DGIS/DANIDA

GOB

MINISTRY OF WATER RESOURCES

BANGLADESH WATER DEVELOPMENT BOARD

MEGHNA ESTUARY STUDY

Volume - 1

INCEPTION REPORT

(MAIN)

APRIL 1996

DHV CONSULTANTS BV

in association with

KAMPSAX INTERNATIONAL
DANISH HYDRAULIC INSTITUTE
RESOURCE ANALYSIS

DEVELOPMENT DESIGN CONSULTANTS
SURFACE WATER MODELLING CENTRE
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EXECUTIVE SUMMARY

1 Introduction

The Meghna Estuary Study (MES) is a component (FAP 5B) of the Flood Action Plan (FAP). The project is being implemented under a cooperation programme between the Governments of Bangladesh, The Netherlands and Denmark. The executing agency is the Bangladesh Water Development Board (BWDB). The coordination with other projects under the Flood Action Plan is to be maintained by the Flood Plan Coordination Organization (FPCO), now WARPO.
The Meghna Estuary Study can be considered as the follow-up of the "marine based" activities of the Land Reclamation Project. The main goals of the study are to retain and increase the operational knowledge of hydraulic and morphological processes in the Meghna Estuary and to develop appropriate approaches and techniques for efficient land reclamation as well as effective river bank protection measures. In the long term the physical safety and social security of the people living in the coastal areas and on the islands in the estuary should be improved.

The objective of this Inception Report is to elaborate the Terms of Reference for the Meghna Estuary Study, dated November 1992, as well as other documents annexed to the invitation to prepare a proposal for the execution of the Meghna Estuary Study Project - FAP 5B.
The Inception Report includes a firm Project Implementation Plan for the 32 months project period as well as confirmation of the approach and methodology to be followed. Several changes in approach, planning aspects and project activities as given in the Terms of Reference have been recommended in the Inception Report.

Prior to the Inception Report an Interim Inception Report was prepared and submitted to BWDB and the Royal Netherlands Embassy in December 1995.

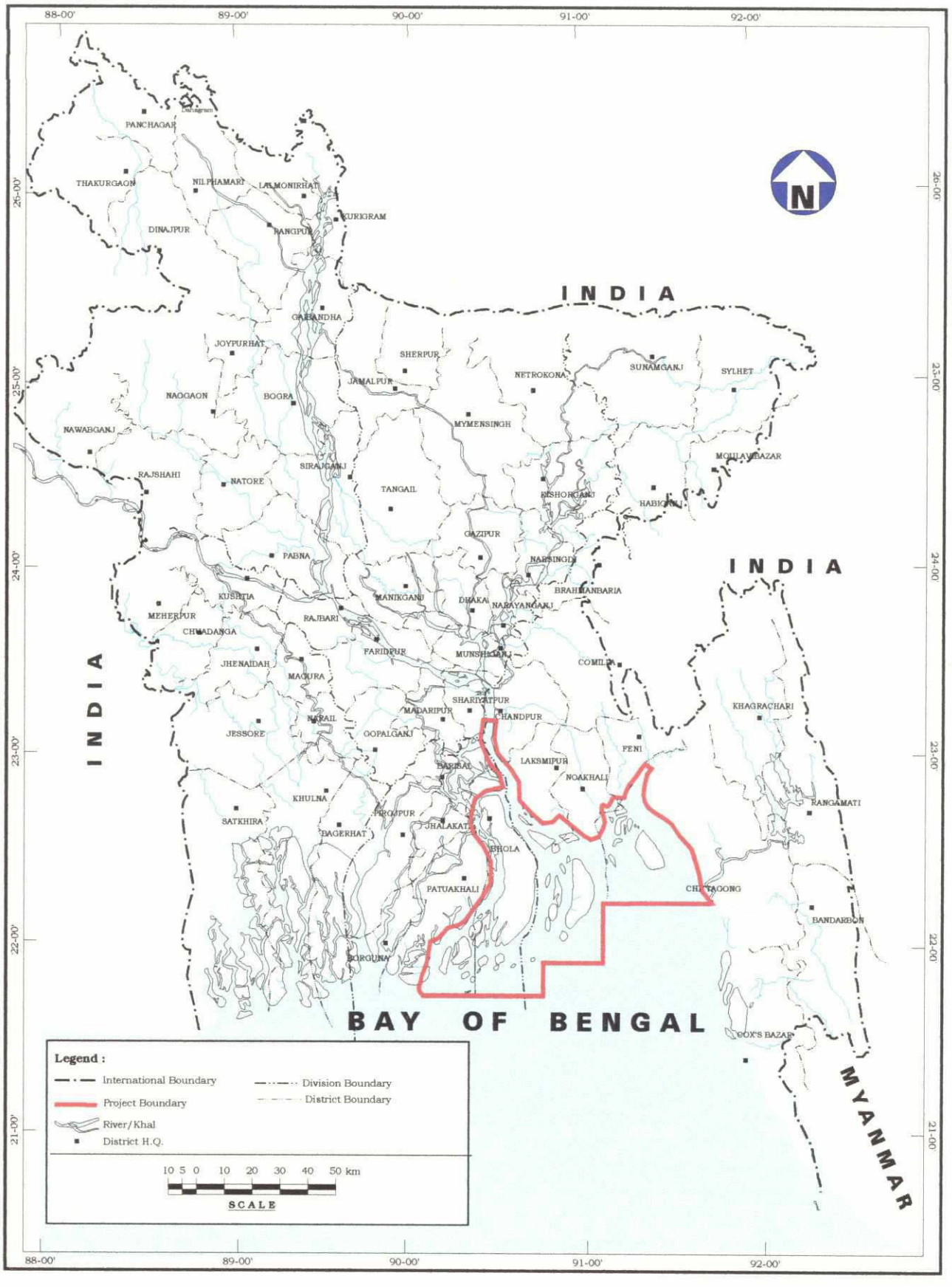
2 Background

The MES area covers the Lower Meghna river from Chandpur town (the downstream extent of FAP9B) to the Bay of Bengal. See also the following pages, showing the location map of the Meghna Estuary Study area and the map with the boundaries of the project area.
For comparison the estuary of the Rhine-Meuse-Scheldt river system has been added on the latter figure at the same scale as the estuary of the Padma-Jamuna-Meghna river system.

By spontaneous intervention of the local population or by specific action of government organizations, land has been reclaimed and embanked along the coast of Noakhali and some of the coastal islands, notably the activities under the Land Reclamation Project (LRP, 1977-1991) and the ongoing Char Development and Settlement Project (CDSP).
Drainage congestion and water logging are considered main obstacles for agricultural development of flood protected areas situated in the Meghna Estuary. Drainage congestion occurs when excessive rain water cannot be removed in time by a drainage system. Such a situation may be more pronounced in the estuary compared to other areas of Bangladesh due to the construction of protection embankments, sedimentation of the natural internal drainage system, land accretion near the outfall of drains, a higher rainfall, etc.
Another restriction for agricultural development in the Meghna Estuary is caused by soil salinity. The LRP studied in detail the soil salinity and concluded that the natural desalinization of accreted and protected land is a slow process. Favourable drainage conditions may accelerate this process. Previous experiences related to water management are very limited in the case of LRP. Nowadays, improved water management concepts and experiences are found with on-going BWDB projects such as CDSP, CPP and more in particular SRP.

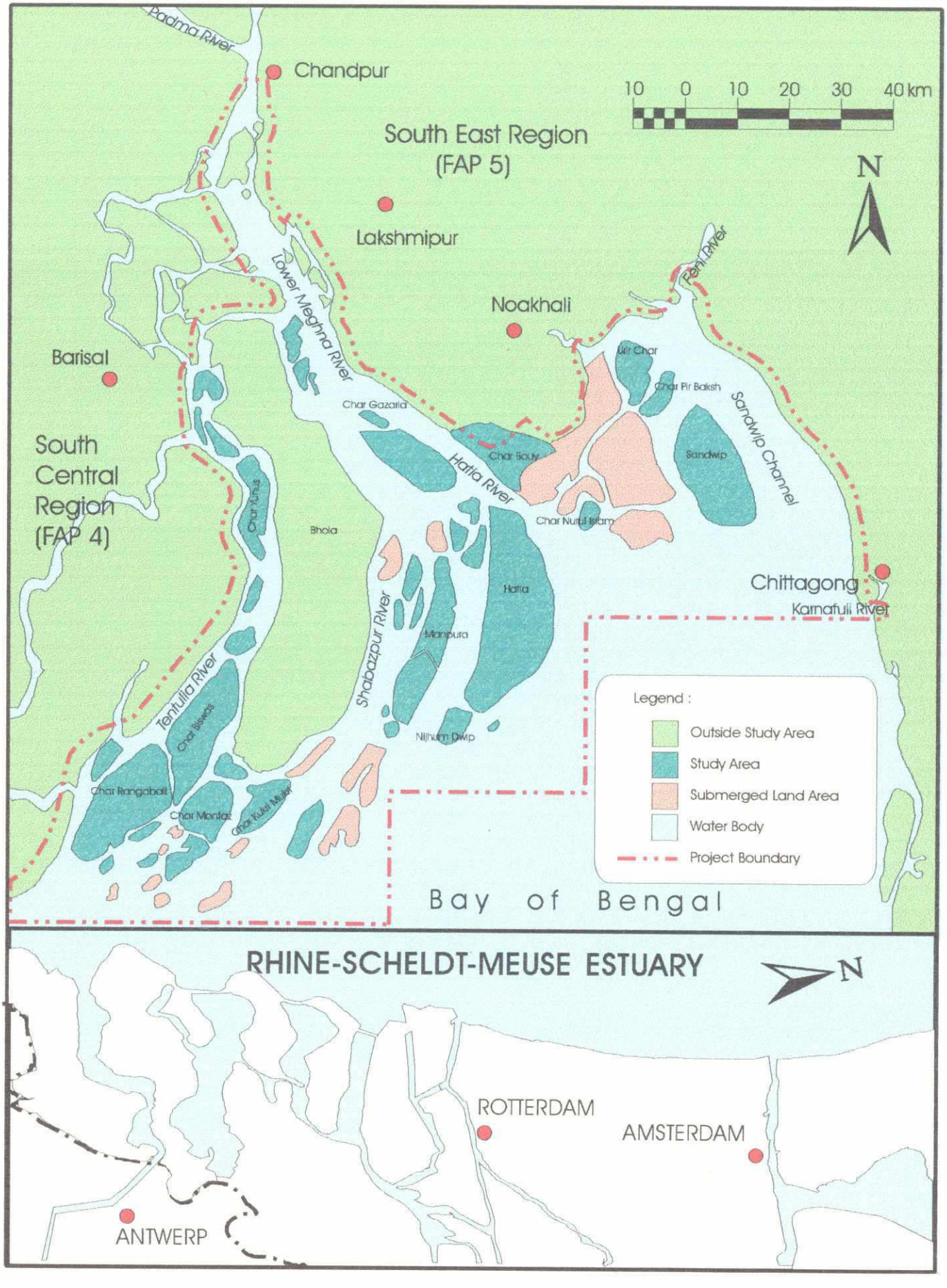
In order to fully justify the technical proposals for reclamation and protection arrangements it is necessary to create a linkage to the possibilities for settlement and rural development in the new and existing char islands, along with the provision of agriculture, livestock and fisheries for feasible settlements.

Location of Meghna Estuary Study Area



PADMA-JAMUNA-MEGHNA ESTUARY

SCALE 1:1,000,000



3 Project description

The description follows the logical frame work sequence of objectives-outputs-activities-inputs

OBJECTIVES

The development objectives of the project are to increase the physical safety and social security of the inhabitants and promote sustainable development in the coastal areas and on the islands.

The immediate objectives are to enhance and strengthen operational knowledge of hydraulic and morphological processes in the Meghna Estuary, find suitable land reclamation and bank protection methods, increase the capacity of BWDB to reclaim new land and protect the eroding river banks and finally to prepare a plan with priority project and programmes for flood protection, agricultural and socio-economic development for early implementation.

OUTPUTS

The outputs to be expected from the Meghna Estuary Study are:

- modernized land-based and marine survey capabilities
- an up-to-date data base
- background data for rural development planning in the project area
- hydraulic and morphological studies
- impact assessment studies
- increased institutional capacity to retain and update the knowledge of the hydraulic and morphological processes in the estuary
- a Master Plan for the development of the estuary
- a Land and Water Development Plan, including a portfolio of rural development projects
- feasibility studies for priority projects and programmes
- pilot projects for establishing effective land reclamation and river bank protection works

ACTIVITIES

The activities required to be carried out during the execution of the study are summarized below.

- land based and marine surveys
  - procurement and installation of survey instruments and software
  - reconnaissance and installation of reference benchmarks and determination of x,y,z coordinates by DGPS
  - coast line and coast line gradient surveys
  - marine surveys, two monsoon seasons (flow, sediment transport and salinity) and two winter seasons (bathymetry, flow, sediment transport and salinity)
  - wave and tide recording at six locations throughout project area by special data logger and water level registration by existing instruments and staff gauges
  - sediment analysis, off-line data processing and survey data reporting

- hydraulic and morphological studies
  - collection and screening of data from BIWTA, BWDB, LRP, Meteorological Department, and other sources
  - analyses of meteorological, hydrodynamic and morphological conditions (states and processes) in the estuary
  - development of a valid reference for impact prediction and comparison
  - set-up and calibration of a nested (5400 - 200 m) grid numerical model for the estuary
  - simulation and evaluation of predicted hydraulic impact (flow, water level, etc.), and comparison with baseline conditions
  - analysis of predicted morphological impact (accretion and erosion), and comparison with baseline conditions

- institutional development
  - assessing alternative institutional arrangements for sustainable data collection and processing linked to the planning process
  - assisting in development of (a cell in) WARPO to carry out its role as macro planning organization
  - assisting in development of (cells in) WARPO and BWDB to formulate and update land and water development plans
  - contribute to feasibility studies of priority projects by identifying what institutional arrangements are needed to ensure implementation of these projects in line with the long-term objectives of MES

- socio-economic studies
  - Collection of socio-economic and general rural development data about the present situation, partly from existing documentation and partly through socio-economic surveys of selected chars
  - Close liaison with CDSP and to some extent Adrasha Gram Project
  - Liaise with Government institutions, involved in settlement and rural development
  - Preparation of inputs for Development Plan

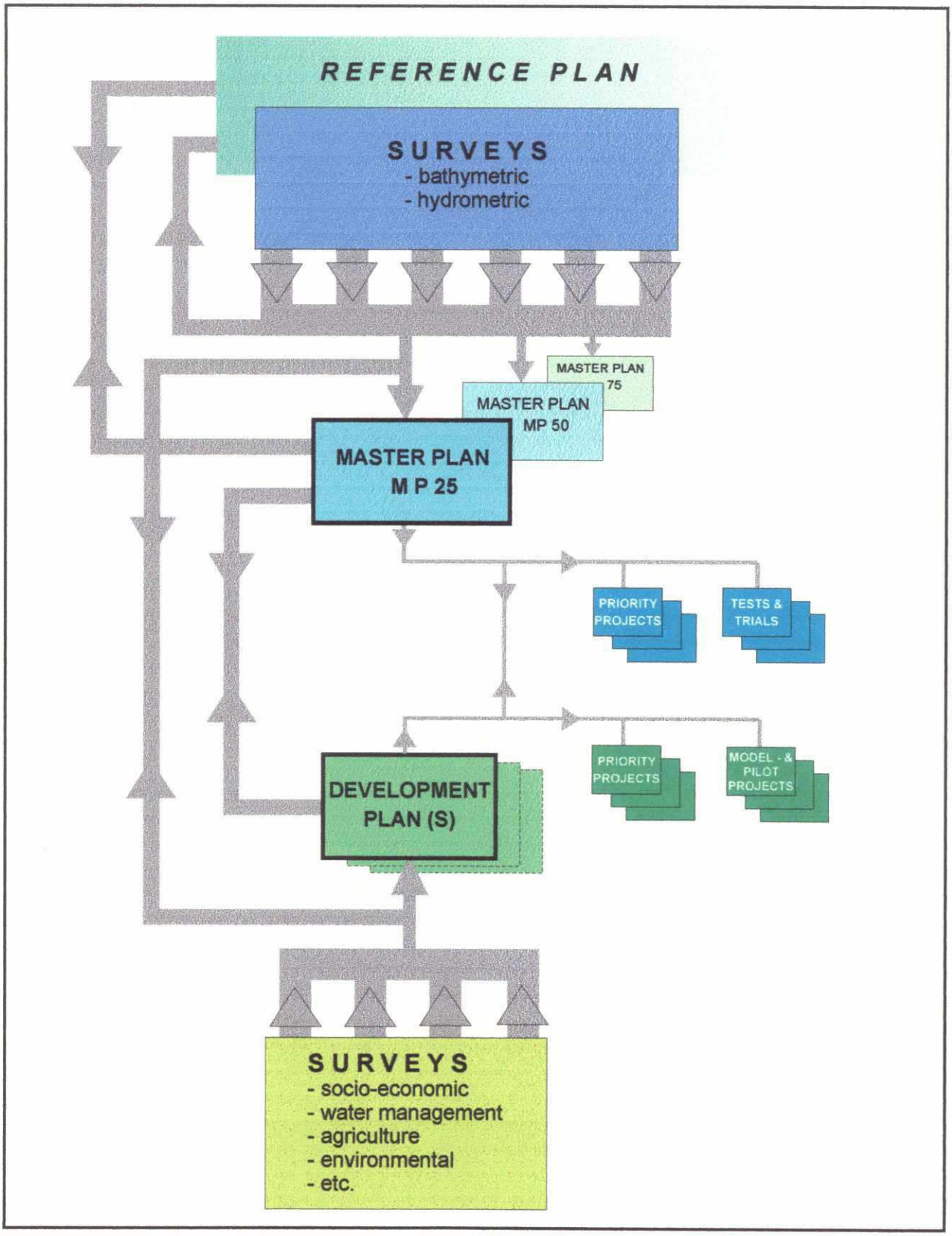
- development of reference scenarios

Especially in an environment that is as dynamic as that covered by the Meghna Estuary Study, developing realistic Reference Scenarios, is considered to be an essential first step in the master planning process. Without those, the preparation of a Master Plan would soon become an exercise in the pursuit of individual preferences and avocations, without any linkages to physical realities and without necessarily taking full account of the potentials the area harbours and of the prevailing limitations.
The expected rise in average sea levels, resulting from global warming, will definitely be a physical reality that has to be linked to the Reference Scenarios.

In attempting to define, from several Reference Scenarios, a Reference Plan that could serve as a reference for any programme of actions planned for the near and medium term future, the following criteria are considered realistic and functional:

- safeguard the fresh water pocket that is available west of the Tetulia river
- make the length of the Lower Meghna to the sea as short as possible, so as to facilitate the discharge of flood waters and to minimize the cost of future works to stabilize the river course
- shorten the coastline of Bangladesh as much as possible, to reduce the costs of maintenance of coastal embankments and of any coastal defence works, thus enhancing the safety of the protected area
- optimize the utilization of the potentials for the reclamation of new land

- preparation of a Master Plan
  - The Master Plan to be prepared during the study will comprise a realistic picture of how the project area could look like after the completion of the Master Plan, that is 25 years from now
  - while covering a period of 25 years, a Master Plan would have to be flexible, requiring regular updating, on the basis of a check of actual conditions and the verification of the impact of interventions applied. This is a continuous process indeed, for which the tools, including the institutional capabilities, should be present. This planning process and an example of a reference scenario are shown in the figures below

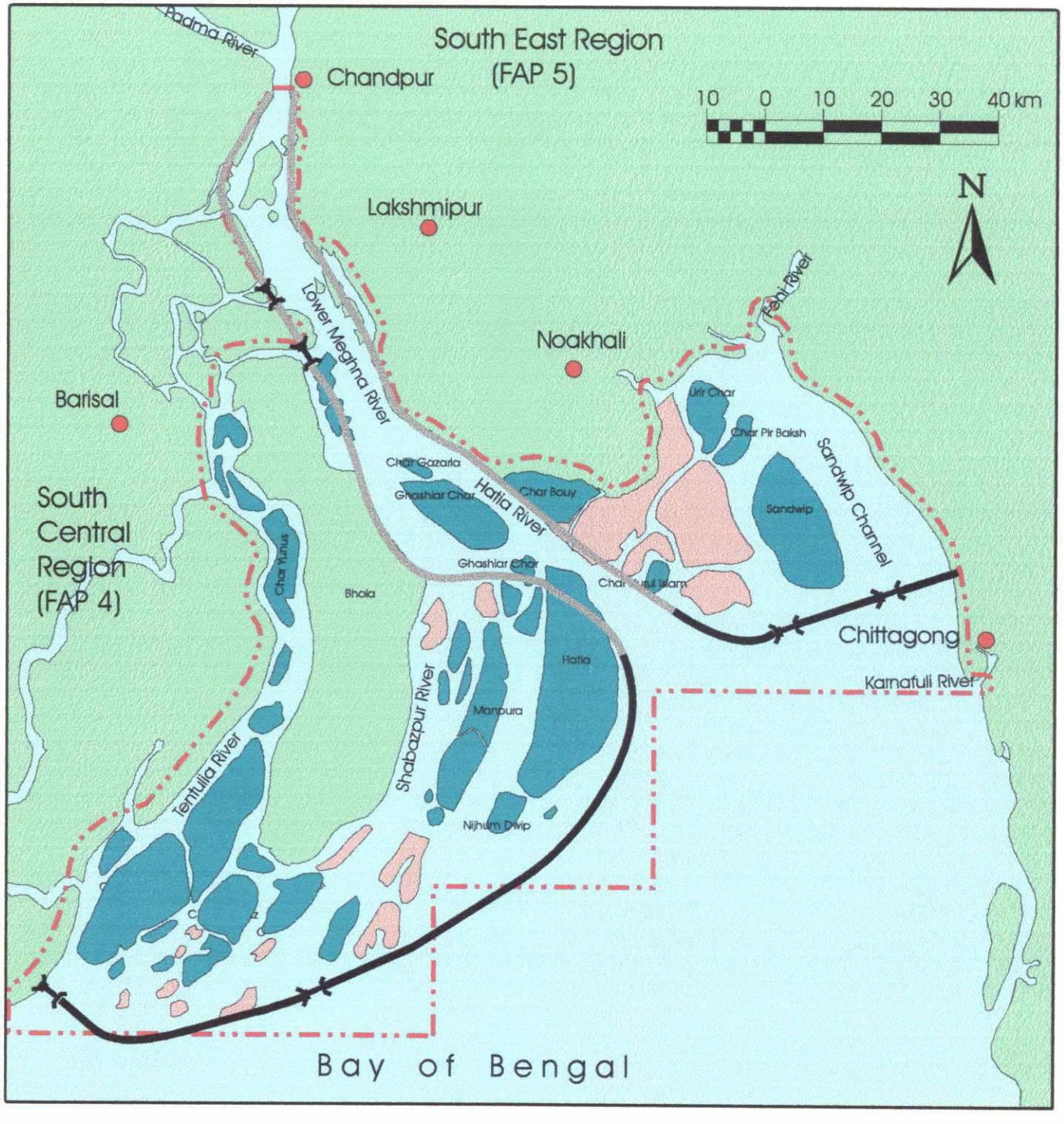


PLANNING PROCESS

MEGHNA ESTUARY

Reference Scenario

SCALE 1:1,000,000



Legend :

- Outside Study Area
- Study Area
- Submerged Land Area
- Water Body
- River embankment + training works
- Coastal embankment
- Regulator - cum - lock
- Project Boundary

Outlines : Interpreted from TM Imagery, Feb.1996

- preparation of a Development Plan
  In preparation of a development plan it is necessary to develop a realistic scenario as an essential first step in the planning process. The main approach to planning of the estuarine region should follow the principles adopted in other FAP regional studies. The planning components will include:
  - Primary Protection systems, including coastal embankments, conservation and development of the foreshore, coastal defence works
  - Secondary Protection systems including secondary embankments, cyclone shelters, protected fresh water ponds
  - Development of protected areas including settlement of new lands, water management systems and associated development of agriculture etc.
  - Non-structural and other systems, including flood/cyclone forecasting and disaster preparedness and management etc.

  The planning and designing of these works require the inputs of the local population who will be duly consulted, following the relevant government guidelines.

- preparation of Priority Projects and Programs:
  - three projects, including Nijhum Dwip that will be studied at feasibility level
  - three projects that will be analyzed at pre-feasibility level
  - a portfolio of rural development projects

- small scale interventions
  - accretion trials at promising locations
  - pilot scheme for bank protection
  - implementation of small cross dams

INPUTS

The project inputs consist of the following components:

- technical assistance (2,125 lakh Taka)
  - provision of expatriate and local experts
  - provision of survey and office equipment
  - provision of operation and maintenance
  - provision of training

- financial assistance (200 lakh Taka)
  - accretion trials
  - bank protection pilot scheme
  - small cross dam construction

- Government of Bangladesh (440 lakh Taka)
  - counterpart personnel
  - survey vessel "Anwesha" and tender boats
  - project personnel for "Anwesha", sediment laboratory and others
  - CDST & VAT

4 Implementation methodologies

The methodologies adopted in the project are as follows:

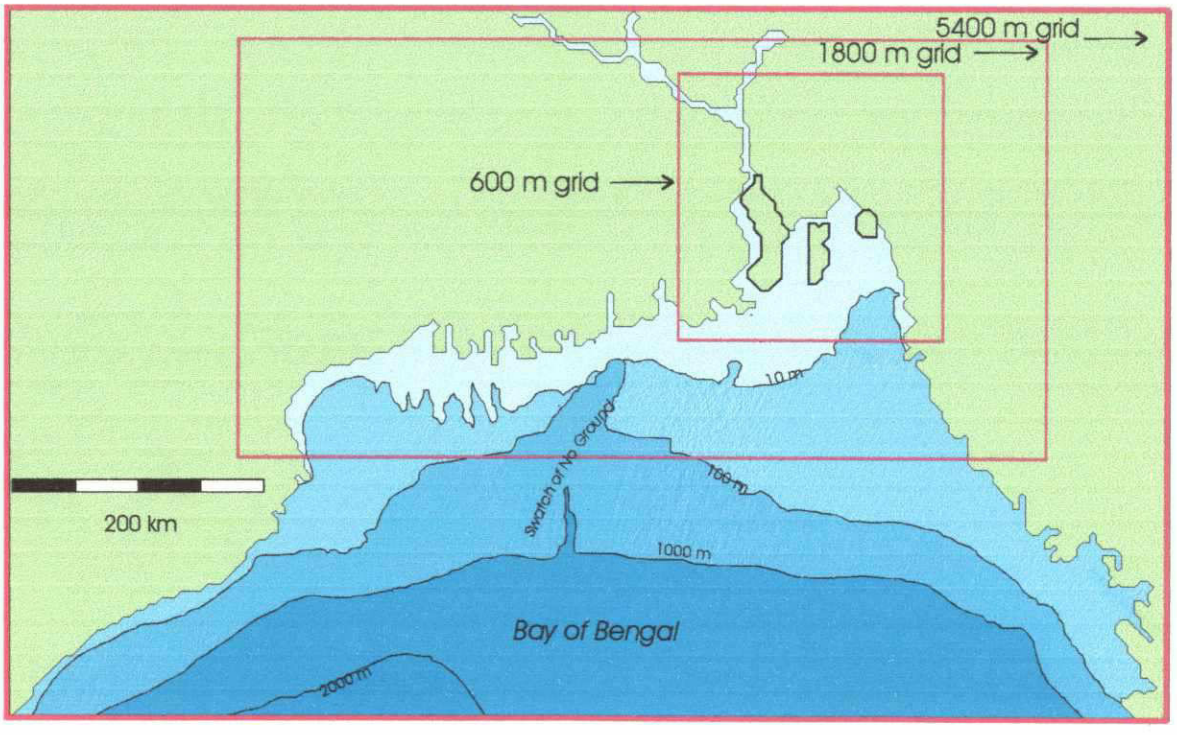
- Data collection
  - bathymetric data collection will be based on the latest DGPS-RTK technology
  - Wave and Tide recording with a logger with a large data storage capacity
  - Acoustic Doppler Current Profiler for accurate measurement of flow velocities
  - S4 current meter for recording the tidal streams

- Geographic Information System
  - capability for in-house processing and storage of existing data
  - durable optical media data storage
  - color printing and plotting

- Planning techniques
  - logical framework for efficient management of the project
  - Gantt chart for day to day planning of project activities
  - problem tree to be used during meetings or workshops with the local population and local agencies to finalize problem analysis

- Feasibility studies
  - project screening
  - updating of project assessment guidelines
  - use of the Multi Criteria Analysis (MCA) for displaying project impacts

- Hydraulic and morphological modelling
  - A 1-D (Mike11) model, covering the main river system and the Meghna Estuary (the so-called SWSMP model)
  - A 2-D (Mike21) 5400 m grid model, covering the northern part of the Bay of Bengal is called Bay of Bengal model (see also the figure below)
  - A 2-D (Mike21) 1800 m grid model, covering the entire coast of Bangladesh and main river system with Meghna estuary
  - A 2-D (Mike21) model with 600 m/200 m grid, covering the main river system and the Meghna estuary which is called Meghna Estuary Model
  - morphological computations, sediment transport, sedimentation and erosion, sediment balance



5 Organization for project implementation

- Project staffing
  - 20 expatriate technical staff, total 126 manmonths
  - 20 local technical staff, total 340 manmonths
  - 10 surveyors and junior technical staff, total 150 manmonths
  - 20 office staff

- Office equipment
  - computers and printers
  - photocopy machines
  - training equipment

- Survey equipment
  - Anwesha survey vessels, two tender boats and one rubber boat
  - positioning system and echosounders
  - current meters, including salinity and temperature measuring equipment
  - wave and tide recorders
  - sediment samplers and laboratory equipment for sediment analysis
  - computers, printers, hydro soft ware

6 Project Implementation Plan

The following Gantt charts have been provided for project implementation:

- Morphology and Hydraulics
- Civil Engineering and Reclamation
- Water Management and Drainage
- Rural Development and Socio-Economic Aspects
- Agricultural Aspects
- Environmental Aspects
- Economic Aspects
- Remote Sensing and GIS
- Institutional Development
- Expatriate Technical Staff
- Local Technical Staff
- Reporting Schedule

7 Reporting

The following reports are to be produced under this project:

- Interim Inception Report
- Inception Report
- Report on institutional strengthening of BWDB
- Proposals for small scale interventions
- Interim Master Plan
- Interim Development Plan
- Proposals for phase II Surveys and Studies
- Feasibility Report on Reassessment of Nijhum Dwip Reclamation
- Draft priority Project/Programme Preparation Report(s)
- Priority Project/Programme Preparation Report(s)
- Draft Master Plan
- Draft Development Plan
- Master Plan
- Development Plan
- Technical reports, notes and working papers
- Quarterly reports

be be

ABBREVIATIONS

ACQ	Name of Computer System for Data Acquisition
ADB	Asian Development Bank
ADCP	Acoustic Doppler Current Profiler
AE	Assistant Engineer
AEZ	Agro-Ecological Zone
AFPM	Active Flood Plain Management
AHI	Assistant Health Inspector
AIT	Asian Institute of Technology
ASA	Association for Social Advancement
AST	Agriculture Sector Team(CIDA)
BADC	Bangladesh Agricultural Development Bank
BDRCS	Bangladesh Red Crescent Society
BIWTA	Bangladesh Inland Water Transport Authority
BRAC	Bangladesh Rural Advancement Committee
BRDB	Bangladesh Rural Development Board
BS	Block Supervisor
BTM	Bangladesh Transverse Mercator
BUET	Bangladesh University of Engineering and Technology
BW	Black and White
BWDB	Bangladesh Water Development Board
CBD	Char Bagadona
CDSP	Char Development and Settlement Project
CE	Chief Engineer
CEP	Coastal Embankment Project
CERP	Coastal Embankment Rehabilitation Project
CFE	Cash Foreign Exchange
CHW	Community Health Worker
CIDA	Canadian International Agency
CIP	Chandpur Irrigation Project
CPP	Compartmentalisation Pilot Project
CSPS	Cyclone Shelter Preparatory Study
CTG	Chittagong
DAE	Department of Agriculture
DANIDA	Danish International Development Agency
DC	Deputy Commissioner
DCR	Duplicate Carbon Receipt
DDP	Delta Development Project
DEM	Digital Elevation Model
DGIS	Directorate General for International Cooperation, the Netherlands
DGPS	Differential Global Positioning System
DLS	Department of Livestock Services
DOE	Department of Environment
DOF	Department of Fisheries
DPHE	Department of Public Health Engineering
DTW	Deep Tubewell
EC	European Community
EE	Executive Engineer
EGIS	Environmental and Geographical Information System
EIAR	Environmental Impact Assessment Report
EIP	Early Implementation Project
EMG	Embankment Management Group
EMP	Environment Management Plan
EOL	End of Line
EPI	Expanded Programme on Immunization
ERD	External Resources Division
ERIM	Environmental Research Institute of Michigan

Abbreviations (continued)

ESCAP	Economic and Social Commission for Asia and the Pacific
EU	European Union
FAO	Food and Agriculture Organisation
FAP	Flood Action Plan
FCD	Flood Control and Drainage
FCDI	Flood Control Drainage and Irrigation
FFDP	Farm Family Development Programme
FFW	Food for Work
FHH	Female Headed Household
FPCO	Flood Plan Coordination Organisation
FWA	Family Welfare Assistant
FWV	Family Welfare Visitor
FY	Financial Year
GIS	Geographical Information System
GK	Ganges Kobadak Irrigation Project
GOB	Government of Bangladesh
GON	Government of The Netherlands
GPS	Global Positioning System
HA	Health Assistant
HH	Head of Household
HI	Health Inspector
HRD	Human Resources Development
HRDP	Homestead Resources Development Programme
HYDRO	Name of a computer system for data acquisition
HYV	High yielding Variety
IBRD	International Bank of Reconstruction and Development(WB)
ID	Identification (code or number)
IDA	International Development Agency(WB)
IDP	Infrastructure Development Programme(LGED)
IEE	Initial Environmental Evaluation
IETC	Irrigation Extension Training Centre(BWDB)
IGA	Income Generating Activities
IGP	Income Generating Programmme
IHE	Institute of Hydraulic Engineering
ILO	International Labour Organisation
IO&M	Improved Operation and Maintenance
IPM	Integrated Pest Management
IRWP	Intensive Rural Works Prograsmme
ISP	Institutional Support Programme
ISS	Institute of Social Studies
JICA	Japan International Cooperation Agency
LAED	Land Accretion and Estuary Development
LCS	Labour Contracting Society
LRP	Land Reclamation Project
MB	Mega Byte
MCA	Multicriteria Ananysis
MCC	Mennonite Central Committee
MES	Meghna Estuary Study
MO	Medical Officer
MOA	Ministry of Agriculture
MOFA	Ministry of Foreign Affairs
MOL	Ministry of Land
MOWR	Ministry of Water Resources
MSS	Multi-spectral Scanner
NGO	Non-Governmental Organisation
NSC	National Steering Committee

Abbreviations (continued)

O&M	Operation and Maintenance
ORS	Oral Rehydration Solution
PCP	Project Concept Paper
PIP	Project Implementation Plan
PMC	Project Management Committee
PP	Project Proforma
PWD	Public Works Department(also name of a reference level)
RRA	Rapid Rural Appraisal
RRI	River Research Institute
RSP	Rural Settlement Project
RTK	Real- Time Kinematic(DGPS)
SC	Steering Committee
SDE	Sub-divisional Engineer
SE	Superintending Engineer
SMG	Structure Management Group
SMO	Subject Matter Officer
SMS	Subject Matter Specialist
SOB	Survey of Bangaladesh
SOL	Start of Line
SPANS	A Software by ISPAN/EGIS
SPARRSO	Space Research and Remote Sensing Organisation
SPOT	French Satellite?
SRDI	Soil Resources and Development Institute
SRP	Systems Rehabilitation Project
SSD	Survey and Study Division
S/T	Salinity/Temperature(of sea water)
SWMC	Surface Water Modelling Centre
TFO	Thana Fishery Officer
THC	Thana Health Complex
TM	Thematic Mapper
TNO	Thana Nirbahi Officer
TOR	Terms of Reference
UNDP	United Nations Development Programme
UP	Union Parisad
WARPO	Water Resources Planning Organisation
WGS 84	World Geodetic System 1984 (a geodetic model of the earth)
WID	Women in Development
WUA	Water Users Association

GLOSSARY

Adarsha Gram	Literally ideal village (also the name of a government settlement program)
Aman	Rice produced during the Kharif I & II seasons
Aus	Rice produced during the Krarif II season
Bari	Homestead
Beel	A natural depression the bottom of which,if undrained, cannot be cultivated
Bishkatali	A plant used as pesticide
Boro	Irrigated rice produced during the Rabi season
Char	Alluvial land or land grown up from river
Chira	Beaten rice/flat rice
Chasi	A farmer
Churanta	Final
Deshi	Local/national
District	Administrative Unit in the charge of a Deputy Commissioner comprising a number opf Thanas
Jama	Deposit
Jamabandi	A stage in land settlement
Kabiraj	Ayurbedic practitioner
Kabuliat	Registration deed between the Government and the tenant
Kanungo	An official in the office of DC involved in the work of land settlement
Katcha	Unmetalled, Immature
Kharif I	Early summer (March through June)
Kharif II	Late summer (July through October)
Khal	Canal/Creek
Khas land	Government land
Khatian	The form in which the record of rights is prepared showing all the details relating to any particular "interest"
Khesari	A species of pulse
Monsoon	Period of rains starting in June and ending in October
Mouza	Village as per revenue unit(and not a village as per social unit)
Muri	Popped rice
Nadi	River
Polder	Land protected by embankment with water management system
Pourashava	Municipality
Pucca	Permanent, Metalled, Concrete, Pitched
Rabi	Winter season (November through February)
Samity	Society
Selami	Fee
Tahsilder	Revenue official in charge of tahsil
Thana	Administrative unit of the Local Government below the district
Union	Lowest self-government unit comprising several villages
Union Parisad	Elected council for adminstration and development activities at the union level
SPANS	A software by ISPAN/EGIS

1 INTRODUCTION

1.1 Objectives of the Inception Report

The Meghna Estuary Study, as described in the Terms of Reference, consists, like any project for that matter, of a judicious combination of inputs, which will allow to perform those activities that are needed to produce a specified output. It implies that one should have a clear understanding of the output to be delivered, in order to define the activities to be undertaken. In the case of MES this is not as easy as probably in most of the other FAP-projects. This applies in particular to the Master Plan to be delivered. The consultants would consider it preposterous to suggest that at this stage they are already in a position to give a full description of what the Master Plan could be.

The first priority of the consultants is to come to learn the characteristics of the area, to try to understand the forces and processes that govern physical developments, to discern patterns and tendencies, that will help them when trying to make a projection of possible developments in the near future. Efforts to develop the Master Plan will be guided by the gradually growing understanding of the dynamics of the project area.

This Inception Report reflects this understanding as the consultants have it at this moment. On the basis of that, a conceptual framework is developed, to structure thinking about the master planning exercise and to guide operations for the near future. So much is sure at this stage, that dedicated surveys, model- and other studies will be needed. These should, of course, never become a goal in themselves, but always be guided by the output they are to deliver.

While the preparation of the Development Plan for the coastal islands included in the project may be more straight forward, it certainly depends on the inputs from various other projects, in particular the Compartmentalisation Pilot Project (CPP, FAP20) and the Char Development and Settlement Project (CDSP). Working relationships with these two projects have been established meanwhile.

The primary objective of this report is to describe as far as possible at this stage, in clear and unambiguous terms the outputs that the project is expected to yield, the approach that the consultants intend to follow and the activities they propose to undertake in order to produce these outputs, and finally the inputs they propose to deploy to that end.

1.2 Brief overview of contents of the Inception Report

This Inception Report contains a summary and maps, a main report with tables and figures in Volume I and annexes in Volume II.

In Chapter 2 the background and context of the Meghna Estuary Study is given including an overview of the Land Reclamation Project as well as a summary of problems that have to be addressed by the Meghna Estuary Study

The description of the project in terms of objectives, outputs, activities and inputs is dealt with in Chapter 3. The main outputs of the MES are: institutional development, surveys, studies, a master plan and a land development plan.

The methodologies that will be used during the elaboration of the study are described in Chapter 4. In particular the use of a Geographic Information System and Remote Sensing data will be an integral part of the study. For planning purposes the log frame approach will be used.

Project implementation and a Project Implementation Plan (PIP) are dealt with in Chapters 5 and 6 respectively. The Project Implementation Plan contains the Gantt Charts for surveys and investigations, studies and hydraulic and morphologic modelling.

Chapter 7 provides a description of the reporting to be produced during the Meghna Estuary Study.

Volume II of the Inception Report contains 15 annexes and provides the contributions of the various disciplines of the Meghna Estuary Study. Special attention and effort has been given to the preparation of Annex 01 Logical Framework.

2 BACKGROUND

2.1 Preparation of the Meghna Estuary Study by GoB and Donors

The Meghna Estuary Study (FAP5B) is a component of the Flood Action Plan for the Government of Bangladesh (GOB), launched with the assistance from the international donor community and coordinated by the World Bank. Most of the 26 components and supporting activities of the Flood Action Plan, which started in 1990, have been completed by now.

The project will be implemented under a cooperation programme between the Governments of Bangladesh, The Netherlands and Denmark. The administrative Agreements between the three governments was signed on 7 December 1995. The executing agency on the Bangladeshi side is the Bangladesh Water Development Board (BWDB). According to the Terms of Reference the coordination with other projects under the Flood Action Plan (FAP) is to be done by the Flood Plan Coordination Organization (FPCO).

MES area covers the Lower Meghna river from Chandpur town (the downstream extent of FAP9B) to the Bay of Bengal. The eastern boundary follows the left bank and the coast line to the mouth of the Karnafuli near Chittagong (the boundaries of FAP5 and FAP5C). The western boundary follows the right banks of the Lower Meghna and Tetulia rivers and the coastline to the bay (partly the boundary of FAP4). The southern boundary, which covers the eastern area and the off shore islands, is not specifically defined. But on the eastern side should covers the entrance to the Karnafuli River. The western boundary may be extended further to the west if it is considered necessary for the complete coverage of the mathematical model - See Figure 1.1.

Although Bhola island is in the project area, its internal area development and water management and water management is covered by FAP4 South West regional Study, and will thus be outside the MES responsibility.

The area has been served by the Land Reclamation Project (LRP beginning 1978 by the assistance from the Government of The Netherlands and by the end of the Project in July 1991, the two Governments, in recognition of the two distinct approaches, divided it into Char Development and Settlement Project (CDSP) and Meghna Estuary Study (MES). After the devastating cyclone in 1991, the Flood Action Plan gave priority to the area and thus the MES is designated as FAP5B.

The Terms of Reference for the project have been revised several times over the last 4 years; the study as it eventually has been formulated is rather complex, covering a number of components that have some degree of coherence. In addition it has connections with some other projects being carried out or completed earlier in the same area. The project also has an important institutional component.

Ultimately the various components have to be brought together in coherent overall plans, in the ToR referred to as the Master Plan for the total area and the Development Plan for the coastal islands included in the project area. This certainly is a complicated matter, which requires a well planned approach and the timely inputs of various experts and supporting tools and equipment, in order to produce eventually the outputs that satisfy the expectations of all participants in the exercise.

2.2 Description as per Terms of Reference of MES

1. Planning the development of the project area, giving due attention to:

   Surveys

   Carrying out a systematic programme of surveys to build up a reliable data base for assessing estuarine behaviour. Most of the hydrographic surveys will be carried out with the survey vessel "Anwesha" and its Tender Boats.

   Data base

   Carrying out a systematic data collection programme and setting-up of a database including the establishment of a GIS data processing and presentation system that is compatible with GIS facilities of other institutions in Bangladesh

   Studies

   Carrying out a systematic programme of hydraulic and morphological modelling to assess the estuarine behaviour.

   Master Plan

   Enhancing the optimum exploitation of the potentials of the area in terms of land reclamation and land use, thus providing new land to landless people.
   The masterplan is expected, in due course, to lead to an enhanced morphological stability and eventually to a shortened coastline. It thus aims at a safer environment for sustained human habitation.

   Land and Water Use

   Mitigating the destructive forces of storm surges (cyclones), thus providing a higher degree of safety to the population and property, and improving the productivity of the coastal islands by introducing better systems for drainage, salinity control and water management (development plan). This would include those areas which are at present not protected and which are not covered by FAP-7.

2. Enhancing understanding of the natural forces that shape the physical properties of the area and which largely determine the potential for settlement and development.
   To the extent that information is available from other FAP studies, of the possible impact of flood protection works along the major rivers on hydraulic and morphological conditions in the rivers, related consequences for the Meghna Estuary should be assessed.

3. An early start to implementation of priority projects and programmes that are compatible with the phased long term and/or development plan. Implementation of works beyond the stage of practical experiments is not included in MES.

4. Practical solutions for an effective continuation of surveys and studies, aimed at sustained and coordinated actions to update and progressively implement the long term plan.

5. Reinforce the capacity of the concerned institutions to survey investigate, plan, design and implement MES, its projects and long term plan.

2.3 Project area

Broadly speaking it includes the following water bodies: the Lower Meghna south of Chandpur, the Tetulia River in the west, the Shahbazpur River, as a direct continuation of the Lower Meghna, the Hatia River, being the area in between Hatia and Sandwip, the coastal waters to the north of these two islands, and finally the Sandwip Channel, in between Sandwip island and the Chittagong main land.

The land area included comprises the two main islands of Hatia and Sandwip, 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 from the project area are Bhola island and the landside areas of the Noakhali mainland. The southern boundary of the project area is not precisely defined. The stepped line indicated in the map attached to the Terms of Reference is not to be taken too rigidly in this respect. The hydraulic models to be used require a more southern boundary. In any case on the eastern side the mouth of the Karnafuli River is to be included as per the Terms of Reference; more to the west the potential areas for land accretion at the southern tips of Hatia and Bhola are to be included as well.

The hydraulic and morphological conditions within the project area vary significantly. Riverine processes dominate in the Lower Meghna and the Tetulia River, and presumably also in the Shahbazpur channel, although little factual information is available on the latter river. Yet, because of tidal influences, in some reaches there could be distinct ebb and flood channels.

The tide, approaching the estuary from south-westerly direction, penetrates strongly into the Lower Meghna; except for periods with very high upland discharges, the vertical tide penetrates up to Chandpur in the monsoon season, and in the dry season even up to Sylhet in the east. While the tide is strong in the Shahbazpur River, it is relatively weak up the Tetulia. The reason presumably is that the outlet of the Tetulia into the Bay of Bengal (those as of adjacent river outlets to the west) is relatively shallow, which in turn is caused by the fact that the Tetulia carries a relatively low discharge, which is insufficient to keep the outlet open.

This is a very fortunate situation indeed, because it implies that there is a very weak exchange between fresh water from upland flow and saline water brought in by the tide. This situation contrasts sharply, for instance, with the Pussur - Sibsa river systems in the western part of the South West region, where the tide is predominant and a very strong saline intrusion occurs. The fresh water pocket which, partly by the grace of the weak tidal penetration, extends from the Tetulia in westerly direction, is to be considered as a very precious resource worth preserving as much as possible. If not also for other reasons, this consideration in itself makes it worthwhile to preserve and whenever possible even to encourage the accretion apparently taking place at the southern end of Bhola island, which will tend to strengthen the formation of a bar separating the Tetulia from the sea.

By contrast in the Hatia Channel, the area in between Hatia and Sandwip and in the Sandwip Channel, tidal forces are predominant. The maximum tidal range may vary from about 3.50 m at the southern end of Hatia and Sandwip to about 7.50 m in the extreme north-eastern end, near the Feni Closure Dam.

Very strong tidal currents could occur, values up to 3.5-4 m/s have been recorded. As a result morphological developments could go very fast in this area. The persistent erosion which occurred along the northern end of Sandwip for several decades up to about 1990 and which is still ongoing at the northern end of Hatia, bear witness in this respect.

Most of the sediment being carried down the Lower Meghna, is washed out into the sea; the coastline of Bangladesh exhibits a remarkable degree of stability, as is evident when comparing the Rennel map of about 2 centuries ago with the present day situation; see also the map attached to the Terms of Reference.

It seems as if about all the sediment brought in by upland flow, is lost to the deeper sea.

Yet the tidal flows entering into the Shahbazpur Channel and the area in between Hatia and Sandwip, are heavily laden with sediment, largely consisting of fine, more cohesive particles, washed back by the sea. This sediment deposits wherever conditions are favourable. The forces that govern the erosion in some places and siltation in others appear to be in some sort of an equilibrium, allowing hardly any net gain of land.

Since times immemorial man has tried to change his natural environment, so as to suit his requirements; the coastal area of Bangladesh is no exception in this respect. Due to the dynamic riverine and marine environment prevailing especially in the eastern part of the project area, only the latest interventions left their traces.

Those which are important for this study, include the following (for a more complete description of these interventions, reference is made to the related studies and reports):

Crossdams nr. 1 and 2

These dams were built respectively in 1957 and 1963. They were constructed across the Bamni Channel, once apparently a major channel of the Lower Meghna. While the latter changed its course in accordance with the present day configuration, massive siltation occurred on both sides of the crossdams since then. This gives an indication of the potentials for land accretion that could prevail in the area.

Coastal embankments

In the 60's and 70's the Coastal Embankment Project has been implemented, extending also into the project area, as shown in Figure 3.1. The embankments, which originally have been designed to prevent flooding at high tidal levels, are not believed to have had an appreciable impact on the accretion of new land in the project area, apart from siltation in some of the drainage channels in the main land of Noakhali.

Closure of channels

In the course of the last decades a number of channels along the coast of main land Noakhali have been closed, the most significant of which are the Daria Nadi closure under the Land Reclamation Project (LRP) in 1982 and the Feni Closure Dam, constructed in 1985. In both cases siltation occurred along the seaward face of the dams. Especially in the case of the Feni Closure Dam the rate and extent of the siltation, known by the name of Muhuri Accretion, is spectacular, again giving an indication of the potentials for the reclamation of new land in the area.

Reclamation of new land

By spontaneous intervention of the local population or by specific action of government organizations, land has been reclaimed and embanked along the coast of Noakhali and some of the coastal islands. Notably the activities under the LRP and the ongoing Char Development and Settlement Project (CDSP) are relevant in this respect. In fact, as required by the Terms of Reference, the MES has to cooperate closely with CDSP.

2.4 Previous hydraulic surveys and model studies

The Land Reclamation Project

The Land Reclamation Project (LRP) (1977-91) comprised comprehensive field investigations and numerical hydraulic modelling, for providing a part of the planning basis of that project.
(In principle, the scope of the MES field programme is to supplement the data produced by the LRP and other previous studies. However, the rapid morphological changes in the estuary, in combination with the general need of simultaneous data, imply a need of a thorough continuation of the field survey activities).

A description of the LRP accomplishments is given in the LRP Final Report', August 1991. In brief, the field programme components were (i) coastline surveys, (ii) bathymetry surveys and transect geometries, (iii) sea level recordings, (iv) flow recordings, (v) wind recordings and salinity recordings (to a minor extent). A catalogue of collected data has been compiled by BWDB/SSD in the publication Inventory of available data and information, BWDB, May 1991.

Numerical hydraulic modelling within the LRP comprised 1-D hydrodynamic modelling (by the NETFLOW model), and 2-D hydrodynamic modelling (in a 1 km grid). Also, detailed 2-D hydrodynamic models were applied for selected areas. The numerical modelling was largely carried out in the Netherlands.

The NETFLOW set-up has subsequently been incorporated in the SWSMP model, which is implemented at the SWMC. The SWSMP model in turn is the origin of the 1-D model that will be used in the present study.

The marine survey activities under LRP have been carried out by the 'Anwesha' which was the main survey vessel of LRP stationed in Chittagong. Today, the vessel is operated by BWDB/SSD, it will also be used for the MES survey activities.

From May 1980 to 1991, 'Anwesha' was in operation for some 50 percent of the time, the remaining time being spent on bunkering, scheduled and unscheduled repair and maintenance, weather downtime, holidays, and unrelated activities. The vessel was docked once per year for routine inspection and maintenance, and also, on several occasions, for major repairs due to accidental damage to the hull or to the propulsion system. Typical reasons for such damage was hitting the seabed, and getting the propeller entangled with fishing nets (to which the vessel is reportedly particularly sensitive, 'LRP, Final Report', p. 32-34).

In 1990, an appraisal mission made the following observations on working conditions in the project area: (Westdijk and Mol, draft, undated):

- travelling distances are enormous
- accessibility is often difficult and sometimes impossible
- local currents are sometimes dangerous according to Dutch standards
- unpredictable and dangerous tidal bores occur in the area; on one occasion, a tidal bore caused the loss of one vessel

Other investigations in the Meghna Estuary

Apart from the LRP, several other relevant marine investigations or study components have been carried out or are in progress in the coastal area of Bangladesh such as for example

- Chittagong Harbour, small studies of siltation and dumping of dredging spoils (1977-78, 1983)
- 2nd Coastal Embankment Rehabilitation Project (CERP II) (BWDB) (1988-91)
- Pussur-Sibsa River and Karnafuli Entrance (Ministry of Shipping, GoB) (comprising marine field surveys, and numerical hydraulic modelling) (1989-92)
- Cyclone Protection Project II (BWDB) (comprising topographic field surveys, and numerical hydraulic modelling) (1990-91)
- SW Area Water Resources Management Project (FAP4) (FPCO) (comprising numerical hydraulic modelling) (1991-93)
- Cyclone Shelter Preparatory Study (Local Government Engineering Department) (comprising topographic and marine field surveys, and numerical hydraulic modelling) (in progress, November 1995 - August 96)

As indicated, some of these investigations have comprised small or comprehensive field surveys, and numerical hydraulic simulation programmes.

Geographically adjoining FAP projects are FAP4 (SW Area Regional Study), FAP5 (SE Regional Study), FAP5C (S Regional Study) (not yet initiated), and FAP9B (Meghna Left Bank Strengthening). The River Survey Project (FAP24) does not cover the Lower Meghna.

A new phase of the Coastal Embankment Rehabilitation Project (CERP) is scheduled for implementation in 1996, and for that purpose a GIS project in the area is under preparation, founded by the CEC.

In connection with the Surface Water Simulation Modelling Programme (SWSMP), the Surface Water Modelling Centre (SWMC) has set up, calibrated and applied a suite of hydraulic models for the Meghna River estuary:

- A 1-D (Mike11) model, covering the main river system and the Meghna Estuary (the so-called SWSMP model)
- A 2-D (Mike21) 6 km grid model, covering the northern part of the Bay of Bengal (the so-called Bay of Bengal model)
- A 2-D (Mike21) 2 km grid model, covering the entire coast of Bangladesh, including the Meghna Estuary
- A 2-D (Mike21) 500 m grid model, covering the Tetulia River and Estuary

The three first-mentioned models have been used for previous studies in the area, such as the Southwest Area Regional Study (FAP4), the Pussur-Sibsa and Karnafuli entrance study, and the Cyclone Protection Project (FAP7). The 2 km grid 2-D model is presently being updated for the purpose of the Cyclone Shelter Preparatory Study (November 1995 - August 1996).

Further, SWMC operates a data base for data storage, and a GIS system for data presentation and impact analysis.

2.5 Drainage and water management

Introduction

Drainage congestion and water logging are considered main obstacles for agricultural development of flood protected areas situated in the Meghna Estuary. Drainage congestion occurs when excessive rainfall cannot be removed in time by a drainage system. Such a situation may be more pronounced in the estuary compared to other areas of Bangladesh due to, a) the construction of protection embankments, b) sedimentation of a natural, internal drainage system, tides and land accretion near the outfall of drains and c) a higher rainfall.

Another restriction for agricultural development in the Meghna Estuary is formed by soil salinity. LRP studied in detail soil salinity and concluded that desalinisation of accreted and protected land is a natural, but slow process. Favourable drainage conditions may accelerate this process.

Previous experiences related to water management are very limited in the case of LRP. Nowadays, improved water management concepts and experiences are found with on-going BWDB projects such as CDSP, CPP and more in particular SRP.

Drainage congestion

Drainage congestion and water logging result in reduced yields and restriction of crops that can be grown throughout the year. High rainfall occurs in the month of July and August. Flooding of Aman rice plots occurs and may submerge recently transplanted rice for several days resulting in considerable yield reductions. LRP and research institutes such as BARI found that farmers who were hampered by water logging had to delay the cultivation of Rabi crops. Fields are still be too wet in December and late rains may damage Rabi crops in case of an inadequate surface drainage system. Besides, if planting is delayed, Rabi crops have to cope with an increasing soil salinity and a decreasing available soil moisture later in the dry season.

In general, problems with drainage congestion worsen after the construction of protection embankments, despite the fact that sufficient drainage sluices have been provided. Drainage congestion is caused by an inadequate internal drainage system and in the coastal area this situation may be aggravated by sedimentation of the drainage system and drainage outfalls combined with a higher rainfall.

The internal drainage of a coastal polder is realised through a natural network of smaller and larger waterways, named khals. These khals are formed during accretion of the land and convey tidal floods and excess rainfall. After construction of a protection embankment, main khals are connected to drainage sluices. The size of sluices depend on the catchment area of a particular sluice. Catchment areas are defined by hydrological boundaries. Natural topographical features such as ridges and depressions form hydrological boundaries, but so do human interventions such as roads, footpaths, crossdams and canals.

LRP developed criteria and a typical layout for a drainage network of main and minor drains. Surface water drainage criteria and a typical layout for a surface drainage system have been tested successfully in research plots of the LRP pilot polder. A main drainage system is formed by the existing khals, but a minor drainage canals has to be constructed in a rational way, followed by settlement or resettlement of the population.

LRP experiences related to settlement issues show that application at a larger scale of such a minor drainage system will be difficult. One of the main lessons learnt from LRP is that settlement policies and issues have to be addressed before accretions are stimulated since resettlement and redistribution of land of fully accreted land, when empoldering can start, is virtually impossible.

It means that newly protected lands may have been occupied for more than 10 to 15 years by the farmers, fishermen and herdsmen. In such a situation, there is little scope to plan a minor drainage layout as it has been developed and tested by LRP and later on proposed in the feasibility study of the Sandwip crossdam.

Other approaches may be tried to develop a required drainage network that meet acceptable drainage criteria in situations that may not differ much from already existing polders with drainage problems. These approaches should have in common that participation of the already settled population takes place in planning, construction as well as management of drainage networks.

The experience of SRP in Polder 55/1, EIP in polder 43/2c and to some extent the drainage study carried out by LRP for the Southern Sudharam area reveal a number of causes for drainage congestion in areas that have been protected against floods. Causes for drainage congestion found so far are,

- Intensification of a road network, once the area is protected against flood. Roads act as hydrological boundaries, especially when no or insufficient culverts and bridges are provided.

- Roads are planned and constructed by LGED and under the Union Parishad. Co-ordination or planning between the Local Administration and BWDB is weak and funds allocated for culverts and bridges, if requested for, are insufficient.

- Properly designed sluices may have to drain out the water of an entirely different catchment area as a result of changing hydrological boundaries caused by crossdams and road construction.

- Little or no maintenance is carried out. Capacity of main drains may have been reduced due to sedimentation or excessive growth of aquatic plants. In most FCD projects, neither BWDB nor any other agency considers it their task to maintain the internal drainage systems. BWDB is in principle only responsible for the constructed embankments and sluices. The area occupied by the drains is registered as Government land (Khas land) and falls under the Ministry of Land (MoL).

- Fishing practices may obstruct the free flow of water in drains. Fishermen do construct structures in cross sections of drains, such as bamboo constructions with fine netting or sometimes even a temporarily or permanent crossdam. It also happens that fishermen make unauthorised use of drainage sluices to catch fish by opening and closing the sluice at moments favourable for fishing, but not necessarily favourable for drainage.

- The operation of drainage sluices is poor due to a frequent absent BWDB sluice operator and a non-functioning sluice committee, which have been established by BWDB. CDSP found that even the pilot polder of LRP formed no exception to this.

From what has been mentioned here, it can be concluded that involvement of the population as well as relevant agencies to solve and prevent drainage congestion and to establish a proper water management in polders seems to be a necessity.

A rather separate problem is sedimentation of outfalls. Examples of such outfalls are mentioned in the drainage study carried out by LRP of the Southern Sudharam Thana. Two main outfalls of this area, the Baggar Dona East khal and the Noakhali khal, cope with sedimentation problems. In the case of the Baggar Dona the problem is siltation of the upper reach while in the case of the Noakhali khal sedimentation takes place at downstream end of the khal where shoals have been formed. An eventual crossdam from the main land to Sandwip as proposed by LRP may further worsen the outfall of the Noakhali Khal as a result of new accretions.

Several proposals have been made by LRP, SRP and the South East Regional Study, FAP 5, to find a solution for the location of a new drainage outfall for Southern Sudharam Thana. Two sites, Chitalkhali (LRP and SRP) and another more south on the West Baggar Dona River near to Ramgati (FAP 5) have been proposed. For a final decision for such a location, morphological and hydraulic studies are required and will be conducted by MES, to improve predictions on the stability of such sites, whether rapid accretion may be expected or whether a considerable change for erosion exists.

Salinity

Salt-tolerant, low yielding Aman varieties are cultivated during the monsoon on fully accreted but still unprotected land.
Farmers will continue cultivating such varieties on land that only recently has been protected by embankments. Cultivation of improved, higher yielding Aman varieties can only be grown if desalinisation has progressed sufficiently. LRP found that south of Noakhali such favourable soil salinity levels can be reached within 4 to 5 years after empoldering the area. However, the slow process of desalinisation may delay the introduction of a second crop such as Rabi crops or an Aus rice crop with more than 10 years.

Desalinisation occurs only during the monsoon when saline groundwater is diluted with fresh rain water. In unprotected areas, resalinisation happens during tidal inundation, when standing saline water percolates into the soil and during the dry season by a capillary rise of saline groundwater. Once accretion has been completed a natural equilibrium of desalinisation and resalinisation may be reached that allows cultivation of salt-tolerant Aman rice varieties.

The construction of embankments will prevent periodically flooding with saline water but the second reason, the capillary rise of saline groundwater will continue to exist. The most effective way to prevent a capillary rise of saline water is to remove salts from the subsoil. This can be achieved through leaching. Leaching occurs when rain water can percolate through the sub soil and wash down salts to deeper groundwater layers. LRP salinity studies revealed that in soils south of Noakhali, deep drainage is the major agent for desalinisation.

LRP found that deep drainage takes place only during the monsoon and can be stimulated by keeping water levels in main khals low. A level of say 1 meter below field level was assumed possible and sufficient to stimulate percolation. To realise such a water level during the monsoon may require re-excavation of main khals, in particular if khals have been exposed to strong sedimentation before empoldering was completed.

Speeding up desalinisation and thus stimulating deep drainage will allow a more rapid development of agricultural production in coastal areas. It means that, if also surface drainage criteria have been met, a timely introduction of HYV Aman varieties and Rabi crops can be realised. Stimulation of desalinisation prevents unnecessary delays of planned benefits from costly interventions such the construction of a crossdam and the construction of embankments and sluices.

Although little is known so far, rates of desalinisation and resalinisation may differ from place to place in the estuary. Soil characteristics such as soil texture and soil profiles that are formed during sedimentation will influence such rates. Soil salinity levels may also differ due to different salinity levels of water that surrounds accretions. Field observations and study of existing soil and water data may provide a better insight in salinity levels and expected desalinisation rates for other areas of the estuary.

Water management

As mentioned earlier, drainage congestion is mainly the result of human interventions such as the construction of crossdams in drains, footpaths and roads without a sufficient number or size of culverts or bridges. Lack of maintenance of khals and outfalls, improper operation of sluices and a detrimental use, from a drainage point of view, of drains by fishermen combined with a rapid deterioration of flood protection and drainage infrastructure due to lack of maintenance contribute to drainage congestion.

The cooperative approach or growth-centre approach followed by LRP, focused on integrated rural development, has so far been less effective to improve water management in LRP polders. To further pursue the development of polders, diversification of coordinating and planning organisations along different interests may be required. At present CDSP started to establish single-purpose Water Users Groups (WUGs) and tries to involve existing multi-purpose Sub-Polder Committees (SPC) in planning, implementation and supervision of O&M of former LRP polders.

Strategies to develop main and minor drainage and irrigation systems through people's participation have been developed and implemented by SRP. Pilot areas in polder 55/1 provide an example of a step-wise approach to develop minor drainage and irrigation systems that start with the organisation of water users in small command areas along hydrological boundaries. Water users in such areas share a common interest. A strong common interest will help to solve for example a drainage problems that those water users have in common, despite their social differences. Although promising experiences have come up, it is too early to draw final conclusions regarding application of such concepts at a larger scale.

Most projects and FAP studies, like FAP 13, the O&M study, seem to agree that organisation and participation of water users in FCDI schemes forms a prerequisite for improving water management. They also agree that, although LGED has also a clear mandate to develop minor irrigation and drainage systems, BWDB is the most logical institute to develop the interior of its FCDI schemes. However, it has also been concluded that to be able to start with such an ambitious task, BWDB needs to be reoriented and reorganised. More O&M funds and additional O&M staff are not sufficient. Despite the establishment of an O&M section, BWDB remains basically a construction-oriented organisation rather than a water management-oriented organisation that tries to establish an effective communication with water users and other relevant organisations such as Fisheries, LGED, DAE, and Union Parishads.

According SRP participation of water users in water management is only possible if those water users are organised. The organisation of water users, mainly farmers, should be done along hydrological boundaries. Farmers in the same command or catchment area have a common interest to solve problems related to irrigation or drainage. At a lower scheme level this means the establishment of Water Users Groups (WUGs) for small command or catchment areas, who will be fully responsible for water management at that level. At medium and higher levels responsibility for water management will be shared between water users and BWDB.

For the Meghna Estuary Study it means that strategies and development plans for improvement of water management and drainage in protected areas, will take into account the above mentioned water management principles, which have been approved by BWDB and which are in line with FAP guidelines for People's Participation.

2.6 Summary of development issues

In order to fully justify the technical proposals for reclamation and protection arrangements it is necessary to create a linkage to the possibilities for settlement and rural development in new - and existing - char island.
Without addressing settlement and rural development issues it may even be questionable to what extent traditional feasibility studies will provide background for proposing any major technical reclamation and protection measures.

The problem which has been faced by all khas land settlement schemes so far - including the reclaimed char areas - is that *the land has already been occupied at the time the settlement scheme has come to the point of implementation*. The actual settlers - in fact illegal settlers - are usually from the very poor strata of society but the de.facto control of the areas is in the hand of people from the local power elite, which is often a mix of the local political and economic power. Absentee land lords living in Dhaka or other big cities are also seen as holding power over large areas of land. This situation is what makes it difficult to undertake a planned settlement afterwards, and the land owner elite seems to constitute a social force strong enough to resist establishment of an efficient and transparent land allocation and formalization system.

The actual and illegal settlers do not have title deed to their plots, and they have often paid a high price to the land lord for the plot. Due to their non-formalized settlement situation their legal position is very weak.

A most crucial issue for the settlers is that they have access to income earning activities, either through agriculture and fishery or non-agricultural/fishery activities. At the outset there are no activities at all in new char areas, thus naturally agriculture, livestock and fishery will be playing an important role. With soil salinity problems and possibly other soil deficiencies it is likely to take some years to develop agriculture to a point where yield reaches an expected level, and even in that case 2 acres (the size prescribed by Ministry of Land for khas land settlers) will normally not be sufficient to sustain a household. The household deficit has consequently to be supplied in other ways which may be fishery or other non-farm activities. The latter are not easily available in new char areas, and support to establishment of new income generating activities should thus be given high rating.

A general experience from rural development in Bangladesh is that many of the government agencies at local level lack capacity to reach out to the beneficiaries in the way that is intended. This general experience is anticipated to be aggravated with increasing remoteness of the areas to be reached, which can be confirmed for mainland char areas in e.g. Noakhali. Presumably the situation is even worse when moving to off-shore char areas which are not even administrative units with the normal thana set-up of administration and departments of line ministries.

Such issues needs to be given special attention in the present project. Experience has been gained over the years and ongoing on these subjects, e.g. from Land Reclamation Project (Dutch funded) and Noakhali Rural Development Project (Danida funded) and experience is presently being gained in e.g. Char Development and Settlement Project (Dutch funded) and Adarsha Gram Project (EU funded). This experience supplemented by own field and institutional investigations shall be the information base for developing improved strategies and interventions in cooperation with government departments and local administrative authorities.

3 PROJECT DESCRIPTION

3.1 Objectives

3.1.1 Development objectives

The development objectives of the project are:

- To increase the physical safety of the population living in the South-Eastern coastal areas of Bangladesh
- To promote sustainable development in these areas.
- To increase the social security for the population in the coastal areas and on the islands.

The indicators to verify this achievement of this long term objective are that during floods and cyclones, comparable to similar events in the past there will be:

- less casualties among the population living in the coastal areas and on the islands
- less damage and loss of property and lifestock along the coastal zone and on the islands

3.1.2 Immediate objectives

- Enhanced operational knowledge of hydraulic and morphological processes in the Meghna Estuary established and institutional capacity to maintain and update the same knowledge strengthened.
- Suitable land reclamation and bank protection methods identified and increased capacity of BWDB to reclaim new land and to install river bank protection works.
- Development plan with priority project and programmes for flood protection, agricultural and socio-economic development prepared for early implementation.

The indicators to verify the achievement of the immediate objectives at the end of the project are:

- a detailed programme for surveys and studies in the Meghna Estuary and an efficient and reliable setup for continuation of the surveys and studies
- a set of bank protection and land reclamation methods applicable in the Meghna Estuary
- a portfolio of projects and programmes ready for early implementation

3.2 Outputs

3.2.1 Institutional development

The short-term objectives of the MES in relation to institutional development are to:

- increase the operational knowledge of the hydro/morphological processes in the Meghna Estuary;
- increase the institutional capacity to retain and update that knowledge;

- develop appropriate approaches for rapid and low-cost land reclamation;
- develop priority projects and programs for early implementation.

In pursuit of these objectives, the project will:

- re-activate, direct, and make recommendations for effective continuation of the survey and study program aimed at sustaining coordinated actions to update and progressively implement a long-term master plan;
- establish a master planning process by developing a master plan for interventions aimed at increasing the land area and the physical safety in the Meghna Estuary;
- establish a development planning process within the framework of the master plan by formulating a land and water development plan for physical development of (parts of) the MES area, with ultimate benefits to the landless poor;
- establish the link between macro and micro planning by conducting feasibility studies in preparation of micro planning for priority projects and programs in the development plan area(s), aimed to benefit the landless poor.

3.2.2 Surveys

Land based and marine surveys

These surveys aim at the following results:

- Upgrading of the survey spread of M/S Anwesha
- Establishment of a grid of geodetic reference points covering the project area
- Generation of competence within BWDB/SSD and SWMC to utilise the supplied data collection and data processing facilities
- Provision of hydraulic data, to serve as a part of the basis for design and impact evaluation within the project

The planned upgrading of the survey spread of M/S Anwesha and its tender boats comprises accurate positioning, state-of-the art survey instruments for bathymetry, flow and S/T measurements and sediment sampling, and computer hardware and software for high-capacity on-line data processing. Hereby, the vessel will have facilities that compare favourably with the best survey units in operation in Bangladesh today. With respect to positioning, which is crucial for the morphological monitoring, the vessel will be equipped with advanced so-called RTK-DGPS 3-dimensional satellite positioning.

As a basis for the surveys, a grid of geodetic reference points is required. Most of the country is already covered by a geodetic grid recently established by Survey of Bangladesh, but this grid does not cover the MES area. Therefore, a grid will be established for the purpose. At the same time, the grid will supply a link with the reference levels of the ongoing water level registrations, and the reference levels of the LRP bathymetry mapping, so that past, present and future data from different sources can be directly compared. The results of the activity will comprise the network itself, as established in the field, together with its BTM coordinates and PWD levels. Also, information will be provided about conversion from WGS84 coordinates.

The survey work will be carried out by BWDB/SSD. Since the scope and facilities are highly extended as compared with for example the LRP, a comprehensive capability upgrading is required for the purpose. This process will take place gradually in the course of the Study. Initially, the field work will be done under supervision and with full-time active participation by expatriate project staff, whereas later on, the work can be done by BWDB/SSD staff with some occasional assistance (backstopping and trouble-shooting) by the foreign specialists. At the end of the project, it is intended that BWDB/SSD can plan and execute estuarine surveys (of the type in question) by own means.

The over-all objective of the surveys is to supply hydraulic data, as a supplement to the data already produced or being produced by BWDB, BIWTA, LRP, and others. The data will serve as an important part of the basis for design and impact evaluation within the project. The anticipated volume of data to be produced within the MES is indicated in Table 3.1:

Registration	Data volume per year
Water level	120 station-months (by MES) + 120 station-months (by BIWTA)
Wind	96 station-months (by Meteorological Department)
Waves	120 station-months
Bathymetric surveys	10,000 km line, maybe 50 maps
Flow transects (with current recordings)	80 transects
S/T profiles	500 profiles
Sediment transport profiles	80 transects
Sediment settling velocity	160 samples
Bed samples	500 samples
Data reports	24 reports

Table 3.1: Estimated data production

Socio-economic surveys

The socio-economic survey will have the following output :

- Contribution to establish background data for rural development planning for the char settlers in the project area.
- Identification of a realistic approach to planning process in the project area by enhancing the optimum exploration of the potentials of project area in terms of land use and socio-economic activities.
- Identification of needs, formulation of ideas and proposal for activities in the rural development planning for the benefit of the settlers.
- Development, of an under standing of gender issues and women's participation in the planning and development process of the char land.

3.2.3 Studies

General

The objective of the hydraulic studies is to provide a part of the basis for feasibility evaluation, design, and impact assessment of different schemes that will be considered in the course of the planning process. For this purpose, the studies must supply

- a baseline description
- impact assessments (predication of consequences of various schemes)
- indications on design modifications or corrective measures for mitigation of adverse consequences
- guidelines for impact monitoring (for validation of the predicted consequences)

Reference for impact assessment

The baseline description will be synthesised into a description of 'present conditions', serving as a reference for the impact evaluation. This reference will be simplified, but well-defined, and with a transparent validity, in order to make it suited for a detailed and consistent impact analysis. It will represent a typical dry season period and a typical monsoon period.

Hydraulic studies

The hydraulic impact is evaluated by predicting the hydraulic conditions after implementation of a given scheme, and by subsequent comparison with the reference conditions.

The following characteristics will be included in the hydraulic impact assessment to the extent that they are relevant from case to case:

- Water level
- Current velocity
- Tidal excursion
- River flow rates (i.e. flow distribution between channels)
- Salinity
- Wave height
- Sedimentation and erosion capacity

This analysis will be largely based on numerical modelling.

Morphological studies

Similarly, the morphological impact is evaluated by predicting the morphological conditions after implementation of a given scheme, and by subsequent comparison with the reference conditions.

The analysis will be partly based on results of the hydraulic impact evaluation, which will establish the sediment transport and erosion capacity for the reference situation and after implementation of a given scheme. Hereby, the impact zones (of increased and reduced accretion and erosion) will be identified.

Reporting

For each case to be studied, results will be presented in maps that show baseline conditions, and predicted deviations from the baseline conditions. The maps will cover those areas where effects of a practical significance are indicated.

Findings will be reported in a series of impact assessment notes that will contain data summaries, outline of main physical processes, basic assumptions, descriptions of applied methodologies, maps, and discussion of the results. For selected development schemes, guidelines will be given on impact monitoring, and mitigation measures will be suggested as prompted by the findings.

3.2.4 Master plan

For centuries accretion and erosion, both natural processes, take place in a highly dynamic Meghna Estuary. The Meghna Estuary Study focuses on an assessment of the potential for accretion and the formulation of early priority projects in the area. The purpose of the project is in the first place to enhance the institutional capacity of the BWDB, among others to apply appropriate land reclamation methods. Secondly, to ensure an early start of implementation of priority reclamation and settlement projects that favour the position of rural poor, landless and destitute women.

The Master Plan to be submitted at the end of the project will comprise the following components:

- A realistic picture of how the consultants believe the project area could look like after the completion of the Master Plan, that is 25 years from now.
- An outline of the strategy to be followed for the implementation of the plan and an indication of how necessary adaptations of the plan could be defined and incorporated in order to keep the plan up-to-date and valid.
- A full description of the sequence and nature of successive interventions that are planned to bring about the envisaged changes. The interventions will comprise reclamation and protection works, embankments and development plans for reclaimed land.
- A description in outline of the projects to be implemented during the next 5-year period, jointly with a justification of the anticipated phasing.
- Jointly with the Development Plan, a full feasibility study for 3 priority projects, scheduled for implementation during the first 5 years; 3 more projects in this category will be analyzed at pre-feasibility level, including design criteria, an outline of the Terms of Reference for the next stage and, if appropriate, a suggestion for possible lumping of projects.
- An indication of additional measures that could be foreseen in case the planned sequence of successive Master Plans would be interrupted for some reason, in order to secure the sustainability of the outcome of this first phase Master Plan.
- An outline for the strategy for the preparation of the next Master Plan, which again is scheduled to cover a period of about 25 years.
- A description of procedures designed to maintain a realistic Reference Plan, as a guide for subsequent master planning exercises.

3.2.5 Development plan

The elaboration of a land and water use Development Plan has to take place within the framework of a Master Plan. The Master Plan will define areas where accretion can be stimulated. The Master Plan will also define the stability of existing accretions for which priority projects are to be formulated. Stability, which means a low risk for future erosion will be an important factor in making the decision where to allocate the scarce resources for reclamation and settlement.

The Land and Water Use Development Plan will provide more insight and criteria for selection of priority project areas among the potential areas identified by the Master Plan.

The Development Plan will describe :

- the present process of land reclamation and settlement
- strategies and models for reclamation and settlement
- priority activities for early implementation
- a portfolio of selected projects and programmes in a format that will allow GOB to invite donor assistance for immediate execution.

Whereas the master plan outlines the long term physical potentials and constraints, the Development Plan will outline the aspirations and potentialities of the population within the given physical framework. The Development Plan produced by MES will include both physical reclamation and protection aspects as well as rural development aspects for support of the development objective of increased physical and social security.

From the settlement and rural development point of view key elements are envisaged to be strategies and interventions to streamline and fasten the formal land allocation process as well as the beneficiary selection process. This has strong institutional linkages involving Ministry of Land, Deputy Commissioner with ADC Revenue, and the TNO with AC Land and other thana staff. As the development plan is foreseen to include a portfolio of relevant projects, it is not unlikely that some of the proposed projects relate to land distribution and settlement.

The rural development process as a whole will be outlined in the development plan for the MES area, and the particular sectoral development shall be discussed and outlined. It should be anticipated that **income generation**, including sectors as agriculture, livestock, open water fishery and aquaculture will play a dominant role. In a more long term perspective non-farm and non-fishery related activities may as well be of great importance. Basically is it a matter of establishing the foundation for economic activities which are sufficient for creation of necessary income for establishing the proper living conditions for the settled population.

A portfolio of rural development projects will be suggested as far as a need is identified and the proper institutional arrangements can be found. The proposals shall be prioritized, some will be presented in outline, others will be developed to feasibility study and appraisal level and some of them shall be recommended for early implementation.

A draft development plan will be prepared during the period March - June 1997, and during the following period until February 1998 the plan and the proposed projects shall be appraised in cooperation with the government departments, the thana and district authorities. During this period new data and information will continuously be available and the proposals and the plan shall be updated accordingly.

3.3 Activities

3.3.1 Institutional development

The Terms of Reference (Section 5.3.14) infer that the consultants should not necessarily take for granted existing task allocations with respect to hydrographic surveying of the coastal water of Bangladesh and this inference could probably be extrapolated to other aspects of MES as well. For the sake of the discussion the consultants have endeavoured indeed to try to take a fresh look at the institutional dimension.

Institutional development has to be based on the fact that the master planning process is a continuous effort; it always is, but certainly so if related to a physical environment as dynamic as the project area.

One can distinguish at least 3 aspects :

- developing the master plan
- continuous updating of the master plan and maintaining links with (other organisations') micro development plans and their implementation
- collection of basic data

The institutional development in support of these activities will consist of:

- assessing alternative institutional arrangements for sustainable data collection and processing linked to the planning process;
- assisting in development of (a cell in) WARPO to carry out its role as macro planning organization:
  - coordinate training of counterpart staff;
  - assist in the formulation of the mandate for planning and enforcement;
  - identify whether BWDB has the proper mandate and capability to plan/develop projects within the master plan, and recommend amendments if necessary;
  - specify the links between BWDB's planning process and WARPO's master planning;
- assisting in development of (cells in) WARPO and BWDB to formulate and update land and water development plans:
  - coordinate training of counterpart staff in WARPO and BWDB;
  - assist in the formulation of the mandate for planning and enforcement;
  - identify institutional arrangements necessary for coordination of sectoral activities in the plan area;

- identify whether institutional arrangements for project implementation exist:
  - which institutions are responsible for implementation of different interventions/activities in the plan area?
  - what are these institutions' capabilities to plan/develop projects within the land and water development plan?
  - what are the links between the institutions' planning processes, master planning by WARPO, and major infrastructure development planning by BWDB?
- assess whether implementation can be in line with the long-term project objectives:
  - does legislation exist to enable transfer of land to the landless poor?
  - is there an institution responsible for enforcement of this legislation?

o contribute to feasibility studies of priority projects by identifying what institutional arrangements are needed to ensure implementation of these projects in line with the long-term objectives of MES:

- for existing land: follow CDSP findings and approaches;
- for new land:
  - does legislation exist to enable transfer of land to the landless poor?
  - is there an institution responsible for enforcement of this legislation?
  - do these arrangements work in practice, and if not, can they be improved?

3.3.2 Surveys

The activities for the field surveys are given in Table 3.2 and Table 3.3

No.	Activity	Description
1	Detailed planning	Elaboration of scope, selection of survey procedures, identification of required instruments and software, procurement budget
2.1	Procurement of survey instruments	Procurement of survey instruments and software, testing, interfacing
2.2	Installation of survey instruments	Installation of equipment onboard Anwesha and its tender boats, testing, finalisation of survey procedures
3	Surveys by Anwesha	2 monsoon season programmes and 2 dry season programmes
3.1	Monsoon season 96	Definition of transect runlines, measurements of flow, sediment transport, salinity
3.2	Dry season 96/97	Definition of bathymetry runlines, measurements of bathymetry, flow, sediment transport, salinity
3.3	Monsoon season 97	Measurements of flow, sediment transport, salinity
3.4	Dry season 97/98	Measurements of bathymetry, flow, sediment transport, salinity
4	Wave and water level registrations	Continuous registrations by self-recording instruments and staff gauges
5	Sediment analyses, off-line data processing, survey data reporting	Laboratory analyses of sediment properties, calculation of flow rates, preparation of bathymetry charts, other analyses (water level, waves, S/T), data reporting
5.1	Monsoon season 96	Analysis, off-line processing, data reporting, 1st survey
5.2	Dry season 96/97	Analysis, off-line processing, data reporting, 2nd survey
5.3	Monsoon season 97	Analysis, off-line processing, data reporting, 3rd survey
5.4	Dry season 97/98	Analysis, off-line processing, data reporting, 4th survey

Table 3.2 Summary of activities, estuarine surveys

No.	Activity	Description
6	Reference bench marks	Reconnaissance, selection of grid point locations, positioning by DGPS
7	Coastlines and coastline gradients, elevation contours of shallow areas	Reconnaissance, establishment of temporary (secondary) bench marks by DGPS, traditional (spot) levelling
7.1	1996/97 survey	1996/97 dry season geodetic survey
7.2	1997/98 survey	1997/98 dry season geodetic survey
8	Supplementary mapping of land elevations	Supplementary geodetic surveying

Table 3.3 Summary of activities, geodetic surveys

3.3.3 Studies

The following activities have been planned for the hydraulic and morphological studies:

No.	Activity	
9	Detailed planning	Elaboration of scope, identification of data demand, identification of interfaces and constraints, selection of approach
10	Review of existing data	Screening and collection of data from BIWTA, BWDB, LRP, Meteorological Department, and other sources
11	Basic assessment of states and processes	Analysis of meteorological, hydrodynamic and morphological conditions (states and processes) in the estuary
12	Selection of baseline conditions	Development of a valid reference for impact prediction and comparison
13	Numerical model set-up	Set-up and calibration of a nested (5400 - 200 m) grid numerical model for the estuary
14.a	Hydraulic impact analysis	Simulation and evaluation of predicted hydraulic impact (flow, water level, etc.), and comparison with baseline conditions
14.b	Morphological impact analysis	Analysis of predicted morphological impact (accretion and erosion), and comparison with baseline conditions
15	Reporting	Contribution to progress reporting and project reports

Table 3.4 Summary of activities, hydraulic and morphological studies

Socio-economic studies will be undertaken to provide an indication of the present socio-economic situation and for the planning process of rural development.

The activities are summarized as follows :

- Collection of socio-economic and general rural development data about the present situation, partly from existing documentation and partly through socio-economic survey of selected chars.
- Close liaison with CDSP and to some extent Adrasha Gram Project.
- Liaison with Government institution which are involved in settlement and rural development.
- Preparation of inputs for Development Plan.

3.3.4 Development of Reference Scenarios and Plans

Whereas the identification of a number of potential projects in the project area, both in the field of the reclamation of new land and the protection of existing land, as done in the past may not be too difficult a task, that should not be equated to having identified the ingredients for a Master Plan, as the consultants have to present.

An overall plan is more than the summation of a number of individual projects. It requires an insight in the potentials of the area and of their limitations as well, and that in turn a basic understanding in the forces and processes that shape it. This applies in particular in this case, when preparing a Master Plan for the Meghna Estuary, where the physical conditions are subject to rather rapid and sometimes even dramatic changes.

The Terms of Reference acknowledge the very special conditions prevailing in the project area and state that the plan to be presented should be flexible. The consultants' proposal characterizes the Master Plan as some sort of a strategic plan, that is not to be considered as a blue print, but rather as a guidance for actions in the near and medium term and that as such is to be updated regularly, taking on board new developments.

Without harbouring any unrealistic views as to what extent it is possible to control or even to influence developments in an environment that is shaped by forces as formidable as are active in the project area, yet one should not lose sight of the fact that it is not a shortage of technical tools that set limits to what can be done with respect to reclamation and/or erosion protection, but rather the prevailing socio-economic realities. Technical measures as designed, for instance, for the Jamuna Bridge, the protection of Chandpur or of Sirajganj, could also be applied in the project area and there is no doubt that they would work there as well as for the places they have been designed for.

There neither need to be any doubt that in some point of time in future, it will be economically justified to apply such measures, to stabilize the course of the Lower Meghna, the Shahbazpur Channel and the Hatia Channel, or whatever channel configuration one might prefer at that time. It should be added immediately that such time is still far away, possibly a century or even longer.

Yet, however far away this time may be, if one would be able to define a future situation that under present conditions appears to be preferable over other possible options that could be envisaged at this moment, then now and in future (as long as the defined situation remains valid considering the changes that doubtlessly will take place) one should refrain from any measures that could block the preferred future situation to evolve.

The envisaged desired situation would thus serve as a Reference Scenario, against which the suitability of any planned intervention should be measured.

Especially in an environment that is as dynamic as that covered by the Meghna Estuary Study, developing a realistic Reference Scenario, is considered to be an essential first step in the master planning process. Without having that, the preparation of a Master Plan would soon become an exercise in the pursuit of individual preferences and avocations, without any linkages to physical realities and without necessarily taking full account of the potentials the area harbours and of the prevailing limitations.

In the Interim Master Plan for the coming 25 years, several Reference Scenarios will be presented. During review of the Interim master Plan, the Reference Scenarios will also be assessed in detail. While preparing the Draft Master Plan, the consultant will organise a workshop on future development of the Meghna Estuary.

On the basis of the comments of the Government of Bangladesh and the Donors as well as the views and opinions expressed during the workshop and additional studies by consultant's team; a Reference Scenario or Plan for the long term development of the Meghna Estuary will be presented in the (Draft) Master Plan.

The main virtue of a Reference Plan is that it provides a consistent framework that structures the master planning process.

In attempting to define a Reference Plan, based on a desirable future situation, that could serve as a reference for any programme of actions planned for the near and medium term future, the following criteria are considered realistic and functional:

- Safeguard the fresh water pocket that is at present available west of the Tetulia.
- Make the length of the Lower Meghna and its extension into the sea (by whatever name it may be known) as short as possible, so as to facilitate the discharge of flood waters and to minimize the cost of future works to stabilize the river course.
- Shorten the coastline of Bangladesh as much as possible, to reduce the costs of maintenance of coastal embankments and of any coastal defence works, thus enhancing the safety of the protected area.
- Optimise the potential for the reclamation of new land.

The application of these considerations yields scenarios as presented in Figures 4.1, 4.2, 4.3 and 4.4. The vision of possible future developments that determine the Reference Plan to be presented together with the Master Plan, are believed to correspond well with the line of thinking underlying the Terms of Reference, which in Section 4.3.1 also envisages a shortening of the coastline of Bangladesh. It should be emphasized once more that the figure is not to be interpreted as a plan that the consultants propose to be taken up for implementation.

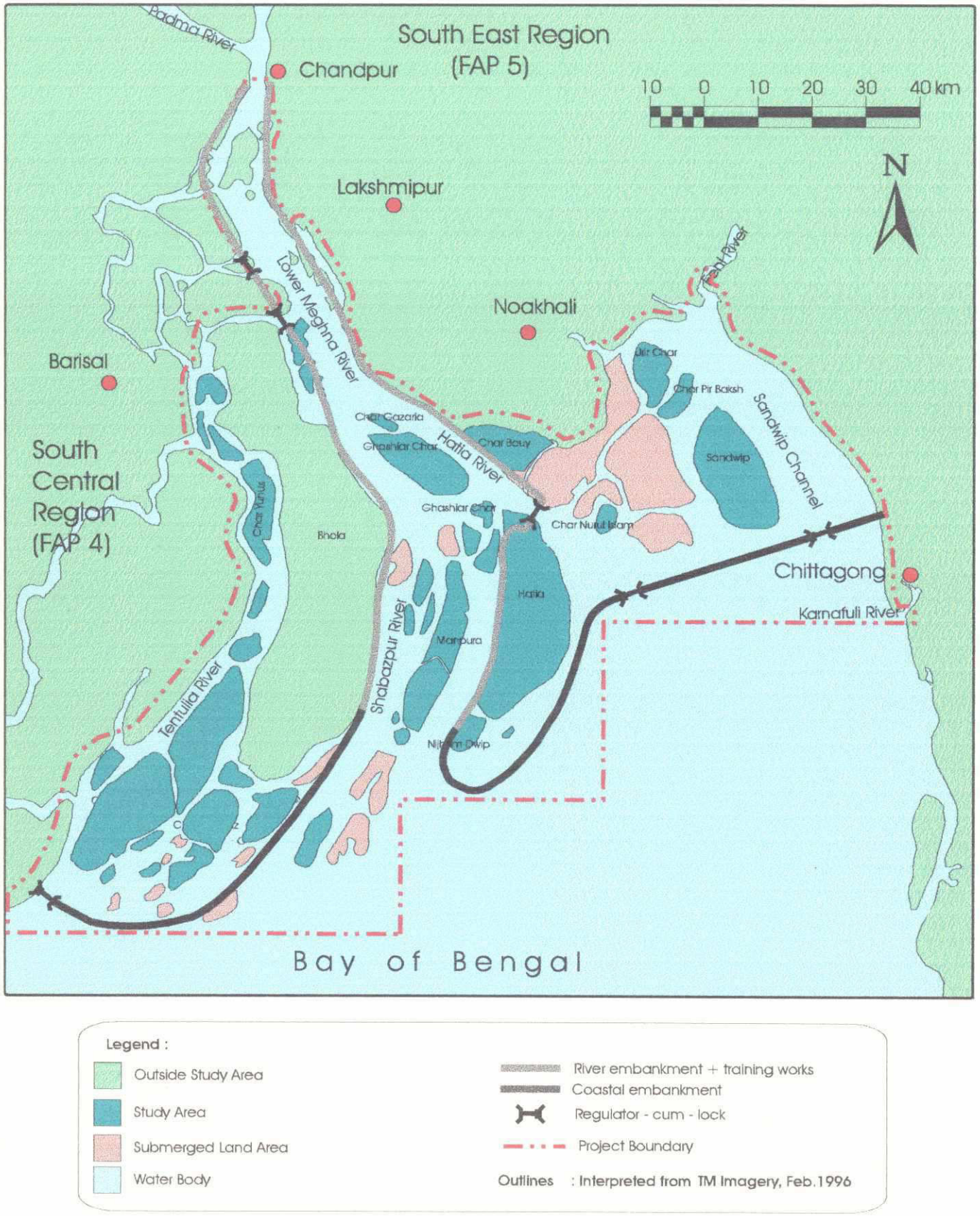
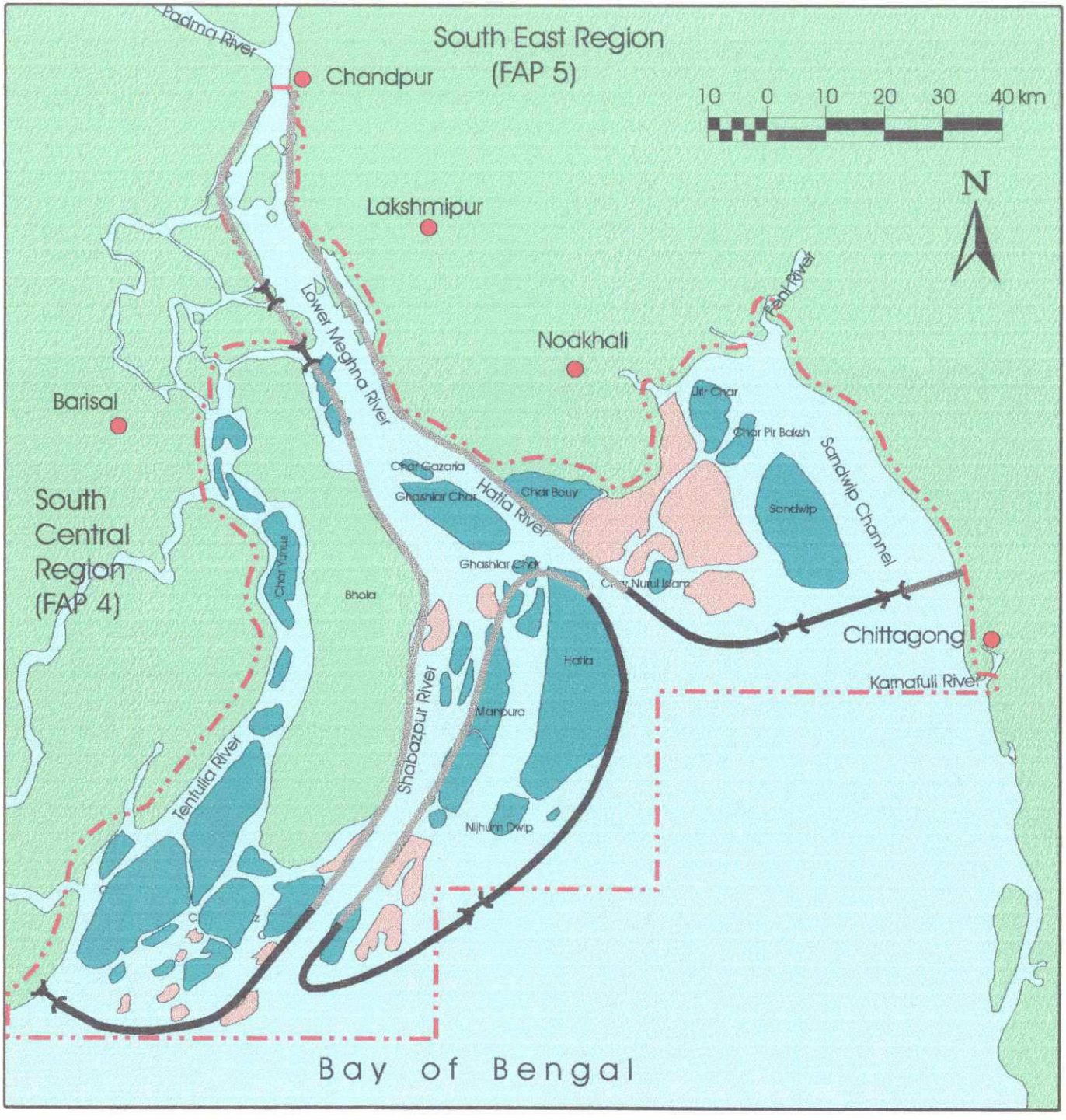


Figure 3.1 : Reference Scenario A



Legend :

- Outside Study Area
- Study Area
- Submerged Land Area
- Water Body
- River embankment + training works
- Coastal embankment
- Regulator - cum - lock
- Project Boundary

Outlines : Interpreted from TM Imagery, Feb.1996

Figure 3.2 : Reference Scenario B

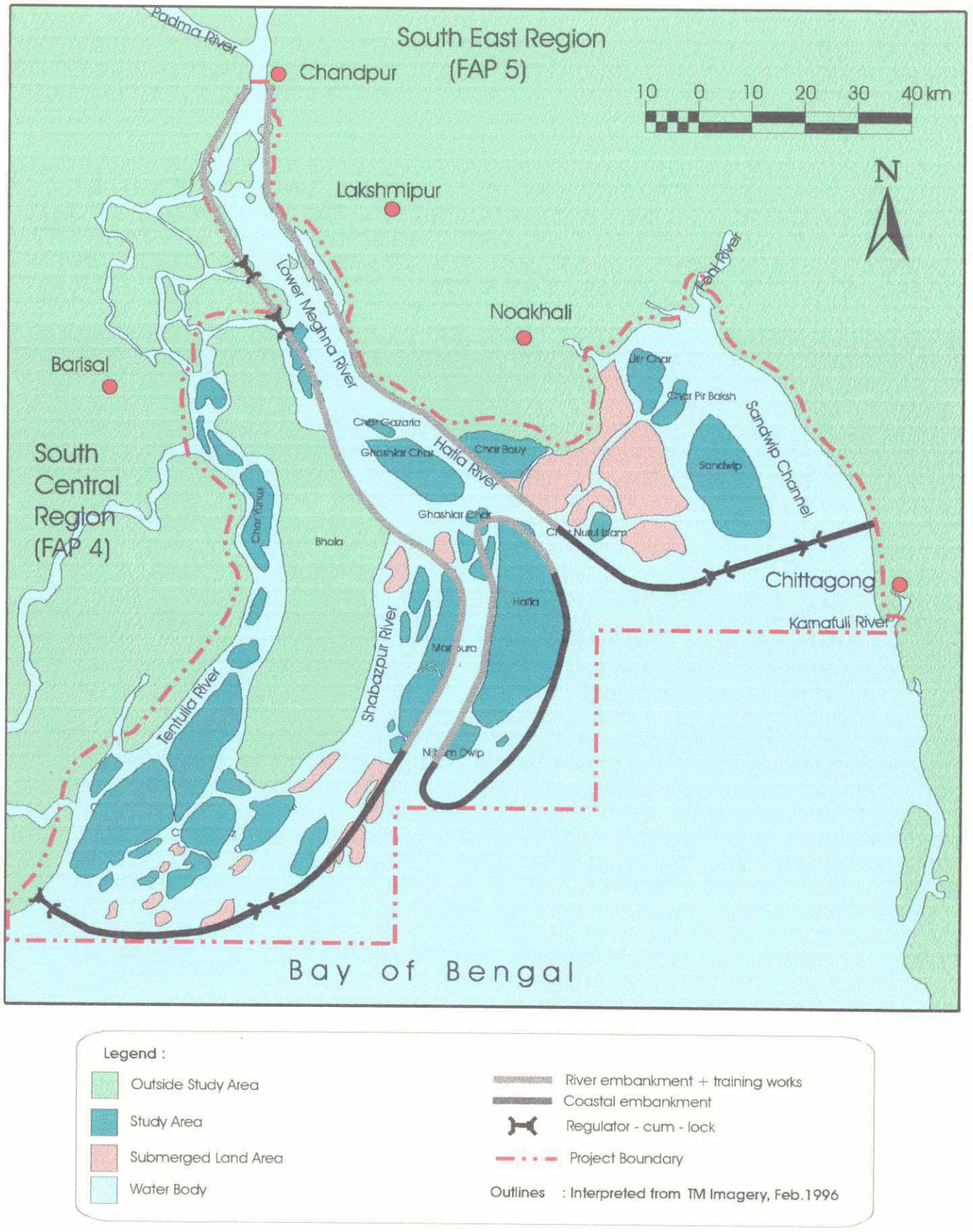


Figure 3.3 : Reference Scenario C

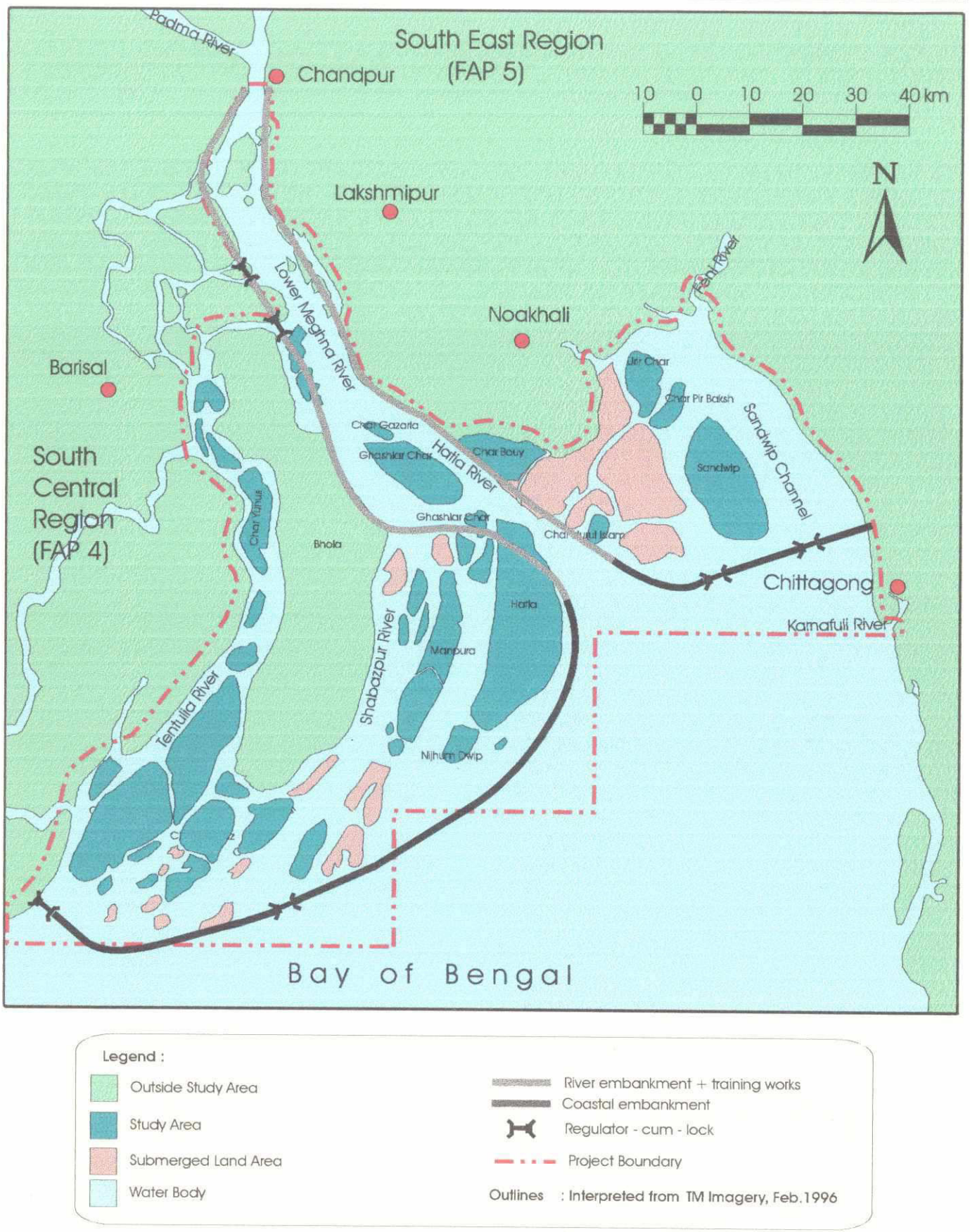


Figure 3.4 : Reference Scenario D

3.3.5 Preparation of Master Plan

The recommended Reference Plan will be a powerful tool for the preparation of a Master Plan, as required per Terms of Reference. If the Reference Plan is acceptable as such, then the Master Plan the consultants propose to prepare would be the first phase on the road that eventually should lead to the situation as envisaged by the Reference Plan. In fact the path to the Reference Plan would consist of a number of successive Master Plans, each covering a period of about 25 years. The name "Master Plan" for each of the stages is still very appropriate, because they are not just well defined successive phases of the Reference Plan: the environment the plan relates to is such that for each of the stages, while continuing from the foregoing, there still are too many uncertainties and variables left over. Planning under such conditions has to be based on new surveys, (model) studies; it is by nature a continuous and iterative process. Such iterative approach is precisely one of the characteristics of a master planning process. The Master Plan to be prepared now, would then be called Master Plan 25 and could be referred to as MP25.

Even, while covering a period of 25 years, a Master Plan would have to be flexible, requiring regular updating, on the basis of a check of actual conditions and the verification of the impact of interventions applied. This is a continuous process indeed, for which the tools, including the institutional capabilities, should be present. One even could say that, unless such facilities are in place, the preparation of a Master Plan, including this first one, would be a vain exercise.

Exactly as foreseen in the Terms of Reference (Section 4.3.2), each of the successive Master Plans will comprise a number of "Building Blocks"; these are defined as individual works or a programme of works, which fit in the future pattern, but which could stand alone for some time, for instance in case there would be a hiatus in the planned sequence of Master Plans

The potentials for the reclamation of new land and the problems associated with the protection of existing land are briefly reviewed in the following sections.

When trying to assess the potentials for the reclamation of new land, some basic considerations should be taken into account. Especially in riverine morphological processes, there often is a close relationship between on the one hand sedimentation and/or protection against erosion in one place and on the other hand actual erosion in another place. In other words, in rivers one should not consider measures to promote accretion or to prevent erosion in one place, without assessing at the same time potential effects in other places.

Therefore in general terms one is inclined to caution against efforts to reclaim land or to prevent erosion being pursued in isolation. These should preferably be part of an overall programme directed towards the management of the river bed over a larger length. This statement may be extended to any alluvial channel through which water is moving. Generally speaking siltation (and erosion prevention) and erosion are two sides of the same coin and should never be studied in isolation one from another.

However, a close relationship between siltation or erosion prevention on the one hand and erosion on the other, as described above, does not necessarily exist when considering reclamation from the sea, although one certainly would have to assess repercussions elsewhere if the possible impact of (tide or wave induced) currents dictate so.

When applying such considerations to the water bodies in the project area, the above implies that in general one should refrain from the reclamation of land in the Lower Meghna, the Shahbazpur River and the Tetulia without studying at the same time possible effects elsewhere. It might well be that opportunities for the reclamation of new land present themselves, but before actively promoting such tendencies, possible morphological responses should be studied carefully.

There also may be good opportunities to reclaim new land along the Hatia River adjacent to the Ramgati main land, but reclamation there could reinforce the erosion of the northern end of Hatia and would therefore require very careful study. Similar considerations apply when considering interventions to reinforce the siltation at the northern end of Sandwip; while there could be opportunities to do so, this almost certainly would intensify ongoing erosion along the southern coastline of Char Pir Baksh to the north.

Generally speaking in Bangladesh the reclamation of new land and the prevention of erosion of existing land is of national importance for a number of reasons. For a country as densely populated as Bangladesh, efforts to retain or even to expand the land area that there is to accommodate the growing population and to grow ever more food, is of critical importance indeed. When analysing the critical economic parameters, measures to prevent erosion usually score lower than land reclamation projects.

A number of relevant studies done under FAP (FAP1 and 9B) confirm the general conclusion that at the present stage of the socio-economic development of Bangladesh, works to protect agricultural land are not feasible from an economic point of view. Only if also urban centres would benefit from such works, or if there were other related benefits, the necessary investments could be justified. One may assume that this applies also for the coastal areas of the country. In fact this should not come as a surprise: the National Committee that studied the erosion of Bhola in 1988 came to the same conclusion.

There could be good reasons to reconsider this matter in future, in the light of the results of FAP21, under which tests are being carried out on low cost bank protection works along the Jamuna. They could lend support to the supposition that the protection of coastal islands may not be unfeasible in all cases.

The consultants will study the feasibility to apply new methods and materials that could come up in the course of the study and that appear to have good potentials for application in the coastal zone of Bangladesh. In particular the effectiveness and practical installation of surface and/or bottom vanes (SBV) will be assessed. Provided that the SBV can be considered as an attractive method of preventing bank erosion or for river training in certain locations, it will be proposed to install this type of protection as a small scale intervention that will be monitored during the project.

3.3.6 Preparation of Development Plan

The Terms of Reference require a comprehensive plan to be prepared for flood protection and the improvement of the internal water management of the coastal islands included in the project area. In fact all inhabited islands are to be included, notably Hatia and Sandwip, the island of Bhola explicitly being excluded (Section 3.3). In Section 4.1.1 it is said that also those areas are to be included which are at present not protected and not covered by FAP7.

Reading through the Terms of Reference, it is clear that one of the main objectives is to provide a higher degree of safety to the population and property against the forces of storm surges (cyclones). In addition, the productivity of the land is to be improved, through better systems for drainage, salinity control and water management (Section 4.1.1).

The link between the Master Plan, as discussed before, and the Development Plan lies in the fact that under latter, in conjunction with CDSP (the ongoing part of LRP) will attempt to produce models for the development and settlement of new land that may have been gained as a result of efforts under the Master Plan (ToR, Section 3.3). Thus it appears that, in addition to the existing islands, also new land is to be covered by the Development Plan, which could be new land that exists already or new land expected to be reclaimed as a result of MES.

Whereas the preparation of the Master Plan is largely driven by the physical potentials that are available in the project area, taking into account some limitations set by the environment, the preparation of the Development plan by contrast will be driven primarily by the demands and aspirations of the population.

Another main difference is that for the preparation of the Development Plan, to a larger extent experiences gained in other projects in Bangladesh and also elsewhere can be called on, whereas in preparing the Master Plan the consultants largely tread in unmapped areas, literally and figuratively speaking.

The greater part of the existing land has been provided with an embankment already, either under the original Coastal Embankment Project, or under some project in connection with cyclone protection, as for instance FAP7. In the coming dry season Phase II of this project is to start. In addition to that in recent years, and especially so since the cyclone of April 1991, a number of additional measures have been taken to enhance the safety of the people on the coastal islands. Quite a number of cyclone shelters has been built, is under construction, or is scheduled to be built. The systems for activating public awareness of impinging danger have been improved; also the road systems are being upgraded. All this will help to make the islands a safer place to live in.

Yet, cyclones are bound to re-occur; even after rehabilitation under the Cyclone Protection Project, the embankments are not designed to prevent flooding in all cases, but to remain stable even in the case of overtopping. Whether they actually are, depends not only on the design criteria and the quality of construction, but to a large degree on the maintenance situation. In any case, what is important in this respect is, that the risks of floods will continue to be there.

The Terms of Reference assume that the planning components will include Primary and Secondary Protection Systems. The first category comprises:

Coastal embankments

Most of the islands have already been provided with embankments, either under the original Coastal Embankment Project or under the Cyclone Protection Project (FAP7); others will be constructed or rehabilitated under Phase II of the latter project. The consultants will closely cooperate with ongoing projects in this field.

If within the project area more embankments are needed than provided for under any of the projects mentioned, they will be taken up in the Development Plan. The accepted design criteria will be followed, possibly with some minor adaptations. For instance the consultants are not in favour of planting trees on embankments. Studies in The Netherlands have shown that trees have to be considered as foreign elements, which tend to weaken the structural strength of the embankment, when subjected to the action of waves.

Conservation and development of the foreshore

Maintaining a sufficiently wide foreshore strengthens the performance of the embankment significantly. It should preferably consist of flat land with a proper vegetation cover, not intersected by borrow pits and the like. Trees will help to absorb part of the energy of incoming waves. Afforestation programmes may be part of the Development Plan.

Coastal defence works

These serve to prevent or delay the erosion of the foreshore and embankment. Although the consultants will endeavor to identify and/or develop cost-effective measures, the options for this will probably be limited, because the cost to install and maintain structures to resist persistent riverine or coastal erosion soon outweigh the benefits, as experience has shown.

The consultants also like to caution against too optimistic expectations on the use of vegetation (trees, mangrove) as a measure to prevent or even delay erosion. At best it could do so temporarily, but vegetation as such does not have the capability to withstand persistent erosion.

Wherever opportune, the consultants will include in the Development Plan a coherent programme of measures for effective primary protection systems.

Under the Development Plan, Secondary Protection Systems should be proposed, which essentially aim at containing the extent of floods once they should occur. One of the measures mentioned there is the provision of secondary embankments, subdividing the islands into smaller units, so that, if the primary embankment would fail at some point, not necessarily the entire island is flooded. This is elsewhere a quite common measure in areas that are prone to flooding and is, for instance, also applied in The Netherlands. It is anticipated that, as far as possible existing infrastructure will be used for the establishment of the Secondary Defence System, such as old embankments, roads etc., in order to minimize the use of land.

Subdividing an island along whatever lines will almost certainly interfere with existing systems for water management, notably drainage. Adaptations of the existing systems will be necessary and in this respect the lessons learnt under the Compartmentalisation Pilot Project will be taken on board. This includes technical aspects, also mathematical modelling. FAP20 is the Compartmentalisation Pilot Project, which has been designed specially to serve as a sort of model for other riverine areas. Under MES, it will be considered whether it is feasible and useful to try to select some typical area and to develop a model for coastal islands, which then could be duplicated in other areas with similar conditions is operative with CDSP will be useful.

But not only the physical dimensions of FAP20 will be useful for the preparation of the Development Plan. The other aspects, and notably so those related to systems for the consultation of the population will be taken on board, in addition to components related to enhance the agricultural production. In this respect also the experiences gained in CDSP will be very useful.

Liaison with CDSP will be especially pursued for that part of the Development Plan that is to deal with the development of new land. A wealth of experience is expected to be available with CDSP, the land-based inheritor of the former LRP, including matters related to the settlement of new land. All efforts will be made to maximize the benefits that can be drawn from the cooperation with CDSP, including those related to the chosen institutional set-up for that project.

The latter has been created specifically to optimize the condition of and the services provided to new settlers. Effective relationships have been established with the project management of CDSP meanwhile and also the project area has been visited briefly. A very fortunate circumstance is, of course, that both CDSP and MES share the guidance of the same Project Director.

Jointly with CDSP the possibility will be studied to develop "model-approaches" for the creation and subsequent reclamation, settlement and development of new land, incorporating all relevant technical and non-technical components. At least two such models may be needed, one for new land adjacent to existing land, thus possibly influencing the drainage of the hinterland, and transforming an existing sea-facing embankment into a "compartment-boundary", and another one relating to new land that has no connection with existing land and thus would be surrounded by open water, obviously entailing a higher degree of risk than the former one.

There are many factors that play a role when the issue of accretions and subsequent settling of new land comes up. Not just any tract of land that emerges at some point of time along the shores of the Bay of Bengal deserves to be reclaimed, settled and developed. The land should have been raised sufficiently high so as to allow gravity drainage after reclamation; under LRP useful studies have been done in this respect.

Should the government, and for that matter BWDB, bė held to provide some level of services whenever people decide to settle spontaneously on some tract of new land, however insecure this still may be? An important point is the durability of new land: investments (also for some provisional cyclone shelters?) will be justified only if it can be made plausible that the new land will enjoy a sufficiently long lifetime. It will be endeavoured to develop practical guidelines, in conjunction with CDSP.

In between the interim and the draft development plan an appraisal process shall be conducted for strategy, plan and project proposals. The appraisal process shall be undertaken in cooperation with departmental staff at central level as well as at district and thana level, and if possible at union level also. In cases where NGOs are involved they have to participate as well. The procedure shall roughly be as follows:

Presentation and initial discussion

Depending on the proposal it shall be decided how much time shall be allocated at central departmental level and how much at local level. On land issues, for instance, it should be considered very important to have thorough discussions with Ministry of Land to reach the fullest extent of commitment and cooperation. Sufficient time shall be spent at district and thana level to make a full presentation of the proposals and have initial discussions. DC, TNO and relevant departmental officers shall be consulted. The concerned union chairmen should also be approached at some stage in the process, however, they may be involved through the Thana Coordination Committee meetings.

Time to respond

Officers at all levels should be given about one month to consider the proposals and give their comments.

Final discussions

A round of meeting shall be held with the same departments and local level institutions as under item a. Their final response shall be discussed and a prioritization of the possible project proposals shall be made. New proposals may also be presented by the concerned authorities. If deemed appropriate for facilitation of the communication process workshops may be conducted. Appraisal of the projects in cooperation with the intended beneficiaries seems more difficult as there are no established procedures to follow and no institutions to approach at that level. It is anticipated that RRP/PRA techniques can be applied for this purpose, mostly applied at village level or a sub-group of the most interested villagers. If cooperatives or informal groups are in existence they could be the focus of communication as well. The approach and methodology for this shall be further developed during the third or fourth quarter of 1997, and the actual field work shall be conducted during fourth quarter of 1997 and first quarter of 1998.

In connection with preparation of the development plan - as well as before and after - a number of feasibility assessments shall be undertaken, not only for settlement and rural development projects but for major project options in relation to land reclamation and physical protection. Such interventions require proper feasibility studies, and it will be important to identify and quantify costs and benefits of socio-economic and human development nature in addition to the economic, financial and technical parameters of cost and benefit.

Once the feasibility study methodology has been decided and actual subjects for study has been defined - probably during first quarter 1997 - the specific data input can be specified. It is likely that socio-economic data from specific areas may be required in this context and 2 - 3 small surveys can be conducted in response to need, and manpower has been allocated accordingly. The survey methodology is expected to be adapted versions of the Rapid rural Appraisal technique.

3.3.7 Preparation of Priority Projects and Programmes

The Terms of Reference mention a number of potential priority projects which should be studied; they have been referred to above. They appear in the lists of 18 potential projects, as prepared under the LRP in 1988. The complete list is given below; these projects will be discussed in more detail in Annex 04. See also Figure 3.5.

1	Six Polder Scheme	10	N,W. Hatia Cross-dam
2	Urir Char Polder	11	Manpura polder
3	Sandwip Cross dam	12	Gazaria Polder
4	S.E.Sandwip Polder	13	N.E. Bhola Bank Protection
5	Feni Polder	14	W. Bhola Protection
6	Char Boya Cross-dam	15	S. Bhola Cross-dams
7	Char Nurul Islam Polder	16	Ramgati Polder
8	South Hatia Cross-dam	17	Sudharam drainage
9	Hatia Bank Protection	18	Ramdaspur Cross-dam

It seems that at the time the list was prepared, the projects included have been studied in isolation. Possible impacts elsewhere may have been studied, but without placing the projects within the wider context of an overall Master Plan.

However, it would go against the philosophy and the essence of MES (ToR, Section 4.1.4) if the evaluation of the individual projects were continued to be pursued without considering them within the context of the basic considerations that underlie the preparation of the Reference Plan and, which after all will be the basis for the Master Plan to be prepared.

Therefore in Annex 04 the priority projects that are included in the project area, will be reviewed, taking into account the basic considerations that govern the proposed Reference Plan.

The Terms of Reference require projects suitable for immediate implementation to be identified and studied at pre-feasibility level at an early stage (Section 4.3.4), the reports to be submitted by month 8 (Section 5.3.10). This will presumably include some of the listed projects, one or two in connection with the protection and/or development of existing land (Section 4.3.4) and in addition possibly some other projects as well, identified in the course of the study. For those projects that appear to have confirmed potentials, even a feasibility study will have to be done (Section 4.3.4), including Nijhum Deep (Section 5.3.11).

Without setting undue limitations on the possible outcome of the study, it is anticipated that in combination with the results of the Development Plan, 3 projects will be analyzed at pre-feasibility level and in addition 3 more at feasibility level. In doing so the caution will be taken at heart, as given in the Terms of Reference (Section 4.3.2) with respect to the limited useful lifetime of feasibility studies of projects situated in this dynamic environment.

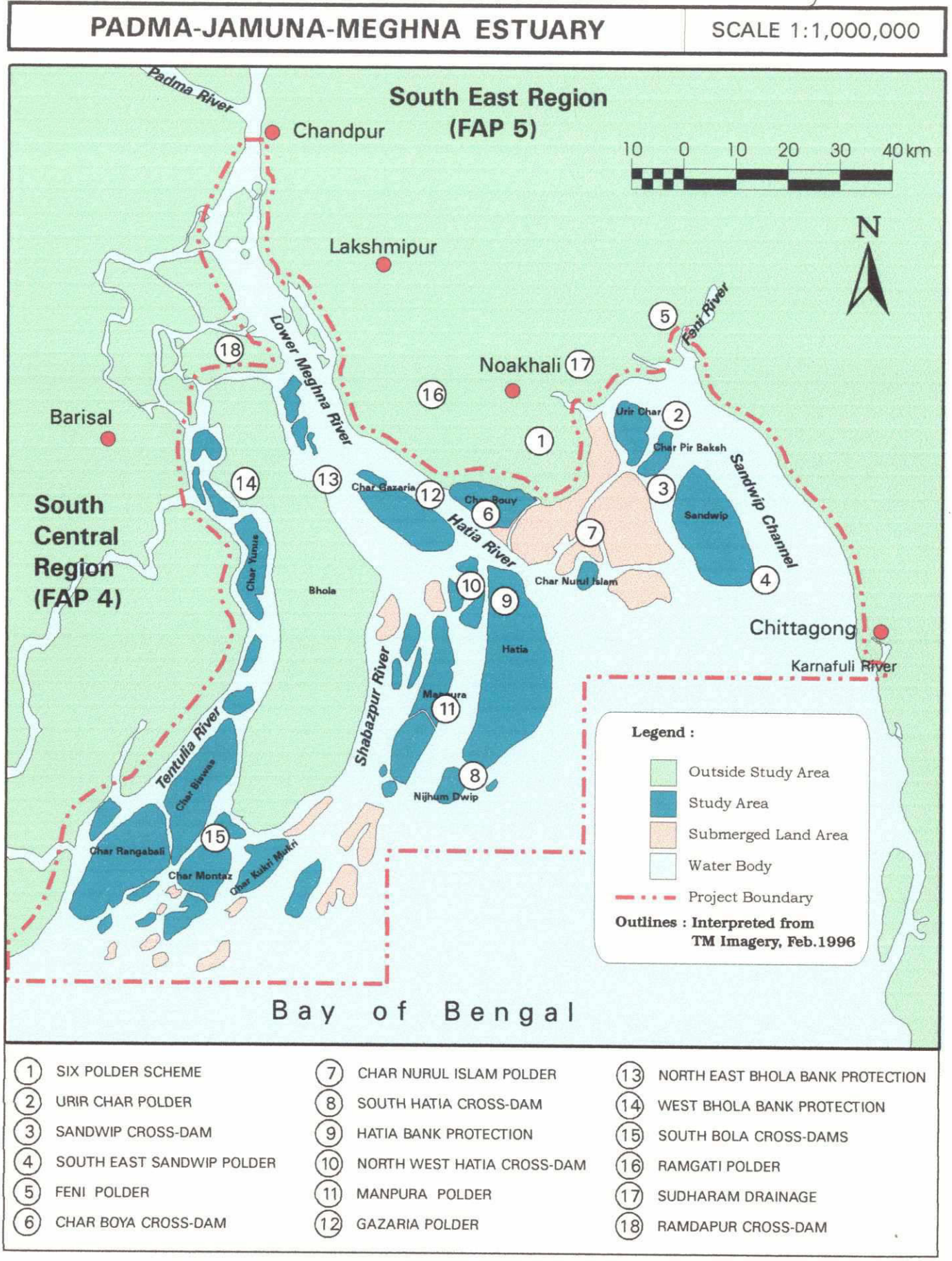


Figure 3.5 : Location of priority projects (according to LRP)

3.3.8 Preparation of Small Scale Interventions

The Terms of Reference make it clear that although a large part of the efforts under MES will have to be directed towards data collection and studies, of which the preparation of realistic Master and Development Plans will be the final result, the need for short term interventions should not be lost sight of. This will remind the consultants of the expectations, notably on the side of Bangladesh, that the potentials for new land and the threat to existing land which are strongly manifest in the project area, get due and urgent attention.

The main contribution of MES in this respect will be to propose approaches and techniques for rapid and low-cost reclamation of new land, employing to the maximum extent local labour and materials (ToR, Section 4.2.5) and to make proposals for effective measures to protect existing land against erosion (Section 4.2.4).

The Terms of Reference are more specific with respect to the reclamation of new land than with respect to the protection of existing land. In general they caution against too high expectations: in Section 4.1.3 it is explained that the implementation of works beyond the stage of practical experiments is not included in MES, while Section 4.3.4 says that even under the first phase of the Master Plan, the interventions in the natural environment are expected to be moderate.
The philosophy of the Terms of Reference (Section 4.3.4) clearly is to gradually build up an understanding of the natural forces and processes at work in the area and not to move into over-ambitious projects and programmes, before having passed through a learning process, moving gradually from small scale interventions to gradually increasing more ambitious ones.

Two main considerations apply in particular in this respect:

- It is one thing to reclaim new land, which may be settled and made productive subsequently, it is quite another thing to ensure its sustainability and to protect this land against erosion if vagaries of nature would reverse fortunes.

- The potentials for the reclamation of land in Bangladesh should not continue to depend to a critical extent on foreign expertise: indigenous capabilities for the identification, preparation and implementation of suitable projects should gradually be developed. This calls for a gradual building up of the size and complexities of interventions earmarked for implementation.

In the Terms of Reference the small cross dams constructed by the people of Manpura Island, in the Shahbazpur River, with the help of BWDB (Section 5.3.10), are mentioned as an example of the interventions that are meant to be taken up under MES. The same type of approach is mentioned in connection with the reassessment of the feasibility study done under LRP, to reclaim land along Nijhum Deep (Section 5.3.11), which the consultants have to do.

Again emphasis is on low cost methods to close tidal channels. It appears that the implementation of the works should be within the capability of local contractors, possibly with some specialist inputs of an expatriate company. The input of expertise from abroad for the preparation of designs and implementation methodologies, for instance with respect to the techniques for the closure of the final gap in some cross dam, would be one of the aspects of MES.

Indigenous measures to influence the movement of sediment in channels have been applied in Bangladesh for many years already: the art of bandalling has been applied along the Brahmaputra and other rivers for a long time, as an effort to maintain a navigation channel through shoaling river stretches. This objective is contrary to the one to be pursued under MES, where siltation is to be promoted.

Nevertheless the experience that is available in the country with respect to the influencing of the movement of sediment will be of value. Also the desk study done under FAP22 will be very useful. Under MES experiments and studies will be made to try to extrapolate experience under riverine conditions to fit with those prevailing in tidal areas, where currents and sediments are essentially different.

In general sediment settles where currents are weak; this is the principle behind the construction of sedimentation fields, as for instance done under the Schlesswig Holstein (SH) method, applied along the German and Dutch coast of the North Sea. The fields are constructed with piles and brushwood, making screens that retain the silt-laden water for some time, giving the sediment the opportunity to settle.

The method can be applied to promote siltation in areas where there is already a tendency for siltation; it is not a method to combat erosion. The method may not fully be adapted to the conditions along the coast of Bangladesh: the amounts of sediment moving around along the coast of Noakhali are so large that, if the SH method would appear to be successful, the construction would probably soon be buried under the accumulated sediment.

The basic elements of the SH method, making screens with bamboos and bamboo-matting, can presumably be applied with a good chance of success in tidal channels. Screens, which need not be too high, could be put in rows across shallow channels with not too high currents, e.g at tidal meeting points, where they would tend to increase the hydraulic resistance and by that slow down currents. Siltation could follow, which, once starting, could be the beginning of a self-reinforcing process. Similarly rows of screens could be put across emerging mudflats, again creating resistance, reducing flow and inducing accelerated siltation.

Various types, dimensions and lay-outs of screens will be tested out, at various locations and, whenever necessary, adapted to the prevailing conditions. The consultants will provide assistance for the siting and design of the works, which then will be implemented under the responsibility of BWDB (Section 5.3.10). Due consultations will be held with the local population, explaining the proposed works (including the limitations of the proposed tests), seeking their support and participation.

In addition to studying and possible recommending small scale interventions aiming at promoting accretion, the consultants will also consider alternative methods for protection of existing land against erosion by the river. Further details are provided in Annex 04.

3.4 Inputs

3.4.1 Technical Assistance

Table 3.5 shows the input in terms of funding by the donor agencies for Technical Assistance. Details about staffing, purchase of equipment, O & M and training are provided in Chapter 5.

Cost in Lakh Taka

	1995	1996		1997		1998		Total
Description	II	I	II	I	II	I	II	
Contract staff	53.7	295.7	215.0	407.4	170.7	399.5	44.2	1586.2
Purchase/Investments	1.3	277.8	5.0	2.5	0.0	0.0	0.0	286.6
Operational costs	4.0	43.2	50.0	37.0	39.5	44.7	12.4	230.8
Training and courses	0.0	0.0	10.0	17.5	12.5	12.5	0.0	52.5
Contingencies	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	59.0	616.7	280.0	464.4	222.7	456.7	56.6	2156.1

Table 3.5 Technical Assistance Input

3.4.2 Financial Assistance

Table 3.6 shows the input in terms of funding by the donor agencies for Financial Assistance. Details about the small scale interventions to be financed from this budget are provided in Chapter 4 and Annex 04.

Cost in Lakh Taka

	1995	1996		1997		1998		Total
Description	II	I	II	I	II	I	II	
Accretion trial	0.0	0.0	0.0	50.0	0.0	0.0	0.0	50.0
Bank protection scheme	0.0	0.0	5.0	95.0	0.0	0.0	0.0	100.0
Bank protection Sonagazi	0.0	0.0	0.0	50.0	0.0	0.0	0.0	50.0
Small cross dams	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.0	0.0	5.0	195.0	0.0	0.0	0.0	200.0

Table 3.6 Financial Assistance Input

3.4.3 Government of Bangladesh

Table 3.7 shows the input in terms of funding by the Government of Bangladesh.
Details about Government of Bangladesh staffing and purchase of equipment are provided in Chapter 5.

Cost in Lakh Taka

	1995	1996		1997		1998		Total
Description	II	I	II	I	II	I	II	
Project personnel GOB	16.0	48.0	48.0	48.0	48.0	48.0	24.0	280.0
CDST & VAT	0.0	70.0	70.0	0.0	0.0	20.0	0.0	160.0
Total	16.0	118.0	118.0	48.0	48.0	68.0	24.0	440.0

Table 3.7 Government of Bangladesh Input

Note : 1 Lakh Taka = NGL 4,000
1 Lakh Taka = DKK 14,000
1 Lakh Taka = US$ 2,500

4 METHODOLOGIES

4.1 Data collection

4.1.1 Marine Surveys

Existing data

There are three main data sources covering the estuary:

- Ongoing monitoring programmes by national agencies
- The LRP
- Other specific studies, completed or in progress

Data from these sources have been, or are being screened and compiled for the purpose of the MES.

Ongoing monitoring activities

Monitoring of meteorological conditions is undertaken by Meteorological Department, and tidal (sea level) registrations are carried out mainly by BIWTA, but also by BWDB and by CPA. BIWTA publishes annual Tide Tables with predicted tidal elevations for a number of stations in the estuary and in the Lower Meghna.

A continuous programme of bathymetric surveying is carried out under the Director of Hydrography. For each year, this programme covers a certain (minor) part of the large area used for navigation.

The Land Reclamation Project

The Land Reclamation Project (LRP) (1977-91) comprised comprehensive field investigations and numerical hydraulic modelling, for providing a part of the planning basis of that project. (In principle, the scope of the MES field programme is to supplement the data produced by the LRP and other previous studies. However, the rapid morphological changes in the estuary, in combination with the general need of simultaneous data, imply a need of a thorough continuation of the field survey activities).

A description of the LRP accomplishments is given in the *'LRP Final Report', August 1991.* In brief, the field programme components were (i) coastline surveys, (ii) bathymetry surveys and transect geometries, (iii) sea level recordings, (iv) flow recordings, (v) wind recordings and salinity recordings (to a minor extent). A catalogue of collected data has been compiled by BWDB/SSD in the publication *'Inventory of available data and information', BWDB, May 1991.*

Other investigations in the Meghna Estuary

Apart from the LRP, several other marine investigations or study components have been carried out or are in progress in the estuary, such as for example

- Chittagong Harbour, small studies of siltation and dumping of dredging spoils (1977-78, 1983)
- 2nd Coastal Embankment Rehabilitation Project (CERP II) (BWDB) (1988-91)
- Pussur-Sibsa River and Karnafuli Entrance (Ministry of Shipping, GoB) (comprising marine field surveys, numerical hydraulic modelling) (1989-92)
- Cyclone Protection Project II (BWDB) (comprising topographic field surveys, and numerical hydraulic modelling) (1990-91)

- SW Area Water Resources Management Project (FAP4) (FPCO) (comprising numerical hydraulic modelling) (1991-93)
- Cyclone Shelter Preparatory Study (Local Government Engineering Department) (comprising topographic and marine field surveys, numerical hydraulic modelling) (in progress, November 1995 - August 96)

As indicated, some of these investigations have comprised small or comprehensive field surveys, and numerical hydraulic simulation programmes.

Geographically adjoining FAP projects are FAP4 (SW Area Regional Study), FAP5A (SE Area Regional Study), FAP5C (S Area Regional Study) (not yet initiated), and FAP9B (Meghna Left Bank Strengthening). The River Survey Project (FAP24) does not cover the Lower Meghna.

Meghna Estuary Study estuarine surveys

The estuarine surveys of the MES aim at producing data for

- The general basis for the physical planning in the estuary
- Hydraulic design of specific land development schemes
- Baseline description of the environmental and morphological state and processes
- Hydrodynamic and morphological impact evaluation

The field measurements for these purposes can be divided into categories as follows:

- Water level registration by self-recording gauges and by staff gauges
- Wave recordings by self-recording gauges
- Bathymetric surveys
- Current and S/T recordings by electromagnetic self-recording instrument
- Measurements of flow transects, flow profiles, and S/T profiles
- Collection of suspended sediment samples for determination of sediment concentration and settling velocity
- Collection of sea bed samples

The MES estuarine surveys comprise the following components:

- Establishment of a geodetic grid for reference stations
- Installation and operation of water level gauges and wave recorders
- Routine measurements from Anwesha: Bathymetric surveys, flow transects, sediment sampling, and S/T profiles
- Data processing and reporting

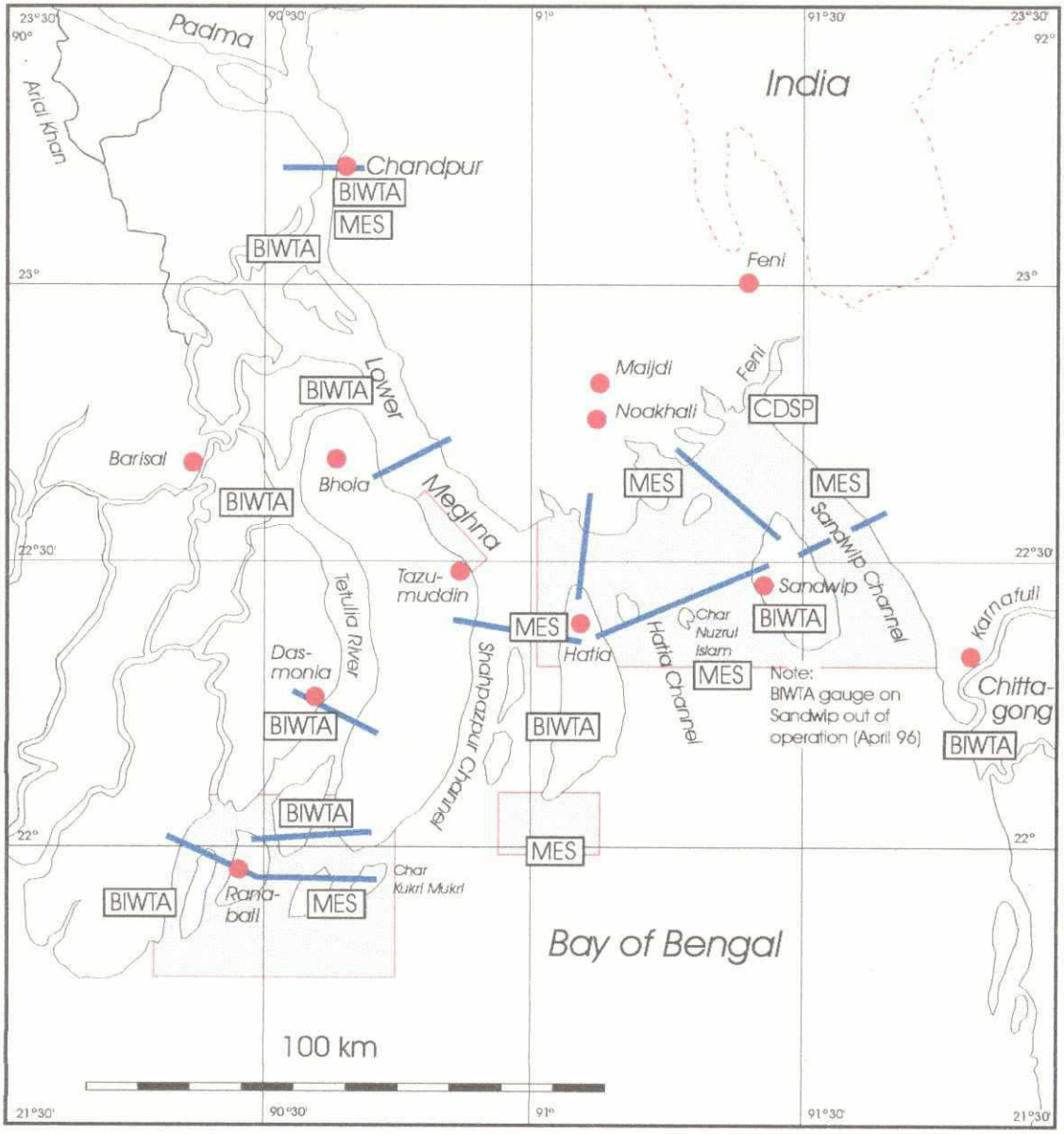
Following the initial mobilisation, this work comprises four campaigns:

- 2 monsoon season campaigns (flow, sediment sampling, and S/T profiles)
- 2 dry season campaigns (bathymetry, flow, sediment sampling, and S/T profiles)

Hereby, the programme has been compressed as compared with the programme presented in the Interim Inception Report, where a total of 5 campaigns was envisaged. This change was necessitated by the period of unavoidable circumstances in early 1996, which delayed the mobilisation. However, the number of effective vessel days remains unchanged.

The anticipated operation areas are indicated in Figure 4.1

The tentative programmes for the different categories of campaigns are indicated in Table 4.1.



MES bathymetry and flow gauging transect

MES priority study area and bathymetry area

BIWTA — BIWTA water level gauge - location shown in BIWTA Tide Tables

MES — MES wave and water level gauge, to be established

CDSP — CDSP wave and water level gauge, to be established

Figure 4.1: Location of survey areas

Activity	Monsoon survey	Dry season survey
Bathymetry		+
Cross-section geometry and flow transects	+	+
Salinity/temperature profiles	+	+
Suspended sediment samples	+	+
Sea bed samples	+	+
Deployment and servicing of instruments	+	+
Transfer and stand-by	+	+

Table 4.1 : Outline of survey activities

The field survey procedures are described in Annex 2, and an outline of the execution of the field programme is included in Annex 3.

4.1.2 Land-based Surveys

Existing topographic information

Information about topographic conditions is available from Survey of Bangladesh and from the Local Government Engineering Department, as well as from the LRP and certain specific studies. An inventory of topographic data from the LRP is included in the publication *'Inventory of available data and information', BWDB, May 1991.*

FAP18 has carried out a comprehensive geodetic mapping in the area, but the results have not been released.

A geodetic survey was planned to take place in early 1996 under the Cyclone Shelter Preparatory Study. However, the work was discontinued during the national political unrest and will not be completed until later on, or perhaps not at all.

A new phase of the Coastal Embankment Rehabilitation Project (CERP) is scheduled to start in 1996. It is anticipated that this project will comprise a certain land survey component.

MES land surveys

Topographic (land) surveys will be carried out by MES with the following objectives:

- To establish a grid of reference bench marks
- To map coastlines and coastline gradients
- To map elevation contours of shallow areas, as a basis for sedimentation/accretion monitoring and sediment budgets
- To carry out supplementary mapping of land elevations as a part of the design basis for priority study areas

The basic grid of reference bench marks is being established by stationary DGPS with an expected accuracy of 5-10 cm per 100 km, both horizontally and vertically. The grid will be linked with the national geodetic grid that has recently been established by Survey of Bangladesh and JICA, but which does not cover the MES area.

The subsequent detailed topographic survey work (as well as the estuarine surveys) will be made relative to this primary grid, which will also serve as a reference for interpretation of long-term water level recordings (by BIWTA and MES), as well as for past bathymetric surveys (by LRP). Hereby, a provision is made for a consistent comparison between data from the various past and present sources.

Socio-economic survey

Both quantitative and qualitative information of the survey areas will be obtained by the following methods :

- Secondary Sources documents that will provide an initial picture of the project area. Sources include national government agencies,(e.g. Thana administration) records and reports of BWDB, BBS, local government agencies, village record (village tax records) and area specific studies (feasibility studies).

- Household survey with pre-designed questionnaires to be administered to randomly selected samples (household heads). Three survey areas will be purposively selected to ensure geographical representation. The sample villages in the survey areas will also be purposively chosen keeping in view of their easy approachability

- In-depth survey of social groups to get insight into people's perceptions, attitudes and behavior in the context of multi-stage process of dialogue between groups by participatory rapid appraisal approach. No formally structured questionnaires will be used. However a checklist of issues or guidelines will be held in mind or noted. This would help direct learning by the investigators from and with local people seeking diversity and differences on rural development planning.

4.2 Geographic Information Systems and Remote Sensing

4.2.1 Introduction

The MES project is anticipated to generate a lot of maps and spatially distributed data. The project will also require a large amount of input maps and other data. Within the project, a GIS database will be developed and maintained, which ensures a proper use and management of the geographical data.

GIS (Geographic Information Systems) is a set of computer programs especially designed for storage, analysis and retrieval of geographic data. The GIS stores the information in data layers or coverages, each containing data on a specific theme. GIS allows for referencing the coverages and updating and retrieving information in the coverages. It also allows for combination of coverages, so GIS can be used to analyse spatial combinations and spatial problems. GIS systems come with a powerful map plotting subsystem, which can be used to produce maps of any combination of the coverages in the database. In principle, these plotted maps can be at any scale desired, but attention should be paid to the fact that GIS can not create accurate data on coverages that were surveyed on a very coarse scale. Data can be fed into the GIS using several methods:

- Interpolation of values of point measurements or model results;

- Digitizing contour lines or boundaries of objects from existing paper maps;

- Importing data already digitized for other purposes;

- Use Remote Sensing techniques to obtain accurate data on areas which are insufficiently surveyed.

Remote Sensing techniques make it possible to obtain information on objects and characteristics on the earth surface without being in direct contact with them. Thus, remote sensing can give information on an area to be studied before any field work is done. Especially when large areas are to be studied the reduction of the amount of fieldwork can be considerable. Traditionally, aerial photography is the most commonly used technique, but more recently other forms of remote sensing, notably satellite imagery, have become available. These images are relatively inexpensive and provide a great deal of information.

Starting with the Landsat MSS-images (Multi-Spectral Scanner images, resolution of ground details 80x80 meters) in 1973, enhanced sensors became available. At present, the most sophisticated satellite sensors are Landsat TM (Thematic Mapper, resolution of ground details approximately 30x30 meter) and SPOT panchromatic (ground resolution 10x10 meter).

In general, two types of satellite image products can be obtained: the black and white or color prints or photomaps, and the digital information on computer tape. Both the products have their own use with specific advantages and disadvantages. The photomaps are readily available for further visual interpretation, and with most of the photos the user does not have to worry about georeferencing and geocorrecting the photo. However, interpretation can only be done visually, while image enhancement and automatic image classification are only possible with digital images on computer tape.

Several studies have been executed to define the applicability of Remote Sensing techniques for the water sector in Bangladesh. The reports of these studies start to appear from around 1975 onward. The use of Remote Sensing in the water sector can be divided into two major groups of applications. The first group is the classification of landuse and cropping patterns, and the second group is the applications for coast line and river bank development.

SPARRSO and ERIM (Environmental Research Institute of Michigan) (SPARRSO and ERIM, 1981) conducted a study in 1981 using Landsat Digital Data for measuring the land accretion in the Coastal Zone of Bangladesh. Their main objectives were: 1) determine whether a net gain or loss of land occurred along the coastline of Bangladesh between 1972 and 1979; 2) to provide some insight into the nature of the interrelationship between the processes of accretion, erosion and sediment transport in the Meghna estuary that are responsible for the changes observed; 3) to predict, on basis of the observations made, where it is likely new land will be formed in the future; and 4) the steps that should be taken to accelerate the process.

In the above mentioned study it is concluded that it was feasible in 1981 to monitor and measure changes in the Meghna delta since 1973. Present day remote sensing techniques provide a much longer record of images available. Moreover, the resolution and spatial characteristics of the modern sensors provide a more detailed insight and overview for the Meghna estuary. However, the primary objective of the SPARRSO and ERIM study remain completely valid.

For the MES project, several applications of GIS and Remote Sensing are anticipated. For processing of GIS and Remote Sensing, a PC based GIS/RS system will be installed at the MES office. Since the capacity of this system will be limited, some tasks will be allocated to other institutes.

The most important anticipated outputs of Remote Sensing in this study are:

- To map the dynamics of the coastline and to be able to give an overview of the areas eroding and those that are accreting.

- To provide data on land use and infrastructure where no other data is available.

Regarding the mapping of the dynamics of the coastline: This is essentially a dynamic view of the area, what is happening where, and could we identify possible causes of the phenomenon.

To do this a multitemporal approach is proposed, meaning we need RS images of the study area reflecting the situation at several moments in time. Each image gives a static description of the situation at that moment, and the stack of images together will uncover the dynamics of the system.

Regarding the mapping of land use and infrastructure data: As much of the land in the Meghna estuary is insufficiently mapped, throughout the project there is a need for (more) detailed information on the actual situation in the area. To help providing this information, a Remote Sensing Landsat TM image of the area has been obtained. Ideally, after processing this Remote Sensing image could provide information on land use, settlement patterns and infrastructure in the area, as well as information on currents and silt loads of the water bodies.

To obtain these results, the following processing steps need to be executed:

- georeferencing the image (make sure a known and correct coordinate system is attached to the image, so that we can correspond locations in the field to locations in the image);
- enhancing the image (contrast stretching etc);
- printing of the image.

4.2.2 In-house applications

The in-house system will be used for digitizing existing paper maps, and the set up and maintenance of the database. Using ArcInfo as the main database platform, data exchange with other groups will be ensured. ArcView will be used for data display and map production.

4.2.3 Environment and GIS support Project EGIS

Modern remote sensing techniques have been applied to geographical research, flood monitoring and natural resources assessment in Bangladesh for more than two decades. The Government of Bangladesh has embraced the use of this technology by establishing the Bangladesh Space Research and Remote Sensing Organisation (SPARRSO).

The Flood Action Plan FAP has addressed principles of Remote Sensing for use in water resources planning and management under FAP 19 the Geographic Information Systems (GIS) project. The FAP 19 project was implemented through EGIS Environmental and GIS Support Project for Water Sector Planning.

The FAP-19 project was coordinated by FPCO and is currently funded by DGIS of the Dutch government. In addition to its main project focus within the FAP, the EGIS team has provided leadership in the development, application and institutionalization of GIS technology in Bangladesh. The processing and handling of the data from the Landsat TM image of 1996 is done by EGIS. The produced the geocorrected maps that are used in this project.

4.2.4 Surface Water Modelling Centre

The Surface Water Modelling Centre (SWMC) is the "centre of excellence" in the field of mathematical river modelling in Bangladesh.

SWMC was created in 1990 based on technology transfer carried out through the Surface Water Simulation Modelling Programme initiated in 1986 and supported by the World Bank and UNDP.

Since 1990, SWMC has been supported financially by DANIDA. SWMC forms and independent unit under the ministry of Water Resources administered through the River Research Institute. The Danish Hydraulic Institute has provided the mathematical modelling technology and carried out the training of SWMC staff.

The large quantities of data required and generated by SWMC are stored in digital format in GIS. This GIS can also be linked to the simulation models to produce flood depth maps and impact assessment.

SWMC is assisting the MES project giving general GIS support and allowing the use of their equipment in the study. They are also involved in the mathematical modelling of the MES, and as such will cooperate in the incorporation of model results in the MES-GIS.
Surface Water Modelling Centre has implemented a GIS system that was developed for the Ministry of Water Resources by the Flood Management Project (FAP25). The system is based on ArcInfo software, like the GIS system used by EGIS.

The following data and information will be supplied by SWMC to the in-house GIS system of the MES:

- Topographic and bathymetric surveys carried out by MES
- Selected historical data, as applied under the project
- Model bathymetries and key results of the numerical model simulations

The data will be transferred in BTM grid and PWD datum.

4.3 Planning techniques

4.3.1 Logical framework

The logical framework is regarded by MES as a tool that will help to improve the management and thus the effectiveness of the project. The logical framework, or logframe, shows the development objectives, immediate objectives, expected output and main project activities in a logical sequence.
Indicators and verificators have been identified to keep track of progress made. Critical assumptions, which require to be monitored, are also mentioned in the logframe. The partially complete logical framework presented in the Draft Project Document (annex 3) has been used as a reference for the first logical framework presented in this document.
It is the intention of the consultants to promote with the logframe approach the active participation of decision-makers and planners (GoB, donors), implementing agencies (BWDB and consultants), as well as the local population and agencies. The latter will be discussed in the next chapter. Such participation may lead to major changes in the orientation of the project, and if decided to do so, these changes will be reflected in a modified logframe.

A direct result of the logframe is a breakdown of main activities into activities for the various project study components, which are subsequently further detailed in Gantt charts which can be found in the detailed project implementation plan. In this way a direct link has been established between daily project activities and the objectives of the study. During implementation of the study, as knowledge and insight will grow, or due to changing circumstances, activities of the various project components may be modified.

The purpose of such modifications is to increase the effectiveness, or, to improve the efficiency of the total of project activities through tuning and coordination. Annual up-dates of the logframe are the result of such minor changes.

In the case of MES, which is a study that consist of various project components, it is considered useful to show the coherence of the components in the study. To make this possible, the overall logical framework is worked out in sub-logical frameworks for each component. In this way, the major activities of the overall logframe have become outputs for the components and in the logframe for each component sub-activities have been formulated. Figure 4.2 shows the principle of interlocking project component logframes into the overall project logframe.

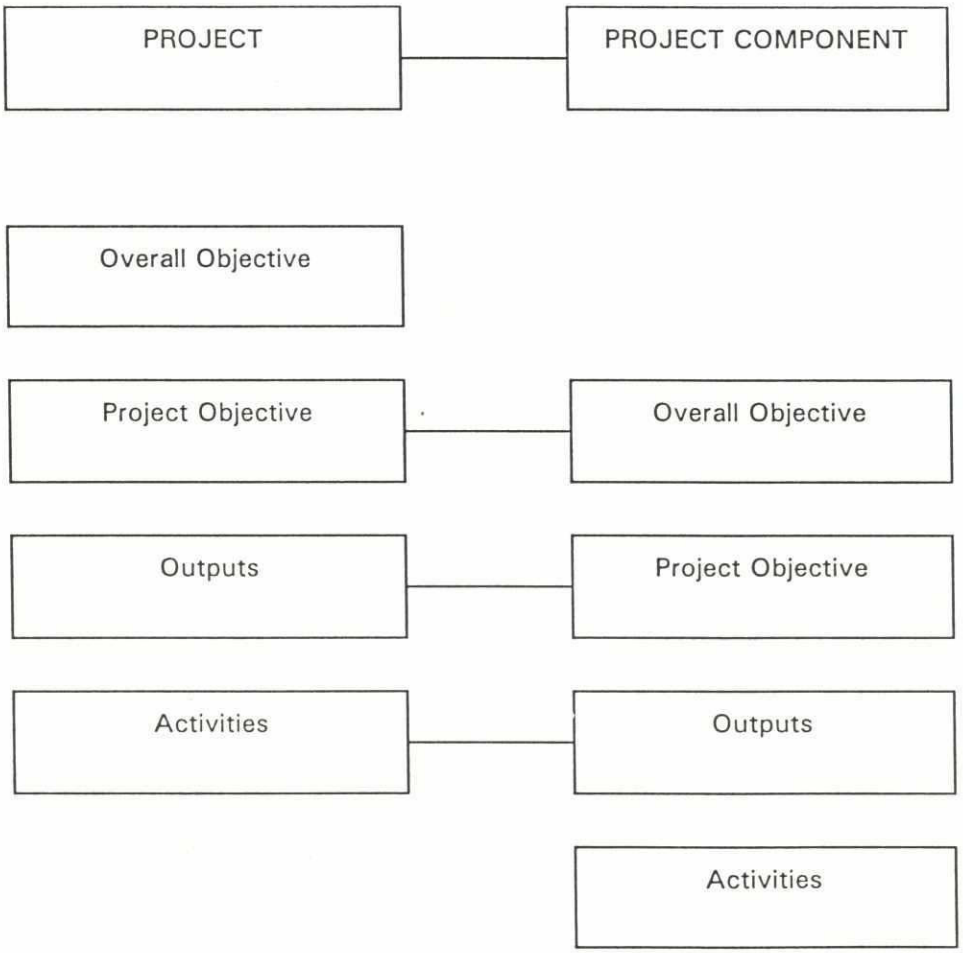


Figure 4.2 : Relation between the Project Log Frame and Log Frame different components of the Project.

4.3.2 Gantt Chart

For day-to-day management of the project, Gantt charts have been prepared for each project component. Whereas the logframe identifies the activities, the Gantt chart describes the detailed activities for each component including starting date and duration. The relative position of the Gantt bar shows which activity is before and after, as well as overlap between activities. Gantt charts are used to present the detailed project implementation plan and will be used to keep track of progress of each project component.

4.3.3 Problem tree

The logframe is more than a table with logic interventions, indicators, verificators and critical assumptions. Using the logframe approach in a broader sense will help to shape and tailor priority projects in particular to address problems and needs of the local population and agencies. Problems and needs related to issues such as flood protection, drainage, settlement and agriculture are being identified in the early stages of the study through, rural household surveys, rapid rural appraisal, walk-throughs, individual and group interviews with the local population and consultation with local agencies.

Participation of local population and agencies in the early formulation of priority projects can be stimulated by the use of so called problem trees. Problem trees reflect a logical hierarchy of causes and effects in a diagram for a particular problem that is considered a main bottle-neck. An example of a problem tree is given in Figure 4.3. In this figure, the main bottle-neck is drainage congestion. The cause-effect relations given is this example may differ from place to place and has been generalised in this example.

The purpose of the use of problem trees in meetings or workshops with the local population and local agencies is to finalise a problem analysis of a main bottle-neck and to discuss the objectives of future priority projects and to some extent the programme of activities of these projects. In such a way, a first outline of a logframe for each priority project can be obtained.

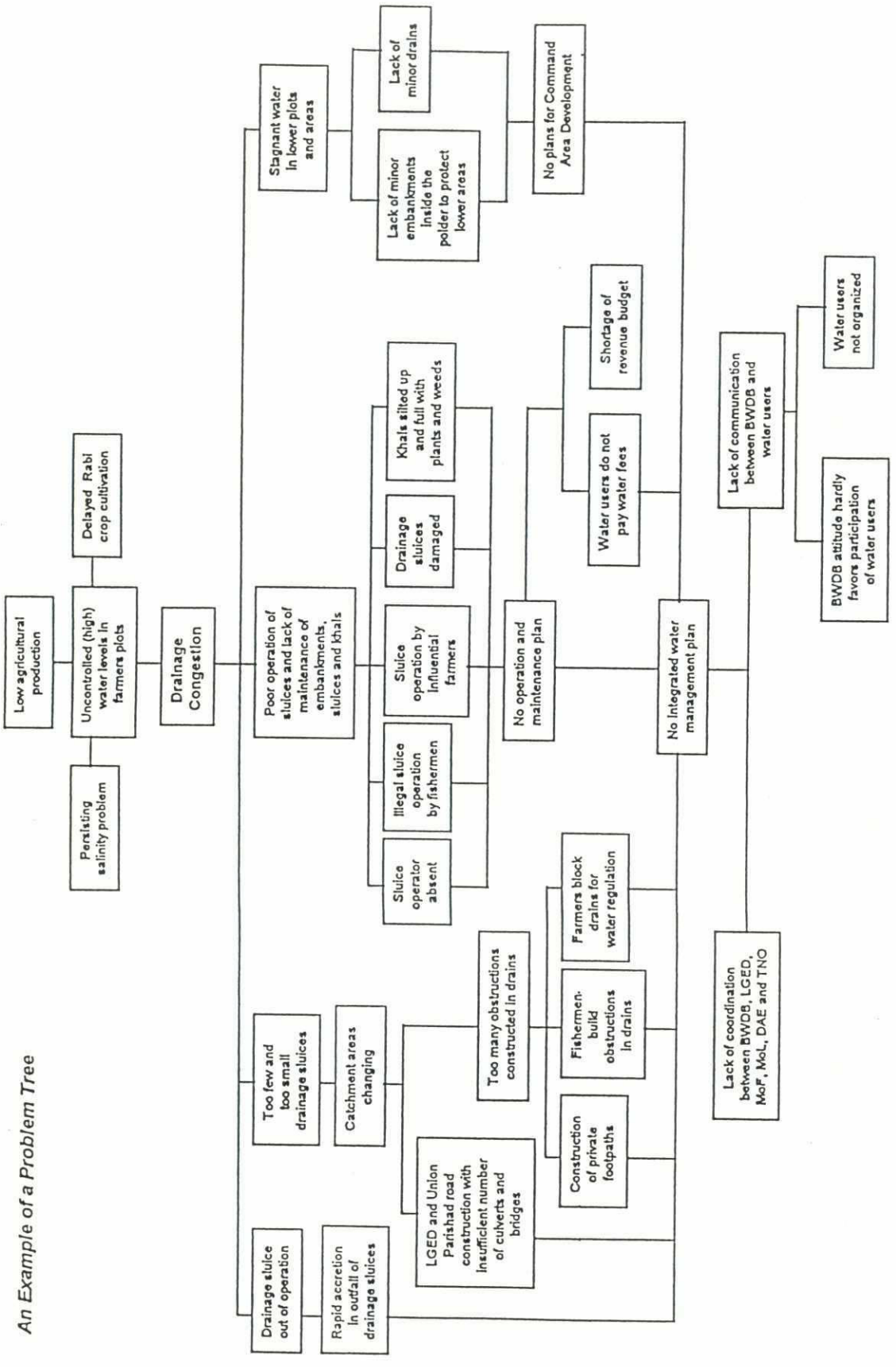


Figure 4.3 : Example of a problem tree for drainage congestion

4.4 Hydraulic and Morphological Modelling

4.4.1 Objective

Natural processes are very complicated process. To handle with hydraulic modelling (Mathematical model), it is also very difficult task. Even though now-a-days, hydraulic model is very much popular. Generally hydraulic (Mathematical) computer models in river hydraulic , its morphology and river estuaries are used, when problems can not sufficiently be solved by sound engineering judgement or desk study alone. In that case they are used as a tool to predict flow velocities, water levels, aggradation and degradation of the bed etc. As with all computer programme, the quality of the results of computations (2-D model in our case) depends to a very large extent on the quality of the input data. For getting quality data extensive surveys and studies will be needed to determine the basic characteristics of tides, current, waves, bathymetry as well as the condition of water management.

Modelling activities will lead to improved understanding of the natural processes of accretion and erosion and of the effects of human interventions, both on the main rivers discharging their water and sediment in the area and on the coastal area itself. This will enable the preparation of a phased long term plan for the estuary. Therefore, the main objectives of the hydraulic modelling are:

- To check the water movement through the different channel as well as the Bay of Bengal of MES area,
- to provide a tool for a detailed and consistent hydraulic impact evaluation of various land development schemes and planning scenarios, relative to a well-defined common reference.

4.4.2 Approach

Previous Model Studies

Hydraulic modelling has been carried out in connection with several previous studies and projects in the area, and is in progress as one component of the ongoing Cyclone Shelter Preparatory Study (CSPS, 1995-1996).

Numerical hydraulic modelling within the Land Reclamation Project (LRP) comprised 1-D(one dimension) hydrodynamic modelling (by the NETFLOW model), and 2-D(two dimension) hydrodynamic modelling (in a 1 Km grid). Also, detailed 2-D hydrodynamic models were applied for selected areas. The numerical modelling of LRP was largely carried out in the Netherlands. The hydraulic model was constructed on the basis of the data collected by the LRP. The model was played an important role in the pre-feasibility studies on measures to protect Sandwip island and Hatia island against erosion and in the feasibility study on the Sandwip crossdam development scheme. Furthermore, the model was used to study the possibility of simulating cyclone-induced storm surges in the delta. They were also studied on land reclamation on south Hatia and South Bhola through these model.

Apart from the LRP, several other relevant marine investigations of study components have been carried out or are in progress in the coastal area of Bangladesh such as for example

- Chittagong Harbour, small studies of siltation and dumping of dredging spoils(1977-78,1983)
- Pussur-Sibsa River and Karnafuli Entrance (Ministry of Shipping, GoB) (comprising marine field surveys, and numerical hydraulic modelling) (1989-91)

- Cyclone Protection Project II (BWDB)(comprising topographic field surveys, and numerical hydraulic modelling (1990-91)

- SW Area Water Resources Management Project(FAP4) (FPCO) (comprising numerical hydraulic modelling) (1991-93)

- Cyclone Shelter Preparatory Study (Local Government Engineering Department) (comprising topographic and marine field surveys, and numerical hydraulic modelling (in progress, November 1995- August 1996)

As indicated, some of these investigations have comprised small or comprehensive field surveys, and numerical hydraulic simulation programmes.

Geographically adjoining FAP projects are FAP4 (SW Area Regional Study), FAP5 (SE Regional Study), FAP5C (S Regional Study) (not yet initiated), and FAP9B (Meghna Left Bank Strengthening). The River Survey Project (FAP24) does not cover the Lower Meghna.

A new phase of the Coastal Embankment Rehabilitation Project (CERP) is scheduled for implementation in 1996, and for that purpose a GIS project in the area is under preparation, founded by the CEC.

The Surface Water Modelling Centre

In connection with the Surface Water Simulation Modelling Programme (SWSMP), the Surface Water Modelling Centre (SWMC) has set up, calibrated and applied a suite of hydraulic models for the Meghna River Estuary:

- A 1-D (Mike11) model, covering the main river system and the Meghna Estuary (the so-called SWSMP model)

- A 2-D (Mike21) 5400 m grid model, covering the northern part of the Bay of Bengal is called 5400 m grid Bay of Bengal model.

- A 2-D (Mike21) 1800 m grid model,covering the entire coast of Bangladesh and main river system with Meghna estuary is called 1800 m grid intermediate model.

- A 2-D (Mike21) model with 600 m grid, covering the main river system and the Meghna estuary which is called 600 m grid Meghna Estuary Model.

- A 2-D (Mike21) model, covering the whole area (stated above) using all 3 models when combined as one nested grid model.

- A 2-D (Mike21) model with 200 m grid, covering small area within the Meghna Estuary Study(MES) area is called local model.

The three first-mentioned models have been used for previous studies in the area, such as the Southwest Area Regional Study (FAP4),the Pussur-Sibsa and Karnafuli entrance study (taking 2 km grid and 6 km grid). At present the Cyclone Protection Project (FAP7) has been working by taking 1800 m grid instead of 2000 m grid and 5400 m grid instead of 6000 m grid. The 1.8 km grid and 5.4 km grid 2-D models is presently being upgraded for the purpose of the Cyclone Shelter Preparatory Study (November 1995- August 1996).

Further, SWMC operates a data base for data storage, and a GIS system for data presentation and impact analysis.

Model studies by MES

The modelling tools are based on numerical models that have been used in the past, as briefly described as follows:

The following data are required as input in the models (refer to Figure 4.4).

- coast contours
- bathymetrics and transect geometries
- hydrodynamic boundary values
- wind field

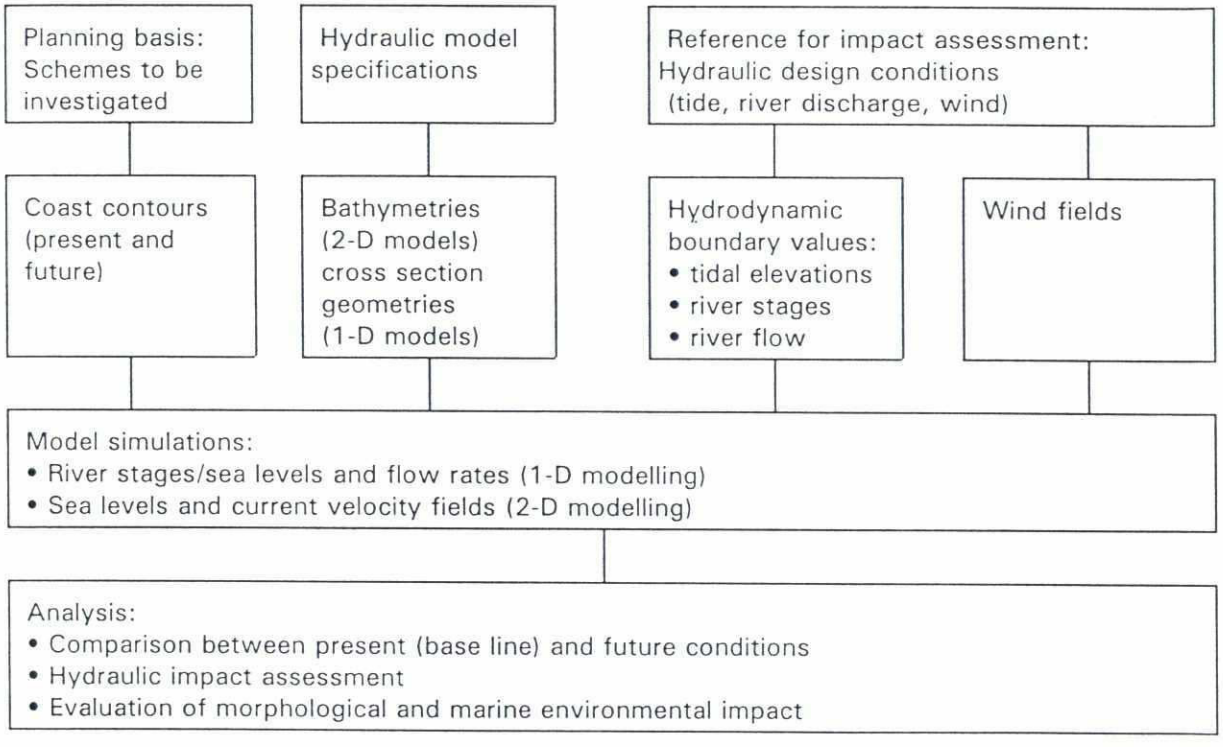


Figure 4.4 : Rationale of hydraulic modelling

The input data will initially be taken from past surveys and monitoring programmes, basically from LRP and other projects in the estuary, BIWTA, and Meteorological Department. In the course of the present project, these data will be updated by results of the MES field surveys and by data from the ongoing marine and Meteorological Department.

For example, the bathymetry of the entire area will be taken from available data sources, notably the LRP. Subsequently, selected critical areas will be successively revised on the basis of the MES bathymetry surveys, in order to upgrade the quality of the impact prediction prior to final recommendations of the MES project.

At present 2-D numerical hydraulic models have been developed in a very good form and is in progress as one component of the ongoing CSPS study(1995-1996).

Therefore, in the present study the latest form of hydraulic models have been used and computations have been carried out on the Surface Water Modelling Centre (SWMC).

For the overall coverage of the estuary area a 2-D model is expected to be adequate.
A 1-D model for the upper part of the Meghna river may be require to establish proper boundary conditions for the 2-D model.

The methodology which can be used for hydraulic model study, comprises the following stages:

- Select the model area, which should contain all locations of interest and whose boundary is located far from these locations
- Specification of numerical constants: grid size, time step etc.
- Schematization of the bathymetry using the most recent maps or data.
- Elaboration of the data collected to provide boundary conditions for the model.
- The model (Mike 21) is to be calibrated using field data which were collected earlier, requiring an extensive data reduction.
- Finally the model can be applied to predict the effect of proposed future works.

Hydraulic design basis for impact assessment

In general, the hydrodynamic impact, the morphological impact, and the marine environmental impact of a given scheme do not necessarily occur under the same oceanographic or meteorological conditions. For example, a morphological impact may occur under high flow and strong winds, whereas a marine environmental impact (such as an increased salinity) of the same scheme may occur under low flow and calm conditions.

Therefore, a critical activity of the miscellaneous impact evaluations is to develop an appropriate hydraulic design basis. This implies a selection of representative 'adverse', 'normal', or 'critical' conditions that have an adequate validity in relation to a specific impact of a given potential scheme.

Approach, 1-D hydrodynamic modelling

The scope of the 1-D modelling is to examine the hydrodynamic impact in the Bangladeshi rivers (if any) of potential MES schemes, or, in other words, the impact outside of the study area of changes within the study area.

For this purpose, the SWSMP model will be used, or rather a part of it, namely the part upstream of the 2-D model boundary.

Approach, 2-D hydrodynamic modelling

The scope of the 2-D modelling is to examine the local and regional hydrodynamic impact of potential schemes within the MES, and also to provide part of the basis for the morphological and marine environmental impact assessment. The 2-D modelling will supply summary information about the wave climate, which will be calculated for average NE monsoon and average SW monsoon wind conditions. In addition, the modelling will serve as a support for analysis of the satellite imagery.

For the purpose, an adaption will be made of the most recent 2-D model of the Meghna Estuary available with the SWMC. Hereby, the model area will be extended to cover the entire MES area, and the grid size will be reduced. The model will be of the so-called nested grid type, with three levels of coupled models, the basic level being SWMC's Bay of Bengal model, which covers an area of 850 km by 600 km with a grid size of 5400 m.

The nested grid approach is required because the outer boundary conditions must be unaffected by the impact to be described by different simulation. Therefore, a regional model of 600 m grid which covers the entire MES area will be set up in this case.

In addition local, fine grid (200 m) models will be set up for examination of MES priority area.

The grids and reference level of all models will be BTM (Horizontal grid) and PWD (Reference level) respectively, in order to conform with the bathymetry surveys, other field measurements, and satellite imagery. The tentative model specification is shown in Table 4.2.

A preliminary simulation programme is given in Table 4.3. The final number of simulations depends on the extent of the impacts of the different schemes: In cases where the impacts is 'regional', rather than 'local', both the regional and the local models must be applied for a valid description, because the impact will penetrate beyond the boundary of the local model.

General	
Horizontal grid :	BTM
Reference level :	PWD
Regional model	
Model orientation :	BTM north
Model area :	184 km by 188 km
Grid size :	600 m
Time step :	90 s
CPU time per day of simulation :	0.68 hour
Each local model	
Model area :	26 - 50 km by 29 - 54 km
Grid size :	200 m
Time step :	30 s
CPU time per day of simulation :	0.6 - 1.6 hours

Table 4.2 : Tentative specifications for 2-D hydrodynamic models

Regional model	
Duration of each simulation :	2 weeks (one fortnightly tidal cycle)
Number of simulation cases,	
dry and flood season baseline :	2 cases
alternative future scenarios :	6 - 12 cases
Each local model	
Duration of each simulation :	2 weeks (one fortnightly tidal cycle)
Number of simulation cases,	
dry and flood season baseline :	1 case
alternative future scenarios :	2 - 4 cases

Table 4.3: Tentative 2-D hydrodynamic simulation programme

Approach other modelling

Depending on the implications of the schemes to be investigated in the course of the project, a need can arise for additional, supplementary model simulations with a different scope and by application of different models than the ones described above.

Examples of such potential model analyses are simulations of wave fields, and modelling of littoral processes, as a support for the morphological impact analysis.

Such modelling will be of a minor extent and will be selected only in cases where work can be saved, or an improved quality can obtained within a given resource allocation, as compared with alternative methods.

Data presentation and storage

Depending on the scope of each particular simulation, the results can comprise for example

- Fields of calculated, characteristic instantaneous current velocities
- Fields of calculated, characteristic neap and spring tidal ranges and tidal stream velocity amplitudes
- Fields of calculated speed differences between 'present' (baseline) and 'future' situation, as well as time series at selected locations
- Longitudinal transacts of calculated set-up from the 1-D modelling (as applicable), by comparison between a 'present' (baseline) and a 'future' situation, as well as time series at selected locations

All 2-D model data (input and output) will be given or produced in the same fixed grid as the one used for the bathymetric and topographic mapping.

4.4.3 Morphological modelling approach

Most of the numerical models used in the hydraulic and morphological field are characterized by the flow chart in Figure 4.6. They contain modules for tides, (if necessary) waves, currents and sediment transport, and a sediment balance module. In many model systems, this is the final result, which is translated into morphological evolutions by expert interpretation. Some other systems contain a time loop mechanism in order to simulate morphological evolutions. These model systems, however, are still in their research phase, and applications are usually restricted to short-term evolutions, e.g. due to one or a few storms or neap-spring tide period.
The hydraulic and morphological models to be discussed in the Meghna Estuary Study belong to the former type, called "initial models"

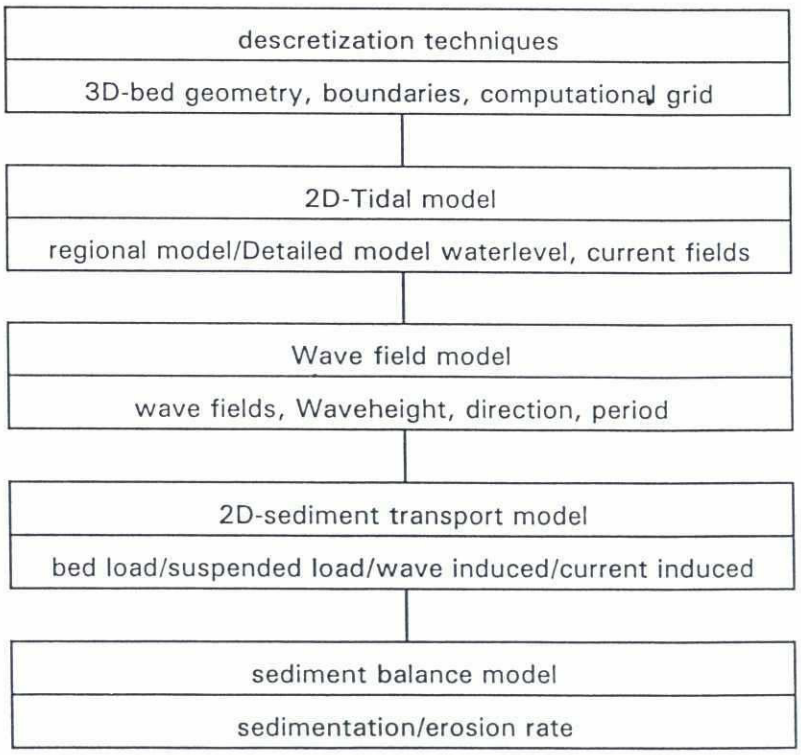


Figure 4.5 : Flow chart morphological modelling

For simulation of hydraulic and morphological characteristics in the Meghna Estuary area, it is necessary to identify the relevant physical processes and the primary driving mechanism behind sediment motion. Preliminary analysis of physical processes in the Meghna Estuary led to the following composition of constituent models:

- 2-D tidal model.
  This should solve the complete shallow water equations, including the tide, the river discharge and wind stress as driving forces. At the present state, wave-driven currents are assumed to be of minor importance in the Meghna estuary. Of course, the model should include a flooding and drying mechanism for large shallow areas (such as North-Sandwip, Urir Char, North Hatia). The model will be established as a structure of nested models with a grid size down to 200m.

- Wave field model.
  This should include 2D-propagation, generation by wind input, and dissipation by bottom friction and breaking. To avoid focusing and tunnelling of wave energy, a refraction model (bottom and current refraction) taking into account of the directional spread of the wave field seemed to be the best solution at the time being. The MIKE-21 program package includes these effects. The wave models will be used for representative wind directions.

- Sediment transport model.
  This should apply to a wave/current environment, and take account of relaxation effects (specially in the case of fine sediments) in the suspended load concentration. For the time being a dedicated model will be used, consisting of a transport formula and a pick-up/ advection/deposition model for the suspended sediment.

- Sediment balance.
  This module should determine the sedimentation/erosion rate from the divergence of the transport field.

The model components could be linked at the software-level through the MIKE-21 program system, providing steering facilities, interfaces between the constituent models and a range of utility programs, and easy access to pre- and post processing facilities.

However the data base generated by the Meghna Estuary Study will not be adequate to produce reliable results of the sediment transport and sediment balance, therefore the sediment transport and morphological computations will be performed separately from the hydro-dynamic calculations with Mike-21.

4.5 Feasibility Studies

4.5.1 Economic aspects - project screening, assessment and preparation

Specification of the objectives for the economic inputs in MES is considered to be a prerequisite for embanking on any study activity - choice of methodology, data collection and analysis. As per FAP 5B TOR, p. 8-9, the economic inputs in MES are particularly required in relation to the following outputs:

- identification and selection of projects for inclusion in the Master Plan (economic level of analysis not specified) for the study area,

- identification and selection of projects for inclusion in a phased Development Plan (pre-feasibility level analysis) for the study area,

- feasibility level analysis for priority projects, and

- preparation of the priority projects for immediate implementation.

For guidance on policy makers objectives and how to perform the project preparation and assessment processes the FAP 5B TOR, p. 13, refers to.

- the general approach for FAP project preparation (listing at the same time only a selection of general project preparation criteria) , and

- the specific project supporting activities of FAP, namely the FPCO Guidelines for Project Assessment, March 1992.

The TOR is thus not specific with regard to a clearly defined set of objectives for the Development Plan or for individual project screenings and assessments either at pre-feasibility or feasibility levels.

4.5.2 The Need for Project Assessment Guidelines

The Guidelines for Project Assessment for FAP projects have been developed to (ref. Guidelines p.4):

- provide a consistent basis for evaluation of benefits and costs of projects (micro planning purposes), and

- provide a sound basis for decision-makers in choosing between alternative possible resource strategies and investments macro planning (macro planning purposes; regional and inter-regional planning).

The guidelines are built on the assumption that any intervention with human and natural environment give rise to multidimensional impacts and externalities (indirect impacts) many of which can not be quantified or even foreseen and internalized. As such, selection of projects can not be done on economic considerations alone. Assessment of projects under FAP involves economic analysis, financial analysis and considerations of other potential effects, including social and environmental impacts, and institutional implications. The Guidelines require that special attention be given to data collection and analysis of potential impacts on fisheries, non-agricultural activities, different social groups and the bio-physical environment.

Environmental Impact Assessment (EIA) is an integrated study process in FAP aiming at predicting environmental consequences of a proposed project and to delineate any environmental management measures which must be integrated into the plan to ensure that the project will be acceptable. Two types of information - summary of positive and negative impacts as well as costing of the Environmental Management Plan to address the impact of each proposed development - are the outputs of the EIA that enter into the analysis. Finally, a frame-work for Multi-Criteria Analysis (MCA) has been set up in order to facilitate the integration of all considerations into a common format for decision making emphasizing (ref. Guidelines p. 4):

- the FAP scope of work as a comprehensive approach towards water management and not only physical flood control, and

- the need to bring regional plans to a common standard, and to study the cumulative effects both within and between regions.

The MES economists have reviewed the Guidelines for Project Assessment (May 1992 issue) and find it conceptionally very interesting and technically in line with standard and widely accepted approaches for project evaluation and appraisal. The Guidelines alert the user to problems and issues specially relevant to water management projects in Bangladesh.

It is felt, however, that the guidelines need to be updated (latest copies are from 1992) and methodologically clarified and operationalised on a number of key issues before it can be directly applied for the MES activities. Some of these issues are.

- the guidelines are not explicit with regard to the project selection criteria - e.g, which criteria should be used when identifying and screening potentially interesting projects for MES (Master as well as Development Plan). Furthermore, the project selection criteria need not be the same at identification and feasibility levels.

- the guidelines are not explicit when it comes to the appropriate steps and depth of the screening activities and feasibility analysis. It is not specified which analytical steps to take and what level of information is required in order to perform satisfactorily:

  - project identification and screening (Master as well as Development Plan level),
  - pre-feasibility analysis,
  - feasibility analysis,and
  - project preparation activities.

- forecasting techniques and procedures for future with (W) and without (WO) project scenarios are not clear. Net incremental differences between the W and the WO scenarios distinguish the impact of the proposed intervention. These impacts will occur against trends and events in society and the natural world that have to be identified, discussed and eventually agreed upon. MES - like other FAP programmes - need a consistent and precise framework for defining future scenarios in relation to e.g. level of population, economic activity and frequency of flood hazards. That the MES projects are long term investments only supports the need for operational guidelines for producing realistic project scenarios - (more than "care" is needed, ref. Guidelines p. 7),

- which components or dimensions (and their operationalisation) should be included in the analysis of total project benefits and costs,

- how to assess quantifiable benefits and costs for main impact areas - social, environment, agriculture, fisheries, general flood damage etc.
  The methodology for including environmental impacts and possible externalities in the analysis should be expanded and brought in line with the latest international developments.

- how to assess qualitative benefits and costs which are not amenable to quantification and evaluation,

- the Multi-Criteria Analysis (MCA) provides a framework for displaying calculated and estimated project impacts in a concise, standardized and comparable way, but is not dealing with a procedure to be used for ranking MES or FAP project alternatives, or alternatives related to regional water management resource strategies and investments (ref. Guidelines p. 18).

It has not (yet) been possible for the MES economists to consult with the economist of FPCO or to consult with colleagues on other FAP projects in order to discuss and learn from their practical experience with the FPCO Guidelines. The economists intend to do so as part of their activities for developing a set of MES Guidelines for Project Assessment using the FPCO Guideline structure as the basis when addressing the above mentioned need for methodological clarification. Additional inputs from the donors with regard to project selection and assessment criteria will be most welcome in this process.

4.6 Institutional setting

4.6.1 Project objectives

The main objective of institutional development in MES is to identify and develop conditions conducive to sustaining and continuing the project activities. These activities are aimed at:

- increasing the operational knowledge of the hydro/morphological processes of the River Meghna;
- increasing the institutional capacity to retain and update that knowledge;
- developing appropriate approaches for rapid and low-cost land reclamation.

From these project objectives, it is clear that the main thrust of the project is establishing and nurturing a planning process, together with data collection and processing in support of that process, in the counterpart organization. A project with such an objective would rightly be called an institutional development project. This impression is reinforced by the fact that, even in addressing tangible interventions to be planned within the framework set by the master plan, the objective is to develop appropriate approaches and not specific engineering artifacts *per se*.

4.6.2 The Terms of Reference

However, the TOR for MES, while stressing the need for sustaining the activities after completion of the project, do not entirely bear out this process orientation. The TOR are most specific on the "hard/ technical" side, where they address the tangible outputs of the process, i.e. the products: data collected, a master plan developed, a land and water use plan formulated, and (an unspecified number of) feasibility studies of priority projects and programs conducted. In addition, the project would identify and support implementation of (an unspecified number of) small-scale interventions. While the "soft"/sustainability side is explicitly addressed, the TOR are somewhat contradictory on this subject.

On the one hand, they require a detailed institutional assessment of the Survey and Studies Division of the BWDB, together with proposals for continuing these activities in the future. On the other hand, the job description for the institutional development specialist (in the TOR from DANIDA) is purely stated in terms of assessing past and possible future roles of Thana and Union Councils, Farmers Cooperatives, and different organizations related with the actual development of the study area.

4.6.3 The nature of MES

There is no doubt as to the project's principal orientation toward planning, in particular macro planning. However, the inclusion of the work for the priority projects and programs, and the institutional development focused on local level implementation, would give the impression that MES attempts to be all things to all people.

It would thus go the same route as the preceding LRP. However, LRP implementation has shown this all encompassing approach to be too difficult in practice. In fact, the land and water-based activities of (master) planning and development have been separated into the two sister projects CDSP and MES for that very reason. It is revealing to note in this regard, that CDSP is termed a project (with specific tangible development objectives), while MES is a study, with the corollary objective to establish the planning process in the counterpart organization.

4.6.4 Institutional development in MES

Institutional development activities in MES must take heed of the process orientation and planning nature of the project, and of the fact that CDSP is developing approaches to actual settlement. Hence it is proposed that institutional development in MES focus on re-activating the data collection and processing activities, and establishing/strengthening the macro-planning capability in the counterpart organization. As such, institutional development would be oriented toward identifying suitable *modi* for continuing these activities after conclusion of the project in an effective and efficient manner. In pursuing this goal, the MES must take due account of institutional changes that may be imminent in the GoB organization with respect to water resources development and management (along the lines presented at the Fourth Conference on FAP held in December, 1995: combining the activities of RRI, SWMC, and BWDB Hydrology Directorates into one organization).

In light of these considerations, it is proposed that MES not deal with grassroots institutional development for people's participation at the project level, as this is far removed from the project's core planning activity. MES should deal with this aspect at a higher level of abstraction insofar as it is relevant for planning, i.e. by determining whether appropriate legislation and arrangements for enforcement exist to make implementation possible. In doing this, MES would not try to re-invent the wheel but adopt the findings of / approaches developed in CDSP. If the nature or scale of interventions suggested by MES requires institutional arrangements beyond those developed in CDSP, MES would identify the relevant institutional gap or overlap and suggest improvements. However, such suggestions would have to be worked out in detail by the project(s) to be formulated for the implementation of such interventions.

An issue related to sustainability of the planning process but not addressed in the TOR is the absence of an institutional framework for coastal zone management. Yet, without appropriate legislation and an organization to enforce it, all planning will come to naught if it is not clear where the responsibility lies for deciding what activities or interventions can be carried out along the coast of Bangladesh. Since this issue as such transcends the scope of the project (it pertains to more than just the MES plan area), the development of relevant institutional arrangements can indeed not be part of MES. However, it is strongly recommended to resolve this issue in the near future.

4.6.5 Sustaining project activities

In seeking ways to sustain the core project activities after conclusion of MES, institutional development in the project must focus on different organizations:

- WARPO is now responsible for macro planning, and will also coordinate FAP activities after the merger with FPCO. The project must establish a close working relationship with WARPO if it is to be successful in transferring its macro planning process to that organization.

- BWDB will continue to be responsible for micro planning, design, implementation, and coordination and supervision of O&M (for large-scale projects on/in the water and on land; LGED is responsible for small-scale projects on land). For subsidiary development of arrangements to align BWDB's micro planning procedures with the macro planning process, the relevant counterpart for MES is the Directorate for Land Accretion and Development (LAED).

- LAED's Surveys and Studies Division in Chittagong is responsible for data collection and processing. This activity has partly been dormant in the past few years and must now be re-activated.

- SWMC under the River Research Institute does surface water modelling.

Despite the fact that all these organizations are relevant for MES, the TOR mention only one counterpart organization, the LAED of the BWDB. However, with its micro planning and implementation orientation BWDB would play its most important role after the project's core (macro) planning process. Thus, it would appear that BWDB's role in MES is significantly overstated in the TOR.

4.6.6 Issues to be settled

In light of the above observations, a number of important issues need to be settled in detail for MES to be able to carry on convincingly:

- Project ownership
  As demonstrated above, the proper counterpart for the project would be WARPO. However, policy control and coordination of the project's activities rest with the BWDB, which also controls the counterpart budget. Especially the latter may have a major impact on GoB support to be provided to the project.
  Therefore appropriate arrangements will have to be made to ensure that WARPO has access to adequate means to participate in and support MES in planning and establishing the planning process.

- Counterpart staff for training
  Establishing, nurturing, and sustaining the (macro) planning process requires a small number of staff assigned to the project on a nearly full-time basis to participate in the day-to-day work developing the master plan and the land and water use development plan. They would thus become not only fully knowledgeable on these plans but also able to continually update them after project end. Since BWDB is not responsible for macro planning, establishing this process there would by definition be unsustainable. Therefore, the counterpart staff should come from WARPO.

  Agreement should be reached with WARPO and BWDB (and possibly also with the donors) on selection and secondment of the staff involved, and on the budget needed for their participation and training.

- Process vs. product
  The plans to be developed in MES are not expected to be definitive but must be continually updated in the on-going planning process to be established. According to the spirit of the TOR, the main thrust of the project is establishing and nurturing this process. However, the letter of the TOR bespeaks an end-product orientation, which is amplified by the inclusion of feasibility studies and small-scale interventions. Agreement should be reached on the process nature of the project and on how success or failure will be determined.

- Focus institutional development on the process
  The proposed emphasis on the planning process does not imply that MES should assume responsibility for institutional development of WARPO as a whole. Rather, arrangements should be made to closely coordinate MES activities with up-coming efforts to that purpose, supported by the World Bank. If those efforts are not to start within the next few months, MES would have to remain limited to training a small number of WARPO counterpart staff and developing procedural links between the macro and micro planning processes.

- Defer to CDSP for people's participation
  Since people's participation becomes particularly relevant during micro planning and implementation, institutional development in the context of feasibility studies will defer to approaches (to be) developed in CDSP. It should be agreed that MES will not become involved in institutional development at the field level, and will consider institutional aspects of implementation only insofar as relevant for planning purposes.

- Sustainability of data collection and processing
  The TOR prescribe an assessment and planning for development of the SSD in Chittagong. However, there is also reference to alternatives outside SSD in this regard. Hence, it may be agreed that the report on institutional development for data collection and processing will not exclusively focus on the SSD, but will include alternative options for continuing routine surveys and studies after conclusion of MES.

- Coastal zone management
  Proper arrangements for coastal zone management (legislation, enforcement) are of the highest importance for MES-developed plans to be effective in practice. However, because the relevance of this issue transcends the scope of MES, it may be agreed that the development of such arrangements is not a proper objective for the project. The project can, however, outline specific criteria for such arrangements from the perspective of the MES master plan.

5 ORGANISATION FOR IMPLEMENTATION

5.1 Project Organisation

The tender of consultancy services for the Meghna Estuary Study in Bangladesh was issued by the Directorate General (DGIS) of the Netherlands' Ministry of Foreign Affairs in April 1995.

The consultancy services have been awarded to the following group of consultants:

DHV Consultants, Amersfoort, the Netherlands (lead consultant)
Kampsax International S/A, Copenhagen, Denmark
Danish Hydraulic Institute, Copenhagen, Denmark
Resource Analysis, Delft, the Netherlands
Development Design Consultants Ltd., Dhaka
Surface Water Modelling Centre, Dhaka and
Aqua Consultants and Associates Ltd., Dhaka

The Main Agreement was signed on 10 December 1995, the starting date of the services was agreed to be 1 November 1995.

The project will be implemented under a cooperation programme between the Governments of Bangladesh, The Netherlands and Denmark. The administrative agreements between the three governments was signed on 7 December 1995.

The executing agency on the Bangladeshi side is the Bangladesh Water Development Board (BWDB). According to the Terms of Reference (TOR) the coordination with the other projects under the Flood Action Plan (FAP) is to be done by the Flood Plan Coordination Organisation (FPCO) presently merged with Water Resources Planning Organization and is known as WARPO.

The organogram for the Meghna Estuary Study project is shown in Figure 5.1

ORGANOGRAM FOR MES PROJECT

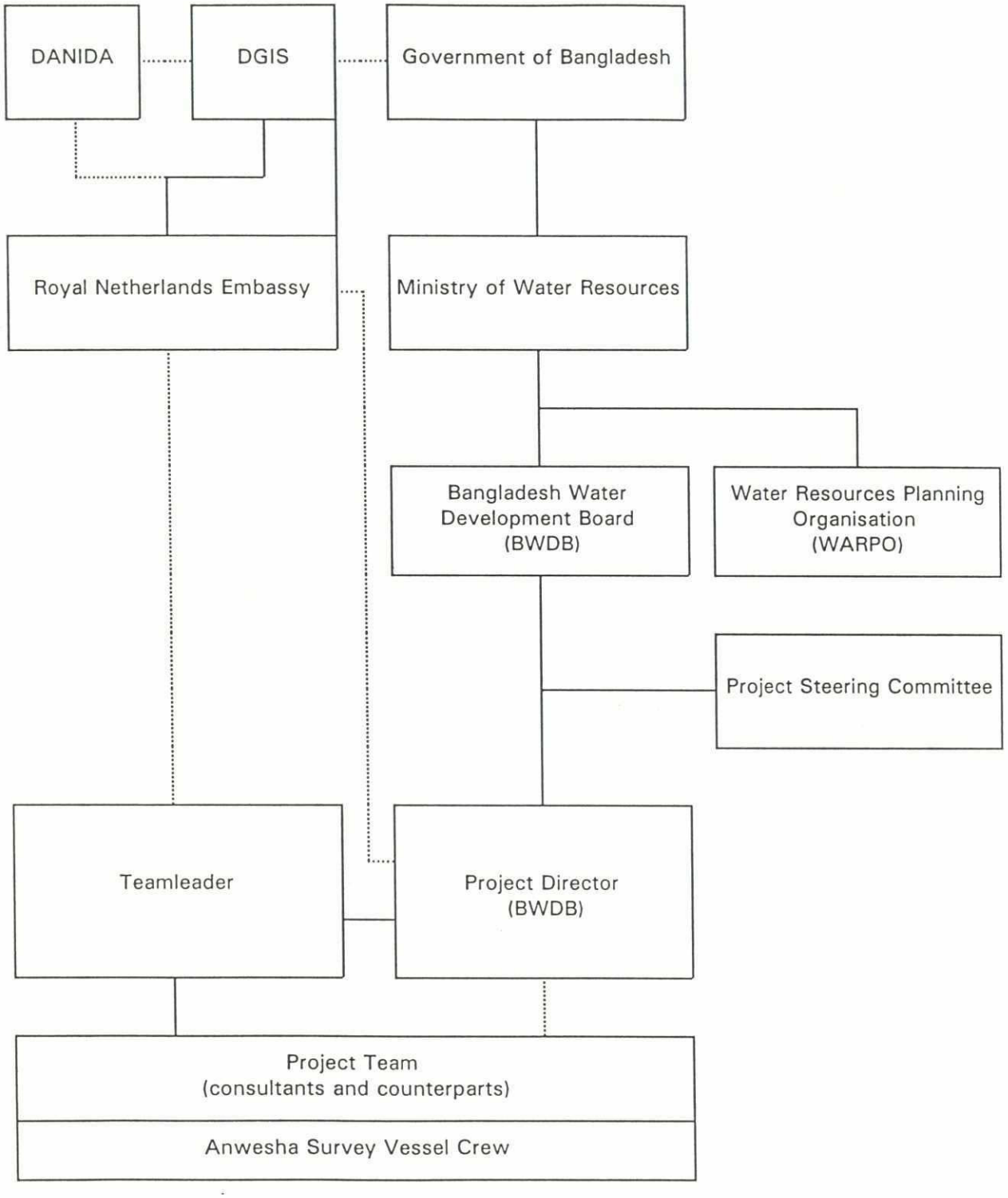


Figure 5.1 : Organogram Meghna Estuary Study

5.2 Project Staffing from BWDB

The following statements show the list of BWDB personnel on behalf of Government of Bangladesh:

A.	Directorate of Land accretion and Estuary Development, Dhaka		
Sl. No.	Description	TAPP Number	Actual Number
1.	Superintending Engineer	1	1
2.	Executive Engineer	1	1
3.	Deputy Director(Absorbed)	1	
4.	Sub-divisional Engineer	2	2
5.	Accounts Officer	1	1
6.	Sub-Assistant Engineer	2	2
7.	Head Assistant	1	1
8.	Draftsman	1	1
9.	Stenographer	1	
10.	U.D.A.	1	1
11.	S.A.A.	2	1
12.	L.D.A.	2	2
13.	Typist	2	1
14.	Driver	1	1
15.	Gestetner Operator	1	1
16.	Guard	2	2
17.	M.L.S.S.	4	4
18.	Sweeper	1	1
	Sub-total of A	27	23

Table 5.1 Staffing Directorate of Land accretion and Estuary Development, Dhaka

B.	Survey and Study Division, BWDB, Chittagong		
Sl. No.	Description	TAPP Number	Actual Number
1.	Executive Engineer	1	1
2.	Deputy Director(Absorbed)	4	4
3.	Assistant Engineer	2	
4.	Divisional Accountant	1	
5.	Draftsman Grade I	1	1
6.	Sub-Assistant Engineer	1	
7.	Head clerk	1	1
8.	S.A.A.	2	1
9.	Steno-Typist	1	
10.	Clerk-cum-Typist	4	4
11.	Accounts Assistant	2	1
12.	Driver	3	2
13.	Store Keeper	1	1
14.	Blue Printer/Machine Oper.	1	
15.	Record Supplier	1	
16.	Guard	3	
17.	M.L.S.S/Peon	4	2
18.	Sweeper	1	1
19.	Orderly Peon	1	1
20.	Office Chowkider	1	
21.	Gardener	1	
	Sub-total of B	37	20

Table 5.2 Staffing Survey and Study Division, BWDB, Chittagong

C.	Survey Vessel		
Sl. No.	Description	TAPP Number	Actual Number
1.	Skipper	1	
2.	Engineer Grade "A"	1	
3.	Engineer Grade "B"	1	1
4.	Skipper Grade-II	1	
5.	Sub-Assistant Engineer	1	
6.	Sailor	6	4
7.	Greaser	2	1
8.	Daughter Vessel Driver	2	
9.	Cook (Cook-B)	1	1
10.	Lasker	2	1
11.	Jetty Guard	3	
12.	Assistant Cook	1	1
	Sub-total of C	22	9

Table 5.3 Staffing Survey Vessel

D.	Measurement Sub-division		
Sl. No.	Description	TAPP Number	Actual Number
1.	Sub-divisional Engineer	1	1
2.	Junior River Surveyor	8	3
3.	Clerk-Cum-Typist	1	
4.	Gauge Reader	4	1
5.	Survey Khalashi	4	3
6.	M.L.S.S/Peon	1	
7.	Guard	1	
	Sub-total of D	20	8

Table 5.4 Staffing Measurement Sub-division

E.	Processing Sub-division		
Sl. No.	Description	TAPP Number	Actual Number
1.	Sub-divisional Engineer	1	1
2.	Assistant Director	1	
3.	Tracer	1	
4.	Draftsman Grade-II	1	
5.	Clerk-cumTypist	1	
6.	M.L.S.S/Peon	1	
7.	Sweeper	1	1
	Sub-total of E	7	2

Table 5.5 Staffing Processing Sub-division

F.	Laboratory Section		
Sl. No.	Description	TAPP Number	Actual Number
1.	Assistant Director	1	
2.	Lab. Technician/Soil Tech.(Grade-C)	2	2
3.	M.L.S.S/Peon Sub-divisional Engineer	1	
	Sub-total of F	4	2

Table 5.6 Staffing Laboratory Section

5.3 Staff mobilization consultants

STATEMENT SHOWING THE LIST OF CONSULTANTS STAFF FOR MES PROJECT

A.	Expatriate Consultants of MES Project		
Sl. No.	Description	TAPP Man-months	Actual Man-months
1.	Project Director		
2.	Team Leader	30	28
3.	Hydraulic Engineer (Estuaries)	12	9
4.	Hydraulic Engineer (Reclamation/Closures)	10	6
5.	Coast/River Morphologist	14	9
6.	Chief Hydrographer	12	10
7.	Economist	10	8
8.	Water Management/Drainage Engr.	10	9
9.	Civil Engineer	8	7
10.	Rural Dev./Social Specialist	12	9
11.	Environmentalist	12	8
12.	Agronomist	7	5
13.	Modelling Specialist	7	5
14.	Institutional Specialist	7	6
15.	Remote Sensing Specialist		2
16.	Special Adviser (as required)	3	1
17.	Special Adviser (as required)		1
18.	Instrument Specialist		3
	Sub-total of A	154	126

Table 5.7 Staffing Expatriate Consultants of MES Project

B. Local Consultants of MES Project			
Sl. No.	Description	TAPP Man-months	Actual Man-months
1.	Co-team Leader	32	32
2.	Hydraulic Engineer (Estuaries)	32	30
3.	Hydraulic Engineer (Reclamation/Closures)	32	30
4.	Morphologist	32	30
5.	Chief Hydrographer	24	22
6.	Economist	20	20
7.	Water Management/Drainage Engr.	32	28
8.	Civil Engineer	32	28
9.	Rural Dev./Social Specialist	25	27
10.	Environmentalist	14	14
11.	Agronomist	22	21
12.	Modelling Specialist	22	28
13.	Institutional Specialist	12	12
14.	Remote Sensing Specialist		12
15.	Special Adviser (as required)	6	6
16.	Surveyors & Junior Specialists	150	150
	Sub-total of B	490	490

Table 5.8 Staffing Local Consultants of MES Project

C. Local contracts of MES Project			
Sl. No.	Description	TAPP Man-months	Actual Man-months
1.	GIS specialist		30
2.	GIS/computer operator		27
3.	Skipper "Anwesha" (temporary contract)		6
4.	Survey crews		40
5.	EGIS (elaboration of existing map/satellite data)		7
	Sub-total of C		110

Table 5.9 Staffing Local Contracts of MES Project

5.4 Office staff

The office of the Consultants is established at "AFROZA" House No.34, Road No. 25, Gulshan, Dhaka 1212. The office will be self sufficient and properly staffed. Table 5.10 showS the staff that has been recruited for the operation and maintenance of the office.

Office staff of MES Project			
Sl. No.	Description	TAPP Number	Actual Number
1.	Office Manger/Administrative Officer	1	1
2.	Accountant	1	1
3.	Secretary		1
4.	Typist/Word Processor	2	1
5.	Librarian/Word processor		1
6.	Driver	3	3
7.	Messenger/peon	4	2
8.	Photocopy operator		1
9.	Kitchen Assistant		1
10.	Guard		3
11.	Gardener		1
	Sub-total of B	11	16

Table 5.10 Staffing Office of MES Project

5.5 Office facilities and vehicles

An office for the Consultants has been hired in Gulshan. It is a two storied building with floor area of about 500 m^2. This has been furnished with appropriate furniture.

The following facilities will be available in the office of the consultant:

- telephone/fax
- computers and printers
- GIS hardware and software
- photocopy machine
- library/conference room
- map storage
- computer data storage
- training equipment

The details of the office equipment are shown in Table 5.11

Sl. No.	Type of Equipment	Quantity	Remarks
1	Computers	1	Office BWDB Dhaka
		1	Office BWDB/SSD Chittagong
		6	Office consultant Dhaka
2	Laser printer	1	Office BWDB Dhaka
		1	Office BWDB/SSD Chittagong
		2	Office consultant Dhaka
3	Color printer	1	Office consultant Dhaka
4	Plotter	1	Office BWDB/SSD Chittagong

Table 5.11 : List of office equipment

Sl. No.	Type of Equipment	Quantity	Remarks
5	Photocopier	1	Office BWDB Dhaka
		1	Office BWDB/SSD Chittagong
		2	Office consultant Dhaka
6	Air conditioners	1	Office BWDB Dhaka
		11	Office consultant Dhaka
7	Fax	1	Office Consultant Dhaka
8	Telephone set	6	Office Consultant Dhaka
9	Fan	2	Office BWDB Dhaka
		2	Office consultant Dhaka
10	Stabilizer	2	Office BWDB Dhaka
		2	Office BWDB/SSD Chittagong
		5	Office consultant Dhaka
11	UPS	1	Office BWDB Dhaka
		1	Office BWDB/SSD Chittagong
		4	Office consultant Dhaka
12	Digitising table	1	Office consultant Dhaka
13	Optical media for data storage	1	Office consultant Dhaka

Table 5.11 : List of office equipment (continued)

The following vehicles were available for transportation of the Consultants in Dhaka and for field trips on 15 April 1996:

1. One Rocky Jeep - Borrowed from Royal Netherlands Embassy
2. One Nissan Landcruiser - Borrowed from Royal Netherlands Embassy
3. One Toyota Microbus - Leased for transport in Dhaka

As per approved TAPP the following vehicles will be imported for the project, only for these vehicles CDST will be paid by the Government:

1. Two Toyota Landcruisers _ For BWDB Dhaka
2. Three Toyota Landcruisers _ For the consultants
3. One Toyota Pick-up _ For BWDB Chittagong

As per consultant's Main Agreement the transport requirements for the Project are as follows:

1. One sedan type car
2. Two minibus
3. Two jeeps

The consultant has proposed to import six vehicles, as specified in the TAPP, instead of the vehicles mentioned in the Main Agreement.

However the three 4WD vehicles, allocated to the consultants, are not adequate to cover their transport requirements. Therefore one microbus has been leased already for the duration of the project and it has been agreed that the Rocky jeep of the Royal Netherlands Embassy can be borrowed until the end of the project.

5.6 ANWESHA and tender boats

The marine survey activities under LRP have been carried out by the 'Anwesha' which was the main survey vessel of LRP stationed in Chittagong. Today, the vessel is operated by BWDB/SSD, it will also be used for the MES survey activities. The main specifications of the vessel are indicated in Table 5.12.

From May 1980 to 1991, 'Anwesha' was in operation for some 50 percent of the time, the remaining time being spent on bunkering, scheduled and unscheduled repair and maintenance, weather downtime, holidays, and unrelated activities. The vessel was docked once per year for routine inspection and maintenance, and also, on several occasions, for major repairs due to accidental damage to the hull or to the propulsion system. Typical reasons for such damage was hitting the seabed, and getting the propeller entangled with fishing nets (to which the vessel is reportedly particularly sensitive, 'LRP, Final Report', p. 32-34).

In 1990, an appraisal mission made the following observations on working conditions in the project area: (Westdijk and Mol, draft, undated):

- travelling distances are enormous
- accessibility is often difficult and sometimes impossible
- local currents are sometimes dangerous according to Dutch standards
- unpredictable and dangerous tidal bores occur in the area
  On one occasion a tidal bore caused the loss of one tender boat

In addition to the LRP field programme, which ended in 1991, the vessel has been used for minor surveys for FAP1 (1990-91) and FAP24 (1992).

Anwesha	Built (Akerboom, Leiden, Holland)		1980
	Length		32 m
	Beam		7 m
	Draft (summer mark)		1.9 m
	Speed	Maximum	10 knots
		Steaming	8 knots
	Tank capacity	fresh water	22,000 l
		fuel	36,000 l
	Power Supply (2x85 kW + 20 kW)		440/220 V AC
	Estimated fuel consumption at maximum speed		190 l/hour
Two tender boats	Length		7 m
	Draft		1 m
	Speed		20 knots
	Estimated fuel consumption at maximum speed each boat		16 l/hour

Source: 'Holland Shipbuilding', May 1980, pp. 36 - 37

Table 5.12 Key specifications of 'Anwesha' and tender boats

The Technical Assistance budget includes provisions 'Operation & Maintenance of the M.V. Aneshwa, Tender Boats and other small boats (Rubber boats) for the duration of the Meghna Estuary Study. These survey vessels will be equipped with new and sophistioned equipment as a part of the Technical Assistance program. The details of the new survey equipment is given in Section 5.7.

The vessels are presently (April 1996) at the dock yard in Naryanganj. The major overhaul was completed by Mid March 1996. After a successful trial run in the presence of the Adviser of the Royal Netherlands Embassy, the ship has been cleared survey work in the Estuary. The overhaul of the Tender boats is expected to be completed shortly.
A well for the ADCP has been installed in the ship after permission was obtained from the Loyds' agent.

The "Anwesha" will remain in Naryanganj until the new survey equipment has been installed on board the ship.

A proposal with cost estimates has been received from BWDB for lengthening of the jetty connecting the landing pontoon for "Anwesha" in Chittagong to the shore.
The adjustment of jetty is required because of shoaling along the river bank. In addition repairs and painting of the steel parts is required to prevent further deterioration of these facilities.

5.7 Survey equipment

The survey equipment that has been purchased for the project is indicated in the following table:

Type of equipment	Number units	Brief details	Remarks
Positioning equipment	4 4	Trimble RTK GOS receivers type 7400MSI, including antenna and cables.(3 mobiles & 1 reference station) UHF Radio link type Radtel including antenna and cable	This equipment is mobilized for the Anwesha,tender boats and reference station operation. The system includes the latest RTK-OTF technology.
Gyro/conpass	1	Gyro compass Tokimec GM 20, RGC signal interface (Anwesha)	Magnetic variations occur within the project area while the ship has unknown deviation in its magnetic compass. Therefore for the determination of true north at different sites in the area, assistance of a gyrocompass is essential.
Auto-pilot	1	Radio Zeeland Delta 510 and F.O stick Delta 600	The auto-pilot is required to keep the ship on course as accurately as possible
Echosounders	1 2	Echosounders duel frequency 30/200 khz,type Atlas Deso 15 or similar including transducers (M/V Anwesha) Echosounder single frequency 200 khz,type Atlas Deso 14 or similar,includingtransducers (tender boats)	A duel frequency echosounder has been included in the equipment list to obtain a proper signal where single frequency equipment fails for muddy conditions of the bed
M/V Anwesha Computer & navigation, datalogging hardware	3 1 2 1 2 Lot	PCs A3 plotter Helmsman display Tape streamer Printer Racks cables etc.	This equipment is required for on-line processing of data from the positioning system and the echosounder on the Anwesha
Tender boats Computer & Navigation, datalogging hardware	2 2 2 2 Lot	PC's portable Tape streamer Helmsman display Printer Racks, cables etc.	This equipment is required for on-line processing of data from the positioning system and the echosounder on the tender boats

Table 5.13 Detailed list of survey equipment

Table 5.13 Detailed list of survey equipment (continued)

Type of equipment	Number units	Brief details	Remarks
Rubber boat with out board engine	1 1 1	Sillinger 490 RIB PRO, V-shape, fibreglass, cloth 1660 DTX 60 HPMercury Water Jet Engine Steering Console and cables for remote control	An 8 - seater rubber boat suitable for use in the Meghna Estuary.
Software	1 1	Hydro software package incl.3 dongles (Anwesha and 2 tender boats) HydroACQ software (Anwesha)	This software is required for on-line processing of data from the position equipment, the gyro - compass and the echosounders
Acoustic Doppler Current Profiles:	1	ADCP, 600 Khz B.B.D.R (Anwesha)	The ADCP will measure the current velocities between the bottom of the ship and the bed of the river/bay
Communication equipment:	2 2	Safecom transceivers & PC/printers (Anwesha,Dhaka) VHF, radio SP ,25 Watt (tender boats)	The safecom system is required for reliable and undisturbed satellite communication between the Anwesha and Dhaka. The transceiver (VHF) will be installed in the office of BWDB/SSD in Chittagong
Power supply units (UPS)	1 2	Stabilized power unit including battery charger, inventer & batteries (Anwesha) Power supply units AC/DC convertor & batteries (tender boats)	The uninterrupted Power Supply (UPS) is required to avoid loss of data in computer when the A/C generator of the tender boats stops suddenly
Self Recording Current Meter	1	Current meter type InterOcean S4 P (including T,C,P and tilt sensors)	This propeller current meter will continuously record the changing tidal velocities. These data will be required as reference for the current measurements by ADCP

22/2

Type of equipment	Number units	Brief details	Remarks
Sediment equipment:	1 3 1	Owen samplers (SK110) Integrated bottle sampler Winch including Grundfos pump and umbilical	This equipment will replace the old equipment on board the "Anwesha"
Tide/Wave Recorders	7 3	Tide/Wave recorders, type Van Essen Air pressure recorders, type Van Essen Diver	The Tide/Wave gauge, electronics and battery (life 10 years) are integrated in a single Titanium housing. The recorder can be easily programmed and data can be read out directly into a standard portable computer.The Tide/Wave gauge will be installed below water level and sufficiently above the bed to avoid loss of equipment or data by deposition of sediment. Three 'Diver' units will be installed on land to record the changes in air pressure. These data wil be used to calculate the actual water level from the water pressure.
Temp./cond. Profiler	2	WTW T/C meter	This equipment will replace the old equipment on board the "Anwesha"
Sediment lab:	1 1 1 1 500 50 100 2	Drying kiln and desiccator (already available) Sieving machine with sieves Balance Mettler AE200 Vacuum pump complete with hose Glassware & filters 0.5 liter bottles 25 l container for water samples 1 l bottles Andreasen settling tube	This equipment will replace the old equipment in the BWDB/SSD laboratory in Chittagong
Service tools & miscellaneous equipment:	2 lot lot	Tool set, incl. scopemeter, Fluke multim., hand tools etc. Service PC etc. Miscellaneous equipment	Required in the BWDB/SSD laboratory in Chittagong
Spare parts	lot		

Table 5.13 Detailed list of survey equipment (continued)

6 PROJECT IMPLEMENTATION PLAN

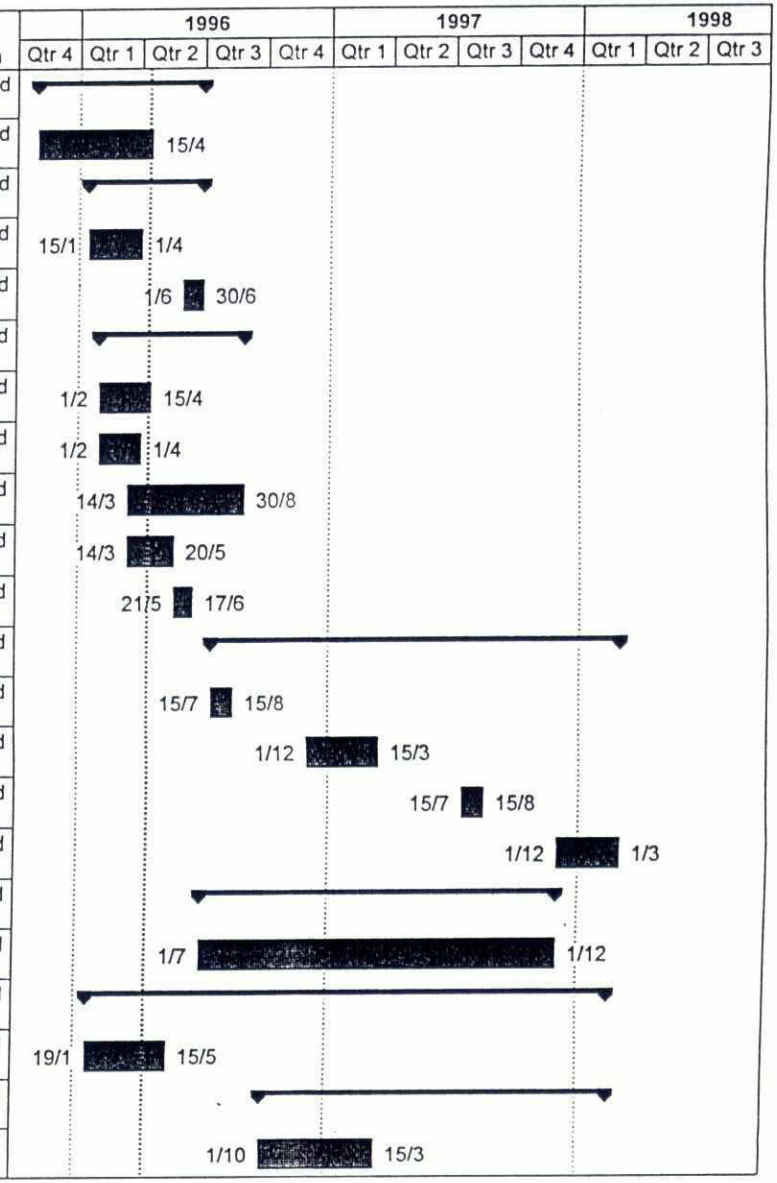
The Project Implementation Plan is provided in the form Gantt charts for the different disciplines that will contribute to the Meghna Estuary Study.
The Gantt charts will be used for day-to-day management of the implementation of the project and to keep track of progress of each project component.

The following Gantt charts have been prepared:

Chart 6.1 : Morphology and Hydraulics
Chart 6.2 : Civil Engineering and Reclamation
Chart 6.3 : Water Management and Drainage
Chart 6.4 : Rural Development and Socio-Economic Aspects
Chart 6.5 : Agricultural Aspects
Chart 6.6 : Environmental Aspects
Chart 6.7 : Economic Aspects
Chart 6.8 : Remote Sensing and GIS
Chart 6.9 : Institutional Development
Chart 6.10 : Expatriate Technical Staff
Chart 6.11 : Local Technical Staff
Chart 6.12 : Reporting Schedule

MEGHNA ESTUARY STUDY
Gantt Chart Morphology and Hydraulics

ID	Task Name	Duration
1	1 PRELIMINARY PHASE	243d
2	1.1 Detailed planning of surveys and studies	167d
3	1.2 Procurement and installation of survey instruments	168d
4	1.2.1 Procurement of survey instruments	78d
5	1.2.2 Installation of survey instruments	30d
6	2 INVENTORY AND PREPARATION OF PRESENT DATA	212d
7	2.1 Inventory of available data	75d
8	2.2 Review of relevant morph. studies & reports	61d
9	2.3 Digitize bathymetric maps & shorelines	170d
10	2.4 Set-up of reliable database system & update	68d
11	2.5 Prepare data inventory report (as part of inventory report)	28d
12	3 SURVEYS BY ANWESHA	595d
13	3.1 Monsoon season 1996, survey 1	32d
14	3.2 Dry season 1996/1997, survey 2	105d
15	3.3 Monsoon season 1997, survey 3	32d
16	3.4 Dry season 1997/1998, survey 4	91d
17	4 WAVES AND WATER LEVELS	519d
18	4.1 Wave and water level registartions	519d
19	5 LAND BASED SURVEYS	759d
20	5.1 Reference bench marks	118d
21	5.2 Coastline and coastline gradients, elevation contours of shallow areas	503d
22	5.2.1 Survey of 1996/1997	166d



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MEGHNA ESTUARY STUDY
Gantt Chart Morphology and Hydraulics

ID	Task Name	Duration
23	5.2.2 Survey of 1997/1998	138d
24	5.3 Supplementary mapping of land elevations	457d
25	6 DATA PROCESSING AND ANALYSIS OF HYDROL. AND MORPHOL. DATA	289d
26	6.1 Numerical model set-up	152d
27	6.2 Selection & data processing of field data	26d
28	6.3 First results morphological changes of the shoreline	26d
29	6.4 Parametrisation of morphometric data	40d
30	6.5 Morph.data at site specific areas	19d
31	7 FIELD SURVEY DATA AND DATABASE WITH DATA OF 1996/1997	126d
32	7.1 Digitize bathymetric data & remote sensing data field survey 1 and 2	121d
33	7.2 Updating of the database (field survey 1 and 2)	121d
34	7.3 Updating of inventory report (field survey 1 and 2)	19d
35	8 DATA PROCESSING AND ANALYSIS WITH DATA OF 1996/1997	103d
36	8.1 Update of selection and processing of field data, survey 1 and 2	39d
37	8.2 Update of the results morphological changes of the shoreline	26d
38	8.3 Update parametrisation of morphometric data	26d
39	8.4 Morph.data at site specific areas	19d
40	9 FIELD SURVEY DATA AND DATABASE WITH DATA OF 1997/1998	112d
41	9.1 Digitize bathymetric data & remote sensing data field survey 3 and 4	91d
42	9.2 Updating of the database (field survey 3 and 4)	91d
43	9.3 Updating of inventory report (field survey 3 and 4)	20d
44	10 DATA PROCESSING AND ANALYSIS WITH DATA OF 1997/1998	85d

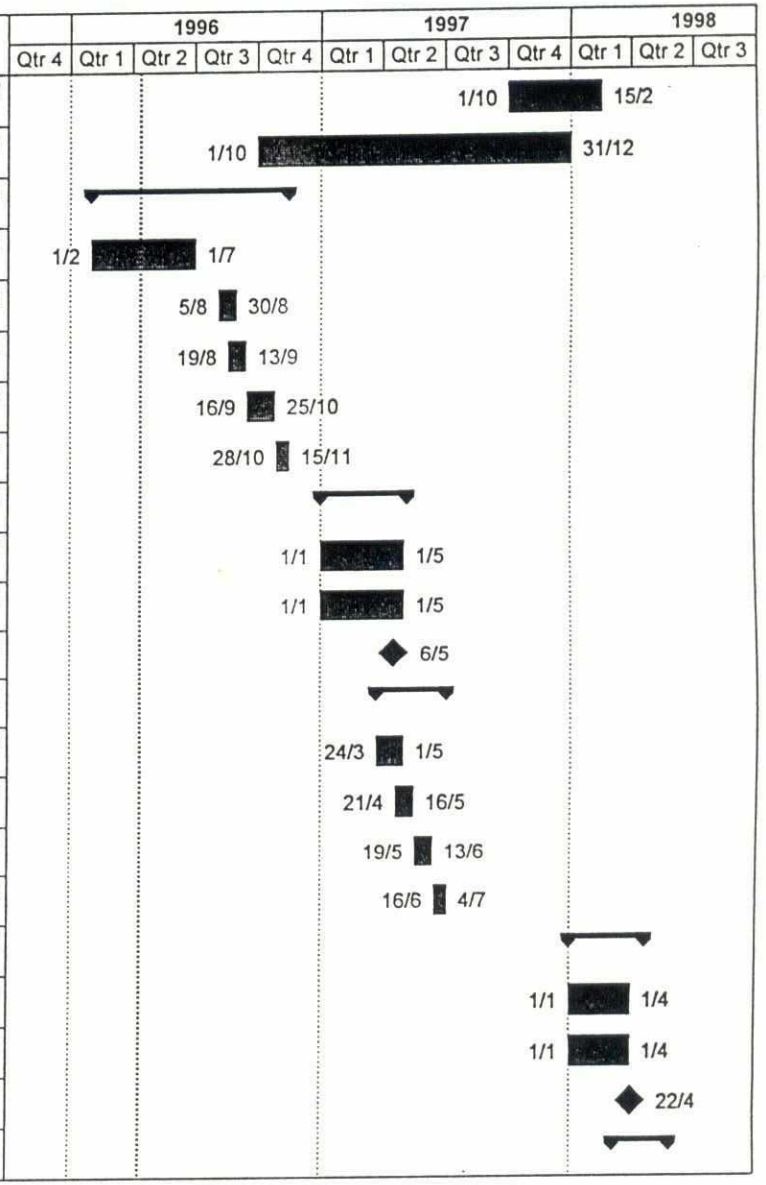

Chart 6.1 : Morphology and Hydraulics (continued)

MEGHNA ESTUARY STUDY
Gantt Chart Morphology and Hydraulics

ID	Task Name	Duration
45	10.1 Update of selection and process. of data, survey 3 and 4, incl. sediment analysis	26d
46	10.2 Update of the results morph.changes of the shoreline	26d
47	10.3 Update parametrisation of morphometric data	26d
48	10.4 Morph.data at site specific areas	19d
49	11 EMPERICAL I/O RELATIONSHIPS AND MORPHOLOGICAL ADAPTION PROCESS	103d
50	11.1 Investigate & determine equil.relationships	33d
51	11.2 Investigate & determine the shoreline & channel stability	40d
52	11.3 Investigate & determine morph.response to input conditions	40d
53	12 UPDATE OF EMPERICAL I/O RELATIONSHIPS	96d
54	12.1 Investigate & determine equil.relationships	33d
55	12.2 Investigate & determine the shoreline & channel stability	40d
56	12.3 Investigate & determine morph.response to input conditions	40d
57	13 NUMERICAL MODELLING ON REGIONAL AND LOCAL SCALE	760d
58	13.1 Review of existing data	75d
59	13.2 Basic assessment of states and processes	48d
60	13.3 Selection of baseline conditions	31d
61	13.4 Numerical modeling on regional scale	760d
62	13.4.1 Hydraulic model set-up	44d
63	13.4.2 Selection & composition of model components	26d
64	13.4.3 Model calibration	40d
65	13.4.4 Production of hydraulic & waves conditions	422d
66	13.4.5 Analysis of model results	609d

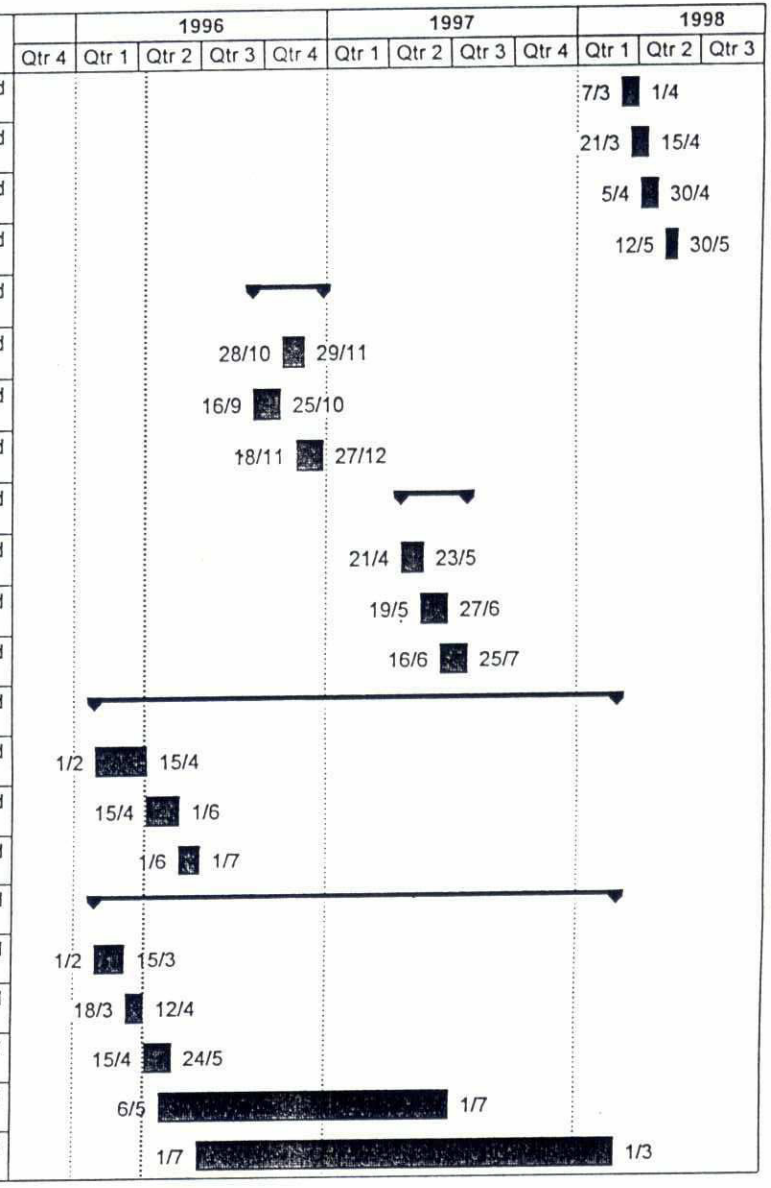

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Chart 6.1 : Morphology and Hydraulics (continued)

MEGHNA ESTUARY STUDY
Gantt Chart Morphology and Hydraulics

ID	Task Name	Duration
67	13.5 Numerical modeling on local scale	486d
68	13.5.1 Hydraulic model set-up	42d
69	13.5.2 Model calibration	56d
70	13.5.3 Production of hydraulic & waves conditions	268d
71	13.5.4 Analysis of model results	304d
72	14 MORPHOLOGICAL EVOLUTION AND POTENTIAL LAND RECLAMATION AREAS	347d
73	14.1 Identification of morph. changes & dominant phys.processes in Meghna estuary	12d
74	14.2 Identification & classification of potential land reclamation areas	12d
75	14.3 Morphological studies (feasibility studies)	105d
76	14.4 Prediction of morphological development	112d
77	15 RESULTS OF MORPHOLOGICAL IMPACT STUDIES	543d
78	15.1 An inventory of available and relevant morphological & hydrological data	1d
79	15.2 A reliable data system containing available and relevant morphol. & hydr.data	1d
80	15.3 Identification & priority ranking of potential land reclamation areas	1d
81	15.4 Identification of the morph. development and processes in feasibility studies	1d
82	15.5 An initial assessment of the overall morphological development	1d

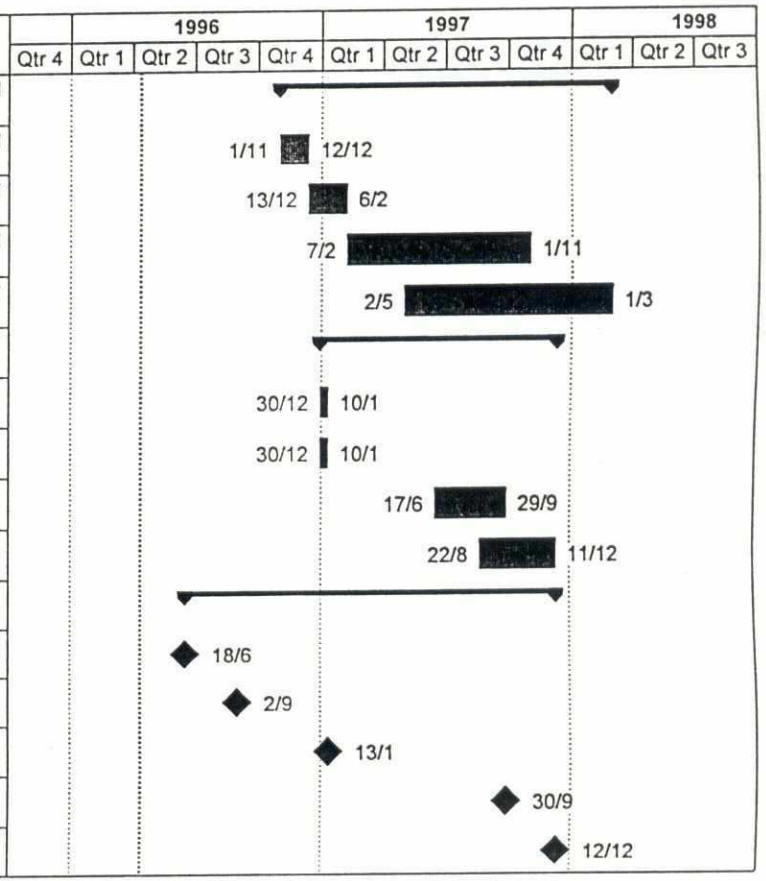

Chart 6.2 : Civil Engineering and Reclamation

MEGHNA ESTUARY STUDY
Gantt Chart Civil Engineering and Reclamation

ID	Task Name	Duration
1	1 PRELIMINARY ACTIVITIES	425d
2	1.1 Review and assess existing reports, data, etc. from LRP and FAP	60d
3	1.2 Study relevant ongoing activities in Meghna Estuary and elsewhere	151d
4	1.2.1 Establish liasons with CDSP and other relevant projects (i.a. FAP)	29d
5	1.2.2 Examine, assess on-going and pipeline studies and projects	151d
6	1.3 Pay field visit to familiarise with project area and civil engineering aspects	425d
7	1.4 Contribute to Inception Report	45d
8	1.4.1 Prepare Project Implementation Plan	31d
9	1.4.2 Prepare contributions to Inception Report concerning civil eng. and reclamation	45d
10	2 SURVEYS AND STUDIES	958d
11	2.1 Study primary and secondary protection systems	882d
12	2.1.1 Carry out surveys and studies of existing protection systems	121d
13	2.1.2 Assess requirements for protection of pop., prop. and sustained agri. development	91d
14	2.1.3 Carry out visual surveys of morphological changes	548d
17	2.1.4 Study, evaluate survey results, satelite imagery and other relevant info	853d
18	2.2 Small scale intervention 1: Low cost measures enhancing accretion	762d
19	2.2.1 Study, evaluate such measures applied in Bangladesh and elsewhere	93d
20	2.2.2 Select low cost methods probably effective, adapt them to estuary conditions	32d
21	2.2.3 Locate areas for accretion enhancing trials	123d
22	2.2.4 Prepare outline designs, work methods, cost estimates for accretion works	137d
23	2.2.5 Discuss trials with BWDB and local authorities	152d
24	2.2.6 Advise BWDB during preparation & implementation of works	288d

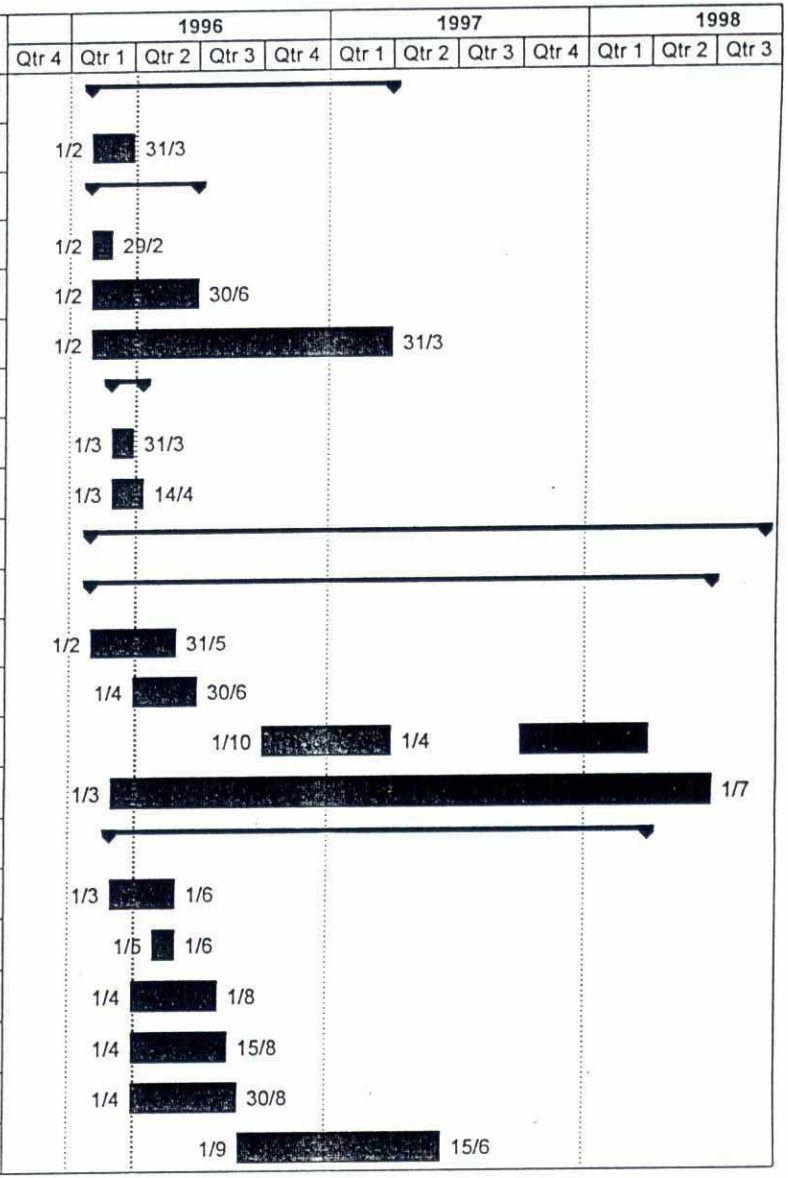

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Chart 6.2 : Civil Engineering and Reclamation (continued)

MEGHNA ESTUARY STUDY
Gantt Chart Civil Engineering and Reclamation

ID	Task Name	Duration
25	2.2.7 Monitor effectiveness of accretion enhancement tr	548d
28	**2.3 Small scale interventions 2: Low cost measures to reduce or check erosion**	868d
29	2.3.1 Study, evaluate such measures applied in Bangladesh and elsewhere	62d
30	2.3.2 Select low cost methods probably effective, adapt them to estuary conditions	31d
31	2.3.3 Locate areas for erosion reduction trials	32d
32	2.3.4 Prepare outline designs, work methods, cost estimates for erosion reduction works	93d
33	2.3.5 Discuss trials with BWDB and local authorities	124d
34	2.3.6 Advise BWDB during preparation & implementation of works	288d
35	2.3.7 Monitor effectiveness of erosion reduction trials	591d
36	**2.4 Small scale interventions 3: Intervention to save Sonagazi Polder embankment**	641d
37	2.4.1 Study, evaluate low cost measures to implement emergency works	31d
38	2.4.2 Prepare designs, work methods, cost estimates for works by local people	32d
39	2.4.3 Discuss trials with BWDB and local authorities	92d
40	2.4.4 Assist BWDB during implementation of works	63d
41	2.4.5 Monitor effectiveness of repair works	488d
42	**3 MASTER PLAN ACTIVITIES**	639d
43	**3.1 Contribute to Interim Master Plan**	166d
44	3.1.1 Study and establish potential measures for land protection	93d
45	3.1.2 Study and establish potential measures for reclamation	93d
46	3.1.3 Prepare planning criteria	74d
47	**3.2 Contribute to preparation of Master Plan**	457d
48	3.2.1 Study, evaluate processes of accretion and erosion	366d

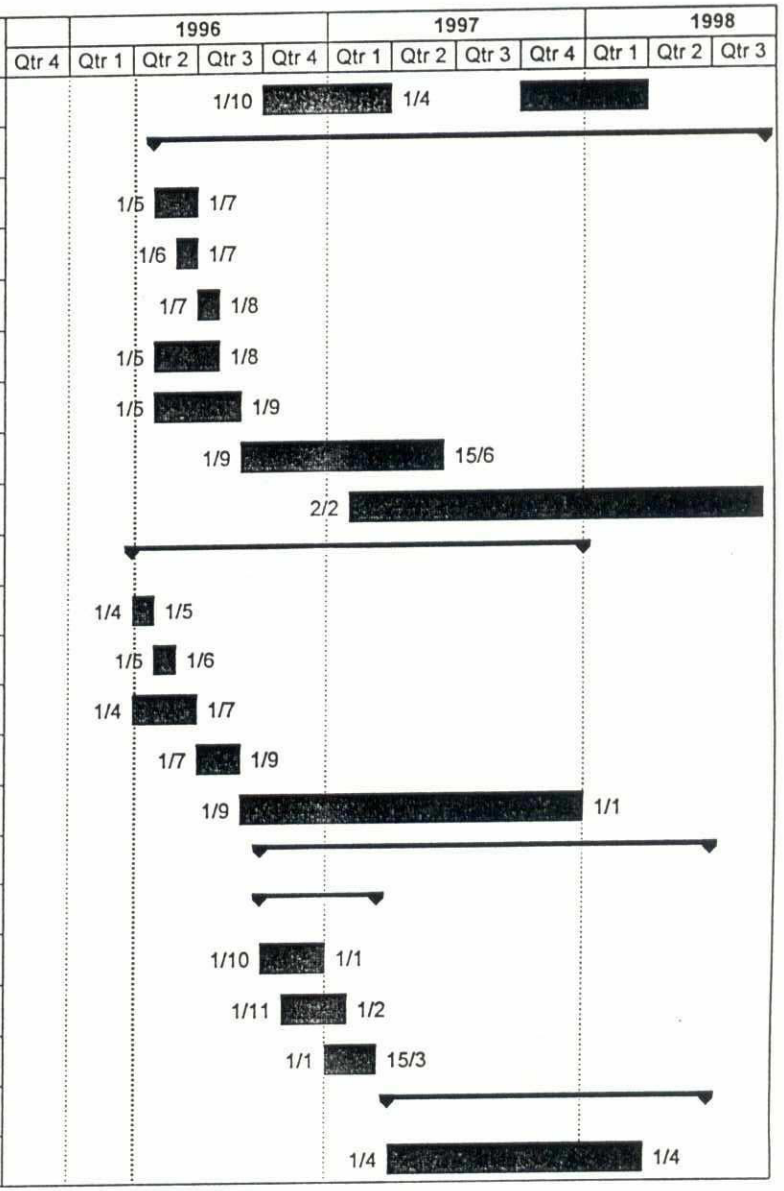

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Chart 6.2 : Civil Engineering and Reclamation (continued)

MEGHNA ESTUARY STUDY
Gantt Chart Civil Engineering and Reclamation

ID	Task Name	Duration
49	3.2.2 Describe hydrological, hydraulic criteria for planning protection systems	366d
50	3.2.3 Study assess, describe methods and potential for land reclamation	457d
51	3.2.4 Study evaluate describe environmental effects on physical estuary development	182d
52	3.2.5 Assist in preparation of long term plan for estuary	92d
53	4 DEVELOPMENT PLAN ACTIVITIES	775d
54	**4.1 Collect data, carry out surveys to establish existing state of dev. on islands**	305d
55	**4.2 Assess various strategies and options**	138d
56	4.2.1 Assess various strategies and options for flood/cyclone protection	93d
57	4.2.2 Assess various strategies and options for reclamation, dev. of protected areas	93d
58	**4.3 Contribute to Interim Development Plan**	244d
59	4.3.1 Identification of projects and prelim. priorities for prim. and sec. protection systems	93d
60	4.3.2 Identification of projects and preliminary priorities for dev. of protected area	121d
61	4.3.3 Identification of projects and preliminary priorities for non-structural systems	60d
62	4.3.4 Provisional assessment of economic and financial viability	90d
63	4.3.5 Provisional assessment of social and environmental impact	62d
64	4.3.6 Formulation of priority projects and programmes for feasibility stage	62d
65	**4.4 Contribute to the Development Plan**	349d
66	4.4.1 Review and discussions with concerned agencies	93d
67	4.4.2 Update etc. of relevant surveys and studies by other projects	213d
68	4.4.3 Confirmation, revision of IDP components	32d
69	4.4.4 Economic, social, environmental impact analyses at prefeasibility level	92d
70	4.4.5 Identification for first stage projects for Phased Development Plan	45d

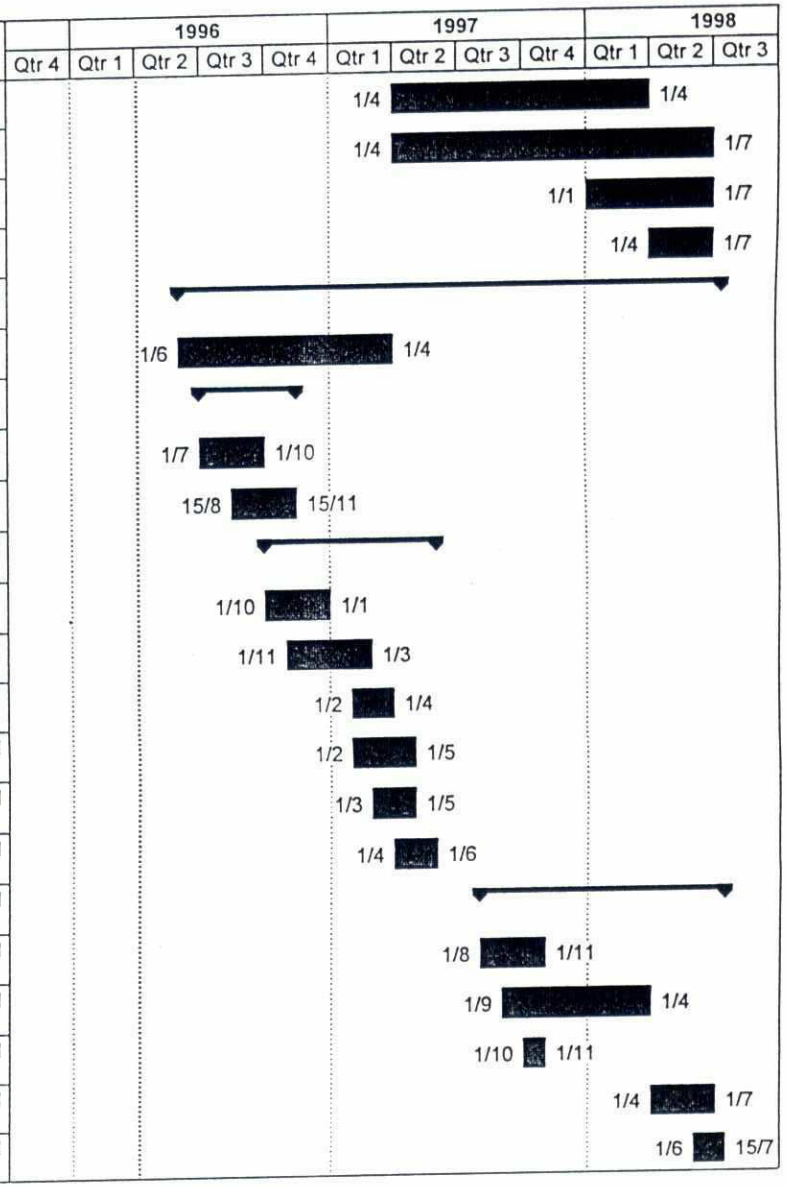

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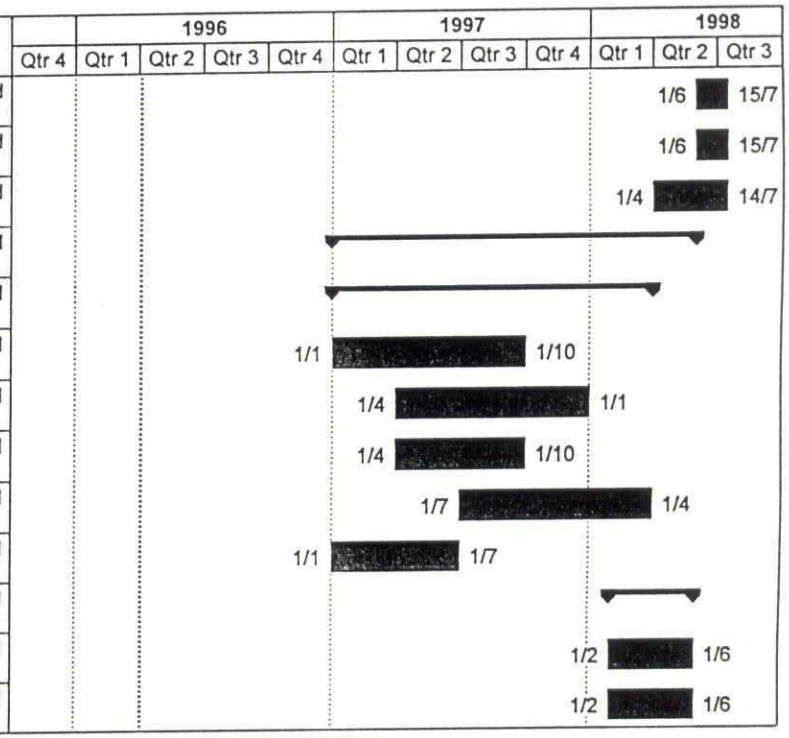
Chart 6.2 : Civil Engineering and Reclamation (continued)

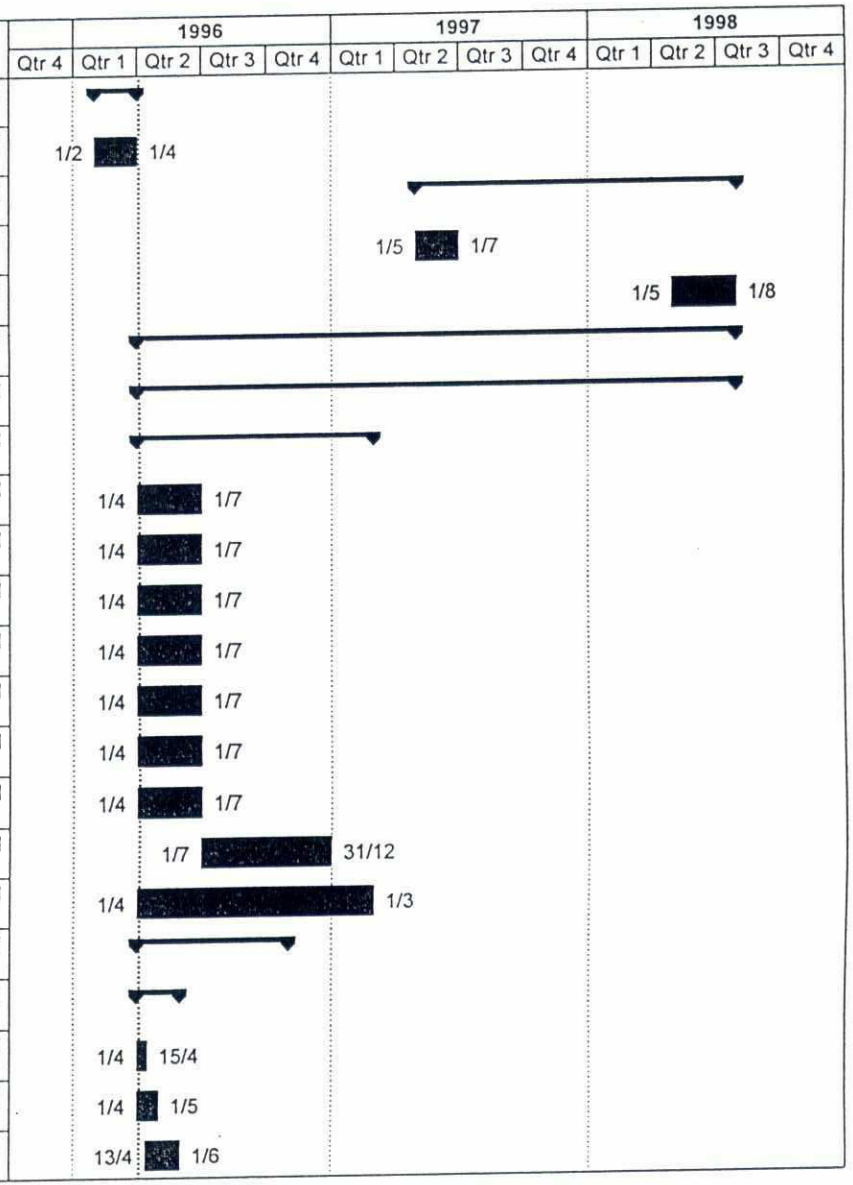
MEGHNA ESTUARY STUDY
Gantt Chart Civil Engineering and Reclamation

ID	Task Name	Duration
71	4.4.6 Financial requirements for Phased Development Plan	45d
72	4.4.7 Institutional recommendations for Phased Development Plan	45d
73	4.4.8 Draft project formulations and TOR of first stage projects	105d
74	5 CONTRIBUTE TO PREPARATION OF PRIORITY PROJECTS	517d
75	5.1 Carry out Priority Project and Programme Preparation	456d
76	5.1.1 Reassessment of South Hatia/Nijum Dwip feasibility study	274d
77	5.1.2 Reassessment of Sandwip cross dam feasibility study	276d
78	5.1.3 Pre-feasibility studies of possible priority projects	184d
79	5.1.4 Feasibility study of most potential priority projects	275d
80	5.2 Carry out programme preparation for non-structural measures	182d
81	5.3 Contribute to Project/programme report	121d
82	5.3.1 Prepare draft concept papers and project proformas	121d
83	5.3.2 Incorporate recommendations of Review Committee	121d



MEGNA ESTUARY STUDY
Gantt Chart Water Management and Drainage

ID	Task Name	Duration
1	1 PRELIMINARY ACTIVITIES	61d
2	1.1 Review and assess existing reports, data, etc. from LRP and FAP	61d
3	2 MASTER PLAN	458d
4	2.1 Contribute to an Interim Master Plan	62d
5	2.2 Contribute to a draft Master Plan	93d
6	3 LAND AND WATER USE DEVELOPMENT PLAN	853d
7	3.1 Development of an Interim Development Plan	853d
8	3.1.1 Collect existing data of the study area	335d
9	3.1.1.1 Collection of meteorological data	92d
10	3.1.1.2 Collection of soil data	92d
11	3.1.1.3 Collection of water salinity data	92d
12	3.1.1.4 Collection of soil salinity data	92d
13	3.1.1.5 Collection of groundwater data	92d
14	3.1.1.6 Collection of land and wate use data	92d
15	3.1.1.7 Inventory of BWDB O&M establishment, staff and ADPs	92d
16	3.1.1.8 Contribute to (GIS) data base for collected data	184d
17	3.1.1.9 Make periodical visits to the estuary for orientation and collection of d	335d
18	3.1.2 Review of water management and drainage projects and studies	215d
19	3.1.2.1 Inventory of relevant projects and studies	62d
20	3.1.2.1.1 Listing of all relevant publications	15d
21	3.1.2.1.2 Acquisition of most relevant publications	31d
22	3.1.2.1.3 Preparation of notes on documents	50d



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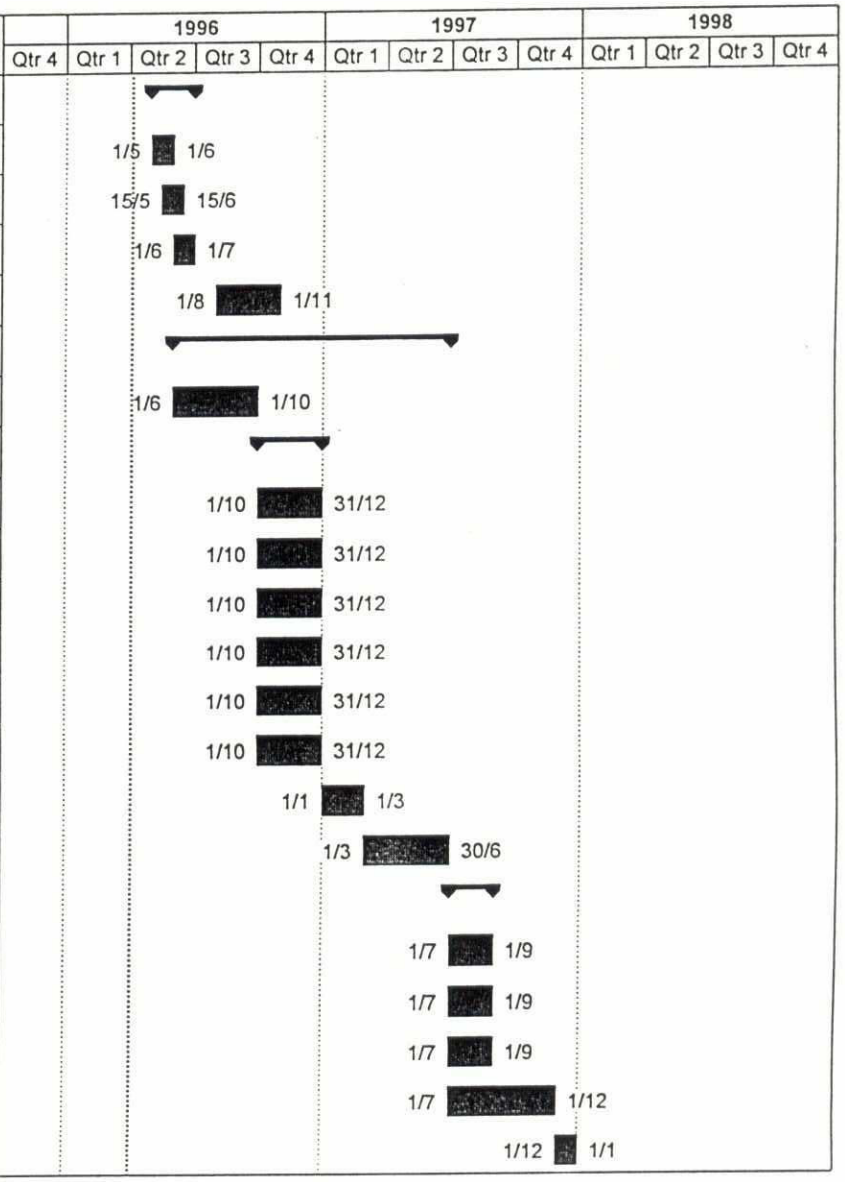
MEGNA ESTUARY STUDY
Gantt Chart Water Management and Drainage

ID	Task Name	Duration
23	3.1.2.2 Field visits of selected projects	62d
24	3.1.2.2.1 Visit CDSP	32d
25	3.1.2.2.2 Visit of CPP	32d
26	3.1.2.2.3 Visit of SRP	31d
27	3.1.2.3 Preparation of Technical Notes on relevant project and study findings	93d
28	**3.1.3 Field investigations and studies of protected and unprot. areas**	395d
29	3.1.3.1 Design and preparation of field investigations and studies	123d
30	3.1.3.2 Field investigation and studies to assess the existing situation	92d
31	3.1.3.2.1 Assess previous and planned drainage and water man. interve	92d
32	3.1.3.2.2 Assess past and present land and water use	92d
33	3.1.3.2.3 Assess salinity problems in protected and unprotected areas	92d
34	3.1.3.2.4 Assess existing drainage infrastructure, problems and prop. so	92d
35	3.1.3.2.5 Assess existing irrigation activities and potential	92d
36	3.1.3.2.6 Assess status of water management in protected areas	92d
37	3.1.3.3 Preparation of Technical Notes on findings of investigations and studi	60d
38	3.1.3.4 Prep. of Tech. Reports on water management and drainage in the Est	122d
39	**3.1.4 Assess alternative strategies for development of protected areas**	63d
40	3.1.4.1 Define scope and options for drainage improvement of protected area	63d
41	3.1.4.2 Define scope and options for improved water man. in protected areas	63d
42	3.1.4.3 Contribute to specification of objectives and criteria for plan formulatio	63d
43	**3.1.5 Contribute to the development of models for protected areas**	154d
44	**3.1.6 Contribute to the preparation of an Interim Development Plan**	32d



MEGNA ESTUARY STUDY
Gantt Chart Water Management and Drainage

ID	Task Name	Duration
45	3.1.7 Contribute to a draft Development Plan	93d
46	4 PRIORITY PROJECTS AND PROGRAMMES	274d
47	4.1 Contribute to project preparation at feasibility level	244d
48	4.2 Contribute to program preparation	244d
49	4.3 Contribute to draft Project and Program Preparation Report	31d

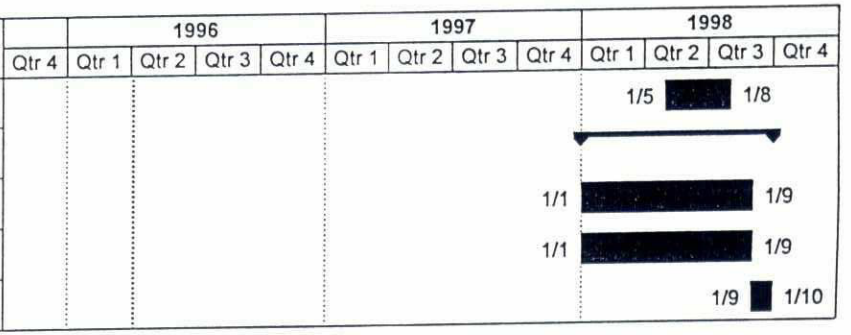
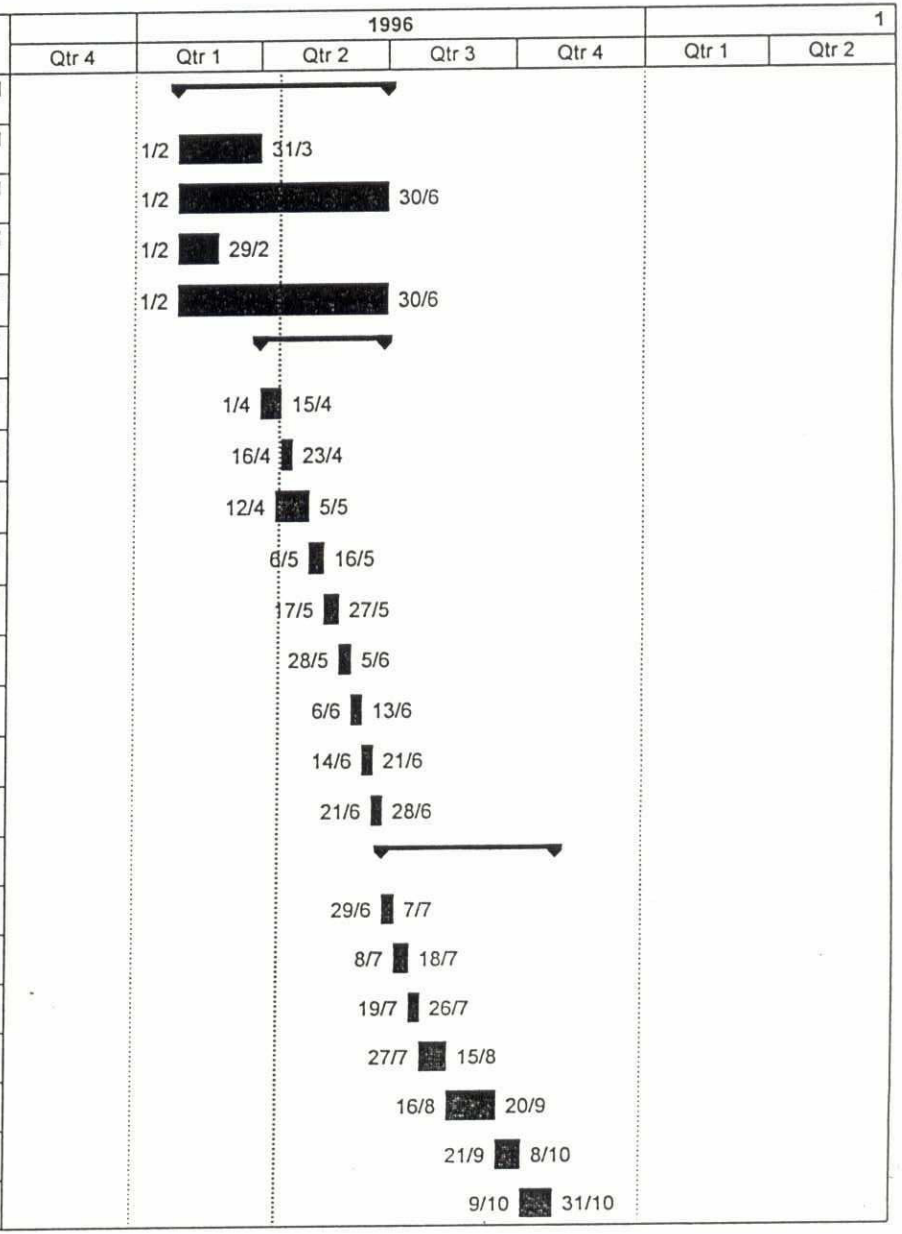


Chart 6.4 : Rural Development and Socio-Economic Aspects

MEGHNA ESTUARY STUDY
Gantt Chart Rural Development and Socio-Economic Aspects

ID	Task Name	Duration
1	1 PRELIMINARY ACTIVITIES	151d
2	1.1 Review and assess existing reports, data, etc. from LRP and FAP	60d
3	1.2 Study relevant ongoing activities in Meghna Estuary and elsewhere	151d
4	1.3 Establish liasons with CDSP and other relevant projects (i.a. FAP)	29d
5	1.4 Examine, assess on-going and pipeline studies and projects	151d
6	2 PREPARATION OF QUESTIONNAIRES	89d
7	2.1 Discussion on questionnaires with CDSP staff and research associates	15d
8	2.2 Field trip for reconnaissance and rapid appraisal of the socio-economics of the	8d
9	2.3 Detail research design for socio-econ. survey and in-depth case studies	24d
10	2.4 First draft preparation of questionnaires	11d
11	2.5 Recruitement of investigators for socio-economic surveys	11d
12	2.6 Training of the investigators	9d
13	2.7 Pre-testing of the questionnaires	8d
14	2.8 Editing and revision of the draft questionnaires	8d
15	2.9 Finalisation of the questionnaires	8d
16	3 PRELIMINARY FIELD INVESTIGATIONS	125d
17	3.1 Plan preparation for field operation	9d
18	3.2 Printing and binding of questionnaires	11d
19	3.3 Field visit for final location of sample areas	8d
20	3.4 Discussion with Gov. and Non Gov. staff on rural development aspects	20d
21	3.5 Identification of samples and listing of household heads	36d
22	3.6 Visit to Adarsha gram projects to assess its status	18d
23	3.7 Secondary data gathering	23d



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MEGHNA ESTUARY STUDY
Gantt Chart Rural Development and Socio-Economic Aspects

ID	Task Name	Duration
24	4 FIELD INVESTIGATIONS AND SURVEY	181d
25	4.1 Field survey and data collection	92d
26	4.2 Data coding, processing and analysis of information	59d
27	4.3 Report writing	25d
28	4.4 Workshop on rural development aspects	5d

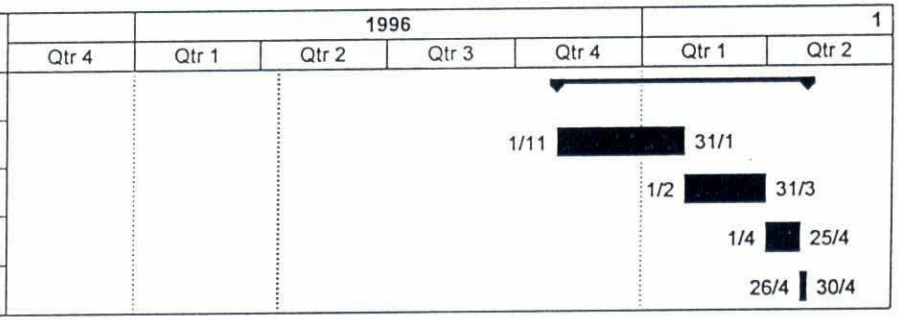


Chart 6.4 : Rural Development and Socio-Economic Aspects (continued)

MEGHNA ESTUARY STUDY
Gantt Chart Agricultural Aspects

ID	Task Name	Duration
1	1 Prelimenary Activities	15d
2	1.1 Collection, review of LRP and FAP reports, maps etc.	8d
3	1.2 Collection of soil reconnaissance and crop production reports	7d
4	2 Development Plan	638d
5	2.1 Reconnaissance field visit and exchange ideas about the objective of the project	22d
6	2.2 Screening and selection of sub-projects for agro-economic survey	8d
7	2.3 Designing and drafting of Rapid Rural Appraisal (RRA) checklist/questionnaires	16d
8	2.4 Training of investigators and pretesting of RRA checklist/questionnaires	15d
9	2.5 Editing and finalization of RRA checklist/questionnaires	8d
10	2.6 Printing of RRA checklist/questionnaires and mobilization of staff	8d
11	2.7 Selection and listing of villages and household heads from each sub-project	7d
12	2.8 Primary data collection from each selected sub-project	30d
13	2.9 Secondary data collection and group interviews from each sub-project	15d
14	2.10 Data coding, processing and analysis for each sub-project	16d
15	2.11 Identification of major constraints for agricultural development	479d
16	2.12 Preparation of eight sub-project reports on priority projects	485d

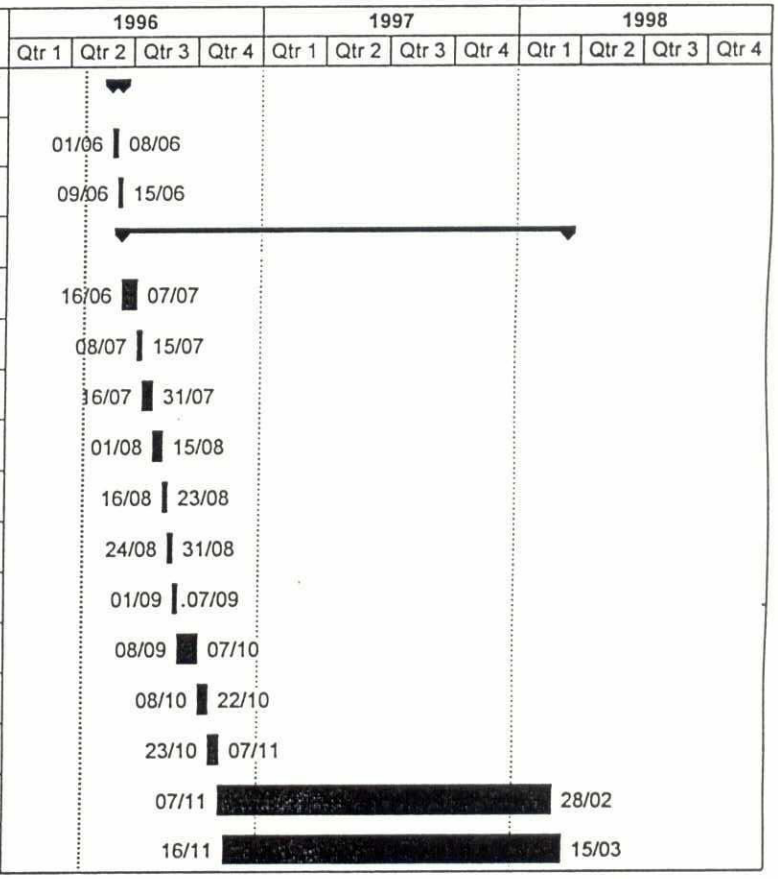
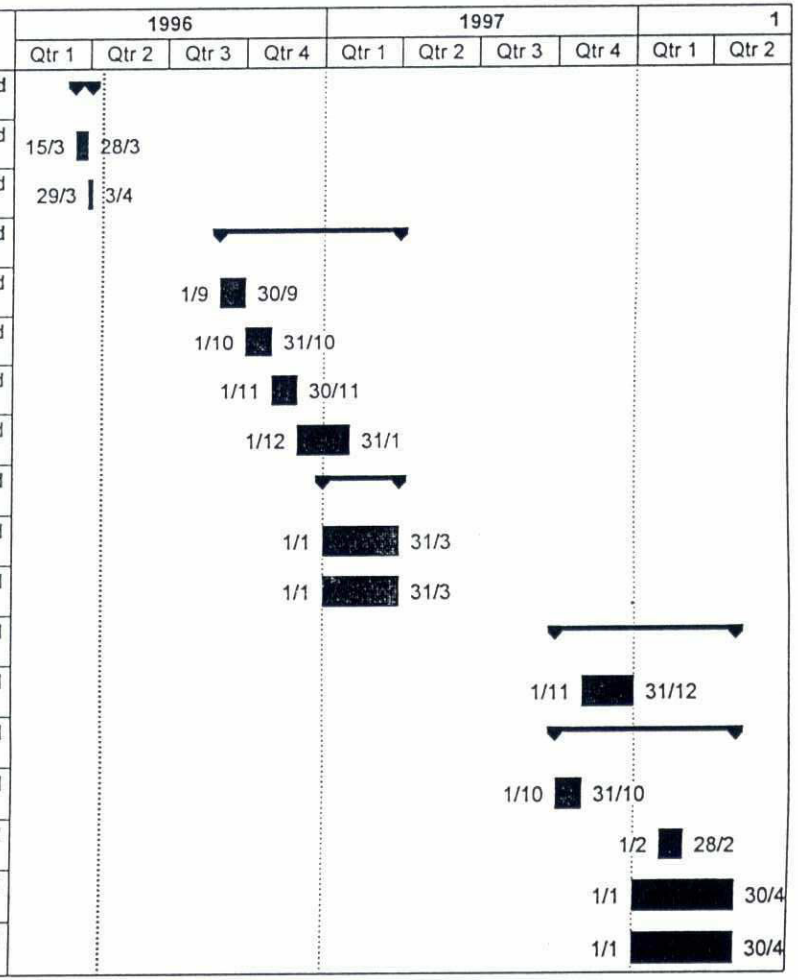


Chart 6.6 : Environmental Aspects

MEGHNA ESTUARY STUDY
Gantt Chart Environmental Aspects

ID	Task Name	Duration
1	1 PRELIMINARY ACTIVITIES	20d
2	1.1 Study relevant LRP and FAP documents regarding environmental aspect	14d
3	1.2 Preparation of a work programme for inception report	6d
4	2 PHASE I	212d
5	2.1 Literature review and discussion	30d
6	2.2 Reconnaissance field visit	31d
7	2.3 Formulation and design of field plan	30d
8	2.4 Field investigations	62d
9	**2.5 Report preparation**	90d
10	2.5.1 IEE : Interim Master Plan	90d
11	2.5.2 IEE : Interim Development Plan	90d
12	3 PHASE II	212d
13	3.1 Field investigations	61d
14	**3.2 Report preparation**	212d
15	3.2.1 EIAR : Nijhum Dwip land reclamation	31d
16	3.2.2 EIAR, Draft Project/Programme preparation report	28d
17	3.2.3 IEE : Draft Master Plan	120d
18	3.2.4 IEE : Draft Development Plan	120d



MEGHNA ESTUARY STUDY
Gantt Chart Economic Aspects

ID	Task Name	Duration
1	**1 Prelimenary Activities**	77d
2	1.1 Collection, review of LRP and FAP reports	77d
3	1.2 Study FCPO and other appraisal guidelines of relevant FAP projects	45d
4	**2 Master Plan**	410d
5	2.1 Ranking of possible projects listed in the Interim Master Plan	15d
6	2.2 Up-date ranking of projects listed in the Master Plan	15d
7	**3 Development Plan**	150d
8	3.1 Develop project assessment models	90d
9	3.2 Develop operative screening models	46d
10	3.3 Review FCPO guidelines for project assessment	91d
11	3.4 Contact and discuss assessment aspects with FCPO economists	46d
12	**4 Priority Projects and Programme**	304d
13	4.1 Recommend on an update of guidelines for project assessment	274d
14	4.2 Prepare proposals for project impact reporting	93d
15	4.3 Develop a format for presenting the multi criteria analysis	76d
16	4.4 Assess alternative project proposals in terms of their scoring	31d

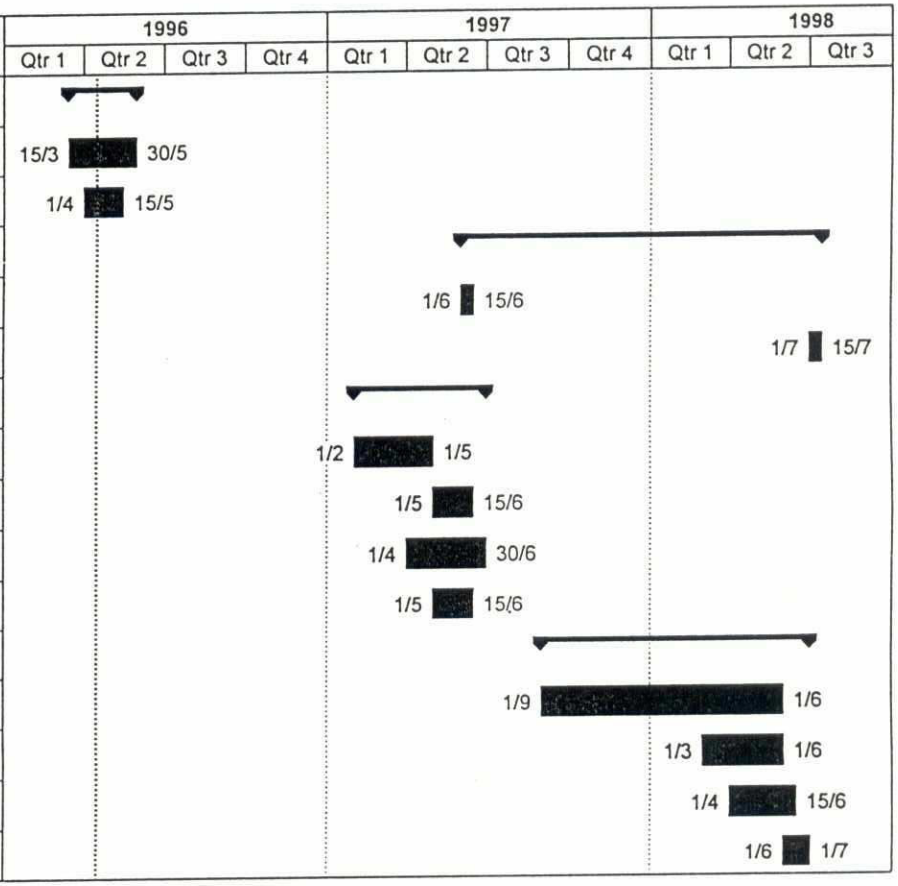


Chart 6.8 : Remote Sensing and GIS

MEGHNA ESTUARY STUDY
Gantt Chart Remote Sensing and GIS

ID	Task Name	Duration
1	1 PRELIMINARY ACTIVITIES	51d
2	1.1 Assessment of RS requirements by having group discussion with different sectors.	36d
3	1.2 Collection of information from different institutions regarding maps and RS data.	30d
4	2 ACTIVITIES SUPPORTING MASTER PLAN AND DEVELOPMENT PLAN	433d
5	2.1 Collection of reports and RS data from different institutions.	107d
6	2.1.1 Procurement of Landsat TM image of 1996	30d
7	2.1.2 Procurement of soil reports and maps from SRDI	21d
8	2.1.3 Procurement of Landsat MSS data	46d
9	2.1.4 Procurement 1:250.000 DHS map	17d
10	2.1.5 Procurement Thana and District maps from LGED	17d
11	2.1.6 Procurement of SPOT bw prints	61d
12	2.1.7 Procurement of 1:50.000 scall fisheries Resources Survey System maps	16d
13	2.2 Inventory of historic maps and topo sheets	90d
14	2.3 Interpr. of Remote Sensing data and preparation of shoreline/bankline GIS maps	214d
15	2.3.1 Preparation of shoreline/bankline maps from Rennells map of 1779 and Landsat map of 1	15d
16	2.3.2 Preparation of shoreline/bankline map from Landsat 1973 at 1:250.000 scale	47d
17	2.3.3 Preparation of GIS map 1:250.000 from 5.2 1-5-1996-31-5-1996	31d
18	2.3.4 Preparation of GIS map from Fisheries Resources Survey System maps	31d
19	2.3.5 Preparation of shoreline/bankline map from Landsat 1984 data at 1:250.000 scale	30d
20	2.3.6 Preparation of GIS map from SPOT 1989 images from National GIS database at 1:250.00	62d
21	2.3.7 Preparation of shoreline/bankline map from Landsat TM data of 1992 at 1:250.000 scale	31d
22	2.3.8 Create Arc View application for showing coastline coverages of various 1973-1996 images	214d

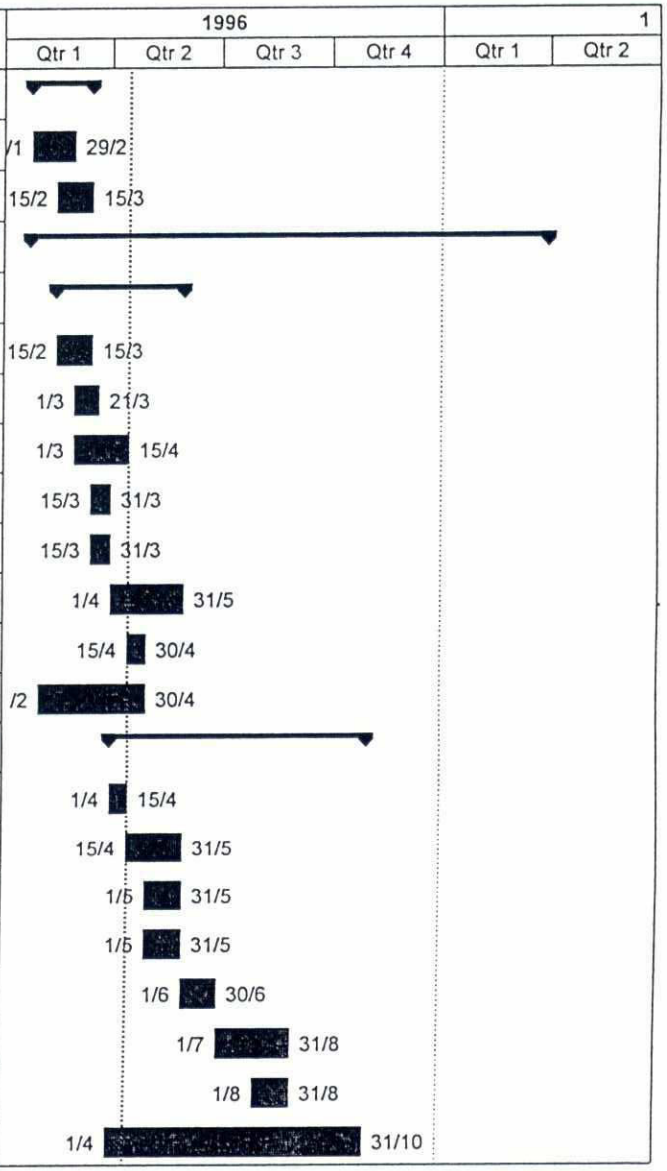


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Chart 6.8 : Remote Sensing and GIS (continued)

MEGHNA ESTUARY STUDY
Gantt Chart Remote Sensing and GIS

ID	Task Name	Duration
23	2.4 Digitizing of bathymetric maps of areas of interest	153d
24	2.5 Visual interpretation of one of the SPOT images of 1989/1990	61d
25	2.6 Preparation of basemap items from BWDB maps	171d
26	2.6.1 Coordination of processing of Landsat TM imageof 1996 through EGIS	62d
27	2.6.2 Coordination of mosaiced image to be presented in the Inception Report	16d
28	2.6.3 Coofdination of preparation of 1:250.000/1:500.000 scale prints of MES project area	62d
29	2.6.4 Coordination of preparation of 1:50.000 maps of detailed study areas	154d
30	2.6.5 Coordination of preparation of shoreline /bankline map from 1996 Landsat TM image	62d
31	2.6.6 Coordination of preparation of shoreline /bankline map from 1996 Landsat TM image	154d
32	2.7 Preparation of reports and final GIS maps	252d
33	2.8 Training in ArcInfo and Arc View	62d
34	2.9 Development of Arc View application	184d
35	2.10 Development of prototype application	93d
36	2.11 Development of application	92d
37	2.12 Digitizing the maps for coastline development prepared under 2.3	154d
38	2.13 Foreign consultant visits to Bangladesh	405d
39	2.13.1 First visit	30d
40	2.13.2 Second visit	32d
41	2.13.3 Third visit	31d

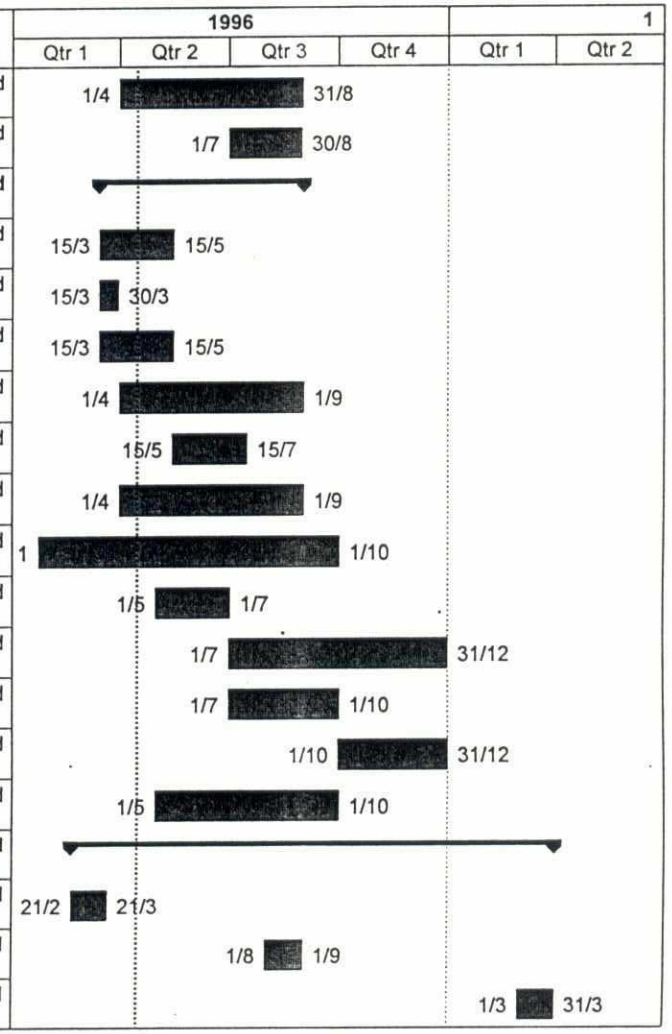

Chart 6.9 : Institutional Development

MEGHNA ESTUARY STUDY
Gantt Chart Institutional Development

ID	Task Name	Duration
1	1 PRELIMINARY ACTIVITIES	32d
2	1.1 Study relevant LRP and FAP documents regarding institutional aspects	26d
3	1.2 Preparation of a work programme for inception report	6d
4	2 PHASE A	273d
5	**2.1 Asses possibilities for sustained data collection and processing**	273d
6	2.1.1 Review the activities to perform by SSD	32d
7	2.1.2 Assess past and current activities	108d
8	2.1.3 Future SSD activities	77d
9	2.1.4 Assessment of the existing institutional capabilities regarding hydrogr. surveying of coastal	62d
10	2.1.5 Recommend optimum institutional arrangements to continue routine surveys and studies	154d
11	2.1.6 Assessing alternative institutional arrangements for sustainable data collection and proces	93d
12	**2.2 Analyzing and Institutionalizing the planning process.**	215d
13	2.2.1 Identify and assess relationship between BWDB and WARPO in planning process	93d
14	2.2.2 Identify on-going plans and projects with impact on institutionalization of MES activities.	62d
15	2.2.3 Identify development needs of WARPO and BWDB.	78d
16	2.2.4 Specify the link between BWDB's planning process and WARPO's master planning	78d
17	2.2.5 Identify links between macro and micro planning of organization active in MES plan area	185d
18	2.2.5.1 Identify organizations which are currently working in the sector-suggested improve	154d
19	2.2.5.2 Recommend on links between these organizations planning and MES	153d
20	2.2.5.3 Assess role of LAED in the estuary planning process	185d
21	**2.3 Institutional arrangement for Implementation of Infrastructure projects**	169d
22	2.3.1 Identify institutions responsible for implementation and interventions	62d

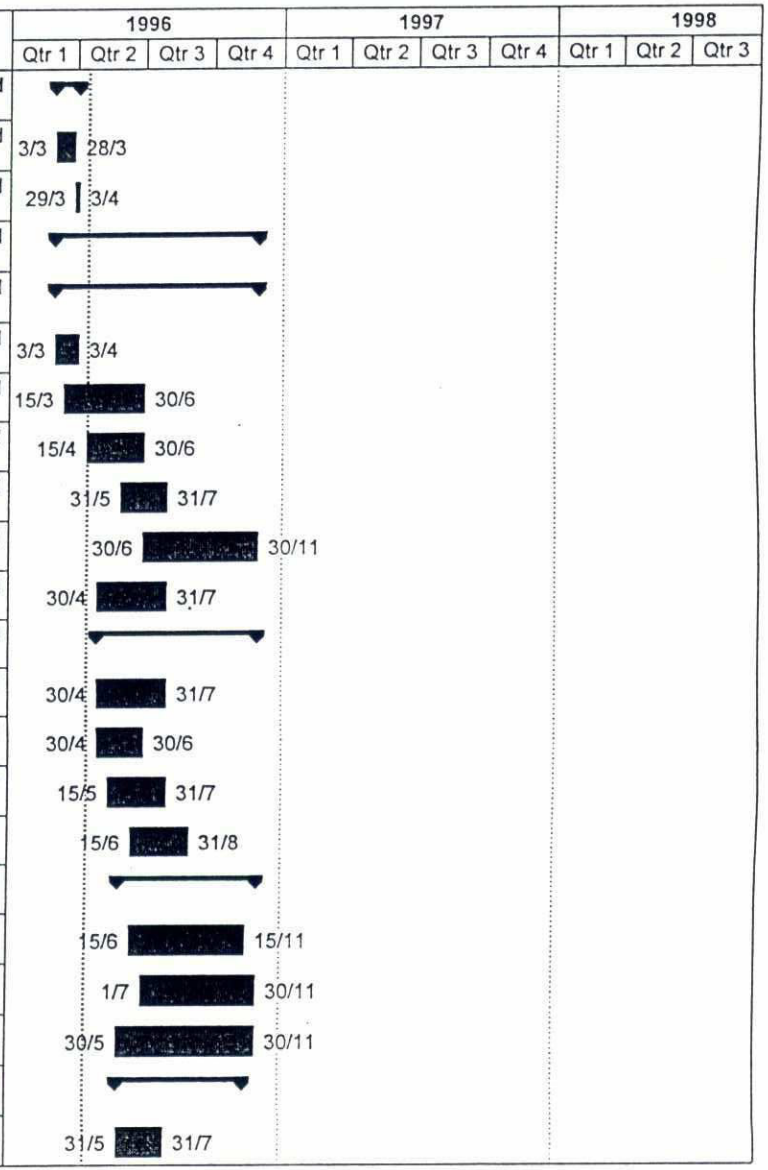

Chart 6.9 : Institutional Development (continued)

MEGHNA ESTUARY STUDY
Gantt Chart Institutional Development

ID	Task Name	Duration
23	2.3.2 Assess whether planned implementation is in line with long term objective of MES	154d
24	2.3.2.1 Assess legal basis for allocation of accreted or reclaimed land	139d
25	2.3.2.2 Assess institutional arrangements for enforcement of land allocation based on law	154d
26	**2.4 Training Assistance and Co-ordination**	215d
27	2.4.1 Training Needs Assessment (TNA) of the institutions involved in MES planning process	215d
28	2.4.1.1 Develop proforma for TNA in terms of institutions building	16d
29	2.4.1.2 Assist in collecting information through TNA format	16d
30	2.4.1.3 Coordinate analysis of information /data so gathered	47d
31	2.4.1.4 Coordinate training needs assessment	62d
32	2.4.1.5 coordinate training program preparation	154d
33	2.4.1.6 Coordinate implementation of training program and assist where required	154d
34	**3 PHASE B**	120d
35	**3.1 Assess sustainability of arrangements for data collection and processing**	120d
36	3.1.1 Review institutional strengthening of relevant organizations	120d
37	3.1.2 Assessment of the institutional capabilities on hydrographic surveying of coastal water	89d
38	3.1.3 Recommend adjustments to institutional arrangements to continue surveys and studies	120d
39	**3.2 Follow-up in institutionalizing the planning process**	120d
40	3.2.1 Review the relationship between BWDB and WARPO in planning process	120d
41	3.2.2 Identify plans and projects with impact on institutionalization of MES activities.	120d
42	3.2.3 Review needs for continuing development of WARPO and BWDB.	89d
43	3.2.4 Review links established between BWDB's planning and WARPO's master planning	89d
44	3.2.5 Review links between macro and micro planning of organizations active in MES plan area	91d

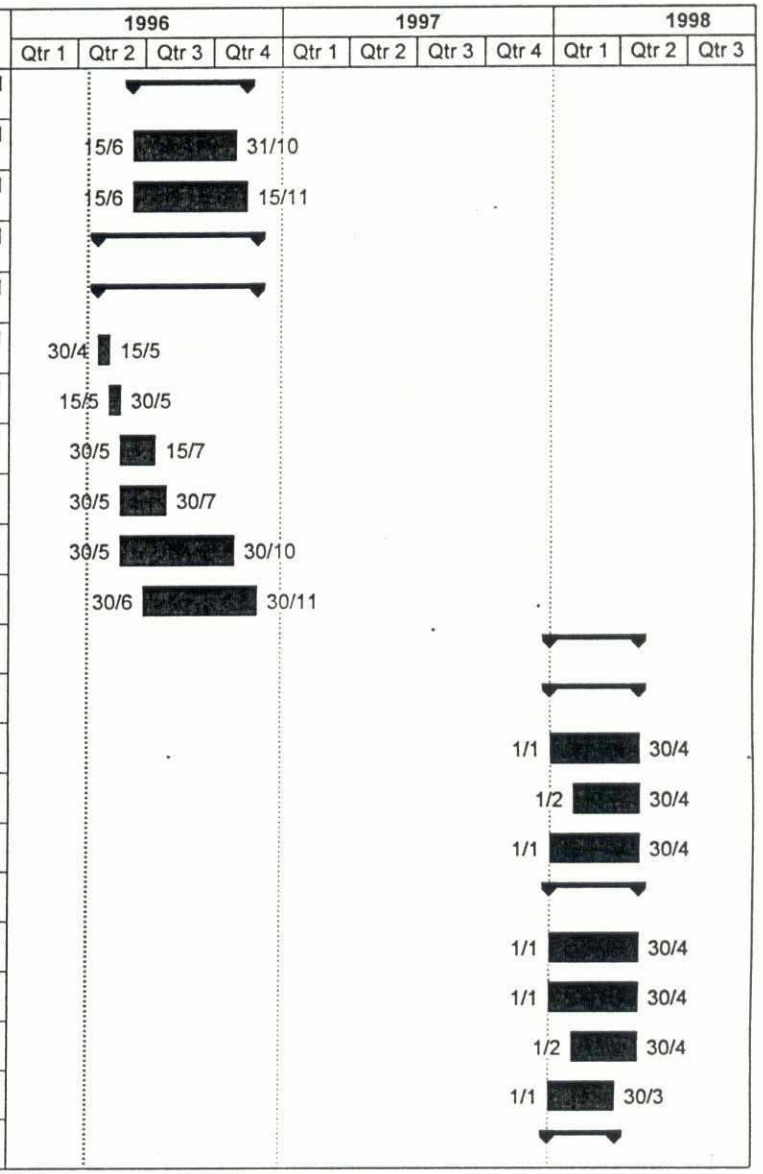

Chart 6.9 : Institutional Development (continued)

MEGHNA ESTUARY STUDY
Gantt Chart Institutional Development

ID	Task Name	Duration
47	**3.3 Follow-up for institutional arrangement for project implementation**	120d
48	3.3.1 Review institutions responsible for implementation and interventions	120d
49	3.3.2 Review institution's capabilities to plan, develop projects	59d
50	3.3.3 Assess whether planned implementation is in line with long term objectives of MES	61d
51	**3.4 Follow-up on training Assistance and Co-ordination**	120d
52	3.4.1 Coordinate training needs assessment	31d
53	3.4.2 Coordinate training program preparation	59d
54	3.4.3 Coordinate implementation of training program	120d

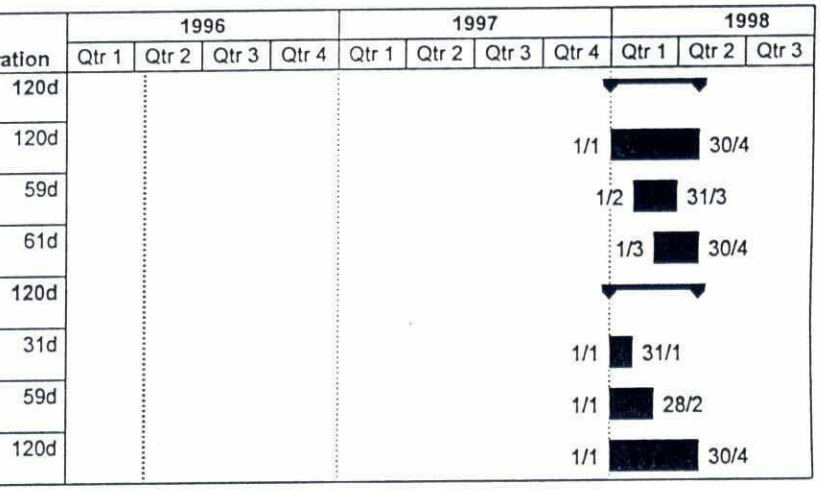

Chart 6.10 : Expatriate Technical Staff

MEGHNA ESTUARY STUDY
Gantt Chart Expatriate Staff

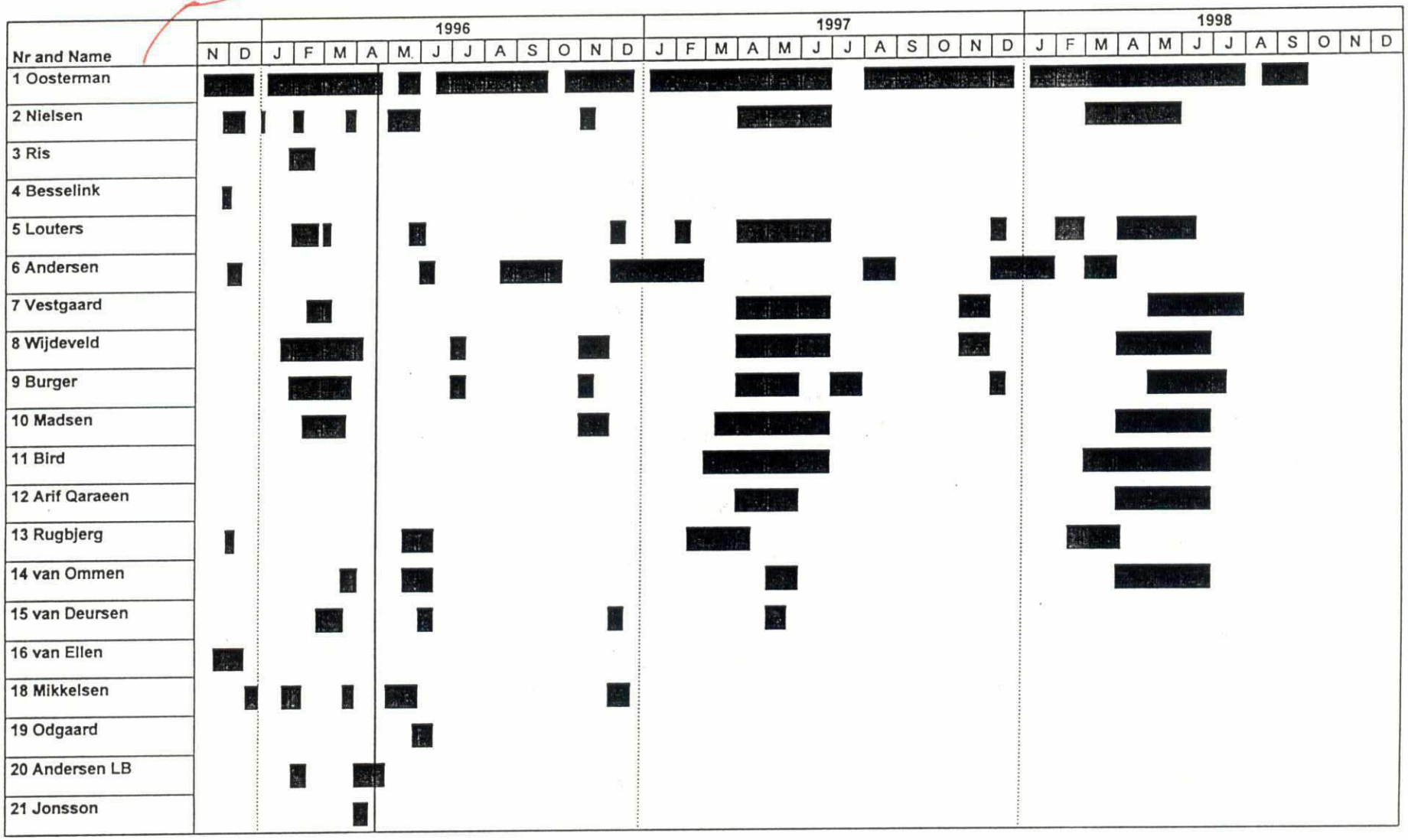

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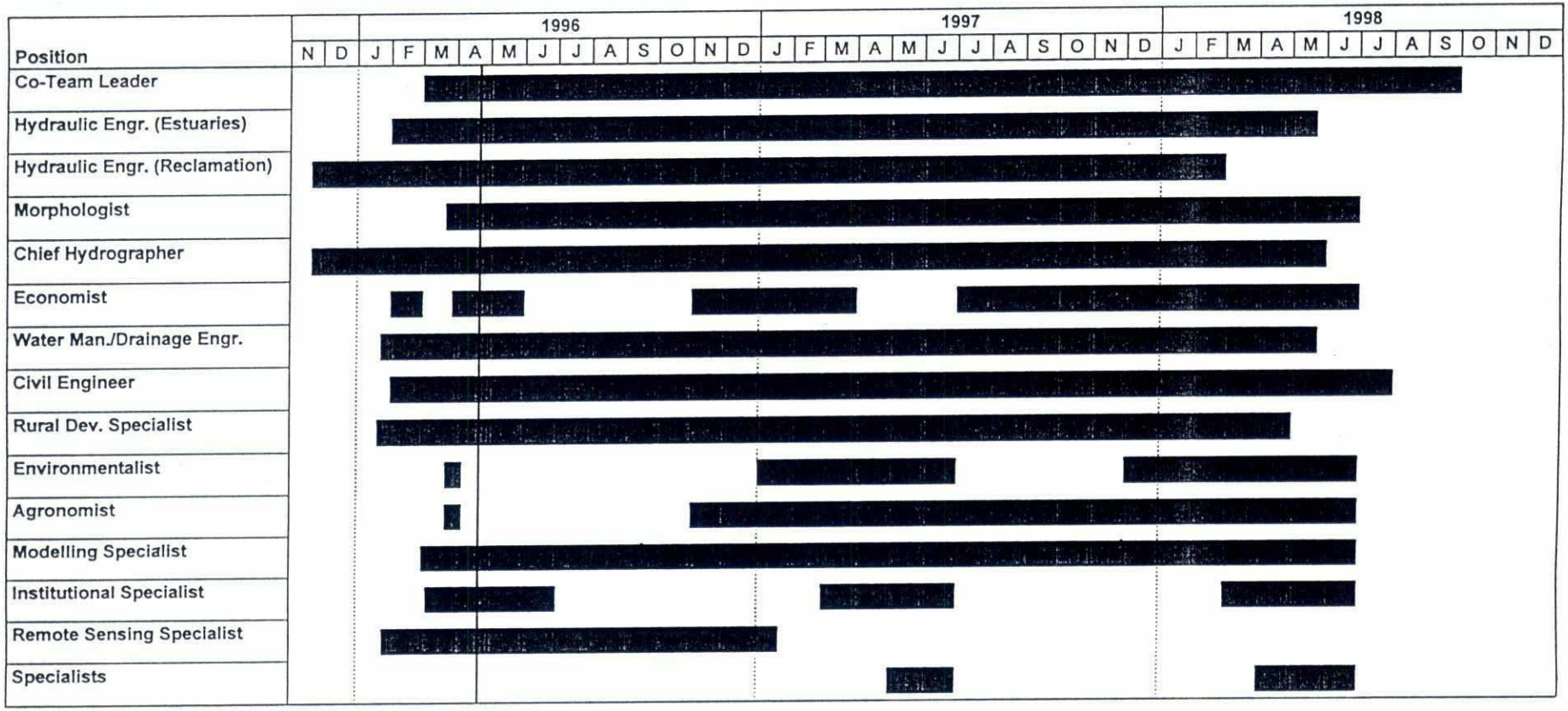
Chart 6.11 : Local Technical Staff

MEGHNA ESTUARY STUDY
Gantt Chart Local Staff



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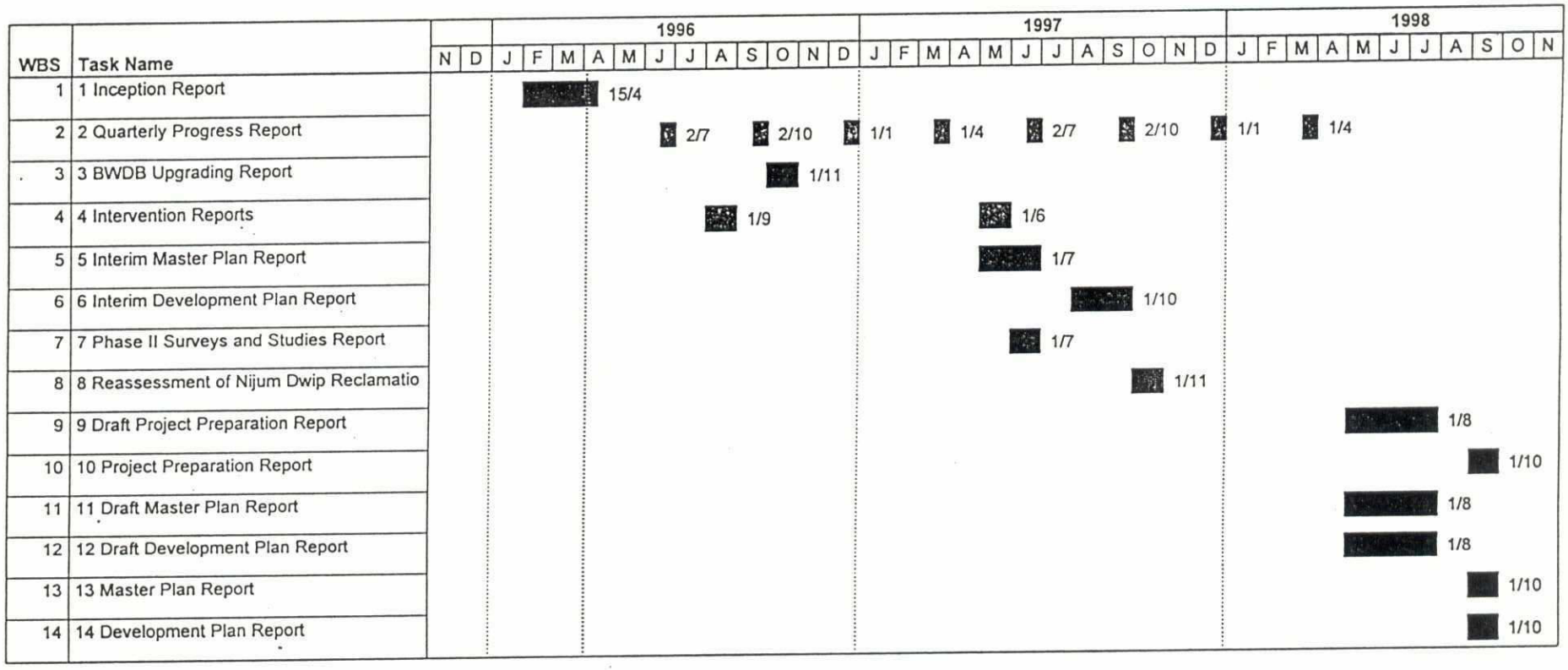
MEGHNA ESTUARY STUDY
Gantt Chart Reporting Schedule



WBS	Task Name
1	1 Inception Report
2	2 Quarterly Progress Report
3	3 BWDB Upgrading Report
4	4 Intervention Reports
5	5 Interim Master Plan Report
6	6 Interim Development Plan Report
7	7 Phase II Surveys and Studies Report
8	8 Reassessment of Nijum Dwip Reclamatio
9	9 Draft Project Preparation Report
10	10 Project Preparation Report
11	11 Draft Master Plan Report
12	12 Draft Development Plan Report
13	13 Master Plan Report
14	14 Development Plan Report

7 REPORTING

7.1 General

Reporting requirements for this project is determined following the guide lines of the TOR. In addition, an interim inception report is prepared following the requirements of the additional TOR. The reports in general will be prepared as draft and submitted to the Project Director for comments. After incorporation of comments and corrections the final reports will be submitted in 30 copies to WARPO for circulation and necessary use.

The following reports will be produced for this project (See Chart 6.12, included in Chapter 6)

Month 1.5	Interim Inception Report.
Month 5.5	Inception Report.
Month 11	Proposals for small scale Interventions.
Month 15	Report on Institutional Strengthening of BWDB.
Month 18	Interim Master Plan Report.
Month 21	Interim Development Plan Report.
Month 23	Proposals for phase II Surveys and Studies
Month 27	Feasibility Report on Reassessment of Nijhum Dwip Reclamation
Month 31	Draft Project/Programme Preparation Report(s).
Month 33	Project/Priority Programme Preparation Report(s).
Month 33	Draft Master Plan Report.
Month 33	Draft Development Plan Report.
Month 35	Master Plan Report.
Month 35	Development plan Report.

Technical reports, notes and working papers will be produced during the course of the assignment as required together wilh quarterly reports after the submission of the inception Report as shown in Chart 6.12.

If the Project Director desires the Consultants will submit the word processing, spread sheet and graphic files on diskette. The consultants will submit two copies of the reports to each of the Donors.

7.2 Planning

7.2.1 Master Plan

A master plan with phased long term project activities will be prepared which will have the main characteristics as detailed below.

- A realistic picture of the project area after it is being implemented with newly accreted land and definite river channels etc.
- A full description of the sequence and nature of successive interventions to bring about the envisaged changes. The interventions will comply reclamation and protection works, embankments and development plans for reclaimed land.
- Full feasibility study for priority projects, scheduled for implementation during the first 5 years and prefeasibility level study of projects, including design criteria, outlines for the Terms of Reference for next stage, if appropriate, suggesting for possible lumping of projects.

- Additional measures that could be foreseen in case the planned sequence of successive implementations would be interrupted for some reason, in order to secure the sustainability of the out-come of this first phase plan.

- Outlines for the strategy for the preparation of the next Master plan, as a guide for subsequent master planning exercises.

The reports of the Interim Master plan, Draft Master plan and Master plan will be prepared in the 18th, 33rd and 35th months of the project respectively.

7.2.2 Development Plan

A comprehensive plan to be prepared for flood protection and the improvement of the internal water management of the coastal islands included in the project area. In fact all inhabited islands are to be included, the island of Bhola to be excluded. An initial phased development plan for submission in the Interim Development plan is to be prepared in the month 21. The process of planning will continue with the guidelines as shown in the Terms of Reference and the Draft Development plan report is to be prepared and submitted for review and comments in the month 33. The Development plan will be finalized and submitted in the month 35 at the closing of the Meghna Estuary Study project.

7.3 Feasibility Studies

7.3.1 Nijhum Dwip Reclamation

The feasibility of reclaiming land along Nijhum Dwip at the southern tip and of Hatia Island as studied under LRP, will be reassessed by considering new parameters. The primary objective will be to test the measures of reclamation by means of timely applied low cost methods of closing tidal channels thus accelerating the siltation process. A comprehensive report including the input of the Ministry of Lands; technical, socio-economic, environmental and institutional aspects will be prepared and submitted in the month 27.

7.3.2 Priority Projects

The Land Reclamation project has already indicated 18 priority areas where projects can be undertaken for land reclamation, water management and drainage. An initial review shows that one of these projects outside the MES project area and two of them are found to be unsuitable for further studies, so 15 priority projects will be studied under MES. Depending on the Interim Master plan (month 18) and the Interim Development plan (month 21) and on the agreement of the FAP Review committee and the Technical Committee, feasibility report for the Priority Projects will be prepared and submitted on the month 33.

7.3.3 Priority Programmes

A Priority Programme for the selected projects as discussed in section 7.3.2 will be prepared and submitted in the month 33.

7.4 Miscellaneous

7.4.1 Institutional Arrangements Marine Surveys

The bathymetric surveys in accordance with an agreed plan will be submitted for approval to the Project Director BWDB. The survey plan will take account of similar surveys by other agencies (BIWTA, NAVY, Chittagong Port Authority). It will reflect the priorities determined by areas of observed intensive siltation and/or erosion and pollution by intended small scale interventions for the preparation of the long term plan. The surveys will be designed to cover the entire area of MES at regular intervals and the proposal for bathymetric survey to be submitted to BWDB for approval at least 3 months before the start of the wet season.

7.4.2 Small scale Interventions

These will comprise opportunities which are expected to arise during the project period in connection with the accretion/reclamation of new land. Small works using local technologies, labour and construction materials which can be rapidly implemented will be envisaged. The Consultant will locate and design the works and monitor their effectiveness. The implementation of these interventions and the construction of the simple structures will be the responsibility of BWDB, with time to time advice from the Consultant.
A list of interventions supported by outline designs and cost estimates, will be provided in the month 11.