DGIS/DANIDA GOB

MINISTRY OF WATER RESOURCES

BANGLADESH WATER DEVELOPMENT BOARD

MEGHNA ESTUARY STUDY

DRAFT MASTER PLAN

VOLUME 8 : ENVIRONMENTAL PROFILE AND ASSESSMENT

November 1998

DHV CONSULTANTS BV

in association with

KAMPSAX INTERNATIONAL
DANISH HYDRAULIC INSTITUTE

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GLOSSARY, ACRONYMS AND ABBREVIATIONS

The spelling of Bangla words is not standardised, with frequent differences between vowel use. The following use the standard set by ISPAN in their reports based upon the work of a professional editor with a large international academic publishing house.

ADAB	-	Association of Development Agencies in Bangladesh, an umbrella forum for nationally based Bangladeshi NGO's.
ADB	-	Asian Development Bank
AFPM	-	Active Flood Plain Management
ARTI	-	Acute Respiratory Tract Infection
BAFU	-	British Aid Fisheries Unit
BARC	-	Bangladesh Agricultural Research Council
BARI	-	Bangladesh Agricultural Research Institute
BBS	-	Bangladesh Bureau of Statistics
BCAS	-	Bangladesh Centre for Advanced Studies
Beel	-	Area of permanent or seasonal water away from a river (Bangla)
BIWTA	-	Bangladesh Inland Water Transport Authority
BNCS	-	Bangladesh National Conservation Strategy
BRAC	-	Bangladesh Rural Advancement Co mmittee, a national NGO
BUP	-	Bangladesh Unnayan Parishad
BWDB	-	Bangladesh Water Development Board
CARDMA	-	Coastal Area Resource Development and Management Association (an NGO)
CDL	-	Community Development Library (an NGO)
CDSP	-	Char Development and Settlement Project
CEMP	-	Coastal Environmental Management Plan
CERP	-	Coastal Embankment Rehabilitation Project
Char	-	Bangla word for accreted land
CIP	-	Chandpur Irrigation Project
cm	-	Centimetre
CPP	-	Cyclone Protection Project
CSPS	-	Cyclone Shelter Preparatory Study
Danida	-	Danish Government aid agency
DEM	-	Digital Elevation Model
DoE	-	Department of Environment (of the Government of Bangladesh)
DUS	-	Dwip Unnayan Songstha, an NGO working on Hatia island, literally translates as Island Development Organisation
Ec	-	Electrical Conductivity, a measure used for indicating salinity, calibrated in parts per million (ppm) or Siemens/cm
EC	-	European Commission
EGIS	-	Environment and GIS Support Programme for the Water Sector, successors to ISPAN FAP 16/19 funded by the Netherlands Government
EIA	-	Environmental Impact Assessment
EMP	-	Environmental Management Plan
ESCAP	-	Economic and Social Co mmission for Asia and the Pacific (a UN organisation)
FAO	-	Food and Agriculture Organisation of the United Nations
FAP	-	Flood Action Plan
FCD/I	-	Flood Control, drainage and Irrigation
FINMAP	-	Mapping component to the Flood Action Plan provided by Finland
FPCO	-	Flood Plan Co-ordination Organisation (of the Ministry of Water Resources) now incorporated into WARPO
g	-	gram
GEMS	-	Global Environmental Monitoring System (of UNEP)
ghat	-	Ferry landing stage (Bangla)
GIS	-	Geographical Information System
GPA	-	Guidelines for Project Assessment
ha	-	hectare
HDI	-	Human Development Index (Measure developed by UNDP)

ICID	-	International Co mmission for Irrigation and Drainage
ICLARM	-	International Center for Living Aquatic Resources Management
IEC's	-	Important Environmental Components
IEE	-	Initial Environmental Examination
IPCC	-	Inter-Government Panel on Climate Change
ISPAN	-	Irrigation Support Programme for Asia and the Near East, funded by USAID and responsible for the Environmental and GIS components of FAP. Now succeeded by EGIS.
IUCN	-	International Union for the Conservation of Nature and Natural Resources
Khal	-	A Bangla word for a water channel excavated by human intervention
Khas	-	Government owned land
Killa	-	A raised area of ground for retreat during times of flood
LGED	-	Local Government Engineering Department
LRP	-	Land Reclamation Project
mm	-	millimetre
m^3/s	-	cubic metres per second
Mauza	-	A Bangla word for the smallest government administration area corresponding to a village revenue unit.
MES	-	Meghna Estuary Study
MOEF	-	Ministry of Environment and Forest
MoL	-	Ministry of Land
MPO	-	Master Plan Organisation (for the water sector in Bangladesh, now WARPO)
MWR	-	Ministry of Water Resources
NCS	-	National Conservation Strategy
NEMAP	-	National Environmental Management and Action Plan
NGO	-	Non-Government Organisation
NMIDP	-	National Minor Irrigation Development Programme
NRDP	-	Noakhali Rural Development Programme
pH	-	Measure of acidity and alkalinity of water (log of hydrogen ion concentration)
PP	-	People's Participation
PWD	-	Public Works Department
RRA	-	Rapid Rural Appraisal
Sadar	-	Government Administrative designation for a town centre headquarters
SOB	-	Survey of Bangladesh
SPARRSO	-	Space Research and Remote Sensing Organisation (of Bangladesh)
SRDI	-	Soil Resources Development Institute
SRP	-	Systems Rehabilitation Project
SWMC	-	Surface Water Modelling Centre, previously FAP 25
mt	-	metric tonne
TAPP	-	Technical Assistance Project Proposal
thana	-	Government administration unit between a union and Zila, has been known in the past as an Upazila (Bangla word)
UNDP	-	United Nations Development Programme
Union	-	Government administration unit between a Mauza and a thana. The lowest level from which representatives are elected.
WARPO	-	Water Resources Planning Organisation of the Ministry of Water Resources
Zila	-	A government administration unit equivalent to a District which is above a thana but below a Division.

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

SUMMARY

The environmental component of the Meghna Estuary Study (MES) aims to place the planning process for the area within the objectives of environmentally sound and sustainable development. The methodology for the assessment, which follows the appropriate EIA Guidelines, is given in Section 1.2.

A baseline environmental profile has been drawn up for the defined study area using the format specified in the ISPAN/WARPO EIA Manual and is given in Section 2. There are eight main conclusions given below, with erosion and accretion processes being the paramount issues. Section 3 addresses the overall environmental policy profile within which the MES falls, including the identified need for integrated coastal zone management. An environmental scoping of 20 possible types of intervention that could be considered for the MES area has been carried out, the types of interventions being specified in Section 4 and listed in Table 4.1. A review of other projects past, planned and on-going in the MES area is given in Section 5.4 as part of the overview of public consultation and scoping. Section 6 outlines the procedures used for scoping and bounding of possible impacts for the whole study area.

Impact assessment has been carried out for the 20 types of possible intervention, with analysis given split by the natural environment and the human environment and also by type of possible intervention. The results are given as a comparative impact assessment matrix in Table 7.1. The broad conclusions of the analysis are indicated below.

The need for an appropriate management structure for project planning and implementation has been identified along with the need for it to be integrated and decentralised. The environmental assessment and management process is seen as an intrinsic part of the Study and Project planning and implementation process.

An environmental scoping of three pre-feasibility studies has also been carried out and the results summarised in Section 7.6. Three self standing environmental assessments have been carried out for the three feasibility studies. These are presented as self standing documents as volumes of the feasibility studies.

CONCLUSIONS

Baseline conditions

The main issues that effect the MES area have been identified from the baseline assessment work and summarised in Section 2.8. They are:

- erosion processes
- accretion processes
- cyclones and flooding
- salinity
- drainage
- land tenure
- land use
- human health

Broad impact analysis of possible interventions

The primary conclusions of the impact analysis of main 20 intervention possibilities considered are:

- the impacts of engineering structural interventions are more complex and problematic than non-structural ones.

20

- if structural interventions are used in appropriate locations and they are well designed, and hence effective, then they may give greater benefits than non-structural measures.

- structural interventions are often more costly than non-structural ones and can cause greater negative impacts if they fail.

- if failure of an intervention occurs then the results can be worse than doing nothing, especially for embankment construction, bank protection and river training.

- intervention types need to be selected very carefully to be appropriate to the specific area concerned, so as to minimise negative environmental impacts and maximise benefits.

- public participation should be an intrinsic part of the planning and design process so that local people's priorities can be considered.

- an appropriate, decentralised institutional structure needs to be established for detailed project planning and implementation.

Conclusions of the pre-feasibility studies

The main environmental impacts and constraints for the three selected pre-feasibility studies and that would require particular study at IEE stage are:

- induced effects on erosion and accretion patterns

- the effect of closing off water passages causing inshore-marine flora and fauna habitat change and also having implications for inland rainfall drainage and waterborne navigation

- water and soil salinity as a constraint to development, restricting potential benefits

- implications for fisheries and socio-economic impacts on fishing households

- human nutrition and health consequences, particularly of changes in fish consumption patterns and waterborne disease vector habitats

The major conclusion of a preliminary analysis of the three proposed pre-feasibility studies is that extensive and highly detailed hydrological modelling is needed over the next five years for the three areas before detailed multi-sectoral studies should commence. In addition the detailed findings of monitoring the Haimchar geotextile trial and the first Nijhum Dwip cross dam (assuming it will be built) need to be fed back into the project planning process. It is considered very important to carry out a needs assessment amongst local people to see if the proposed interventions address people's highest priority concerns.

Experience from the three feasibility studies carried out for the MES indicate that if an inter-disciplinary and flexible planning approach is followed then most predicted negative impacts can be avoided or minimised and benefits can be increased. However the overall cumulative negative impacts on in-shore marine fisheries could be serious although the predicted decline irrespective of any MES intervention is so severe that the differential impact is not that great.

A significant problem with all of these proposed interventions is that the predicted value of the economic benefits is low and long term. Whilst social benefits could be used as an additional justification, they would need to be carefully targeted to be in line with government and any potential donor policies and priorities. Feedback is required from government to give its priorities and to see what type of project it is prepared to fund and under what conditions.

In addition the estimated intervention costs per beneficiary household are high, especially compared to other alternative uses of the resources, and other water sector proposed projects in Bangladesh (e.g. flood proofing at Jamalpur) that have recently been declined donor funding. Priorities need to be set at national level, perhaps as part of the National Water Master Plan, based upon likely economic resources that could be made available for development.

Conclusions of the feasibility studies

The self standing EIA documents for each of the MES feasibility studies all have a short summary, conclusions and recommendations in the front of them. In addition the feasibility study Main Reports have a 10 to 15 page environmental section which summaries the impact analysis and gives the conclusions, recommendations and future work programme. A significant conclusion is that there are no environmental grounds that seriously negate the benefits of the proposed interventions, however care is needed in implementation. For the two integrated development projects a long term phased approach is favoured with continuous monitoring.

RECOMMENDATIONS

The main recommendations from the environmental component of the MES are:

- environmental assessment procedures should be followed for each feasibility and pre-feasibility study outlined in the Master Plan, the overall strategy for which uses an area based development approach;
- adequate resources to carry out such an assessment process should be provided as an intrinsic part of the study process, along with sufficient time and specialist staffing to collect baseline data over a 12 month period at minimum and a suitable inter-disciplinary institutional structure;
- a decentralised integrated institutional structure needs to be set up for project implementation that is capable of co-ordinating all aspects rural development. At the present moment LGED is well placed to actually implement construction of some types of work and BWDB others;
- a development planning and implementation for the MES area needs to be put into the framework of an integrated coastal zone management plan with an appropriate inter-disciplinary institutional structure.

FUTURE ENVIRONMENTAL WORK PROGRAMME

The future environmental programme for the MES should be an integrated part of the Study, not separate. The first requirement is to continue the monitoring of key environmental parameters, particularly erosion and accretion, plus fisheries systems. For the next stage of the three feasibility studies there is a need for a environmental input into detailed design and particularly the drawing up of environmental management clauses for construction contracts. During the construction period adequate and effective management structures would need to be put in place to ensure adequate compliance to environmental management clauses in the contracts and also a monitoring programme with a feed back mechanism so that any changes that require action can be identified and steps taken to address them.

All future feasibility studies should have a full integrated non-engineering component, including an environmental assessment sub-component.

1. STUDY SETTING

1.1 Aims and objectives of the environmental component of the MES

The aim of the Master Plan and Development Plan for the Meghna Estuary Study is to draw up a phased management and intervention strategy for the long term development of the area. The Master Plan is to be a 25 year rolling programme, whilst the Development Plan has a five to ten year time horizon. The Terms of Reference for the Study specifically require three priority interventions to be identified and carried through to feasibility study. In addition a further three interventions are to be identified for pre-feasibility study.

As part of the planning process environmental issues are to be born in mind when drawing up the Master Plan and Development Plan. A baseline environmental profile has been drawn up for the whole study area which allows the main environmental issues to be identified so that any constraints that they create to intervention selection can be borne in mind. A broad scoping of environmental issues has then take place which allows for the identification of likely impacts of different possible types of interventions.

For the three selected interventions for which feasibility studies have been carried out, specific environmental assessments have been produced:

- an Initial Environmental Examination (IEE) for Haimchar Erosion Control Project
- an Environmental Impact Assessment for Nijhum Dwip Integrated Development Project
- an Environmental Impact Assessment for Char Montaz - Kukri Mukri Integrated Development Project.

This work for the feasibility studies has been produced as separate self-standing documents and the results are not included in this Environmental Profile Annex to the Draft Master Plan. They are however referred to in the text.

1.2 Methodology

The scope of environmental assessment covers both the natural environment and the human environment, their interaction and particularly induced change caused by proposed human interventions. The basic philosophy followed for environmental assessment follows that outlined in World Bank Operational Directive 4:01 (Ref: World Bank, 1991). A set of Guidelines for Environmental Impact Assessment (EIA) have been drawn up for the water sector in Bangladesh (Ref: FPCO, 1992). These Guidelines are supported by a Manual for EIA (Ref: ISPAN, 1995). These guidelines now have to be fitted within the framework of the DoE procedures as outlined in the Environmental Rules of August 1997.

Potential donors other than the World Bank also have their own EIA Guidelines, but by following the FPCO/WARPO Guidelines it is normally the case that most donor requirements will be satisfied. The Asian Development Bank (ADB) Guidelines (Ref: Asian Development Bank, June 1991 and November 1991) are arranged by the sectoral nature of the proposed intervention and this can cause great confusion when an intervention cuts across different sectors. The European Commission have their own Directive, DG VIII, (Ref: European Commission, 1995?) and the EC's Country Office in Dhaka have put out their own notes for EIA (Ref: European Commission, Dhaka, June 1996). It is assumed that by following the FPCO Guidelines as far as is practical and appropriate then the environmental assessment will be considered adequate by the two donor governments of the MES.

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

The overall methodology for assessing such proposed interventions in Bangladesh has been drawn up and is given in the Guidelines for Project Assessment (GPA), (Ref: FPCO, 1994). These Guidelines include the methodology for economic and financial analysis, but also recognise that there are many benefits of interventions which can not be judged purely in economic terms. This is particularly true of social impacts which can be difficult to quantify, let alone place an economic value against. In order to allow a relative assessment to be carried out, a multi-criteria analysis can be used which allows for prioritisation of expected benefits in relation to policy objectives. The GPA also gives methodologies for assessment of agricultural and fisheries benefits.

For regional studies it is first necessary to build up a baseline assessment of the area and identify future trends. These trends include those that are naturally on-going and also those that are due to existing and already proposed human interventions. Once the overall policy objectives for development in the area have been established and constraints to development identified then a phased management and intervention programme can be drawn up.

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

The overall aim is that no person should be made worse off as a result of the intervention, and any predicted negative impacts have to be mitigated for, either by avoidance or implementing specially targeted programmes. The mitigation programmes are to be incorporated into an Environmental Management Plan (EMP) for the area, the implementation costs of which are to be included in the economic and financial analysis of the proposed intervention.

The outputs of the EIA are to feed into the multi-criteria analysis and then the economic and financial analysis of the project. A residual environmental analysis is also carried out which identifies those negative impacts where mitigation measures are unlikely to fully effective. Using the multi-criteria analysis judgements can be made as to the priorities for development in the area. These judgements should be based upon formulated policy objectives. A multi-criteria analysis allows both quantifiable and non-quantifiable issues to be compared and ranked against each other for decision taking. The outputs of multi-criteria analysis can then be fed back into economic and financial analysis of any proposed intervention.

There is also a requirement for public participation in the EIA process. Such work has to address the possible differing priorities of various social groups and those in a variety of locations, both inside and outside the intervention area. Use of the Guidelines for People's Participation in Water Development Projects (Ref: Ministry of Water Resources, 1994) was suspended in 1996, but a revised draft is presently being prepared and reviewed. In the meantime the experiences of the SRP and Jamalpur Refinement Study (Ref: SOGREAH, March 1996) were reviewed so that an appropriate strategy of public participation for the MES could be derived.

1.3 Definition of the study area

The location of the study area in the national context is given in Figure 1.1.Figure 1.2 is the study area map which clearly defines the limits to be all the land and water between the main lower Meghna river bank south of Chandpur and 500 metres from the river bank. It should be noted that strictly speaking Bhola Island is not included in the study area as it has already been subject to a separate irrigation study. The designated MES Planning Zones, which have been derived using morphological criteria, are shown in Figure 3, along with the sub-division of these into Planning Units. The overview of the area can be seen in Figure 1.4 which is a Landsat image of the area dated February 1996.

Figure 1.1: MES National Location

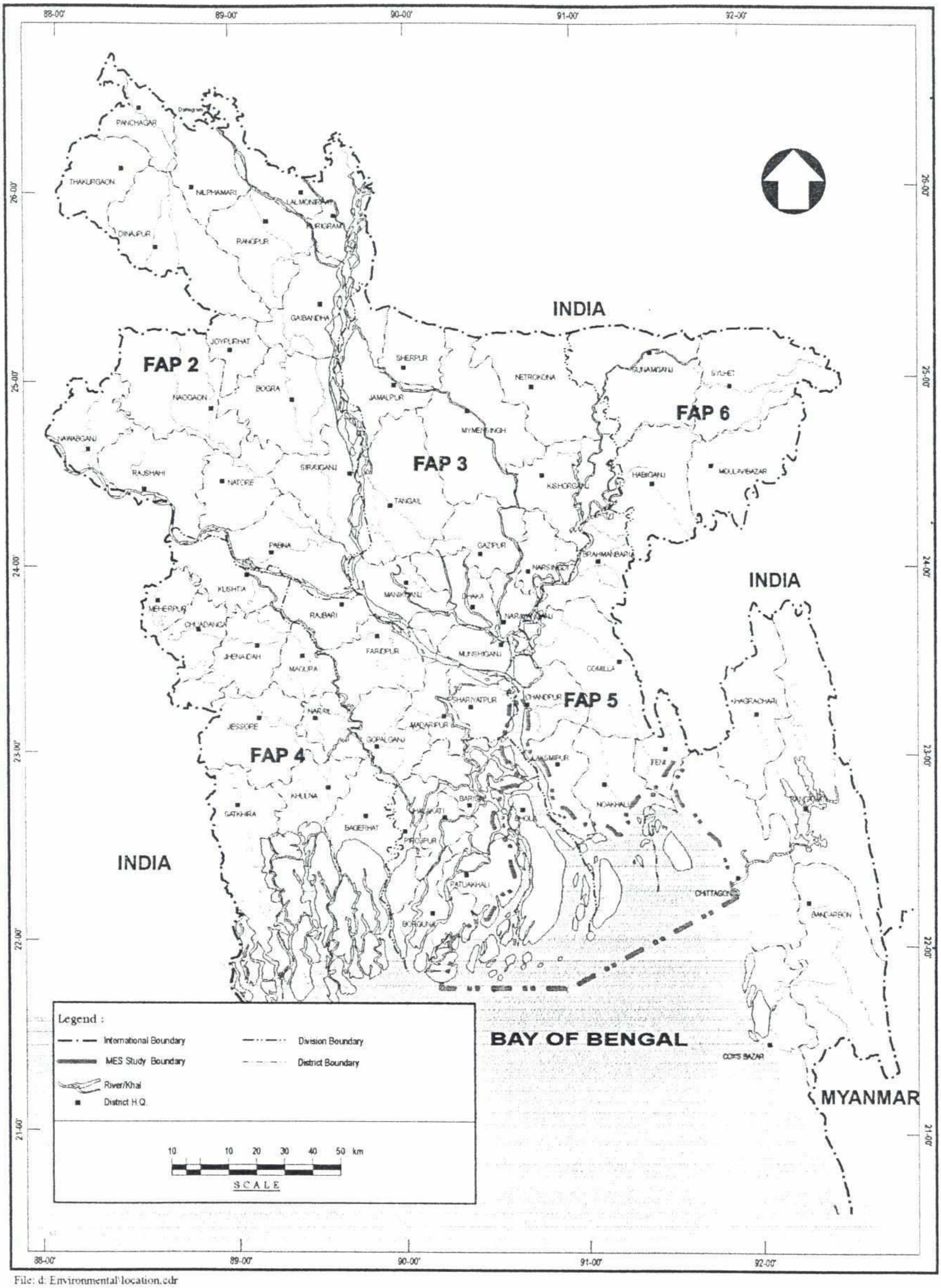

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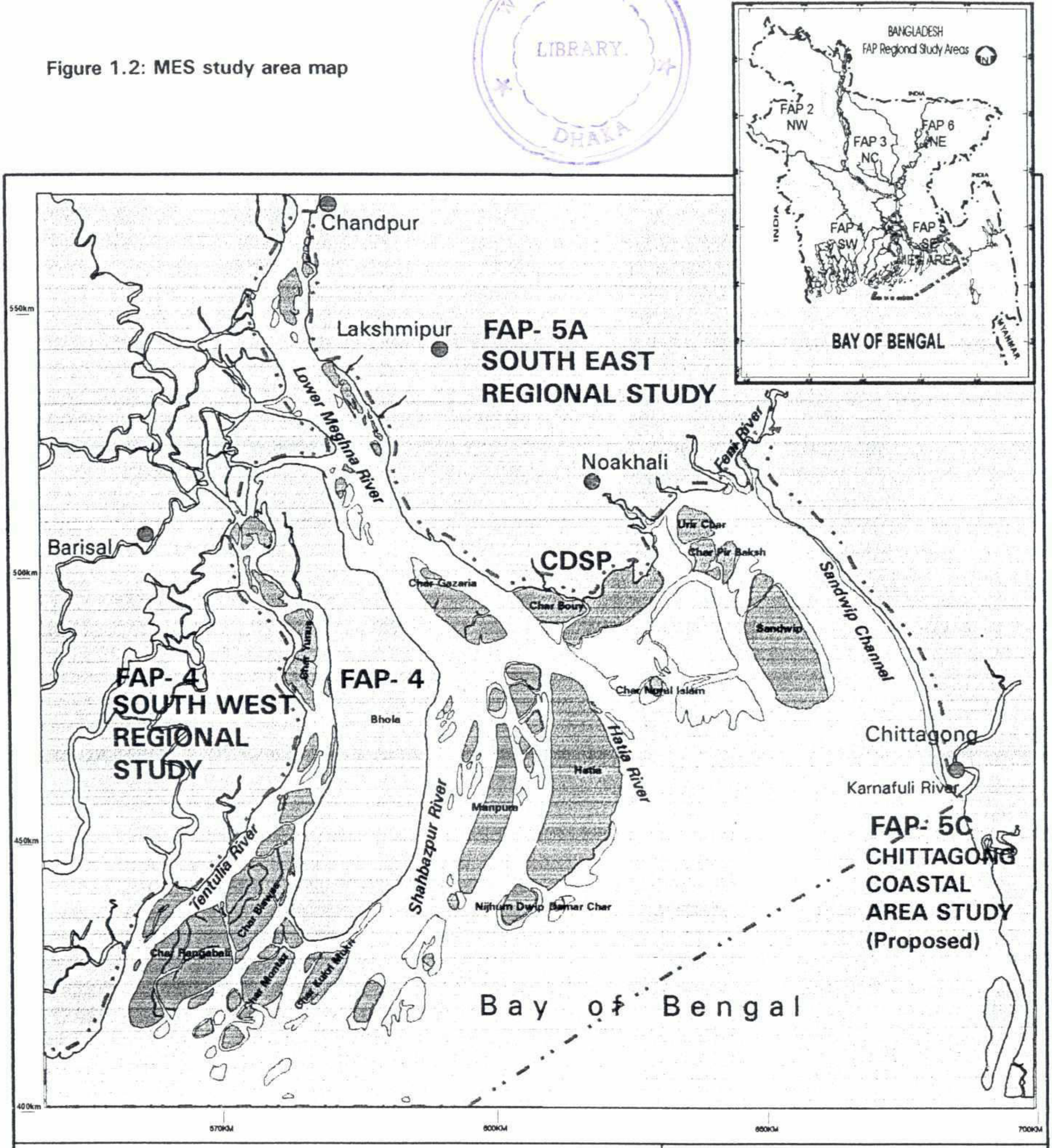
Figure 1.2: MES study area map



LEGEND

STUDY BOUNDARY

LAND IN STUDY AREA

TIDAL MUD FLATS

DISTRICT HQ

REMARK: BHOLA IS EXCLUDED FROM THE STUDY AREA

MEGHNA ESTUARY STUDY

MES STUDY AREA MAP

PROJECTION BANGLADESH TRANSVERSE MERCATOR

SOURCE LANDSAT IMAGERY FEBRUARY 1996

PRODUCED BY mes MES ENVIRONMENT, GIS/RS/CAD UNIT

10 0 10 20 30 40KM

SCALE

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Figure 1.3: MES Planning Zones and Units

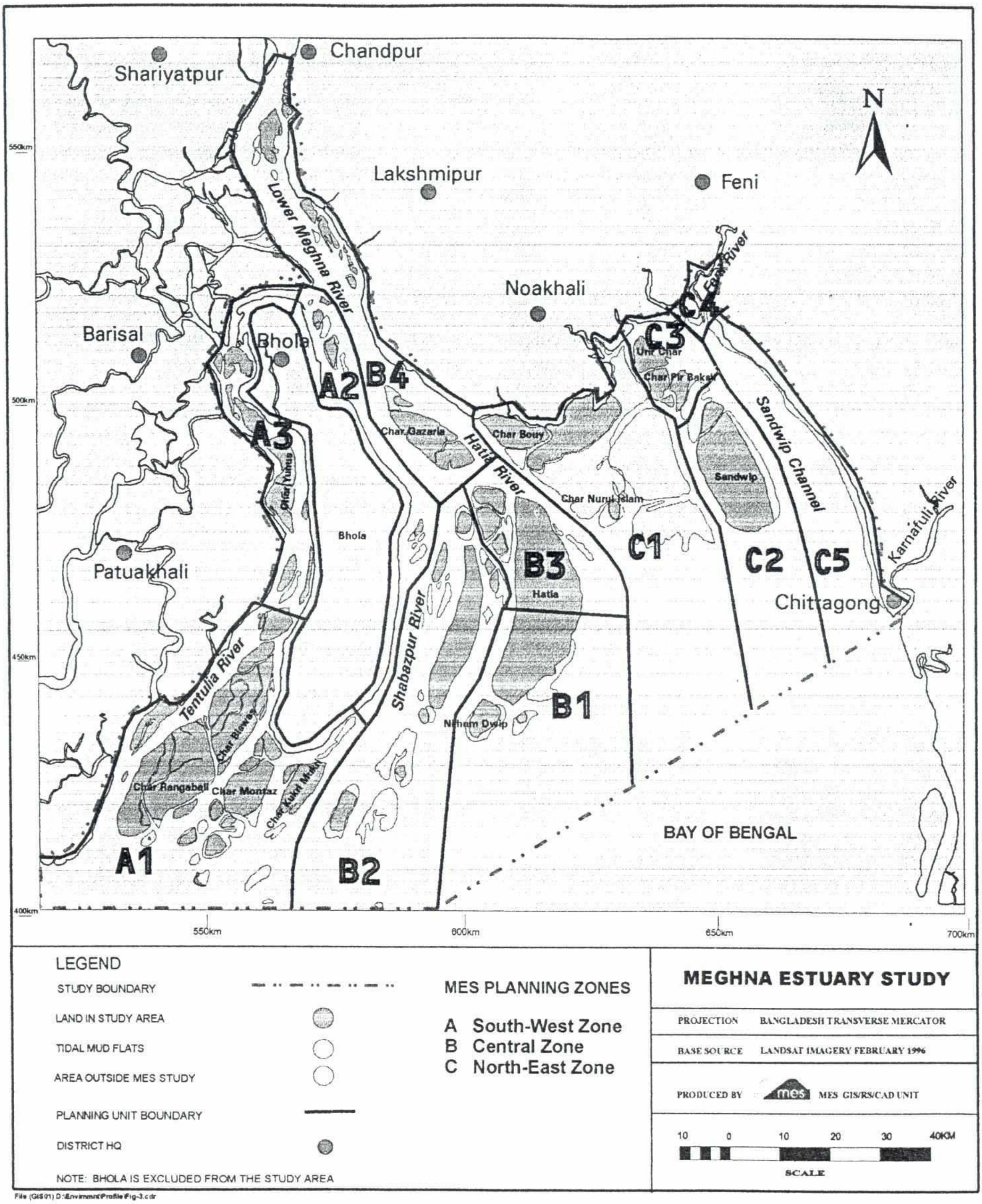
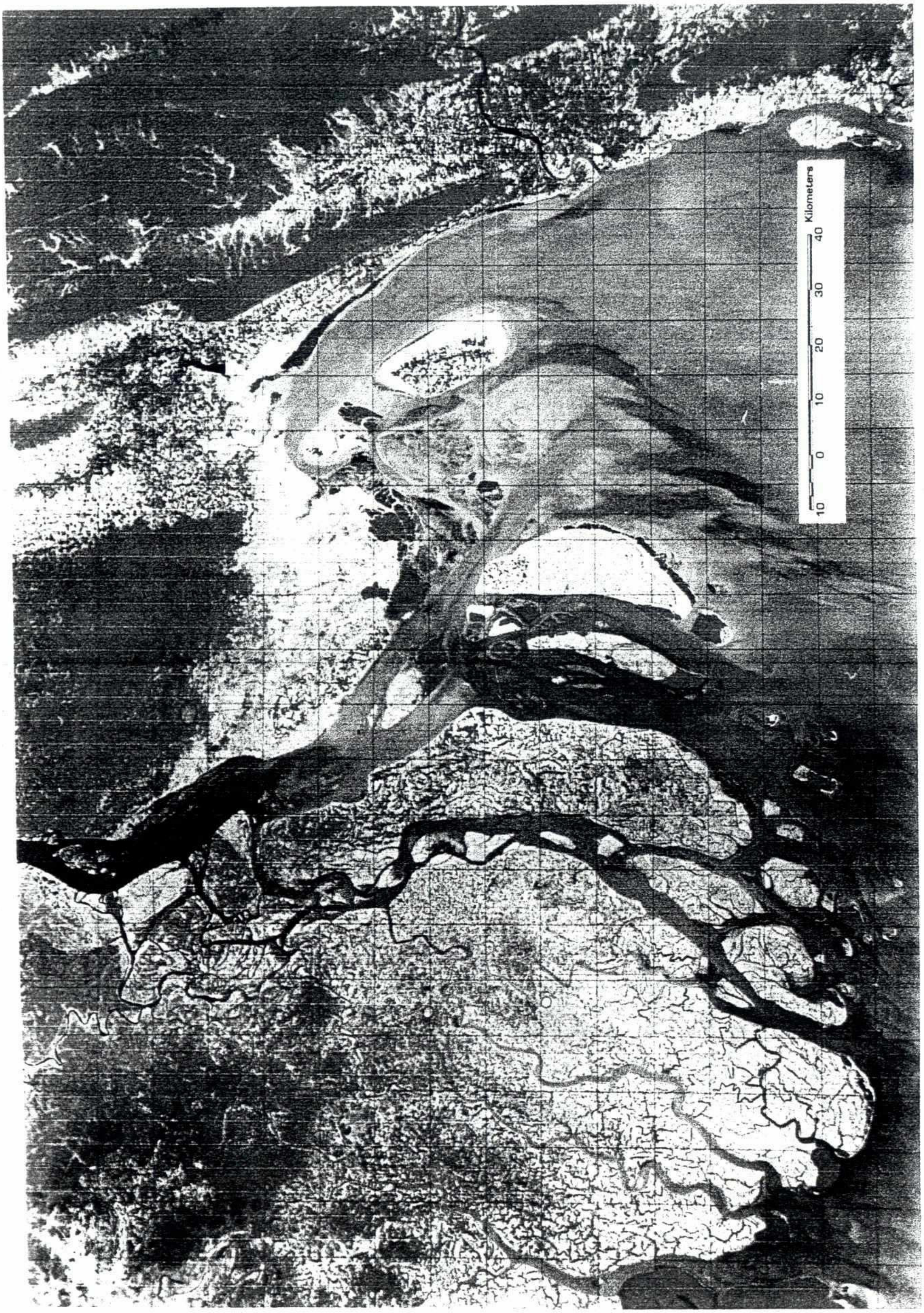


Figure 1.4: Landsat Imagery of February 1996



1.4 Scope, resources and limitations of the environmental assessment

The original Terms of Reference for the MES were drawn up in 1992 before most of the procedures and EIA guidelines for the FAP were in place. The inadequate discipline cover and restricted man months for international specialists was noted in the Inception Report (Ref: DHV consultants BV et al, April 1996) and proposals made to address this to some degree by providing inputs from specialists in forestry, fisheries and livestock. However there was no provision for a full time international Deputy Team Leader position with specific responsibility for non-engineering issues, a post which has been found desirable on most integrated regional studies for the water sector in Bangladesh. The result is that some difficulty was experienced in maintaining continuity of supervision of the work.

The non-engineering components of the MES were only fully mobilised by the beginning of March 1997, and even then the fisheries and forestry international specialists could not be started, as formal approval of the Inception Report (Ref: DHV Consultants BV et al, April 1996) and the revised Terms of Reference had still not been given over one year after submission. There was discipline cover with local specialists in broad environmental issues, soil and land resources, agriculture, forestry, fisheries, socio-economics, participation, economics and general rural development. In addition the work on river and coastal morphology, climatology, bathymetry, remote sensing and GIS was fed into the environmental assessment component. However the local staffing of some of these components was not continuous and ensuring adequate international supervision and co-ordination was problematic.

The collection of environmental data for the whole study area used existing information as an initial step, with additional data being made available through the life of the study. However highly detailed data collection was confined to the three feasibility study areas. It is now generally accepted in Bangladesh that any primary data collection for EIA requires a set of seasonal data to be collected over a 12 month period. Steps were taken to do this for one of the feasibility study areas (Nijhum Dwip), but for the other two this was not possible as their final selection could not be made until into the last year of the Study. Whilst it would have been desirable to have more dry season data for water and soil quality assessment, the lack of this has not been an impediment for selection of Important Environmental Components (IEC) and impact analysis.

1.5 Interface with other study components

An inter-disciplinary approach was followed for the non engineering components of the study, covering the subject areas listed in Section 1.4 above. A logical framework analysis was also developed for the overall MES which demonstrated what data was needed at which stage to allow rational decision taking for the planning process. The environmental assessment work was carried out as a component within the overall framework of the MES. For the feasibility studies all work was carried out in a fully integrated manner with staff jointly visiting the field for data collection.

1.6 Layout and format of the environmental profile and assessment report

The layout of the Environmental Reports follows the contents list in Chapter 6 of the EIA manual (Ref: ISPAN April 1995a), as far as is possible and sensible for an EIA in a coastal area. For the overall MES Environmental Profile Annex an additional Section on Environmental Policy Objectives has been added after the Baseline Profile Section and before the section dealing with intervention possibilities.

1.7 Acknowledgements

During the course of the work many people have been consulted at all levels of society, in Dhaka, at Regional, thana and union level and also on the site. In addition a large body of knowledge was already held by staff working on the study due to their previous activities on similar studies in the country, particularly those in coastal areas and under the FAP. A listing of contacts and liaisons is given in Appendix 3.

2. BASELINE PROFILE OF THE MES AREA

An environmental profile of the defined MES area has been drawn up using existing information and newly collected data from the MES work. The profile given below follows the order laid out in the ISPAN/WARPO EIA Manual, suitably adapted to be appropriate to the MES area. Considerably more detail for some disciplines is available in separate annexes to the Master Plan, especially for morphology and hydrology, rural development, agriculture and forestry.

2.1 Natural physical environment

2.1.1 Climate

Climatic norms for five locations within the MES area (Sitakunda and Sandwip in the east, Chandpur in the north, Hatia in the south and Patuakhali in the west) are shown in Figure II.2 of the Environmental Annex. These give mean monthly figures over a 27 year period which tend to reduce the effect of extreme conditions and do not show trends over time. However there are identifiable variations across the study area:

- Wind speeds are highest in Patuakhali during April and generally lowest across the study area in December. However peak wind conditions occur during cyclone conditions which are discussed below.

- Mean daily temperatures do not show great variation across the area, with constant highs from May to September. The winter minima tend to be lower in Patuakhali, which is further inland, and Chandpur which is the furthest north.

- Sunshine hours are shortest in July at Patuakhali, due to cloud cover during the monsoon, and highest in December and January inland at Chandpur.

- The lowest humidity (60 per cent) occurs in Chandpur during February, the highest (90 per cent) in the off-shore islands of Hatia and Sandwip during July.

Mean monthly rainfall conditions for the five selected locations are shown together in Figures 9a to 9e and an isohyet map in Figure 2.1. The monthly figures hide the significance of extreme daily rainfall conditions which are often responsible for local flooding. In general the isohyets follow the coastline, with the islands of Sandwip and Hatia having the highest amounts (3,600 mm). Noakhali has the greatest quantities (3,200 mm) for mainland coastal areas and Chandpur has the lowest mean annual rainfall. The mean monthly figures show the peaks to be in July and highest at Sandwip and Sitakunda, where as the lows are near rainless conditions across the whole study area in January.

An indication of the difference in tidal range at locations across the MES area is given in Figure 2.2. The range is greatest at Feni (7 metres) and lowest (less than 2 metres) in the north west of the area, with Chandpur at the upstream edge of the study area having a range of 0.75 metres. The timing of spring and neap tides relative to cyclone surges and monsoon river levels is critical in determining flood risks in the area.

Cyclone risk is indicated in Figure 2.13, the zoning being based upon the landfall locations of past cyclones. The greatest risk lies in the east of the study area between the Feni river and to south of Chittagong. The lowest risk is in the central part west of Sandwip and east of Manpura, including Noakhali and Hatia. The tracks of significant cyclone events area also shown and of significance is the 1960 event which was from south to north directly up the Meghna river. An early SWMC hydro-dynamic model was developed for the Cyclone Shelter Preparatory Study covering the 1970 and 1991 cyclone events. The outputs of this work clearly demonstrate that peak cyclone water levels are highest further inland and on the leeward side of off-shore islands, due to the funnelling effect of land formation.

Figure 2.1: MES Rainfall Isohyet Map

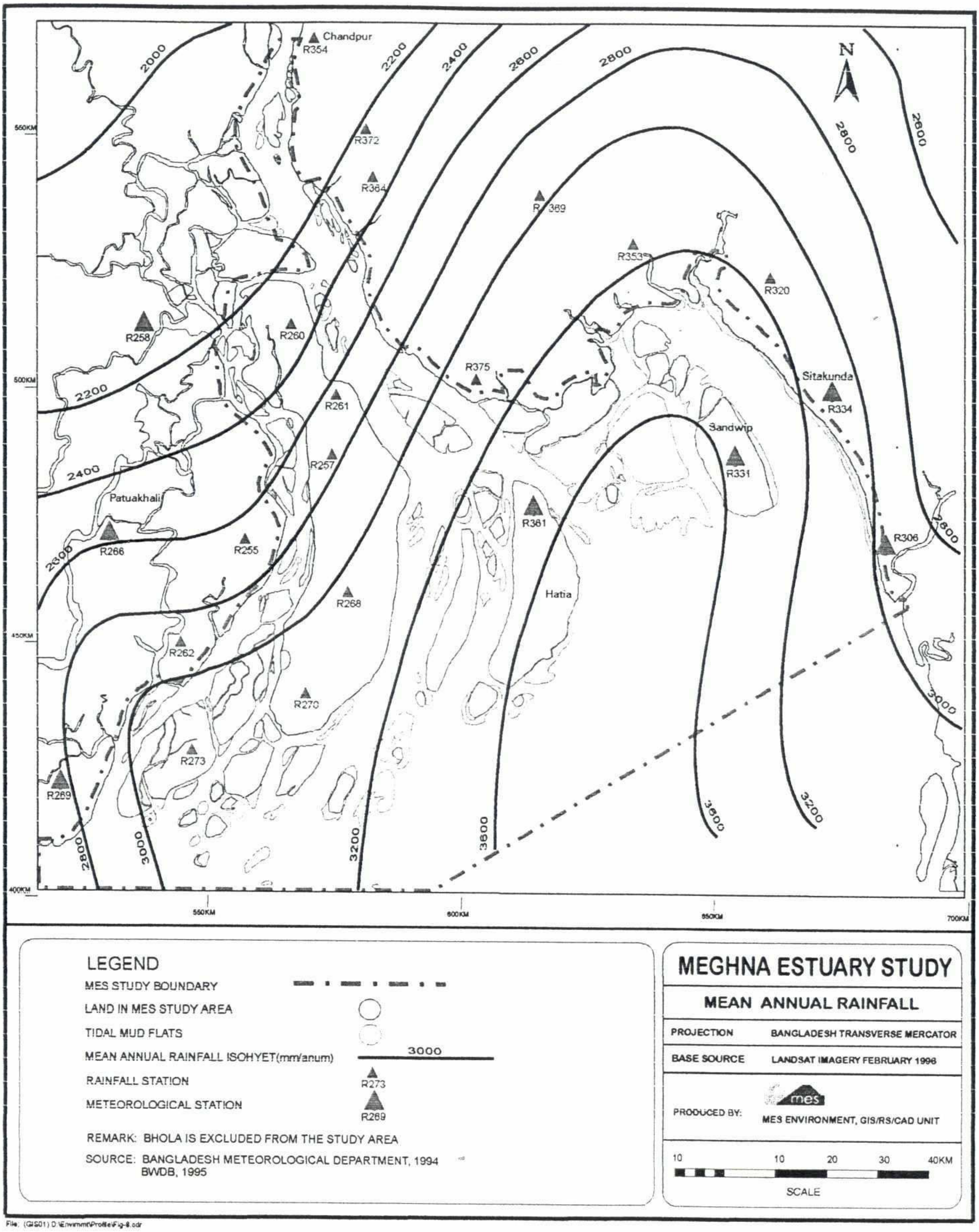
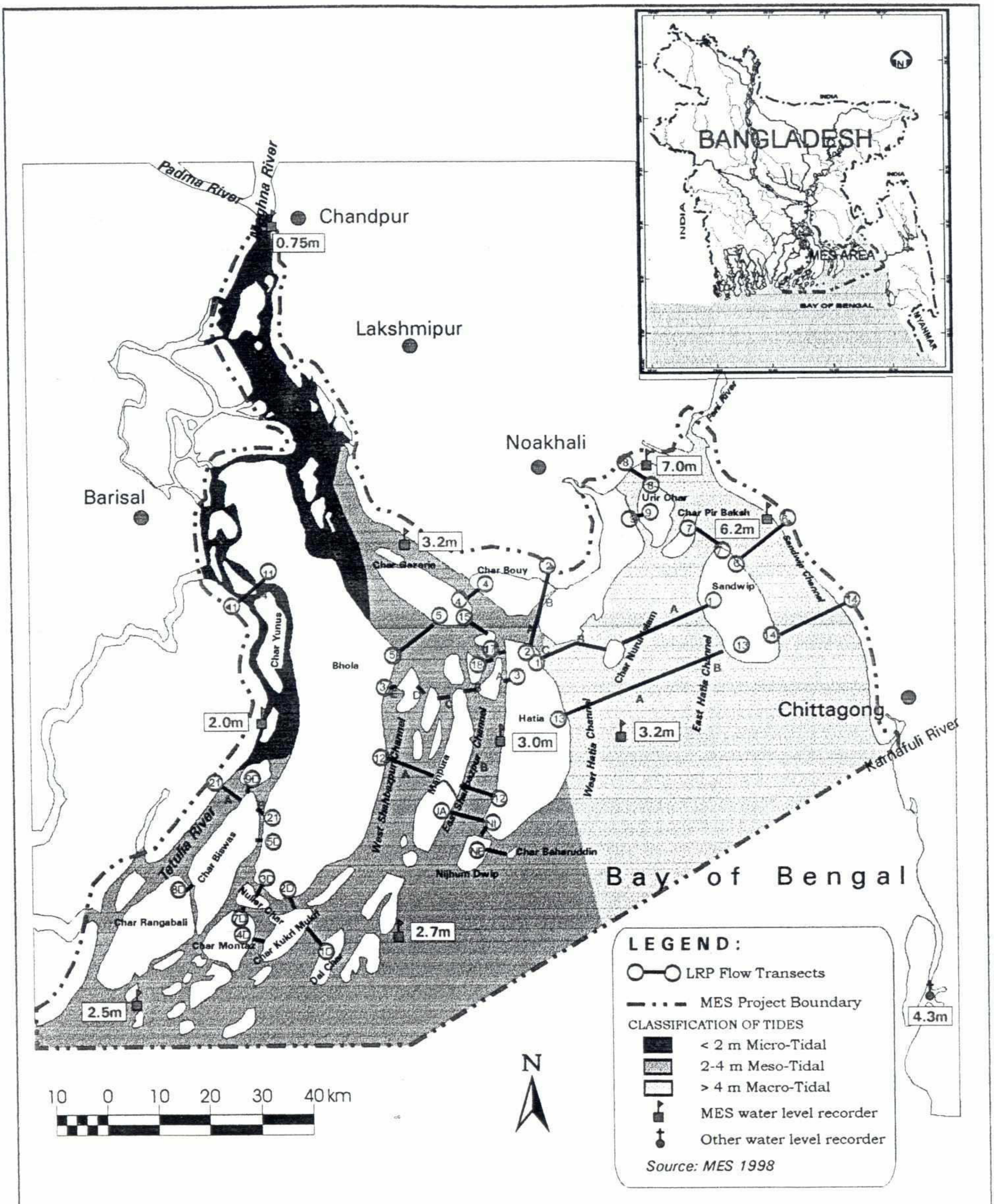


Figure 2.2 : Tidal Range Map



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2.1.2 Hydrology

As part of the MES work a hydro-dynamic model of the study area was developed by the SWMC. The model utilised the newly collected MES bathymetry data as shown in Figure 2.3 and the Digital Elevation Model (DEM) derived from the Finmap 1:10,000 topographic maps of 1990, a simplified version of which is shown in Figure II.1. The model also utilises the available rainfall, river flow, water level and sedimentation data. Outputs of the model were used for the feasibility studies.

Water level data clearly demonstrates the seasonal effect of monsoon flow in the river system superimposed upon the lunar tidal pattern. The effects of predicted sea level rise (0.27 metres by the year 2020) are discussed below. Flooding of land is also influenced by the effects of local rainfall and the efficiency of the drainage system. In embanked areas drainage depends on the number, size and location of water control structures and the ability of the operation of these to use the available tidal range. The retention of rainfall within the drainage system is also important as a source of irrigation water supply into the dry season, as groundwater is saline.

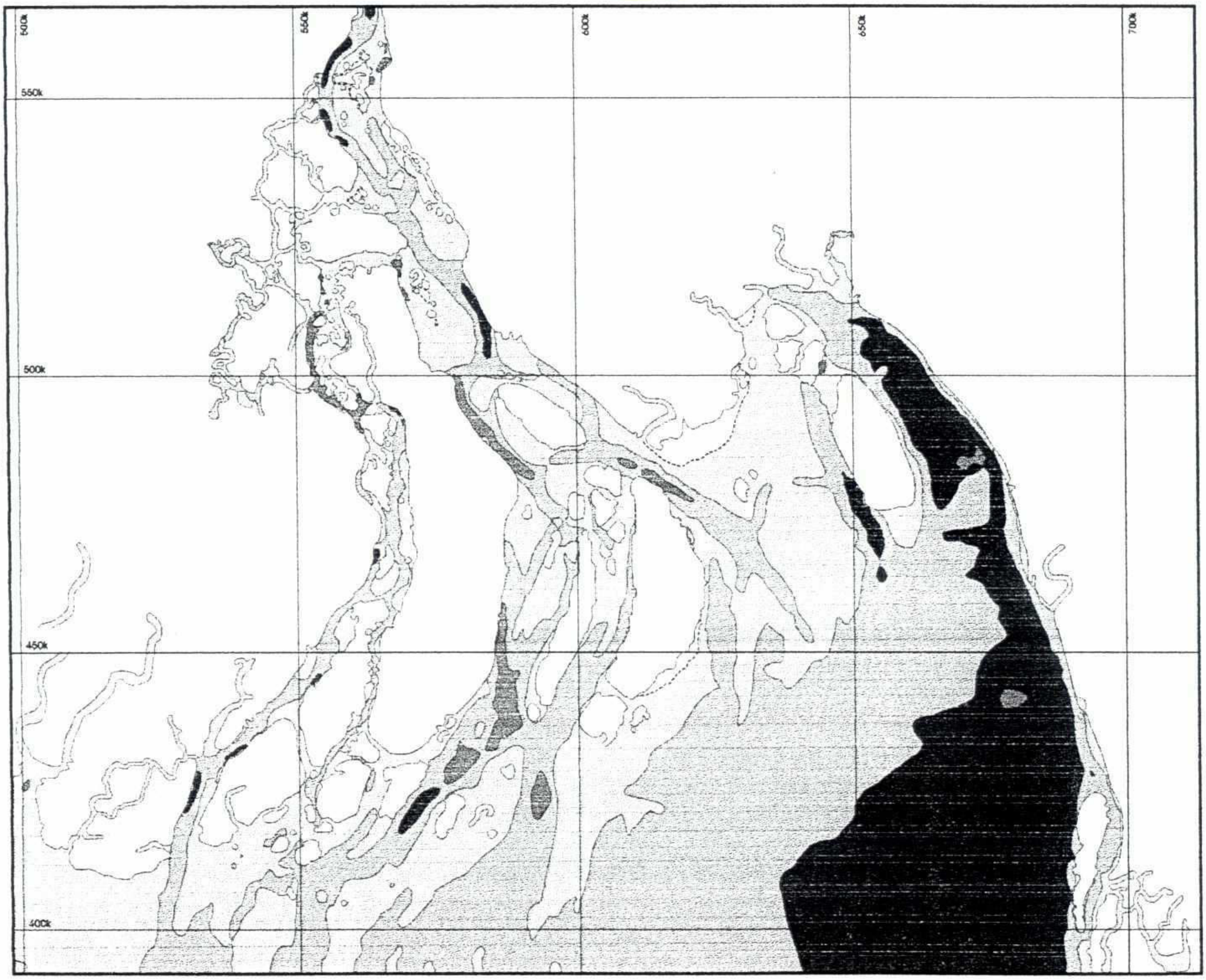
There is existing DoE surface water quality monitoring at Chittagong and Chandpur (Ref: DoE, 1993), plus some on-off dry and wet season sampling at the Rahmatkhali regulator carried out under FAP 4. As part of the MES feasibility study work water samples were collected and analysed at South Hatia, Nijhum Dwip and Char Montaz and the results are given in the EIA reports of those studies. The most important parameter is salinity and the MES sampling programme in the riverine areas has updated the work of the LRP, given in Figure 2.4. The salinity interface moves according to seasonal flow in the main river system, being furthest out to sea during October and closest inland during May. This poses a constraint on agricultural use of unembanked land as the salinity levels increase during the dry season when there is a demand for surface irrigation water. There appear to be no problems with pollution from agro-chemicals as application rates are low, mainly due to their cost and difficulty in distribution. This corresponds with the findings of the NMIDP (Ref: Halcrow, 1995).

Erosion and accretion are the key variables in the MES area and these have been mapped in detail using time series satellite imagery. More detail is given in the Morphology Annex and MES Technical Note 009 (Ref: DHV, June 1997), but a brief overview of the situation indicates that there has been more accretion than erosion in the area from both 1776 (the date of Rennall's map, see Rennell 1776 for a description of how the map was made) to 1996 and 1973 to 1996. Over the last six years the rate of accretion has been considerable, however the rate of land loss due to erosion is also increasing but not as fast as accretion. A comparison of the coastline between 1776 and 1996 is given in Figure II.4 and it can be seen that there is a trend for strings of islands to develop out to sea which gradually become consolidated and join to the mainland. Between 1776 and 1996 there was on average 9,900 ha per year more accretion than erosion. More detailed mapping of the changes between 1973 and 1996 can be seen in Figure 2.5 and measurement of this indicates that there was 16,400 ha per year more erosion than accretion. The increments of the 1973 to 1996 change are shown in Figure II.5, the conclusion being that the amount of accretion greater than erosion has increased greatly in the period 1993 to 1996 to nearly 20,500 ha per year. However there are still significant areas of main bank erosion which cause considerable loss, the mean estimate for the period 1973 to 1996 being 3,700 ha per annum and for 1993 to 1996 5,700 ha. Using the above analysis, predictions have been made as to possible future erosion and accretion patterns and these are mapped in Figure 2.6.

The suspended sediment concentrations in the MES are mapped in Figure II.6 and indicate that the highest levels (over 2.2 gm/l) are in the north east, south of Feni and Noakhali, brought in by the north flowing return current along the Chittagong coast. Sediment concentrations are also visible in the satellite image given as Figure 1.4. Medium concentrations of 1.3 to 2.2 gm/l are found in the islands east of Bhola, whereas the lowest concentrations are to the west.

26

Figure 2.3: Bathymetry



LEGEND:

- Above 0 m
- 0 to -5 m
- -5 to -10 m
- below -10 m

Datum: PWD
Grid: BTM
Ref: MES Estuary Survey, June 1998
Source: MES 1998

MEGHNA ESTUARY STUDY	
BATHYMETRY	
PROJECTION	BANGLADESH TRANSVERSE MERCATOR
SOURCE	LANDSAT IMAGERY FEBRUARY 1996
PRODUCED BY	mes MES ENVIRONMENT, GIS/RS/CAD UNIT

SCALE: 10 0 10 20 30 40KM

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28

Figure 2.4: MES Surface Water Salinity Map

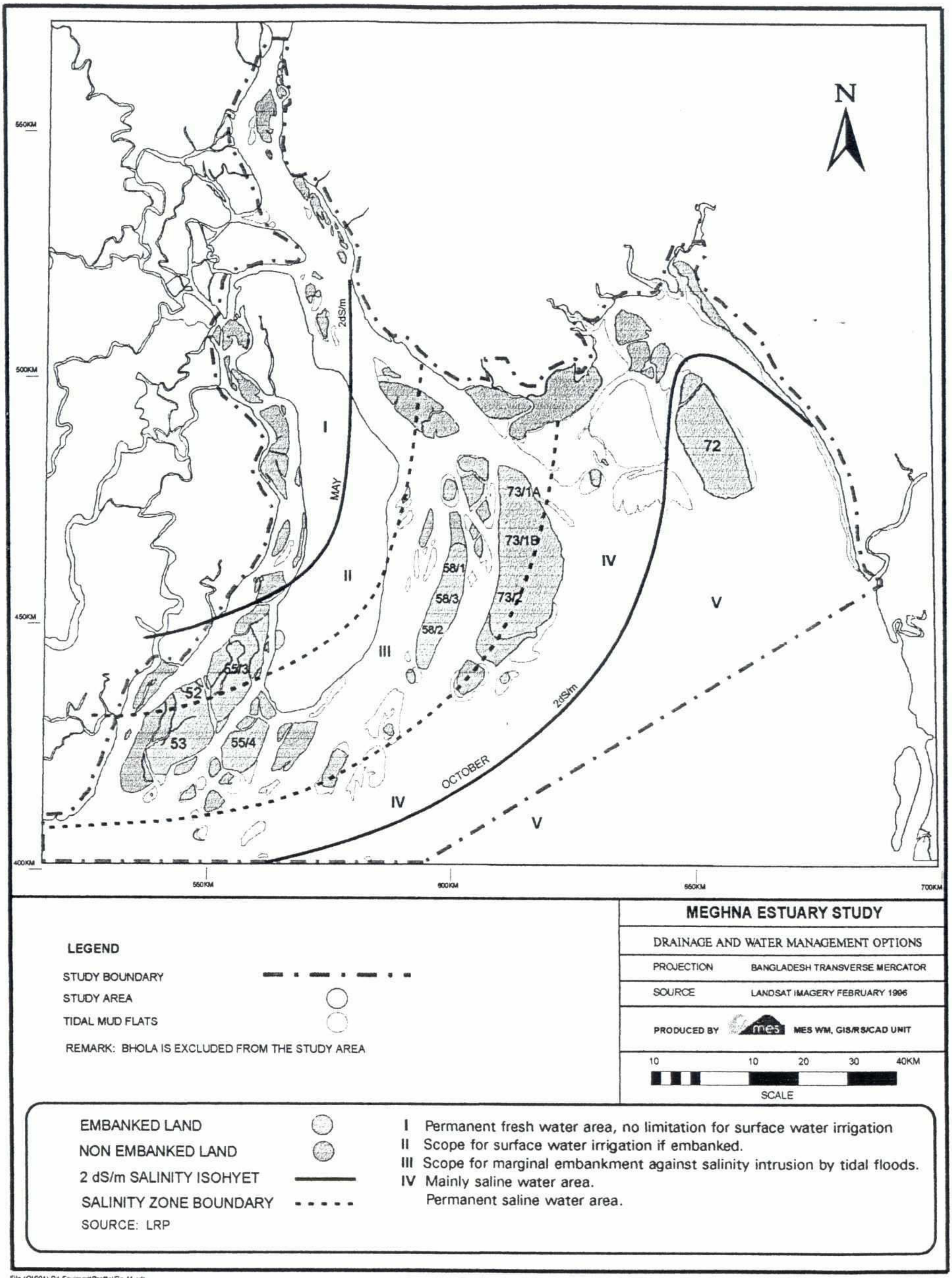

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Figure 2.5: Erosion and Accretion Mapping 1973 to 1996

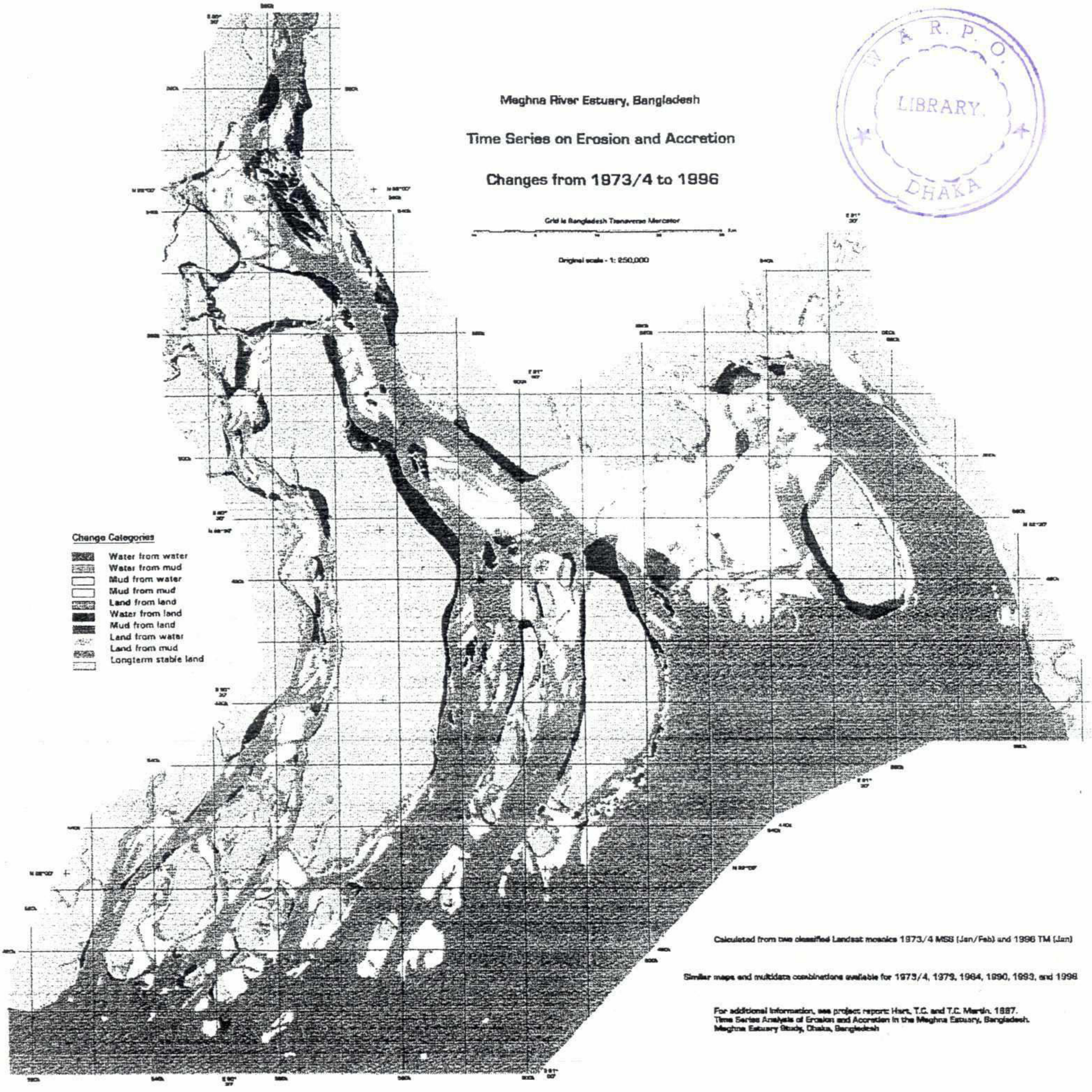
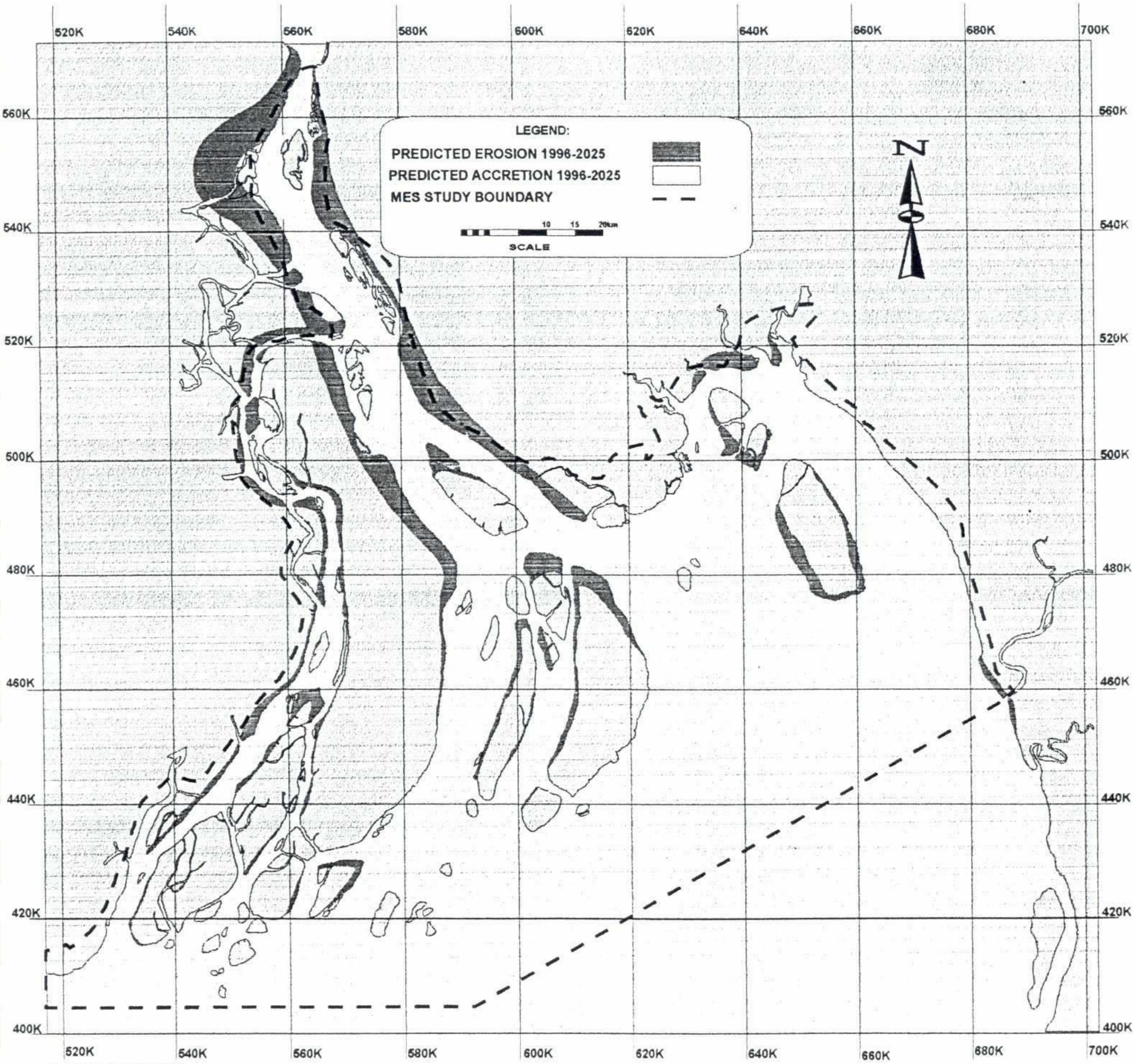


Figure 2.6: Predicted erosion and accretion 1996 to 2025



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The situation with regard to groundwater in the study area is summarised in Figure 2.7, giving details of depth and quality. The conclusions are that depth to non saline water is in the order of 270 metres and abstraction costs are thus high when compared to the north of the country. As a result, groundwater is reserved for domestic drinking water supply and not used for irrigation. There are high levels of iron in the north of the study area and recent studies have shown that the Chandpur area has one of the highest incidences of natural arsenic pollution in groundwater when compared to the rest of the country.

2.1.3 Land resources

Topography of the study area is indicated in Figure II.1 using the DEM constructed from the 1990 Finmap work. All of the off-shore islands lie less than 4 metres above mean sea level and many below 2 metres. Topography greatly influences flood risk and land type in Bangladesh. The 1988 FAO Agro-Ecological Zone mapping is given in Figure 2.8, showing that most of the study area is classified as Young Meghna Estuarine Floodplain, with the exception of the Chittagong Coastal Plain to the east.

The classification of soil types are shown in Figure 2.9 which has been compiled from published SRDI maps (Ref: SRDI, 1989-1995). The soils are characterised by being relatively young, have low levels of organic matter and are highly prone to residual salinity. Detailed soil chemistry data exists at SRDI for many thanas in the study area, including mapping at 1:50,000 scale, although much of this is as yet unpublished. Use has been made of the SRDI data where possible and additional soil sampling has been carried out for the Nijhum Dwip and Char Montaz feasibility study areas. The results of this work are written up in the feasibility study EIA reports and confirm that salinity and low organic content are the two most serious problems in the area, although in some localised areas waterlogging is a problem due to poor drainage from rainfall, made worse by the construction of embankments with insufficient openings. Soil capability is indicated in Figure 2.10, again compiled from SRDI data. The capability mapping also confirms that salinity is a major constraint, both seasonally and generally as a residual problem, along with flood risk, both from high tides and cyclone surges. Salinity issues have been studied by BARC (Ref: BARC, 1990?) and addressed by Brammer (Ref: Brammer, 1996) and Rahman (Ref: Rahman R, 1990). Detailed studies were carried out by the LRP at Nijhum Dwip (Ref: LRP, November 1990).

2.2 Natural biological environment

Broad habitats are mapped in Figure 2.11 and comprise terrestrial, freshwater, inshore marine and offshore marine. The boundary between freshwater and marine habitats is considered to be the 10 ppm salinity limit and the boundary between in-shore and off-shore habitats has been taken as five kilometres from the nearest land. Master species lists for flora, fauna and fish are given as Tables I.1, I.2 and I.3 respectively with the habitats of each species being indicated. Fish habitats are also indicated on Figure 2.12.

2.2.1 Terrestrial habitats

Terrestrial habitats are shown in Figure 2.11 and the distribution of forested areas is given in Figure 2.30 along with a schedule of measured areas in Table 2.1.It should be noted that all major forest in the study area is planted and not natural vegetation. The most diversity in flora occurs in planted homestead vegetation, including that on embankments planted by erosion displacees who are resident there. Newly accreted land is colonised by uri grassland which provides large expanses of animal grazing land. The situation is very dynamic with new land emerging all the time and there is a natural succession of colonised flora which is modified by human activity, particularly the planting of mangroves on newly accreted land. There would appear to be no major threatened species.

The greatest diversity of terrestrial fauna also occurs in areas of planted homestead vegetation and to a lesser extent in planted mangrove areas, but the latter tend to exhibit less variation. The more extensive mangrove areas are able to support larger fauna species such as deer, although these are introduced rather than naturally occurring. Again there appear to be no threatened species in the study area.

Figure 2.7: Groundwater Depths and Water Quality

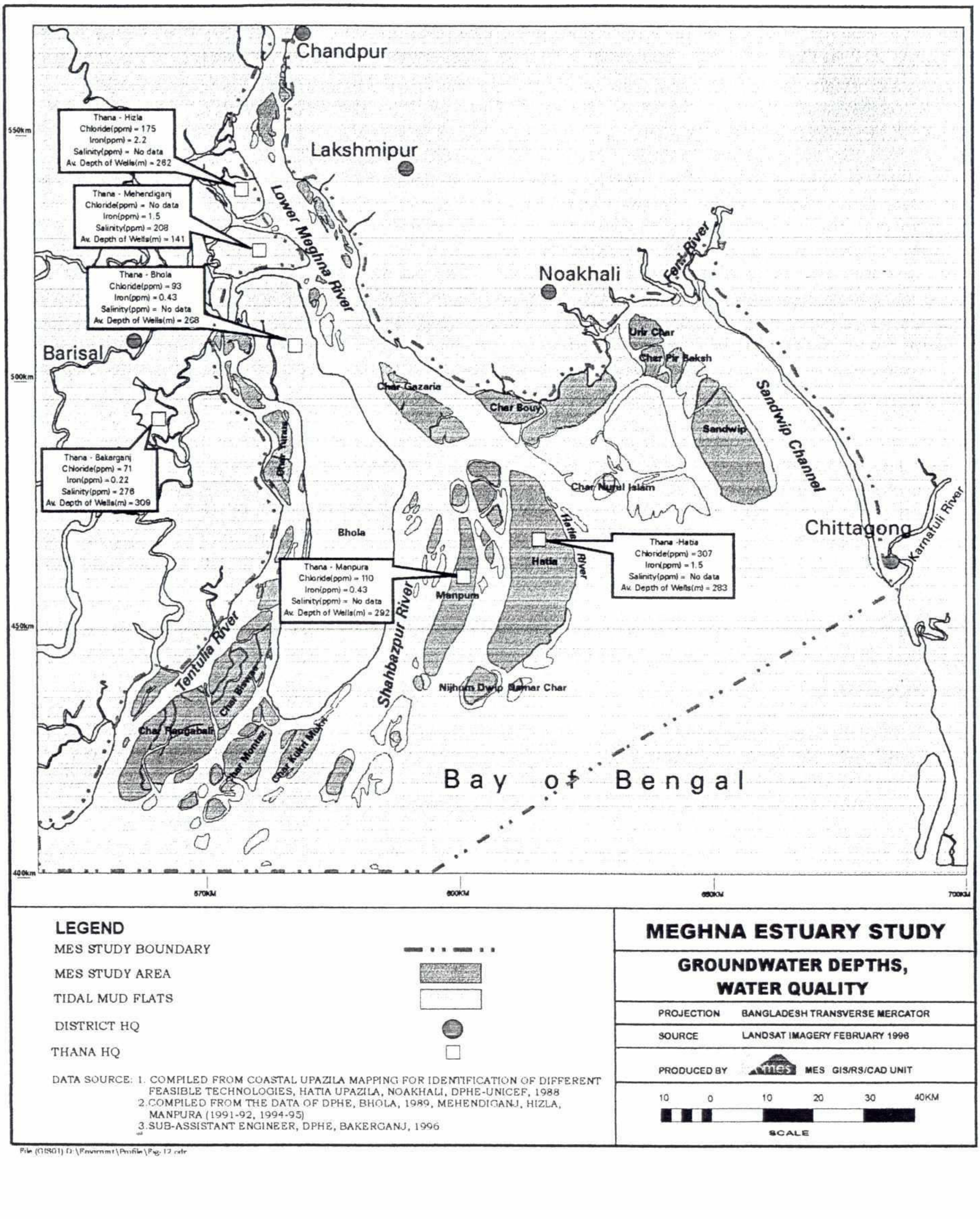

Figure 2.8: Agro-Ecological Zone Map

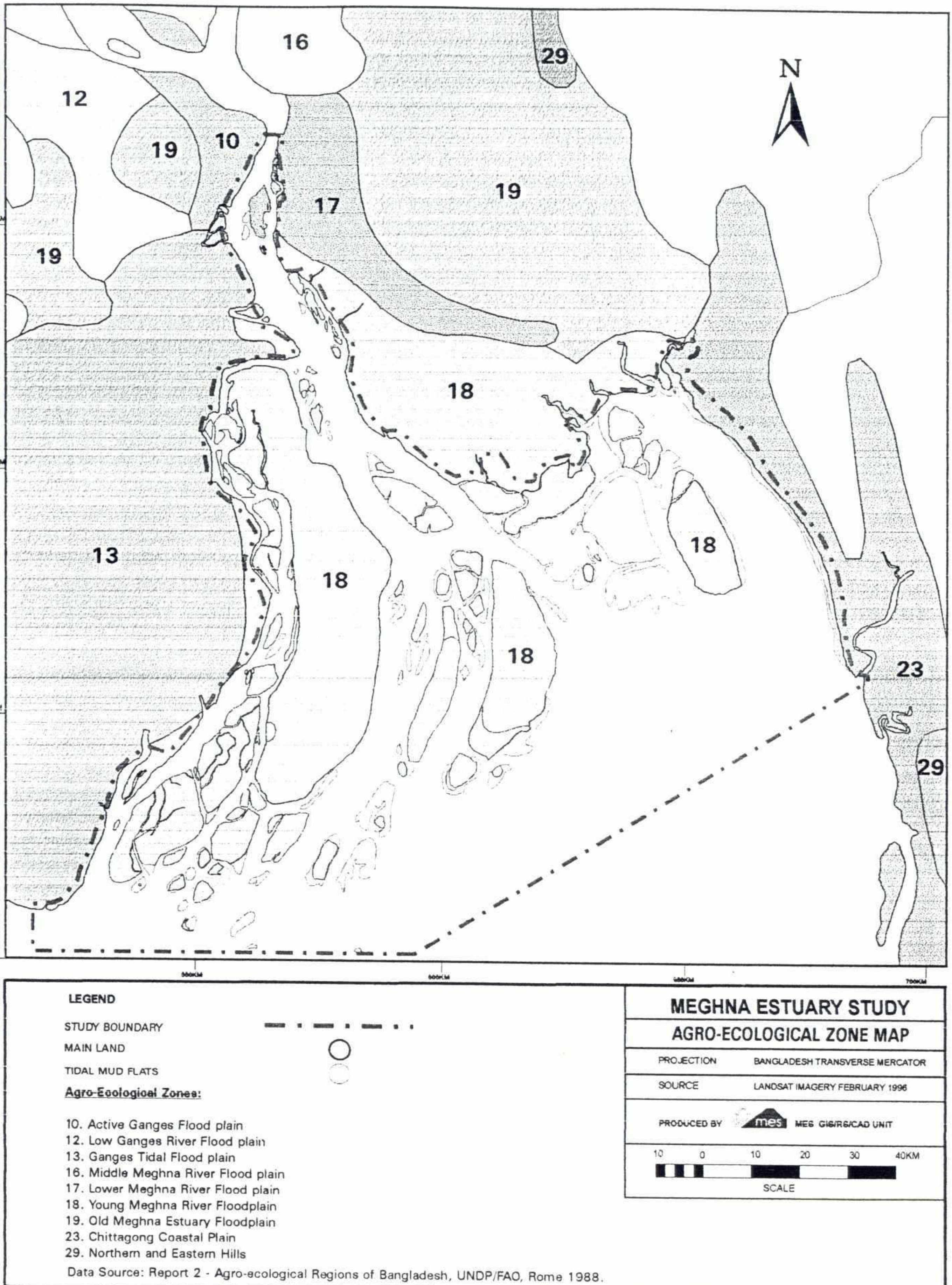

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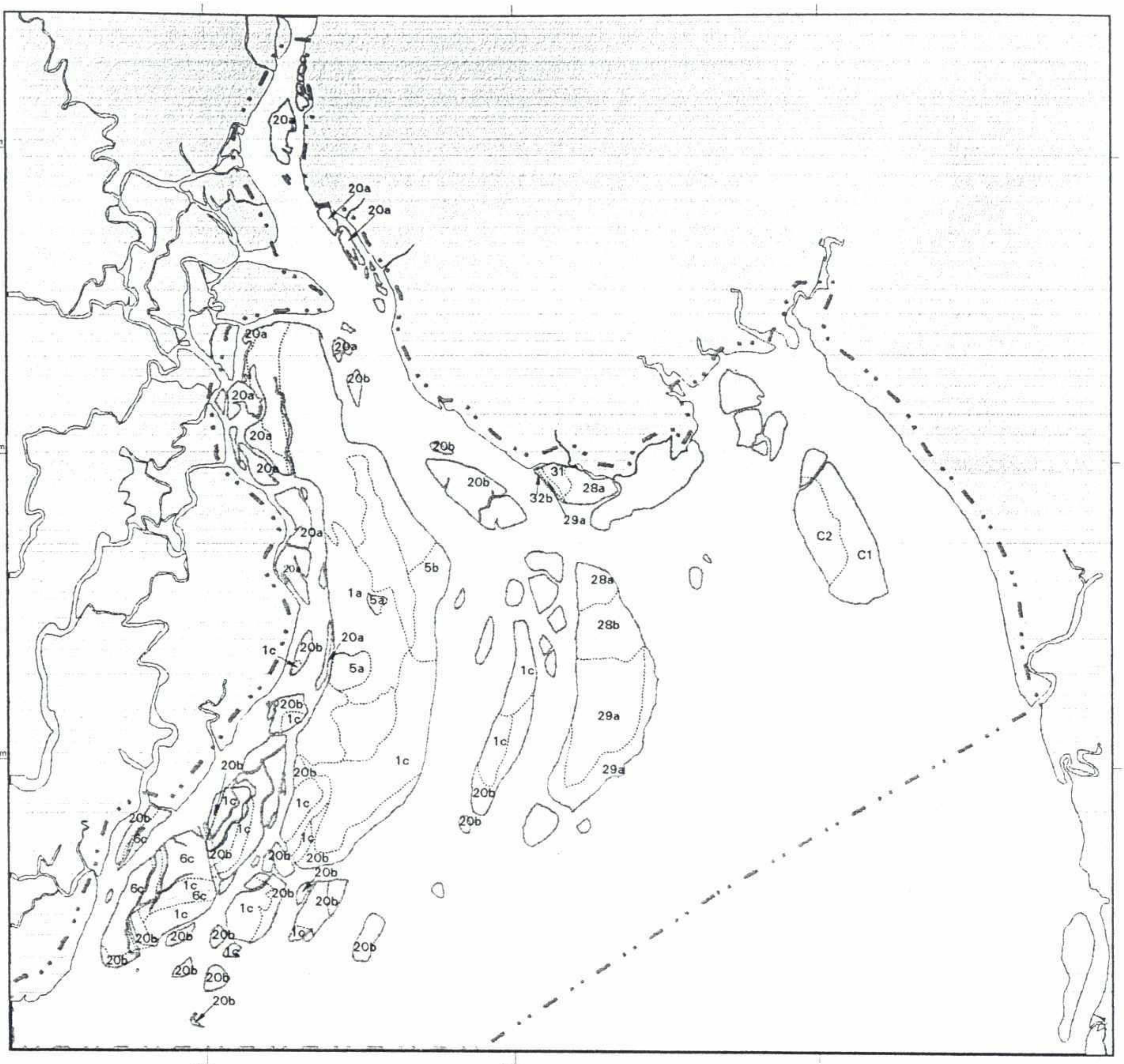
Figure 2.9: SRDI Soil Type Map



LEGEND

Study Boundary — · · — ·

Young Meghna Estuarine Floodplain:

C1: Ramgati-Musapur Association
C2: Sandwip-Musapur Association
Nilkamal-Ramgati Association:
1a: Non-saline phase
1c: Saline, storm-surge hazard phase
2: Ramgati-Nilkamal Association
3: Ramgati Association

Old lower Meghna Tidal Floodplain:

4: Bhola-Jhalakati Association
Jhalakati-Bhola Association:
5a: Non-saline phase
5b: Saline phase
6c: Storm-surge hazard phase

Miscellaneous Landtypes:

20a: Non-saline phase
20b: Saline phase
M: Mud

Lower Meghna Tidal Floodplain:

Hatia Association:
28a: Moderately and slightly developed, cultivated phase
28b: Slightly developed cultivated phase
Hatia-Ramgati Association:
29a: Slightly developed cultivated phase
Ramgati-Hatia Assocaition :
31: Ramgati undeveloped-Hatia slightly developed cultivated phase
Ramgati Association: -
32b: Undeveloped, uncultivated phase

Source : Reconnaissance Soil Survey Reports of Noakhali, Barisal and Chittagong Districts, Published by SRDI during 1965-66 upto 1971-72

MEGHNA ESTUARY STUDY

SRDI SOIL TYPE MAP

PROJECTION	BANGLADESH TRANSVERSE MERCATOR
SOURCE	LANDSAT IMAGERY FEBRUARY 1996
PRODUCED BY	mes MES ENVIRONMENT, GIS/RS/CAD UNIT

10 0 10 20 30 40KM

SCALE

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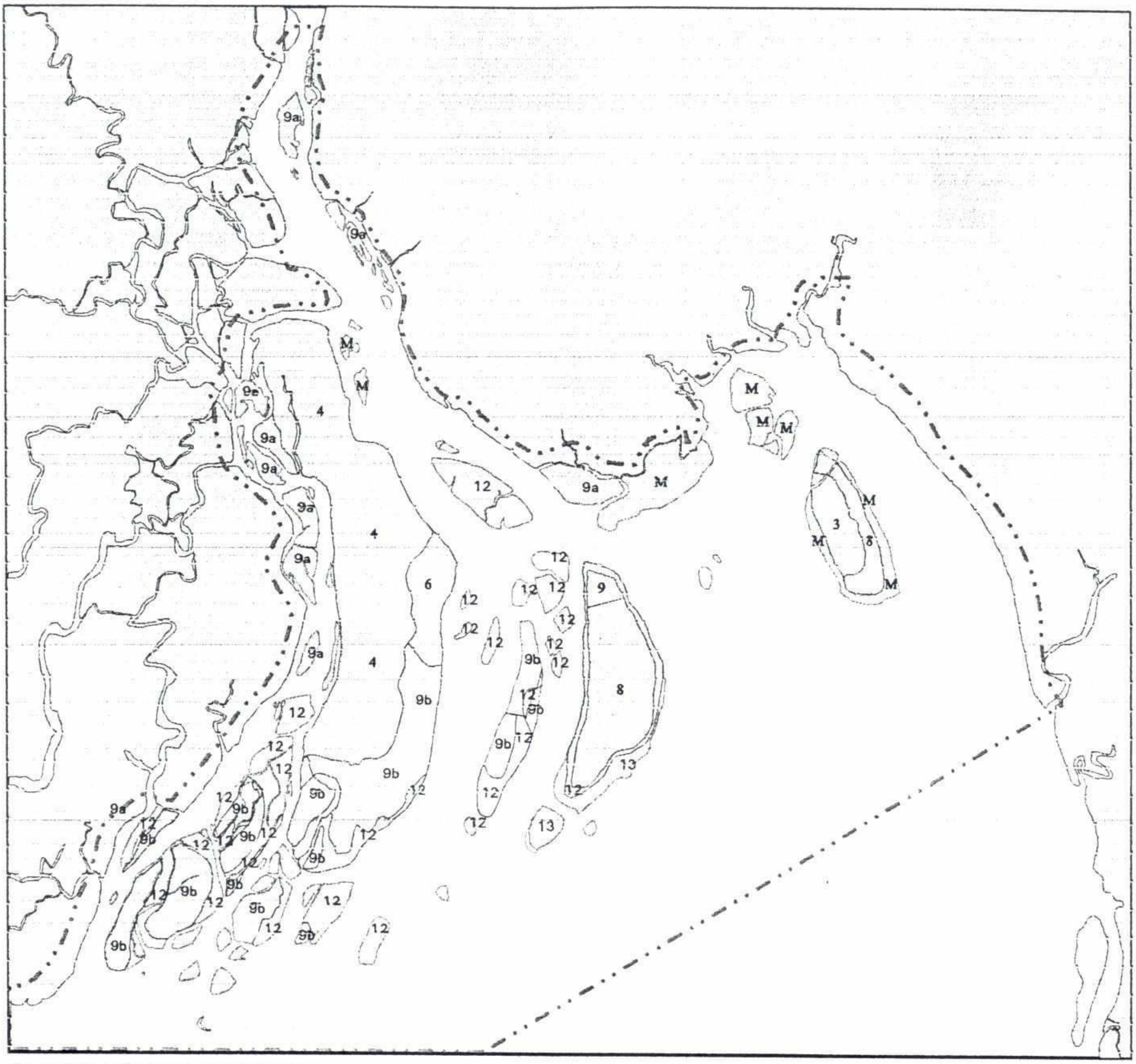
Figure 2.10: SRDI Soil Capability Map



LEGEND

Location Bhola

4 : Predominantly moderate agricultural land, tidal flooded.
6 : Predominantly moderate agricultural land, tidal flooded, slightly to moderately saline in the dry season.
9a : Poor and very poor agricultural land, non-saline land.
9b : Poor and very poor agricultural land, damage from storm surges.
12 : Poor and very poor agricultural land, mud and charland.

Location Hatia:

8 : Mainly moderate agricultural land, shallowly flooded, slight to moderate saline.
9 : Mainly moderate agricultural land, shallowly flooded, moderate hazard of damage from storm surges.
12 : Mainly poor agricultural land, seasonally shallowly flooded with severe hazard of damage from storm surges saline.
13 : Non-agricultural land, seasonally shallowly flooded saline with severe hazard of damage from storm surges.

Location Sandwip:

3 : Mainly good and moderate with some very poor agricultural land, predominantly medium high land, part slightly saline, locally with severe hazard of river erosion.
8 : Mainly poor with some moderate and very poor agricultural land, predominantly medium high land, moderately to slightly saline, part with severe hazard of river erosion.

Nijhum Dwip Integrated Development Project Area

Data Source: Reconnaissance Soil Survey Reports of Noakhali, Barisal and Chittagong Districts, published by SRDI during 1965-66 upto 1971-72

MEGHNA ESTUARY STUDY

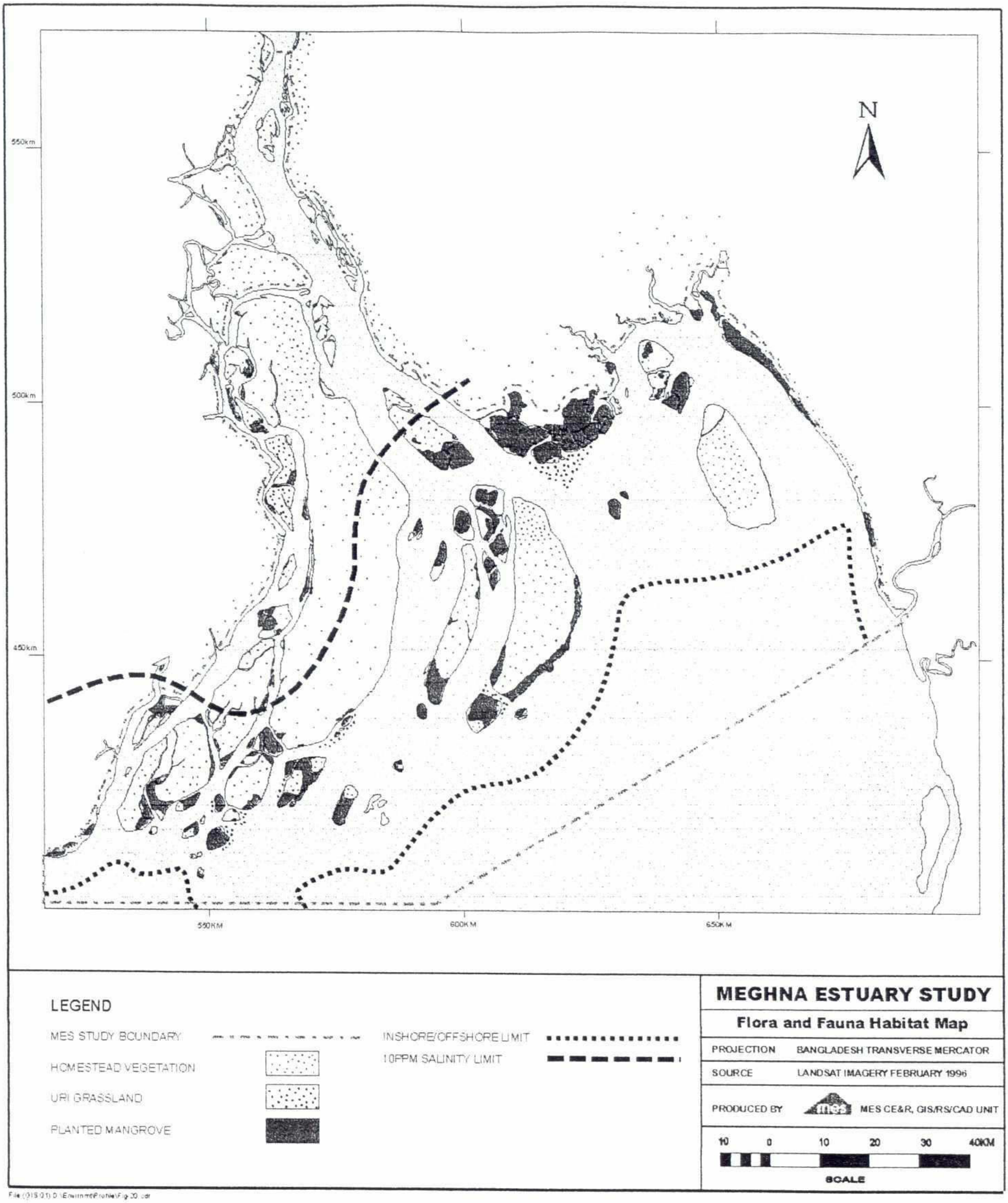
SRDI SOIL CAPABILITY MAP

PROJECTION	BANGLADESH TRANSVERSE MERCATOR
SOURCE	LANDSAT IMAGERY FEBRUARY 1996
PRODUCED BY	mes MES ENVIRONMENT, GIS/RS/CAD UNIT

10 0 10 20 30 40KM

SCALE

Figure 2.11: Flora and Fauna Habitat Map



2.2.2 Freshwater habitats

The main freshwater habitats in the study area are indicated in Figure 2.12, the fisheries systems map. The important dividing line is the 10 ppt salinity limit the location of which indicates the effect of the Tentulia river system in extending freshwater habitats further towards the coast in the east of the study area when compared to the main Meghna river. Discussion of the interaction between freshwater and saline water habitats is given in Volume 6, Fisheries. The main conclusions are that there are fish species which have seasonal freshwater habitats inland (most are outside the MES area) and spawning areas of the southern tips of the island chains which are saline. A crucial issue is the movement of species between these two environments and the obstruction of passage by the construction of embankments and water control structures. The natural accretion of land also disrupts this pattern by blocking routes. A listing of fish species in the study area is given in Table 3.

2.2.3 Inshore marine habitats

In-shore marine habitats have been defined as those within five kilometres of any land area. These include large areas of tidal mudflats, particularly in the south east of the study area. These in-shore areas are very dynamic as they progress through the process of land stabilisation and new mud flats appear. There are significant water bird habitats on these tidal mud flats as recorded by the Asian Wetlands Bureau (Ref: Asian Wetlands Bureau, Date Unknown). The main threatened fauna species is the Gangetic dolphin, but the main threat is from human persecution for medicinal use rather than a lack of habitat. The hilsha fish spawning areas off the southern tips of the island chains are of great economic importance are discussed in Volume 6, Fisheries. However, there is still insufficient knowledge as to if the fish spawn on the mudflats or the channels between the islands. A study has been proposed to address this issue. The creeks in the inter-tidal area are the habitats of three important species (Bagda, Golda and Pangash) and again these habitats are dynamic as creeks silt up and new ones emerge. There is significant over fishing in the area which poses a considerable threat to the sustainability of the aquatic population. Without concerted action there will be serious economic and nutritional consequences to a significant number of the human population in the study area.

2.2.4 Off-Shore marine habitats

Off-shore marine habitats have been defined as those more than five kilometres from the nearest land. The area has extensive fish resources but like the inshore habitats is under threat from over fishing, particularly shrimp trawling. The areas has been studied as part of the international Bay of Bengal project and the findings of this are summarised in Volume 6, Fisheries.

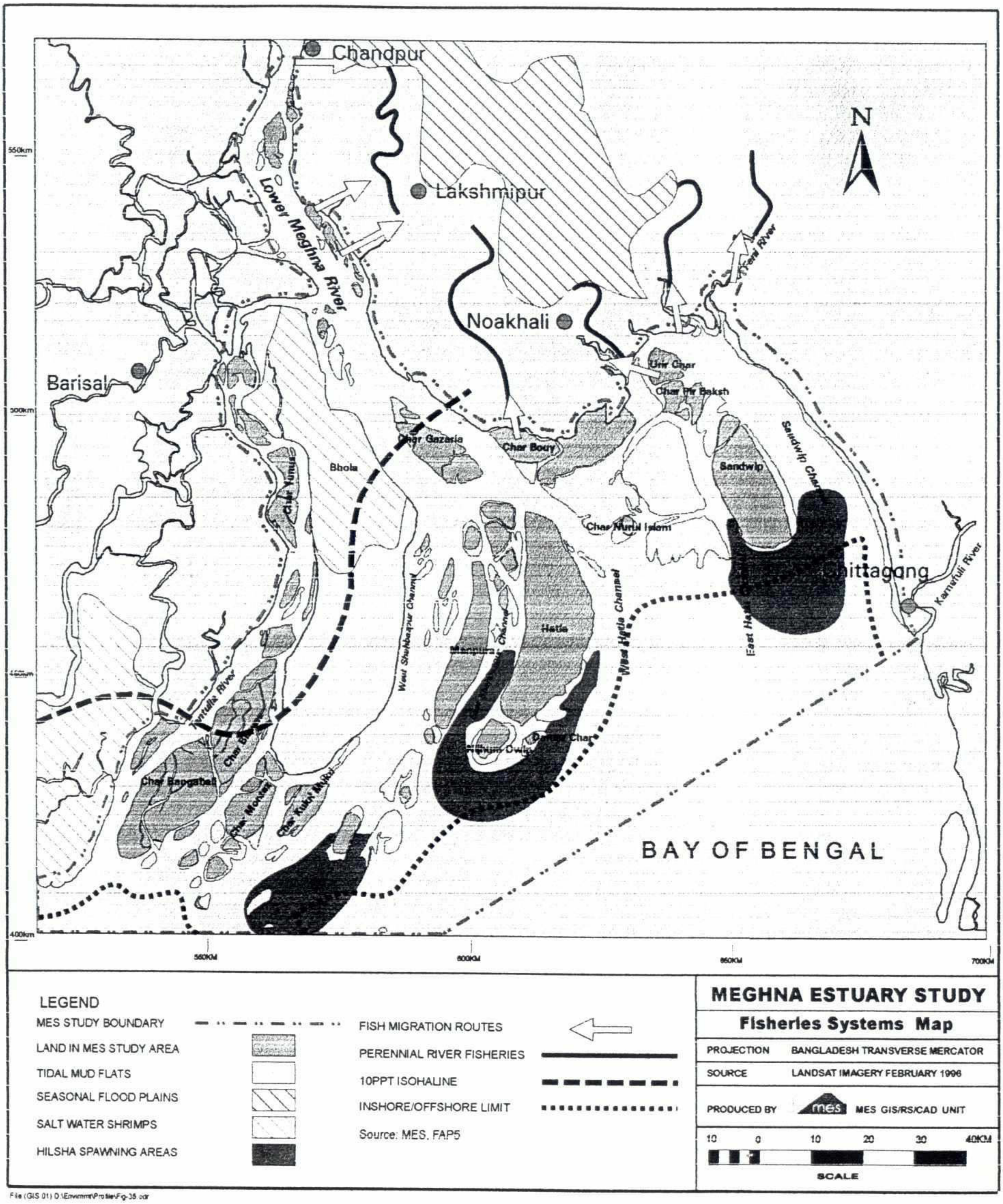
2.2.5 Biodiversity and conservation

The greatest terrestrial biodiversity is found in homestead vegetation although the larger planted mangrove areas are able to support the larger fauna species. Aquatic fauna is under threat due to over fishing. The area is very dynamic due to the rate of accretion. The study area contains no registered conservation areas, although proposals have been put forward by the forest Department to give the island of Nijhum Dwip some protection status. Enforcement of this would be extremely difficult due to the establishment of seven cluster settlements of erosion displacees in the area after the 1970 cyclone. Nijhum Dwip is an artificial environment, unlike the Sundarbans to the west of the Study area, and as such is of no great international importance.

2.2.6 Sensitive areas

The most sensitive areas are the fish breeding grounds south of Sandwip, Nijhum Dwip and Char Montaz which are the breeding grounds for Hilsha (see Volume 6, Fisheries), the most important commercial fish species in Bangladesh. The large areas of tidal mudflats are significant bird habitats and are expanding all the time. Attempts to make Nijhum Dwip a conservation area have been rendered near impossible by the establishment of cluster settlements in the area. The main issue is how to manage the island in a way which benefits both the natural environment and its human occupants.

Figure 2.12: Fisheries Systems Map



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2.3 Natural risks and hazards

2.3.1 Storms and cyclones

The situation with regard to cyclones has been discussed under the climate section above. Figure 2.13 shows the cyclone risk, the zoning being based upon the landfall locations of past cyclones. The tracks of significant cyclone events are also shown. The outputs of SWMC modelling work clearly demonstrate that peak cyclone water levels are highest further inland and on the leeward side of off-shore islands, due to the funnelling effect of land formation. Cyclones are the most significant cause of death from all natural disasters in the study area. Considerable damage is done by the wind and a significant number of human casualties are from wind blow debris, particularly corrugated iron sheet.

2.3.2 Flooding

Flooding in the study area occurs from very different sources; local rainfall, high river levels from upstream catchment rainfall (which can be exacerbated by high tidal conditions) and cyclones.

Local rainfall flooding is particularly problematic in areas that have been embanked when land levels were still relatively low and provided with inadequate drainage provision. Drainage is easier in areas with a greater tidal range. In areas of extensive accretion (such as Noakhali south), drainage becomes increasingly difficult due to shallow gradients and distance from the coast combined with a narrow tide time window.

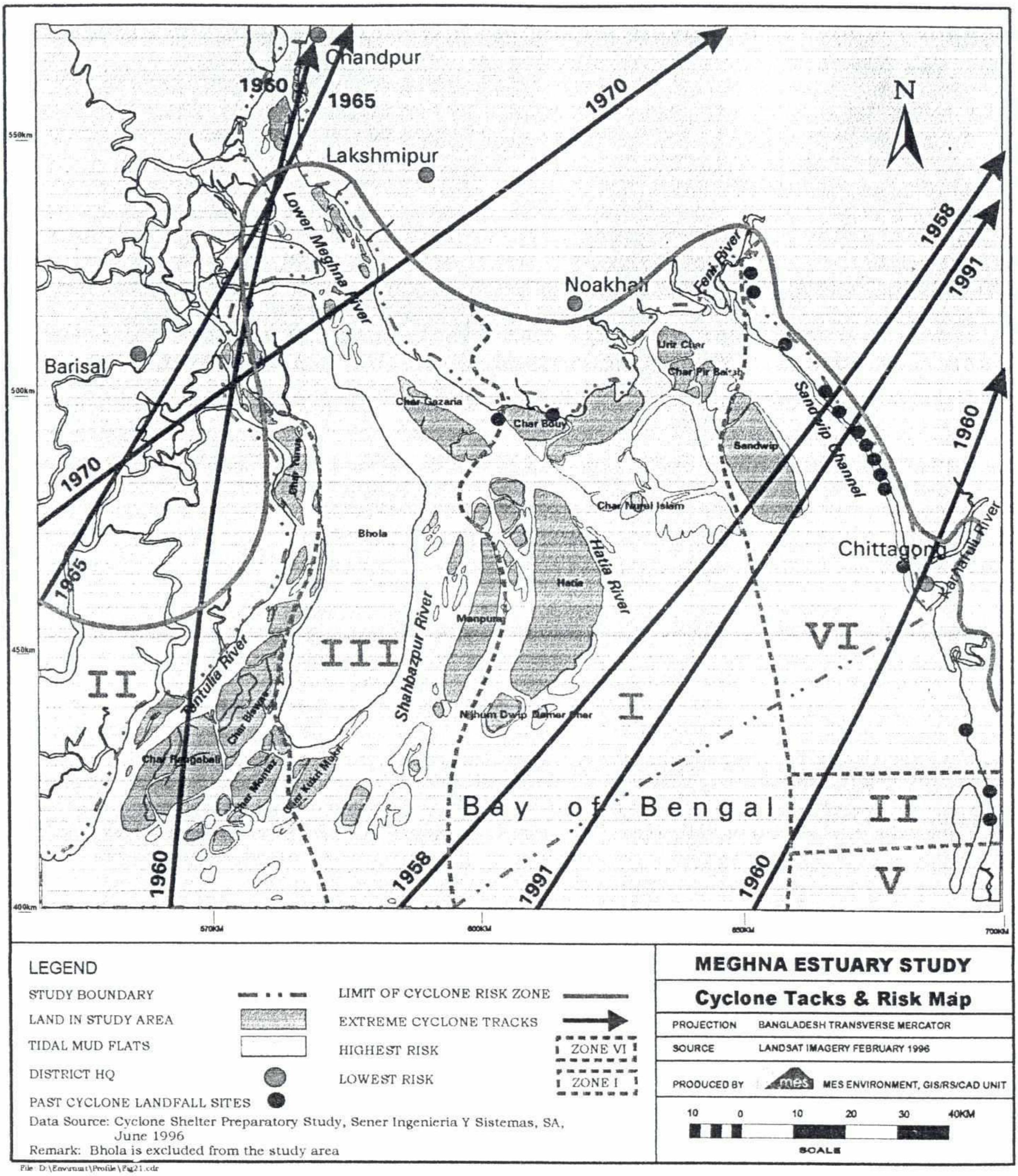
Flooding from high river levels is of greatest risk to areas outside of embankments. River levels are dependant upon the annual flood cycle caused by monsoon flow conditions with the lunar tidal cycle imposed on top of this. The tidal effects obviously decrease further upstream of the main Meghna channel to the point at which in Chandpur the annual range in level is 4 metres, the lunar cycle rang is 1 metres and the daily range 0.75 metres. However, those areas with the greatest daily tidal range are able to drain more rapidly once a flood occurs. The biggest problem is that flooding by saline water restricts economic use of the land, causing soil salinity both in the short term and also as along term residual problem.

Peak flood levels due to cyclones vary greatly according to the location of the track and intensity of the storm. The 1991 event caused a surge of up to 5 metres with an additional 2 metres of wave height. The exact timing of the cyclone relative to annual monsoon flood levels, as well as lunar and daily tidal conditions is critical in determining the severity of flooding. Cyclone flooding is particularly problematic due to the speed with which it arrives and human casualties can be very high, 140,000 people being killed in the 1991 event and 240,000 in 1970.

2.3.3 Sea level rise

It has often been claimed that rising sea levels brought about by global warming will cause a catastrophe for Bangladesh. The most recent work carried out on this using the latest world circulation model from the University of East Anglia (Ref: Bangladesh Unnayan Parishad 1993), indicates that the maximum rise is likely to be 0.27 metres by the year 2030. The present rate of natural land accretion in the Meghna estuary is far in excess of this. In essence the benefits of land accretion to Bangladesh in the Meghna Estuary due to erosion in the upper catchment of its rivers more than compensates for any potential dis-benefits due to global warming. The biggest problem is likely to occur in areas that have already been embanked with inadequately high earthworks. However, 0.27 metres is a small proportion of the presently needed embankment height to protect against 1 in 30 year cyclones.

Figure 2.13: Cyclone Tracks and Risk Map



2.3.4 Seismic Activity

The seismic risk map for the area is given in Figure 2.14 which is derived from the national seismic risk zoning map of Bangladesh (Ref: Geological Survey of Bangladesh, November 1979). The Study Area straddles all three seismic risk zones but is predominantly in the medium risk zone II. However it should be noted that the seismic risk gradient is quite steep to the east towards the Chittagong Hill Tracts, which lie in an area of high risk. Damaging earthquakes in Bangladesh are infrequent but severe. The last major event was in June 1897 and are well documented in accounts of the time (Ref: Government of the People's Republic of Bangladesh, 1977). Due to the fact that buildings were made of lightweight non rigid materials the human casualties were surprisingly low. The effects of earthquakes in saturated alluvial deposits can be catastrophic for any structure, including embankments, due to liquefaction. Past evidence is that such infrequent but severe earthquakes in Bangladesh primarily occur during the monsoon period when water levels in the inland river system are high. The implications for embankment failure under such conditions are obviously more serious than in other times of the year and the orientation of embankments to the shock wave and the nature of their construction is critical in determining how well they would survive a seismic event. However for much of the MES area the highest water levels are during lunar high tide cycles, although the further inland it gets, the monsoonal seasonal effects become more pronounced. The conclusion is thus that for the MES area of medium seismic risk the timing of events relative to the lunar high tide is more important than to the monsoon period. It must also be pointed out that the risk of coastal embankment failure is significantly less than on an internal river embankment due to the fact that the design slopes are far less steep.

2.4 Human social environment

Details of the human social environment can be found in Volume 4, Rural Development, of the Master Plan, the analysis of which is based upon the detailed socio-economic surveys carried out in the MES area. The main features are outlined below but giving a less detailed but wider overview based upon 100 per cent data collected in the 1981 and 1991 national censuses (Ref: BBS, 1985 and 1992/5).

The disaggregated Human Development Index (HDI) for Bangladesh (Ref: UNDP, 1997), indicates that of the 9 districts in the study area only one (Bhola, which is actually excluded from strict definition of the MES) lies in the bottom half of all 60 districts in the country, all the others lie in the top 40 per cent. However the data hides the fact that many of the island areas have the lowest levels within the districts, with most of the districts including significant areas of productive and stable mainland.

2.4.1 Political and institutional administration

Figure 2.15 shows the administration structure in the study area which includes parts of 9 districts and 31 thanas based upon the BBS small areas atlases (Ref: BBS, 1985) and LGED maps. Tables I.4 and I.5 give the BBS data for seven important human environmental parameters down to thana level for both 1981 and 1991. These parameters have been mapped for 1991 and also for trends between 1981 and 1991. Cross checks with detailed socio-economic surveys have shown that the accuracy of the BBS 1991 data is reasonably good and has the great advantage of being 100 per cent data. There are some obvious discrepancies which have been recognised, some caused by changed definitions of data collection classes between 1981 and 1991.

2.4.2 Human population

The human population density for 1991 is mapped in Figure 2.16 and the trends for 1981 to 1991 in Figure 2.17. The land area that has been used for 1991 is that visible from the 1990 satellite image rather than the BBS areas which include areas of open water over which the thana has authority. Similarly the trend data has used the satellite imagery land areas of 1983. The mean 1991 density including all of the 31 thanas was 862 people/ km^2 with the highest rates being at Chittagong (9,043/km^2) and Chandpur (2,445/km^2). The lowest rates are in the south west (Galachipa at 362/km^2) and south (Manpura at 364/km^2). Low to medium levels are found in southern Bhola and on the newly accreted land south of Noakhali plus the north west of the study area. High medium levels can be seen from the Feni river east and southwards to Chittagong, south of Chandpur and northern Bhola. Population density increase between 1981 and 1991 was greatest in Chittagong due to rural to urban in-migration. The second highest increase was in Manpura and the far south west due to in-migration onto newly accreted land.

Figure 2.14: Seismic Risk Map

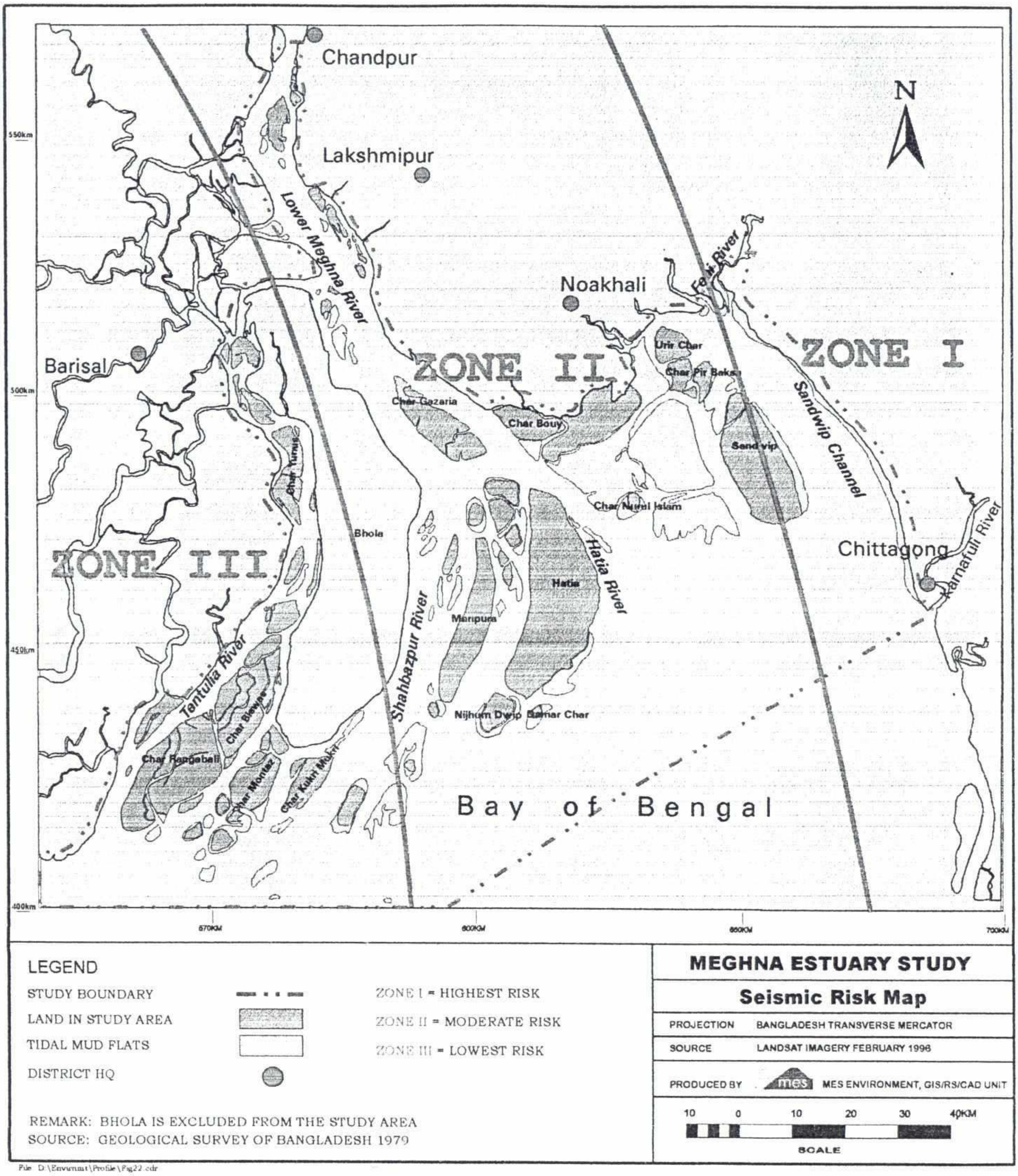


Figure 2.15: Administration map

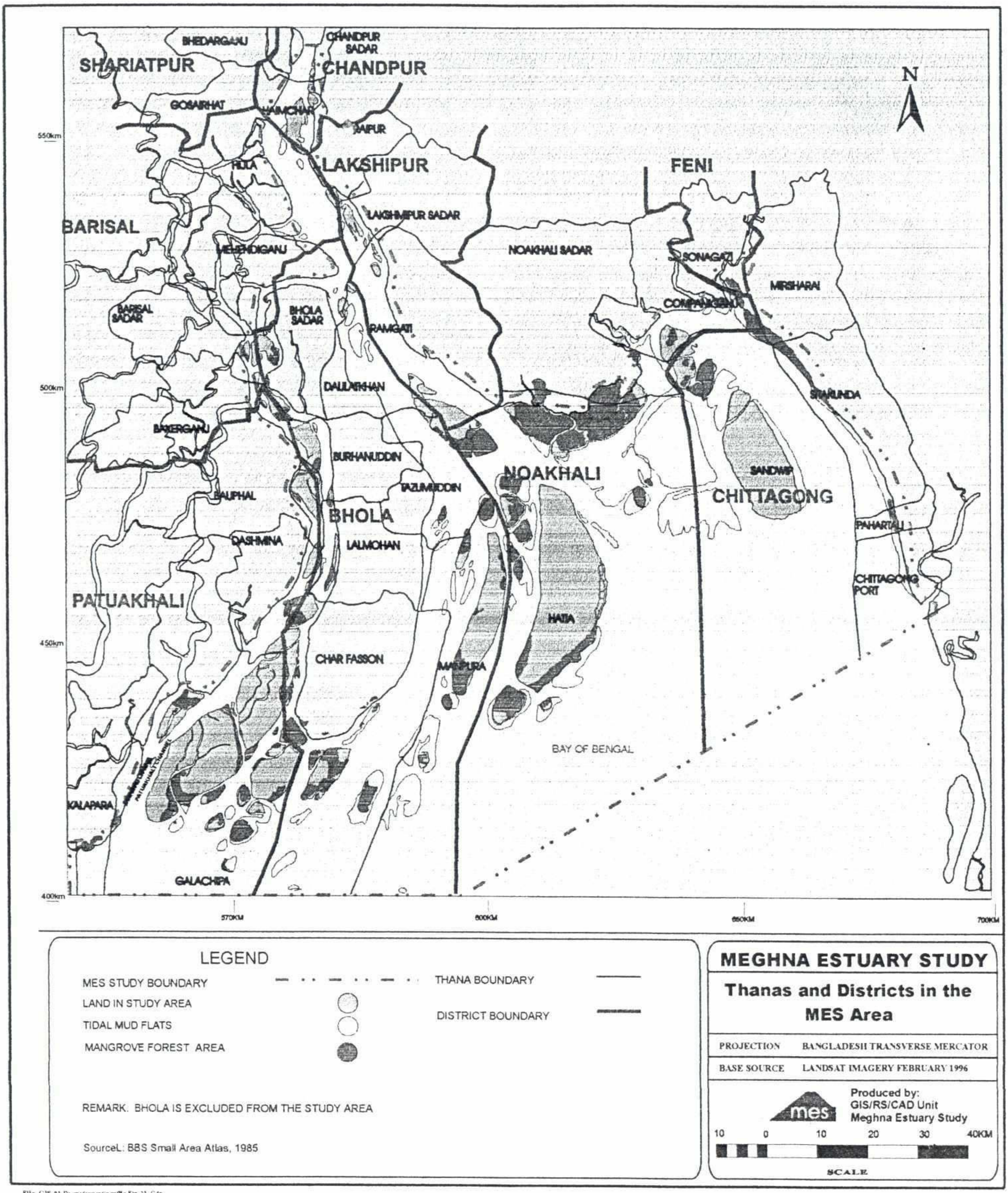
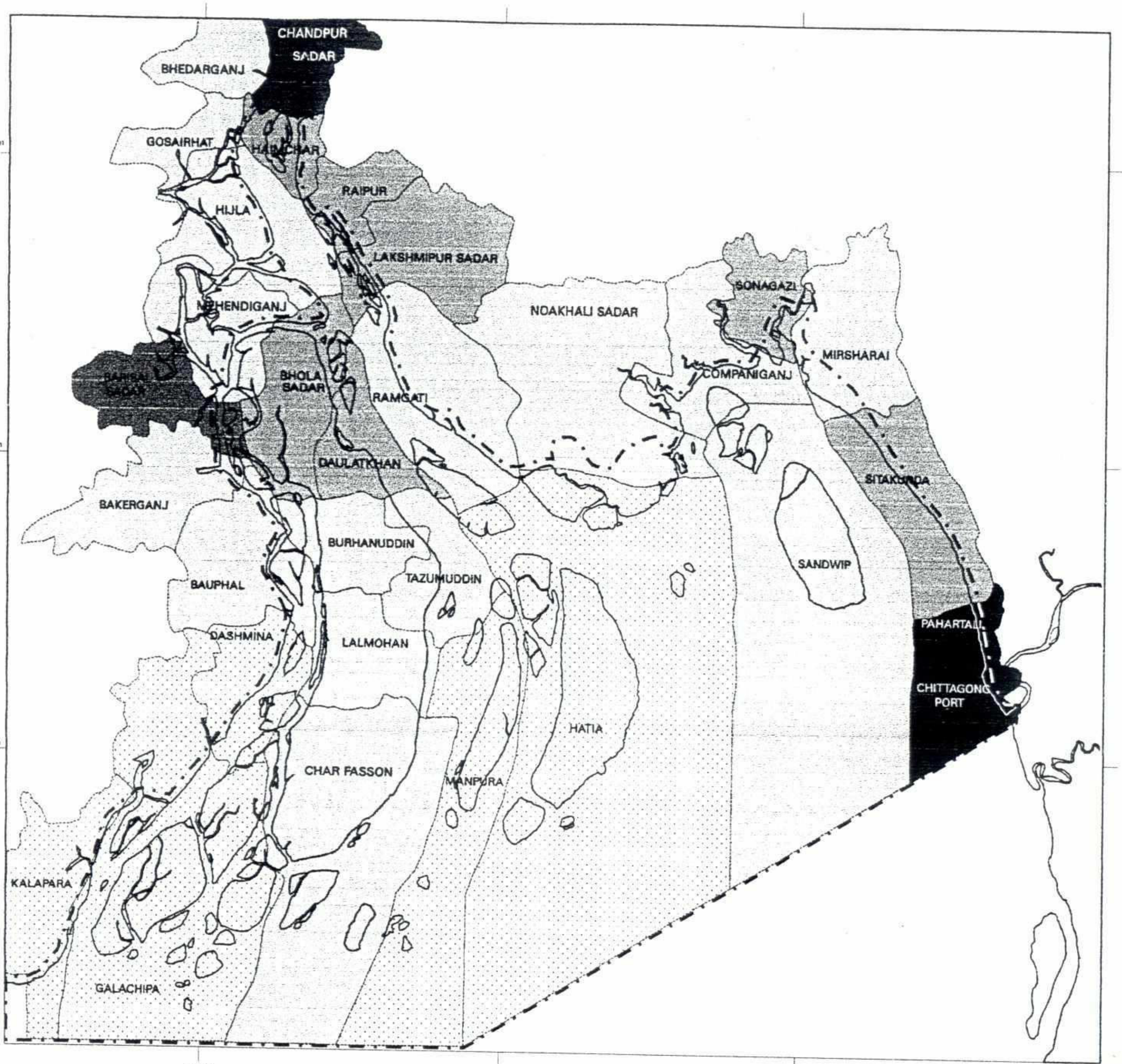


Figure 2.16: Human Population Density 1991



LEGEND:

0-515 people/km	
516-1030 people/km	
1031-1546 people/km	
1547-2062 people/km	
2063-2578 people/km	
Over 2579 people/km	

Project Boundary

Thana Boundary

MEGHNA ESTUARY STUDY

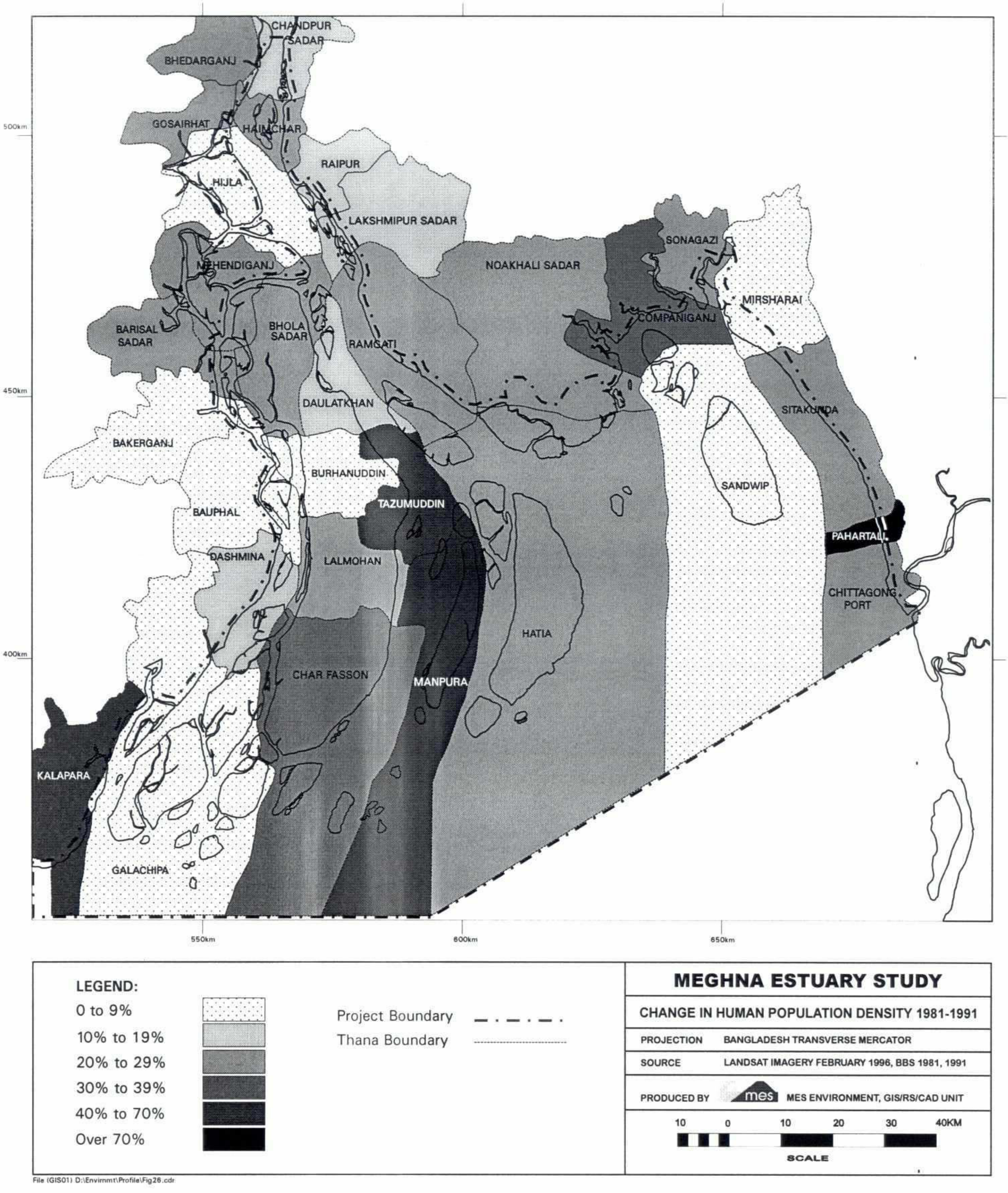
HUMAN POPULATION DENSITY 1991

PROJECTION	BANGLADESH TRANSVERSE MERCATOR
SOURCE	LANDSAT IMAGERY FEBRUARY 1996, BBS 1981,1991
PRODUCED BY	MES ENVIRONMENT, GIS/RS/CAD UNIT

10 0 10 20 30 40KM

SCALE

Figure 2.17: Change in human population density 1981-1991



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Medium level increases were in the central part (Hatia and Noakhali south) partly due to natural increase and in-migration. The lowest levels were on Sandwip (at 7 per cent over 10 years way below the national average population growth rate) probably due to higher mortality rates from the cyclone and out migration. There were also low increases in the west central area.

The mean household size for 1991 is mapped in Figure 2.18 and trends between 1981 and 1991 in Figure 2.19. The overall mean household size in 1981 was 5.74 and in 1991 5.61. This is greater than the national figure, but the reduction between 1981 and 1991 was much smaller. The largest households tend to be in the south central area where increases in household size were recorded between 1981 and 1991 along with the Noakhali south areas, contrary to National trends of household fragmentation.

2.4.3 Gender issues

As part of the needs assessment exercise for the three feasibility studies the women were separately asked as to their priority problems. When compared to the men, women were more concerned with improving health service provision, domestic water supply and access to these. In addition women in the some of the remoter parts of the study area requested better communications, particularly those from erosion displaced households who had been forced to re-locate but wished to retain contacts with family members. In general women rated the need for construction of cyclone shelters as a lower priority than men. In Char Montaz women rated the construction of new cluster settlements much higher than men. As a general reaction women perceived that the provision of more agricultural land was of great importance to increase their level of welfare, although in Char Montaz the first priority of all social groups was provision of a health centre.

2.4.4 Settlement pattern and history

Figure II.7 shows the Rennall's map of 1776. When superimposed upon the present map of the area derived from Landsat imagery of February 1996 (see Figure II.4) it can be seen that the area is very dynamic. There is a long history of settlement in parts of the study area, including the main towns of Chittagong and Chandpur. Other major settlements, including district headquarters towns, have been relocated as a result of erosion, these include Lakshmipur (Lockipur), Noakhali and Hatia. The distribution of settlement on the islands is well indicated by homestead vegetation as shown in Figure 2.11 (this is mapped from the red band of the satellite image shown in Figure 1.4 disregarding the planted mangrove areas), although the newer settled areas are less apparent due to the time that it takes for homestead vegetation to establish itself.

2.4.5 Land holding and tenure

The 1991 BBS data showing the proportion of households with agricultural land is given in Figure 2.20. It can be seen that a larger proportion (over 60 per cent) own land in the mainland, particularly on the south western and north western parts of the study area. Unsurprisingly the lowest proportion is in the urbanised area of Chittagong (below 30 per cent). The newer accreted islands have proportions of between 30 per cent and 50 per cent. The change in agricultural land holding between 1981 and 1991 is given in Figure 2.21. In the central and southern parts of the study area there have actually been increases in the proportion of households owning agricultural land. This is contrary to the national trend but may be due to allocation of newly accreted land.

With regard to ownership of newly accreted land, the main issue is how allocation of such areas is handled by the local administration. The difficulties in allocating such land have been well demonstrated by the CDSP (Ref: CDSP, 1998), and have posed a major threat to the progress of their projects in South Noakhali. Lack of security of tenure has been cited by many people in the study area to be constraint to agricultural development.

Figure 2.18: Mean household size 1991

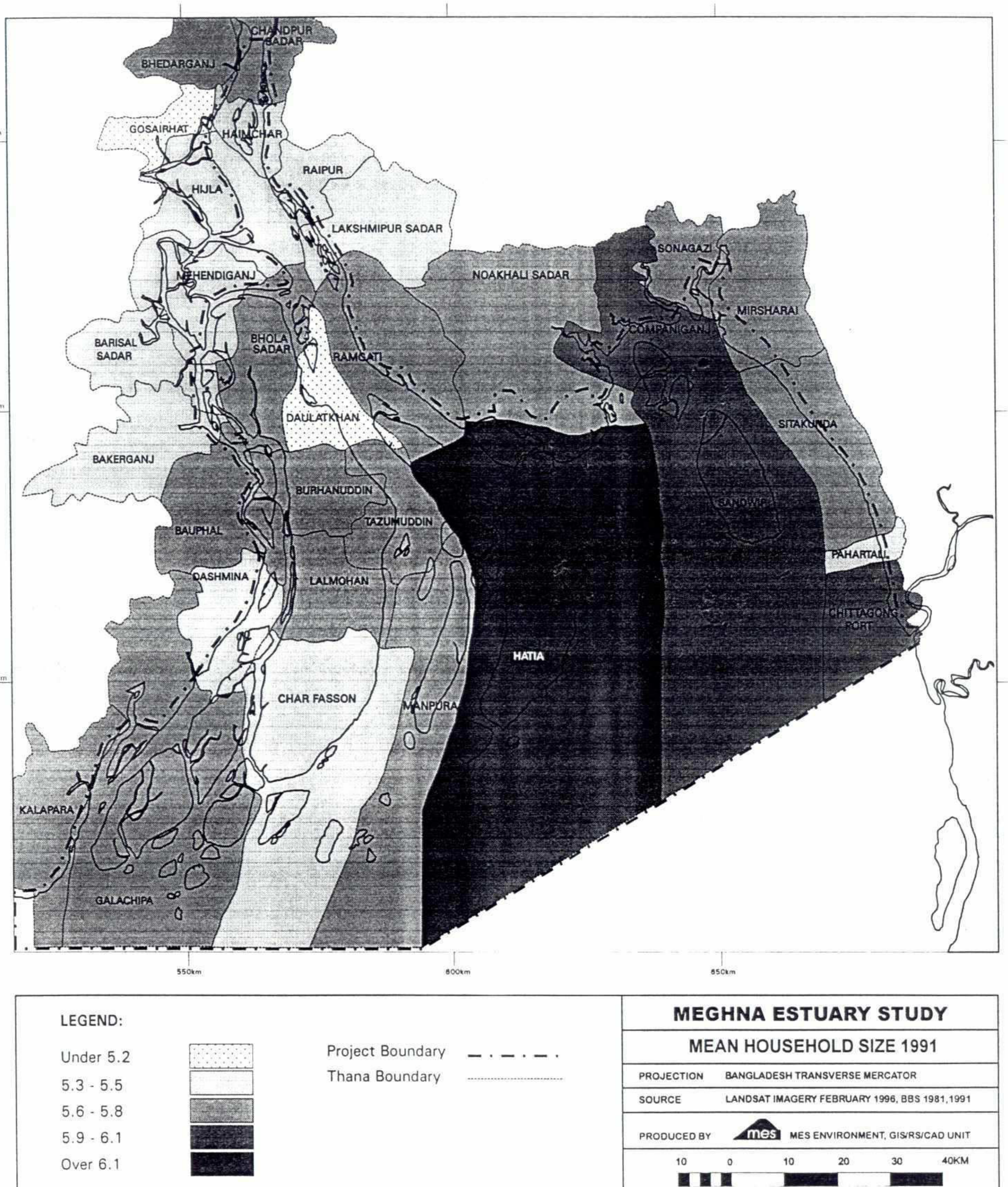

Figure 2.19 : Change in mean household size 1981-1991

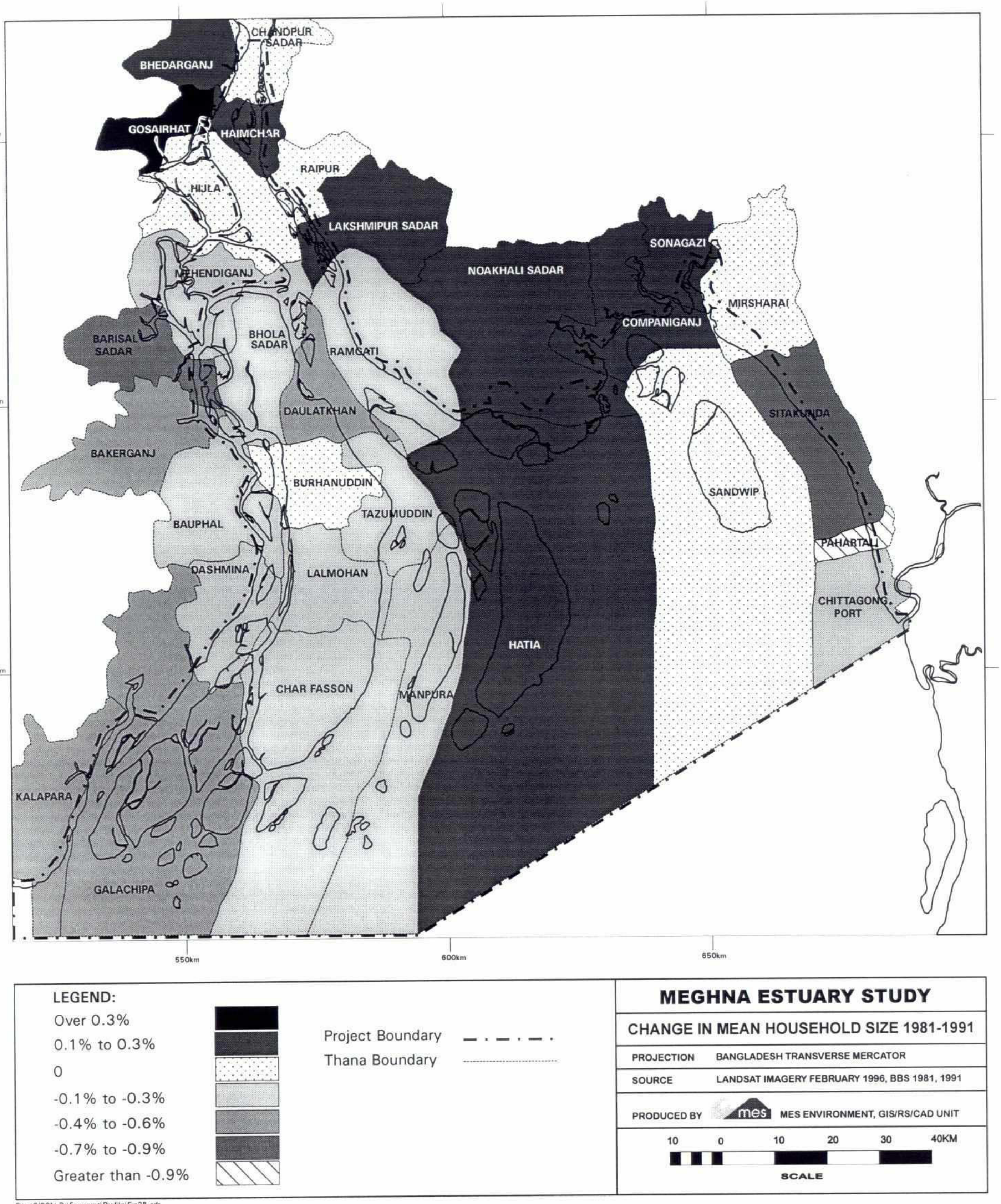

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Figure 2.20: Proportion of households with agricultural land 1991

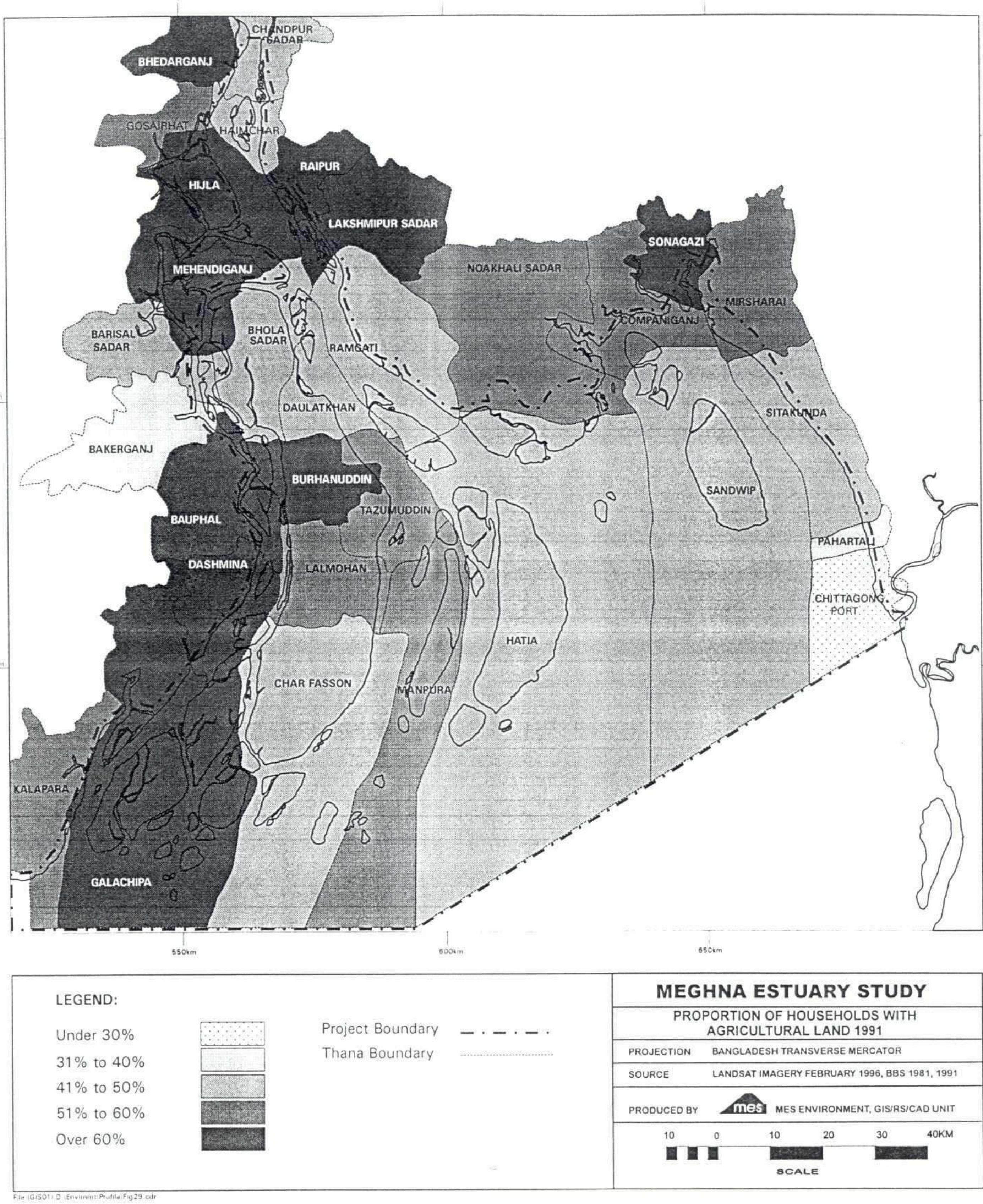
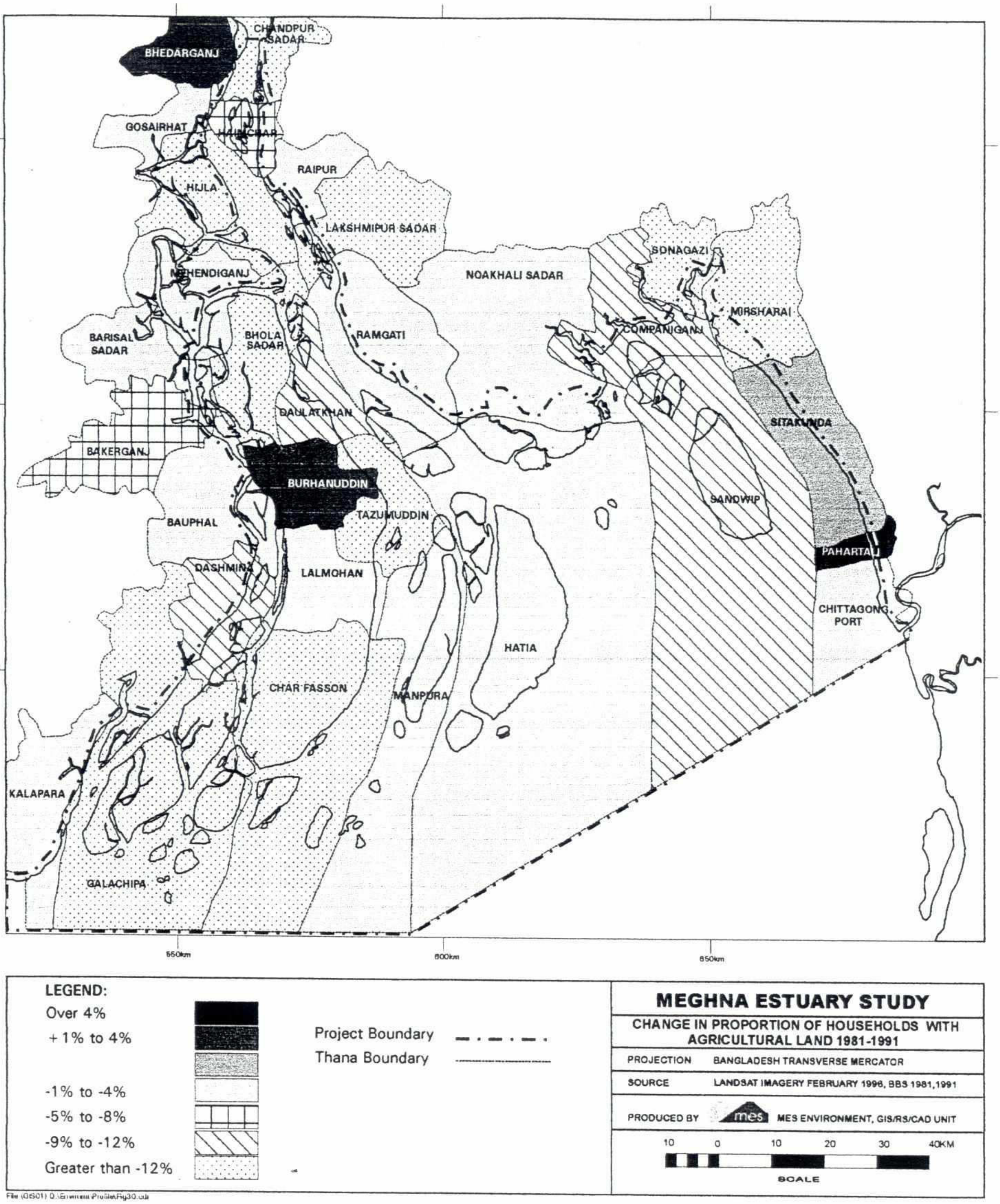


Figure 2.21: Change in Proportion of Households with Agricultural Land 1981-1991



The LRP, as part of their work for Nijhum Dwip (Ref: LRP, December 1990), generated a conceptual model for land use of newly accreted land. Three main variables were identified; height above tidal level, if all newly accreted land were planted with forest as soon as it accreted to an appropriate height for planting, and if it were embanked or not. Figure II.10 reproduces the illustrations of this model for different scenarios. The implementation of such development requires that newly accreted land is handed over for use by the Forest Department for a specified number of years until the land has accreted to a height at which it can be embanked and used for settlement and cropping. Appropriate land tenure arrangements are thus critical for successful use of newly accreted land.

2.4.6 Common resource rights

Common resources are defined as those with free public access. In Bangladesh such resources are in steep decline due to the high human population densities and the intensity of resource use. However in the coastal areas, particularly on newly accreted land, there are still significant common resource rights:

Fish

By definition marine fisheries resources are "free goods" although they may be controlled by government regulation. Further details are given in the Volume 6, Fisheries. The main issue is that availability of such free good fisheries has been declining recently as fishing activity has increased, often as a result of erosion displacees being forced into fishing as a livelihood. Without action to address this issue there is a real risk that the fisheries stocks may collapse with serious socio-economic and human nutrition implications.

Fuel wood

In areas of high human population density there are severe pressures on domestic fuel provision. There situation is particularly serious in areas of river bank erosion such as Haimchar. The result of such a situation is that other sources of fuel have to be used , particularly animal dung, and any fuelwood that is available is sold for relatively high prices. The use of animal dung also means that artificial fertilisers have to be used if high yielding seed varieties are used. However in the newly accreted areas that have been planted with mangrove and homestead vegetation there is a good supply of fuelwood, although the taking of this from forest department areas is illegal but occurs. The off-shore island such as Nijhum Dwip have abundant supplies of fuel wood just from natural off-take levels. The situation across the study area is thus very variable.

Grazing

As with fuel wood, the density of human settlement is the key indicator of grazing land availability. In high human population areas there is very little open grazing land available and nearly all animals are stall fed, mainly using crop residuals including rice straw. However, in the newly accreted lands there are extensive areas of Uri grassland available for grazing, particularly outside the embanked areas. These constitute a very valuable resource and there is evidence from such areas that economic returns from livestock grazing are greater than cropping. further details are given in Volume 5, Agriculture and Farming Systems.

Fodder

The main source of fodder is crop residuals, particularly rice straw. However this competes with the use of rice straw for domestic fuel in places where there is little fuelwood or animal dung. In many areas of high human population pressure any source of vegetation is used for fodder.

2.4.7 Domestic energy and fuel

The implications of lack of fuelwood have been discussed above, specifically the need to use animal dung and rice straw as domestic fuel and the complex inter-relationship this has on soil fertility and livestock management. The situation in the study area is very varied indeed, with a very health energy balance in many of the newly accreted lands, (particularly those that are forested), but severe problems in areas of high population density, particularly erosion prone areas.

2.4.8 Domestic water supply

The level of provision of "safe" domestic water supply for 1991 by thana is given in Figure 2.22. The highest levels are in the larger urban areas (93 per cent of households in Chittagong) and the lowest (60 per cent and lower) south of Chandpur and at Ramgati. The main source of supply is from deep groundwater as shallow groundwater is saline. Provision of surface water in newly accreted land is a necessary pre-requisite for settlement. Areas with high levels of erosion displacees create pressure on existing water supply sources and in such cases households may be forced to use unsafe surface water sources. The incidence of natural arsenic pollution in the middle groundwater aquifer has been found to be a problem in Bangladesh. The Chandpur area in the north end of the study area has one of the highest number of cases in the country. A special programme has been set up to address this problem at a national level.

The trend in "safe" water supply provision between 1981 and 1991 is shown in Figure 2.23. It can be seen that overall there has been significant progress with increasing provision, with a maximum of 55 per cent increase in the west of the study area, with a norm of about 25 per cent covering most of the islands. The lowest is in Ramgati (11 per cent) and Songhazi (17 per cent) on the mainland the former having low 1991 levels the latter having had high 1981 levels of provision.

2.4.9 Sanitation

The level of sanitation provision in 1991 at thana level is shown in Figure 2.24. There is no equivalent data available for 1981 to show trends. The overall levels of sanitation provision are very low indeed and are a major reason for high levels of diarrhoeal disease (see Section 2.4.10). Sanitation provision is highest in the urban area of Chittagong (around 50 per cent) and lowest in the south west and main islands. However the seriousness of the problem is apparent when the data is compared to human population density. Many of the areas in the north and South Noakhali parts of the study area have population densities of near 1,000 people per km^2 but less than 10 per cent have sanitation provision.

2.4.10 Health

The disease incidence data recording the number of monthly cases of the top 12 diseases for 10 of the thana headquarters health centres for the last five years in the Study area was obtained and analysed. these were selected to give a range of different conditions across the study area. Unfortunately it was not possible to obtain the data for Ramgati which would have provided a fuller picture of the area. From the health centre data it was seen that diarrhoeal disease is the most co mmon recorded disease in six of the 10 thanas and high in the other four. Skin Disease was the highest recorded cases in Chandpur and Bhola whereas worms were highest in Galachipa and Char Fasson, although Char Fasson also had high levels of Acute Respiratory Tract Infection (ARTI).

Great care has to be exercised in using the thana health centre data at it records registered cases that come to the centre. A general rule of thumb is that such health centres serve a radius of approximately 5 km although it is likely to be far greater than this in the remoter areas with lower population densities. The real difficulty is assessing how many unregistered cases there are which lie outside the reach of the health centre. It is often the case that high recorded levels are an indication of a well run and accessible health centre. There are also some months for which data is missing for some diseases, for which there are quite likely to be very understandable reasons. For this reason mean monthly case numbers were calculated. Detailed write ups for the relevant thanas appear in the feasibility study EIAs.

Figure 2.22: Water supply provision 1991

LEGEND:

Under 60%	
60%-69%	
70%-79%	
80%-89%	
Over 89%	

Project Boundary — · — · — ·
Thana Boundary ....

MEGHNA ESTUARY STUDY

WATER SUPPLY PROVISION 1991

PROJECTION	BANGLADESH TRANSVERSE MERCATOR
SOURCE	LANDSAT IMAGERY FEBRUARY 1996, BBS 1981,1991
PRODUCED BY	mes MES ENVIRONMENT, GIS/RS/CAD UNIT

10 0 10 20 30 40KM

SCALE

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Figure 2.23: Change in water supply provision 1981-1991

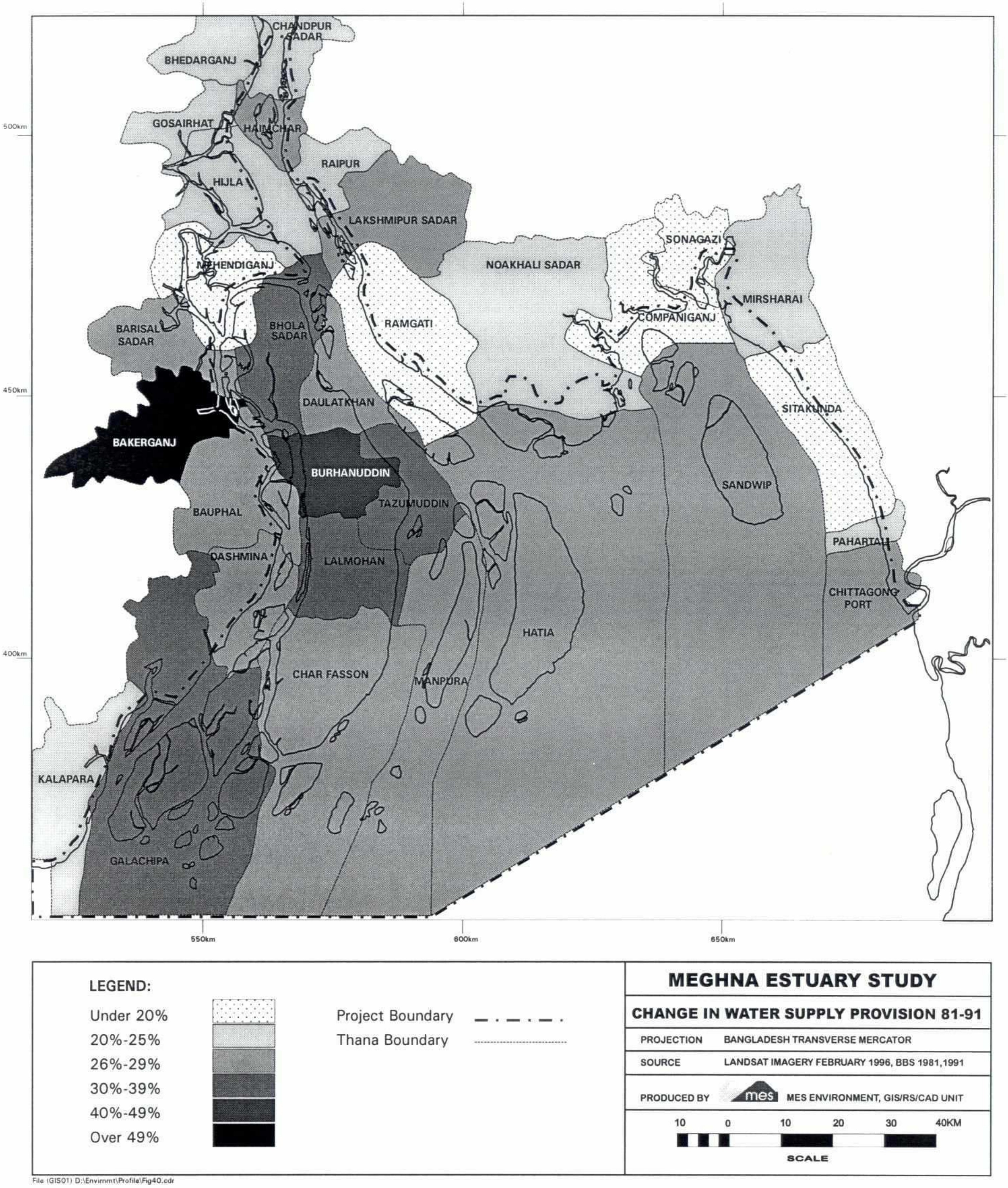

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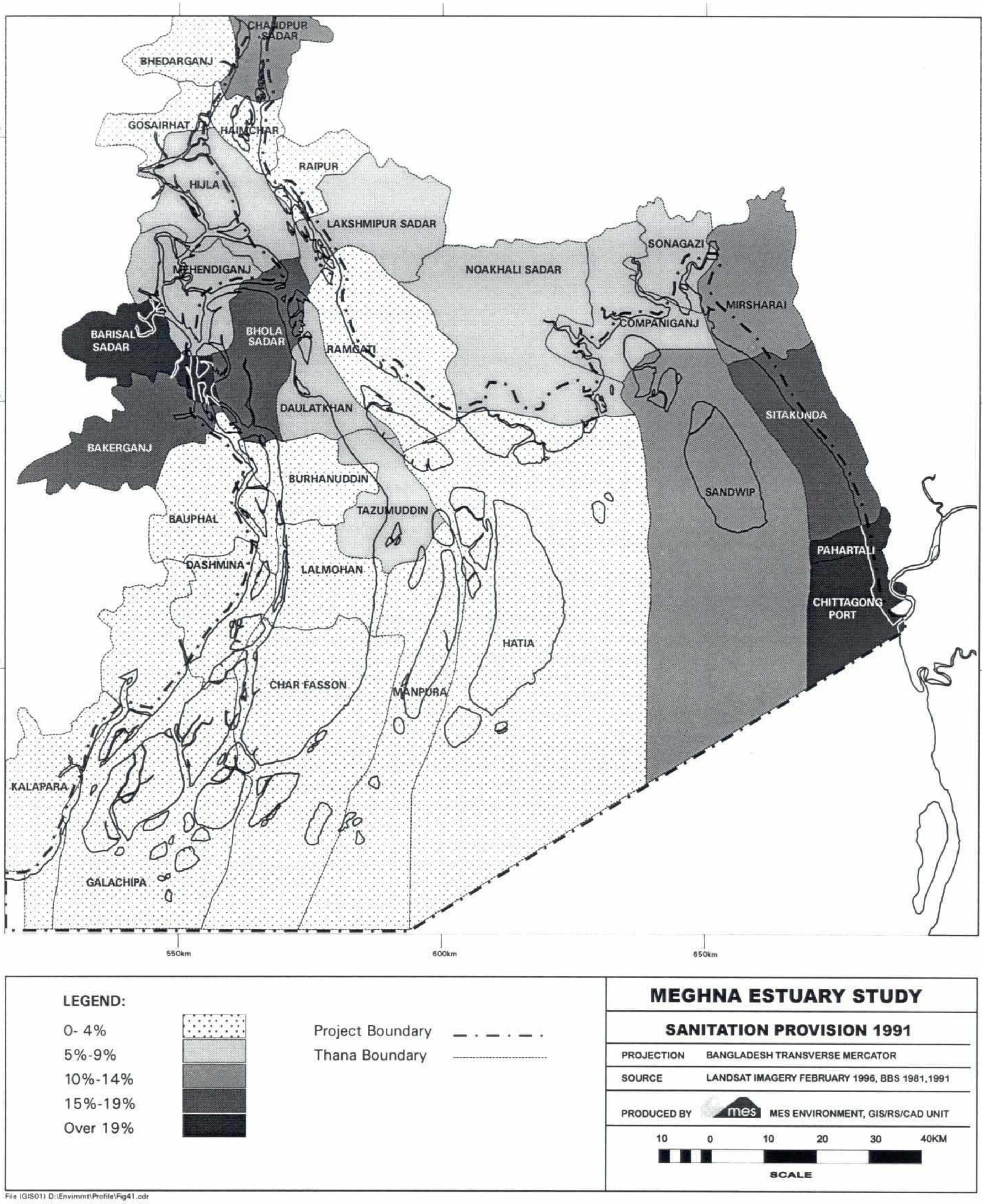
Figure 2.24: Sanitation provision 1991



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Overall diarrhoeal disease is considered to be the most serious problem in the area and the spatial variation in recorded cases can be seen in Figure 2.25. Not withstanding the issues outlined in the previous paragraph, it should be understood that the data in Figure 2.25 hides the variation in recorded cases from year to year and also the variation from one season to another within any year. Some of the key factors which influence diarrhoeal disease levels are human population density, access to safe drinking water and sanitation as well as flooding conditions due to the fact it is normally a waterborne disease. Whilst there would appear to be complex relationships between all these factors, only detailed study at local level is likely to allow any conclusions to be draw. This has been done for the feasibility study EIAs.

2.4.11 Nutrition

There is very little data on nutritional status in the study area. Poor nutrition is recorded in the monthly health centre data but definition of this is likely to vary greatly from place to place. Only proper nutrition studies (such as those carried.out by Helen Keller International) can give a better picture of the situation. however for the feasibility study EIAs household food consumption surveys were carried out and the results of these are written up in the EIA reports. The conclusions of the work at Nijhum Dwip were that, in general, people were relatively well fed when compared to the rest of Bangladesh, mainly because they had access to good supplies of fish which many caught themselves. A significant conclusion was that in the remoter islands people were often better fed as they consumed much of what they produced rather than selling it for cash, as there was very limited markets. The level of nutrition in the Haimchar and Chandpur area was poor, mainly because of the large number of erosion displacees and it is caused by impoverishment due to the loss of economic livelihood. The data from the Chandpur thana health centre bears this out.

2.4.12 Education and literacy

The literacy rates for the area in 1991 derived from the BBS census data are mapped in Figure 2.26. These indicate the low levels of literacy (below 25 per cent) in the islands of the south of the study area and also more surprisingly in the far north west. The highest literacy levels (over 50 per cent) are in the urban areas of Chittagong and Barisal and their surrounding thanas have levels in the order of 30 per cent to 40 per cent. The change in literacy levels between 1981 and 1991 is mapped in Figure 2.27, and shows that the areas of highest literacy in 1991 had the greatest increases in the previous ten years. Even so there were significant increases in literacy with the exception of Sonagazi which recorded a fall. One possible reason for this may be the in-migration of poorly educated people into the area between 1981 and 1991.

2.4.13 Archaeological and cultural sites

Due to the fact that much of the study area is relatively recently accreted in historical terms, there are very few significant cultural and archaeological sites. However in the past some significant settlements have been eroded away, particularly Hatia and Lakshmipur (Luckipour). Chandpur town has been under erosion threat for a significant period and some old buildings have been lost to erosion. The mosque at Chandpur has been under erosion threat for a considerable period of time and as part of the town protection works a lot of resources have been expended to prevent this.

2.4.14 Landscape aesthetics

The issue of landscape aesthetics is nor often one that is raised in Bangladesh. However, the coastal area does have its own unique landscape. The newer accreted areas are very flat and due to the low human population densities are unusually quiet and tranquil outside the cyclone periods. The planted vegetation provides variety and orientation.

Figure 2.25: Diarrhoeal disease

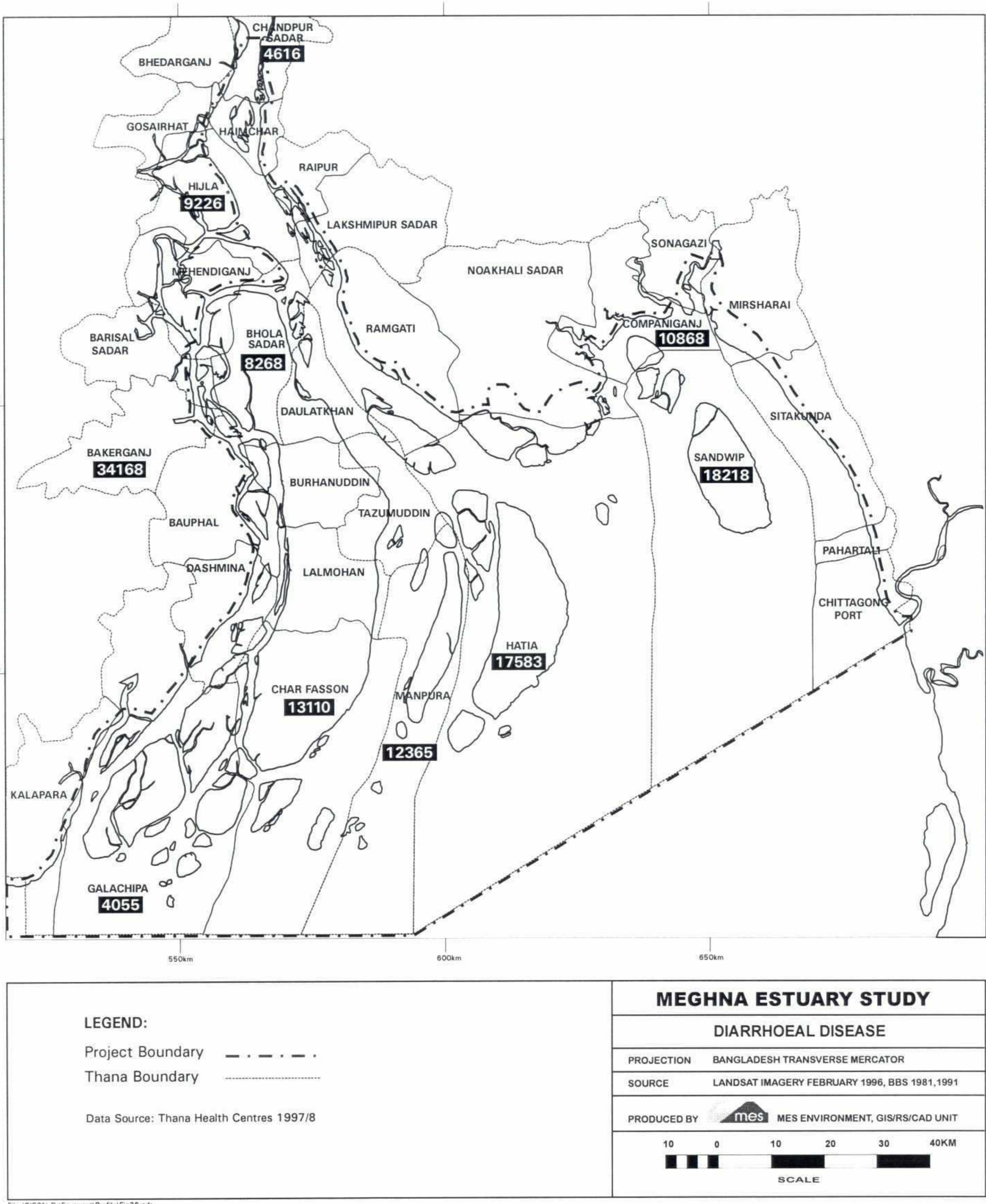

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Figure 2.26: Literacy rate 1991

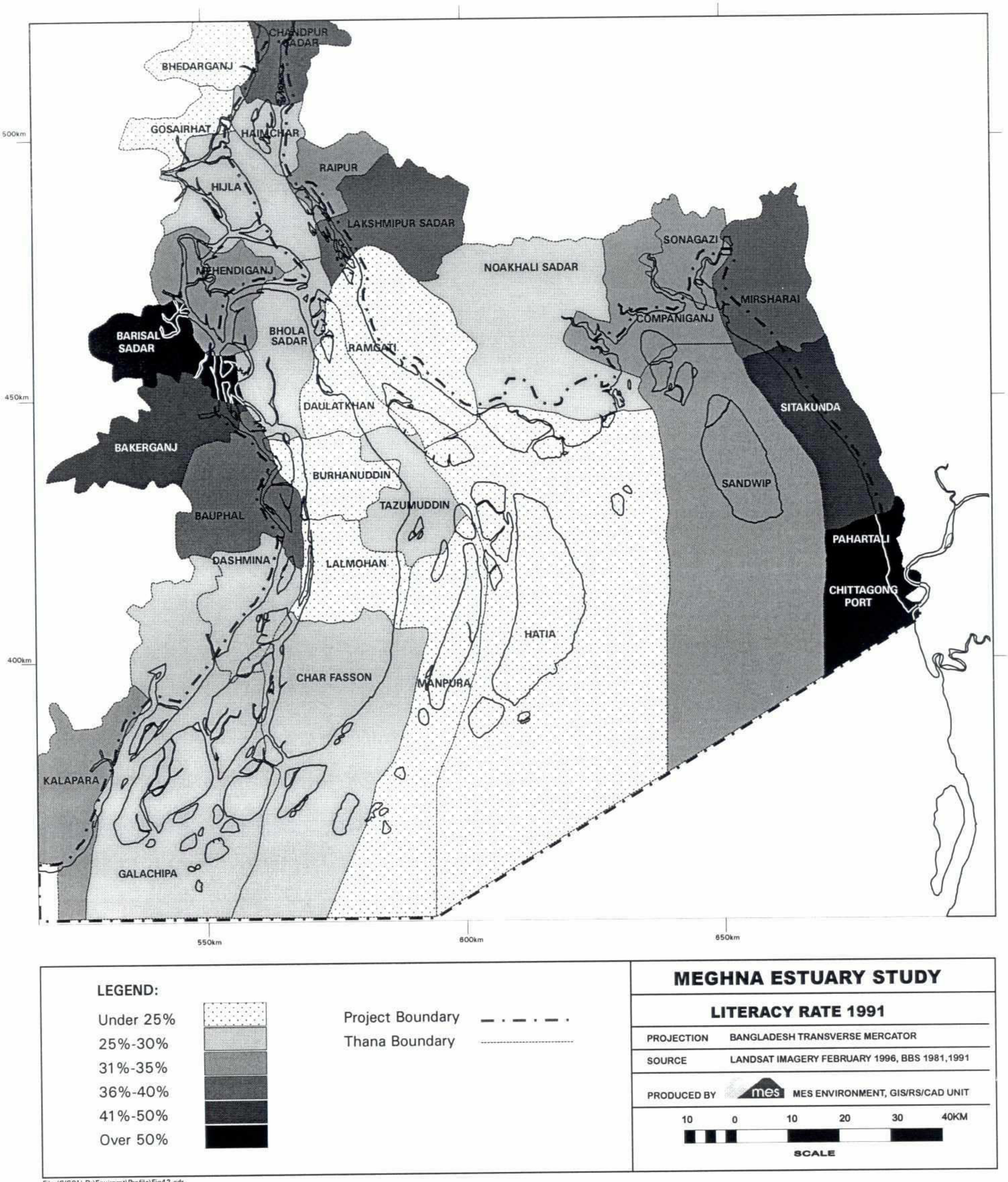
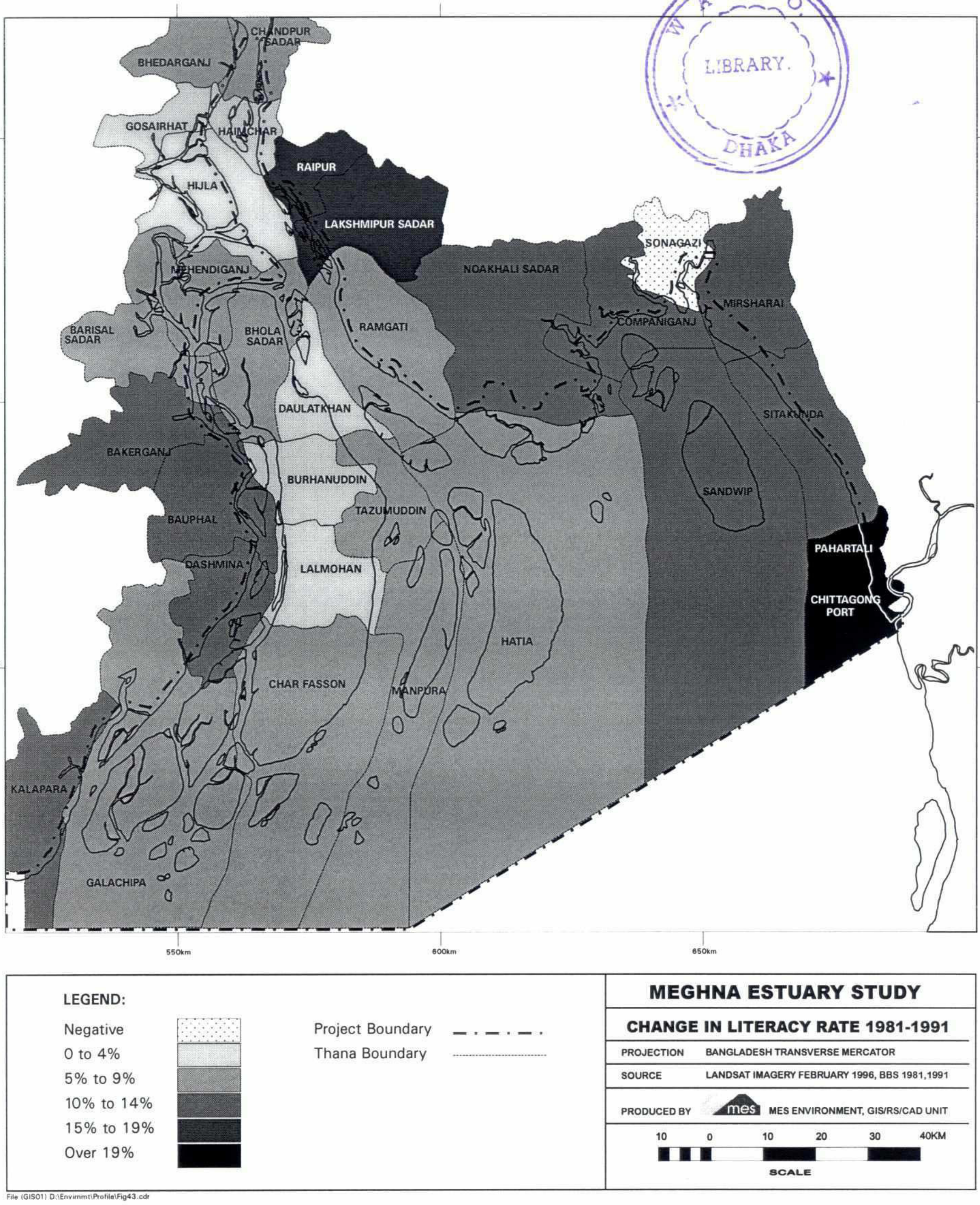


Figure 2.27: Change in literacy rate 1981-1991



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2.5 Human economic environment

2.5.1 Agriculture

Details of the situation with regard to agricultural development are given in Volume 5 of the Master Plan. The proportion of people over the age of 10 who had agriculture as their primary source of income in 1991 is shown down to thana level in Figure 2.28. Care has to be taken with this data as women often give housework as their main occupation, even though they may be in a household primarily dependant upon agriculture and may do significant agricultural work themselves. The variation across the study area is considerable, with the lowest proportions being unsurprisingly in the urban areas of Chittagong. The highest levels are in the north west of the study area, closely followed by the island west of Sandwip.

Figure 2.29 shows the change in proportion of people over the age of 10 who have agriculture as their main economic activity between the years 1981 and 1991. contrary to the national trend, Hatia, middle Bhola and the mainland west of Bhola have an increasing proportion of the population working in agriculture. In Hatia this may be due to in-migrants who are agriculturalists where as the original population are primarily fishing households. Another factor in the less remote areas is that more children over the age of 10 are undergoing full time education and hence causing a fall in the proportion working in agriculture.

A simplified cropping diagram for the study area is given in Figure II.9. This will obviously vary across the area according to the degree to which flood conditions restrict rice cultivation in the monsoon and surface irrigation allows it in the rest of the year. In the islands the system is essentially rain fed and dry farming system crops are grown outside the monsoon. Cropping intensity is mapped in Figure II.8. In general the highest intensities are inland where irrigation is possible and the lowest on the islands. A major exception is Sandwip which is surprisingly high, however it must also be remembered that yields in the coastal areas are much lower than inland so total production per unit area is still low.

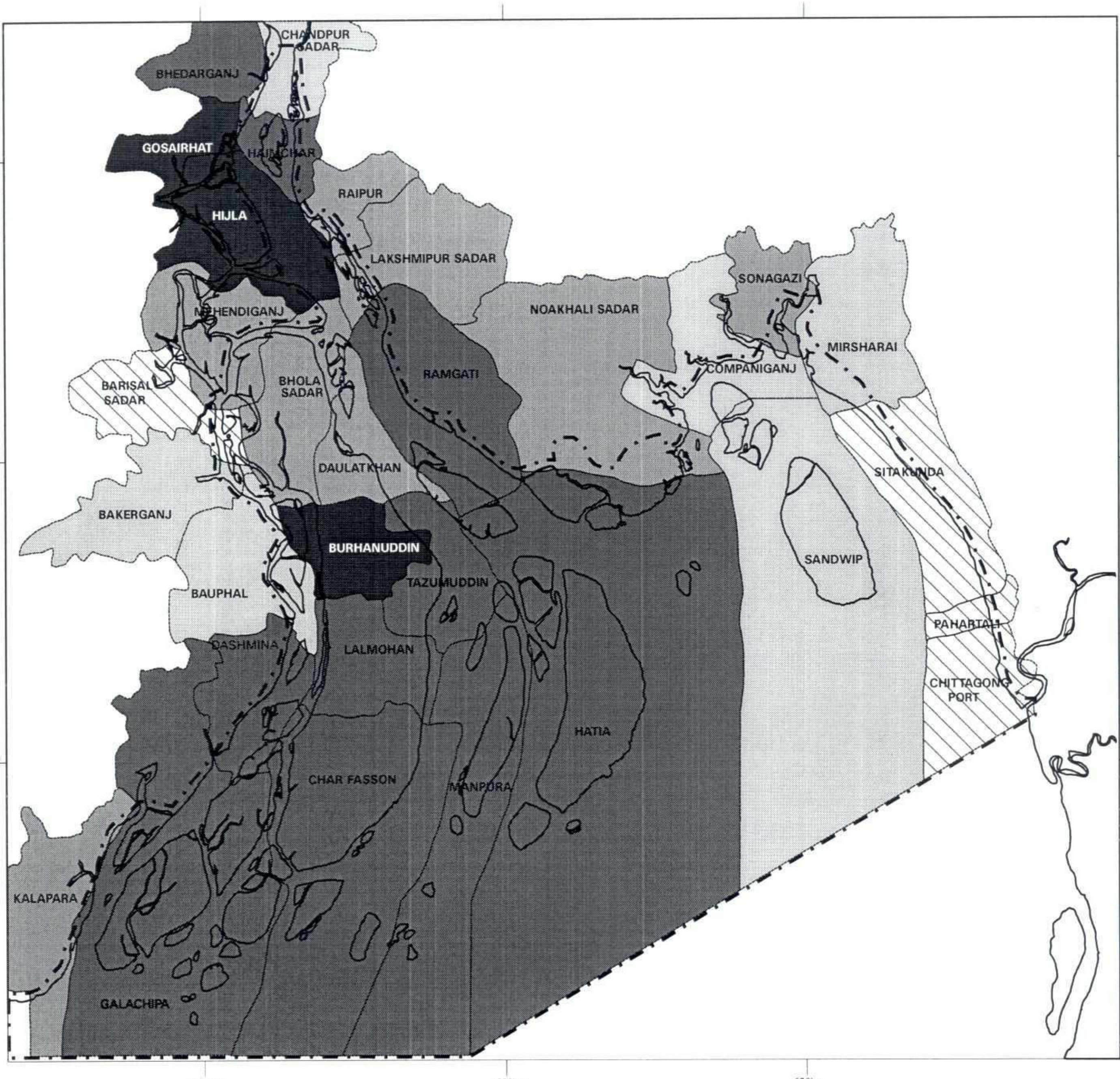
The main constraints to raising agricultural production in the area are poor quality soils, residual soil salinity and saline water inflow, low crop yields and low economic returns to agriculture, not helped by poor marketing networks and large pest losses in some years. Essentially farmers follow a risk minimisation strategy by mixing agriculture with livestock and fishing. The use of agricultural inputs is low, partly due to cost but mainly because of the difficulty of distribution of fertilisers and agricultural chemicals to such remote locations.

The provision and maintenance of adequate embankments with effective rainfall drainage which also prevents saline intrusion is a pre-requisite for increasing crop production. Security of title to land in newly accreted areas is also important.

2.5.2 Livestock

The situation with regard to livestock in the study area is dealt with in the Agricultural Volume 5. There are extensive grazing areas used by large livestock in some parts of the study area. These lie outside the embankments and include large areas of Uri grass, however many are flooded by lunar high tides and during cyclone surges with the result that animals have to be periodically moved off the areas. In the embanked areas grazing is carried out on harvested fields and in the dry season in places where no cropping is possible (often due to lack of irrigation water). In places of more intensive cropping and when grazing areas are flooded or cropped then animals are stall fed, mainly on crop residuals. At certain times of the year and in the mainland areas, (particularly amongst erosion displaced communities), fodder is in short supply. The cyclones of 1970 and 1991 drowned large numbers of livestock and the lack of salt free drinking water killed others later. The need for raised mounds for retreat during cyclones (known as Killas) has been investigated by the Cyclone Shelter Preparatory Study who have conducted livestock censuses and estimates of numbers killed in cyclones. Small livestock (sheep and goats) which are kept at the homestead, are often the responsibility of women as are poultry, including ducks. The general levels of animal disease are high and extension services, particularly in the remote islands, are poor to the point of being non-existent.

Figure 2.28: Proportion of Population with Agriculture as Main Source of Income 1991



LEGEND:

- Under 10%
- 10% to 19%
- 20% to 25%
- 26% to 29%
- Over 29%

Project Boundary

Thana Boundary

MEGHNA ESTUARY STUDY

PROPORTION OF POPULATION WITH AGRICULTURE AS MAIN SOURCE OF INCOME 1991

PROJECTION	BANGLADESH TRANSVERSE MERCATOR
SOURCE	LANDSAT IMAGERY FEBRUARY 1996, BBS 1981,1991
PRODUCED BY	mes MES ENVIRONMENT, GIS/RS/CAD UNIT

10 0 10 20 30 40KM

SCALE

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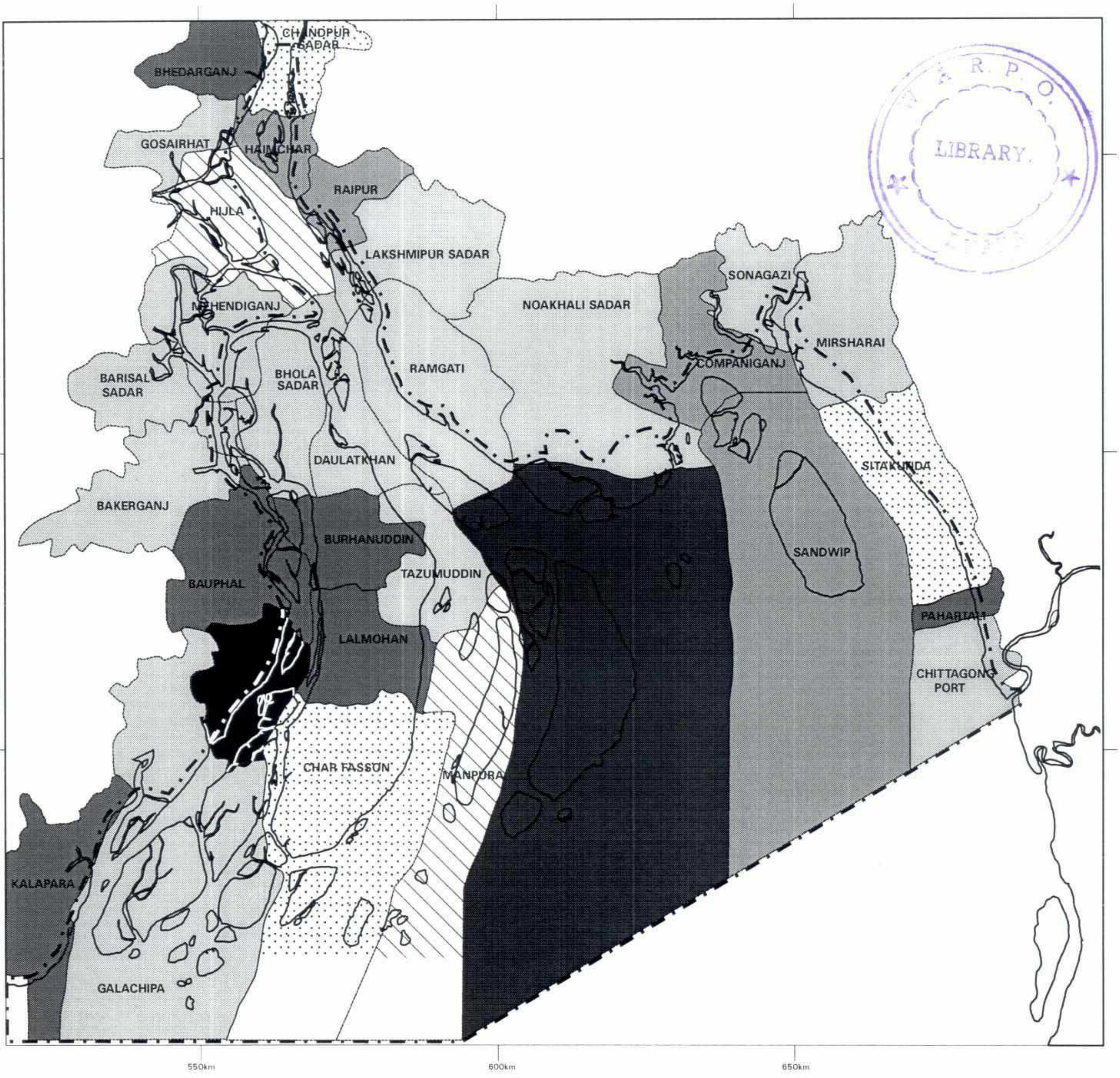
Figure 2.29: Change in Proportion of Population with Agriculture as Main Source of Income 1981-1991



LEGEND:

- Over 4%
- 3% to 4%
- 1% to 2%
- 0
- -1% to -2%
- -3% to -4%
- Greater than -4%

Project Boundary — · — · — ·
Thana Boundary ---------------

MEGHNA ESTUARY STUDY	
CHANGE IN PROPORTION OF POPULATION WITH AGRICULTURE AS MAIN SOURCE OF INCOME 81-91	
PROJECTION	BANGLADESH TRANSVERSE MERCATOR
SOURCE	LANDSAT IMAGERY FEBRUARY 1996, BBS 1981,1991
PRODUCED BY	MES ENVIRONMENT, GIS/RS/CAD UNIT

10 0 10 20 30 40KM
SCALE

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2.5.3 Forestry

The location of forested areas is given in Figure 2.30 and scheduled in Table 2.1. Further details are given in the Forestry Volume 7 and MES Technical note 018. All of the forest cover in the study area is planted, either as blocks of mangrove or in homesteads. Using satellite imagery interpretation techniques it is estimated that in 1996 there were some 56,000 ha of planted mangrove in the study area with some 4,000 ha per annum having been planted from mid 1970's to 1986. Some of the planted areas have been eroded away and some suffered from sediment blanketing. Since 1986 the area of new planting per annum has declined and not kept pace with new land accretion.

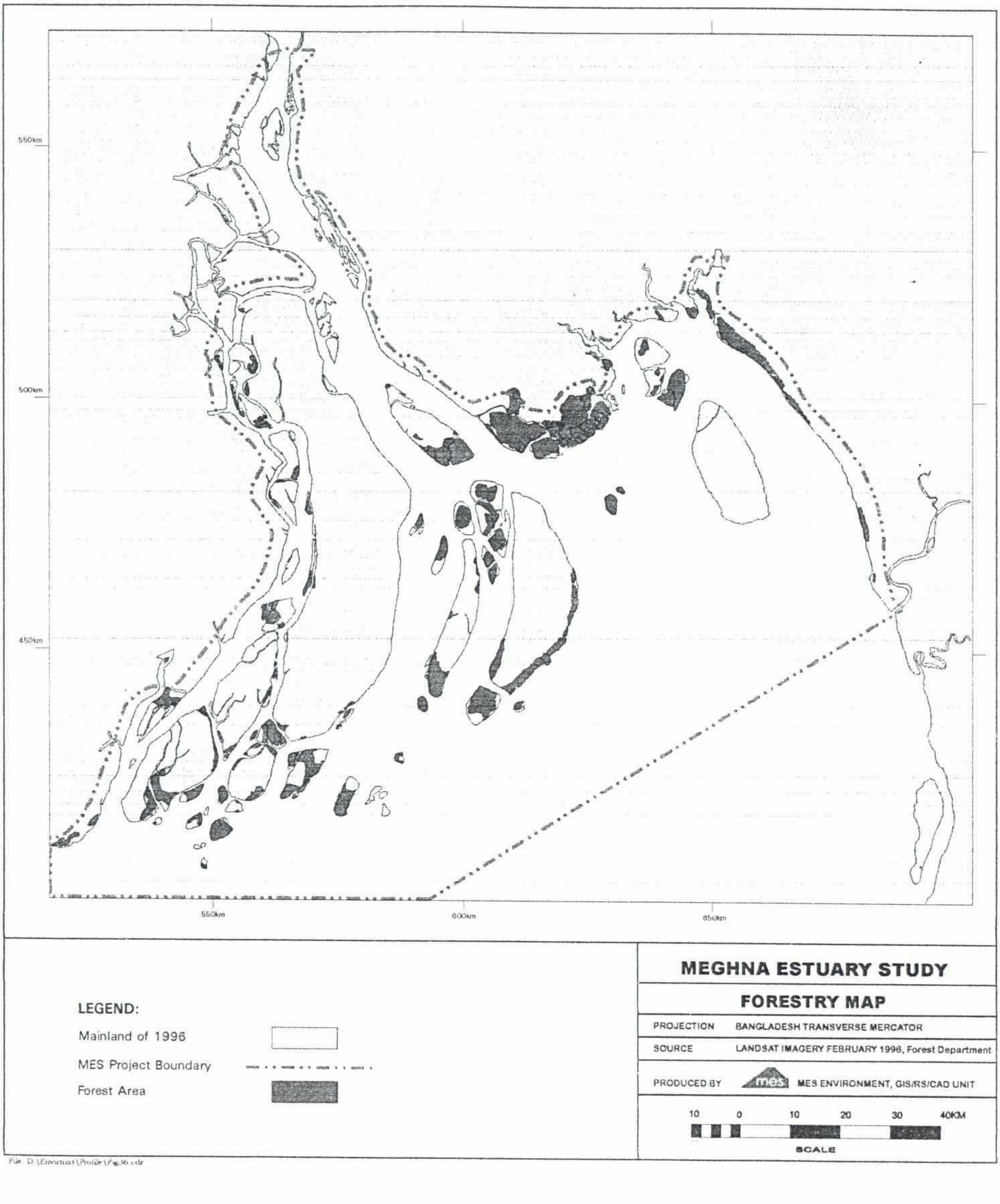
Table 2.1 : Forested areas

Age class	Year	Age	Chittagong	Noakhali	Bhola	Patuakhali	Total (h)
1971-75	73	25	137	721	224	256	1338
1976-80	78	20	1210	6374	1980	2263	11827
1981-85	83	15	1686	8880	2758	3153	16476
1986-90	88	10	1352	7121	2212	2528	13213
1991-95	93	5	921	4852	1507	1723	9004
1996-00	98	1	458	2410	749	856	4472
			5764	30358	9430	10779	56330

Source : Technical note 13 from landsat imagery, February 1996

Planted mangrove provides a very useful function in stabilising mudflats, promoting natural accretion and dissipating wave energy, especially during cyclones. It was estimated that in the 1991 cyclones a forested width of 0.2 km to 1.5 km could dissipate 2 metres of wave energy, improving the protection return period of embankments from 1 in 30 years to 1 in 50 years. However mangroves do not prevent erosion and are themselves at risk from loss. Forest areas also provide biodiversity, including the creation of shrimp habitats. If well managed (thinning at 8 years and felling at their peak followed by re-planting) forestry could also provide an economically useful sustainable resource. Mangrove forests are an ideal land use for newly accreted areas prior to them accreting to a level at which they can be embanked and used for cropping. The past difficulty has been the lack of a sustainable management policy by the Forest Department to thin, cut and replant existing areas to fund the planting of newly accreted land as a rolling programme. Species selection to be appropriate to salinity and inundation conditions as well as land level is critical. Suitable arrangements need to be modified by which the Forest Department have a right to use newly accreted land but have to relinquish it once it attains a suitable height for embanking. However such arrangements must take into consideration the stage of growth of the trees and the desirability of maintaining a minimum 1 km band of mangrove cover around all land. If well managed such an arrangement would also make it much harder for private individuals to illegally appropriate newly accreted land.

Figure 2.30: Forestry Map



2.5.4 Fisheries

The situation with regard to fisheries in the study area is outlined in Volume 6 of the Master Plan and a map of the fisheries system is given as Figure 2.12. A considerable number of households depend upon fishing for their economic livelihood and also directly consumed food. The high levels of fish consumption in the remoter areas are the reason that, despite being financially poor, many households are relatively well nourished.

The degree to which households depend upon fishing varies across the study area. Full time fishing households dominate the off-shore and to a lesser extent the in-shore areas, with part-time fishermen (i.e. they still catch fish for sale but this is their secondary occupation) also participating in some in-shore fishing as well as freshwater and shrimp collection. Many households catch fish occasionally for self consumption.

The main issue is that availability of such free good fisheries has been declining recently as fishing activity has increased, often as a result of erosion displacees being forced into fishing as a livelihood. Without action to address this issue there is a real risk that the fisheries stocks may collapse with serious socio-economic and human nutrition implications.

Aquaculture is poorly developed and there is scope to increase this in suitable locations which are protected from flooding and cyclones. There is very little commercial shrimp aquaculture in the immediate study area and in other parts of Bangladesh such operations are presently suffering from problems of disease and water management. The potential lies in developing carp pond aquaculture.

2.5.5 Industry

There is very little significant industry in the immediate study area, the only activities being some agricultural and fish processing which employ very few people. However the Chittagong coastal plain which forms the eastern boundary of the study area has significant industry including iron, steel, cement and fertiliser production. There is a large ship breaking operation just north of Chittagong which has associated pollution control and safety problems.

2.5.6 Other non-farm wage paid employment

In some parts of the study area non-farm wage paid employment is important, particularly for landless erosion displacees and also in urban areas. A significant number of households are dependant upon members working as boatmen and traders. In urban and peri-urban areas business and other services industries are important. At the Haimchar area 35 per cent of households were dependant upon wage paid labour, 5 per cent in fishing, 14 per cent as boatmen and 16 per cent in business.

2.5.7 Infrastructure

Roads and embankments

The road network is surprisingly well developed on some of the older islands such as Hatia but non existent in newer islands. All roads which are to be usable throughout the monsoon season have to be on raised embankments to avoid the risk of flooding. Flood protection embankments are increasingly being taken over by LGED and developed for multi-purpose use, including brick paved roads and settlement, both for temporary refuge and permanently for erosion displacees. There are also linear tree planting programmes being developed on road verges by LGED, and the Forest Department, often implemented by NGO's. However erosion of the embankments by the main river can seriously disrupt the road network and long detours then have to be used. The road system on islands is highly dependant upon links to the waterborne transport system.

Railways

The are no railways in the main part of the study area, although there is a railhead at Chandpur with important link services to ferries, and the main Chittagong to Feni railway line runs along the eastern boundary of the study area. In normal monsoon seasons the railway is the most reliable form of transport as only very rarely is it affected by flooding.

Navigation

A map of harbours and markets is given as Figure 2.31 and the BIWTA classification of navigable routes in Figure 2.32. The designated depths of navigable routes are given in Figure II.11. The designated depths are used as the justification for dredging work by the BIWTA. The main navigation routes through the area are those from Chittagong to Chandpur, Barisal, Khulna and Cox's Bazar. These are all affected by changing erosion and accretion patterns and need to be locally re-routed when island emerge or deeper-channels occur.

The local network of ferries link the ghats and harbours shown in Figure 2.31. The islands of Sandwip, Hatia, Nijhum Dwip, Manpura and Bhola are all highly dependant upon these local ferry services. In general communications to these areas are best serves from the eastern mainland ferry points at Rahmatkhali (for northern Bhola) and Char Battar (Ramgati) for Hatia. Char Battar is problematic due to the narrow tidal window and long approach through newly accreted land. The main difficulty in such situations is extending the link road network through unstable recently accreted land and establishing new ghats that have wider tidal windows. Studies of the country boat sector in Bangladesh (Ref: BIWTA, 1994) have indicated the need for improved interchange facilities by the provision of boat centres.

Energy and power

Public electricity to the larger islands is well established from local generating plants, although these may not necessarily operate 24 hours. In remoter areas those who are able have their own small generators and some households may share use of these.

Telecommunications

There are microwave telephone facilities to the larger islands which connect to the national system. There is also a radio system established for dissemination of cyclone warnings which also use the national public radio system.

Figure: 2.31: Harbours and Markets

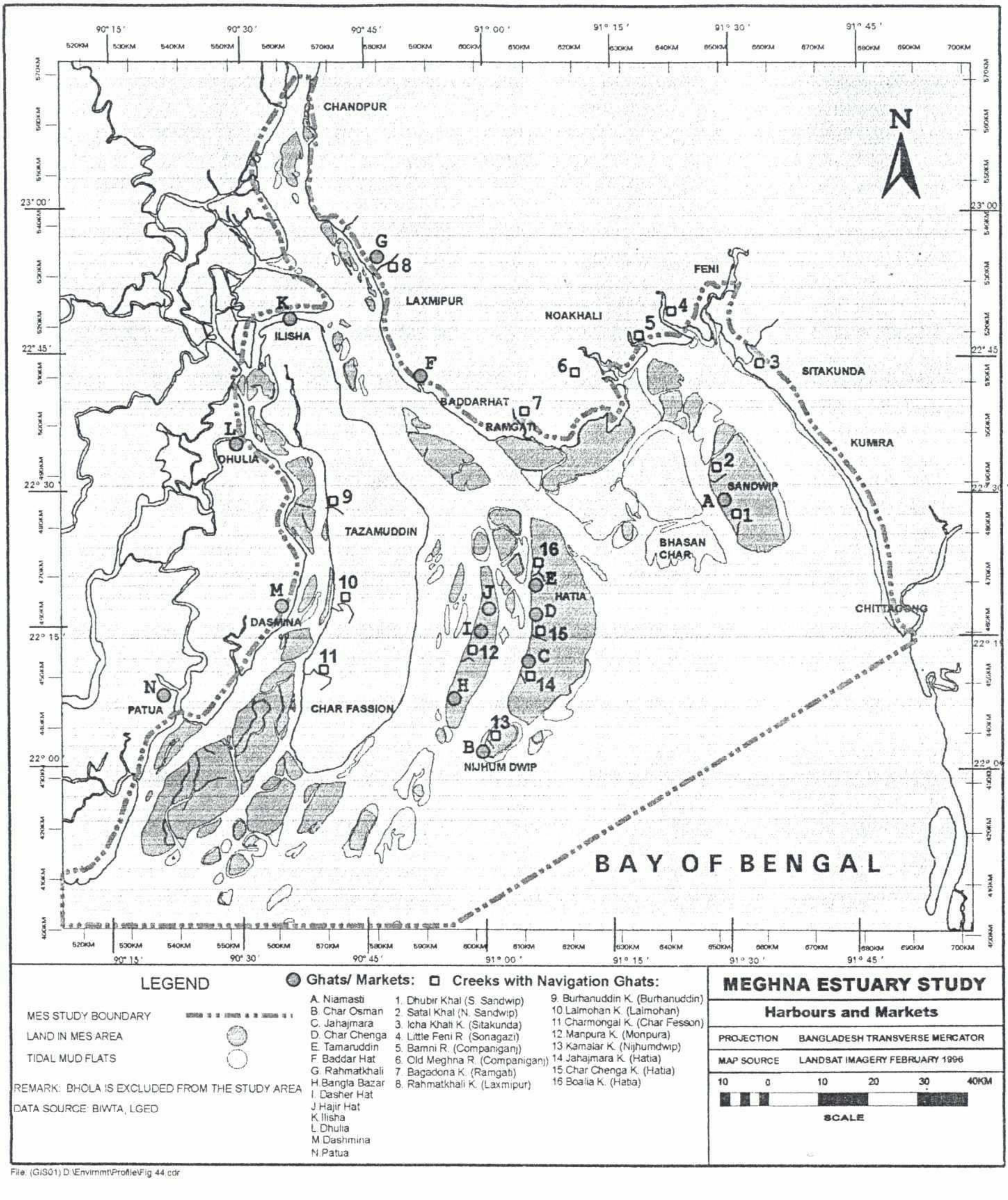


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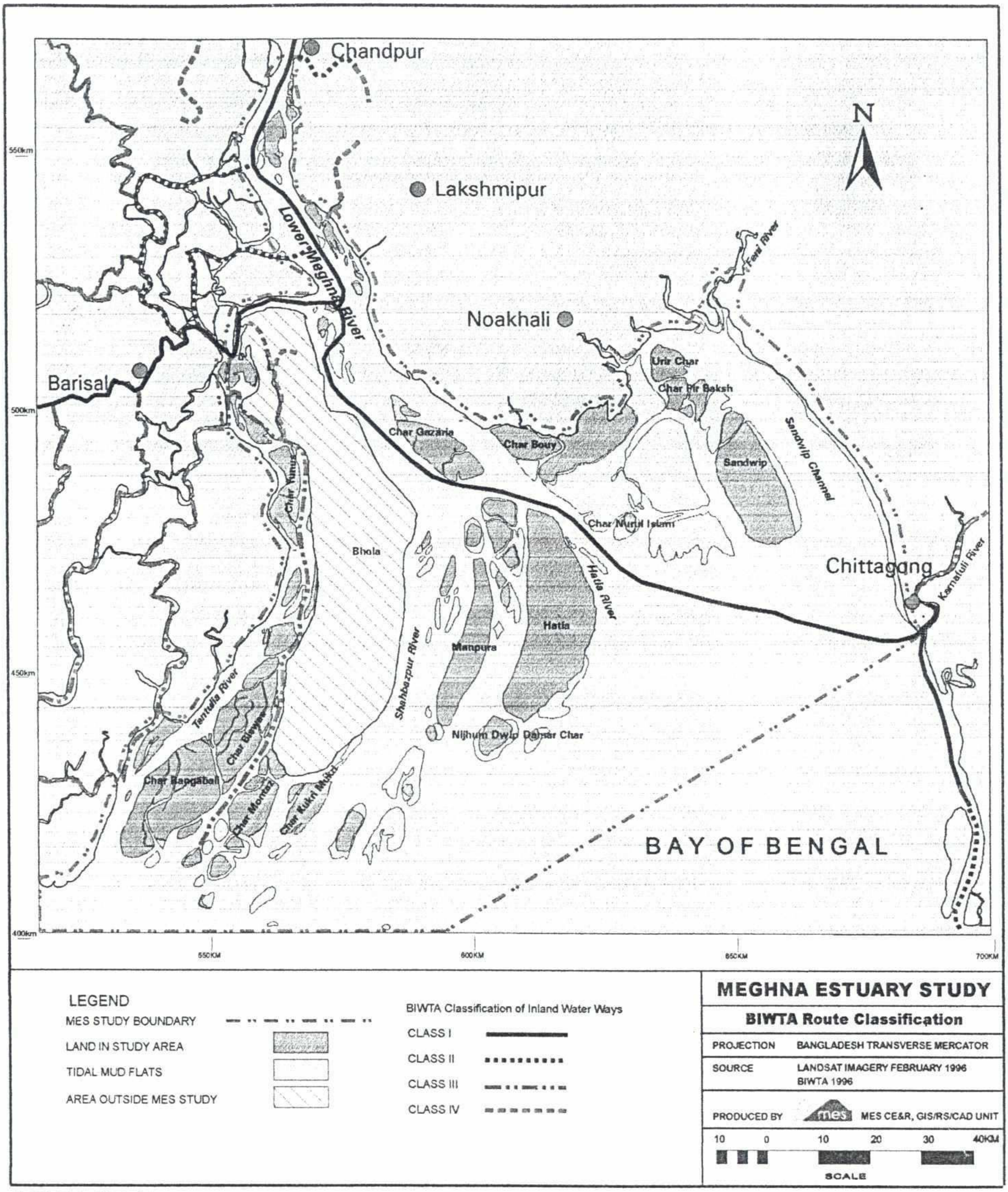
Figure 2.32: BIWTA Route Classification



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2.6 Social risks and hazards

Social risks and hazards include the implications of natural hazards (outlined in Section 2.3) to social and economic conditions in the area.

2.6.1 Storms and cyclones

Cyclones are the primary cause of direct hazard death in Bangladesh, often made worse by the secondary impacts of disease. The cyclone risk and tracks in the study area are shown in Figure 2.13 from which it can be seen that the highest risk area is the Chittagong coast which has the highest human population densities. The most severe recent cyclones were in 1970 and 1991, the loss of human life in 1970 being estimated at around 240,000 and for 1991 about 120,000 (Ref: Bangladesh Unnayan Parishad, 1993 and also Senar Ingenieria y Sistemas SA, 1996). However the 1960 cyclone events (there were two within 21 days) were potentially also damaging as they were south to north up the Meghna River. Fortunately they were not so intense and only 11,000 people were killed. Such cyclones also kill large numbers of livestock, cause widespread disruption, including forced migration and saline intrusion which destroys crops and reduces subsequent yields (Ref: BCAS, 1991 and 1992 as well as CDL, January 1992).

2.6.2 Floods

Flooding from local rainfall very rarely kills people but depending upon its timing relative to the agricultural calendar can destroy standing crops and prevent planting. In places where three crops a year are grown this is a serious constraint, however in the study area this situation is unusual. The biggest problem usually lies behind flood control embankments where in sufficient drainage provision has been made.

Flooding from the main rivers effects those people on the outside of the primary flood embankments. At the northern end of the study area this type of flooding can be of quite long duration but comes slowly and is normally predictable. As a result many homesteads are raised above the previous peak flood levels, but problems exist in areas where flood protection embankments have eroded away and areas previously unaffected become at risk. During such flood times agricultural activity ceases but conditions for fishing improve. Higher than "normal" peak floods can cause loss of possessions and damage to immovable assets and infrastructure.

Flooding from the sea can be far more damaging than river flooding, as it is more sudden, being driven either by storms (cyclones are extreme conditions) or during high lunar tides. Whilst it drains away much more quickly due to the tidal range and the fact that there are no embankments to impede it, the saline nature of the water causes severe problems for agricultural production.

2.6.3 Erosion

Main river bank and coastal erosion causes loss of immovable assets and infrastructure, forced relocation, loss of livelihood, economic dislocation and if insufficient alternative economic activity can be found then eventually to impoverishment. Loss of agricultural land is one of the main reasons for landlessness in the country, the other being debt.

2.6.4 Earthquakes

As stated in Section 2.3.4, the seismic risk in the area is infrequent but severe. The last two major earthquakes in the area (1762 and 1897) caused very few human deaths, mainly because traditional lightweight building materials were being used. The implications for a similar seismic event today are likely to be much more serious in built up areas as rigid building materials are far more commonly used. However, due to the fact that the design of coastal embankments has much shallower gradients than inland river embankments, the risk of failure during a seismic event is considerably less.

2.6.5 Famine

There were famines in the area during 1943 and 1970/71. The 1943 Bengal famine was mainly due to food grains being diverted to the war effort against the Japanese, where as the 1970 famine was due to the effects of the 1970 cyclone and later compounded by the war with Pakistan.

2.6.6 Disease

Waterborne disease is a major cause of death amongst young children and the old in the study area. Diarrhoeal disease has been identified as the highest reported disease in 6 out of 10 thana health centres in the study area as outlined in Section 2.4.10 and Figure 2.25. Infant mortality rates in the off-shore islands appear to be much higher than the national level (Ref: Volume 4 Rural Development, Population Pyramids).

2.6.7 Pollution

The biggest pollution problem in the study area are the high faecal coliform levels in open surface water, particularly in mainland areas with high human population densities. There are localised problems of urban and industrial pollution in Chittagong and particularly ship breaking operations to the north of the City.

2.6.8 Social instability and conflict

The two main reasons for social instability in the study area stem from the morphological processes, namely erosion and accretion. River bank and coastal erosion causes major disruption and conflict as households and whole communities that loose their land are forced to relocate in alternative places, either urban areas, newly accreted land or on the land of another community. The accretion of new land can also creates conflict over land claims, both in area where old rights may still exist or where illegal land grabbing occurs. There are very serious problems with this in the CDSP areas of southern Noakhali but it is relatively uncommon in the off-shore islands, helped by the fact that in the past the Forest department have planted newly accreted land.

2.6.9 Economic instability

Economic instability occurs after natural disaster, particularly cyclones, flooding and land loss due to erosion. The main problems are the difficulty in re-establishing economic activity and this is often hardest in the case of erosion victims who often have to look for completely new alternative livelihoods.

2.6.10 Political instability

The off-shore islands lay beyond the normal day to day control of government functions. However, like many of the river island Chars in inland Bangladesh there are rarely serious political problems. The main disputes lie in areas of illegal land grabbing in southern Noakhali.

2.7 External considerations

2.7.1 Upstream constraints

There are proposed or recently constructed projects upstream of the study area which may impose some constraints upon the possibilities for its development. A significant issue is the degree any upstream development would change velocities and sediment levels in the river system and the effects that would occur in the Meghna downstream of Chandpur. Specific projects are discussed below:

Jamuna multipurpose bridge

The construction of the Jamuna bridge has resulted in the peak flow width of the Jamuna river being restricted to 4.5 km width instead of 12 km. From the experience of the first two years flood conditions and study of the predictive hydro-dynamic model, it would appear that the main effect has been to increase velocities through the restricted width rather than raise peak flood levels upstream of the bridge. The unknown factor is how much more sediment is likely to be put into transport and for how far downstream of the bridge. It would seem unlikely that there would be any significant impact downstream of the confluence with the Padma near Aricha, although the results of the environmental monitoring being carried out for the bridge would need to be studied to verify this.

Ganges barrage and Gorai dredging

The idea of constructing a barrage across the river Ganges just downstream of the Gorai intake has recently been revived, linked to diversion of dry season Ganges flow into the Gorai system. Such an intervention may well affect the velocity and sediment load downstream of the abstraction point and hence into the Meghna at Chandpur. The changes in sediment are unlikely to be that significant as the Brahmaputra/Jamuna system carries far higher sediment concentrations than either the Ganges/Padma or the Meghna systems. However any changes in dry season sediment load and velocity could have implications for erosion patterns in the MES area downstream of Chandpur. The more significant impact is likely to be on flow in the dry season which could possibly cause the salinity interface to move slightly further up the Meghna towards Chandpur (see Figure 2.4). However the western edge of the MES area, and particularly the Tentulia river system could possibly experience greater dry season flows of less saline water. The EIA work being carried out for the Gorai projects should address these issues.

Other upstream development possibilities

Other possible upstream interventions include a barrage on the Brahmaputra and development on the feeder rivers in Nepal, China and India, possibly including hydro power development and abstraction for irrigation. Only an integrated basin planning approach will be able to manage these issues in an environmentally sound and sustainable manner.

2.7.2 Downstream constraints

The one main possible downstream constraint is that by changing current patterns and sedimentation in the northern part of the study area, there may be generated impacts to the island Chars downstream. Specifically changes to the erosion and accretion patterns. Due to the dynamic nature of the area these issues would need to be studied on a case by case basis with appropriate hydro-dynamic modelling techniques and satellite imagery monitoring. The EIA work for proposed projects is addressing these issues. For example in the case of the Haimchar erosion control project the possibility of induced erosion to island chars has been raised with people having land rights on the islands and there is a consensus view that prevention of mainland erosion is of far greater importance than possible loss of newly accreted islands that have low economic productivity.

2.7.3 Integrated coastal zone management

There is an urgent need to plan the development of the Meghna Estuary Study area within the context of an integrated coastal zone management framework. This has been discussed with various bodies and is outlined in Section 3 below.

2.7.4 Sea level rise

As stated in Section 2.3.3, the scenario for sea level change in the Meghna estuary area is for a rise of 0.27 metres by the year 2030 (Ref: Bangladesh Unnayan Parishad, 1993). For offshore islands the recent natural rates of accretion are much faster and higher than this. However the design of any proposed embankments should take the predicted changes in sea level into account, although compared to the requirement to cope with cyclone surges, the added height needed is comparatively small. Further details of sea level rise issues are discussed in Section 3 as part of the discussion of environmental policy issues.

2.8 Conclusions

The following section abstracts and summarises the key environmental issues in the Meghna Estuary study area.

2.8.1 Erosion

River bank and coastal erosion processes and the human responses to it constitute the most important issue in the study area. Details of the physical processes are given in Volume 2, Morphological Processes. In summary, whilst the overall amount of land erosion is less than accretion, the rate of erosion has been increasing in the last few years (from 3,700 ha a year between 1973 to 1996, up to 5,700 ha a year between 1993 to 1996), but this is still not as fast as the increasing rate of accretion.

The human implications of erosion are very serious indeed, as the majority of the land lost is developed and far more productive than newly accreted land. Erosion creates social and economic disruption requiring re-location, the search for alternative economic livelihoods and often leads to impoverishment. There are also significant economic losses from immovable assets and infrastructure which are swept away, some of which have to be replaced.

2.8.2 Accretion

The erosion in upstream countries of the catchments of the rivers in Bangladesh creates high sediment levels in the river systems which cause considerable accretion in the MES area. The amount of accretion and the rate of increase is greater than the area lost by erosion, the mean annual rate of accretion being 20,100 ha between 1973 and 1996 increasing to 26,200 ha per annum between 1993 and 1996. More details of accretion processes are given in Volume 2, Morphological Processes. Although a considerable amount of land is accreted, it is of poor quality, with low mineralogy and organic matter, as well as being saline. Much of the newly accreted land is low and hence more at risk to the effects of cyclones and flooding. It takes a considerable period of time for the land to stabilise, for organic matter to develop and salinity to reduce. The planting of mangroves assists this process, but productive cropping is really only worthwhile once the land has been embanked. Even when embanked there are problems of residual soil salinity and drainage, with crop yields remaining low.

2.8.3 Cyclones and flooding

The major cause of human death from natural disasters in the study area is from cyclones. In 1970 some 240,000 people were lost and in 1991 120,000. Warning systems are in place throughout the area and cyclone shelters have been constructed, although there are insufficient places for all residents. The cost of provision of these is quite high but can be more easily justified when used in a multi-purpose way as health centres, community centres and schools. A considerable number of livestock are lost in cyclones and the provision of raised platforms (Killas) for livestock refuges can also be used as elevated market places. A significant conclusion is that no human settlement should be encouraged outside of embankments. The planting of mangroves on land outside the embankments is effective at dissipating wave energy during cyclones. In order to prevent saline intrusion from cyclone surges and lunar high tides it is necessary to have effective embankments and with adequate drainage to prevent rainfall flooding inside them. The retention of the last of the monsoon rainfall in the drainage system can be used for irrigation into the dry season. The embankments should be developed for multipurpose use, including roads and permanent settlement. Flooding from the river system is controlled by the construction of flood embankments, but in some locations these are at risk from river bank erosion. It is imperative that such embankments are retired early enough to prevent catastrophic flooding when they fail due to erosion.

2.8.4 Salinity

Salinity caused by the inflow of sea water during cyclones and lunar high tides is a major constraint to agricultural development in the study area. The construction of embankments with adequate drainage facilities can reduce this problem, but care needs to be taken not to embank land before it has accreted to an adequate level to allow gravity drainage. The operation of the water control structures needs to be efficient and responsive to local needs. Irrespective of prevention of saline inflow there is still a long term problem of from residual soil salinity which takes many years to reduce and results in low agricultural yields made worse by the lack of organic matter in the soil. The planting of vegetation cover on newly accreted land assists in the build up of organic matter in the soil.

2.8.5 Drainage

As mentioned in the context of flooding and salinity there is a need for adequate drainage provision inside embankments that is well managed and responsive to local needs. The aim is to prevent saline inflow yet at the same time allow adequate drainage of rainfall flooding using gravity. For this reason it is important that land is allowed to accrete to an adequate level to allow for drainage. This level will be dependant upon tidal range in the area and is site specific and not the same across the study area.

2.8.6 Land tenure

The ownership of newly accreted land is vested in the state and the policy of allowing the Forest Department user rights to plant such areas helps prevent illegal occupation. However the reluctance or inability of the Forestry Department to manage the land sustainably and use the revenues to plant new areas has meant that this valuable opportunity is being lost. In southern Noakhali (the CDSP area) there are severe problems with illegal occupation by large powerful vested interests but in the off-shore islands this would appear to be a rare occurrence. Once an adequate land level has been reached then consideration should be given to embankment construction for both homestead residence and to develop agricultural land with a lessened risk of cyclone damage and saline intrusion. The construction of cluster villages in such newly embanked areas is favoured by some communities but not by others. Such cluster villages should always be located inside the embankment and linked with it by an all season raised road. Secure title to both homesteads and agricultural land is a pre-requisite for sound development.

2.8.7 Land use

It is evident that at present households in the study area follow a risk minimisation strategy with regard to economic livelihoods, combining agriculture with livestock rearing and fishing. However most have expressed the wish that they aspire to be full-time farmers, and bearing in mid the present over-fishing in the area, this would seem to be a positive aspiration in terms of resource use. The conceptual model for land use developed by the LRP follows a succession based upon speed and height of accretion, a decision to plant forestry or not, use of the land for grazing followed by construction of embankments with adequate drainage to allow agricultural land allocation and cropping.

This model would seem to be of value and relevance to most of the newly accreted land in the area. However a decentralised and integrated approach with an appropriate institutional structure is needed to successfully implement such a programme. A major problem is that the costs of embankment construction are high compared to the poor yields and returns from agriculture. the construction cost are also high on a per household basis when compared to other possibilities for economic development in other parts of the country.

2.8.8 Human health

In many parts of the study area there were urgent calls for provision of health centres in the remoter island areas. There appears to be high infant mortality in the area and diarrhoeal disease is the most co mmon reported illness. Whilst water supply provision has improved in the last 10 years there are problems in maintaining this as the source relies upon pumped deep groundwater. Sanitation provision is very low indeed to the point of non-existence and is a major reason for the high diarrhoeal disease levels. In the forested areas there are outbreaks of malaria although they appear to be the milder vivax form. In one of the feasibility study areas provision of adequate health centres was considered by local people to be more important than any water engineering intervention. In Nijhum Dwip such provision was rated higher than construction of cyclone shelters.

3. ENVIRONMENTAL POLICY OBJECTIVES

3.1 National environmental policy

3.1.1 Bangladesh National Conservation Strategy (BNCS) and National Environmental Management and Action Plan (NEMAP)

Following a seminar in 1986, the Government of Bangladesh initiated the process of drawing up the BNCS with assistance from the International union for the Conservation of Nature and Natural Resources (IUCN). In 1987 an inter-ministerial committee was constituted which included representatives from eighteen ministries. This committee was entrusted with the responsibility of forming the BNCS into a secretariat under the Bangladesh Agricultural Research Council (BARC) and also developing a prospectus as part of the first phase of activity of the BNCS. The draft report of the prospectus was completed in November 1987.

The BNCS (Ref: IUCN, 1991) identified four major ecosystems of greatest ecological importance in the country. These included the coastal zone, the Sundarbans (natural mangrove forests within the coastal zone and now a designated Ramsar Site), the hill forests and also the wetlands in lowland Bangladesh. With regard to the coastal areas, some preliminary observations were that, whilst the construction of large scale engineering project, such as embankments and cross-dams, may have produced benefits in creating more accreted land and protection from tidal surges, there was an urgent need to evaluate these measures in an integrated way for environmental impacts, both positive and negative.

A Ministry of Environment and Forest was formed, and within it the Department of Environment (DoE). An environmental policy paper and Environmental Action Plan was drawn up in 1992 (Ref: Ministry of Environment and Forest, 1992). Under the National Environmental Management Action Plan (NEMAP) programme, there is a specific Coastal and Marine Resources Management component (Ref: DoE, 1995, especially Section 5.7 of the Summary). The DoE are presently in the process of drawing up the framework for a programme to develop a Coastal Management Plan with the help of UNDP. There is an urgent need to get this formulated with the inclusion of all concerned parties to avoid wasteful duplicate programmes being formed. It can thus be appreciated the MES is in danger of drawing up a management plan for its study area in advance of an overall coastal management plan being formulated. There is a very pressing need for an appropriate integrated institutional structure for such work. The recently produced World Bank document on Integrated Coastal Planning (Ref: World Bank, 1996) is highly relevant, and it is important to learn from the experience of other countries with similar ecological conditions who have already gone through such a process.

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3.1.2 Department of Environment (DoE)

The DoE is a relatively young Government Department and is still institutionally weak and short of both human, technical and financial resources. As part of the NEMAP process it is proposed to set up a special Coastal and Marine Resources Management component as outlined above. The legal framework for environmental assessment has been in place since August 1997 and is discussed below.

A significant perceived issue for the coastal areas of Bangladesh are the implications for predicted sea level rise brought about by global warming. This issue is also discussed below, but the DoE's specific role in addressing the issue has been to currently put forward documentation for a study on National Climate Change, proposed as a lead into drawing up a National Climate Change Action Plan for Bangladesh.

The main objectives of the proposed study are:

- to prepare a National Climate Change Action Plan and the associated national communication system required for implementation
- to identify priority mitigation and adaptation technologies and also carry out a detailed assessment of their implementation
- to identify and prepare priority project profiles for mitigation and adaptation to climate change
- to undertake outreach and public awareness activities to increase support for implementation of the National Climate Change Action Plan.

The DOE have also issued a TAPP to set up a programme for assembling data for the coastal areas of the country.

3.2 Environmental legislation and procedures

The Terms of Reference for the MES state that the environmental assessment procedures to be followed for the study are those given in the FPCO/WARPO EIA Guidelines (Ref: FPCO, 1992). These Environmental Impact Assessment Guidelines follow the spirit of World Bank Operational Directive 4:01 (Ref: World Bank, 1991) which has become the international standard for such work. There is also a manual for EIA for the water sector in Bangladesh that was produced by ISPAN (Ref: ISPAN 1995a) as part of the Flood Action Plan (FAP), which supports the EIA Guidelines. A review of environmental legislation in Bangladesh was carried out by ISPAN (Ref: ISPAN, 1993).

The recently enacted Environmental Conservation Rules of Bangladesh (Ref: Abdus, 1998, Chapter III of which contains a translation into English of the Rules which were published in Bangla in the Government Gazette of August 1997), contain the Ministry of Environment and Forest legal procedures for EIA as allowed under the Environmental Conservation Act of 1995. The Act delegates the Department of Environment as the responsible body for enforcing EIA. The overall policy objectives for environmental management in Bangladesh were contained in the National Conservation Strategy (NCS) and these were formulated into an implementation strategy as part of the National Environmental Management Action Plan (NEMAP). The Environmental Rules give the criteria for grading different types of proposed interventions by likely severity of impact and the steps required for the granting of Environmental Clearance Certificates. The DoE procedures have recently been outlined in more detail in the DoE EIA Guidelines for Industries (Ref: Department of the Environment dated June 1997) which, despite its title, covers water sector interventions, including flood control embankments, polders and dikes, water supply and sanitation programmes, as well as roads and bridges.

Under the Environmental Rules it is not absolutely clear into which category many of the possible MES interventions would fall, as apart from the fact that the legislation has been primarily drawn up for dealing with the construction of new industrial operations, the four part classification by severity puts all water related interventions in the most severe class with the one exception of water treatment plants which manage to appear in two classes. Within the most severe Class D (Red), Section 66 includes all flood control embankments, polders and dikes, both their construction, reconstruction and extension.

3.3 Coastal zone management

The Bangladesh coastal ecology is one of the most fragile in the country and the interactions of terrestrial, aquatic and human components are extremely complex and dynamic. In addition there are enormous pressures to exploit the area for human use, made more urgent by the recent discovery of significant off-shore gas reserves. Since 1986 there has been a growing lobby in Bangladesh in favour of drawing up a long term and rolling Integrated Coastal Management Plan for the country, with an appropriate institutional structure for its implementation, in an attempt to ensure environmentally sound and sustainable development. The following programmes have attempted to address this issue and come up with the following recommendations:

3.3.1 ESCAP Coastal Environmental Action Plan

ESCAP, as part of the United Nations, and in partnership with the Government of Bangladesh, developed the outlines for a Coastal Environmental Management Plan (CEMP) for Bangladesh through a series of studies and seminars. The outputs were a sectoral analysis, from the point of view of environmentally sound development of coastal areas of Bangladesh, with identification of constraints to drawing up such a programme and recommendations for the following:

- the need for policy enunciation and reform of administrative and regulatory procedures to allow an integrated planning procedure to be mobilised.
- instigation of further action-research and investigation to create a comprehensive environmental data base for coastal areas in the country
- implementation of selected investment projects in the country
- eablishment of programmes to promote public awareness of the situation in coastal areas through environmental NGO's and media groups.

These issues have now been taken on board by the NEMAP activities indicated above. The ADB have also produced a manual for evaluation of Coastal Zone Projects (Ref: ADB, June 1991).

3.3.2 UNDP

Under a UNDP supported programme for co-ordination of cyclone rehabilitation work for the Ministry of Relief, a Concept Plan for Integrated Coastal Protection was produced in 1992 (Ref: Mott MacDonald, 1992). The purpose of the plan was to outline an integrated approach to coastal protection against cyclones and tidal surges, and to indicate how long term measures can be implemented in a co-ordinated and consistent manner, taking due account of the need to prioritise investments.

The particular measures required to protect the coastal areas and its inhabitants were considered to be:

- non-structural measures including warning dissemination systems, training, community mobilisation etc.

- structural measures such as embankment construction and related activities, forestry planting, construction of raised shelters, upgrading road and transport systems as well as protecting water supplies.

The follow up work to this programme is the Cyclone Shelter Preparatory Study (Ref: Sener Ingenieria y Sistemas SA, 1996), the outputs of which are presently under review.

The UNDP also produced a country wide environmental policy review in 1995 (Ref: UNDP, April 1995), which identified the main environmental issues of concern and reviewed government policy to address these.

3.3.3 The World Bank

The suggestion of drawing up an Integrated Coastal Zone Management Plan has recently found favour with the World Bank, whilst reviewing the Cyclone Shelter Programme and following the Bank's own guideline (Ref: World Bank, 1996). The wish to set up such a programme was reflected in a meeting between the Bank's representatives and the Meghna Estuary Study team in early 1998. An indication was given that such a programme may commence in the year 2002. The Bangladesh Water and Flood Management Study (Ref: FPCO, September 1995) produced under the technical supervision of the World Bank sets the framework for water resources planning for the country over the next 25 years. It is now being refined under the National Water Management Plan.

3.4 Global warming and sea level rise

To outsiders unfamiliar with the details of the Meghna Estuary, sea level rise would seem to be a significant potential problem, as Bangladesh is very flat, low lying and densely populated. However recent work, including that carried out by the Meghna Estuary Study, has shown that natural land accretion rates for most of the area are way in excess of even the most extreme predicted sea level rise scenarios. The time series Landsat imagery analysis shows that between 1973 and 1996 there was, on average, 1,642 ha a year more accretion than erosion. A significant finding is that between 1993 and 1996 the mean figure was 20,470 ha per year. Put bluntly, the gully erosion in the upper catchment of the Brahmaputra river system in the Himalayas of China and Nepal is producing an overall environmental benefit to Bangladesh in terms of land accretion. There are of course associated dis-benefits, such as smothering of agricultural land with sandy material which is low in organic matter and the closing of channels with resulting disruption to waterborne navigation and lack of water for irrigation. It must also be appreciated that in an area prone to tidal surges of up to 5 metres height with 2 metres of waves on top of this, the predicted sea level rise of 0.2 metres by the year 2026 (Ref: BUP, 1993) is insignificant. However this does not mean that the issue of sea level rise should be totally dismissed and it is important that the implications of research work, and especially the outputs of global predictive models, are borne in mind, particularly when considering engineering design criteria. The induced impacts of proposed interventions under the MES, (such as changed tidal patterns, flow regimes and accretion rates), also need to be considered in the light of sea level rise, as complex cumulative impacts can arise in what is simplistically known as the one plus one equals three situation.

The following organisations have been or are presently carrying out work related to sea level change due to global climate change:

3.4.1 Inter-Governmental Panel on Climate Change (IPCC)

There is an inter-government panel charged with co-ordinating Bangladesh's approach to induced sea level change. This is working to a "Business-as-usual" emission scenario and presently using an average rate of global sea level rise of 0.06 metres per decade, primarily attributed to thermal expansion of the melting of some land ice. However there are likely to be significant regional variations in the rate of rise.

3.4.2 Coastal Area Resource Development and Management Association (CARDMA)

CARDMA, a national NGO lobbying for coastal areas, has tried to initiate plantation programmes in the coastal areas to accelerate the siltation process and stabilisation of soil and hence promote natural accretion processes as a counter to sea level rise. In addition CARDMA see that there is a need to create and manage a coastal forest belt to protect life and property of the inhabitants from tidal surge (by diffusing wave energy) and to develop and increase the national stock of woody bio-mass of mangrove origin for use as firewood and timber, as well as it role in habitat provision for wildlife (Ref: CARDMA, 1988).

3.4.3 Bangladesh Unnayan Parishad (BUP)

BUP have carried out a significant study on global warming and sea level change in association with BCAS and climate change research centres in the UK and New Zealand. A seven volume report was produced which includes likely socio-economic implications of sea level change (Ref: BUP, 1993).

3.5 Conclusions

The major conclusion with reference to the MES work is that an inter-disciplinary Coastal Zone Management Plan is required as a matter of urgency, along with a suitable institutional framework for planning and implementation. There would seem to be no justification for having special "environmental projects" as part of the MES. A much more constructive approach is to include environmental considerations for all the proposed interventions put forward by the MES as an intrinsic part of the planning process. The environmental assessment process aims to achieve this by identifying impacts and then reducing the negative ones and promoting those that are positive. As part of the MES planning procedure, proposed interventions and mitigation programmes have been identified that address existing environmental conditions as part of the EIA process. A basic objective is that no person is to be made worse off as a result of an intervention, and all negative impacts have to be mitigated for with the cost of mitigation included in the economic and financial analysis of the proposed intervention. There are thus no special environmental sector programmes as part of the MES.

4. POSSIBLE INTERVENTIONS

4.1 Range of possible interventions

The broad range of possible types of intervention being considered for the MES area are listed in Table 4.1. In all there are 20 broad types of intervention, split into three main types:

- non-engineering sector programmes
- non-structural interventions
- engineering structural interventions.

The possible interventions cover a full range from agricultural extension, through non-structural programmes (such as cyclone warning systems), to large scale construction of physical infrastructure. The selection of one of these possible interventions does not normally preclude others, they are in general mutually exclusive. The issue is to select those interventions which are most appropriate for a specific location and group of people, based upon policy aims and objectives, plus the desires of the local population.

In addition there are environmental mitigation and enhancement programmes which are not interventions in their own right, but are considered as part of the EIA process for project evaluation, aimed at avoiding, minimising or mitigating potential negative impacts and maximising positive ones.

Table 4.1 : Proposed types of intervention

1.	**NON ENGINEERING SECTOR PROGRAMMES**
1.1	Farming: (Systems Approach)
	Agriculture: Secure Land Title, Extension, Credit, Marketing, Co-Ops, Storage, Processing
	Livestock: Diversification, Improved Breeding Stock, Fodder
	Homestead Production: Diversification, Tree Crops And Fuelwood
1.2	Fisheries:
	Sustainable Management, Training, Credit, Gear Changes, Landing Stations, Hatcheries, Storage/Processing, Marketing
1.3	Forestry:
	Sustainable Planting and Management
1.4	Navigation:
	Nothing Proposed
1.5	Environmental Management:
	Mitigation And Enhancement of Proposed Interventions
2.	**NON STRUCTURAL INTERVENTIONS**
2.1	Flood and Cyclone Warning
2.2	Disaster Preparedness and Management
2.3	Flood Proofing:
	Raise Existing Houses
	Consider for New Settlement Design
2.4	Social Infrastructure:
	Health
	Education
3.	**ENGINEERING STRUCTURAL COMPONENTS**
3.1	Primary Flood Protection:
3.1.1	Coastal Embankment Construction
3.1.2	Foreshore Conservation - Forestry Planting
3.2	Secondary Flood Protection:
3.2.1	Secondary Embankment Construction
3.2.2	Water Management Systems (Including Drainage)
3.3	Settlement Schemes
3.4	Rural Physical Infrastructure:
	Water Supply, Sanitation, Roads, Upgrading Markets
3.5	Cyclone Shelters and Raised Platforms
3.6	Erosion Strategy:
3.6.1	Bank Protection and River Training Works
3.6.2	Erosion Management
3.7	Enhancement of Accretion:
3.7.1	Mangrove Planting
3.7.2	Settling Basins
3.7.3	Cross Dams
20.	Broad Types of Intervention Plus Environmental Management

The aim of carrying out a broad environmental impact assessment of possible intervention types in the MES area is to identify major impacts, both positive and negative, so that the selection of intervention types and phasing of the Master Plan and Development Plan can take these into consideration. Specifically the need for carrying out an Initial Environmental Evaluation (IEE) followed by an EIA can be assessed, particularly for the selected pre-feasibility and feasibility studies. It is important that sufficient environmental evaluation is carried out at this stage of the planning process so that relevant Terms of Reference can be drawn up for EIA and also ensure that there is sufficient time and resources available for baseline data collection and analysis.

In drawing up the list of possible interventions for insertion in a comparative matrix it is important to accurately define both the types of intervention and the various environmental issues or components. Specific queries have arisen over the possible bank protection and river training interventions, where there is likely to be a big difference between building a new embankment which is designed to prevent erosion, rather than reinforcing an existing flood protection embankment so that it can perform the same role. For the purposes of the comparative environmental analysis it has been assumed for bank protection works that an existing flood protection embankment is already in place. If an analysis of building a completely new erosion protection embankment is required then the impacts of building a flood protection embankment and an erosion protection embankment must be aggregated. The other major clarification required is for water management systems. There are a wide range of measures that could be considered, however drainage improvement, including provision of water control structures which allow outflow of excessive rainfall run off at low tide and prevent inflow of saline water at high tide or during storm surges, is the main intervention considered.

4.2 Planning zones and units

As part of the planning process the MES area has been divided into three Planning Zones based upon morphological criteria. In addition these zones have been sub-divided into Planning Units totalling 12 in number. The Planning Zones and Units are mapped in Figure 1.3. The proposed Draft Master Plan is thus an area based approach, phased over a 25 year period.

4.3 Possible phased area based approach

A map of possible interventions based upon the Planning Zones and Units is given in Figure 4.1. It is an area based approach and hence modular in concept. The 20 different types of intervention have been grouped into four broad categories which comprise seven types of works:

- bank protection
- land accretion promotion
- possible cross-dam sites
- potential areas for embankment construction
- potential erosion management areas
- potential char development areas
- other types of development.

A 25 year development programme has been draw-up for the development of such a strategy. Three of the Planning Units have been selected for study in years 0 to 5 and a further two for years 5 to 10.

4.4 Pilot schemes, feasibility studies and pre-feasibility studies

Two pilot schemes to test the use of geotextile technology for erosion control and bank protection have been instigated at Haimchar (south of Chandpur) and Khorki (north east Bhola). Environmental appraisals for Khorki were carried out in early 1997 and for Haimchar in mid 1998. The Haimchar assessment for the Pilot scheme has been incorporated into the IEE for the full scale Haimchar Erosion Control Project Feasibility Study. The assessments of both of the Pilot Schemes concluded that as their philosophy was to preserve the existing situation, there could be no reason

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to object to them on environmental grounds. A third Pilot Scheme for cross dam construction is proposed for Char Montaz and has been subjected to a full EIA as part of the feasibility study programme.

Three feasibility studies have been carried out for the following projects which are identified as the first phase of the Draft Master Plan in years 0 to 5. They are:

Haimchar Erosion Control Project
Nijhum Dwip Integrated Development Project
Char Montaz - Kukri Mukri Integrated Development Project

An self standing IEE has been produced for the Haimchar Project and full EIAs for the Nijhum Dwip and Char Montaz - Kukri Mukri Projects. These are produced as Part 2 of the appropriate feasibility studies.

Three pre-feasibility studies in two additional planning units have also been identified for possible implementation in years 5 to 10. These are:

Rangabali-Char Biswas Development Project
Hatia Manpura Development Project
Urir Char-Char Pir Bakah Development Project

The three pre-feasibility studies have been subjected to brief environmental scoping exercises and are written up in Volume 5. The conclusion of these is that adequate resources and time have to be made available to do full EIAs as part of the follow-up feasibility study programmes. A listing of data collection requirements for these has been made, based upon the experience at Nijhum Dwip and Char Montaz.

The location of the trials, feasibility and pre-feasibility studies is given in Figure 4.2.

Figure 4.1: Potential Intervention

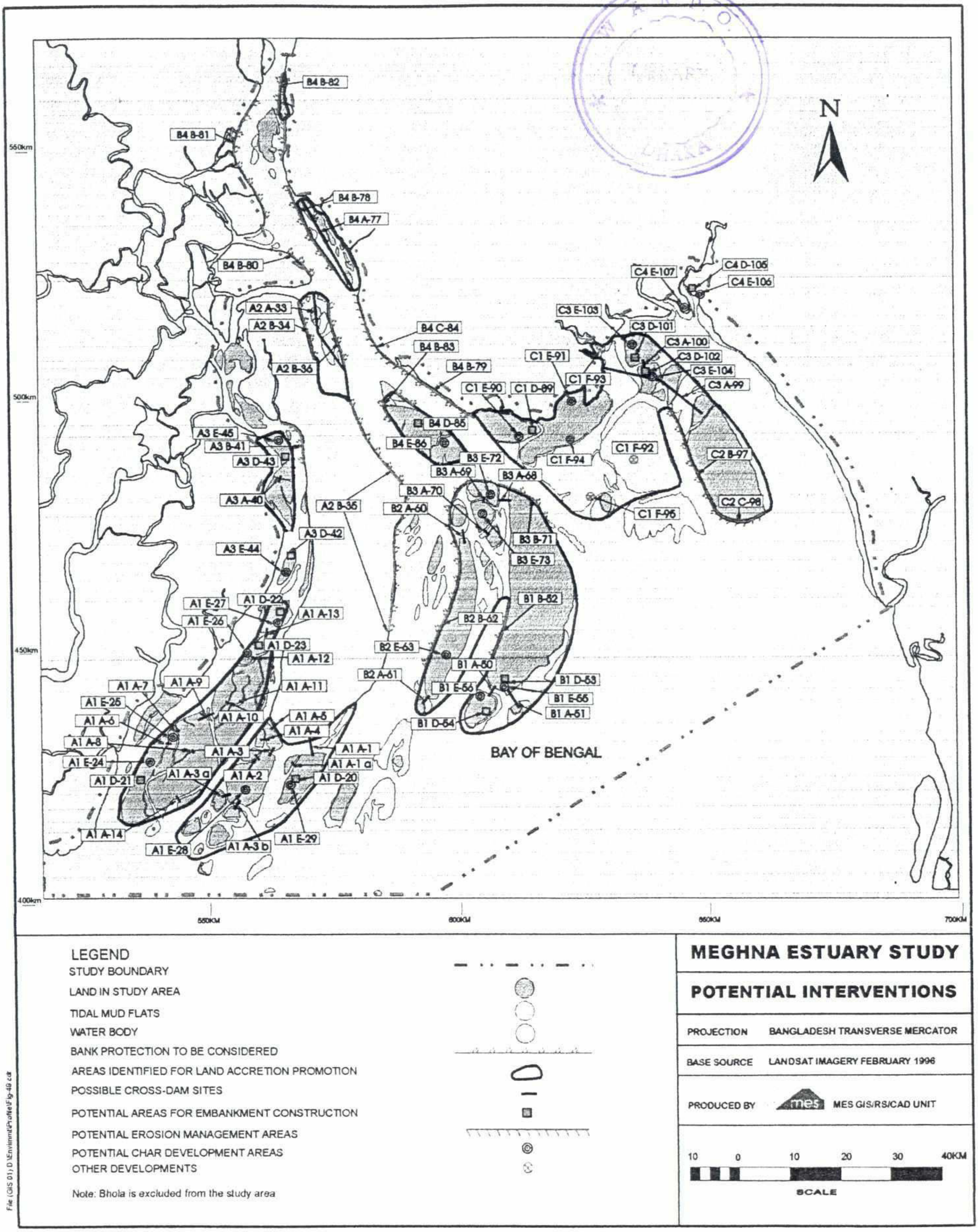
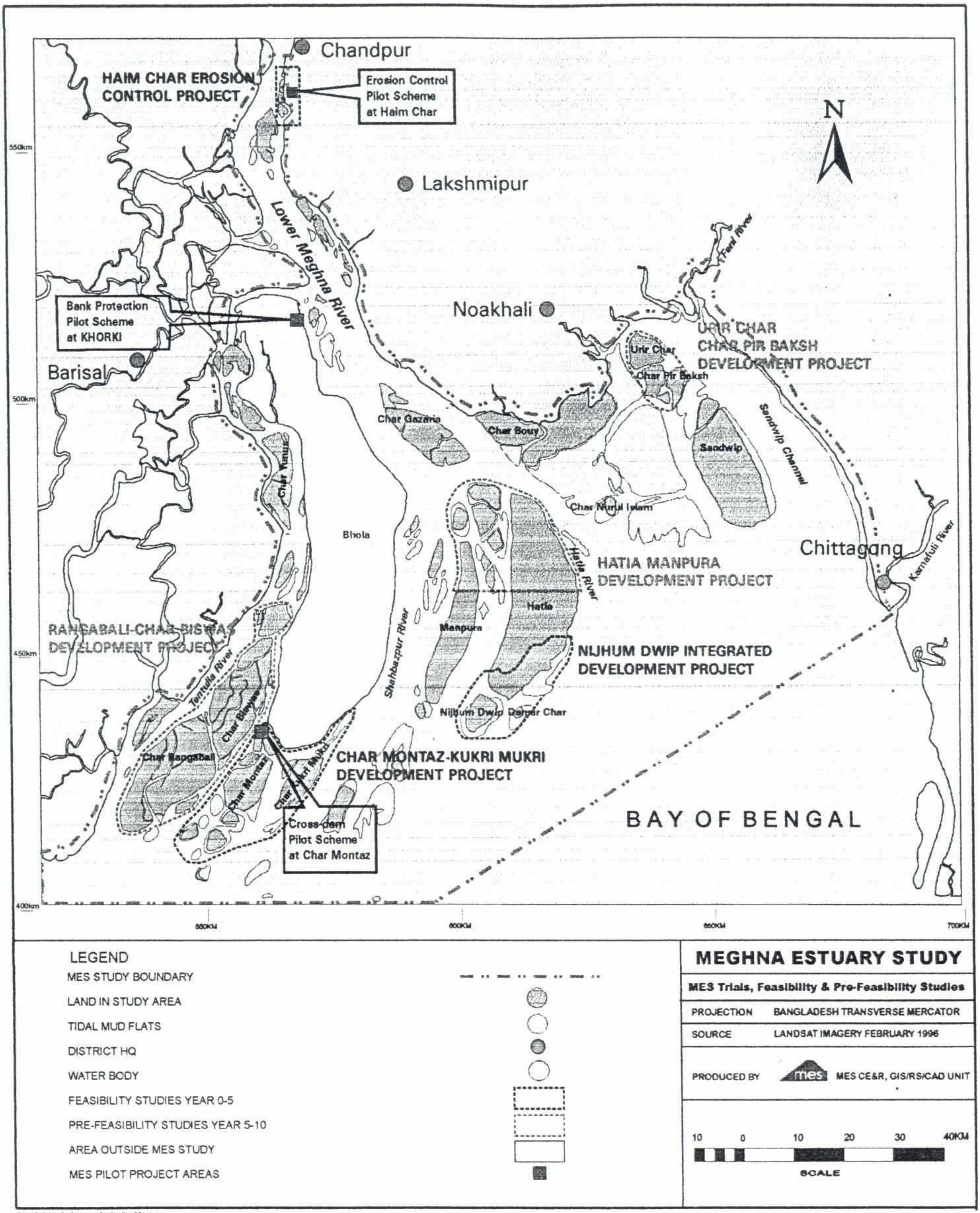


Figure 4.2: MES Trials, Feasibility and Pre-Feasibility Studies



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5. PROJECT SCOPING AND PUBLIC CONSULTATION

5.1 Local people

The responses of local people to the different possible interventions were obtained by carrying out a needs assessment in the three feasibility study locations. In each of the areas sample households from different locations and social groups were interviewed, including a separate samples for women, land owning farmers, share cropping farmers, landless labourers, full-time fishermen and boat operators. In all 336 people were interviewed. The samples were stratified by land ownership class and included those inside and outside existing embankments. The results of the needs assessments are given in the Feasibility EIA Reports. The broad conclusion is that there can be significant variation in people's aspirations and expectations across the study area, across social groups and also in micro-locations. An important conclusion is that provision of health service infrastructure is viewed to be a higher priority than the construction of water management infrastructure in the remoter parts of the study area. It is thus necessary to carry out needs assessment work for every selected feasibility study location at an appropriate time to design and adjust programmes to be in line with local people's expectations and to obtain a commitment from them to actively support the proposed intervention. Detailed socio-economic surveys were also made of 789 households comprising 5,000 people as part of the study, during which time the objectives of the study were explained and the views of local people solicited.

Experience from other projects, particularly the Jamalpur Refinement Study, points to the danger of carrying out extensive programmes of village meetings before there is a firm commitment to fund and implement programmes. Local people's expectations can be artificially raised in such situations leading to a lack of credibility for the project.

5.2 Government officials and elected representatives

Meetings were held with a wide range of government officials at national, district and the local level. A list of these is included in Appendix 3. Due to the inter-disciplinary nature of the Study these cover a wide range of government departments and expertise. A major workshop was held in Dhaka during March 1998 to present the findings of the Interim Master and Development Plans, including a presentation on environmental aspects. Invitees included a wide range of people from different government departments as well as non-government organisations.

5.3 Non Government Organisations

Various non government organisations were contacted during the course of the study and are listed in Appendix 3. In addition some nationally based NGO's were invited to the workshop held in Dhaka in March 1998. The NGO's contacted during the course of the Study included national based technical and lobbying organisations such as BCAS and CARDMA, as well as local based NGO's working in the study area, such as those on Hatia.

5.4 Other studies, projects and programmes

There are a large number of other Projects and Studies in the MES area. Attempts were made to visit them and review their work and explain the aims and objectives of the MES. A list of Projects contacted and individuals met is included in Appendix 3. A map showing the location of the more significant Studies and Projects is given as Figure II.12. The location of the different elements of the Cyclone Embankment Rehabilitation Project is given in Figure II.13. The status and interface with the MES is discussed below:

5.4.1 Land Reclamation Project (LRP)

The LRP (not reclamation in the true sense of regaining land that has previously been lost to human use, it was concerned with accretion of entirely new land), was the forerunner of the CDSP and MES. It looked at possibilities for accretion promotion in the coastal area and carried out an initial feasibility study for two cross dams at South Hatia (Ref: Land Reclamation Project, 1990). The conclusions of the study were that the construction costs of the cross dams were too high to be justified by the predicted benefits. The present MES feasibility study addressed this problem by using more cost effective cross dam construction techniques using geotextiles. The LRP also commissioned an environmental scoping study for the cross dams (Ref: Rahman A and Huq S, 1990), the conclusion of which was that there were no really serious negative impacts that would render it ill advisable

5.4.2 Char Development Settlement Project (CDSP)

The CDSP followed on from the LRP by taking over the land based components of the LRP, specifically the newly accreted lands south of Noakhali created by the large coastal cross dam constructions of the 1960's and also other new land accretion in southern Feni. Liaison was made with the CDSP and issues of co mmon interest discussed, particularly the long term implications of soil salinity for agriculture on accreted land that may be 15 or even 30 years old. The CDSP review of environmental issues relevant to their work was also assessed (Ref: Goffau, 1994). The CDSP in many ways follows on from the cluster settlement programmes initiated by Adars ha Gram (Ref: Ministry of Land, 1996).

5.4.3 FAP South West Regional Study (FAP 4)

Under the FAP the country was divided into five planning regions, the area to the west of the MES area, including Bhola Island, being designated the South West Region (see Figure 1). The main outcome of the study was a drawing up of a list of possible discrete water resources based interventions rather than a phased area based management programme (Ref: Halcrow, August 1993). A follow-up study carried out feasibility studies for seven of the identified projects, none of which lie in the MES area. Whilst the development of some of these seven projects may have long term implications for the western part of the MES, there are unlikely to be any impacts or constraints in the Feasibility study areas.

5.4.4 FAP South East Regional Study (FAP 5)

The FAP 4 study area was to the east of Meghna and is shown in Figure 1.1.The outcome of the study was a phased area management plan for the region with a subdivision into 13 planning units. An environmental baseline description of the area was given (Ref: Sir M MacDonald and Partners, August 1991, 1992 and August 1993) and the environmental implications of the implementation of the proposed plan were also assessed. Two detailed feasibility studies were also carried out, the Noakhali North Drainage and Irrigation feasibility study (Ref: Sir M MacDonald and Partners Limited, October 1993) being particularly relevant to the MES as it tackles the need for remodelling the drainage system of existing cultivated land to mitigate the induced flooding and drainage congestion created by the construction of coastal cross-dams to the south. The findings of the study were that the cost of the proposed intervention can easily be justified by the benefits to agriculture created by reducing flood extent and increasing access to irrigation water in the dry season. Strictly speaking the costs of drainage remodelling should have been apportioned against the benefits of construction of the coastal cross-dams when they were studied. This would have reduced the overall benefit calculation of the cross dams. This situation illustrates the need to address changed drainage patterns as result of cross-dam construction as part of integrated project analysis.

The regional study phased programme would appear to have no proposed interventions that directly impinge on the study area.

5.4.5 Chandpur Irrigation Project and SRP

The Haimchar project area lies within the area of the Chandpur Irrigation Project (CIP) which became fully operational in 1979, the location of which is shown in Figure II.12. An assessment of the effectiveness of the CIP was carried out in 1990 (Ref: Thompson, 1990) and in addition the Systems Rehabilitation Project (SRP) carried out an assessment of CIP during the mid 1990's. As part of the SRP assessment, the Surface Water Modelling Centre (SWMC) produced a detailed hydro-dynamic model of the CIP area to identify shortcomings in the hydrological design of CIP, particularly flooding inside the constructed embankments caused by inappropriate design and poor water management. The model was used as a tool by the SRP to draw up criteria for operation of the CIP, particularly taking into consideration local people's experiences. The broad conclusions of Thompson's work on the CIP were that, whilst the actual economic rate of return achieved by the project was significantly lower than that predicted (5 per cent) and for which the economic calculations were carried out for, overall the project was beneficial. There were significant losses of flood plain fisheries caused by the construction of embankments which prevented migration, but significant aquaculture had also been developed inside the embankment, often using the borrow pits created by the construction of the embankments.

It is significant to note that in the 1988 floods the CIP embankment did not fail (probably because it had been retired early enough), unlike that at Meghna Donagoda where embankment failure resulted in longer flooding than if there had been no embankment.

5.4.6 Other flood control, drainage and irrigation projects

Evaluations of Flood Control, Drainage and Irrigation projects (FCD/I) similar to Chandpur Irrigation Projects, were undertaken under FAP 12/13. In all 13 case examples were evaluated, including the Meghna Donagoda Project but not the CIP. The conclusions were that in over half of the cases the economic implications of negative environmental impacts (especially flood plain fish loss) were so great as to negate the predicted benefits. Mitigation by using aquaculture would not benefit the part-time and occasional fishing households who depended upon such "free good" fisheries for part of their livelihood and are the main source of their protein intake.

The island of Bhola has been subjected to a separate water sector study (Ref: BWDB, 1995) and an EIA. Strictly speaking the area is not included in the MES area but is an enclave within it and as such it is inappropriate to disregard it. The aim of the project is to increase the use of rainfall fed surface irrigation by retaining the last of the monsoon rainfall in a deepened drainage system. A case study EIA for the first phase of the project was carried out by ISPAN (Ref: ISPAN, 1994), which included some hydro-dynamic modelling of the area.

5.4.7 Systems Rehabilitation Project (SRP)

As part of a country wide assessment of 63 selected existing FCD/I projects that were actually constructed, both the North and South Hatia polders No 73/1 and 73/2 (the embanked part of south Hatia) were studied (Ref: Halcrow, 1994). The conclusions were that major works were required to ensure that it achieved its designed objectives. Specifically the sea facing embankment needed to be re-sectioned and raised to fulfil an adequate design criteria, and the drainage system needed remodelling and provided with adequate outlet structures with gates that are operated in an appropriate manner to prevent saline intrusion and yet allow drainage of monsoon rainfall run-off at low tide. These works have subsequently been carried out and the crucial factor is their sustainability. In addition SRP did an assessment of coastal polder No 61/1 at Sitakunda (see Figure II.12). This area was also included in the CERP. Again the conclusions were similar to other polders, namely that the embankments needed rehabilitation to a suitable height and cross-section and the drainage facilities remodelled to be effective along with appropriate operation and maintenance.

5.4.8 Cyclone Protection Project (FAP 7) and Coastal Embankment Rehabilitation Project

The CPP project carried out studies for the phased rehabilitation of the coastal embankment following the 1991 cyclone. The locations of the areas are given in Figure II.13. The study had multi-disciplinary components, including forestry, and came up with revised design criteria for coastal embankments. A significant finding was that the planting of mangroves on the seaward side of coastal embankments significantly dissipated wave energy and was cost effective (Ref: Kampsax, 1992). In those places where there was no existing mangrove cover the damage to the embankment had been significantly worse than in those places were it existed. An Initial Environmental Examination of the project was also carried out, (Ref: Environmental Resources

Limited, 1992), which concluded that implementation of the works was of a high priority and should go ahead, but care would need to be taken over significant issues, particularly resettlement of those people living on the existing embankment that was to be re-sectioned and land acquisition on new alignments. The need for all coastal work to be carried out within the framework of an integrated coastal zone management programme was also raised and reference made to the work of ESCAP (Ref: ESCAP, 1987?) and CARDMA (Ref: CARDMA, 1988 and 1989).

The implementation of the project was known as CERP and the first part of Phase 1 construction was mobilised in 1993. A monitoring of direct construction impacts was carried out (Ref: Bird, October 1993) which highlighted the need for appropriate measures to be taken for the second part of the Phase I works. The phase I works are presently being completed and have a large forestry component. The Phase II works detailed studies are about to be let.

5.4.9 Cyclone shelters

Many shelters have been constructed in the coastal area since the 1991 cyclone, some directly by government, some through the Red Crescent and others by NGO's including BRAC. The government of Saudi Arabia and the European Commission have been the main donors. The Cyclone Shelter Preparatory Study aimed to set criteria for locating, sizing and designing of shelters, including a risk assessment methodology. A risk map based upon landfall locations of cyclone tracks was produced by them (see Figure 2.13). The Cyclone Shelter Study targeted Hatia as the case study vulnerable area within the MES area and carried out a detailed thana assessment, including a loss of life and livestock (Ref: Sener Ingenieria y Sistemas SA, 1996). In addition, in conjunction with SWMC, the CSPS produced a preliminary cyclone surge hydro-dynamic model of the area. The model is in the process of being refined combining the MES bathymetry data and digitisation of the Finmap 1991 land levels. As part of the early stage of the Cyclone Shelter Study the need for an integrated coastal management plan was identified (Ref: Mott MacDonald, 1992). The conclusions of the Cyclone Shelter Study are that the costs of adequate shelter provision are high at around $US 150 per head and feedback is required as to a policy for provision.

5.4.10 Forestry projects

There have been extensive studies and implementation programmes for forestry development in the coastal areas of Bangladesh over the last 25 years. All of the mangroves in the MES study area are planted and none are natural woodland. A National Forestry Master Plan (Ref: Asian Development Bank, 1993 and FAO, March 1997) has been drawn up and under it regional sub-plans have been developed with the South Noakhali area being covered by a recently issued Integrated Forest Management Plan (Ref: Canonizado, 1998). The plan outlines a proposed planting programme for the area but still fails to address the issue of sustainability and the need to fund the programme from revenue. Forestry in the area has also been addressed as part of the Coastal Green Belt Project, the Coastal Tree and Palm Project, (Ref: Fountain, 1993) and as a part of the CPP (Ref: Kampsax, May 1992, Appendix H). As mentioned above the present CERP Phase has a significant forestry component.

5.4.11 Other embankment and bank protection projects

As part of the environmental assessment process, the EIA work carried out for the Brahmaputra Right Embankment (Ref: Halcrow, 1992), the FAP 21/22 Bank Protection Project (Ref: Rhein-Ruhr Ing, 1993) and the Coastal Embankment Rehabilitation Project (Ref: Bird, 1993) was reviewed. The issues raised by these projects were born in mind when considering the proposed MES interventions. The Meghna Left Bank Erosion Control Project (FAP 9b) carried out a study for bank protection work at Haimchar (Ref: Haskoning, 1992) which was reviewed by the MES as part of the Haimchar Erosion Control Feasibility Study. The conclusions were that revetment techniques using conventional measures were prohibitively expensive. The secondary towns project under FAP 5a looked at flood protection for five main towns outside Dhaka. The conclusions were that highly site specific interventions would be required at each place.

5.5 Feasibility project planning response to consultation

As stated in Section 5.1 above, a needs assessment was carried out in the Feasibility study areas. The results of these assessments confirmed that the basis for the three interventions was in line with peoples wishes, although these varied according to the location and social group of the people. Attempts were made in all case to address peoples preferences and priorities, in the case of Nijhum Dwip and Char Montaz by opening out the proposed interventions to be fully integrated rural development projects. It is considered unwise to undertake any more detailed participation work in the feasibility study areas until a firm commitment to funding and implementation can be given. The need to produce a Public Response Document and No Objection Certificate is a pre-requisite to gain an Environmental Clearance Certificate from the DoE before construction can commence.

6. ENVIRONMENTAL SCOPING AND BOUNDING

6.1 Technical scoping exercise

An environmental scoping exercise was carried out to allow a comparison to be made between all of the 20 possible types of intervention listed in Table 4.1. The basis of the scoping was the master checklist of environmental components for work in the coastal areas of Bangladesh, compiled for all work in the MES and outlined in the MES Interim Development Plan, (Ref: DHV, December 1997, the environmental assessment matrix given in Figures 8.1 and 8.2 gives the full listing of the checklist). The master list is shown in the left hand column of Table 7.1, working systematically from the natural environment to the human environment in the same order as the baseline profile in Section 2, based upon that in the EIA Manual and Guidelines.

6.2 Bounding of possible impact areas

The delineation of likely environmental impacts created by the possible interventions, (known by the term "bounding" in the FPCO/WARPO EIA Guidelines and Manual), can only be carried out on a project by project basis once detailed project interventions are decided and studied. The spatial limits of impacts will vary according to the type and mix of intervention components and their specific location. For the three feasibility Studies this has been done in the self-standing EIA reports. A general observation is that because the Planning Unit boundaries are normally islands any impacts are normally quite self contained. There are hence far fewer cases of impact cascades, which can be a significant problem and complexity in mainland development, as the FAP 3 Regional Study ably demonstrated. In short the MES proposed intervention has far more self contained spatial components than any other FAP regional study. The issue of cumulative and external impacts is discussed in Section 8.

7. IMPACT ASSESSMENT

7.1 Impact methodology

A broad comparative environmental matrix is show in Table 7.1, split for ease between the natural environment and the human environment. This split, particularly in a country like Bangladesh which is well endowed in natural resources and has high human population densities with intensive use and interaction of these, is very artificial. Care has thus to be taken in clearly defining the environmental components. Specific clarification and definitions are:

- marine fisheries resources are defined as those greater than 5 km from the shore
- seismic activity is considered as a possible constraint to development not an induced impact, i.e. interventions have to be designed with due regard to seismic risk and intensity

Table 7.1 : Environmental scoping of important environmental components

	Farming	Fisheries	Forestry	Navigation	Environmental Mitigation and Enhancement	Flood and Cyclone Warning	Disaster Preparedness Management	Food Proofing	Social Infrastructure	Coastal Embankment Construction	Foreshore Conservation	Secondary Embankment Construction	Water Management Systems	Settlement Schemes	Rural Physical Infrastructure	Cyclone Shelters and Platforms	Bank Protection and River Training	Erosion Management	Mangrove Planting	Settling Basins	Cross Dams
NATURAL ENVIRONMENT																					
Natural Physical Environment																					
Climate																					
Rainfall																					
High Tides			+							- +	+						+		+	+	+ -
Storm Surges			+							- +	+						+		+	+	- +
Cyclones			+								+						+		+	+	
Hydrology																					
Surface Water																					
Quantity																					
Rainfall flooding										-		-	+		-		-			? -	? -
River flooding										+ -		+ -	+				+			+	+
Tidal/Sea flooding			+							+	+		+				+		+	+	+
Drainage										-		-	+				-			-	-
Irrigation	-									+		+	+		-		+				+
Quality																					
Salinity										+		+	+				+			+	+
Domestic water supply														+	+						
Irrigation										+		+	+				+				+
Erosion																	+				
Sedimentation											-		+ -				+ -			+	+
Accretion			-							-	+		?				?		+	+	+
Groundwater																					
Availability																					
Domestic water supply														+	+						
Irrigation																					
Quality																					
Salinity										+				+	+		+				
Land																					
Topography										-	+						+			+	+
Land Type										+	+		+				+			+	+

	Farming	Fisheries	Forestry	Navigation	Environmental Mitigation and Enhancement	Flood and Cyclone Warning	Disaster Preparedness Management	Food Proofing	Social Infrastructure	Coastal Embankment Construction	Foreshore Conservation	Secondary Embankment Construction	Water Management Systems	Settlement Schemes	Rural Physical Infrastructure	Cyclone Shelters and Platforms	Bank Protection and River Training	Erosion Management	Mangrove Planting	Settling Basins	Cross Dams
Soil:																					
Type										+	+						+			+	+
Quality	- +		+							+	+		+				+		+	+	
Chemistry	?									+			+							+	+
Waterlogging										+ -		-	+		-		+ -			?	?
Erosion																	+				
Capability										+	+		+				+			+	+
Natural Biological Environment																					
Terrestrial Habitats:																					
Flora	+ -		+					+		+	+	+	+	+	+		+		+	+	+
Fauna	-		+							+ -	+	+ -	+ -	+ -	+ -		+ -		+	+	+
Freshwater Habitats:																					
Flora										+	+	+ -	+ -	+ -	+ -					-	- ?
Fauna	-									+	+	+ -	-	+ -	+ -					-	- ?
Fish	-	+ -	+							-	+	-	- (?)	+ (?)	-				+	?	-
Marine Habitats:																					
Flora				-																	?
Fauna				-																	?
Fish		+ -																			?
Bio-Diversity and Conservation	+ -		+							+ -	+	+ -	- +	+ -	- +		+ -		+	+	+ -
Sensitive Areas	-		+	-						-	+	-	-	-	-				+	+ -	+ -
Natural Risk and Hazards																					
Storms and Cyclones			+							+	+	+	+	+			+		+	+	+ -
Flood										+ -	+	+ -	+	+	-		+ -			+ -	+ -
Seismic Activity										-		-			-		-				-
HUMAN ENVIRONMENT																					
Social Environment																					
Political and Institutional Administration						+		+		+		+		+	+	+	+				
Human Population																					
Gender Issues	+ -					+ -		+ -						+	+	+					
Settlement Pattern and History				?				+ -		+		+		+	+	+	+	+		+	+
Land Holding and Tenure	+		- +					?		+	+	+	+	+	+	+	+		- +	+	+

	Farming	Fisheries	Forestry	Navigation	Environmental Mitigation and Enhancement	Flood and Cyclone Warning	Disaster Preparedness Management	Food Proofing	Social Infrastructure	Coastal Embankment Construction	Foreshore Conservation	Secondary Embankment Construction	Water Management Systems	Settlement Schemes	Rural Physical Infrastructure	Cyclone Shelters and Platforms	Bank Protection and River Training	Erosion Management	Mangrove Planting	Settling Basins	Cross Dams
Common Resource Rights																					
Fish	-	+	+	+		+				-	+	-	-	-	-		-		+	?	-
Fuelwood	-		+							+ -	+	+ -		-	+ -		+		+	?	+
Grazing	-		+							-	+	+ -		-	+ -		?		+	+	+
Fodder	+		+							+ -	+	+ -		-			?		+		
Domestic Energy and Fuel	-		+				+	+		+ -	+	+ -		-	+ -	+	+ -	+	+	?	+
Domestic Water Supply							+	+	+	+		+		+	+	+	+	+			
Sanitation							+	+	+	+		+	?	+	+	+	+				
Health																					
Waterborne Disease						+	+	+	+	+ -		+ -	?	+	+	+	+ -	+		?	? -
Insect-borne Disease			-						+		-			+					-	?	?
Mental Health						+	+	+	+	+		+		+	+	+	+				
Nutrition	- +	+							+	-		-	-	+	-		-			?	-
Education and Literacy					-			+	+	+				+		+	+				+
Archeological and Cultural Sites																					
Landscape Aesthetics	-		+					-		?	+	?		?	?	-	?		+	?	?
Economic Environment																					
Agriculture	+		-	+				+	+	+		+ -	+	-	+	+	+			+	+
Homestead Production	+					+			+	+		+		+	+		+				
Livestock	+ -		+ -	+		+		+		- +	+ -	+ -		+ -		+	+		+ -	+	+
Forestry	-		+							- +	+	+ -		-	+ -		+		+	+	+
Fisheries	-	+	+ -	+		+				-	+	- ?	- (+)	- +	- +		-		+	?	-
Industry	+	+	+			+		+		+		+			+	+	+				+
Other Non-Farm Wage Paid Employment	+	+	+	+		+		+		+	+	+	+	+	+	+	+			+	+
Infrastructure and Communications																					
Roads				+				?		+		+	?	+	+		+	+			+
Navigation				+		+				-	+	-	+ -		-		- +			-	-
Energy and Power								+		+		+			+	+	+	+			+
Telecommunications						+	+	+								+					
Social Risk and Hazards																					
Storms/Cyclones	-	-	+	+ -		+		+	+	+	+	+	+	+		+	+		+	+	+
Flood	-		+	+		+		+		+ -	+	-	+	+	-	+	+ -		+	- ?	- ?
Erosion																	+	+			

	Farming	Fisheries	Forestry	Navigation	Environmental Mitigation and Enhancement	Flood and Cyclone Warning	Disaster Preparedness Management	Food Proofing	Social Infrastructure	Coastal Embankment Construction	Foreshore Conservation	Secondary Embankment Construction	Water Management Systems	Settlement Schemes	Rural Physical Infrastructure	Cyclone Shelters and Platforms	Bank Protection and River Training	Erosion Management	Mangrove Planting	Settling Basins	Cross Dams
Earthquakes								?		?		?			?	?	?				?
Famine	+	+		+		+		+		+		+			+	+	+				+
Disease						+		+	+	+ -		+ -	?		+	+	+ -	+			
Pollution				-						+ -		+ -	?		+	+	+ -			?	?
EXTERNAL FACTORS																					
Upstream Constraints												-	+				- +			?	?
Upstream Impacts										-		-			-					?	?
Downstram Constraints												-	?							?	?
Downstram Impacts										-		- +	- ?		-		- +			?	?
DIRECT CONSTRUCTION IMPACTS																					
Land Acquisition			?					?		-	-	-	-		-	(?)	- ?		?	+	+
Compensation								?		-	-	-	-		-		-		?	+	+
Resettlement										-		-		+	-		- ? +				+
Source: MES 1998																					
Legend:																					
+ Probable Positive Impact																					
- Probable Negative Impact																					
? Insufficient Data or Understanding to give Rating																					
( ) Uncertainty Exists with Rating																					

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- the component entitled "human population" refers to possible induced changes in human population numbers through changes in birth and survival rates (e.g. from health programmes aimed at improving child mortality or conversely family planning), rather than changes in human population numbers due to induced in or out-migration

- the component called land holding and tenure includes increased land values.

It should also be noted that there are major issues concerning the need for and nature of an institutional management structure required for implementing any intervention. A strong case could be made for having an institutional management component for the study as a project in its own right with a public participation programme. Similarly there would appear to be a need for an operation and maintenance component, again with an appropriate public participation element.

The likely nature of impacts has been predicted from reviewing similar interventions previously carried out in Bangladesh. Of particular importance are the Flood Control, Drainage and Irrigation Projects (FCD/I) reviewed as part of the FAP 12/13 work and the case study EIA work carried out by ISPAN as part of the FAP, (particularly the Bhola case study).

Impacts can be either direct (some times known as Primary Impacts) or indirect, caused by complex linkages between environmental components. The ratings shown in the matrix are given from the perspective of the human use of resources. These ratings are positive and negative in comparison to a future "do nothing" situation, which takes into account future without project trends. If there is thought to be little change over the future without intervention situation, then the matrix is left blank. There are some cases when an impact is thought likely to occur but its nature is uncertain, in which case a question mark is inserted. There are also cases where there are likely to be complex simultaneous positive and negative impacts and the aim of any mitigation programme would be to try and ensure that the positive impacts outweigh the negative ones. The present analysis assumes no mitigation programmes are in place. A detailed IEE and EIA process on a project by project basis would identify suitable measures, and an analysis matrix would identify the effectiveness of these mitigation measures.

There are also complexities of social differentiation of impacts (for instance by land holding size groups, income groups or occupations) and also spatial variation of impacts depending on the specific nature and location of the intervention. The likely upstream and downstream constraints and impacts of the broad interventions have also been considered, but these refer to areas outside the designated intervention area. There are also likely to be significant variations in impacts within the intervention area.

The time period over which prediction of impacts can be estimated is problematic when compared to the study planning time horizon of 25 years and the economic analysis period of 30 years. It is very difficult and often impossible to predict many of the likely environmental impacts over such a long period. Standard EIA procedure divides impacts into those which are immediate, medium term and long term. Immediate impacts include those that result from commencement of construction (such as land acquisition) and also those that are apparent as soon as commissioning and operation commence. Medium term impacts are those experienced some five to ten years after commissioning and often reflect benefits that start to come on stream and the overcoming of negative impacts associated with the start up of operations. Longer term impacts are in the time period of 10 to 25 years and often include impacts on the natural environment which are slow to be apparent but are often irreversible. A good example of these is induced change to vegetation caused by changes in flooding conditions.

7.2 Impacts on the natural environment

Interpretation of the matrix shows that most impacts on the natural environment (both positive and negative) are from major structural interventions and many of these are highly complex. The one notable exception is forestry planting (also a major element of both the foreshore conservation and mangrove planting interventions), which has significant positive impacts on the natural environment and very few negative ones. The intensification of farming systems is often at the expense of the natural environment and may compete with other land uses and co mmon resource use such as grazing, forestry and fisheries. However the degree to which displacement occurs depends upon the age of the land, particularly its topographic level and hence risk of saline intrusion and soil quality. The establishment of rice monoculture normally results in losses of fauna and particularly fish habitats. However the indirect result of homestead development is normally an improvement of flora biodiversity.

The induced impacts of new embankment construction on the natural environment can often be negative if care is not taken to minimise these at both the conception and design stages. One of the most significant impacts is the reduction of the free flow interface between the river system and seasonal flood plains which results in the loss of fish migration and hence fisheries resources in the newly embanked land. Assuming that the newly built embankment performs as intended, then the flood plain areas in the newly embanked areas will also be significantly reduced and hence fish habitat and aquatic flora areas will decrease. However the construction of some embankments has actually resulted in creating more rainfall flooding inside the embankment as drainage networks have been disrupted. Whilst this may increase the size and duration of seasonal flooded areas and hence fish habitats, the restriction of migratory species inflow would reduce the number of nutritionally and economically valuable fish.

The development of appropriate water management systems, including drainage remodelling, will reduce flood plain areas and hence fisheries habitats. However if well designed and managed it is possible to improve internal river fish habitats by maintaining all year water in the deepened drainage system. An environmental analysis of the construction of cross dams and settling basins is very difficult, as they are such site specific interventions. There are likely to be complex induced impacts on sedimentation as a result of these two types of intervention which could reduce aquatic and marine habitats but increase terrestrial ones.

7.3 Impacts on the human environment

A broad conclusion of the analysis is that most non engineering sector programmes and non structural interventions give positive impacts to the human environment, although some of these may not be particularly large. The engineering structural interventions are far more complex, giving larger impacts, both positive and negative, but often at a greater intervention cost, with the complication that some of the positive and negative impacts my be simultaneous. The most significant negative impacts are likely to result from new embankment construction which may increase rainfall run-off flooding yet reduce fisheries resources as explained above. The indirect consequences of these changes in flood regime on human health (particularly the risk of increased waterborne disease) and reduced nutritional level due to cuts in available protein intake from fish, can be considerable but will vary greatly depending upon the location of the intervention. The need for land acquisition, compensation and resettlement can be a significant cost and create a major constraint to large scale infrastructure construction.

A significant issue is that the benefits to agriculture of many of the possible interventions may not be that great, particularly in the newly accreted lands where saline intrusion remains a significant problem and the land levels are still too low to safely build embankments without creating severe drainage problems. The present Guidelines for Project Assessment (GPA) emphasise economic returns to cultivation as a justification for interventions. However in the more marginal areas there is likely to be a need for incorporating the benefits to an integrated farming system, including livestock, forestry and fisheries, into the analysis. The overall benefits (particularly social ones) of carrying out interventions in the least developed areas, rather than the more developed areas where economic returns may be higher, need to be taken into consideration as part of the multi-criteria analysis.

The level of risk attached to economic activity may also increase greatly as a result of constructing flood protection embankments and erosion protection works. The consequences of failure of either of these two types of intervention can often be far more serious than if they were not built in the

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first place, as increased investments based upon the assumed protection offered by these interventions could be lost.

7.4 Conclusions by possible intervention

7.4.1 Farming

The proposed farming intervention is an integrated farming systems approach, with an emphasis on promoting household production from all types of agricultural activity. A significant feature of this programme would be ensuring secure legal title to land. In general the environmental impacts from this type of intervention in the MES area are likely to be positive. The only major exception is in places where land levels have already accreted enough to allow two or more crops to grow each year. In such places agricultural intensification could result in soil degradation if insufficient organic fertiliser is used. It is also likely that fish habitats would decline as seasonal shallowly flooded land is converted into paddy fields. Such a process could have induced impacts upon fisheries resources and human nutrition. Co mmon resource rights to grazing land, forestry and hence fuelwood and rural energy balance would also be restricted as they may be in competition for land resource use.

7.4.2 Fisheries

The aim of a fisheries programme would be to reform the fishing system to try and make it more sustainable, bearing in mind the present level of over-fishing. The programme would include provision of extension services, including credit, replacement of fishing gear, along with consideration of storage and processing facilities. Provided that fish catch levels are kept within naturally sustainable limits, there are unlikely to be any significant negative impacts. However the positive impacts could be restricted primarily to fishing households, although in some parts of the MES areas these are a significant proportion of the total population. If agricultural households have sufficient cash to purchase fish then there will be benefits to cash incomes of fishing households and fish traders, as well as human nutrition benefits to those consuming more fish. However there is also the risk that better marketing may result in fishing households selling more of the fish that they catch and as a result directly consuming less, causing a decline in their human nutrition. The conservation of fish habitats may also pre-empt the use of some accreting areas for forestry or agricultural use, due to competition for resources.

7.4.3 Forestry

The main emphasis of a forestry component would be planting on newly accreted land. The following comments also apply to the foreshore conservation and mangrove planting interventions.

The impacts of forestry planting in the MES are nearly all positive, the only exception being the increased risk of malaria that forest habitats create by providing a suitable breeding ground for mosquitoes. The planting of forestry may also be in competition for use of land as grazing, (although with careful and sensitive management both can co-exist to each others benefit), agriculture (especially when the forest cover is so well developed it is passed its optimum growing age and should be thinned and even cleared), and less problematically fisheries (although mangroves are better habitats for many species than open water). The benefits of planting are considerable, including a quantifiable economic benefit from dissipating wave energy (reducing the return period of a 1 in 50 year cyclone event to 1 in 30 years by dissipating 2 metres of wave energy) and assisting in land accretion, stabilisation and improvement of soil quality. In addition there are benefits to flora and fauna habitats and co mmon good resources which helps rural energy balance and also improves landscape aesthetics.

7.4.4 Navigation

The main possible intervention for the navigation sector would be provision of more and improved ghats, but this would not be directly under MES but possibly through LGED. There are obvious benefits to boat owners and crew as well as fishing households and all households depending upon trading of goods and services. There are very minor dis-benefits caused by pollution from engine boats and some disturbance to environmentally sensitive areas and marine habitats.

7.4.5 Flood and cyclone warning

There are benefits all round from flood and cyclone warning programmes, including direct saving of human life and loss of human assets. However these are difficult to quantify and harder still to value and are subject to complex value judgements which have to be part of a multi-criteria analysis. There are no significant negative impacts.

7.4.6 Disaster preparedness and management

Like flood and cyclone warning programmes there are no negative impacts of disaster preparedness and management programmes. However the benefits are also difficult to quantify and value but centre around saving human life and allowing households to re-establish their economy more quickly after a cyclone.

7.4.7 Flood proofing

The concept of flood proofing is not so readily adaptable to the coastal areas as for inland river flooding in Bangladesh. Alternatives include raising existing houses and ensuring that all new settlement takes into consideration the need for minimising flood damage. However the raising of existing houses is likely to be of very limited effectiveness in the coastal areas where at least 5m of height over a normal high tide is needed and up to 8m in very exposed areas, to avoid damage from a 1991 type cyclone. There may be a real danger of giving people a false sense of security in areas outside embankments, where the provision of large cyclone shelters and raised platforms is a far safer alternative. Flood proofing is better suited to areas inside embankments which suffer from rainfall run-off flooding. There are few negative impacts of this type of intervention although such programmes require great care and detailed working with a significant participation component to be successful and can be relatively expensive.

7.4.8 Social infrastructure

The main components of social infrastructure programmes include health and education. Bangladesh has made significant and impressive strides in these areas in the last 10 years and the MES area is no exception. However there is still room for additional provision of medical facilities, particularly on the remoter islands, and for secondary education. There are no significant negative impacts of such programmes except the social division that may be created when one area is provided for but not another. The overall benefits are considerable in the medium term, especially in areas with poor existing provision, but quantification and valuation still remain difficult. Justification remains part of national policy as defined in provision standards.

7.4.9 Coastal flood protection embankment

The construction of new coastal flood protection embankments can be highly problematic. It is imperative that if serious future drainage problems are to be avoided then the land levels before construction of the embankment must be adequate to allow outflow of monsoon rainfall run-off using the tidal range and a suitable drainage management strategy. The main negative impacts of coastal embankment construction include the disruption of fisheries migration from the river and marine systems to the flood plains on the land. This is of significant economic and human nutritional importance in many areas of Bangladesh. However the benefits of coastal embankment construction are likely to be much greater than similar structures for river flood protection inland of Bangladesh. Such a conclusion assumes that the embankments are designed and built to withstand cyclone conditions (a 5 metre storm surge with 2 metres of wave height in 1991), including the induced impact of increasing flood heights further inland that such embankment construction appears to create.

There are also serious dis-benefits created by the need to acquire land with resulting compensation and resettlement provision. Such situations can be compounded in places where an existing embankment has to be retired inland to avoid bank edge erosion. This can create the situation where some people have less protection than previously and in their eyes this is due to the project. If the embankment were to fail then the losses are likely to be more severe than if there were no embankment.

There is considerable scope to maximise the benefits of flood protection embankment construction by following a multipurpose use strategy, with planned use of the embankment for formalised settlement, tree planting and also provision of a road on the crest.

7.4.10 Foreshore conservation

The planting of forestry on the foreshore with the aim of dissipating wave energy and promoting accretion has all the benefits of forestry planting outlined in the forestry section above. There are significant benefits and few negative impacts, although land acquisition can often be a problem in foreshore areas that have land rights on them (be they formal or not). This occurs in areas that were previously land but had then eroded and are now accreting again. Similar problems also exist in areas where the coastal flood protection embankment has been retired.

7.4.11 Secondary embankment construction

Secondary embankment construction has all of the dis-benefits of coastal flood protection embankments and few of the benefits. The drainage congestion caused by such embankments can, and has, caused serious crop loss and damage to infrastructure in other parts of Bangladesh. The main benefit is seen to be containment of flooding in the case of a breach in a primary flood protection embankment. Provided that secondary embankments can be combined with the existing road construction programme and the location and sizing of openings is designed for maximum flow conditions, then the some of the dis-benefits can be minimised. However the main conclusion is that secondary embankment construction is highly problematic and some regional studies in the FAP concluded that it would be beneficial for some of the existing secondary embankments to be demolished. The situation in coastal areas is not the same, but the construction of secondary embankments would seem difficult to justify in comparison to other options.

7.4.12 Water management systems (including drainage)

The main work required for effective water management is remodelling of the drainage network, by deepening and re-profiling, and the provision of structures with suitable control gates to allow two way flow using tidal difference for drainage and retention of rainfall water for irrigation, as well as preventing saline water inflow. The consequences of such works, assuming that they operate as intended, are a reduction in flood plain area with a resulting loss of flood plain fisheries. However if well managed it is possible to develop all year round fish habitats in the deepened drainage channels. However such a step may compete with water demand for surface irrigation, especially as groundwater quality in the area is poor and expensive to abstract. There are normally significant, if temporary, employment generation benefits during construction of such works.

7.4.13 Settlement programmes

One of the major cited benefits of promoting land accretion in the coastal areas of Bangladesh is that it allows landless people, and particularly erosion displacees, to be settled in the area. The basic philosophy of the LRP and CDSP assumes that this is an intrinsic benefit of sedimentation promotion. Whilst there is an understandable desire to ease the plight of landless people, fundamental questions need to be asked as to how wise such a policy this is bearing in mind the cyclone risk in the area and the fact that even embanked land takes at least 15 years to become productive for agriculture. The costs per household of such interventions are also relatively high.

Assuming that a rational settlement programme is developed with appropriate infrastructure provision (raised house building, agricultural land allocation, water supply and sanitation provision, schools, health centres, aquaculture ponds, access roads and if necessary cyclone shelters), then there are normally significant benefits to household livelihoods, although they may take some time to be realised. Terrestrial flora and biodiversity is likely to improve as homestead vegetation is planted, however existing nearby planted mangrove areas are likely to come under increased pressure of human use as would be other co mmon good resources.

The most crucial factor to ensuring success is that there is a systematic and transparent system of land and house plot allocation that is fair, equitable and timely. Without such a component the benefits are unlikely to be realised.

7.4.14 Rural physical infrastructure

The main components of rural infrastructure work include water supply and sanitation provision, road construction and upgrading of markets. Water supply and sanitation construction is of direct benefit with very few negative impacts, although the lack of sealed pit latrine technology in Bangladesh has been causing significant faecal pollution problems to shallow groundwater aquifers. However in the coastal areas the deep groundwater aquifer is used for drinking water supplies for most households. The main requirement for the planning of such infrastructure provision is for rational use to be made of the available resources, along with inter-department co-operation, to avoid wastage. LGED and DPHE are well placed institutionally to do such work and LGED has its own set of environmental guidelines for design and implementation. The construction of roads is far more problematic, as they have to be on embankments and create all the problems of flood protection embankments, but made worse by the fact that many are inside embanked areas and are likely to cause significant induced rainfall flooding and drainage congestion.

7.4.15 Cyclone shelters and platforms

The provision of cyclone shelters and raised platforms for livestock (Killas) has significant social benefits, especially when they are used for schools, health and community centres. However construction costs are high, the estimates for adequate shelters being $150 per head of population. The main justification is the saving of human life, a social and moral criteria not an economic one. The multi-criteria analysis is thus needed to justify such work. There are no significant negative environmental impacts of their provision provided adequate water supply and sanitation facilities are included.

7.4.16 Bank protection and river training

Bank protection and river training can be technically problematic and costly, being normally only justified for very large urban areas. It is also a risky strategy and if it should fail then the implications are often more serious than doing nothing, as people may have invested in an area in the assumption that the works will hold. In environmental terms such works are normally trying to fight natural processes and on rivers as large as those in Bangladesh the success record is not good. However new and cheaper technology is being developed and is being tried on an experimental basis at Haimchar (south of Chandpur) and Khorki (north east Hatia). If these tests prove successful with the minimum of negative impacts, (the technique is particularly attractive as it avoids land acquisition), then there would be a justification for their wider use, as the loss of land due to erosion is the single most important reason for household economic destitution in Bangladesh. However adequate design for any embankment construction must take into account seismic conditions. Any catastrophic failure is likely to have severe and rapid consequences, made worse by the fact that most earthquakes in Bangladesh have occurred in the monsoon season when water levels are highest.

7.4.17 Erosion management

The concept of erosion management is a planned response to an acceptance that main river bank erosion will occur. Whilst this may be seen as defeatist, it is an acceptance of reality and allows for a rational strategy to be drawn up for the removal and replacement of infrastructure and provision for relocation of people. At present the BWDB do have a general policy of trying to retire

7.6.1 Main predicted impacts

The main environmental impacts and constraints that would require particular study at IEE stage are:

- induced effects on erosion and accretion patterns

- the effect of closing off water passages causing inshore-marine flora and fauna habitat change and also having implications for inland rainfall drainage and waterborne navigation

- water and soil salinity as a constraint to development, restricting potential benefits

- implications for fisheries and socio-economic impacts on fishing households

- human nutrition and health consequences, particularly of changes in fish consumption patterns and waterborne disease vector habitats.

7.6.2 Rangabali - Char Biswas (western half of planning unit A1)

The proposed intervention consists of the following:

- 9 cross dams
- 4 areas of char development (integrated rural development)
- 3 areas of sea facing enclosed embankment construction

In addition to the main impacts outlined above there could well be cumulative impacts brought about by carrying out such a wide scale intervention. It would be wise to carry out sedimentation monitoring for at least five years before doing any feasibility study. The erosion prediction analysis indicates that the northern part of the area is under significant erosion threat over the next 25 years.

7.6.3 Hatia - Manpura (north Hatia planning unit B3)

The proposed intervention consists of:

- 4 cross dams
- 2 areas of char development
- bank protection on an extensive length of coastline.

There should be considerable environmental concern as to the advisability of such extensive bank protection works, especially in an area that has been so unstable in the past and is predicted to be so. The concept of encircled bank protection seems ill advised at present, as there could well be induced impacts downstream, including the Nijhum Dwip area. The cross dams will also cause major barriers to fish movement. It would seem necessary to wait at least five years for the results of the Haimchar geotextile trials and their monitoring to be seen and analysed, before embarking on such detailed studies in Planning Unit B3.

7.6.4 Urir Char-Char Pir Baksh (northern part of planning unit C3)

The proposed intervention consists of:

- 2 cross dams
- 2 areas of char development
- 2 areas of sea facing enclosed embankment construction.

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The LRP carried out a feasibility study for the cross dam part of this work as the Sandwip Cross Dam. The conclusions were that it was not cost justified. In September 1995 LGED carried out a preliminary study for a link road through the area which included the two cross dams, although the locations and alignments were slightly different. The LGED work (Ref: LGED, 1995), concluded that an integrated planning and implementation approach was required that would be multi-sectoral. Work on the MES has indicated that this area of Bangladesh is very unstable and unpredictable, there are two active erosion channels, one to the north and the other to the southwest of the area. The area is hydrologically complex and there is a risk that the proposed intervention may actually reduce "free" natural sedimentation in useful areas. The present erosion predictions also indicate that the area of one of the cross dams is active. The tidal range is very great (up to 6m) and flow velocities are high. It is thus considered necessary to carry out detailed hydrological and sedimentation studies over the next five years before considering if a feasibility study should be carried out.

7.6.5 Broad environmental conclusions for the pre-feasibility studies

The major conclusion of a preliminary analysis of the three proposed pre-feasibility studies is that extensive and highly detailed hydrological modelling is needed over the next five years for the three areas before detailed multi-sectoral studies should commence. In addition the detailed findings of monitoring the Haimchar geotextile trial and the first Nijhum Dwip cross dam (assuming it will be built) need to be fed back into the project planning process. It is considered very important to carry out a needs assessment amongst local people to see if the proposed interventions address people's highest priority concerns.

Experience from the three feasibility studies carried out for the MES indicates that if an inter-disciplinary and flexible planning approach is followed then most predicted negative impacts can be avoided or minimised and benefits can be increased. However, the overall cumulative negative impacts on in-shore marine fisheries could be serious although the predicted decline irrespective of any MES intervention is so severe that the differential impact is not that great.

A significant problem with all of these proposed interventions is that the predicted value of the economic benefits is low and long term. Whilst social benefits could be used as an additional justification, they would need to be carefully targeted to be in line with government and any potential donor policies and priorities. Feedback is required from government to give its priorities and to see what type of project it is prepared to fund and under what conditions.

In addition the estimated intervention costs per beneficiary household are high, especially compared to other alternative uses of the resources, and other water sector proposed projects in Bangladesh (e.g. flood proofing at Jamalpur) that have recently been declined donor funding. Priorities need to be set at national level, perhaps as part of the National Water Master Plan, based upon likely economic resources that could be made available for development.

7.7 Feasibility study impact assessment

The self standing EIA documents for each of the MES feasibility studies all have a short summary, conclusions and recommendations in the front of them. In addition the feasibility study Main Reports have a 10 to 15 page environmental section which summaries the impact analysis and gives the conclusions, recommendations and future work programme. A significant conclusion is that there are no environmental grounds that seriously negate the benefits of the proposed interventions, however care is needed in implementation. For the two integrated development projects a long term phased approach is favoured with continuous monitoring.

8. EXTERNAL AND CUMULATIVE IMPACTS

8.1 Upstream constraints and impacts

The situation with regard to existing and future upstream constraints in the study area has been addressed in Section 2.7.1, including discussion of the potential impacts of Jamuna Bridge, the proposed Ganges Barrage, dredging of the Gorai river, a proposed barrage across the Brahmaputra and development in the upstream catchments outside Bangladesh.

The potential interventions shown in Figure 4.1, are unlikely to directly impact on the upstream areas, it is more the case that potential upstream developments need to be borne in mind when considering proposals for the MES area in case they could influence the effectiveness of the MES proposals. The main constraints that upstream developments could cause revolve around changes in flow velocity and sedimentation concentrations which could lead to different erosion and accretion patterns. It is thus vital that all upstream developments are subject to full environmental assessment, including consideration of external impacts, and a rational decision taking framework is in place to balance these issues. WARPO would seem to be the institution with the remit to do this.

Within the MES area there could be some complex interactions caused by changes in sedimentation, velocity, erosion and accretion. Again the EIA process needs to address these issues on a project by project basis but it is vital that baseline data collection programmes continue to collect the relevant data to monitor developments in these parameters. In addition the hydro-dynamic modelling needs to be perfected to allow the detailed impacts of possible interventions to be predicted. The next phase of the MES proposes to do this.

8.2 Downstream constraints and impacts

The existing and possible future downstream constraints have been outlined in Section 2.7.2. As with the upstream constraints and impacts, the main issues centre upon any induced changes in flow velocity, sedimentation concentrations, erosion and accretion. Again the hydro-dynamic modelling needs to be perfected to be able to predict these under a range of different scenarios. The EIA work for each proposed project would need to address these issues.

8.3 Cumulative impacts

It is highly unlikely that the full range of possible interventions shown in Figure 4.1 would ever be implemented. The results of the three feasibility studies carried out as part of the MES indicate that capital costs for accretion promotion and appropriate land development are high. It is hard to believe that any donor or the Government of Bangladesh would feel able to commit themselves to the resources needed to implement even part of the 25 year programme.

However there is a chance that some of the earlier phased interventions could be taken for further study and trial implementation in the foreseeable future. In such a situation there is concern that the aggregated impacts of separate interventions may be greater than the sum of their parts and may reach threshold levels at which sustainability in the natural environment may be threatened. There is a real concern that this may be the case with fisheries breeding and spawning habitats. A habitat monitoring programme for the three major Hilsha spawning areas is thus considered imperative, along with a gradual intervention strategy for any development in these areas.

8.4 Sea level rise

Discussion of the scenarios for sea level rise in the study area has been discussed in Sections 2.3.3, 2.7.4 and 3.4. The overall conclusion is that the predicted rate of rise in land level due to natural accretion is way in excess of even the most extreme scenario for sea level rise. The main difficulty is likely to occur in land that has already been embanked, although the predicted rise (0.27 metres by the year 2030) is relatively small when compared to tidal ranges and peak surges in the study Area. It is imperative however that the design of any new embankments and the rehabilitation of existing ones takes this into consideration. The planting of mangroves on embankment foreshores is also a very beneficial step in dissipation wave energy and reducing peak flood levels.

The implementation of any of the possible interventions will not create changes in general sea level, however there could be localised impacts on peak tide levels in some cases (particularly the Sandwip cross dam) which could negate their benefits. Such impacts would need to be addressed on a project by project case as part of the EIA process. Sea level rise is thus seen more as a general existing constraint to be designed for rather than an induced impact.

9. ENVIRONMENTAL MANAGEMENT

The most important requirement for sound environmental management in the MES area is to establish an appropriate integrated institutional structure that can oversee inter-disciplinary development in the area. The proposal to draw up an integrated coastal zone plan under an appropriate authority would be the first major step in the process, and has been discussed in Section 3.3. Until such an integrated approach exists then environmental management can only really be carried out on a project by project basis as part of the environmental assessment process. The following issues have been addressed as part of the three feasibility studies:

9.1 Environmental mitigation

From the results of the feasibility studies, the biggest drawback of any proposed land accretion promotion interventions in the study area is the relatively high cost and slow benefit stream of such projects. Provided that interventions are drawn up in a multi-disciplinary way with due regard for environmental considerations, there are, in general, very few serious negative impacts and hence little need for mitigation measures to ensure that no person is worse off as a result of any proposed intervention.

Some possible environmental mitigation measures have been identified for specific types of impacts. Such measures include the relocation of fishing ghats by constructing boat centres (Ref: BIWTA, 1994) and the provision of health centres with a specific remit to tackle malaria problems in forested areas.

The experience of the CPP/CERP projects indicate that the most effective mitigation can come from taking more care over the direct construction impacts. A methodology for assessing such impacts for coastal areas in Bangladesh has been developed and a checklist has been included as an annex in each of the feasibility studies. In order to achieve sound environmental management of construction works it is necessary to have an appropriate environmental input into the detailed design process, including the drawing up of environmental criteria for engineering design and the drafting of environmental management clauses in construction contracts. The necessary arrangements for enforcement of such clauses are also required.

9.2 Environmental enhancements

Environmental enhancements are those measures that can be taken to increase possible positive impacts of proposed interventions. Such measures should be an intrinsic part of sound environmental planning practise, but often need to be targeted in highly specific ways, often guided by policy aims and objectives. In the feasibility studies the main scope for such measures was found to be in managing direct construction impacts using the checklist approach developed for CPP/CERP.

9.3 Compensation measures

The main need for compensation measures for any proposed intervention in the MES area stems from the need for land acquisition, compensation and resettlement. In order to address such issues individual assessments are needed as part of feasibility studies. The basic aim is that nobody is to be made worse off as a result of the intervention. With careful planning the need for resettlement can be minimised and if well handled an actually produce an enhancement in the medium term.

9.4 Environmental monitoring

There is a pressing need to continue the collection of key environmental data carried out as part of the MES. The most important parameters are erosion and accretion which are best mapped and analysed by using time series satellite imagery. In addition the hydro-dynamic model needs to be refined by analysed adding data collected in the field on bathymetry, water levels and sediment load. Using the newly digitised Finmap DEM the existing cyclone simulation models could be improved. In addition there is a need to monitor the marine fisheries situation in the MES area and particularly the role of the off-shore island tips in providing spawning habitats for hilsha fish. Specific monitoring programmes needed for the three feasibility studies have been outlined in the self-standing EIA reports. Ideally the environmental monitoring of the area should be fed into an integrated coastal zone management framework as outlined in Section 3.3.

9.5 Public participation

The experience of the three feasibility studies has indicated that public participation work for the proposed interventions should be confined to carrying out a needs assessment. The results of such needs assessment can be fed back into the planning process to modify proposed interventions and in extreme cases radically alter them. More detailed participatory work should only be carried out once there is a firm commitment to fund and implement a project to avoid artificially raising the expectations of local people as has happened at Jamalpur (Ref: SOGREAH, June 1997 and March 1996).

9.6 Institutional arrangements for environmental management

The requirements for an appropriate inter-disciplinary institutional structure for implementing any proposed interventions have been outlined in the introduction to Section 9 above. It is reiterated that without such a structure there is little chance that the benefits of increased land accretion can be converted into tangible economic benefits, particularly at the household level. The difficulties experienced by CDSP in working with a large number of government departments demonstrate the need for a appropriate institution structure with a locally based decentralised operation for project implementation.

10. CONCLUSIONS, RECOMMENDATIONS AND ENVIRONMENTAL WORK PROGRAMME

10.1 Conclusions

10.1.1 Baseline conditions

The main issues that effect the MES area have been identified from the baseline assessment work and summarised in Section 2.8. They are:

- erosion processes
- accretion processes
- cyclones and flooding
- salinity
- drainage
- land tenure
- land use
- human health.

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10.1.2 Broad impact analysis of possible interventions

The conclusions of the impact analysis of main 20 intervention possibilities considered are:

- the impacts of engineering structural interventions are more complex and problematic than non-structural ones
- if structural interventions are used in appropriate locations and they are well designed, and hence effective, then they may give greater benefits than non-structural measures
- structural interventions are often more costly than non-structural ones and can cause greater negative impacts if they fail
- if failure of an intervention occurs then the results can be worse than doing nothing, especially for embankment construction, bank protection and river training
- intervention types need to be selected very carefully to be appropriate to the specific area concerned, so as to minimise negative environmental impacts and maximise benefits
- public participation should be an intrinsic part of the planning and design process so that local people's priorities can be considered
- an appropriate, decentralised institutional structure needs to be established for detailed project planning and implementation.

10.1.3 Conclusions of the pre-feasibility studies

The main environmental impacts and constraints for the three selected pre-feasibility studies and that would require particular study at IEE stage are:

- induced effects on erosion and accretion patterns
- the effect of closing off water passages causing inshore-marine flora and fauna habitat change and also having implications for inland rainfall drainage and waterborne navigation
- water and soil salinity as a constraint to development, restricting potential benefits
- implications for fisheries and socio-economic impacts on fishing households
- human nutrition and health consequences, particularly of changes in fish consumption patterns and waterborne disease vector habitats

The major conclusion of a preliminary analysis of the three proposed pre-feasibility studies is that extensive and highly detailed hydrological modelling is needed over the next five years for the three areas before detailed multi-sectoral studies should commence. In addition the detailed findings of monitoring the Haimchar geotextile trial and the first Nijhum Dwip cross dam (assuming it will be built) need to be fed back into the project planning process. It is considered very important to carry out a needs assessment amongst local people to see if the proposed interventions address people's highest priority concerns.

Experience from the three feasibility studies carried out for the MES indicate that if an inter-disciplinary and flexible planning approach is followed then most predicted negative impacts can be avoided or minimised and benefits can be increased. however the overall cumulative negative impacts on in-shore marine fisheries could be serious although the predicted decline irrespective of any MES intervention is so severe that the differential impact is not that great.

A significant problem with all of these proposed interventions is that the predicted value of the economic benefits is low and long term. Whilst social benefits could be used as an additional justification, they would need to be carefully targeted to be in line with government and any potential donor policies and priorities. Feedback is required from government to give its priorities and to see what type of project it is prepared to fund and under what conditions.

In addition the estimated intervention costs per beneficiary household are high, especially compared to other alternative uses of the resources, and other water sector proposed projects in Bangladesh (e.g. flood proofing at Jamalpur) that have recently been declined donor funding. Priorities need to be set at national level, perhaps as part of the National Water Master Plan, based upon likely economic resources that could be made available for development.

10.1.4 Conclusions of the feasibility studies

The self standing EIA documents for each of the MES feasibility studies all have a short summary, conclusions and recommendations in the front of them. In addition the feasibility study Main Reports have a 10 to 15 page environmental section which summaries the impact analysis and gives the conclusions, recommendations and future work programme. A significant conclusion is that there are no environmental grounds that seriously negate the benefits of the proposed interventions, however care is needed in implementation. For the two integrated development projects a long term phased approach is favoured with continuous monitoring.

10.2 Recommendations

The main recommendations from the environmental component of the MES are:

- environmental assessment procedures should be followed for each feasibility and pre-feasibility study outlined in the Master Plan, the overall strategy for which uses an area based development approach;

- adequate resources to carry out such an assessment process should be provided as an intrinsic part of the study process, along with sufficient time and specialist staffing to collect baseline data over a 12 month period at minimum and a suitable inter-disciplinary institutional structure;

- a decentralised integrated institutional structure needs to be set up for project implementation that is capable of co-ordinating all aspects rural development. At the present moment LGED is well placed to actually implement construction of some types of work and BWDB others;

- a development planning and implementation for the MES area needs to be put into the framework of an integrated coastal zone management plan with an appropriate inter-disciplinary institutional structure.

10.3 Future environmental work programme

The future environmental programme for the MES should be an integrated part of the Study, not separate. The first requirement is to continue the monitoring of key environmental parameters, particularly erosion and accretion, plus fisheries systems. For the next stage of the three feasibility studies there is a need for a environmental input into detailed design and particularly the drawing up of environmental management clauses for construction contracts. During the construction period adequate and effective management structures would need to be put in place to ensure adequate compliance to environmental management clauses in the contracts and also a monitoring programme with a feed back mechanism so that any changes that require action can be identified and steps taken to address them.

All future feasibility studies should have a full integrated non-engineering component, including an environmental assessment sub-component.

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REFERENCES AND BIBLIOGRAPHY

References are cited in the text of the report by author and date. Publications relating to wider issues in the area and giving more detail on associated subject matter are also included below. Readers interested in following this up are advised to consult Golam Monowar Kamal's Bibliography (Ref: Kamal, 1994).

Abdus Sattar Sayed, 1998, Introduction to Environmental Laws of Bangladesh, Ace Data Products, Dhaka, Bangladesh, 1998.

Abedin M Z and Quddus M A, March 1990, Household Fuel Availability and Homegardens in Selected Locations of Bangladesh, BARI, Gazipur, Bangladesh, 1990.

Adnan S, April 1988, Socio-Economic Trends in Greater Noakhali: 1975-1987, Research and Advisory Services for the Monitoring and Evaluation Unit NRDP/Danida, Noakhali, Bangladesh, 1988.

Asian Development Bank, January 1993, Forestry Master Plan, for the Ministry of Environment and Forests, Dhaka, Bangladesh, 1993.

Asian Development Bank, November 1991, Environmental Guidelines for Selected Agricultural and Natural Resources Development Projects, ADB, Manilla, Philippines, 1991.

Asian Development Bank, June 1991, Environmental Evaluation of Coastal Zone Projects: Methods and Approaches, ADB Environment Paper No 8, ADB, Manilla, Philippines, 1991.

Asian Wetlands Bureau, Date Unknown, A Directory of Asian Wetlands, (section on Bangladesh p 541-581), IUCN, Gland, Switzerland.

Bangladesh Bureau of Statistics, 1985 and 1992/1995, Census Data for 1981 and 1991 covering the 9 districts of the study area, BBS, Ministry of Planning, Dhaka, Bangladesh.

Bangladesh Bureau of Statistics, 1986-1995, Small Area Atlases for the 9 Districts of the study area, BBS, Ministry of Planning, Dhaka, Bangladesh.

Bangladesh Inland Water Transport Authority, 1994, Experimental Project for Improving the Efficiency and Profitability of Country Boat Operation, National Oceanographic and Maritime Institute, Dhaka, Bangladesh, 1994.

Bangladesh Unnayan Parishad, 1993, Bangladesh: Greenhouse Effect and Climate Change (a set of 7 reports), BUP, Dhaka, Bangladesh, 1993.

Bangladesh Water Development Board, November 1995, Second Bhola Irrigation Project, Piloting the Project Impact Monitoring System, BWDB, Ministry of Water Resources, Dhaka, Bangladesh, 1995.

Bangladesh Agricultural Research Council, 1990?, Salinity Problems and Crop Intensification in the Coastal Regions of Bangladesh, BARC, Bangladesh, 1990?

Bangladesh Agricultural Research Institute, July 1988, Homestead Plantation and Agroforestry in Bangladesh, BARI, Gazipur, Bangladesh, 1988.

Banu T, January 1995, Homestead Agriculture and Food Processing Project: Lessons Learnt and Their Replaceability, BARD, Comilla, Bangladesh, 1995.

BCAS, 1992, Cyclone '91 Revisited, BCAS, Dhaka, Bangladesh.

2016

BCAS, 1991, Cyclone 91, BCAS, Dhaka, Bangladesh.

BCAS, February 1989, National Seminar on Forest Resources Management in Bangladesh: Issues, Problems and Prospects, BCAS, Dhaka, Bangladesh, 1989.

Bird A, October 1993, Coastal Embankment Rehabilitation Project, Environmental Considerations for Project Implementation, for BCEOM/Kampsax, Cambridge, England, 1993.

Bangladesh Inland Water Transport Authority (BIWTA), 1994, Experimental Project for Improving the Efficiency and Profitability of Country Boat Operation, National Oceanographic and Maritime Institute, Dhaka, Bangladesh, 1994.

Bra mmer H, 1996, The Geography of the Soils of Bangladesh, University Press, Dhaka, Bangladesh, 1996.

Canonizado J A, April 1998, Integrated Forest Management Plan for the Noakhali Forest Division, Mandala Agricultural Development Corporation for the Forest Department, Ministry of Environment and Forests, Dhaka, Bangladesh, 1998.

Char Development Support Project (CDSP), 1998, CDSP Progress Report, Dhaka, Bangladesh, 1998.

Coastal Area Resource Development and Management Association, March 1989, The Greenhouse Effect and Coastal Area of Bangladesh, CARDMA, Dhaka, Bangladesh, 1989.

Coastal Area Resource Development and Management Association, 1989?, Coastal Resource Development and Management Part II, CARDMA, Dhaka, Bangladesh, 1989?

CARDMA, 1988, Bangladesh Coastal Area Resource Development and Management, Report 1, CARDMA, Dhaka, Bangladesh, 1988.

Carpenter R A and Maragos J E, October 1989, How to Assess Environmental Impacts on Tropical Islands and Coastal Areas, Environment and Policy Institute, East-West Center, Honolulu, Hawaii, U.S.A.

Community Development Library, January 1992a, Living with Cyclone, CDL, Dhaka, Bangladesh, 1992.

Community Development Library, January 1992b, The April Disaster, CDL, Dhaka, Bangladesh, 1992.

Department of Environment, June 1997, EIA Guidelines for Industries, Ministry of Environment and Forest, Dhaka, Bangladesh, 1997.

Department of the Environment, 1995, National Environment Management Action Plan: Volume 1 Summary, Volume II Main Report, Ministry of Environment and Forest, Dhaka, Bangladesh.

Department of Environment, 1993, Water Quality Data of Rivers (1981-1990), DoE, Dhaka, Bangladesh, 1993.

DHV Consultants BV, December 1997, Interim Development Plan, Meghna Estuary Study, for the Bangladesh Water Development Board, Ministry of Water Resources, Dhaka, Bangladesh, 1997.

DHV Consultants BV, June 1997, Meghna Estuary Study, Technical Note MES 009, Time series Analysis of Erosion and Accretion, for BWDB, MWR, Dhaka, Bangladesh.

208

DHV Consultants BV et al, April 1996, Meghna Estuary Study, Inception Report, 3 Volumes, for the Bangladesh Water Development Board, Ministry of Water Resources, Dhaka, Bangladesh, 1996.

Dougherty T C and Hall A W, March 1995, A Guide to the Environmental Impact Assessment of Irrigation and Drainage Projects in Developing Countries, HR Wallingford, UK, 1995.

EGIS, June 1996, Spatial Representation and Analysis of Hydraulic and Morphological Data, for WARPO, Ministry of Water Resources, Dhaka, Bangladesh, 1996.

Environmental Resources Limited, July 1992, Environmental Assessment of the Coastal Embankment Rehabilitation Project, for the Co mmission of the European Communities, Brussels, Belgium, 1992.

ESCAP, 1987?, Coastal Environmental Management Plan for Bangladesh, Volume 2 Final Report, Economic and Social Co mmission for Asia and the Pacific, Bangkok, Thailand, 1987.

European Co mmission, 1995? DG VIII - Users Guide to Environmental Procedures, EC, Brussels, Belgium, 1995?

European Co mmission Dhaka, June 1996, Notes to Assist TA in the Implementation of EC Financed Projects in Bangladesh, EC, Dhaka, Bangladesh, 1996.

FAO, March 1997, Support to Master Plan for the Forestry Sector, Extracts From Second Mission Report, for the Ministry of Environment and Forest, Dhaka, Bangladesh, 1997.

Fountain Renewable Resources Ltd, September 1993, Tree and Palm Plantation Project in Cyclone Prone Areas of Bangladesh, Inception Report, 1993.

FPCO (now WARPO), September 1995, Bangladesh Water and Flood Management Strategy, FPCO, Ministry of Water Resources, Dhaka, Bangladesh, 1995.

FPCO (now WARPO), October 1992, Guidelines for Environmental Impact Assessment, FPCO, Ministry of Irrigation, Water Development and Flood Control, Dhaka, Bangladesh, 1992.

FPCO (now WARPO), May 1992 revised March 1994, Guidelines for Project Assessment, FPCO, Ministry of Irrigation Water Development and Flood Control, Dhaka, Bangladesh, 1992 revised March 1994 with new Annex 1.

Geological Survey of Bangladesh, November 1979, Seismic Zoning Map of Bangladesh and Outline of a Code for Earthquake resistant Design of Structures, Geological Survey of Bangladesh, Dacca, Bangladesh, 1979.

Goffau A, December 1994, Char Development and Settlement Project: Environmental Aspects, Mission Report No 5, Haskoning, Dhaka, Bangladesh, 1994.

Government of the People's Republic of Bangladesh, Bangladesh District Gazetteers, Noakhali 1977, Bakerganj 1980, Patuakhali 1982), Cabinet Secretariat Establishment Division, Bangladesh Government Press, Dhaka, Bangladesh, 1977, 1980 and 1982.

Halcrow et al, February 1995, Topic Report on Pesticide and Fertilizer Use in Bangladesh, National Minor Irrigation Development Project, for the Ministry of Agriculture, Dhaka, Bangladesh, 1995.

Halcrow, 1994, BWDB Systems Rehabilitation Project, Feasibility Reports:
Polder 58/3 - Char Faizuddin Sub-Project, August 1992
Polder 35/1 Sub-Project - Sarankhola, October 1994
Polder 73/1A,B Sub-Project - North Hatia, October 1994
Polder 73/2 Sub-Project - South Hatia, October 1994

For the Bangladesh Water Development Board, Ministry of Irrigation, Water Development and Flood Control, Dhaka, Bangladesh, 1994.

Halcrow, August 1993, Southwest Area Water Resources Management Project, Final Report:
Volume 6 Land Resources, Agriculture and Fisheries
Volume 7 Forestry and Navigation
Volume 9 Impact Studies
Volume 13 Pre-Feasibility Study of Selected Projects
for FPCO, Ministry of Irrigation, Water Development and Flood Control, Dhaka, Bangladesh, 1993.

Halcrow, 1992, River Training Studies on the Brahmaputra River, Environmental Impact Assessment, for the Bangladesh Water Development Board, Dhaka, Bangladesh, 1992.

Hamilton L S and Snedaker S C, 1984, Handbook for Mangrove Area Management, IUCN, Gland, Switzerland, 1984.

Haroun Er Rashid, 1991, The Geography of Bangladesh, 2nd revised Edition, University Press Ltd, Dhaka, Bangladesh, 1991.

Haskoning, 1992, Meghna River Bank Protection - Short Term Study, for the Bangladesh Water Development Board, MIWR, Dhaka, Bangladesh, 1992.

Hunting Technical Services, September 1992, Social Forestry and FCD/I Project Maintenance, for the Flood Plan Co-ordination Organisation, Ministry of Irrigation, Water Development and Flood Control, Dhaka, Bangladesh, 1992.

International Centre for Diarrhoeal Disease Research Bangladesh, 1996, Annual Report 1995, ICDDR-B, Dhaka, Bangladesh, 1996.

International Centre for Diarrhoeal Disease Research Bangladesh, April 1985, An Evaluation of the ICDDR-B Training Programme: Diarrhoeal Disease Epidemic Control, ICDDR-B, Dhaka, Bangladesh, 1985.

International Centre for Diarrhoeal Disease Research Bangladesh, August 1978, Index to Publications and Scientific Presentations 1960-1976, ICDDR-B, Dhaka, Bangladesh, 1978.

International Co mmission on Irrigation and Drainage, 1993, The ICID Environmental Check-List, HR Wallingford, UK, 1993.

ISPAN, June 1995, A Study of Sedimentation in the Brahmaputra-Jamuna Floodplain, for FPCO, Ministry of Water resources, Dhaka, Bangladesh, 1995.

ISPAN, April 1995a, Manual for Environmental Assessment, for FPCO, Ministry of Water Resources, Dhaka, Bangladesh, 1995.

ISPAN, April 1995b, Charland Summary Report, for FPCO, Ministry of Water Resources, Dhaka, Bangladesh, 1995.

ISPAN, April 1995c, The Dynamic Physical and Human Environment of Riverine Charlands: Brahmaputra-Jamuna, for FPCO, Ministry of Water Resources, Dhaka, Bangladesh, 1995.

ISPAN, April 1995d, The Dynamic Physical and Human Environment of Riverine Charlands: Meghna, for FPCO, Ministry of Water Resources, Dhaka, Bangladesh, 1995.

ISPAN, April 1995e, Upper Meghna Charland, Socio-Economic RRA, for FPCO, Ministry of Water Resources, Dhaka, Bangladesh, 1995.

ISPAN, April 1995f, Meghna Confluence Charland Socio-Economic RRA, for FPCO, Ministry of Water Resources, Dhaka, Bangladesh, 1995.

ISPAN, 1994, Environmental Impact Assessment Case Study, Bhelumia-Bheduria Project (Bhola), for the Flood Plan Coordination Organization, Ministry of Irrigation Water Development and Flood Control, Dhaka, Bangladesh, 1994.

ISPAN, September 1993, An Outline of Policies and Legislation Related to Environment in Bangladesh, for the Flood Plan Coordination Organisation, Ministry of Irrigation, Water Development and Flood Control, Dhaka, Bangladesh, 1993.

International Union for the Conservation of Nature and Natural Resources, July 1991, The National Conservation Strategy of Bangladesh, Ministry of Environment and Forest, Dhaka, Bangladesh, 1991.

International Union for the Conservation of Nature and Natural Resources, December 1989, Embankment Conservation and Enhancement for the Meghna-Dhonagoda Irrigation Area, IUCN, Gland, Switzerland, 1989.

Jayasinghe A P and Rahman M, April 1993, Gumti Phase II Sub-Project: Hydraulic Gates and Other Electro-Mechanical Gates, for Mott MacDonald Limited, Dhaka, Bangladesh, 1993.

Kamal G M, 1994, Environmental Bibliography of Bangladesh, Swedish International Development Authority, Dhaka, Bangladesh, 1994.

Kampsax International A/S, May 1992, Cyclone Protection Project -FAP 7, Final Project Preparation Report, Appendix H Afforestation, Appendix J Fisheries, for the Ministry of Irrigation, Water Development and Flood Control, Dhaka, Bangladesh, 1992.

Karim A, January 1992, Vegetation Ecology of the Sundarbans - Annotated Bibliography, ISPAN, Dhaka, Bangladesh, 1992.

LGED, September 1995, Technical Report on Sandwip-char Elahi Road Link Proposal, institutional Support Project, Local Government Engineering Department, Dhaka, Bangladesh, 1995.

Land Reclamation Project, December 1990, Feasibility Study on South Hatia Cross-Dams, Bangladesh Water Development Board, Dhaka, Bangladesh, 1990.

Land Reclamation Project, November 1990, Soil, Agriculture, Land Use and Salinity Investigation of South Hatia-Nijhum Dwip Project, for Bangladesh Water Development Board, Dhaka, Bangladesh, 1990.

Sir M MacDonald and Partners Limited, October 1993, South East Region Water Resources Development Programme, Noakhali North Drainage and Irrigation Feasibility Study, Executive Summary, Volume 1 Main Report, Volume 3 Annex D Ecology, Volume 4 Annex E Agriculture, Volume 5 Annex F Fisheries, Volume 6 Annex G, Sociology and Public Participation, Volume 7 Annex H, Environmental Impact Assessment, for UNDP/World Bank and BWDB, MIWDFC, Dhaka, Bangladesh, 1993.

Sir M MacDonald and Partners Limited, August 1993, South East Region Water Resources Development Programme, Regional Plan Report:
Volume 1 Part 1 The Existing Situation,
Volume 2 Part 2 The Regional Water Plan
for Bangladesh Water Development Board, Ministry of Irrigation, Water Development and Flood Control, Dhaka, Bangladesh, 1993.

Sir M MacDonald and Partners Limited, 1992, South East Region Water Resources Development Programme, Regional Plan Report, Annexes Volume III, Annex I Soils, Annex II Agriculture, Annex

III Socio-economics, Annex IV Environment, for World Bank and Government of Bangladesh, Dhaka, Bangladesh, 1992.

Sir M MacDonald and Partners Limited, August 1991, South East Regional Study, Draft Initial Environmental Evaluation, Dhaka, Bangladesh, 1991.

Ministry of Environment and Forest, 1995, National Environment Management Action Plan (NEMAP), Volume Ia Summary, Volume II Main Report, MoEF, Dhaka, Bangladesh, 1995.

Ministry of Environment and Forest, 1992, Environment Policy and Environmental Action Plan, Ministry of Environment and Forest, Dhaka, Bangladesh, 1992.

Ministry of Land, 1996, Adars ha Gram Project Annual Report for 1995, MoL, Dhaka, Bangladesh.

Ministry of Water Resources, August 1994, Guidelines for People's Participation in Water Development Project, MWR, Dhaka, Bangladesh, 1994.

Mott MacDonald Limited, June 1993, Gumti Phase II, Sub-Project Feasibility Study, Draft Final Report, Annex on Sociology and Public Participation, for the World Bank, Dhaka, Bangladesh, 1993.

Mott MacDonald International Ltd, October 1992, Working Paper No 9, Concept Plan for Integrated Coastal Management, for the Disaster Coordination and Monitoring Unit of the Ministry of Relief, Dhaka, Bangladesh.

Rahman A and Huq S, June 1990, Feasibility Study on South Hatia Cross-Dams: Environmental Report, for Land Reclamation Project, Bangladesh Water Development Board, Dhaka, Bangladesh, 1990.

Rahman R, September 1990, Towards Sustainable Development: Land Resources in Bangladesh, IUCN, Dhaka, Bangladesh, 1990.

Rennell J, 1776, An Actual Survey of the Provinces of Bengal, Bahar &c. Published by Laurie & Whittle, London, England, May 1794.

Rhein-Ruhr Ing et al, 1993, Bank Protection and River Training (AFPM) Pilot Project FAP 21/22, Final Report Planning Study, Volume IV, Annex 8, Environmental Assessment, for the FPCO, Ministry of Irrigation, Water Development and Flood Control, Dhaka, Bangladesh, 1993.

Sener Ingenieria y Sistemas SA, June 1996, Cyclone Shelter Preparatory Study, Stage 1 Feasibility Phase, Draft Final Report:
-Supporting Volume 1, Mathematical Modelling of Cyclone Surge and Related Flooding, Part B Appendices
-Thana Overview Report- Hatia Thana
for the European Co mmission, Dhaka, Bangladesh, 1996.

Soil Resources Development Institute, 1989-1995, Thana Land and Soil Utilisation Guides (in Bangla):
Barisal Sadar Thana, August 1989
Sitakunda Thana, November 1990
Raipur Thana, August 1991
Bauphal Thana, August 1991
Kalapara Thana, September 1991
Bhola Sadar Thana, July 1993
Hatiya Thana, March 1995
Dashmina Thana, June 1995
SRDI, BARC, Ministry of Agriculture, Dhaka, Bangladesh.

SOGREAH et al, June 1997, Jamalpur Project Refinement Study, Executive Summary, for the Water Resources Planning Organisation, Ministry of Water Resources, Dhaka, Bangladesh, 1997.

SOGREAH/Halcrow, March 1996, Jamalpur Project Refinement Study (FAP-3.1), Discussion Paper for People's Participation, for the Water Resources Planning Organisation, Ministry of Water Resources, Dhaka, Bangladesh, 1996.

Sorensen J and West N, June 1990, Impact Assessment and Coastal Management, International Coastal Resources, Management Project, Coastal Resources Center, University of Rhode Island, U.S.A.

Thompson P and Johnson D, October 1996, Birding in Bangladesh, Dhaka, Bangladesh, 1996.

Thompson P, 1990, The Impact of Flood Control on Agriculture and Rural Development in Bangladesh: Post-evaluation of the Chandpur Project, Flood Hazard Research Centre, Middlesex Polytechnic, Endfield, London, England, 1990.

UNDP, 1997, Human Development, UNDP, Rome, Italy, 1997.

UNDP, April 1995, Human Development in Bangladesh, UNDP, Dhaka, Bangladesh, 1995.

USAID, January 1991, Urban Impacts on the Coastal Zones of Developing Countries: Problem Identification and Recommentations for Mitigations, USAID, Washington D.C. USA, 1991.

World Bank (Ed Post and Lundin), 1996, Guidelines for Integrated Coastal Zone Management, World Bank, Washington, USA, 1996.

World Bank, 1991, OD 4:01 Environmental Assessment, The World Bank, Washington, USA, 1991.

World Bank, 1990, OD 4:30 Involuntary Resettlement, The World Bank, Washington, USA, 1990.

APPENDICES

LIST OF TABLES

Table I.1 : Flora species list

Scientific Name	Family	English Name	Local Name
Abelmoschus esculentus	Malvaceae	Lady's finger	Dheras
Acacia auriculiformis	Leguminosae		Akashmoni
Acacia nilotica	Leguminosae	Babul tree	Babla
Acanthus illicifolius	Acanthaceae		Hargozakata
Achras sapota		Sapota	Safeda
Aegle marmelos	Rutaceae	Wood apple	Bel
Albizia lebbeck	Leguminosae	Indian walnut	Sirish
Albizia procera	Leguminosae	White siris	Koroi
Allium cepa		Onion	Peaj
Allium sativum		Garlic	Rosun
Alocasia indica	Araceae	Glant taro, Arum	Mankachu
Alternanthera philoxeroides	Amaranthaceae		Helencha
Amaranths lividus		Amaranths	Danta
Annona reticulata		Bullock heart	Nona
Anthocephalus chinensis	Rubiaceae		Kadam
Areca catechu	Palmae	Betel nut	Supari
Artocarpus chaplasha			Chambal
Artocarpus heterophyllus	Moraceae	Jackfruit	Kanthal
Averrhoa carambola		Carambola	Kamranga
Azadirachta indica	Meliaceae	Margosa tree	Nim
Bambusa tulda	Gramineae	Bamboo	Jowa bans
Barringtonia acutangula		Indian Oak	Hijal
Basella alba	Basellaceae	Malabar night shade	Pui
Benincasa hispida	Cucurbitaceae	White gourd	Chalkumra
Bombax ceiba	Bombacaceae	Red silk cotton tree, kapok	Shimul
Borassus flabellifer	Palmae	Palm tree	Tal
Brassica oleracea var. botrydis	Cruciferae	Cauliflower	Fulkapi
Bruguiera gymnorhiza	Rhizophoraceae		Kankra
Cajanus cajan	Leguminosae	Pigion pea	Arohar
Calamus viminalis	Palmae	Rattan, cane	Bet
Callophyllum inophyllum	Gultiferae		Ponyal
Calotropis gigantia	Asclepiadaceae		Akanda
Calotropis procera	Asclepiadiacea	Milk weed	Swet akanda
Capsicum annum	Solanaceae	Chilly	Kachamarich
Carica papaya	Caricaceae	Papaya	Pepe
Carissa carandus		Karanda	Karamcha
Citrus aurantifolia	Rutaceae	Lemon	Lebu
Citrus grandis	Rutaceae	Grapefruit	Jambura
Cassia fistula	Leguminosae		Bandarlathi, Sonali
Casuarina equisetifolia	Casuarinaceae		Jhau
Chrysopogon aciculatus	Gramineae		Chorekanta
Chrysopogon aciculatus	Graminae		Premkata
Clynogyne dichotoma	Marantaceae		Patipata
Cocos nucifera	Palmae	Coconut palm	Narikel, Dab
Codiaeum variegatum	Euphorbiaceae		Patabahar
Colocasia esculenta	Araceae	Common arum	Kachu

Scientific Name	Family	English Name	Local Name
Cucurbita maxima	Cucurbitaceae	Pumkin	Mistikumra
Curcuma longa		Turmeric	Halud
Cynodon dactylon	Gramineae	Bahama grass	Durba, Durbaghas
Dalbergia sisso	Leguminosae	Sissoo	Sishookat
Delonix regia	Leguminosae		Krishnachura
Derris indica	Leguminosae		Karanja
Derris trifoliata	Leguminosae		Gilalata
Diospyros peregrina	Ebenaceae	Wild mangosteen	Gab
Dolichos lablab		Country bean	Sim
Elettaria cardamomum		Cardamum	Alachi
Enhydra fluctuans	Composiatae		Helencha
Eriocaulon sp	Eriocaulaceae		Ghaspata
Erythrina variegata	Leguminosae	Ceral tree	Mandar
Eugenia javanica		Waxapple	Jamrul
Euphorbia hirta	Euphorbiaceae		Dudhia
Exoecaria agallocha	Euphorbiaceae		Gewa
Ficus altissima	Moraceae		Bot
Ficus benghalensis	Moraceae	Banyan tree	Bot
Ficus hispida	Moraceae	Banyan tree	Kakdumur
Ficus religiosa	Moraceae		Panbot
Gumelina arbaria		White teak	Gamari
Hibiscus esculentus		Okra	Dharas
Hibiscus tiliaceus	Malvaceae		Bhola
Imperata cylindrica	Gramineae		Ulukhor
Ipomoea aquatica	Convolvulaceae	Water bird weed	Kalmi
Ipomoea batatus	Convolvulaceae	Sweet potato	Misti alu
Ipomoea fistulosa	Convolvulaceae	Moon flower	Dholkalmi
Lablab purpureus	Leguminosae	Common Bean	Sim
Lagenaria siceraria	Cucurbitaceae	Bottle gourd	Lau
Lannea coromandelica	Anacardiaceae		Bhadi, Jiga
Lathyrus sativus	Leguminosae	Chicklingvetch	Khesari
Leucaena leucocephala	Leguminosae		Telikadam
Luffa acutangala	Cucurbitaceae	Ribbed luffa	Jhinga
Mangifera indica	Anacardiaceae	Mango	Am
Manilkarka zapota	Sapotaceae	Sapota	Safeda
Momordica charantea	Cucurbitaceae	Bitter gourd	Karalla
Momordica cochinchinensis		Spiny gourd	Kankrol
Moringa oleifera	Moringaceae	Horse Raddish, ben oil tree, Round drum	Sajna
Musa sapientum	Musaceae		Kola
Myriostachya wightiana	Gramineae		Dhanshi
Nymphaea nouchali	Nymphaeaceae	Water lily	Shapla
Oryza sativa	Gramineae	Paddy	Dhan
Pandanus foetidus	Pandanaceae		Kewakata
Peper betel		Betel leaf	Pan
Phoenix sylvestris	Palmae	Date palm	Khejur
Phyllanthus amaras	Euphorbiaceae		Bhui amla
Pimenta acris		Bay leaf	Tejpata

Scientific Name	Family	English Name	Local Name
Polyalthia longifolia	Annonaceae		Debdaru, Saralgoch
Pongamia pinnata	Leguminosae	Indian beach	Karanja, Karamcha
Psidium guajava	Myrtaceae	Guava	Peyara
Punica granatum		Pomegranate	Dalim
Raphanus sativus		Radish	Mula
Ricinus communis	Euphorbiaceae	Castor oil plant	Veranda
Saccharum spontaneum	Gramineae	Thatch grass	Kash, Kaicha
Samanea saman	Leguminosae	Raintree	Raintree
Solanum melongena		Eggplant	Begun
Sonneratia apetala	Sonneratiaceae		Keora
Sonneratia caseolaris	Sonneratiaceae		Saila/Shyola
Spinacea oleracea	Chenopodiaceae	Spinach	Palongshak
Swietenia mahagoni	Meliaceae		Mehogini
Syzigium cumini	Myrtaceae	Black plum	Jam
Tamarindus indica	Leguminosae	Tamarind	Tetul
Terminalia arjuna	Combretaceae	Arjuna tree	Arjun
Terminalia catappa		Indian almond	Badam
Trichosanthes anguina	Cucurbitaceae	Snakegourd	Chichinga
Trichosanthes diocia		Pulwal	Patal
Typha elephantina	Typhaceae	Elephant grass	Hoglapata
Vigna mungo	Leguminosae	Black gram	Mash kalai
Vigna radiata	Leguminosae	Green gram	Moog
Vigna sinensis	Leguminosae	Cowpea, String bean	Barbati
Vitex negundo	Verbenaceae		Nishinda
Xanthium indicum	Compositae		Ghagra
Xeromphis spinosa	Rubiaceae		Mainakata
Zizyphus jujuba	Rhamnaceae	Indian jujube	Baroi
Zizyphus mauritiana	Rhamnaceae	Indian plum	Kul

Source: Master List from Bangladesh National Herbarium and Field Verification, 1997 - 1998.

Note : The Flora species list consists of Timber species, Economic tree species and Vegetable species

Table I.2 : Fauna species listing

Bangla Name	English Name	Scientific Name	Remarks
REPTILES			
Ajagar	Python	Python molurus	I
Anjila	Skink	Mabuya carinata	C
Atail kacho	Blind snake	Typlina porrectus	C
Darash sap	Rat snake	Ptyas mucosus	C
Dora sap	Checkered keelback	Xenochrophis piscator	C
Gokhra sap	Cobra	Naja naja	UC
Jalbora	Dogfaced water snake	Cerberus phynchops	UC
Kalo gui	Monitor lizard	Varanus bengalensis	IT
Kasim	Flap - shell turtle	Lissemys punctata	C
Kochchop	Tortoise	Kachuga tecta	C
Laldora	Rednecked keelback	Rhabdophis subminiata	C
Matia sap	Olive keelback	Enhydris enhydris	C
Roktochosa	Garden lizard	Calotes sp.	UC
Sona gui	Yellow lizard	Varanus flaviscence	UC
Tiktikee	Wall lizard	Hemidactylus	C
Tokkhok	Gecko	Gecko gecko	UC
AMPHIBIANS			
Kotkoti bang	Skipper frog	Rana Cyanophlyctis	UC
Kuno bang	Toad	Bufo melanostictus	C
Sona bang	Bullfrog	Rana tigrina	UC
BIRDS			
Ababil	Palm swift	Cypslurus pervus	C
Bali hans	Lesser whistling teal	Dendrocygna javanica	C
Baz	Kestrel	Falco tinnunculus	C
Bhatsalik	Common myna	Acridotheres tristis	C
Bhuban cheel	Periah kite	Milvus migrans	C
Boro bok	Great egret	Bubulcus ibis	C
Bulbul	Red-vented bulbul	Pycnonotus jacosus	C
Cheuya pakhi			
Chonkho cheel	Brahminy kite	Haliaster indus	C
Chorui	House sparrow	Passer domesticus	C
Dahuk	Water hen	Gallicrex cinerea	C
Darkak	Jungle crow	Corvus macrorynchos	C
Doyal	Magpie robin	Copsychus saularis	C
Finga	Black drongo	Dicrurus macrocercus	C
Go salik	Pied myna	Sturnus contra	C
Holdey Pakhi	Blackheaded oriole	Oriolus xanthomus	UC
Hot titi	Red-wattled lapwing	Vanellus indicus	C
Jhuti salik	Jungle myna	Acridotheres fuscus	C
Kabutor	Pigeon		
Kali bok	Black bittern	Ixobrychus flavicollis	C
Kalo pipi	Coot	Fulica atra	C
Kani bok	Pond heron	Ardeola grayii	C
Kokil	Koel	Eudynamys scolopacea	C
Kura	Grey-headed fishing eagle	Icyhthophaga ichthydetus	R
Lal bok	Cinnamon bittern	Ixobrychus cinnanmeocus	C

Bangla Name	English Name	Scientific Name	Remarks
Machranga	White-throated kingfisher	Halcyon pileata	C
Mala gugu	Ring dove	Streptopeliatranquebarica	UC
Mautushi	Purple sunbird	Nectarinia asiatica	C
Nishi bok	Night heron	Nycticorax nycticorax	UC
Nishichor	Nightijar	Caprimulgus macrunus	UC
Nol bok	Grey heron	Ardea cinerea	C
Pancowri	Little cormorant	Phalacrocorax carto	UC
Papya	Pied grested cuckoo	Clamator jacobinus	UC
Patikak	House crow	Corvus splendens	C
Sada bok	Little egret	Egretta garzetta	C
Sada cheel	Black - wing kite	Elanus cacruleus	C
Satbhai	Common babbler	Turdoides striatus	C
Showkoon	White - backed Vulture	Gyps bengalensis	UC
Suichora	Common bee eater	Merops leschenaulti	C
Teya	Perakeet	Psittacula krameri	C
Tuntune	Tailor bird	Orthotomus sutorius	C
Utala pakhi			
MAMMALS			
Badur	False vampire bat	Megaderma lyra	C
Banar/ Bandar	Monkeys	Macaca mulatta	I
Bege	Mongoose	Herpestes edwardsi	C
Chika / Suchey	House shrew	Suncus murinus	C
Chitra Harin	Spotted deer	Axis axis	I
Indur	Rat	Bandicota bengalensis	C
Kathbiraly	Squirrel	Callosciurus pygerythrus	UC
Khargosh	Rabbit	Caprolagus hispidus	UC
Sehsu, Chuchum	Gangetic dolphin	Platanista gangetica	C (SW)
Uud	Otter	Lutra perspicillata	IT

Note: C = Common, UC = Uncommon, R = Rare, IT = Internationally Threatened,
I = Recently Introduced

Source : Checklist of FAP16 Bhola EIA and Thompson 1996. Field Interviews, March/April 1997.

Table I.3 : Fish species listings

Bengali name	English name	Scientific name	Remarks	
			Status	Habitat
Achila/Tiktiki machh	Greater lizard fish	*Saurida tumbil*	F	OS
Air		*Mystus aor*	F	RC
Baga champa Chingri	Shrimp	*Penaeus merguensis*	C	OS
Bagatara Chingri	Shrimp	*Penaeus semisalcus*	F	IS
Bagatara Chingri	Shrimp	*Penaeus semisulcatus*	C	OS
Bagda Chingri	Shrimp	*Penaeus monodon*	C	IS
Bagda Chingri	Shrimp	*Penaeus monodon*	C	OS
Baim	Spiny eel	*Mastacembelus armatug*	C	VWB
Batashi		*Pseuttotropius atheronoides*	C	VWB
Bele		*Glossogobius giuris*	C	R,C,CR
Berguni	Therapon perch	*Therapon jarbua*	F	OS
Bhetki/koral mach	Giant sea perch	*Lates calcarifer*	F	IS
Bhetki/Koral mach	Giant sea perch	*Lates calcarifer*	F	OS
Bom maittya	Eastern little tuna	*Euthynmus affinis*	C	OS
Catla	Carp	*Catla catla*	C	P
Chaga Chingri	Shrimp	*Penaeus indicus*	C	OS
Champa	Indian mackeral	*Rastrelliger kanagurta*	C	OS
Chan chanda	Moon fish	*Mene maculata*	C	OS
Chhuri machh	Ribbon fish	*Lepturacanthus sevala*	F	OS
Chingri	Tiger shrimp	*Penaeus monodon*	F	F.C.
Darkuta	Forsteis barrawda	*Sphyraena forsteri*	C	OS
Dom mach	Silver- biddies	*Gerres filamentosus*	F	OS
Dora kata Chingri	Shrimp	*Penaeus japanicus*	C	OS
Dorakata Chingri	Shrimp	*Penaeus japanicus*	F	IS
Folichanda	Silver pomfret	*Pampus argentens*	C	OS
Gajar	Snakehead	*Canna marulius*	R	P
Gang Tengra	Cat fish	*Gangata viridescens*	F	C
Ghhoa Icha	Lobster	*Panulirus polyphagus*	F	OS
Golda Chingri	Prawn	*Macrobrachium rosenbergi*	F	IS
Goti poa	Croaker	*Otolithes macuptus*	F	OS
Gura Icha	Shrimp	*Nematopalaemon tenuipes*	F	IS
Hail chanda	Black pomfret	*Parastromateus niger*	C	OS
Hatir kann	Spade fish	*Ephippus orbis*	C	OS
Haturi Hanger	Hammer-hedded shark	*Sphyma blochii*	F	OS
Haush/Sankush	Sting ray	*Himanture uarnak*	C	OS
Hichiri machh	White sardine	*Escualosa thoracata*	F	OS
Hilsha	Hilsha shad	*Hilsha ilisha*	C	IS, OS
Horine Chingri	Shrimp	*Metapenaeus monoceros*	C	OS
Hundra machh	Laddy fish	*Sillago domina*	F	OS
Jagri	Silver- biddies	*Pentaprion longmanus*	F	OS
Kala poa	Spotted croaker	*Protonibea diacanthis*	C	OS
Kalabaus	Carp	*Labeo calbasu*	C	P
Kamat/Hangar	Milk shark	*Scoliodon walbeehmii*	C	OS
Kata mach	Cat fish	*Arius* s.p	C	IS
Kata mach	Cat fish	*Arius* s.p	F	OS
Khorul	Mullet	*Liga subvirdis*	F	OS
Kukurjib	Long tongue sole	*Cynoglossus lingua*	C	OS
Laita	Bombay duck	*Herpodon nehereus*	F	IS
Lakhua	Indian salmon	*Polynemus indicus*	C	OS

Bengali name	English name	Scientific name	Remarks	
			Status	Habitat
Lal chewa		*Odontamblyopus rubicundus*	C	IS, OS
Lal datina	Longspine sea bream	*Argyrops spinifer*	C	OS
Lal poa	Silver pennah croaker	*Johnius argentatus*	C	OS
Loittya mach	Bombay duck	*Harpodon nehereus*	C	OS
Moori	Djeddaba crevalle	*Alepes djeddaba*	C	OS
Mrigal	Carp	*Cirrhinus mrigola*	C	P
Murbailla	Flat head fish	*Platycephalus indicus*	F	OS
Nuilla	Squid	*Loligo* s.p	F	OS
Nunatengra/Guilla	Bagrid catfish	*Mystus gulio*	F	OS
Nune Cheai	Cuttle fish	*Sepia* s.p	F	OS
Octopus	Common octopus	*Octopus vulgaris*	C	OS
Olua	Pointed tail anchovy	*Collia dussumieri*	R	OS
Pangas	Cat fish	*Pangasius pangasius*	R	C
Pangas	Fatty cat fish	*Pangasius pangasius*	R	IS
Pangas	Fatty cat fish	*Pangasius pangasius*	R	OS
Pann mach	Sickle fish	*Derepane longimanna*	C	OS
Pari machh	Purple spotted (big eye)	*Pariacanthus tayenus*	R	OS
Phasa	Moustached thryssa	*Thryssa mystax*	F	OS
Phase	Moustached thrysa	*Thrysa mystax*	F	IS
Pitabri	Skate	*Rhycholbatus djeddensis*	F	OS
Poa	Croaker	*Otolithes cuviert*	C	IS
Poa	Croker	*Otolithes cuviert*	C	OS
Ranga choukya	Red snapper	*Lutjanus johni*	F	OS
Ruda Chingri	Shrimp	*Parapenaeopsis scuptilis*	C	OS
Rui	Carp	*Labeo rohita*	C	P
Rupban	Bream	*Nemipterus japanicus*	F	OS
Rupchanda	Chinese pomfret	*Pampus chinensis*	C	OS
Sada datine	Lined silver grunter	*Pomadasys hasta*	F	OS
Sadha mach	Falsh trevally	*Lactarius lactarius*	C	OS
Samudra serboti	Indian halibut	*Psettodes erumei*	R	OS
Shada chewa		*Tryauchen vagina*	C	C
Shada chewa		*Tryanchen vagina*	C	IS
Shingi	Catfish	*Heteropneustes fossilis*	C	CR,C,P
Shol	Snakehead	*Channa striatus*	R	P
Sila / Gool kakra	Mud crub	*Scylla serrata*	C	IS
Sonali bata	Goat fish	*Upeneus sulphurens*	F	OS
Surma machh	Mackerel	*Scomberomorus commerson*	C	OS
Taka chanda	Shortnose pouy fish	*Leiognathus brevirostris*	C	OS
Tapsi	Paradisethread fin	*Polynemus paradiscus*	C	IS
Teilla phasa	Harifin anchory	*Setipinnae taty*	F	OS
Thailla	Four finger threod fin	*Eleutheronema terradoctylum*	C	OS
Zazi kakra	Blue swimmer carb	*Neptune pelagicus*	C	IS

Codes :

Habitat: R= River, C= Canal, P= Pond, F= Flood plain, IS = Inshore, OS=Offshore, VWB = Various Water Bodies, CR = Creeks
Status : C= Common, R= Rare, F= Fairly Common.

Source : Field Survey and Thana Fisheries Office, Patuakhali, Bhola 1997-1998.

Table I.4 : BBS Demographic data 1981 and 1991 by thana

NO	DISTRICT	THANA	BBS CODE	MEASURED AREA 1990 (ha)	POPULATION 1981	POPULATION 1991	POPULATION DENSITY 1991 person/km2	HOUSEHOLDS 1981	HOUSEHOLDS 1991	MEAN HH SIZE 1981	MEAN HH SIZE 1991	CHANGE IN MEAN HH SIZE 81-91
1	Barisal	Bakerganj	0607	38622	312086	336706	872	54212	63177	5.76	5.33	-0.43
2	Barisal	Hizla	0636	29059	155025	166265	572	27994	30184	5.54	5.51	-0.03
3	Barisal	Barisal Sadar	0651	25868	340841	414281	1602	54424	75126	6.26	5.51	-0.75
4	Barisal	Mehendiganj	0662	29838	241104	292436	980	43822	55128	5.50	5.30	-0.20
5	Bhola	Bhola Sadar	0918	28013	274784	351674	1255	48874	62042	5.62	5.67	0.05
6	Bhola	Burhanuddin	0921	26110	202620	208478	798	36535	37413	5.55	5.57	0.03
7	Bhola	Char Fasson	0925	54442	252680	342038	628	45804	63740	5.52	5.37	-0.15
8	Bhola	Daulatkhan	0929	11032	139439	153458	1391	25090	29233	5.56	5.25	-0.31
9	Bhola	Lalmohan	0954	28965	195987	252497	872	34505	44967	5.68	5.62	-0.06
10	Bhola	Manpura	0965	14129	33687	51361	364	5795	8959	5.81	5.73	-0.08
11	Bhola	Tazumuddin	0991	11733	71065	116822	996	12174	20444	5.84	5.71	-0.12
12	Chandpur	Chandpur Sadar	1322	16230	336867	396872	2445	59819	70424	5.63	5.64	0.00
13	Chandpur	Haimchar	1347	6896	94033	113306	1643	18299	20946	5.14	5.41	0.27
14	Chittagong	Bandar (Port)	1520	4395	206013	210090	4780	32317	34430	6.37	6.10	-0.27
15	Chittagong	Mirsharai	1553	43122	307016	333594	774	52728	57140	5.82	5.84	0.02
16	Chittagong	Pahartali	1555	2267	97518	204998	9043	9767	38379	9.98	5.34	-4.64
17	Chittagong	Sandwip	1578	27320	264188	281076	1029	44044	46863	6.00	6.00	0.00
18	Chittagong	Sitakunda	1586	22649	236664	287453	1269	37015	50386	6.39	5.71	-0.69
19	Feni	Sonagazi	3094	17686	179563	215122	1216	31546	37184	5.69	5.79	0.09
20	Lakshmipur	Lakshmipur Sadar	5143	40689	473611	525188	1291	87051	95664	5.44	5.49	0.05
21	Lakshmipur	Raipur	5158	16030	185852	213573	1332	34808	40618	5.34	5.26	-0.08
22	Lakshmipur	Ramgati	5173	43591	263681	335243	769	45398	59387	5.81	5.65	-0.16
23	Noakhali	Companiganj	7521	25254	136879	183351	726	24291	30847	5.63	5.94	0.31
24	Noakhali	Hatiya	7536	58726	234869	295501	503	39956	47970	5.88	6.16	0.28
25	Noakhali	Noakhali Sadar	7587	86326	483160	625520	725	87752	110349	5.51	5.67	0.16
26	Patuakhali	Bauphal	7838	38982	266709	288825	741	46188	50755	5.77	5.69	-0.08
27	Patuakhali	Dashmina	7852	24041	95554	106539	443	16947	19863	5.64	5.36	-0.27
28	Patuakhali	Galachipa	7857	79148	268076	286307	362	43920	49982	6.10	5.73	-0.38
29	Patuakhali	Kalapara	7866	47012	124362	174921	372	20411	31324	6.09	5.58	-0.51
30	Shariyatpur	Bhedarganj	8614	25175	166789	207258	823	29956	36550	5.57	5.67	0.10
31	Shariyatpur	Gosairhat	8636	14532	92592	115882	797	21534	22906	4.30	5.06	0.76
TOTALS				937882	6733314	8086635	862	1172976	1442380	5.74	5.61	-0.13

NOTES:
1. Order and spelling are according to 1991 BBS Census
2. Measured areas are from Satellite Imagery not BBS

Table I.5: BBS Key Data 1981 and 1991 by thana

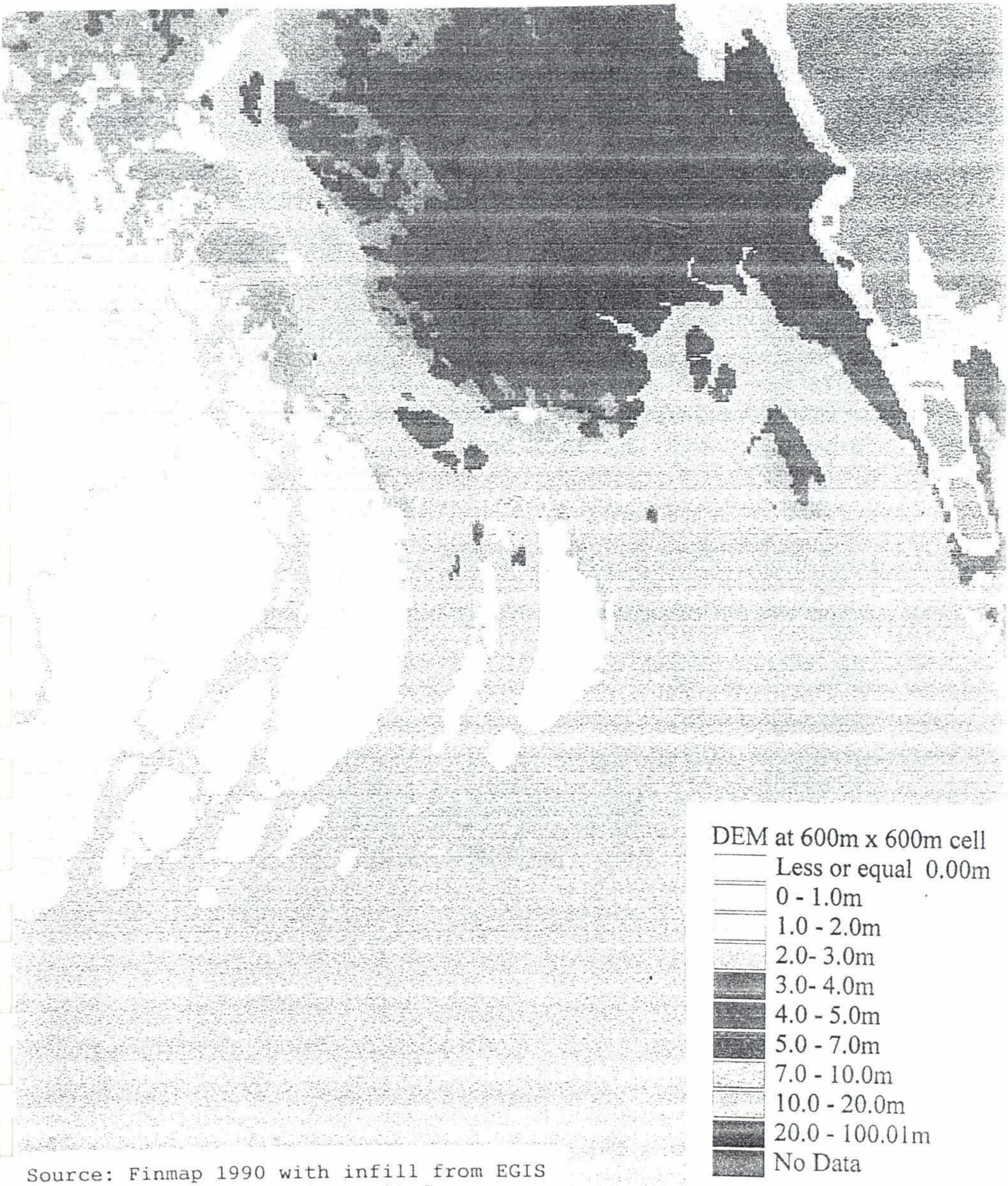
NO	DISTRICT	THANA	BBS CODE	HOUSE-HOLDS 1981	HOUSE-HOLDS 1991	% HH OWNING AG LAND 1981	% DU OWNING LAND 1991	CHANGE IN% HH OWNING LAND 81-91	% POP AGE 10-29 IN CULTIV 1981	% POP OVER 10 IN AG 1991	CHANGE OF % POP IN AG 1981-1991	LITERACY RATE (7YRS) 1981	LITERACY RATE (7YRS) 1991	CHANGE IN LITERACY 1981-1991	%HH WITH POT WATER 1981	% DU SAFE DRINKING WATER 1991	CHANGE IN HH WITH POT WATER 81-91	% DU WITH SANITATION 1991
1	Barisal	Bakerganj	0607	54212	63177	70.1	32.2	-37.9	18.0	15.6	-2.4	37.3	47.1	9.8	18.3	73.8	55.5	15.6
2	Barisal	Hizla	0636	27994	30184	63.5	68.0	4.5	36.9	31.4	-5.5	24.5	27.7	3.2	44.9	65.7	20.8	5.9
3	Barisal	Barisal Sadar	0651	54424	75126	48.6	47.2	-1.4	9.5	8.1	-1.4	47.6	53.5	5.9	47.0	73.3	26.3	30.5
4	Barisal	Mehendiganj	0662	43822	55128	66.8	62.6	-4.2	23.9	22.6	-1.3	26.0	30.7	4.7	39.7	63.1	23.4	5.6
5	Bhola	Bhola Sadar	0918	48874	62042	46.2	40.9	-5.3	23.1	20.8	-2.3	20.5	25.8	5.3	53.0	83.5	30.5	15.9
6	Bhola	Burhanuddin	0921	36535	37413	59.9	63.2	3.3	27.7	29.8	2.1	19.4	21.2	1.8	43.6	87.2	43.6	4.4
7	Bhola	Char Fasson	0925	45804	63740	53.9	48.2	-5.7	28.7	28.6	-0.1	17.2	25.5	8.3	44.0	69.9	25.9	3.8
8	Bhola	Daulatkhan	0929	25090	29233	55.3	44.3	-11.0	24.4	23.1	-1.3	20.8	24.5	3.7	65.7	93.0	27.3	7.7
9	Bhola	Lalmohan	0954	34505	44967	57.1	53.3	-3.8	27.5	28.7	1.2	18.1	20.3	2.2	46.3	77.4	31.1	2.9
10	Bhola	Manpura	0965	5795	8959	53.0	52.0	-1.0	49.5	28.4	-21.1	14.4	21.3	6.9	59.4	84.6	25.2	3.6
11	Bhola	Tazumuddin	0991	12174	20444	60.8	54.1	-6.7	30.2	29.3	-0.9	20.1	27.0	6.9	42.6	76.9	34.3	4.4
12	Chandpur	Chandpur Sadar	1322	59819	70424	51.7	46.6	-5.1	14.5	13.6	-0.9	33.1	40.1	7.0	54.8	76.0	21.2	12.3
13	Chandpur	Haimchar	1347	18299	20946	66.1	46.8	-19.3	29.7	27.1	-2.6	20.7	25.4	4.7	34.1	60.4	26.3	3.2
14	Chittagong	Bandar (Port)	1520	32317	34430	29.1	25.0	-4.1	4.5	1.5	-3.0	27.4	56.3	28.9	66.6	92.8	26.2	50.3
15	Chittagong	Mirsharai	1553	52728	57140	61.6	55.0	-6.6	19.6	19.2	-0.4	23.2	37.2	14.0	44.7	68.7	24.0	10.7
16	Chittagong	Pahartali	1555	9767	38379	2.7	31.3	28.6	0.2	0.7	0.5	12.8	54.1	41.3	64.2	88.9	24.7	45.9
17	Chittagong	Sandwip	1578	44044	46863	51.7	41.0	-10.7	18.9	15.8	-3.1	21.9	35.1	13.2	34.7	64.0	29.3	11.7
18	Chittagong	Sitakunda	1586	37015	50386	39.9	39.5	-0.4	9.4	8.9	-0.5	27.3	41.1	13.8	53.5	68.2	14.7	16.2
19	Feni	Sonagazi	3094	31546	37184	68.9	61.8	-7.1	21.1	19.8	-1.3	60.8	32.2	-28.6	66.3	82.6	16.3	8.6
20	Lakshmipur	Lakshmipur Sadar	5143	87051	95664	70.2	65.0	-5.2	22.1	20.5	-1.6	21.8	37.8	16.0	47.4	75.0	27.6	7.0
21	Lakshmipur	Raipur	5158	34808	40618	64.2	61.1	-3.1	26.3	22.9	-3.4	19.1	34.6	15.5	43.2	64.9	21.7	4.0
22	Lakshmipur	Ramgati	5173	45398	59387	54.5	50.3	-4.2	29.2	27.5	-1.7	12.4	19.9	7.5	46.1	56.9	10.8	2.5
23	Noakhali	Companiganj	7521	24291	30847	66.0	56.6	-9.4	19.7	17.2	-2.5	19.7	34.5	14.8	59.0	77.3	18.3	7.5
24	Noakhali	Hatiya	7536	39956	47970	51.9	47.9	-4.0	21.8	25.9	4.1	13.8	21.0	7.2	45.6	73.0	27.4	3.1
25	Noakhali	Noakhali Sadar	7587	87752	110349	60.4	58.9	-1.5	22.0	21.0	-1.0	19.3	30.2	10.9	38.4	61.0	22.6	6.8
26	Patuakhali	Bauphal	7838	46188	50755	71.5	68.6	-2.9	18.4	18.8	0.4	26.1	37.9	11.8	37.5	63.5	26.0	2.1
27	Patuakhali	Dashmina	7852	16947	19863	74.4	63.1	-11.3	21.5	27.4	5.9	19.1	29.5	10.4	40.9	67.9	27.0	0.1
28	Patuakhali	Galachipa	7857	43920	49982	70.3	63.9	-6.4	27.8	26.4	-1.4	21.0	29.4	8.4	46.8	85.5	38.7	0.8
29	Patuakhali	Kalapara	7866	20411	31324	61.7	58.0	-3.7	22.5	23.3	0.8	23.9	34.9	11.0	48.4	82.9	34.5	3.5
30	Shariyatpur	Bhedarganj	8614	29956	36550	62.2	64.4	2.2	27.4	29.2	1.8	15.9	22.5	6.6	61.8	87.2	25.4	3.4
31	Shariyatpur	Gosairhat	8636	21534	22906	60.9	58.8	-2.1	32.8	30.8	-2.0	16.8	20.2	3.4	61.1	83.4	22.3	4.0
TOTALS				1172976	1442380	58.7				20.1								

NOTES:

1. Order and spelling are according to 1991 BBS Census
2. The definition of a household and a dwelling unit is different!

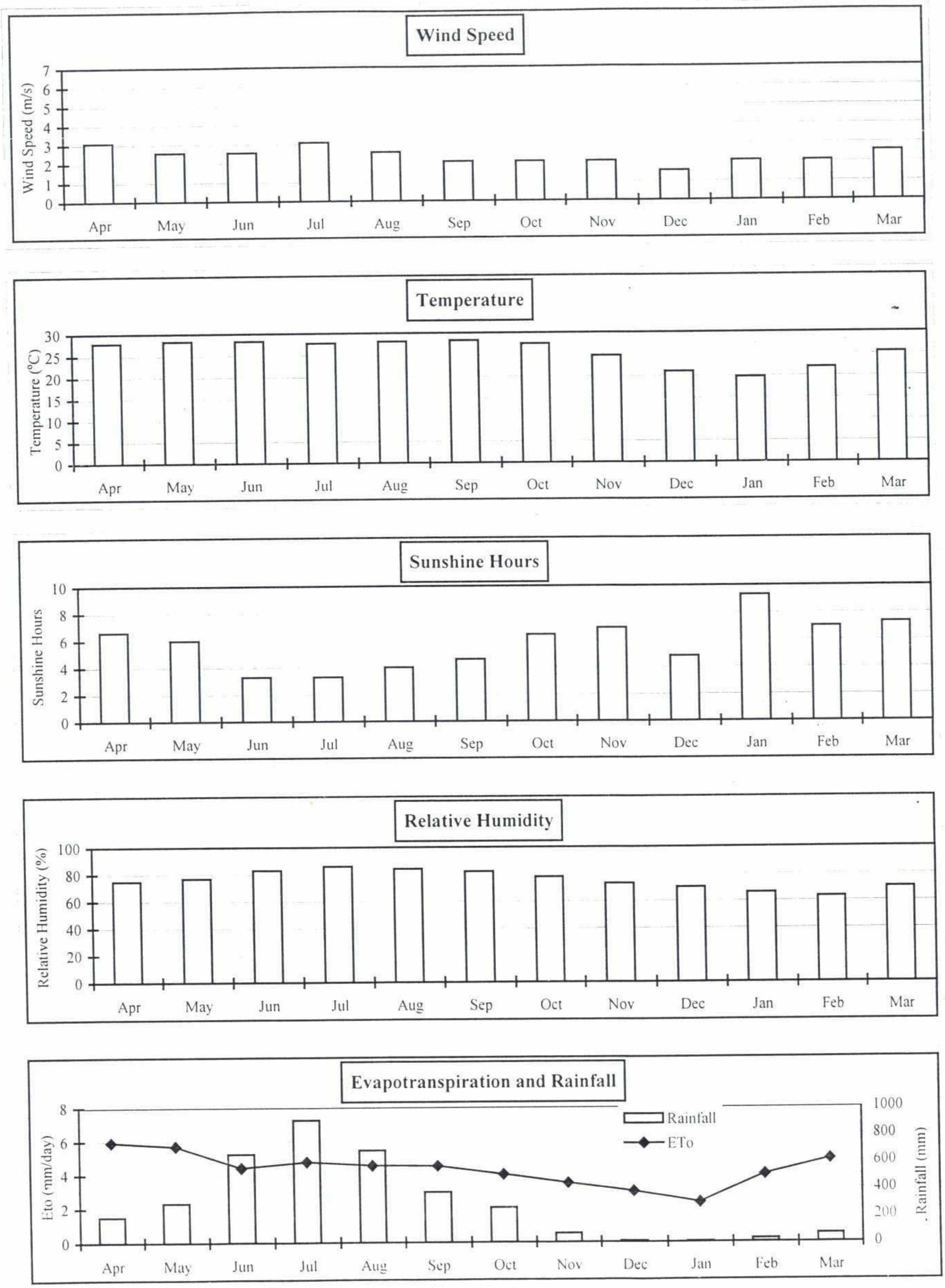
LIST OF FIGURES

Figure II.1: Topography-Digital Elevation Model Output



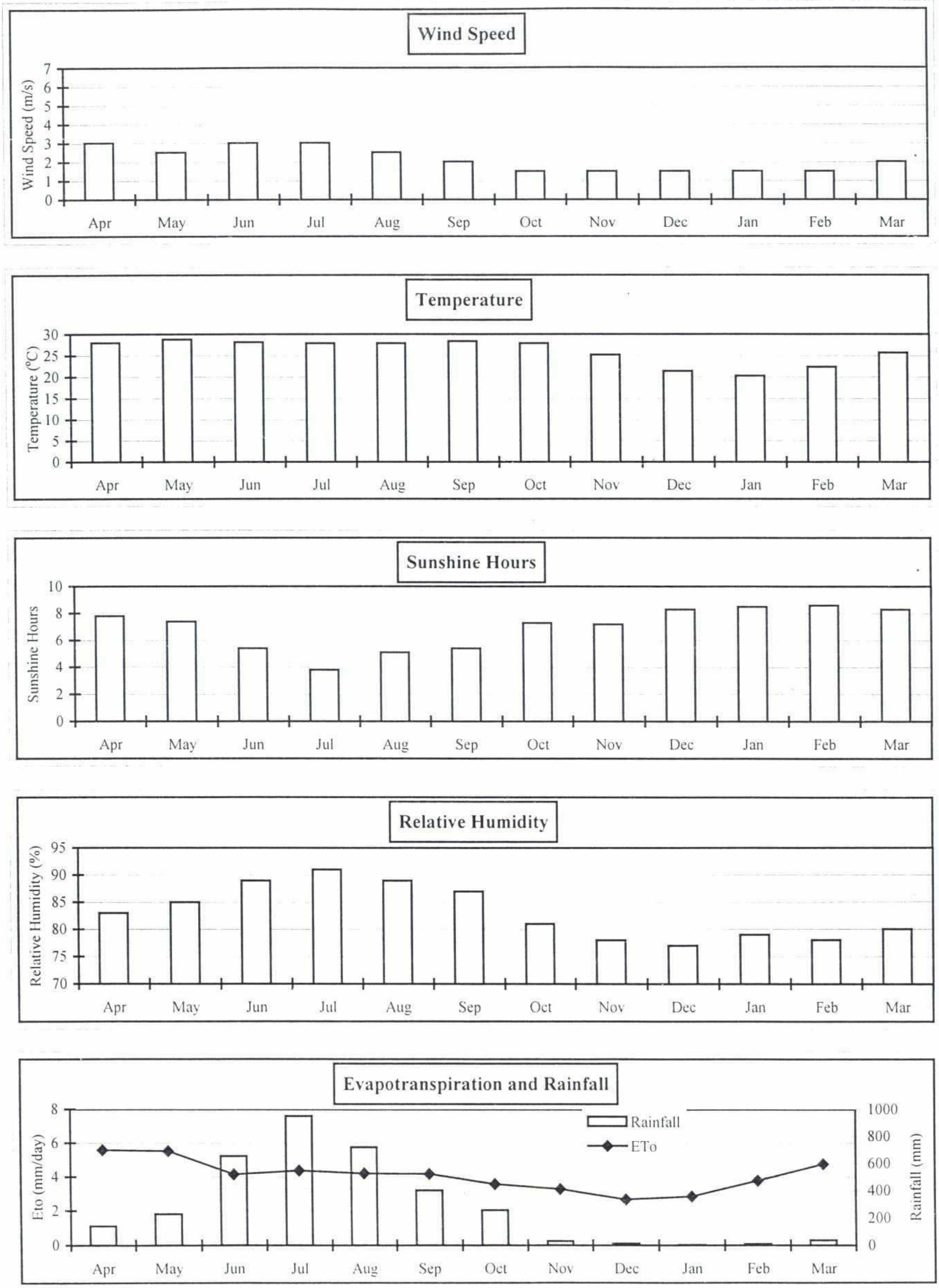
Source: Finmap 1990 with infill from EGIS
Cyclone Shelter Preparitory Study

Figure II.2a: Climatic norms at Sitakunda 1962-1989



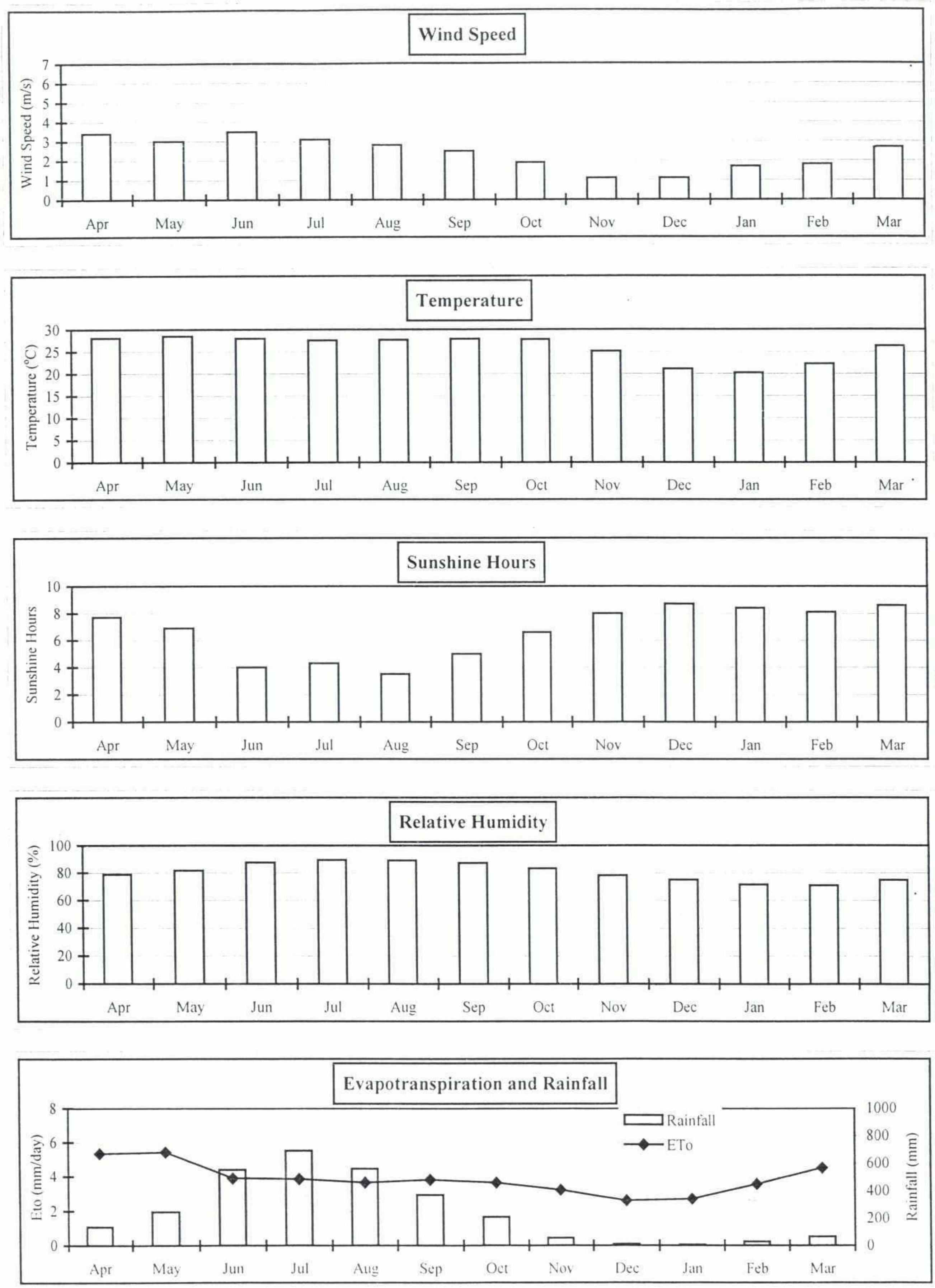
Source : Bangladesh Meteorological Department (BMD).

Figure II.2b: Climatic norms at Sandwip 1962-1989



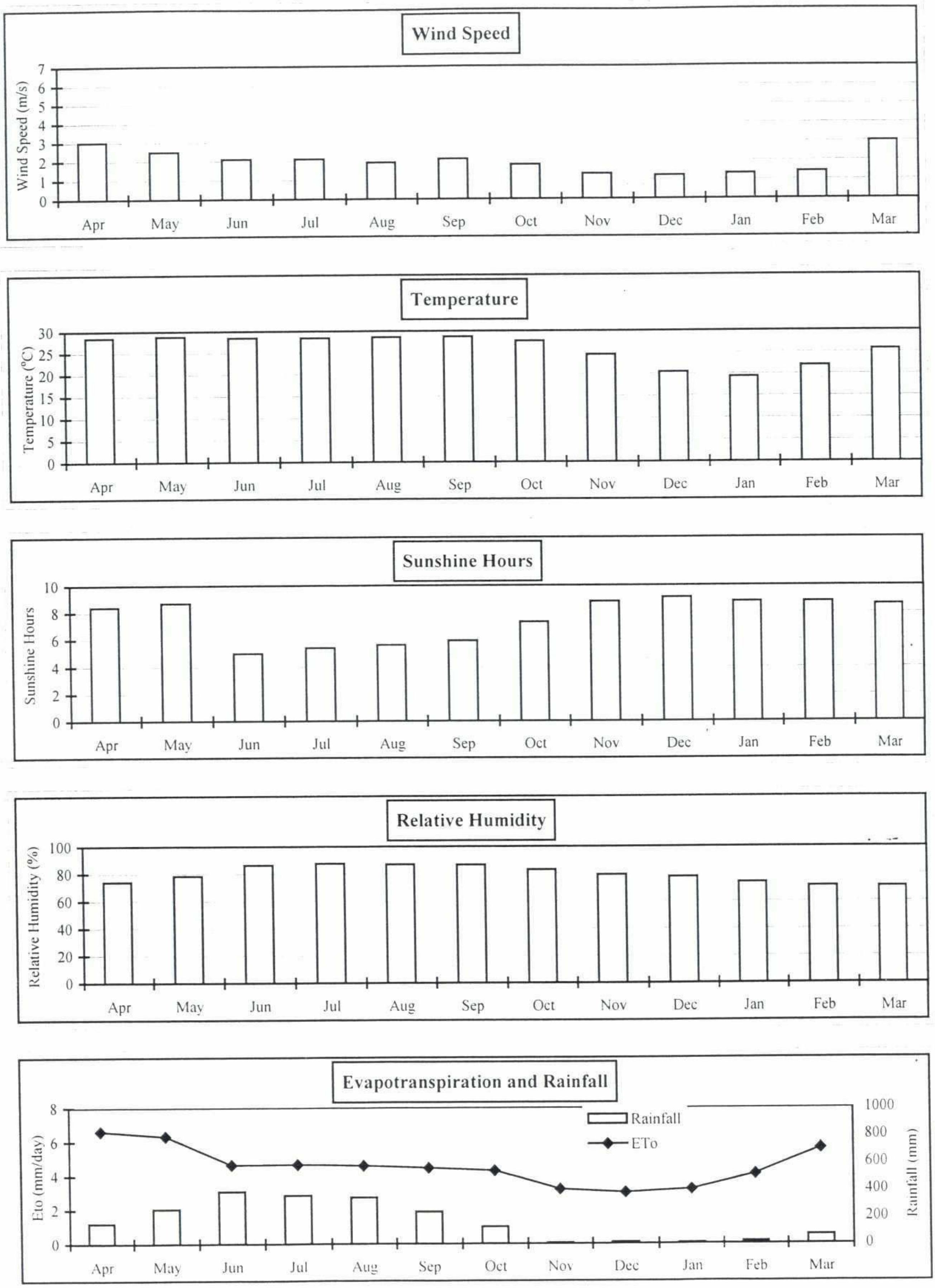
Source : Bangladesh Meteorological Department (BMD).

Figure II.2c: Climatic norms at Hatia 1962-1989



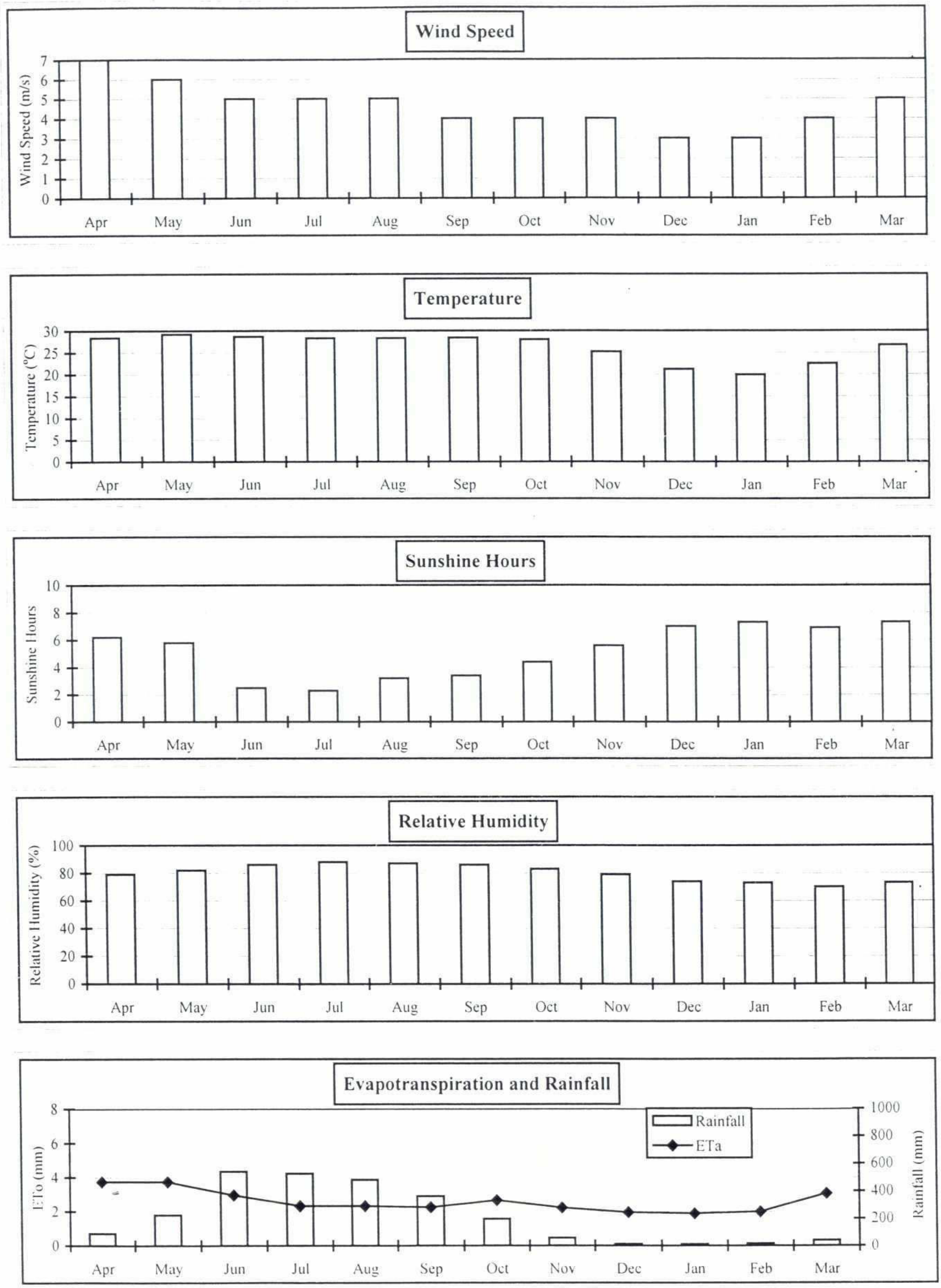
Source : Bangladesh Meteorological Department (BMD).

Figure II.2d: Climatic norms at Chandpur 1962-1989



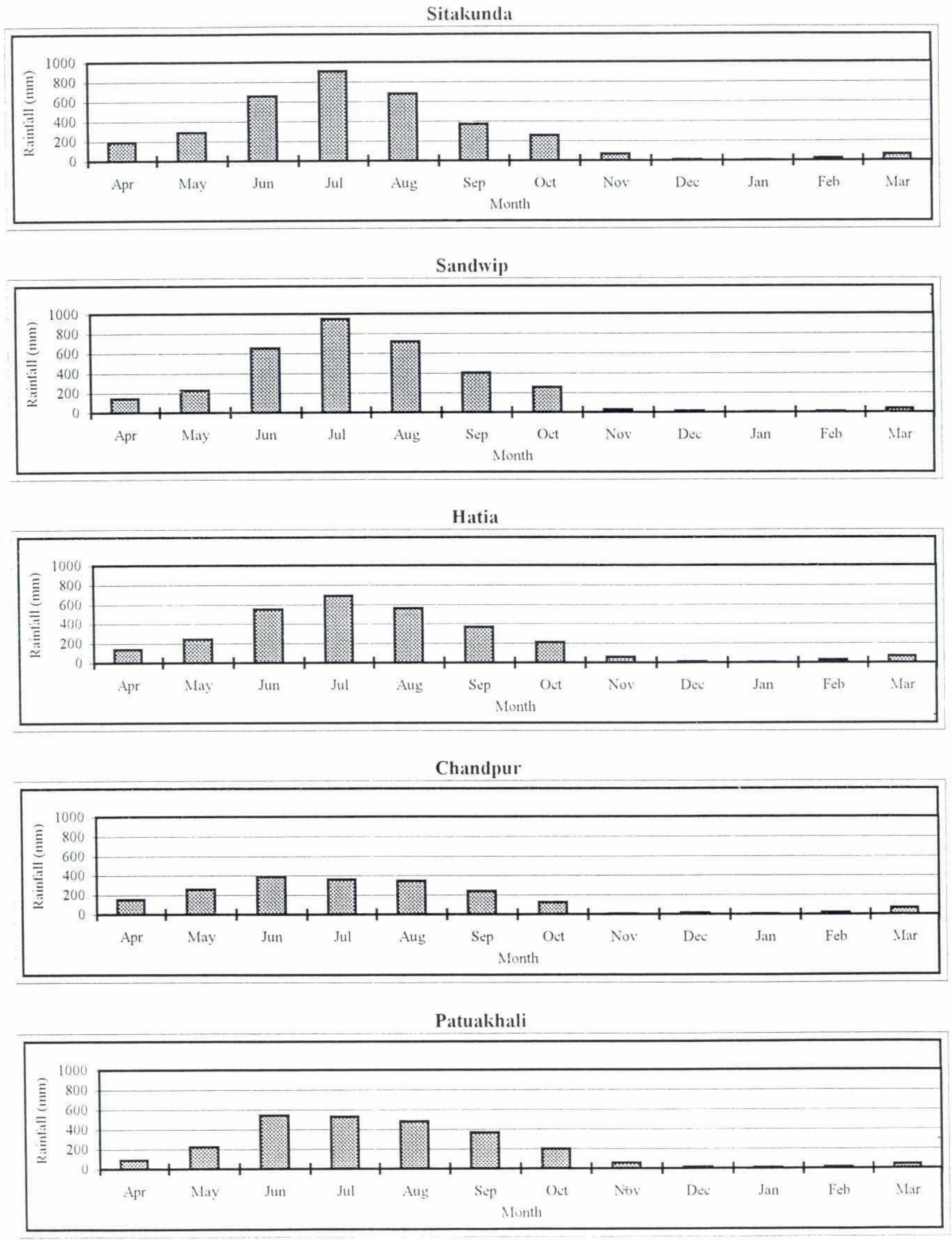
Source : SE Regional Study, Sir M MacDonald and Partners Ltd. 1993

Figure II.2e: Climatic norms at Patuakhali (1962-1989)



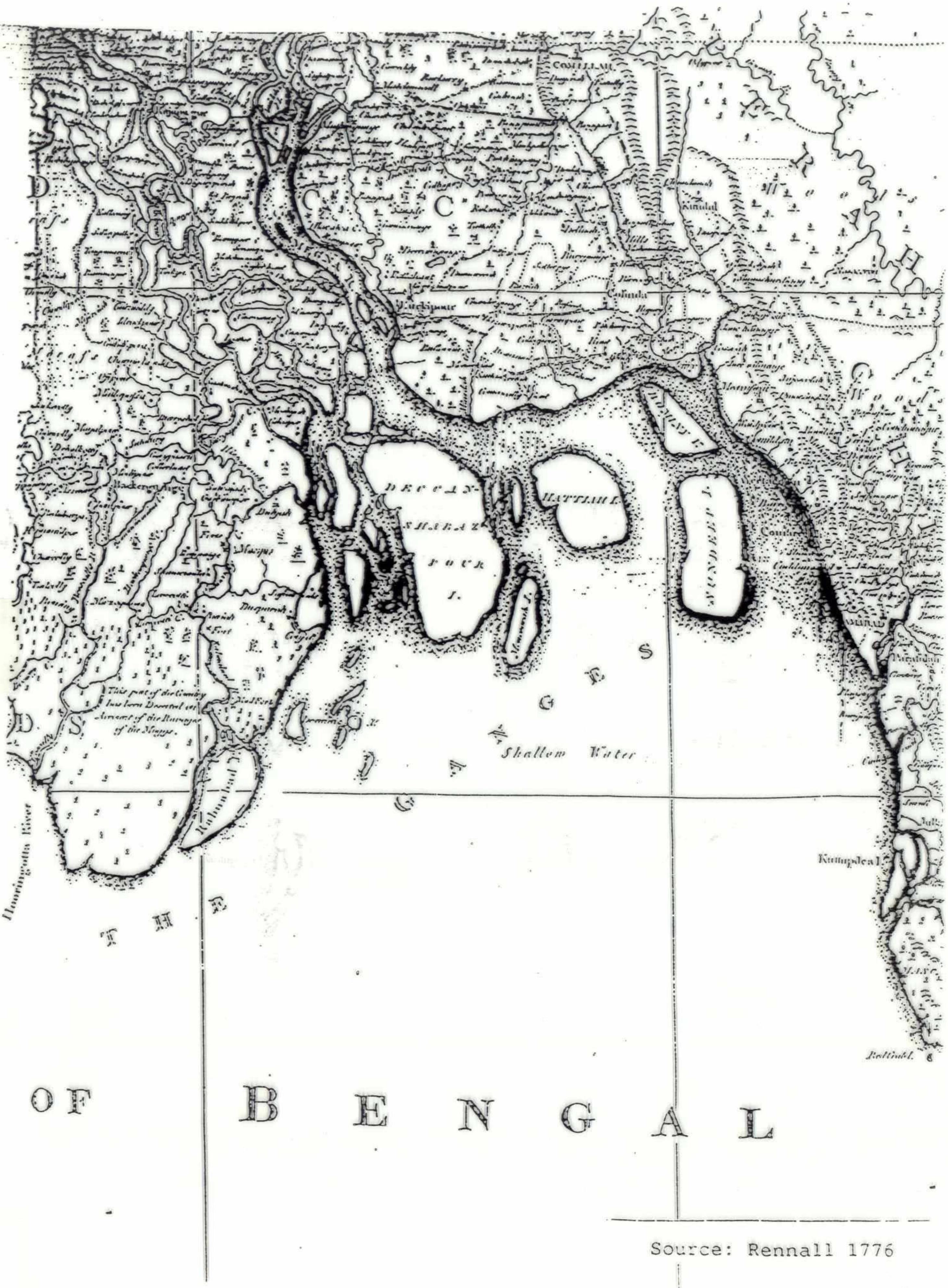
Source : Bangladesh Meteorological Department (BMD).

Figure II.3: Mean annual rainfall charts (1962-89)



Source : Surface Water Hydrology-II, BWDB.

Figure II.4: Coastline Change 1976 to 1996



Source: Rennall 1776

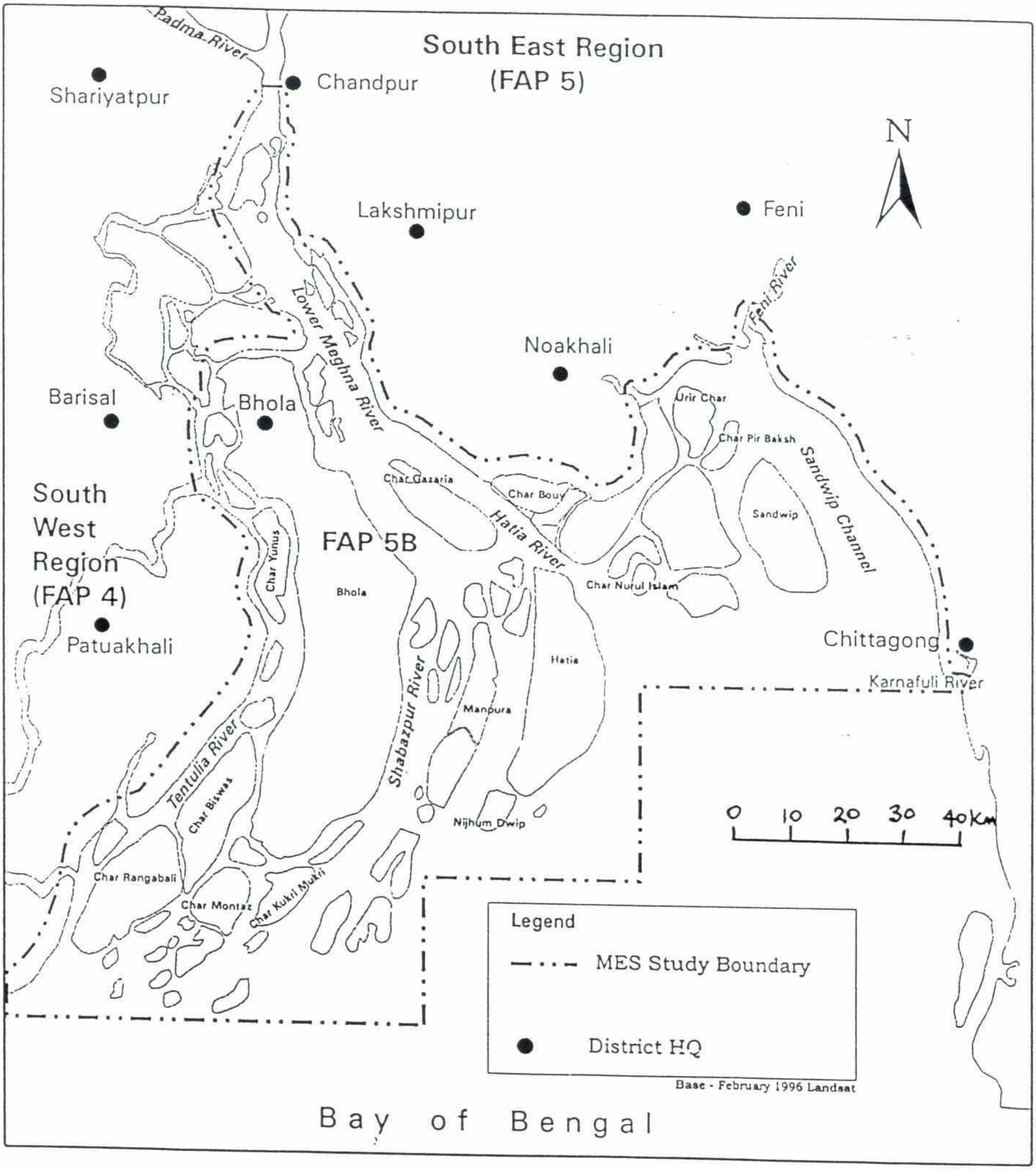
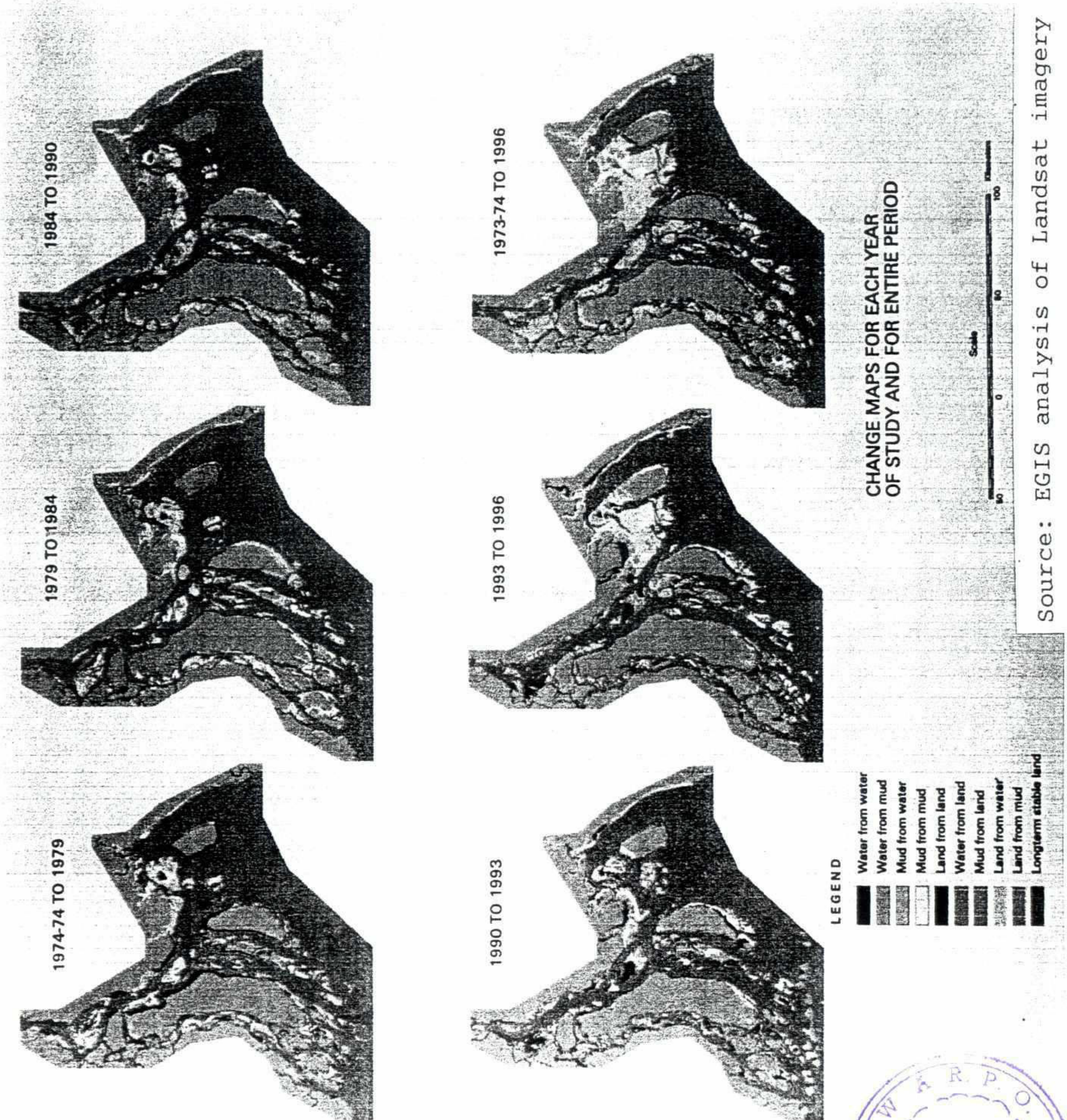
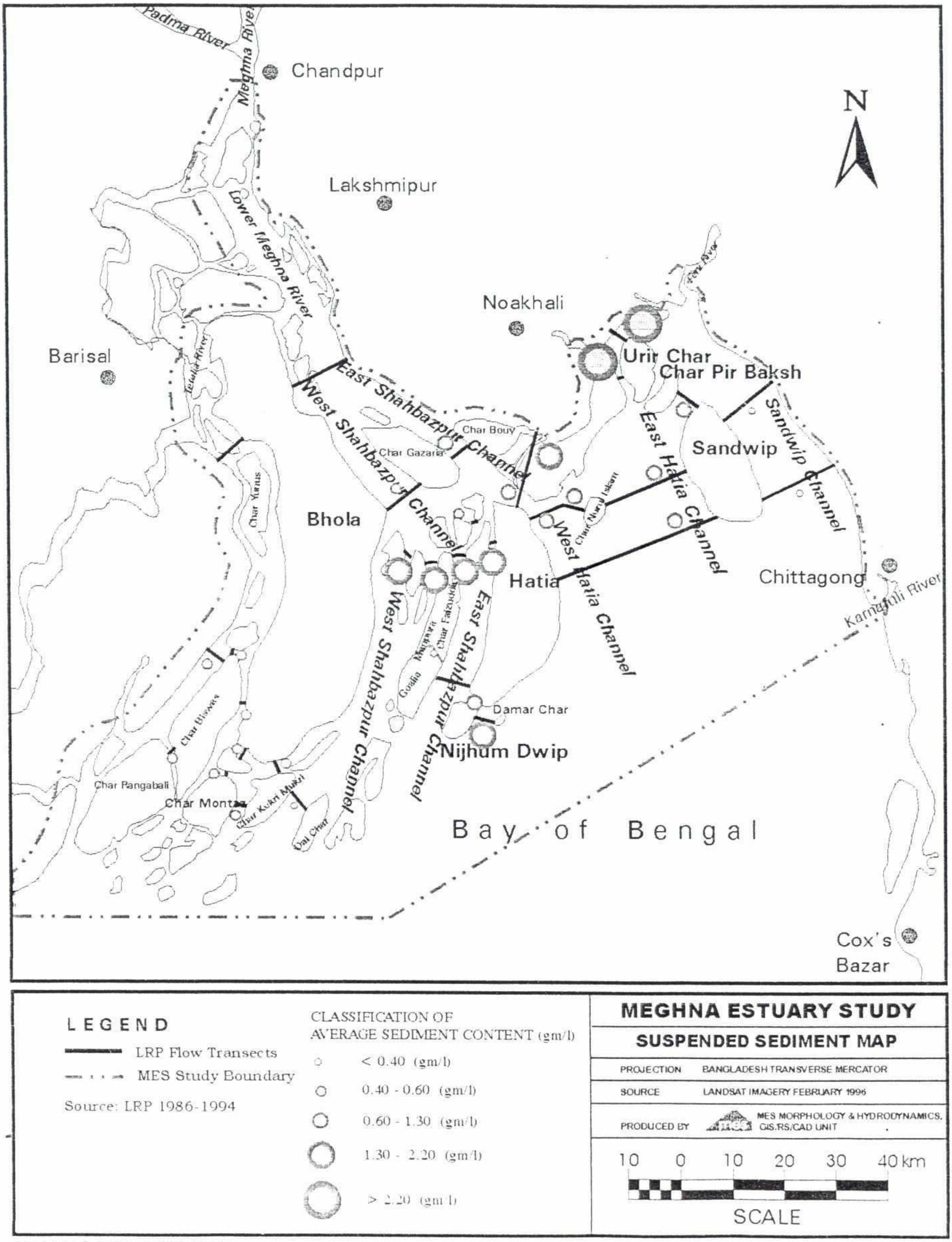

Padma River
South East Region
(FAP 5)
Shariyatpur
Chandpur
N
Lakshmipur
Feni
Feni River
Lower Meghna River
Noakhali
Barisal
Bhola
Urir Char
Char Pir Baksh
Sandwip Channel
Char Gazaria
Char Bouy
Sandwip
South
West
Region
(FAP 4)
Char Yunus
FAP 5B
Hatia River
Char Nurul Islam
Bhola
Patuakhali
Chittagong
Hatia
Karnafuli River
Shabazpur River
Manpura
Tentulia River
Char Biswas
0 10 20 30 40Km
Nijhum Dwip
Char Rangabali
Char Montaz
Char Kukri Mukri
Legend
MES Study Boundary
District HQ
Base - February 1996 Landsat
Bay of Bengal

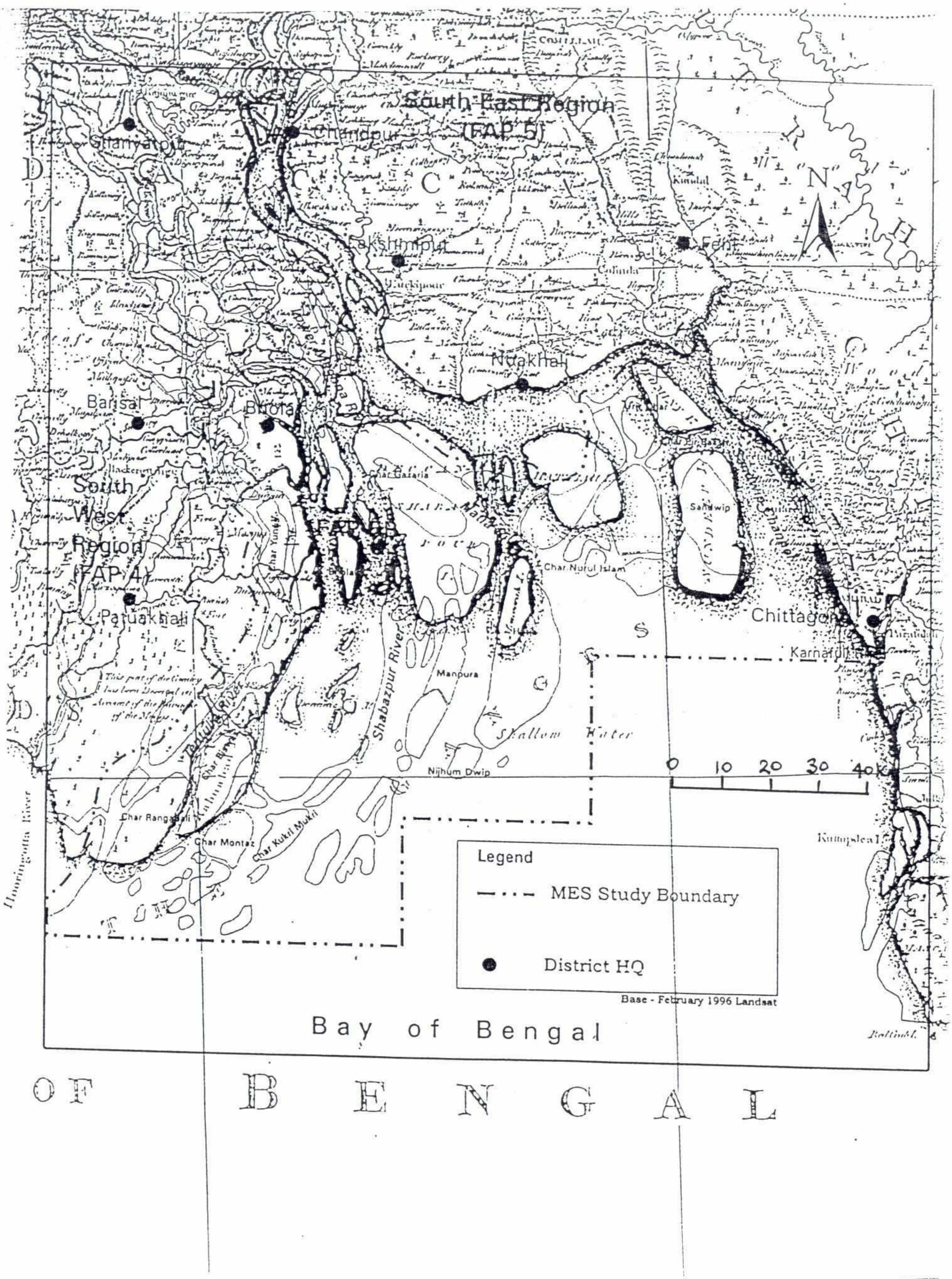
Figure II.5: Erosion and Accretion Mapping 1973, 1979, 1984, 1990, 1993 and 1996



Source: EGIS analysis of Landsat imagery

Figure II.6: Suspended Sediment Map





Source: Rennall 1776

Figure II.8: Agriculture Cropping Intensity Map

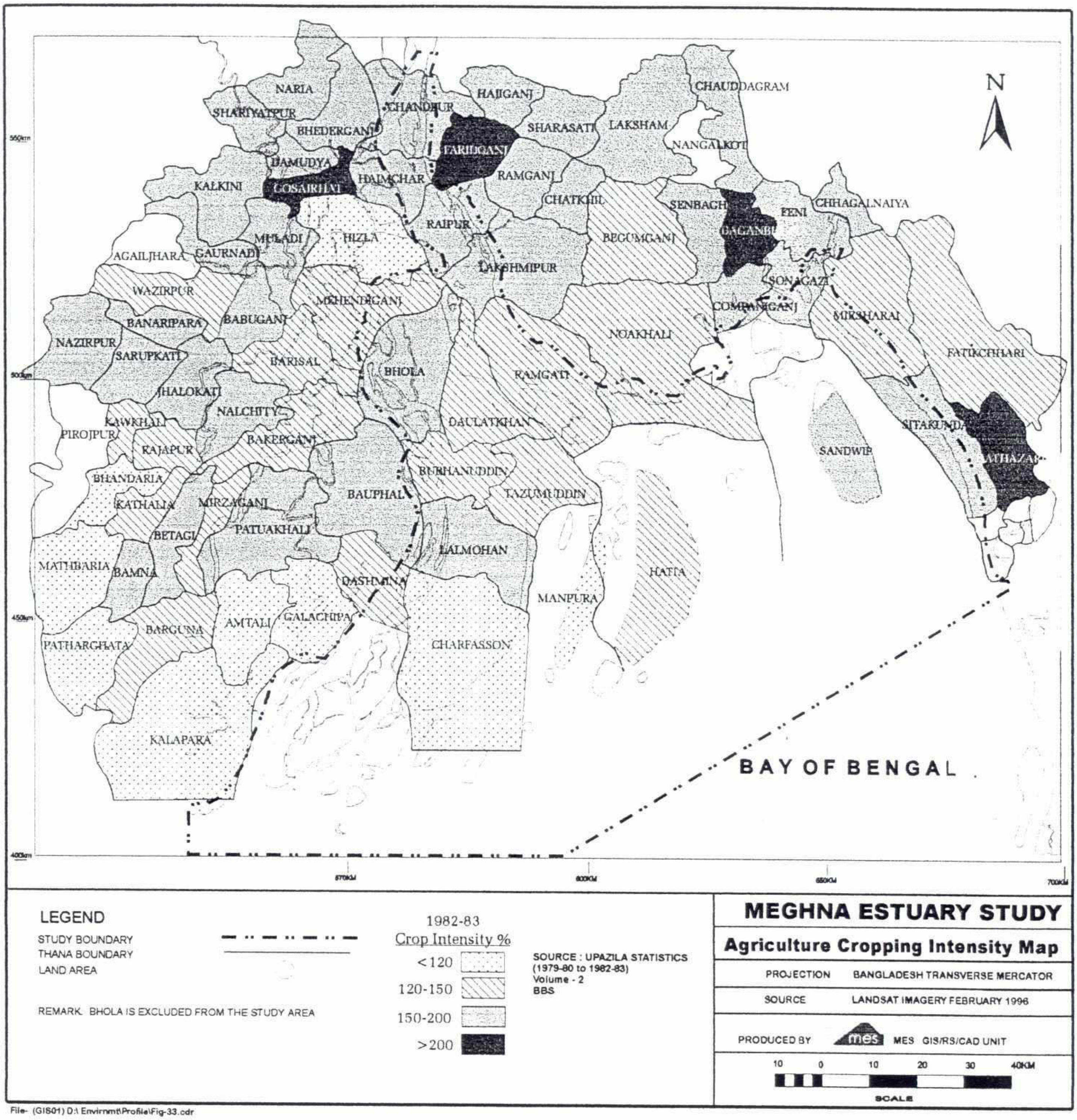


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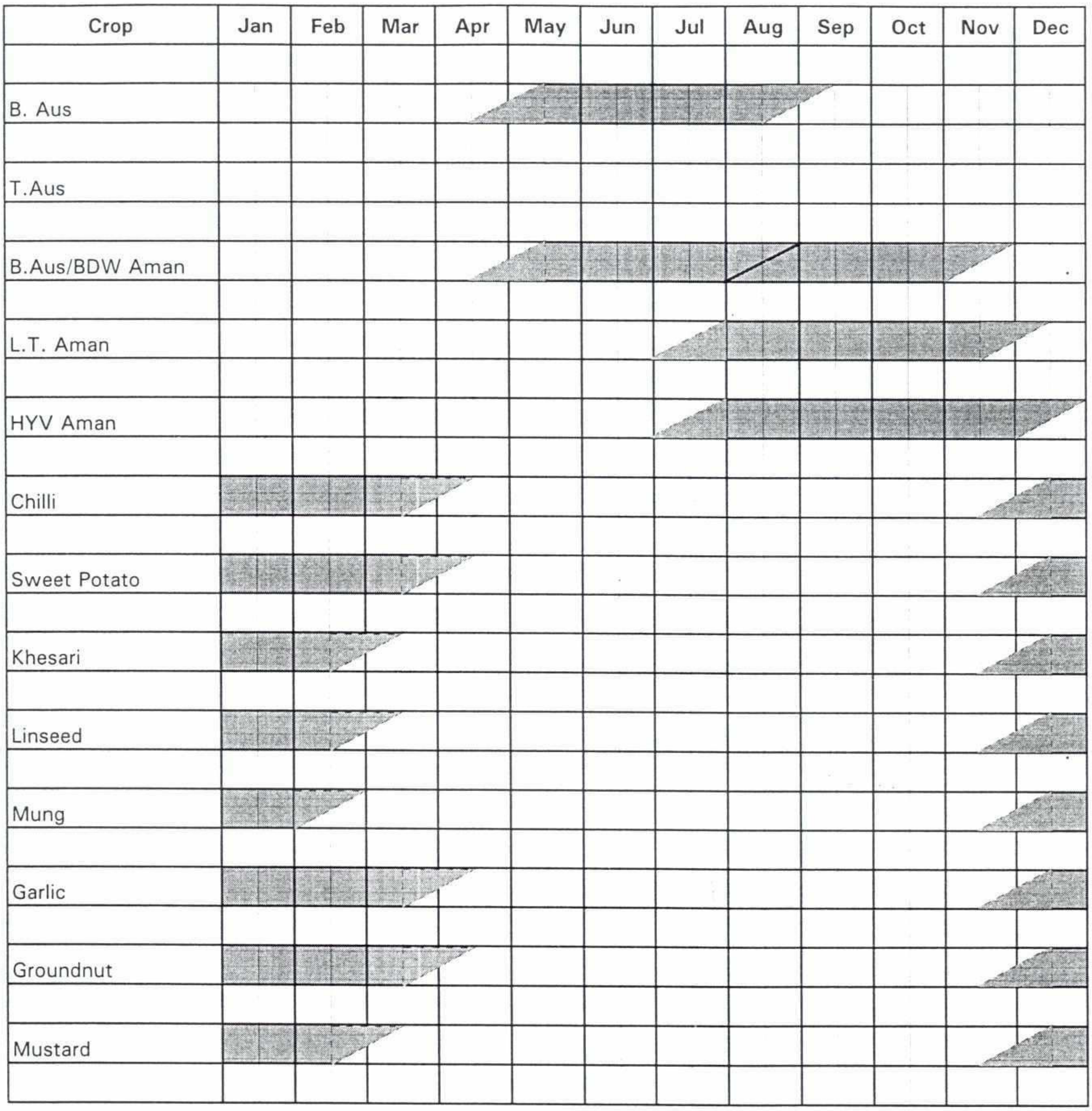
Figure II.9: Cropping Diagram



Source: Field Survey 1997 - 1998

Figure II.10: LRP Conceptual Model of Land Use on Newly Accreted Land

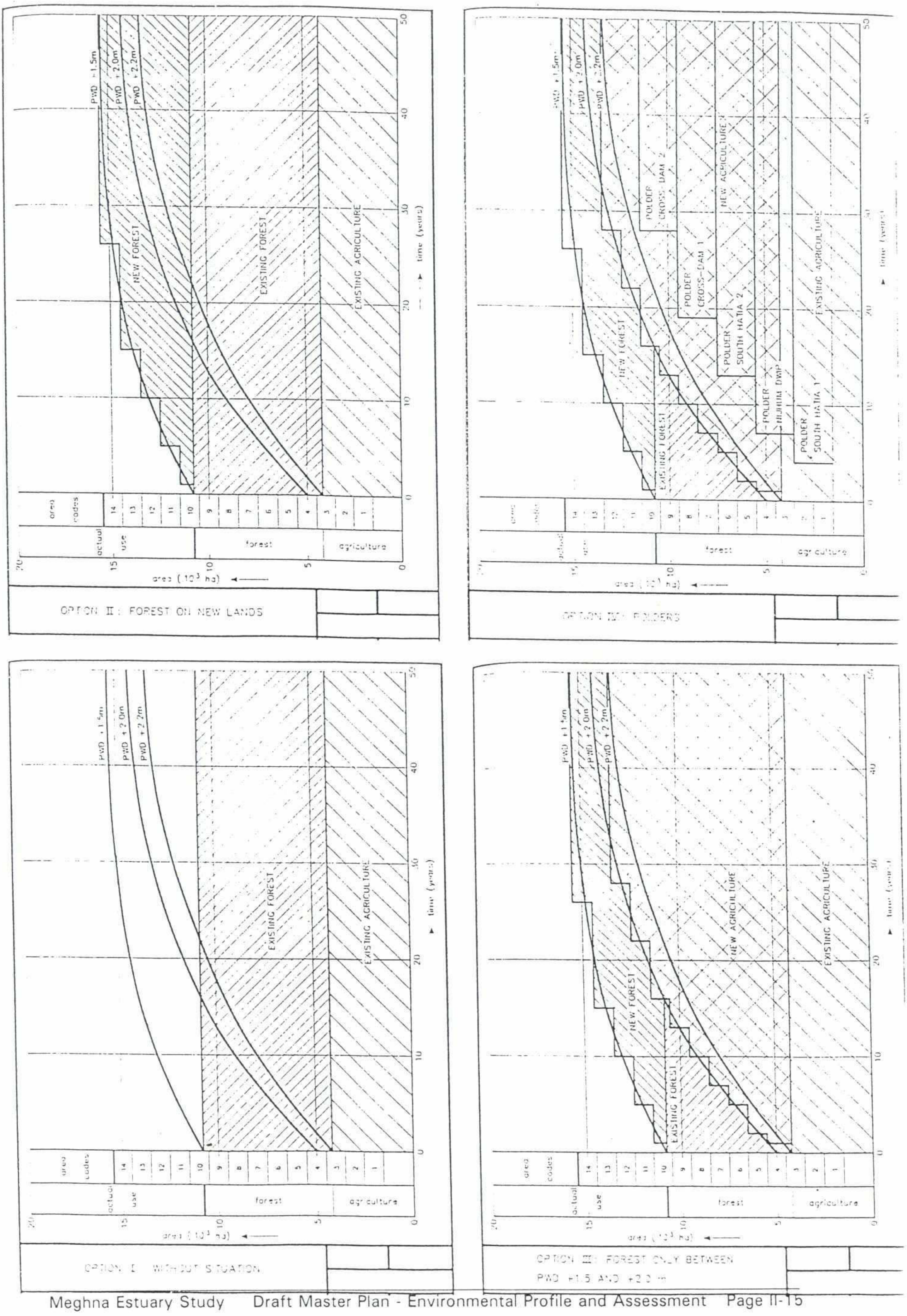


Figure II.11: BIWTA Route Depths

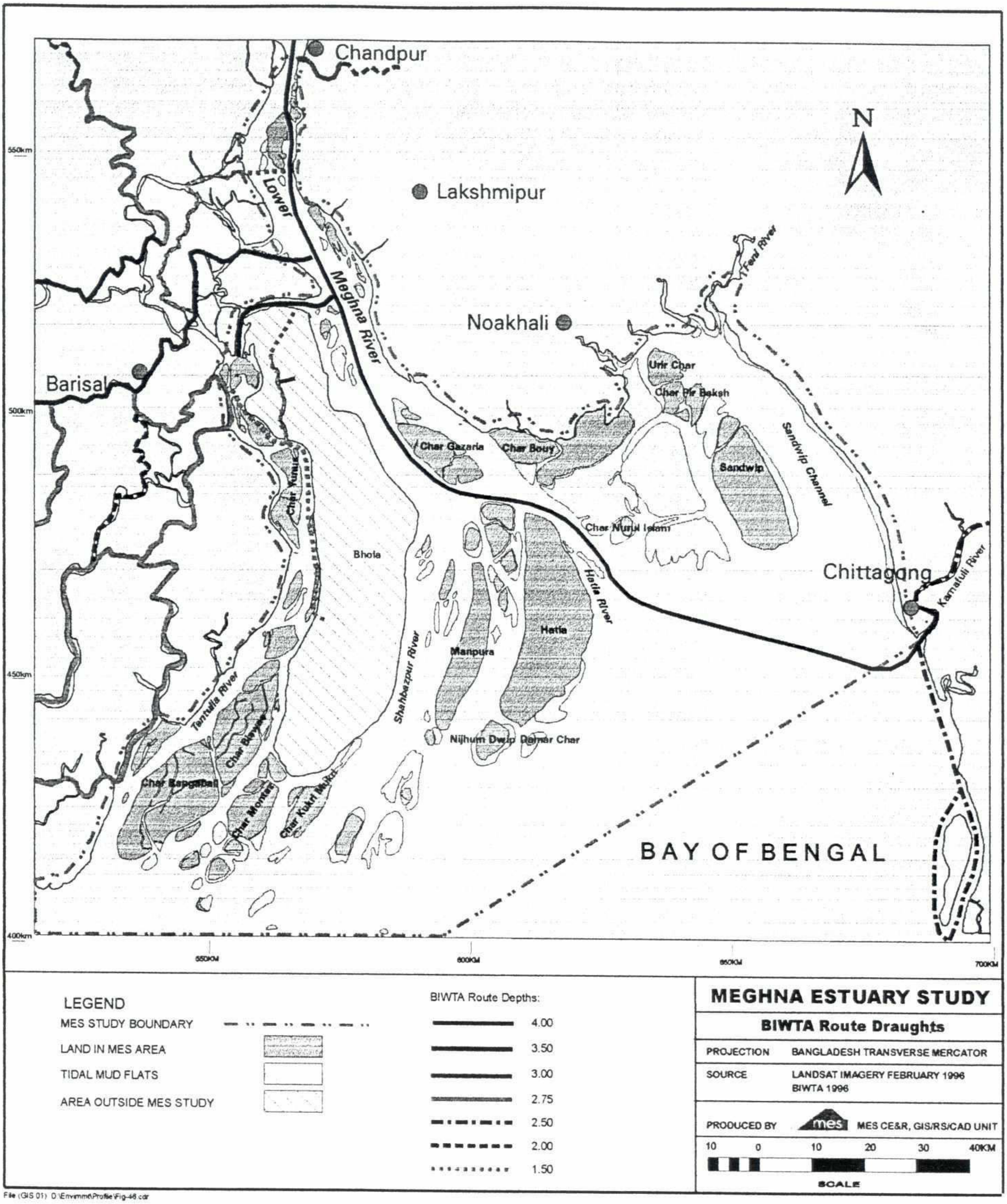


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Figure II.12: Other Studies, Projects and Programmes

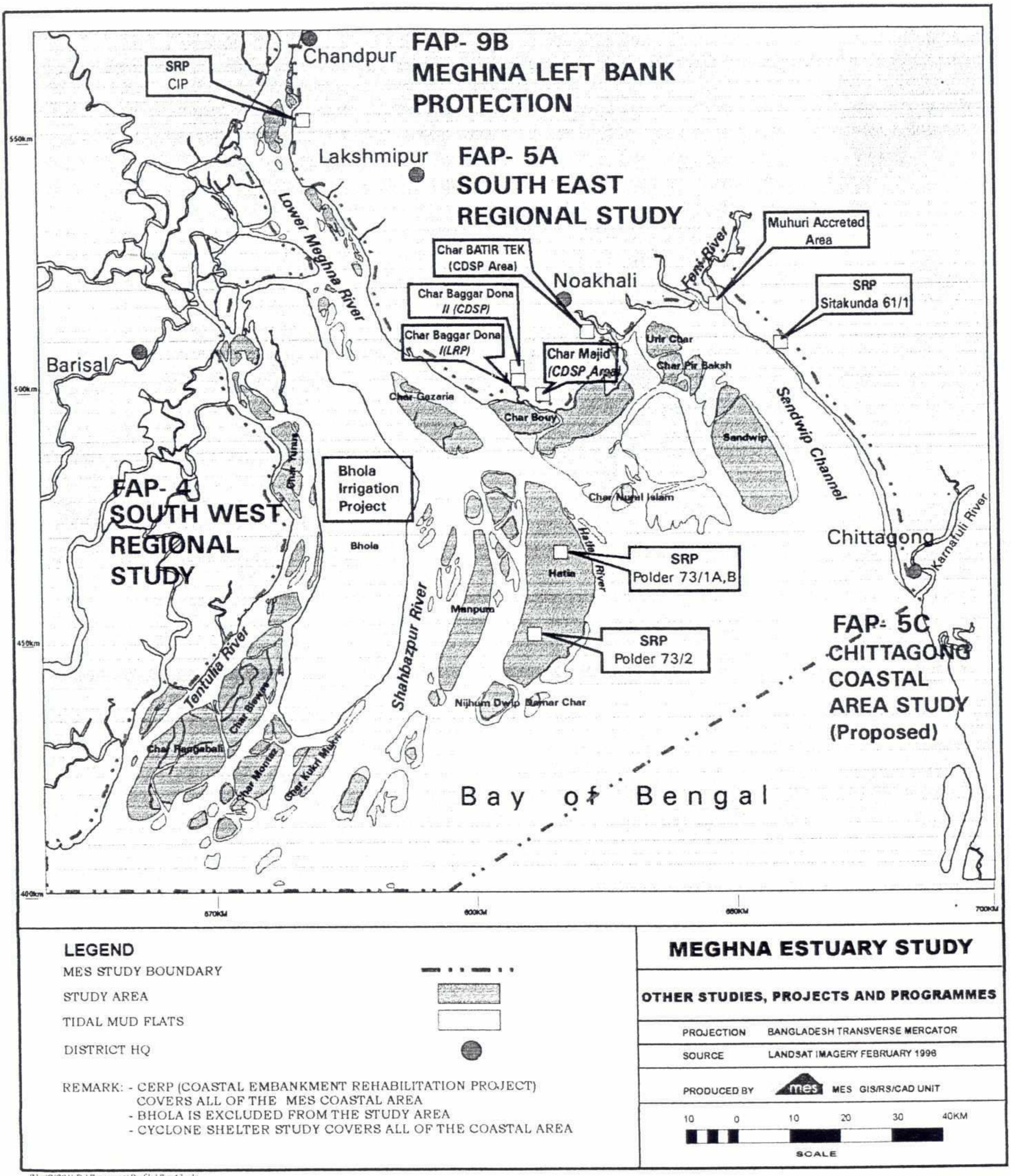
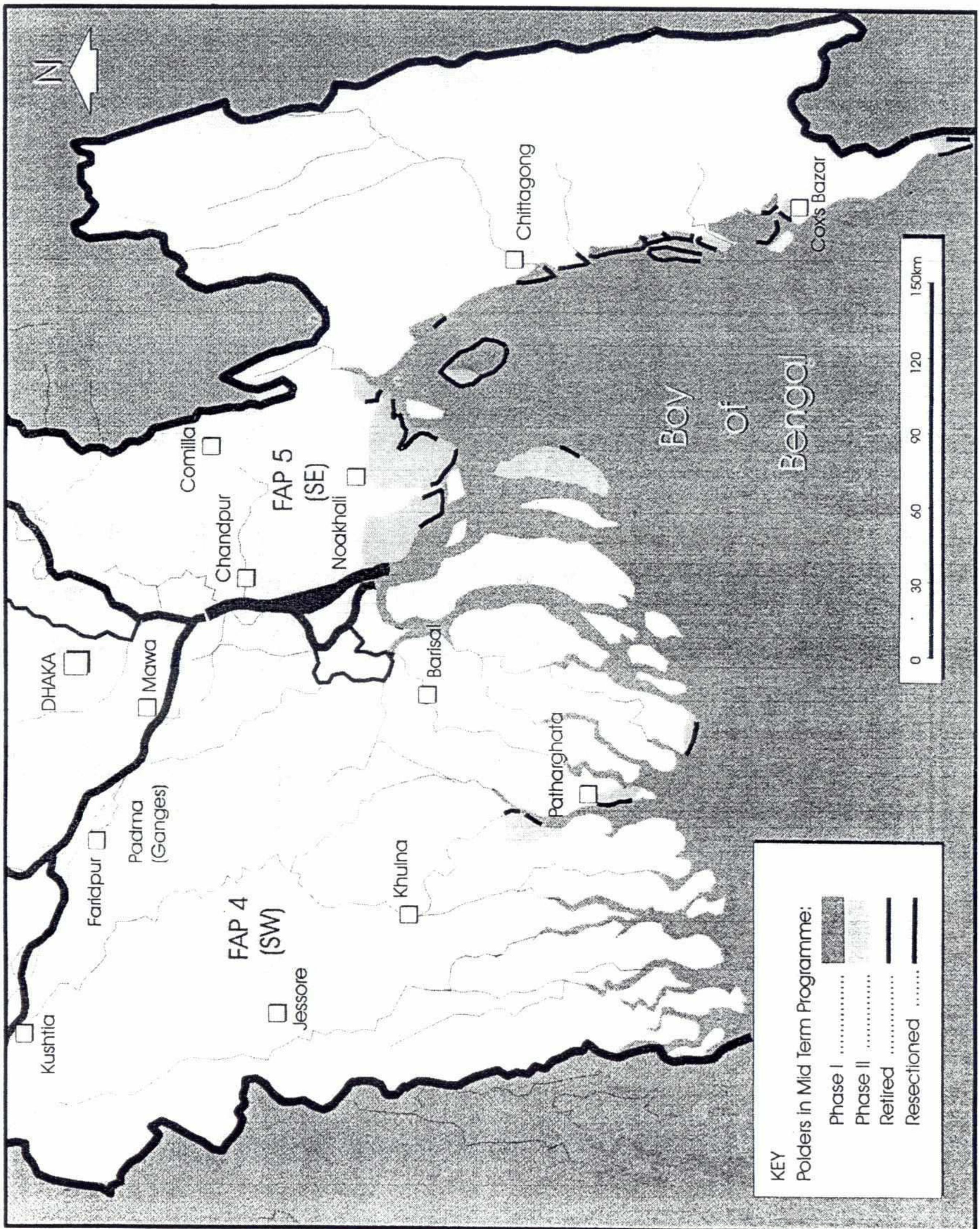


Figure II.13: Coastal Embankment Rehabilitation Project



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ENVIRONMENTAL CONTACTS AND LIAISON

Considerable liaison with other studies, projects and organisations has taken place during the course of the MES and also prior to this by study staff working on related programmes. The following people and organisations have been contacted with specific reference to environmental aspects in the Study Area:

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Eunus Ali, JIS, Chandpur

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Anwar Hossain, Deputy Director

Soil Resources Development Institute
Mustafizur Rahman, Director
S.M.Shaheed, Ex Director
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Majibur Rahman, Senior Scientific Officer
Mainuddin Ahmed, Senior Scientific Officer

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Md Jahangir Alam, Senior Research Officer

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Dhaka University
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Jahangirnagar University
Anwarul Islam, Professor of Zoology

Bangladesh Agricultural University, Mymensingh
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Azam Ali, Public Health Specialist
Afsana Wahab, Women and Child Development Specialist

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Jorge Barenstein

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Olena Reza, Research Officer

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Alam, Laboratory Chief

Coastal Area Resource Development and Management Association (CARDMA)
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BIRTAN, Noakhali
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Abu Taher, Field Assistant

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Md. Rafiq Alam

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Md Mahtaluddin, Field Worker, Char Montaz
Md Nasiruddin

Individuals:
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Mike Dapplyn, formerly Team Leader for FAP 12
Parvin Saltana, formerly Co-Team Leader for FAP 12
Paul Thompson, formerly Team Leader for FAP 13

PARTICIPANTS AT THE WORKSHOP HELD IN DHAKA ON 23rd MARCH 1998

See listing of participants in proceedings

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Southern Hatia/Nijhum Dwip:

Abul Kalam, Chairman, Jahajmara Union Parishad, Jahajmara, Hatia
Jamal Uddin Mohammad, Union Parishad Member, Jahajmara, Hatia
Mohiuddin Mohammad, Union Parishad Member, Jahajmara, Hatia
Khabirul Haq Belal, Union Parishad Member, Jahajmara, Hatia
Abul Kalam Azad, Union Parishad Member, Char Macpherson Mauza, Jahajmara Union, Hatia
Abdul Jalil, Union Parishad Member, Char Hare Mauza, Jahajmara Union, Hatia

Plus 112 people interviewed for the needs assessment and 1,158 people in 160 households interviewed for the socio-economic and agro/socio-economic surveys.

Haim Char:

Shaymal Chandra Mondal, Secretary, Char Bhairabi Union Parishad, Haim Char Thana, Chandpur District
Mostafa, Member, Gazipur Union Council, Haim Char Thana, Chandpur District
Ishaque Khokon, Chairman, Haim Char Union Council, Haim Char Thana, Chandpur District
Asmat Ali Sardar, Member, Haim Char Union Council, Haim Char Thana, Chandpur District
Hazrat Ali Soni, Member, Haim Char Union Council, Haim Char Thana, Chandpur District
Abdul Latif Sarker, Representative for Char Koralia, Haim Char Union Council, Haim Char Thana, Chandpur District

Local Residents, Haim Char:

Ahsan Ullah Sarker, Char Koralia, Haim Char Union and Thana
Farid Miah, Char Koralia, Haim Char Union and Thana
Sirajul Hoq, Char Koralia, Haim Char Union and Thana
Noor Mohammad Dewan, Haim Char Bazar, Haim Char Union and Thana

The 171 people who took part in the needs assessment
The 34 farming households interviewed in the Agro Socio-Economic Survey

Elected Representatives and Local Residents, Char Montaz and Kukri Mukri:

Sahid Talukder, Chairman, Char Montaz
Bibuti Bhusham Babu, Union Parishad Chairman, Kukri Mukri
Abdulqader, Union Parishad Secretary, Kukri Mukri
Wahab Khaliba, Trader, Char Bestin, Char Montaz
Atiqual Islam, Farmer, Char Laksmi
Md Zahidul, Fish Trader, Char Montaz
Md Salem, Bagda Fry Trader, Char Montaz
Abdul Roub Mocedah, Kukri Mukuri

Plus 112 people interviewed for the needs assessment and 990 people in 160 households interviewed for the socio-economic surveys