beneficiaries will have their greatest influence. The Water Users Committee (WUC), Water Users Association (WUA) will be the body that approves the water management plan prepared by BWDB, DLWU in co-operation with all other water users.

Future planning of maintenance of MES projects will consist of preventive maintenance, periodic maintenance and emergency maintenance, following the concept of SRP.

Water levels and discharges will be controlled through the implementation of a water management plan. Transparent rules for the operation of all hydraulic structures will base to be formulated with the users.

Maintenance works must be implemented to keep the system functional. Realistic and appropriate planning and budgeting procedures will be designed and introduced to ensure that available funds most effectively take care of the most urgent need.

Appropriate procedures will be designed and implemented to ensure monitoring of all activities to meet specific requirements of operation and maintenance.

4.8 Rural infrastructure

The anticipated and sustained levels of success of development initiatives associated with Development Plan implementations will, to a large extent, reflect the level of infrastructural support provided by the several associated agencies. Principal responsibility for the provision of this support clearly lies with respective government departments. Support services are conveniently categorized as either physical or social infrastructure.

The provision of both physical and social infrastructural support services will be phased over the duration of respective project area development programmes. A rural road, for example, proposed as an essential pre-requisite to the marketing of produce in excess of self-sufficiency, may only be possible if built on a causeway or embankment. In areas where land accretion is a principal project objective such a construction may only be feasible some years after project completion.

The enhanced Monitoring and Evaluation capability to be established in WARPO must be geared to identify needs for infrastructural provisions throughout the succession of land management strategies in respective project areas.

Many of the projects will include land accretion as an important feature. It is unlikely, however, that accreted areas will be occupied by settlers for some years. Areas accreted will be brought under some form of management (including forestry) at the earliest opportunity and this may result in a substantial increase in local population numbers. Where this happens provision must be made for corresponding increases in cyclone shelter provision. This issue must be given priority as, for some years, these *char* areas will remain outside of any embankment.

Throughout the coastal zone household economies will be dominated by combinations of agriculture, livestock and fishing.

At the time of project identification and preparation (appraisal) an assessment must be made of respective sector *thana* offices and associated extension capabilities. This assessment will take the form of an institutional needs analysis.
The resulting project document will include a component aimed at providing sufficient numbers of trained field officers and material support. Shortage of transport is likely to be identified as a widespread shortfall.

Schools, health centres and drinking water provision will be given high priority and hence be provided as components to be included in the initial project preparation and implemented alongside other designated components.

Coordination must be established amongst those government departments responsible for infrastructure provision. Responsibility for this coordination and the management of their sequential provision will lie with the Coastal Zone Management Officer in WARPO.

Rural infrastructure is expensive to provide and adequate provision must be made for its maintenance before implementation. The identification of infrastructural needs must be made in the context of the pre-identified economic development potential and its proposed realization. In other words, the provision of rural infrastructure must be targeted at facilitating exploitation of a pre-identified economic development potential.

Timely provision of physical constructions, such as school buildings and medical centres, will be essential though not adequate. Essential human resources, such as teachers and trained medical staff, must be engaged. In these remote areas special incentives will probably be needed to ensure adequate staffing levels.

4.9 Land Distribution and Settlement

A strategy is proposed which must guide preparation and implementation of development initiatives throughout the Meghna Estuary Study Area. The strategy comprises provisional criteria to be consulted by respective regulatory authorities in their evaluation of proposed development initiatives in the Area.

The selection of *chars* must be undertaken within the larger context of GoB policy on coastal development. It is essential for the credibility of the whole Meghna Estuary development initiative that the procedure for selection be totally transparent and based upon a set of objective criteria, rather than reflecting personal, financial or technical interests. A series of selection criteria must be discussed and decided upon by all agencies (and prospective settlers) involved in char settlement.

An important issue in this regard is that being selected for development intervention will be to anticipate the investment of considerable amounts of financial aid and other assistance. For this reason there will likely be lobbying by those with interests in particular chars that 'their' char be chosen as a focus of development project activities.

An intervention must be associated with the exploitation of some pre-identified potential for economic development. It is anticipated that these potentials will be land-based with some form of household based farming system approach. In many areas fishing must be an important feature of household economics.

A possible exception to this stipulation is where interventions are targeted solely on protection measures. A successional land and resource management strategy has to be identified before settlement takes place. This reflects the characteristic successional ecology of these coastal areas.

A rural development component must be introduced and described during project identification and project preparation and appraisal. A suitably financed and staffed project for this component must be included to enable the potential for economic development to be realized.

Appropriate infrastructural support will have to be provided, thereby ensuring for participants adequate levels of physical and social security. Shortfalls in physical and social infrastructure necessary to support and sustain the proposed economic development must be identified during project appraisal. Adequate provision will be made in the project budget to overcome these shortfalls.

The proposed intervention must be environmentally sound, exploiting as diverse as possible natural resource base; it must be sustainable and self-sustaining.

The estuary and coastal regions are of an essentially unstable and dynamic nature. Adequate provision must be made for environmental inquiry and mitigation. Farming systems and household economies should reflect a multi-sectoral management strategy as the potential of resources in particular sectors are limited and would be easily over-exploited.

Management strategies for respective plots must be developmental, changing over time, reflecting changes in local ecological circumstances. An early opportunity might be the construction of household salt (or brackish) water shrimp rearing pools.

There is much evidence from the study area that newly accreted char areas rapidly become the subject of conflicts between influential local figures seeking to extend their personal land holdings. To date, the Forestry Department has been able to establish mangrove plantations on many of these lands and such conflicts have been avoided.

At the time of planting areas will be mapped. One acre plots will be marked on the map of the area and householder names allocated to respective plots. A provisional settlement plan will be prepared and road alignments sketched in. It is essential to generate a feeling of responsibility for, ownership of, their future holdings amongst groups of prospective settler households.

Where land settlement is considered, poverty alleviation will be a prime objective with hitherto landless households being the first priority settlers. Households displaced, either directly or indirectly, by physical activities associated with project implementation must be compensated for this loss. The offer of re-settlement and associated benefits will constitute part of this compensation.

Land tenure is probably the single most important issue that must be addressed in any intervention in which rural development is prescribed. Development of natural resources on char lands is a long term and arduous process with high levels of risk. Security of tenure is a pre-requisite to ensuring settler household commitment.

Land is the prime and most valued resource. To avoid corruption and mis-appropriation of land rights the household selection process must be clear and comprehensible to all. It must be totally transparent and made with reference to a non-controversial list of objective criteria.

There is pressing need to establish several capabilities within local institutions to ensure implementation of development activities and interventions independently of project presence and/or motivations. Institutionalizing these processes will also ensure consistent levels and qualities of services and inputs.

5.0 PLANNING CONSIDERATIONS FOR PHYSICAL INTERVENTIONS

5.1 Acceleration of Accretion by Cross Dam Construction

Physical intervention by constructing cross dam will constitute a very effective method of acceleration of accretion in the estuary area. A prime reason for constructing cross dams is that they will lead to a unification of respective chars into a single land mass by closing the intervening channels and creeks.

Chars will be connected by promoting and accelerating accretion (land formation) on both sides of cross-dams. In the longer term this process promises an increase in the area of land for agriculture and improved communication.

Construction of cross-dam will accelerate accretion by reducing of flow velocity in the closed channel section and stop bank erosion on both sides of the cross dam.

The conventional methods of construction of the cross dam body consists of gunny bags filled with clayey soil. MES, however, is developing effective cost measures using *caissons* made of bamboos and *bullahs* laid perpendicular to the flow along the channel and dumping inside the *caisson* with clay filled gunny bags. This method will need precision management and programming. Synthetic geotextile fabrics will be used to function as protection of the channel bed against erosion during construction of the cross dam.

Planning and design considerations of the cross dam construction are produced below by mentioning the source where the details of these considerations can be found for any future reference.

Site selection should be made by taking care of the safety of site from exposed wave and winds, straight part of the channel with uniform bottom depth across the width, availability of good quality of filling material for gunny bags (earth having clay contents of approximately 25% or more).

Collection of data on water levels and tides, current velocities along the width of the channel to be closed, discharge measurement during both spring and neap tide, meteorological condition, soil condition and availability of its required quality, semi-detailed hydrographic survey.

Availability of sufficient borrow areas of specified filling materials including availability of other construction materials and labour on top of bottom mattresses. Detailed descriptions are provided in various reports on closure dams in tidal channels.

Determination of crest height, crest width, side slopes, selection of bed protection material, final closure gap and computation of velocities at different stages of closure operation - most importantly during final closure. Choice of closure method to be made as to whether the horizontal, vertical or combined method to be used.

This conventional type of cross dams is very costly. The MES is planning to introduce a low cost device for construction of cross dam. One such cross dam as pilot project is proposed for implementation by MES in char Montaz. The construction work is going to start from December 1997 and end in mid February 1998.

Planing and design considerations of this low cost device are collection of hydrologic and hydraulic data as mentioned before, core materials, selection of construction materials for *caisson*, crest level, crest width, bed protection and alignment of cross dam.

In designing subsequent development interventions involving the construction of cross dams, either individually or as a component in a larger project, reference must be made to the findings and recommendations of these trial constructions.

5.2 River Bank Protection and Coastal Defence Work

This includes installation of toe and bank protection to prevent river banks from erosion owing to high velocity flow, wave actions striking the river bank, rapid drop of water level, non-cohesive soils and human interference.

This can be attained by direct intervention by protecting the embankment or banks of river by means of revetment which constitutes a properly designed layer of filter material covered with graded stones or concrete block sufficiently heavy to remain stable in the current and under wave attack.

Indirect ways to deal with this is either to stop or slow down the erosion of embankments and river banks. This can be attained by: diversion of flow from the bank by construction of groynes and other low cost flow diversion devices, bottom or surface vanes or by installation of a geotextile screen to induce accumulation of sediment in the areas under erosion.

Most direct and effective way to combat erosion for bank and toe protection is the installation of revetment works. This sort of protection of river bank covers continuously the entire slope of the bank extending into the river bed.

Planning and design considerations of this type of bank and toe protection work should be such that:

- the bank soil is protected from being washed away from the action of erosion forces of flowing water and dynamic action of waves;
- the work remains stable under most unfavourable condition i.e. combination of strong current, heavy wave attack, rapid pressure fluctuation, settlement and liquefaction of the materials under the revetment;
- it resists destructive action of men, animals, vegetation etc.

To achieve the condition above the revetment has to be designed taking appropriate design considerations. These include:

- The dimensioning and layout of the revetment based on surveys, and types of the revetment to be selected whether to be of open joint type or closed joint type.
- Hydraulic and hydrologic factors for design of structural elements constitutes collecting data on water level, discharge, flow velocity, wave height; and determining anticipated scoured bed level of river including at what frequency of water level and discharge the revetments need to be designed.

- Stability of revetment under current attack. This has to be based on established equation relating to the size of the revetment materials. This relates to weight, dimensions of stones and other factors like velocity, water depth, slope of bank, etc.

- Stability of revetment under wave attack. This also relates to computation of the size of the revetment materials as per available methods and equations to resist against wave attack to the surface of the revetment.

- Toe protection methods of revetment. This relates to protection of revetment by extension to maximum scour depth and placing launchable stones, This also constitutes the determination of the dimensions, thickness and size of stone in launching apron.

- Selection of filter materials: This is one of the most important component as the stability of the whole revetment depends on the type and composition of the filter layer. The function of the filter is to prevent migration of subsoil particles out of the bank slope and to allow at the same time the movement of the water through the filter. Two types of filters are used, the granular filter and fibre filter. Both these filters are designed taking into consideration the retention criteria and permeability criteria whereas granular filter is made of loose, bounded or packed grains and the fibre filter is made of natural or synthetic materials like geotextile.

River bank protection and coastal defense works can also be done by construction of groynes. The groynes are dams more or less perpendicular or at certain angle to the bank protruding into the channel. Construction of groyne does not provide any direct protection to the bank under erosion but if the method if planned and implemented properly, this keeps the erosive flow at a distance from the bank and thus prevents erosion.

The cost of protection by groynes is less expensive than that of the revetments but it is not as effective as the revetment works. Moreover the design of groynes should be done with caution. Experience acquired in other projects has to be taken into account; all relevant characteristics of the construction site have to be collected; and possible mathematical and physical models have to be built to avoid any uncertainties, which may lead the whole thing to a very costly surprise.

Planning and design considerations in respect of bank protection by constructing groynes are indicated below:

- Selection of types of groynes and the materials used should be determined. Types may be of (i) submersible or non submersible (ii) permeable or impermeable (iii) attracting, repelling or deflecting (iv) single or a series of groynes;

- Hydraulic and hydrological factors such as water level, discharge, flow velocity, current pattern and velocity, wave heights and other characteristics of wave; and the anticipated scour bed level of the channel have to be established;

- Length and spacing of the groynes should be determined in respect of shape of cross-section and extent of protection required;

- Shape of the groyne heads whether Bell head, T- head, L- head and Hockey stick-head should be determined;

- Cross section and orientation of the groynes should be ascertained based on experience. A groyne may be permeable or impermeable depending on the condition of the sites where the groynes are to be installed and most importantly the orientation should be based on proper judgment and if possible either physical and mathematical modeling should be done to ensure the stability and effectiveness;

- There are other types of protection works as bamboo spurs, porcupines which are of limited application and are suitable for use in bank protection and river training in small and interior rivers. These are not considered effective for the Meghna Estuary areas;

All types of bank protection works mentioned above are very expensive and sometimes have to be abandoned when their cost effectiveness is computed and show very low output.

There are some low-cost flow diversion devices which can be used to check or reduce erosion by diverting the aggressive flow away from the river bank, and to initiate or enhance the settlement of sediment by diverting the flow of bed load towards it.

One such pilot project is planned under MES programme which is scheduled to be taken up during January to May, 1998. This pilot project will be taken up at Khorki at the northeast coast of Bhola.

Planning and design considerations of these low cost devices are the installation of anchor, fabrication of geotextile screens and floats, and to provide protection of shoreline.

Retired embankments.

Many stretches of the river bank on both sides of the Meghna estuary are permanently at risk from erosion damage. Rates of erosion can be spectacular, with the water course moving from side to side over a distance of one or two kilometers during a period of less than ten years.

The lands at either side of the river are susceptible to regular flooding and, although they are not saline, the volume and power of these floodwaters inflicts high levels of damage and places large numbers of people in severe danger.

In response to these circumstances the Government of Bangladesh has repeatedly emphasized the need for high embankments to be constructed along river banks. These high embankments involve high levels of capital investment. What is more, in such a dynamic environment, there is considerable risk that these costly embankments will, themselves, be eroded away before their normal economic life is finished. Not only does this expose both land and people to flooding once more, it places responsibility on Government to commit further large sums of money to retiring the damaged embankments.

Current thinking is that it might be better to accept the fact of erosion and to construct high embankments at a distance from the present river bank. The distance from the existing bank would be an estimate of the extent of bank erosion over a predetermined number of years. An indicative period might be from ten to twenty years.

Constructing high embankments at a distance of perhaps two kilometers from the existing river bank will, of course, expose large numbers of people to regular flooding and associated risks.

Measures to provide protection from these risks include the construction of low level flood barriers in place of river side embankments, and the construction of raised platforms, or *killas*, which will provide some shelter for both people and livestock.

Both flood barriers and *killas* can be constructed by low technology, labour intensive methods, thereby offering local people a supplementary cash income.

5.3 Erosion Management

Erosion management comes into consideration as temporary measure at emergency or due to time constraint, lack of fund or any other reason where the erosion protection measures become not feasible and at the same time the protection of agriculture land, lives and properties of the people from erosion becomes eminent.

This can be done by means of constructing a retired embankment at safe distance from the erosion point just to safeguard the lives and properties of the people and to contain the erosion within the retired embankment up to the time when some other alternative measures can be taken up.

This category of project also includes shifting of people and their properties to safety where lives of the people are at stake. The salvation works like shifting of people for safety of their lives and properties are generally the responsibility of Zila and Upazila authorities.

Planning considerations for erosion management have not been precisely defined in this report. These should generally depend on type, extent, environment and behavior of erosion; and at what speed and ferocity the erosion takes place.

5.4 Empoldering

Flood Protection will increase the safety of people and properties. It also opens the way for economic development, in particular agricultural development since the intrusion of saline water through tidal floods can be stopped.
The main objective for empoldering of coastal lands is to provide safety and security of life and property of the inhabitants. Unprotected land permanently inhabited by fishermen, and landless farmers can be found throughout the estuary.

Not all lands that emerge and where people start to settle can be empoldered. There are a number of considerations to take into account before empoldering an unprotected land.

The main consideration for empoldering is the land level. Land which does not attain the mean HWL shall not be considered for empolderment. Such land will face two main problems regarding;

- Drainage: Lower land levels result in a less drainage efficiency that operates by gravity. Drainage gradients will be smaller and the periods in which no drainage is possible (higher out side water levels) will increase.

- Desalinization: Natural desalinization will be slow and empolderment of lands with high initial salinity levels will delay the future benefits of empoldering. Cultivation of rabi, dry season crops (aus) and improved rice varieties will be delayed due to high soil salinity levels.

The hydraulic infrastructure of the old land has to be taken into account. Empolderment of the foreshore accreted land of an existing polder should not affect the drainage condition of the protected land.

From an economic point of view, an empolderment with a minimum embankment length and a minimum number of sluices for a maximum number of hectares will be the most attractive solution. The security and safety of life and property inside a polder can further be improved through compartmentalization into several sub polders with hydrological boundaries. This has already been elaborated in section 4.7 of this report.

5.5 Char Development

There are four important stages in development of char land in the Meghna estuary.

- Ensure protection of people and property against floods;
- Safeguard and stimulate desalinization of protected land;
- Develop an adequate drainage system for protected land;
- Improve water management of polders and develop irrigation where possible.

Char land which are relatively low remains unprotected. In some places part of the land is still too low for empolderment. Unprotected land permanently inhabited by fishermen, farmers and landless, can be found throughout the estuary. Not all lands that emerge and where people start to settle can be empoldered. There are a number of considerations to take into account such as land level, primary protection, secondary protection etc.

Interventions such as excavation of khals, placement of culverts and eventually the construction of minor seasonal embankments (creation of compartment) can improve the scope for agriculture in low lying char lands. The latter is mainly to protect a standing crop (late rabi-crop, aus or recently planted aman), in the months of March till June, when high water levels are still relatively low, but open water salinity levels are in most cases too high.

5.6 Miscellaneous Measures

These measures include development of tidal mudflats by taking up appropriate measures to induce accretion process and also taking up other measures as and when felt necessary. Planning and design consideration of accelerating accretion to raise the level of land already in natural formation are presented below.

- Small scale intervention for accelerating accretion: A method for accelerating sediment deposit in an area which is already in formation can be achieved by constructing sedimentation fields comprising making of compartments by bamboo groynes filled with brushwood. However the cost effectiveness of such measures is doubtful;
- Planting of mangroves on young chars. This is generally done by Forest Department.

6 IMPACT ASSESSMENT

6.1 Project Assessment

The aim of the final Master Plan and Development Plan for the Meghna Estuary Study is to draw up a phased management and intervention strategy for the long term development of the area. The Master Plan is to be a 25 year rolling programme, whilst the Development Plan has a five to ten year time horizon.

The Terms of Reference for the Study specifically require three priority interventions to be identified and carried through to feasibility study. In addition a further three interventions are to be identified for pre-feasibility study.

The methodology for assessing such proposed interventions in Bangladesh has been drawn up and is given in the Guidelines for Project Assessment (GPA), (Ref: FPCO, 1994). These Guidelines include the methodology for economic and financial analysis, but also recognise that there are many benefits of interventions which cannot be judged purely in economic terms.

This is particularly true of social impacts which can be difficult to quantify, let alone place an economic value against. In order to allow a relative assessment to be carried out a multi-criteria analysis is to be used which allows for prioritisation of expected benefits in relation to policy objectives. The GPA also gives methodologies for assessment of agricultural and fisheries benefits.

For regional studies it is first necessary to build up a baseline assessment of the area and identify future trends. These trends include those that are naturally on-going and also those that are due to existing and already proposed human interventions.

Once the overall policy objectives for development in the area have been established and constraints to development identified then a phased management and intervention programme can be drawn up.

6.2 Environmental Assessment

The scope of environmental assessment covers both the natural environment and the human environment, their interaction and particularly induced change caused by proposed human interventions. The basic philosophy followed for environmental assessment follows that outlined in World Bank Operational Directive 4:01.
In 1992, the Flood Protection Coordination Organisation published a set of Guidelines for Environmental Impact Assessment (EIA) for the water sector in Bangladesh. These Guidelines are supported by a Manual for EIA, prepared by ISPAN and published in 1995.

The methodology for EIA requires that the present environmental situation in the Study Area is investigated and understood so that the key environmental constraints to development can be identified. The baseline assessment work carried out so far for the Study Area indicates that the key parameters are erosion and accretion processes plus the risk from cyclones. The environmental assessment work then needs to predict the likely future situation in the area without any new interventions.

For Project level EIA predictions need to be made (particularly using the outputs of the hydro-dynamic modelling) as to the likely future with intervention situation. Such analysis allows identification, quantification and, where possible, valuation of the predicted impacts, both positive and negative, that are due to the intervention.

The overall aim is that no person should be made worse off as a result of the intervention, and any predicted negative impacts have to be mitigated for, either by avoidance or implementing specially targeted programmes.

Mitigation programmes are to be incorporated into an Environmental Management Plan (EMP) for the area, the implementation costs of which are to be included in the economic and financial analysis of the proposed intervention.

The outputs of the EIA are to feed into the multi-criteria analysis and then the economic and financial analysis of the project. A residual environmental analysis is also carried out which identifies those negative impacts where mitigation measures are unlikely to be fully effective.

There is also a requirement for public participation in the EIA process. Such work has to address the possible differing priorities of various social groups and those in a variety of locations, both inside and outside the project intervention area.

6.3 Multi-Criteria Analysis

The EIA will be a component in a multi-criteria analysis. This will enable prioritisation of development issues in respective areas. These judgements will be based upon criteria and objectives decided upon earlier. A multi-criteria analysis ensures that both quantifiable and non-quantifiable issues are allocated appropriate levels of importance in decision making. The outputs of multi-criteria analysis will thus be incorporated into economic and financial analysis of respective proposed intervention.

Guidelines for Project Assessment (GPA) state that multi-criteria analysis does yet have limitations. To meet these shortcomings in the context of MES GPA will be supplemented by Simple Multi-Attribute Rating Techniques (SMART). This involves a technique to reveal the preferences of decision makers towards the ranking of alternative projects or components.

Annex A **MES Physical Interventions**

Plans for possible civil engineering and reclamation works have been studied. works to be included in the Master plan should be related to:

- erosion protection and prevention
- accretion of new land
- empoldering and development

The selection of engineering interventions is based on a review of existing reports, such as LRP and FAP, studies of ongoing activities in the estuary area and elsewhere, field visits to familiarize with project area and its civil engineering aspects.

Study of primary and secondary protection system, civil engineering inventories of existing projects, visual survey of morphological changes, small scale interventions both for erosion and accretion and low cost method for construction of cross dams has been completed.

Although the potentials for reclamation of new land would be the main objectives for the preparation of master plan for the estuary, there are other considerations like coastal protection, charland development, navigation route for seagoing and for coastal/inland navigation and fisheries which have also been considered. Accordingly the protential intervention or projects have been identified and listed in Table 1.3.1, above.

Based on results and findings of combination of review and study activities, 79 sub-projects are preliminarily proposed under the following categories.

- Cross dam	project type - A
- Bank protection	project Type - B
- Erosion Management	project type - C
- Empoldering	project type - D
- Char development	project type - E
- Miscellaneous measures	project type - F

A short description of the interventions and their type are given below. A list of project zones and sub-zones is presented in Table 4.4.1 and a map showing the projects in coded form can be found as Figure 4.4.1, on pages included in this annex.

Sub-zone area A1 of MES at South Bhola comprises Char Biswas, Rangabali, Chota Baishdia, Bara Baishdia complex at South-west of Bhola and Char Montaz, Kukri Mukri complex at South of Bhola.

In the Char Biswas Rangabali, Chota and Bara Baishdia complex there are 9 proposed cross dams, 3 empoldering and 4 char development projects. There are several tidal channels, rivers, canals and creeks in this area which will contribute to accretion at both up and downstream if intervened through cross dam creating an integrated land mass.

Considering the above idea cross dams over 3 creeks at Rangabali and 3 creeks at Char Biswas have been proposed to bring each of them into a single unit. Subsequently these two units will be connected together by constructing a cross dam over the channel between Rangabali and Char Biswas.

Land thus formed will be extended further by connecting Char Biswas with Kachur Char and Rangabali with Char Kashem through cross dams. Thus by constructing 9 proposed cross dams an integrated land mass extended between Kachur Char at north and south end of Bara Baishdia at south will be developed.

The above process will then be followed by empoldering the Char Bara Baishdia-Char Ganga; and North coast of Char Biswas and Kachur char after they attain height above 2.00 m PWD.

Development of the chars may be done in both unprotected and protected lands. Improvement of drainage system by re-excavating the existing channels, compartmentalization by temporary dykes, provision of culverts, household forestry etc may form part of the components for char development on unprotected lands. On protected land improvement of drainage facilities by additional sluices if needed, re-excavating the existing channels and removing artificial barriers from the drainage routes may form part of the components for char development.

Other components may be the improvement of road communication in co-ordination with LGED and Union Parishads, improvement of marketing, health, sanitary and education facilities. The above items along with some other appropriate ones may be taken up for char development in both Char Biswas-Rangabali and Chota Baishdia-Bara Baishdia Complex as well as in Char Montaz-Kukri Mukri Complex.

In the Char Montaz- Kukri Mukri Complex 3 nos of cross dams have been proposed over internal creeks of char Montaz to make it a continuous land mass through accretion. This land mass will be connected with Bhola main land through another cross dam. On the eastern side the char Kukri Mukri will also be connected with Bhola main land through a cross dam. These will help development of an integrated land mass connecting the entire Char Montaz-Kukri Mukri complex with Bhola island. In the next stage the land will be developed through char development system and protected through empolderment.

The subzone area A2 at North Bhola and Bhola east coast covers Khorki and Chowkighata-Tazamuddin area. Opposite to Khorki coast there is a series of chars under formation.

These chars may be interconnected through cross dams to make it a land mass. There is erosion at Khorki and Chowkighata-Tazamuddin Coast line. Protective measure and accretion accelerating process at Khorki coast will help reducing the channel section in between Khorki and the char lands. Bank protection at Chowkighata-Tazamuddin bank is needed to protect the coast line from erosion.

Subzone area A3 covers west side of Bhola island comprising Char Yunus, Char Kushum and Gangapur Coast. Char Yunus has two components - north and south which are proposed to be connected through a cross dam to be constructed to accelerate accretion of the channel in between.

The Gangapur coast of Bhola is under erosion threat and needs to be protected. Char Kushum and Char Yunus are not yet protected and are proposed to be empoldered after they attain the height of above R. L. 2.00 m PWD. Char development activities at these two chars may be taken up simultaneously.

Subzone area B1 covers South Hatia-Nijhum Dwip and Damar Char Area. The Channels in between South Hatia-Nijhum Dwip and South Hatia-Damar char are of accretion type. But past experience indicates that these channels will not be completely silted up foreseeable future without intervention.
Two cross dams in between these two gaps are recommended which will help connecting these two islands with South Hatia through accretion over a large area. At West Hatia coast there is embankment under erosion threat where the bank protection work has been proposed.

A large area of land has been accreted outside the existing embankment at South and South-East side of Hatia. This land is partially being used for agriculture and partially for afforestation by Forestry department.

This land, Nijhum Dwip, Damar char and the expected accreted land due to construction of the two cross dams will form a unit land mass which will be empoldered after attainment of height above 2.00 m PWD. Char development activities are also to be taken up in the area for development of drainage, irrigation, communication system.

Subzone area B2 covers Monpura island. This island may be connected to Bakshi Majhir char at north and Char Nizam at South through cross dams to accelerate accretion in the channels to make it a single land mass. At West Monpura Coast of concave shape there is erosion threat which needs bank protection measures. Accordingly the bank protection work has been included in the planning.

Subzone area B3 covers Hatia island at North. There are a number of islands in between North Hatia and North Monpura which may be interconnected through cross dams. A cross dam is recommended in between Moulvir char and Dhal char, Dhal char and Char Parvez to connect the chars which will finally be connected to north Hatia by another cross dam in between. These cross dams along with cross dams in subzone area B2 at north Monpura will make an integrated land mass together with North Hatia and North Monpura.

North Hatia is under severe erosion since long. A large part of North Hatia has been eroded away requiring the island to be protected through Bank Protection system. Moulvir char and Dhal char along with the expected accreted land due to cross dam intervention need to be developed through char development process and as such the provision has been kept in the list of projects.

The subzone B4 consists of left bank of Meghna starting from Chandpur down to Char Alexander at Noakhali and also Char Gazaria. There is a series of chars along the coast near Raipur and Lakshmipur. Cross dam is proposed to interconnect all the chars. There is tendency of erosion in this coast.

Bank protection is needed at Honor char- Haimchar and along almost the full length of east coast of Meghna starting from Raipur upto Char Boya. However, rate of erosion at Ramgati is more and as such erosion management measure has been proposed. Char Gazaria situated at the midstream of Meghna may be empoldered and char development activities may be taken up there.

Subzone C1 includes island and accreted mudflats at South of Noakhali Sadar Thana. Sandwip Urirchar Complex falls under subzone C2 and C3. Proposed Sandwip cross dam between Char Lakhi, Urirchar and Sandwip will accelerate accretion in this area helping to develop a land mass extending westward upto South of Char Clark. Erosion continues at west and south of Sandwip where bank protection and erosion management is proposed.

Char Buoya, Urir char and Char Pir Baksh may be empoldered to protect them from flood after they attain height of above 2.0 m PWD. Simultaneously Char Development activities also should continue. There are mud flats at South of Char Clark which are slightly above or below low water level. Appropriate measures will be taken up to raise these mudflats by enhancing accretion.

Muhuri and Little Feni accreted areas fall under subzone C4. Muhuri accretion area may be empoldered after attainment of height above 2.0 m PWD. Simultaneously char development process also may continue both at Muhuri and Little Feni accreted area.

Annex B

A DRAFT MASTER PLAN FOR THE MEGHNA ESTUARY

1.0 Introduction
1.1 Background
1.2 Objectives of this report
1.3 Expected outputs

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2.1.1 Morphological aspects
2.1.2 The Processes of Accretion and Erosion
2.1.3 Climate

3.0 Social and Administrative Setting
3.1 Demography and population
3.2 Income levels and sources of income
3.3 Administrative structure and responsibilities
3.4 Government policy and land settlement
3.5 Gender Issues

4.0 Land Reclamation
4.1 Morphological aspects
4.2 Projections of accretion
4.3 Scenarios of coastal char land development
4.4 The role of afforestation

5.0 Protection Measures
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5.1.2 Hydrological and Hydraulic Considerations
5.1.3 Bank protection
5.1.4 Coastal protection
5.2 Secondary protection
5.2.1 Flood/cyclone forecasting and warning
5.2.2 Disaster preparedness and management
5.2.3 Cyclone shelters
5.2.4 Environmental mitigation programmes
5.2.5 Afforestation

6.0 Infrastructure
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6.5 Harbours,
6.6 Markets and trade
6.7 Health provision: water/seasonal variation
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7.0 Socio Economic Profile
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7.3 Existing community level organisations
7.4 Industrial and private sector involvement
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8.1.3 Agricultural crops
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8.1.5 Homestead production and tree crops
8.1.6 Farming systems development
8.1.7 Existing and recent programmes and projects
8.2 Forestry
8.2.1 The coastal zone forest resource and classification
8.2.2 Existing Forest Policy, regulation and control
8.2.3 Existing and recent programmes and projects, research and implementation
8.2.4 Social forestry
8.3 Fisheries
8.3.1 Marine and inland fisheries
8.3.2 Species and production levels
8.3.3 Local and international trade
8.3.4 Regulation and control
8.3.5 Existing infrastructure provision
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8.3.7 Present fisheries constraints and mitigation

9.0 Integrated Land Management

9.1 Inside embankments
9.2 Outside embankments

10.0 Environnmental considerations for development

10.1 Sociological
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10.1.2 Education and literacy
10.1.3 Health and nutritional levels
10.1.4 Family planning
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