REPORT ON

REMOTE SENSING AND MONITORING COMPONENT FOR MANGROVE AFFORESTATION PROGRAMME OF SECOND FORESTRY PROJECT (CR. 1634-BD)

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Prepared by

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PREFACE

Although the coastal mangrove afforestation programme was initiated long ago (1965/66), the Department of Forests, Govt. of the People's Republic of Bangladesh continued its efforts to follow-up the programme under the financial assistance of the World Bank. Mangrove afforestation programme of the Second Forestry Project (1985-90) has been a follow-up of the First Forestry Project (1980-85). Bangladesh Space Research and Remote Sensing Organization (SPARRSO) was entrusted with the responsibility of monitoring the mangrove afforestation programme of the Department of Forests during the period 1985-90 using remote sensing techniques.

The project activity included the study of satellite and aerial photographic data along with ground information collected from the field to produce maps in the scale of 1:10,000 showing the plantation areas as well as the morphological changes in the coast. This was done under a contract signed between SPARRSO and the Ministry of Environment and Forests.

The project period was, however, extended upto October 1993. The arduous task of surveying and mapping of the entire coastal afforestation area (division-wise) was completed by SPARRSO. This report is the outcome of the total project activities.

ACKNOWLEDGEMENTS

Monitoring of mangrove afforestation in the coastal area is a difficult task. SPARRSO took-up this arduous job of monitoring the mangrove afforestation through the application of remote sensing techniques. The maps prepared by SPARRSO during the first phase were used as base materials by the scientists in completing the second phase.

SPARRSO gratefully acknowledges the sincere support and cooperation provided by the Department of Forests. The cooperation of the Range Officers, Beat Officers and their staff is highly commendable. The Divisional Forest Officers and other concerned officers of the plantation divisions have been extremely cooperative and helpful in providing SPARRSO with the plantation journals and all other relevant information and logistics support particularly during ground truth missions. SPARRSO owes them sincere thanks. The kind cooperation and valuable suggestions and support provided from time to time by the Chief Conservator of Forests, the Deputy Chief Conservator of Forests, the Conservator of Forests (Plantation Circle) is gratefully acknowledged by SPARRSO.

SPARRSO also gratefully acknowledges the valuable suggestions and support provided by the World Bank.

SPARRSO is also grateful to all the concerned Ministries, Divisions and Organizations for the kind help and cooperation extended by them for smooth and successful implementation of the project.

The project is indebted to Dr. A.A.Z. Ahmad, Chairman, SPARRSO for his constant and valuable guidance during the period of implementation of the project.

EXECUTIVE SUMMARY

The first coastal mangrove afforestation programme in Bangladesh was executed by the Department of Forests in 1965/66 in a limited scale. They started the programme out of their own fund and the species planted were the same as those existing in the natural mangrove areas. The successes were encouraging and as a result an aided project was taken up under financial assistance of the World Bank (Forestry-I) during 1980-85 when an area of over 89,000 acres was brought under plantation successfully. The brief objectives of the plantation are :

- to accelerate the process of land accretion in the coastal region, to stabilize the accreted land and to protect them from erosion.
- to provide fuel wood and timber for various uses including industries and to improve the socio-economic condition of the people in the coastal belt.
- A Second Phase of the Mangrove Plantation Programme was taken up during 1985-90 period under the World Bank assistance to further extend the afforestation programme to improve the coastal ecology and to provide the people with some protection against disasters like cyclones and storm surges.

Execution of the remote sensing monitoring component of the project was entrusted with SPARRSO. The project period was, however, extended upto October 1993 due to various unavoidable reasons. A major event took place during this period. A devastating cyclone hit the coast on 29 April 1991 causing loss not only to the life and property of the people but also to the plantation programme itself. In many places plants were damaged or eroded away by the cyclone and the associated storm surge. In some places sands were deposited damaging plantation areas totally.

The scheduled aerial photography of the coastal area under the project could not be taken due to various factors. However, the study was conducted by procuring aerial photographs from the Bangladesh Inland Water Transport Authority (BIWTA).

Plantation journals and other logistics support were provided by the Department of Forests. A training course was arranged in SPARRSO for the Range Officers to make them aware of the technology. Senior officials (Divisional Forest Officers) were also provided with some orientation in SPARRSO. Three Assistant Conservators of Forests were attached with SPARRSO for six months for in-depth training. Three Research Fellows, one Cartographer, two Draftsmen, one Typist and one MLSS were recruited for the project activities.

Satellite imagery were analysed both visually and digitally to identify plantation areas, damages, newly accreted lands, and other geomorphological changes in the coastal area. The detailed plantation maps were prepared from the stereoscopic study of 1:30,000 scale aerial photographs. The final maps contain year-wise plantation areas, cyclone damages, erosion and accretion of land and the recent geomorphological features.

Ground truth missions were conducted by SPARRSO personnel to supplement the remote sensing study. One hundred and ninety two maps at the scale of 1:10,000 were prepared and were bound in four volumes Division-wise viz. Chittagong, Noakhali, Bhola and Patuakhali.

A total of 45,087 acres of plantation have been found to be surviving through this study during the project period 1985-90.

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1. INTRODUCTION

Bangladesh is a delta of the three mighty rivers, the Ganges, the Brahmaputra and the Meghna. These three rivers and their numerous tributaries carry huge amount of sediment to the Bay of Bengal. Bangladesh has a vast coastal area to its south and has a large area with dense coverage of mangroves. The coastal area of Bangladesh is characterised by complex hydro-dynamic and oceanographic features having wide seasonal variations of river discharges, tidal actions and meteorological conditions. The tropical cyclones being formed in the Bay of Bengal hit Bangladesh coast almost every year. The cyclones and wind actions with associated storm surges, monsoon activities, tidal actions and the river hydrologic processes mainly control the coastal environment. Though huge amount of sediment is carried by the rivers every year, the accretion process is very slow and there is erosion over some areas in the estuary of the Meghna river. From a number of remote sensing studies at SPARRSO it is seen that there is a net soil accretion in the coast of Bangladesh.

It should be mentioned here that Bangladesh is a small country with high population density. It needs more land to meet its enormous population pressure. This need can only be met by reclaiming lands from the sea along the coast. The islands along the shore formed by the depositions of alluvium are always subject to erosion. The idea behind this mangrove plantation project was mainly to provide stability to these offshore islands and to accelerate the process of accretion. Moreover, this would protect the land from the onslaughts of tropical cyclones and storm/tidal surges.

Mangrove afforestation along the coast of Bangladesh was started in 1965/66 by the Forest Department with a view to accelerating the accretion process in the coast and stabilizing the lands which had already been accreted. The programme continued till 1979. The results of these scattered coastal plantations encouraged the Government to undertake a 5-year comprehensive Coastal Mangrove Afforestation Programme from 1980/81 to 1984/85 (Phase-I). Under this, a sub-project, Monitoring of Coastal Afforestation using Remote Sensing Technology was undertaken and completed by SPARRSO. The details of the historical background of coastal plantation programme have been given in the Phase-I Report (1988).

As a follow-up of the first phase, the second phase of mangrove afforestation project was undertaken to continue further plantation in the coastal area. This Mangrove Afforestation Project Phase-II has a similar remote sensing and monitoring component as in Phase-I. SPARRSO undertook the responsibility for implementing the monitoring part of the project by using satellite remote sensing data, aerial photographs and the ground truth information.

Aerial photographs were used for classification of plantations and accreted lands, and for preparation of base maps. Landsat imagery were used for the study of general situation of land accretion and erosion taking place in the coastal region of Bangladesh.

There was a provision for taking infra-red (IR) aerial photographs under this project but it could not be materialized due to the constraint of time for completing the required formalities. However, the need was met by procuring the IR photographs taken by the Bangladesh Inland Water Transport Authority (BIWTA). This was decided in consultation with the Department of Forests and the World Bank. The photographs were taken in February 1990 in the scale of 1:30,000. For the present mapping purpose these were enlarged to 1:10,000 scale. But in some cases Landsat TM and SPOT satellite data were used when the aerial photography could not be used due to high tidal conditions. The maps of the coastal region prepared by SPARRSO for the Second Phase will serve as an authentic information base for planning and management of the coastal mangroves.

2. OBJECTIVES OF REMOTE SENSING AND MONITORING COMPONENT

The prime objectives of this component are :

- To update the Phase-I maps by incorporating year to year information on tidal flats and plantations during the period 1985-1990.
- To monitor the physical conditions of the plantations raised during the above-mentioned period.
- To incorporate the areas of accreted and eroded lands during the above-mentioned period in those maps.

3. PROJECT AREA

The area of Mangrove Afforestation Project covered the coastal zone of Bangladesh extending from Laldia island located at the east of the Haringhata river to St. Martin's island located at the south western tip of Teknaf. The area lies within 20°30'N to 22°45'N latitudes and 89°45'E to 92°30'E longitudes. The Mangrove Afforestation Project area in the coastal region has been shown in Figure-1. The description of the geographic conditions of the project area are given below :

3.1 Climatic Conditions

The coastal region of Bangladesh is characterised by tropical monsoon climate with three distinct seasons, which are: (i) monsoon (June-October), (ii) cool dry period with very little rains (November-February), and (iii) hot dry period (March-May). The vapour-laden sea breeze blows from different directions during different seasons and different hours of the day.

The mean maximum temperature of the region lies between 27.2°C (at the end of January) and 31.1°C (in the first week of April), and the mean minimum temperature lies between 13.3°C (in January) and 23.8°C (in April). Isotherm of the region has been shown in Figure-2 (Rashid, 1977).

Being situated in the monsoon region, the region receives heavy rainfall, usually over 2540 mm annually. The region covering the area from the Sundarbans to the coast of Chittagong (east of Sandwip island) has an annual average rainfall of 2794 mm. The southern coast receives more rainfall than the northern coast of Chittagong region. Mean rainfall in Cox's Bazar region is 3556 mm and in the Teknaf region it is 5080mm. Rainfall distribution pattern in the coastal region has been shown in Figure-3 (Rashid, 1977). Most of the coastal rainfall occurs during the south-western monsoon period (June-October) from the monsoon depressions forming in the Bay of Bengal and travelling to the lands.

The coastal zone of Bangladesh is frequently hit by tropical cyclones which affect the coastal environment by the wind action, the storm surges and the enormous rainfall associated with them. The satellite picture of the devastating cyclone of 29 April 1991 which hit the coast of Bangladesh is given in Figure-4a. The tracks of some of the tropical cyclones formed in the Bay of Bengal are shown in Figure-4b along with their landfall.

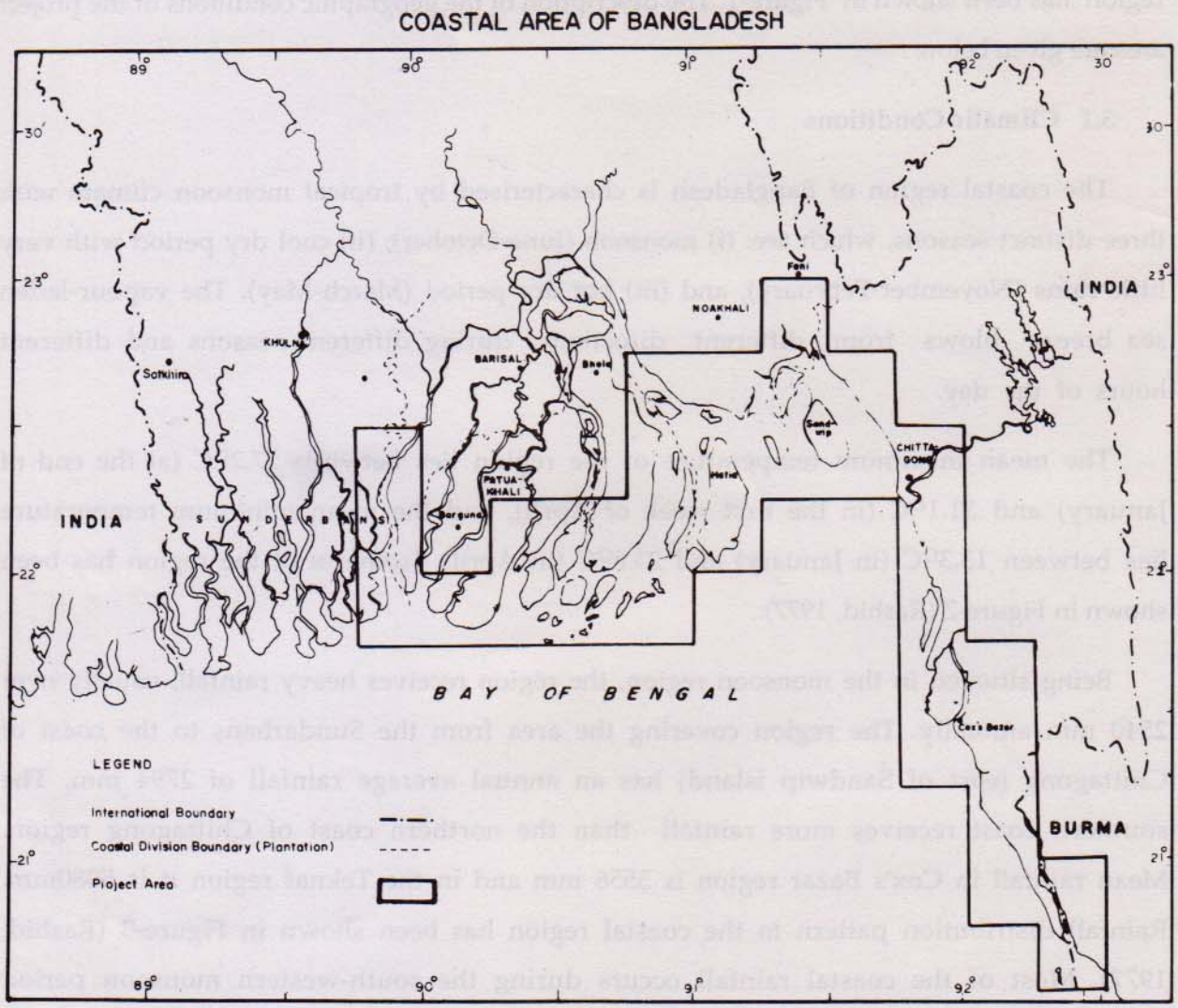


Fig. 1 Project area of mangrove afforestation in the coastal region of Bangladesh

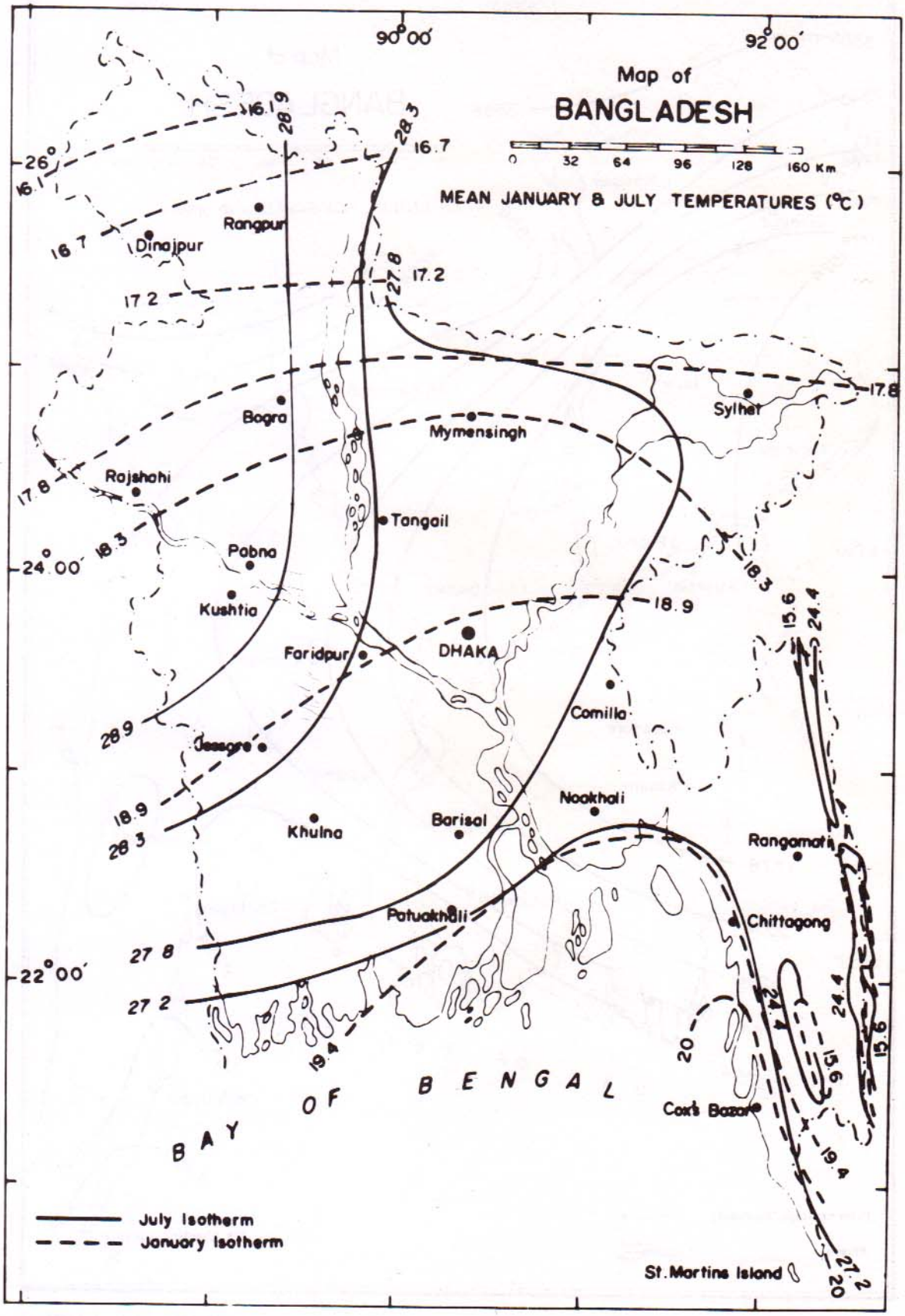
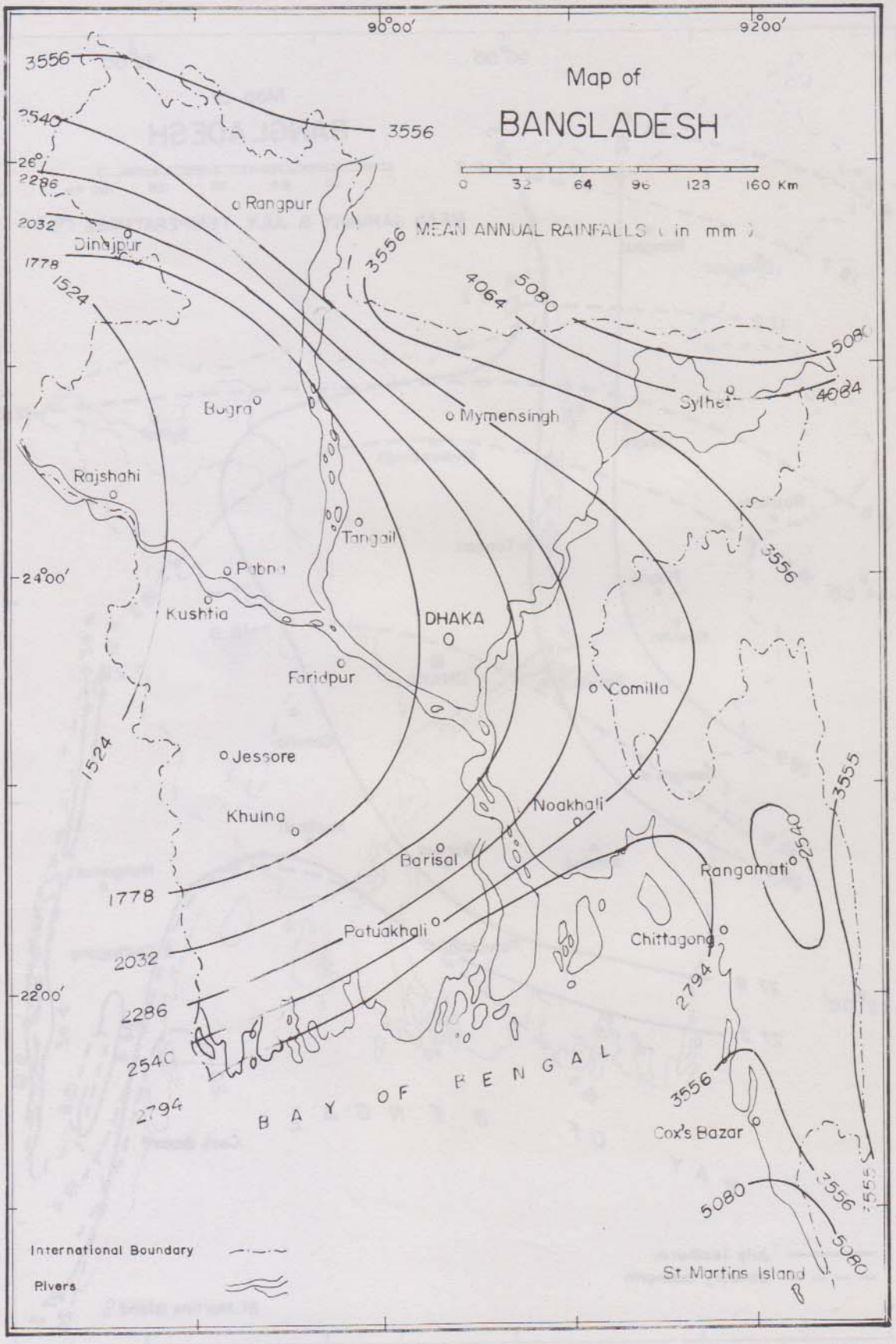


Fig. 2 Isotherm of mean January and July temperature



Source: Rashid (1977)

Fig. 3 Mean annual rainfall distribution

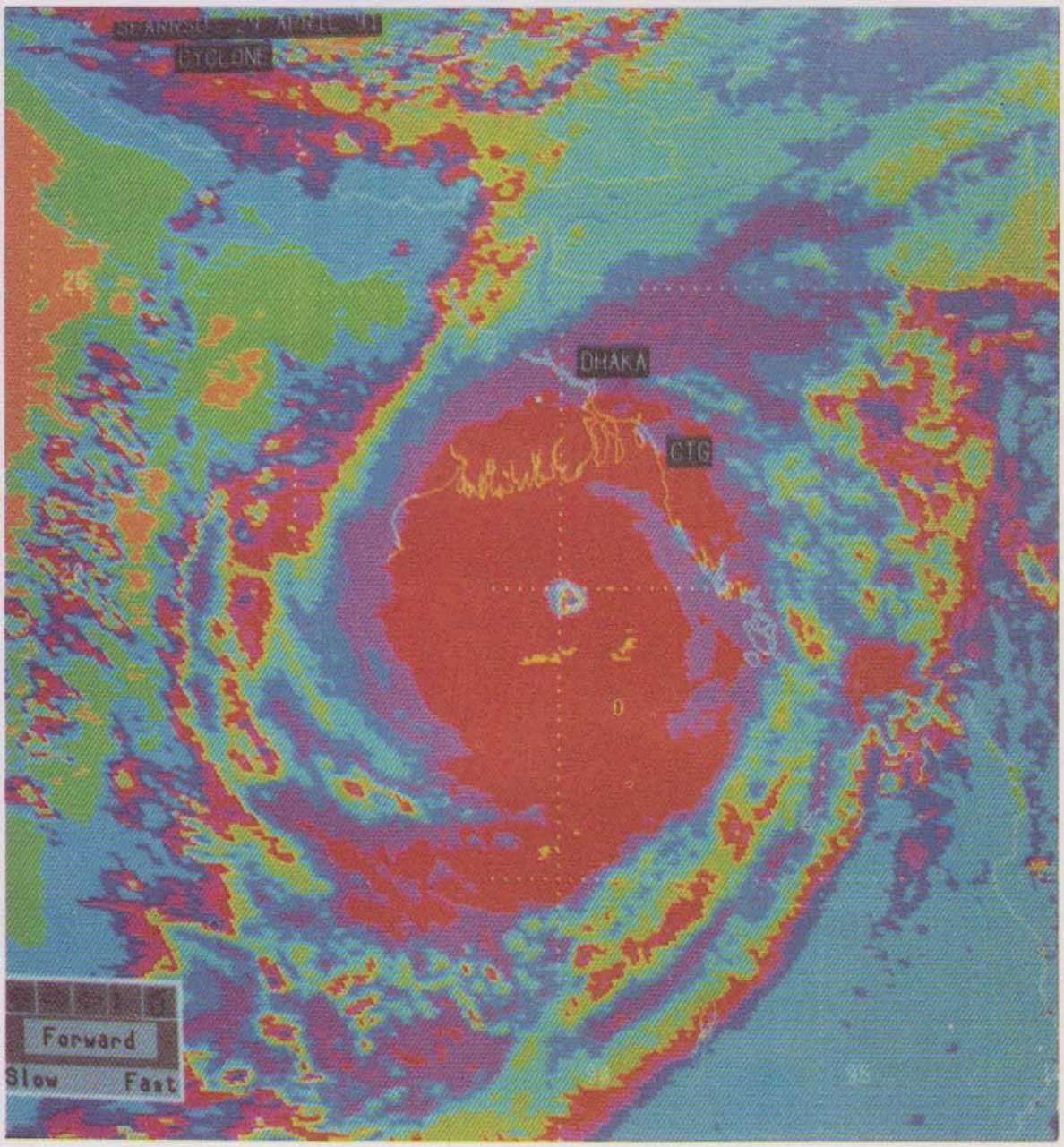


Fig. 4a Satellite picture of the 29th April 1991 cyclone

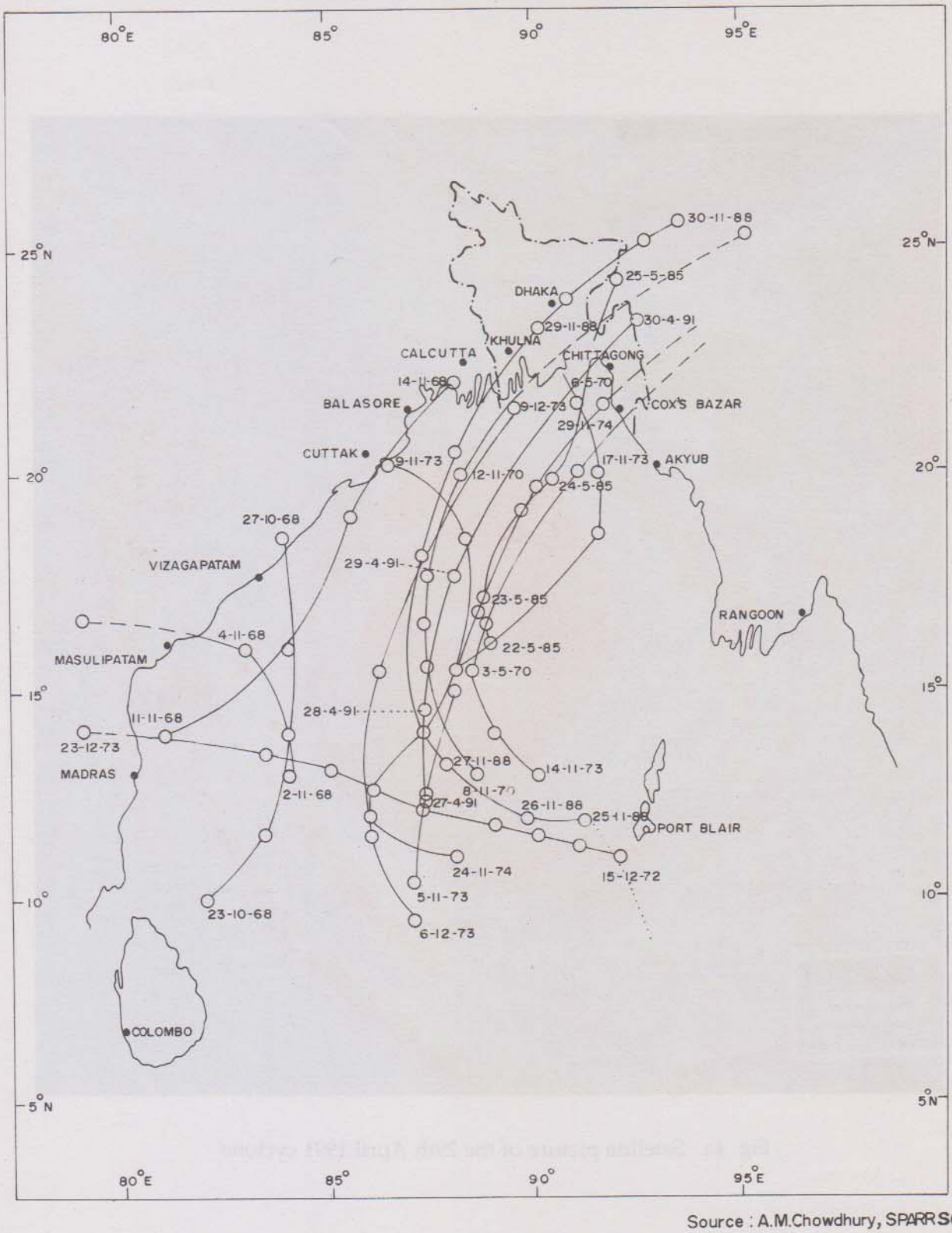


Fig. 4b Tracks of Tropical Cyclones in the Bay of Bengal (1968-1991)

3.2 Geomorphological and Hydrological Conditions

A huge quantity of water flows through Bangladesh into the Bay of Bengal. It is estimated that in an average year, 870 million acre-feet (MAF) of water flows into the country from the neighbouring countries - India, Nepal, Bhutan and China.

Bangladesh is a delta of three mighty river systems, namely, the Ganges, the Brahmaputra-Jamuna and the Meghna. The entire river system of the country carries down annually about 1.5 - 2.5 billion tons of suspended sediments and pours these sediments down into the coastal region of the country.

The typical hydrological condition prevailing in the coastal region of Bangladesh coupled with this huge quantity of suspended sediments carried by the rivers together with the effects of tidal flow has created three distinct geomorphological patterns observed in the following regions of Bangladesh coast (Pramanik, 1983) as shown in Figure-5.

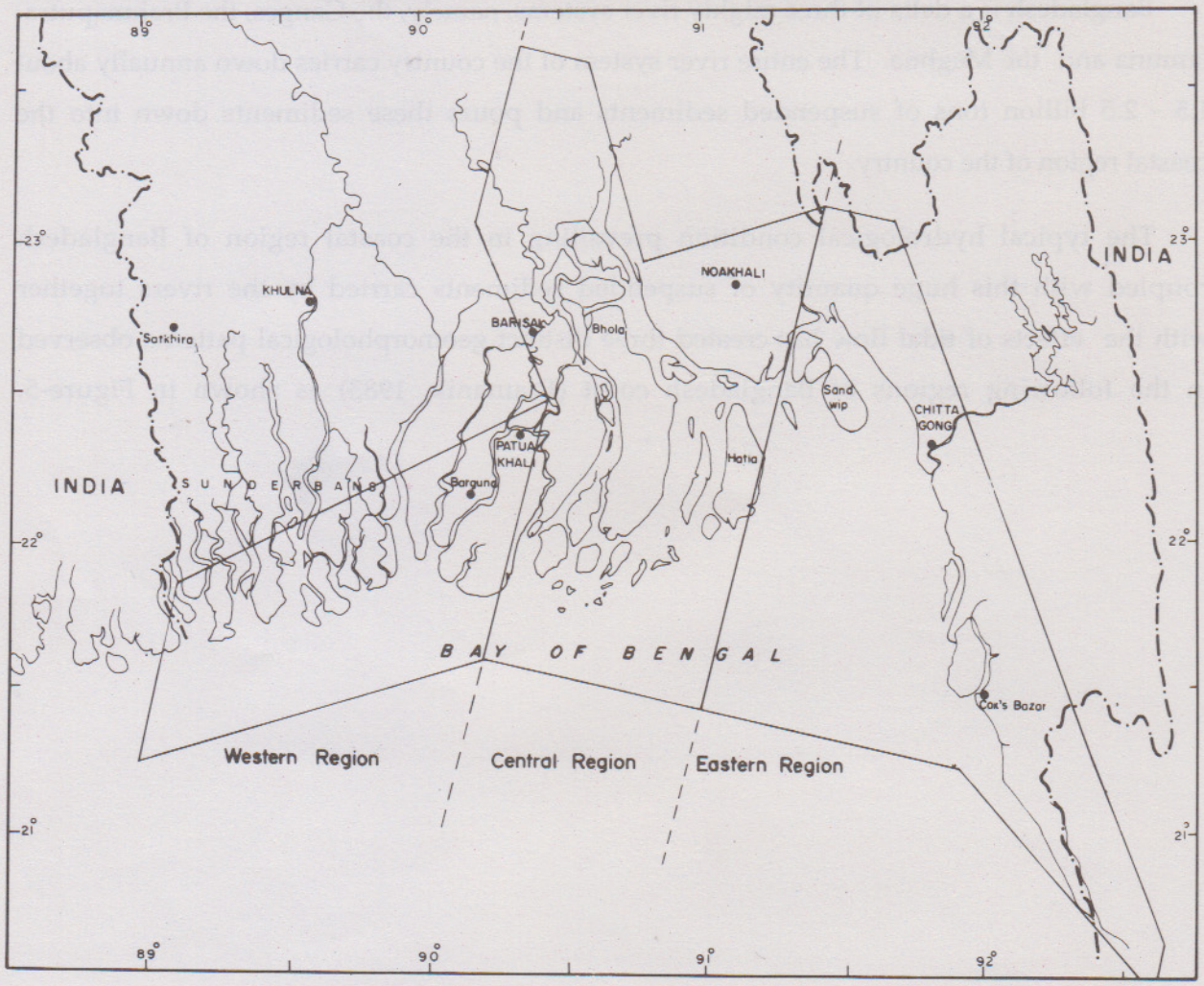


Fig. 5 Geomorphological and hydrological regions in the coastal zone of Bangladesh

3.2.1 The Western Region

The western part of the coastal region of Bangladesh extending from the international border river of the Hariabhanga to the Rabnabad Channel (the Tetulia River) lying south-west of Bhola island, falls under the hydrological influence of the river system of the moribund delta of the Ganges-Brahmaputra rivers. The south-western part of this region is covered with the natural mangrove forest belt of the Sundarbans. Sedimentation load of the river discharge in this region is relatively less than other areas in the central region.

Accretion in this area is less due to the presence of "the Swatch of No Ground" in which the rivers discharge their flows causing very little sedimentation.

3.2.2 The Central Region

The central region covers an area extending from the east of the Rabnabad channel to the mouth of the Feni river forming an arch-shaped configuration (Figure-6) of the sea coast. The estuarine area of the Lower Meghna and the Feni rivers is the most active land accretion zone. The discharge from the rivers of this region is characterised by heavy load of suspended sediments. The brackish water inter-face causes slowing down of the sediment-laden water flow and results in heavy siltation of suspended sediments. This active phenomenon has resulted in the accretion of a large area of new lands in this region.

The sedimentation pattern in this region seems to be due to the flow pattern influenced by the 'suction effect' of the "the Swatch of No Ground" which is located in the south western direction from this region (Figure-7).

The central region of the sedimentation zone is relatively shallow. Studies based on the visual interpretation of infrared colour aerial photographs and Landsat imagery and supported by ground truth observations apparently indicate that the process of land accretion is very active in this region. A large area of land is in the process of formation. During low tide even low draft mechanized country boats cannot move freely in any direction within this region due to the existence of submerged accreted land.

3.2.3 The Eastern Region

The eastern region of the coast lies along the north-south elongated fold hill ranges of the Tripura-Chittagong region. The eastern coast extends from the mouth of the Feni river to the south of Teknaf. The coastline is bordered with continuous submerged bed of sands. Due to steeper gradient of the region, the condition of tidal flow in this region is quite different from other parts of the coastal area.

Like the western region, the sedimentation phenomenon in this region does not influence the land accretion process significantly. Except in the Feni river estuarine area along the coastline of the Sitakunda Hills range, the entire extension of the Chittagong coastline does not have appreciable change of geomorphological condition in terms of land accretion.

Details may be found in the previous report of SPARRSO (Report, Forestry-I, CR 1042-BD, 1988).

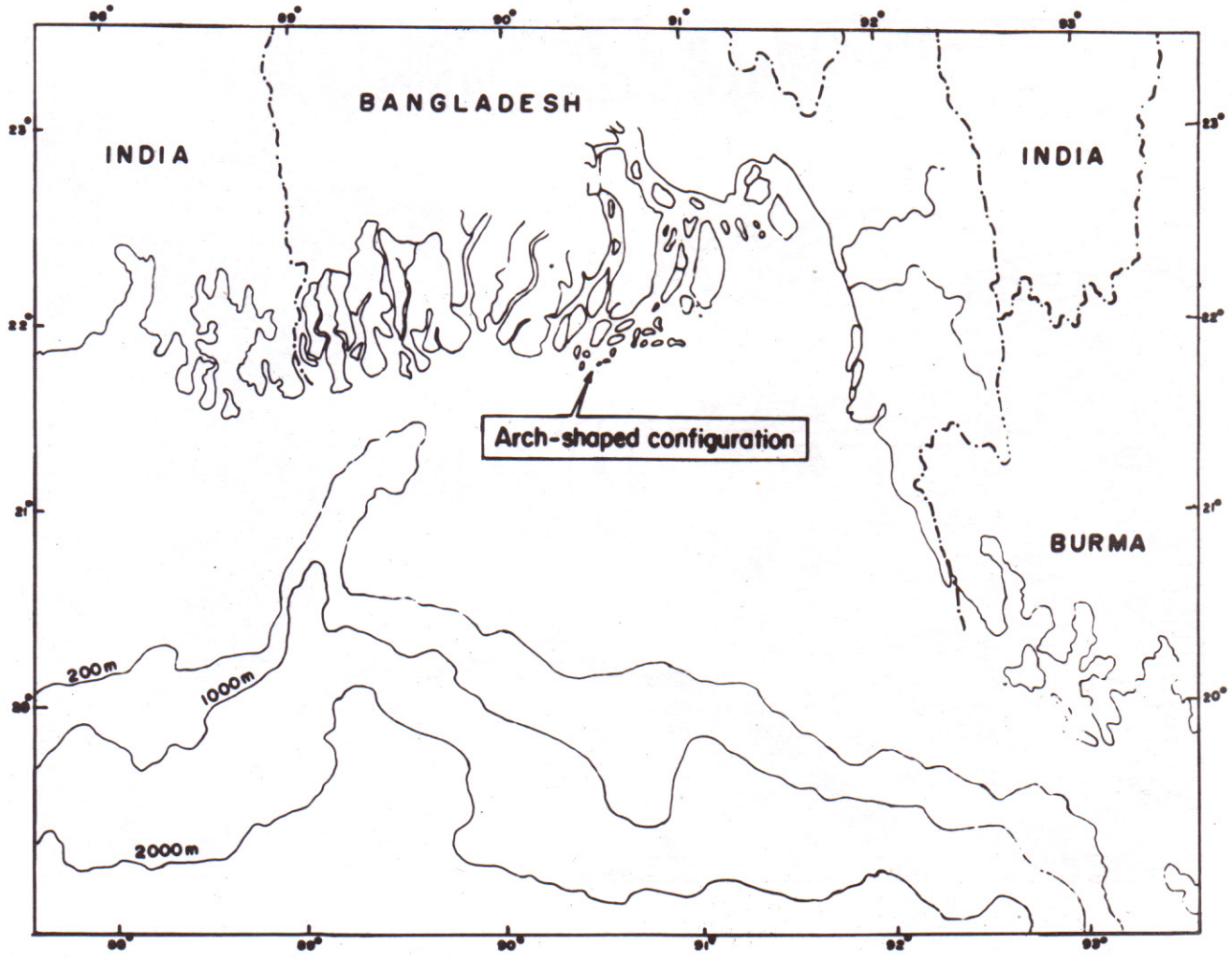


Fig. 6 Arch-shaped configuration of the central region

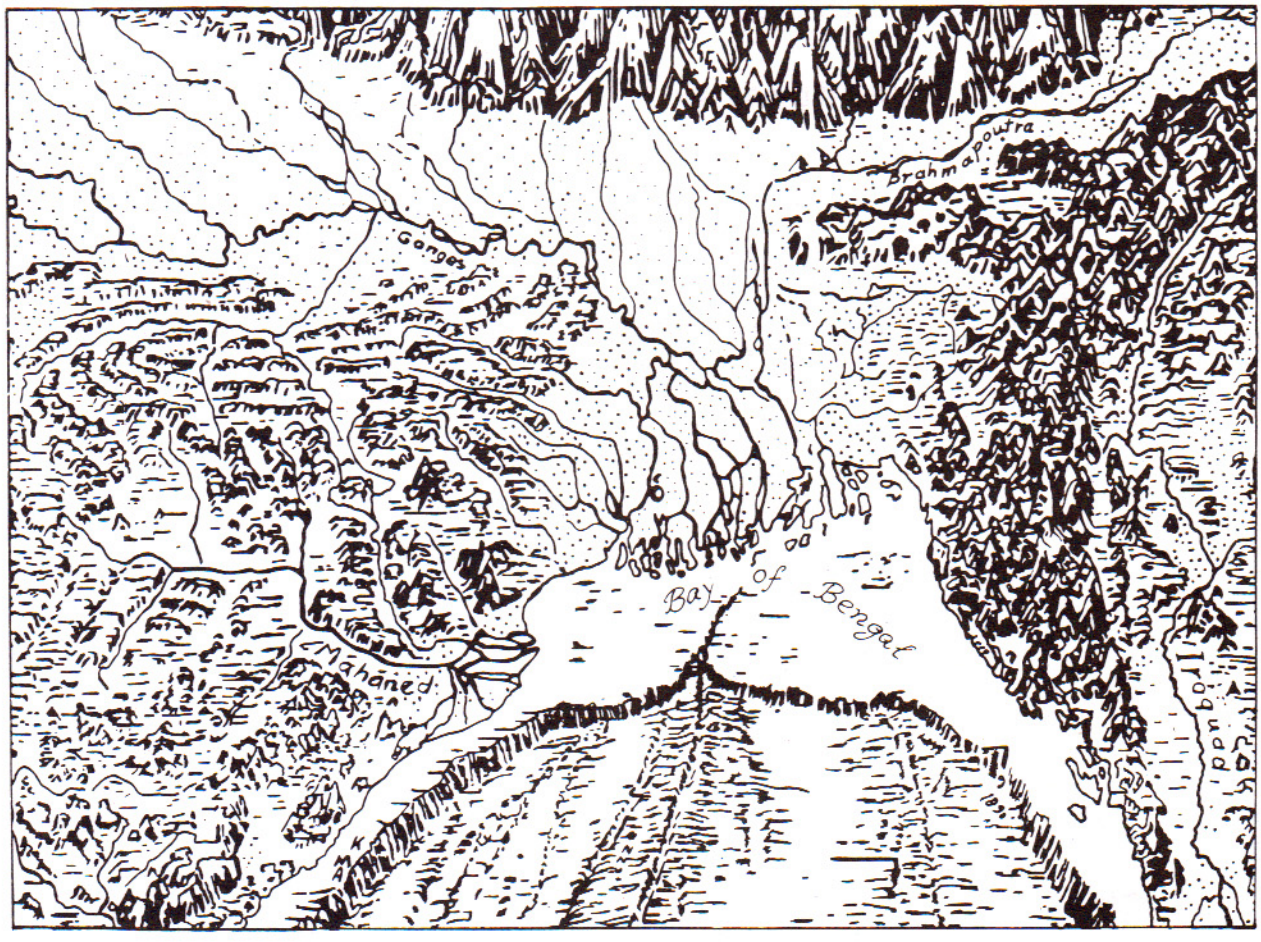


Fig. 7 Physiographic diagram of the Bay of Bengal showing the Swatch of No Ground

3.3 The Mangroves

A group of natural vegetation which is composed of halophytic tree species is loosely termed as mangroves. Mangroves are salt–tolerant ecosystems in the tropical and sub-tropical inter-tidal region of the world. The forest may extend from a few hundred metres to several kilometres from the sea shore depending on the environmental condition. The trees are generally evergreeen and the height may extend upto 30 metres or more. The forest floors are flooded twice every day by tidal water throughout the year.

Many mangrove species possess unique adaptation such as prop roots, pheumato phones, lenticels and viviparases germination that permit this existence in the coastal environment. They have the common requirement of fresh water, nutrient and oxygen like non-mangrove species.

It is thought that mangrove ecosystems contain about 60 species of trees and shrubs and more than 20 additional species are also frequently associated with mangrove flora globally. The key mangrove species belong to Rizophoraceae, Avicennia and Sonneratia. Heritiera fomes, H. Littoratis and Nypa fruticans are also included as members of this flora. The Indopacific flora is richer than the others. Most of the species are found in Asia and the Pacific. Mangroves have been least developed in Malaysia. There are some 45 millions hectare of mangrove forest land scattered throughout most of the subtropical and tropical countries of the world. Half of the mangrove forest are located within Asia and Oceania and the rest lies between Africa and the tropics of the western hemisphere.

The Mangrove forest of Bangladesh occurs in the form of natural forest as well as plantation. The Sundarbans, the largest Mangrove forest of the world is located in the greater Khulna district of Bangladesh and 24 Parganas of West Bengal (India). The Chokoria Sundarban is another natural mangrove forest of Bangladesh. It is situated in Cox's Bazar district. At present the forest ecosystem of this forest has been destroyed and shrimp culture has been developed over the whole area except some poor patches of mangroves along the banks of the canals.

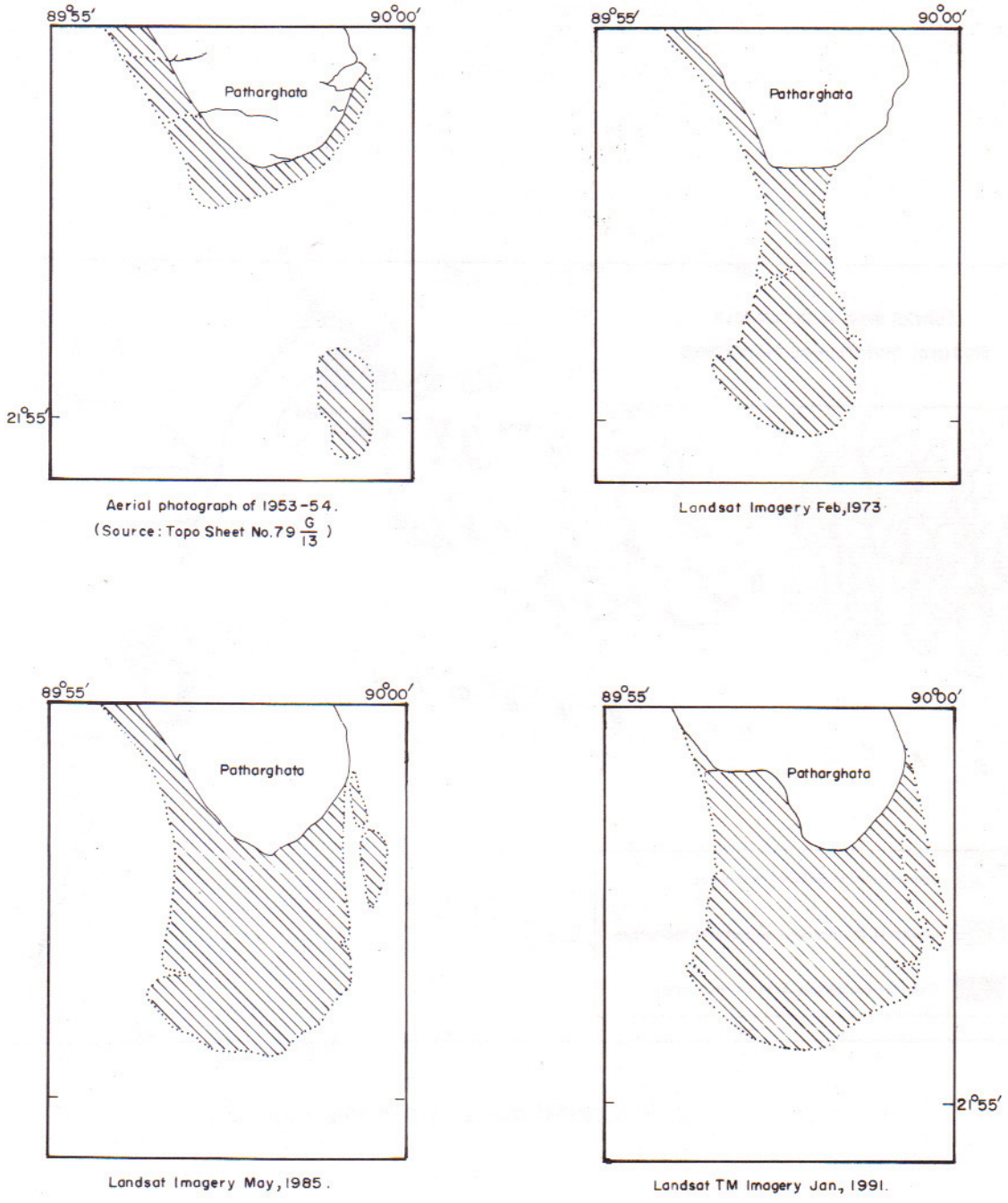
3.4 Coastal Afforestation

To protect the newly accreted land masses in the coastal region from erosion processes and natural hazards and to stabilize the land for human settlement and other uses, in other words, to protect and improve the overall coastal ecology the Forest Department of Bangladesh took initiatives in 1965-66 to raise artificial mangroves along the available lands in the coast. The embankment (polders) and the offshore islands are very much vulnerable to the cyclones, storm surges and other natural disasters. The coastal afforestation programme would thus provide natural protections against these adverse conditions.

The successes achieved in this programme showed some positive results in stabilising the planted area and enhancing accretion process in some places. Comparison of Landsat imagery of different years shows that Laldia which was an isolated island in 1953, became connected to the mainland through accelerated accretion due to plantation (Figure-8). The Forest Department of Bangladesh was encouraged to take up a giant programme of coastal afforestation under the World Bank aided project "Mangrove Afforestation Project, Forestry-1 (CR 1042-BD)" over a period of five years from 1980-85. During implementation of this project a total area of 88,203 acres (35,722 ha) was afforested successfully (Phase-I Report, 1988).

The present phase (Phase-II) is a continuation of the mangrove afforestation programme taken up during the Phase-I. A general representation of coastal afforestation area has been given in Figure-9.

Since the beginning of the coastal afforestation programme in 1966, several species of mangrove and non-mangrove trees were planted according to available type of land. The species are Babul (Acacia arabica), Keora (Sonneratia apetala), Baen (Avicennia officinalis) and Kankra (Bruguiera gymnorhiza). Besides these species Golpata (Nypa fruticans) was planted at the early stage of the programme. Details of the previous plantations are given in the Phase-I Report (1988). Plantations have also been raised with the same species as mentioned above during the Phase-II programme.



Scale 1:160,000 (approx)

Land accretion phenomenon in Laldia
Island showing acceleration of accretion by Mangrove
Plantations from 1953-54 to 1991

Fig. 8 Laldia Island

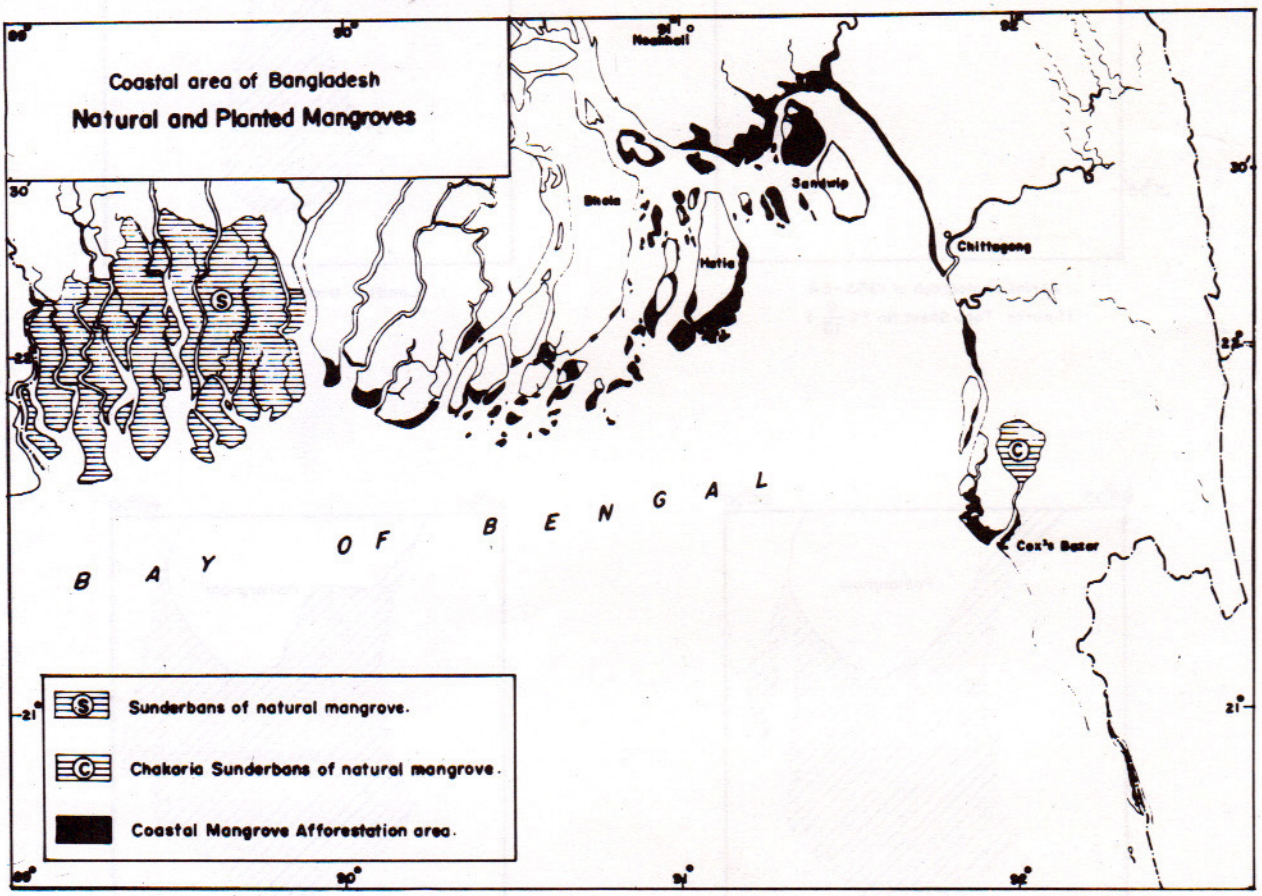


Fig. 9 Coastal mangrove afforestation area

During plantation survey by SPARRSO under Phase-II project in Patuakhali, Barisal and Noakhali plantation divisions, it was observed that Keora maintained good growth everywhere in this region. This is possibly due to favourable adaptability of Keora at low concentration of salinity as this region falls within the flushing zone of the river net-work system.

In the coastal region of Chittagong and Noakhali patchy areas of Kankra plantation were found. But the growth of plants appeared to be stunted.

4. DATA USED FOR THE STUDY

The following data were used:

- Landsat imagery of the years 1984, 1986 and 1988 and SPOT satellite data of 1989.
- CCT data of Landsat MSS of 1984 and TM of 1987, 1990 and 1991.
- Black and white aerial photographs taken in February 1990 at scale 1:30,000.
- Infrared coloured (IRC) aerial photographs taken in February 1990 at 1:30,000 scale.
- Toposheets in the scale of 1:50,000 prepared by the Survey of Bangladesh.
- Plantation journals of the Department of Forests.
- Data collected from ground visits and surveys.
- Reports and maps prepared during Phase-I of the Mangrove Afforestation Project.

5. DATA ANALYSIS AND INTERPRETATION

5.1 Satellite Image Analysis and Interpretation

The satellite data required for the project work were procured and analysed visually as well as with the help of computer to locate and identify the land accretion and erosion phenomena within the project area and to study the condition of the plantation raised during the project period.

The Landsat TM CCT data of 1 November 1988 Path 137, Row 44 was procured by SPARRSO under the Agroclimatic Environmental Monitoring Project (ACEMP). The Landsat TM has 7 spectral bands with maximum ground resolution of 30m. The data have been processed in the I^2S Image Processing System (Model 75) using the

image processing software S575. The image covers the Barisal and Patuakhali Mangrove Plantation Divisions along with Reserve Forest of Tangragiri and Kuakata and natural mangrove forest area of the Sundarbans. The processing consists of linear enhancement of bands 3,4 and 5. After enhancement, the digital data were transferred to colour transparent negative film (false colour composite of bands 4 (red), 5 (green) and 3 (blue) using Optronics and then hard copy print was produced.

In the imagery (Figure-10) the red colour represents green thick vegetation, white represents dry bare soil, dark tone represents clear water, sky blue represents water with suspended sediments, light sky blue represents shallowly merged areas with muds and whitish blue areas (sharply separated from surrounding water) represent newly accreted lands.

From the imagery it is seen that the Sundarbans and other mangrove vegetations have more or less massive and uniform red/dark-red tones with minimum textural variation compared to other vegetations which are represented by non-uniform red tones with high textural/spectral variations. Thus the mangrove areas could be visually identified. The mangrove plantation areas have been identified in the imagery using the previous ground knowledge of the SPARRSO scientists and the locations have been pointed by arrows. It can however be mentioned that very recent plantations are not visible in this image.

A contact print (negative hard copy) of the Optronics transparency has been made for analysis (Figure-11). It is seen that the dark mangrove areas appear as light blue, other vegetations appear dark blue and water is found to be red. In this imagery the mangrove areas are also nicely represented with the advantage that the mangrove vegetation appears completely different from other coastal features.

The Landsat TM colour composite image covering the area of Patuakhali and Bhola Plantation Divisions has been given in Figure-12. In the image, the mangrove afforestation areas appear in smooth textured light and dark red tone. The stable agricultural lands and the newly accreted lands are seen in the imagery in yellow and whitish blue respectively.

The Landsat MSS colour composite image of 1984 (Figure-13a) shows that Char Srizoni of Noakhali Plantation Divison was an isolated island in 1984. The same area in the TM image of 1991 (Figure-13b) has been found to be connected with the main land due to accretion accelerated through mangrove plantations. Char Majid, Char Clark, Char Noman of Char Bata Range of Noakhali Plantation Division have been also extended towards south, south-east and east through the process of accretion due to successive plantation of mangroves. It is seen from the comparison of the imagery of 1984 and 1991 (Figures-13a,b) that erosion is very active in the western part of Urir Char whereas a substantial land has been accreted to the east and north of the island. It is observed from the image and also from field observations that the eroded area of Urir Char had established mangrove plantations. It is assumed that had there been no mangrove plantations, the area would have eroded faster. This kind of erosion is also active in the southern part of Char Dighal which is causing washout of the established old plantations along this part of the coast. The causes behind this erosion might be some hydro-dynamical processes in the Meghna estuary.

It is evident in the satellite imagery that old plantation of Jahajmara, Char Osman (Figure-14a) and southern Moheskhali (Figure-14b) etc. area have been affected seriously by sand deposition due to wave and tidal actions. This shifting sand is enchroaching the existing plantation sites. This was confirmed during the ground truth missions.

The details on the mapping of the mangrove afforestation and the other physical changes over the study area have been discussed in the following sections.

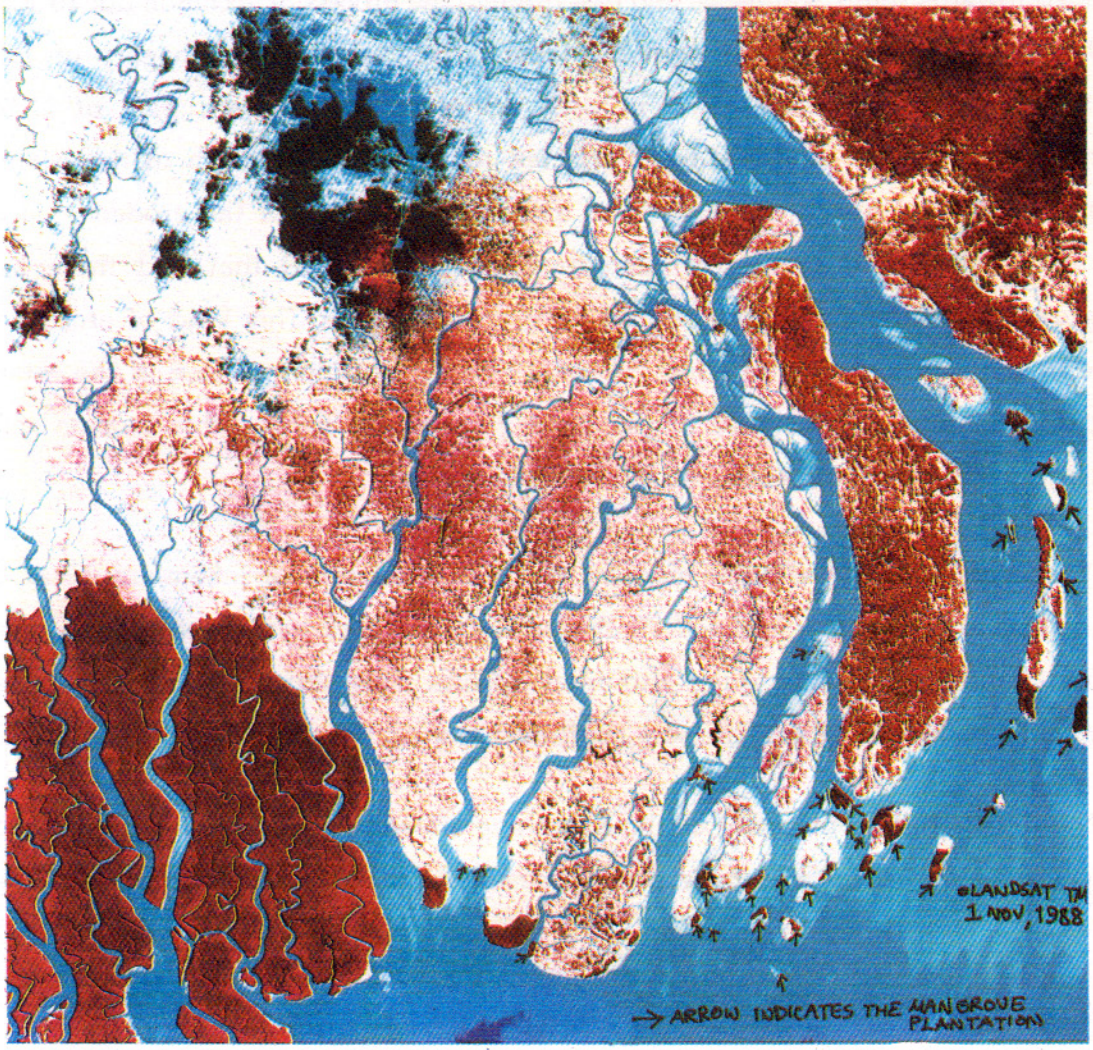


Fig. 10 Computer enhanced colour composite image (bands 3,4,5 of Landsat TM 1987)

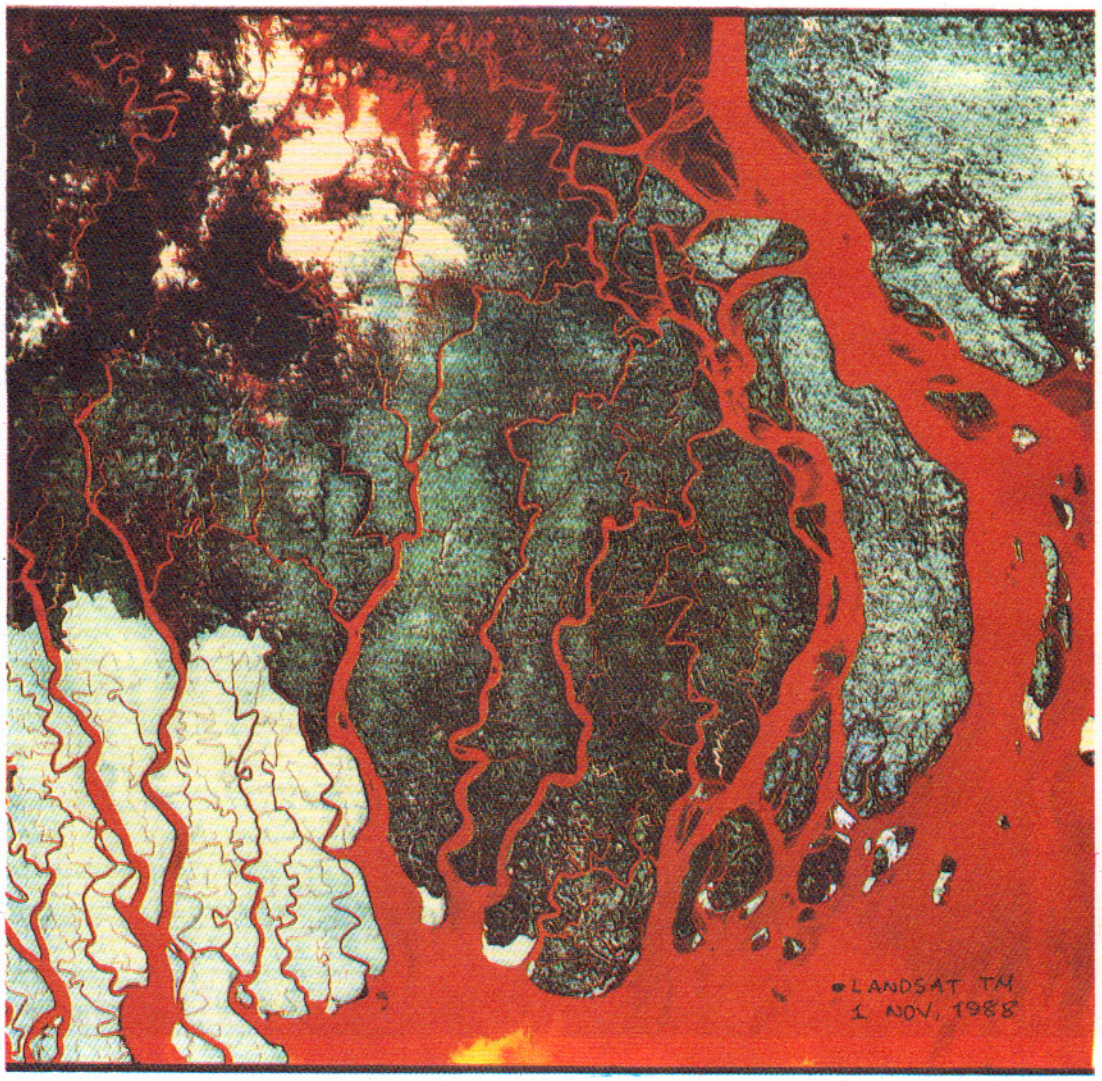


Fig. 11 Computer enhanced colour composite image in negative form (band 3,4,5 of Landsat TM 1987)

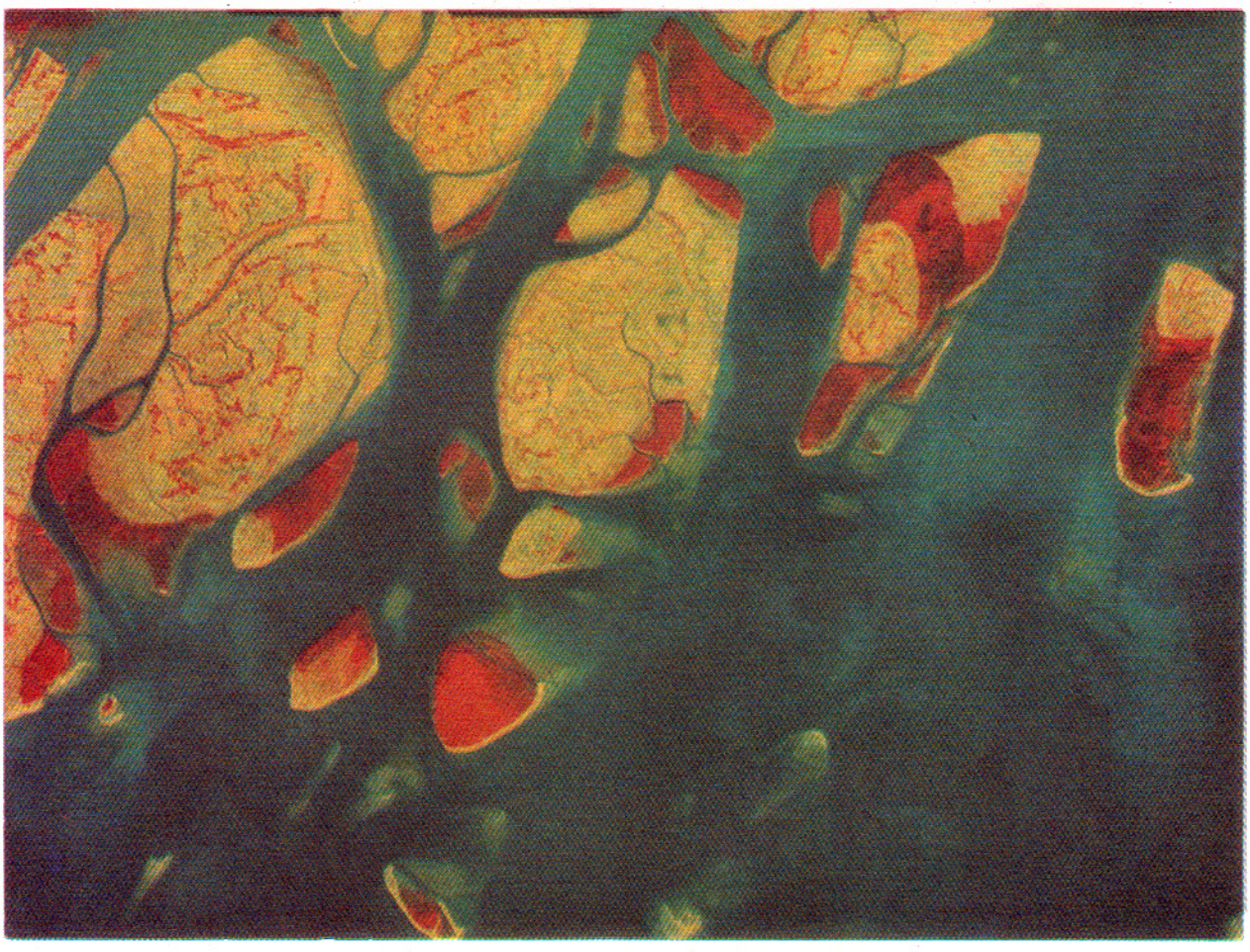


Fig. 12 Satellite imagery (TM 1991) showing mangrove plantation in red

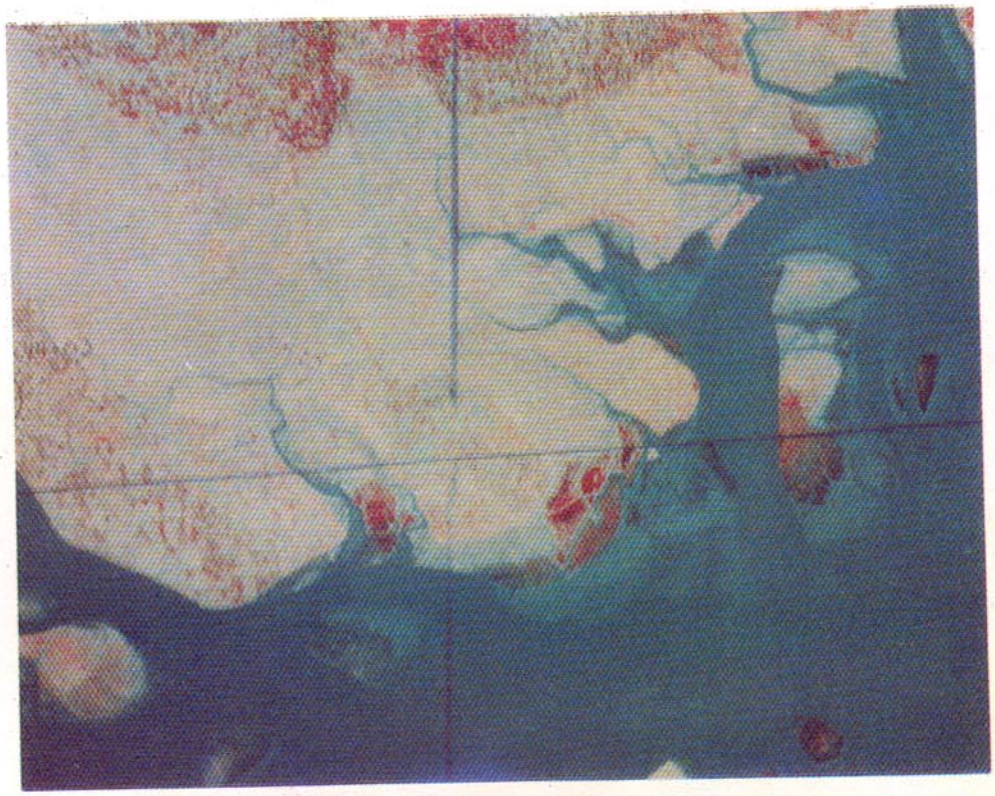


Fig.13a Satellite imagery of 1984 (MSS data) covering part of Noakhali and Chittagong coasts

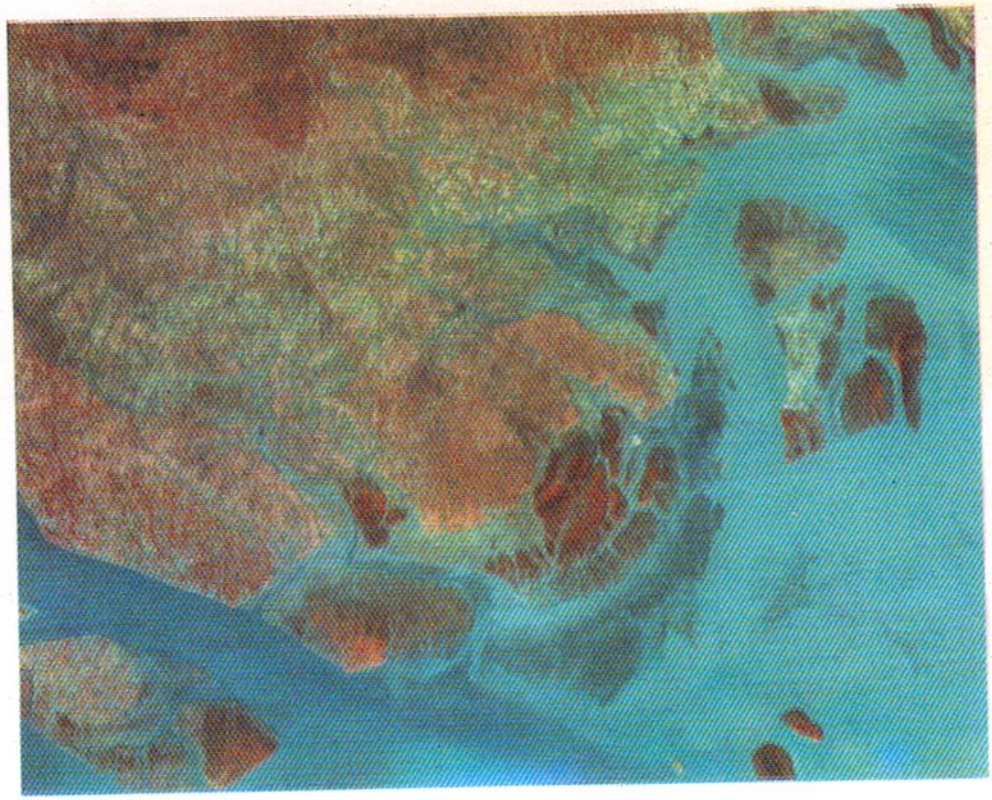


Fig.13b Satellite imagery of 1991 (TM data) covering part of Noakhali and Chittagong coasts

Fig.14a Sand deposition in Jahajmara area (Noakhali Plantation Division)
as seen in satellite imagery (TM 1990)

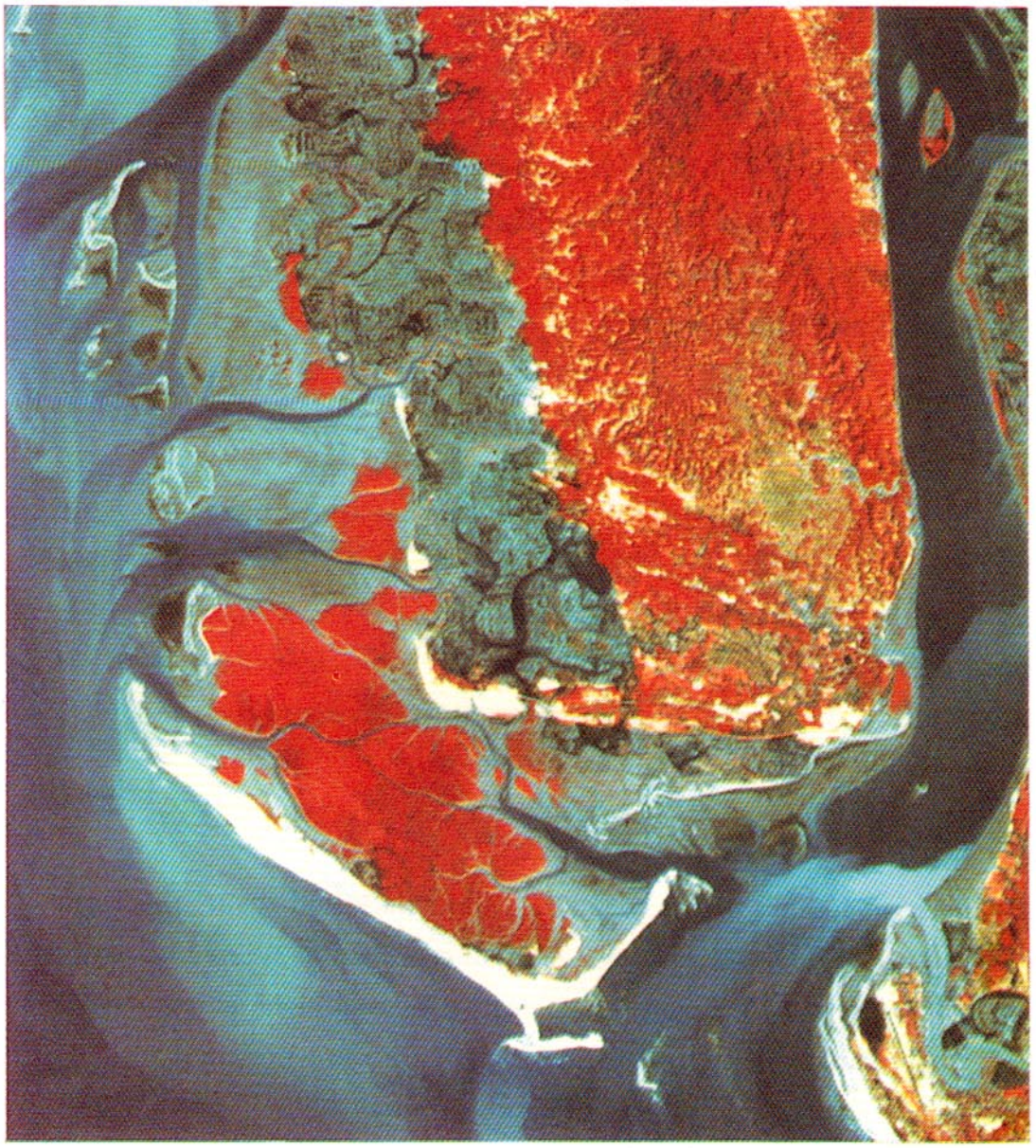


Fig.14b Sand deposition in southern Moheshkhali area as seen through satellite imagery (TM 1990)

5.2 Mapping of Mangrove Afforestation during Phase II Project

The detailed mapping of the mangrove afforestation was done using aerial photographs and ground truth information following the procedure as described below:

5.2.1 Preparation of base map

Base maps at scale 1:10,000 of the entire project area have been prepared on the basis of the maps of the same scale prepared by SPARRSO during the First Phase (1980-85) of the project. During preparation of these maps the topographic maps prepared by the Survey of Bangladesh were also consulted. The older plantations have been plotted in their proper locations. The geomorphological features have been included in the base maps.

5.2.2 Incorporation of plantation journals

The plantation journals supplied by the Forest Dedepartment have been useful for the preliminary identification of the plantation areas. The plantation blocks were transferred on the base maps from plantation journals. The area of the newly planted plots were measured from these base maps for their comparison with the journal statements. These have also been summarized division-wise for identification of the discrepancies among the two area statements.

5.2.3 Interpretation of aerial photographs

For stereoscopic study of the plantation area, black and white aerial photographs were procured from the Survey of Bangladesh but could not be utilised because of the fact that those photographs were taken during high tidal conditions in the coast. However, colour IR photographs taken in low-tide conditions were procured from the Inland Water Transport authority (IWTA) for interpretation and classification of the mangrove plantations. The photogrphs were in the scale of 1:30,000. Based on the stereoscopic interpretation the plantations have been classified into two classes : old and new plantations. The classification criterion is the following.

Old plantations : Plantations having height more than five feet (1.524 metres).

New plantations : Plantations having height less than or equal to five feet (1.524 metres).

The plantations were also classified as thick and thin plantatiions. The thick plantation areas are those having more than 40% plants alive and thin plantations are those areas where less than 40% plants are alive. Plantation blocks, damaged areas, sands and other geomorphologic features were interpreted from these photographs. The interpreted results were then enlarged to the scale of the base map (1:10,000). These preliminary maps were corrected during the ground truth missions of SPARRSO personnel.

5.2.4 Field verification of the interpretation

The interpreted results obtained on the basis of the plantation journals and the aerial photographs were taken to the ground for their verification. The aerial photographs enlarged to the scale of the preliminary maps (1:10,000) were also carried to the field during ground truth missions. A devastating cyclone had taken place and hit the coast of Bangladesh on 29 April 1991 which had damaged a considerable area of the newly planted mangroves including some older plantations. A statement of the damage caused by the cyclone was also received from the Department of Forests. These damaged areas were physically visited by the SPARRSO scientists during ground truth missions. Other physical features relating to erosion/accretion and deposition of sands were also verified physically. Yearwise plantation blocks over the project period were identified and corrected on the base map. During the field survey information were also collected on the condition of the plantation sites. The species of the planted samplings were also noted down. The areas, where plant heights and densities were not identifiable in the photographs, were physically checked for proper incorporation in the final maps. The latest geomorphological changes with respect to the plantation maps of Phase-I have been incorporated in the maps after verification on the ground. Some of the photographs taken in the ground have been given in Figures 15 *a-l* describing the field conditions.

Fig.15a Alluvial deposition in the coast

Fig.15b Very early stage of plantation in tidal flats

Fig.15c New plantation in growing stage

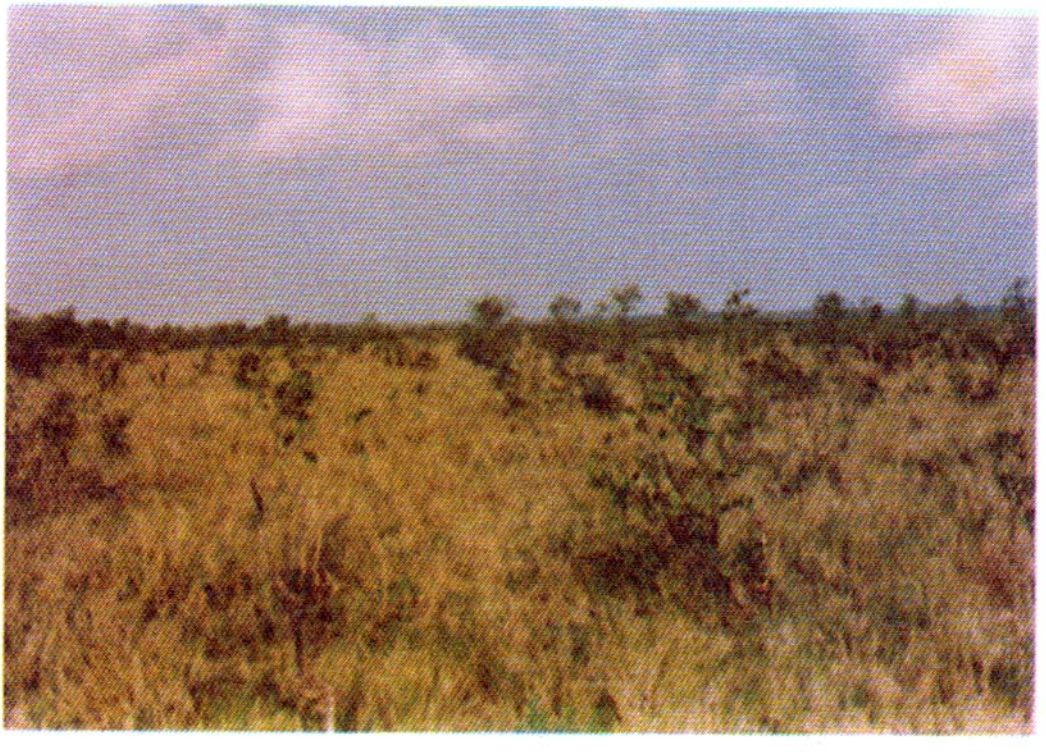


Fig.15d Growing plantation in Uri grass

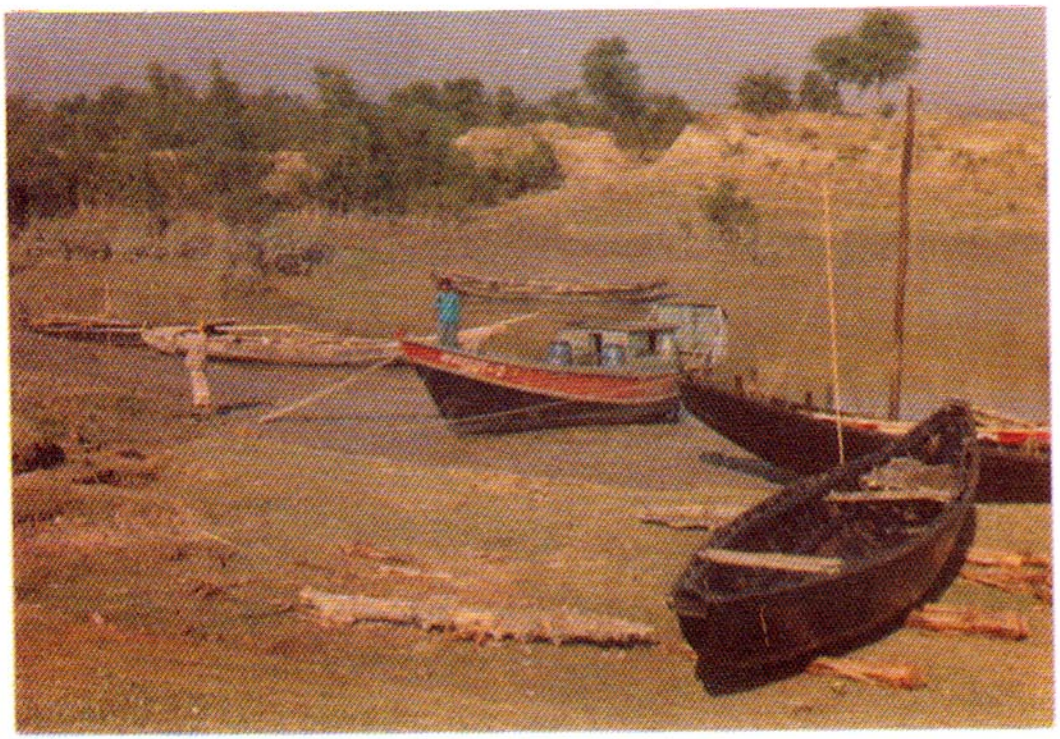


Fig.15e Plantation along embankment

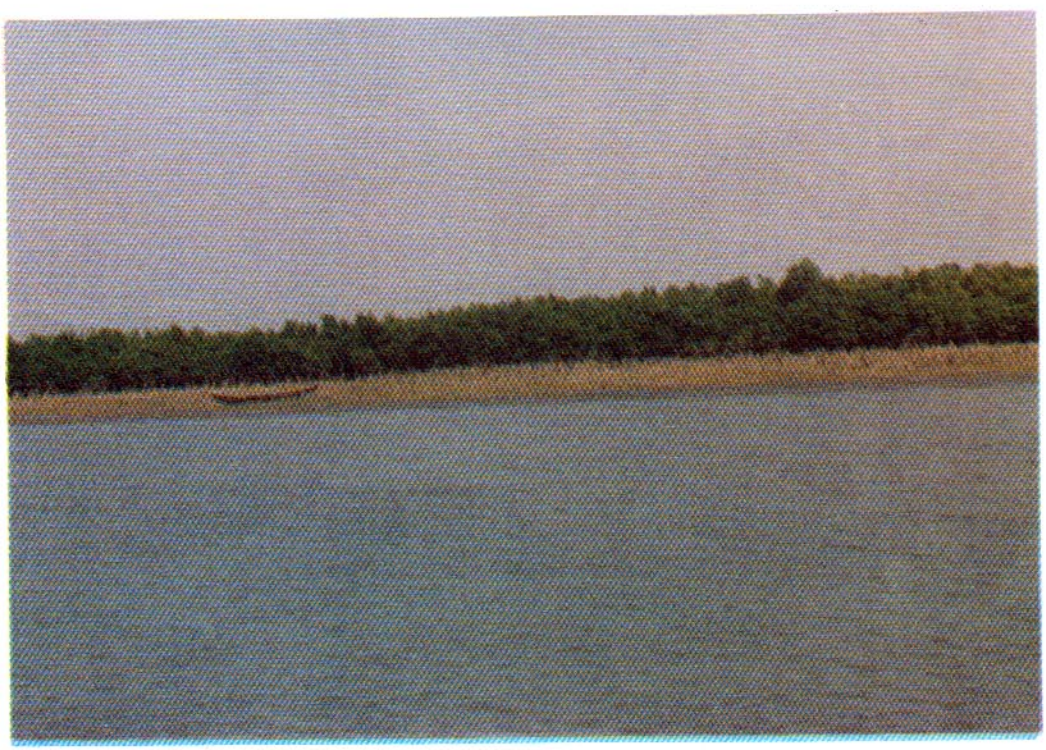


Fig.15f Old plantation seen behind newly planted saplings near the shore .

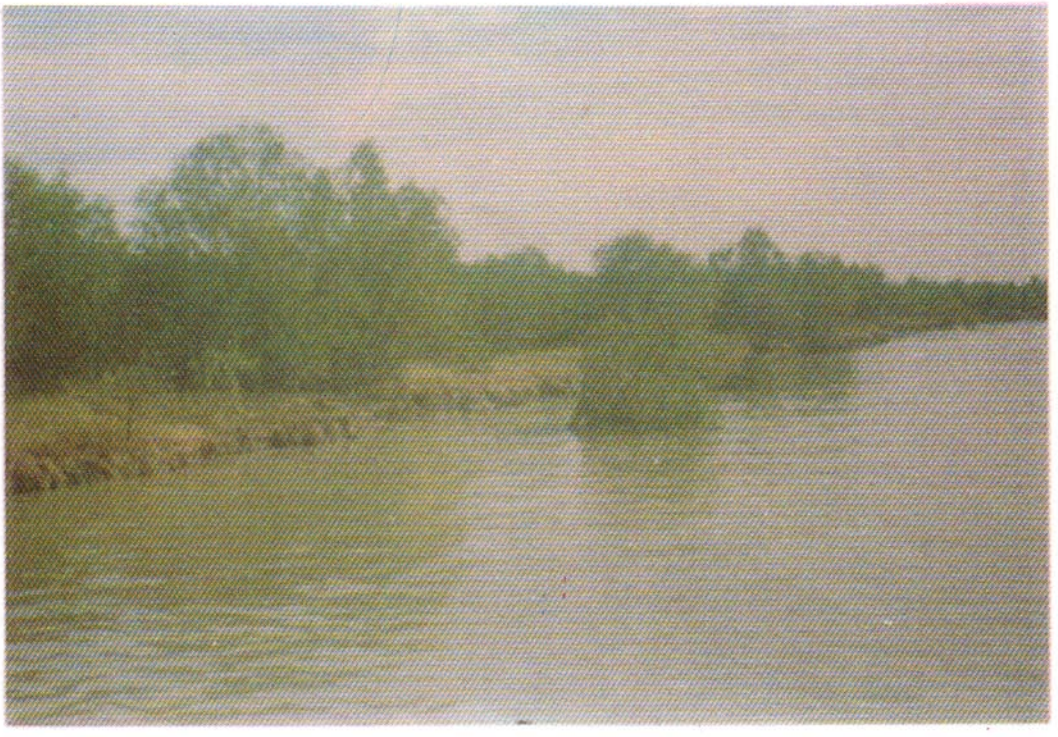


Fig.15g Bank erosion damaging mangrove

Fig.15h Erosion due to wave and tidal actions

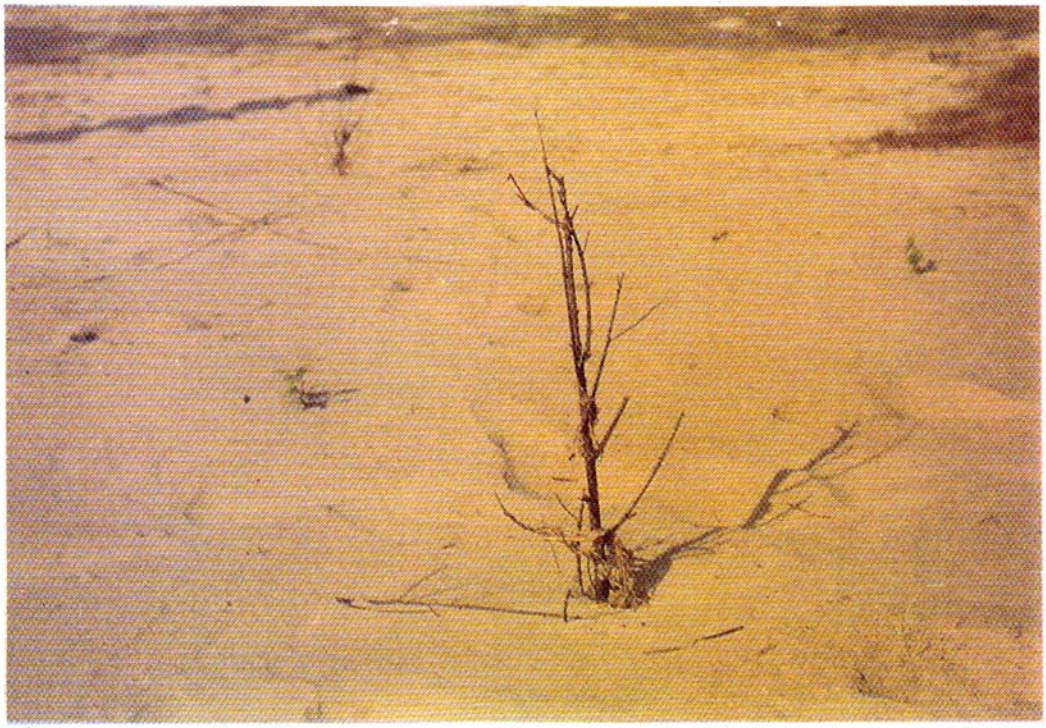


Fig.15i Onslaught of sand deposition in plantation area

Fig.15j Wind action causing damage to old plantation

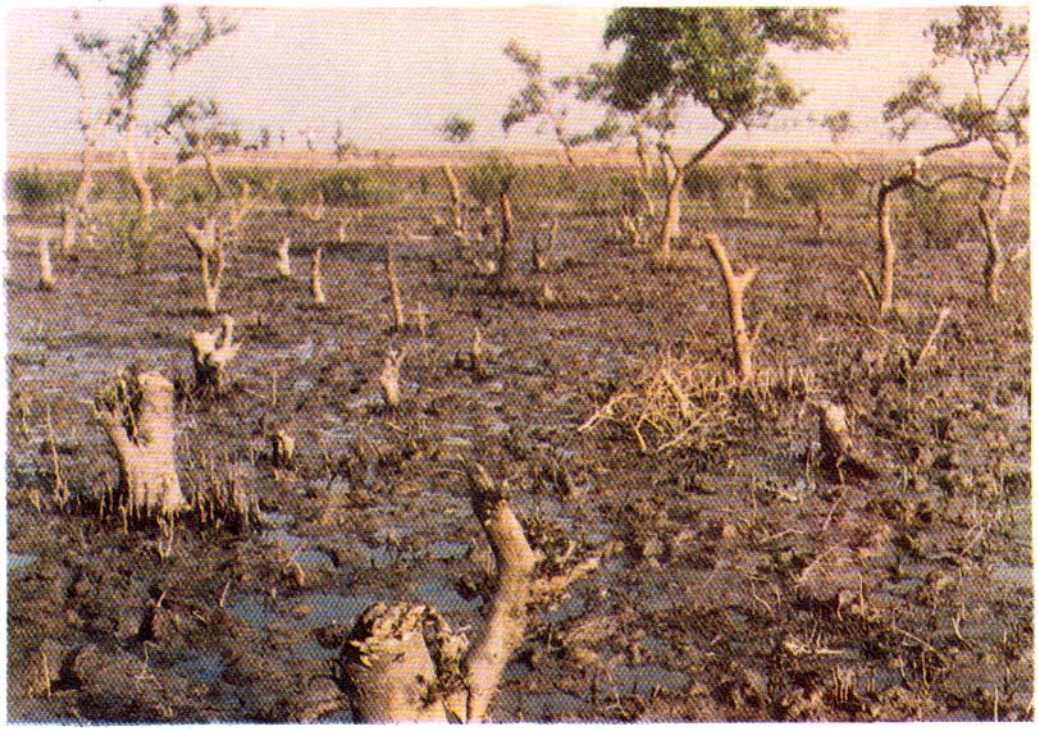


Fig.15k Encroachment due to human activity

Fig.15-l Successful mangrove afforestation

6. RESULTS

6.1 Preparation of Final Maps

The final maps were prepared from the preliminary maps by incorporating the corrections using the ground truth data. The following features have been shown in the maps.

- Boundary of divisions/districts etc.
- Rivers, canals, roads, railways etc.
- Old and new plantation areas
- Land erosion, accretion
- Mud flat
- Sandy areas
- Plant density.

Maps were prepared with the appropriate symbols at 1:10,000 scale. These maps will be used for implementation and management of the afforestation programmes at the field level.

One hundred and ninety two (192) sheets of maps were prepared covering the entire project area. Ammonia prints of some sample maps were sent for comments of the Department of Forests. After thorough discussions on the quality of the maps with the concerned officials of the Department of Forests, the Ministry of Environment and Forests and the World Bank, the final decisions were taken regarding the printing of the whole set of maps. The maps of each division have been printed and bound into a volume and thus there are four volumes of maps comprising a set for the four divisions. The volume number and the corresponding divisions are given below :

Volume No	Division
I	Barisal
II	Patuakhali
III	Chittagong
IV	Noakhali

Nine (9) sets of maps have been handed over to the Department of Forests. These maps will be used for implementation and management of the coastal afforestation programme.

6.2 Plantation Statistics

Statements showing the conditions and area of plantation centre-wise for each range belonging to each forest division have been prepared. These statments are given in Annexure I.

A separate statement on the division-wise plantation is given in Table 1.

Table 1

Summary of Coastal Afforestation Data under the 2nd Forestry Project

Plantation Division	Plantation as per Forest Journal (acres)	SPARRSO Findings					Percentage of existing plantation at the end of the Phase II project
		Existing plantation (acres)	Blank area found (acres)	Erosion area found (acres)	Embankment plantation (acres)	Total area checked (acres)	
Chittagong	21,220	10,932	7,294	2,631	-	20,857	52
Noakhali	29,285	21,099	5,966	1,887	-	28,952	72
Bhola	15,858	9,034	3,541	1,843	617	15,035	61
Patukhali	10,205	3,405	5,546	810	-	9,761	33
Total:	76,568	44,470	22,347	7,171	617	74,605	58.88

Note: *Total plantation = 44,470 + 617 = 45,087 acres*

It is seen from the Table that the existing plantation area during Phase-II is 45,087 acres including embankment plantation compared to the journal statement of 76,568 acres. 22,347 acres (29.19% of the area of the journal statement) has been found to be blank and 7,171 acres (9.37%) has been eroded by wave, wind, tidal and storm surge actions and destroyed by sand depositions.

7. CONCLUSIONS AND RECOMMENDATIONS

Bangladesh is a small country with high population density. This is situated on the active delta of the mighty river system: the Ganges, the Brahmaputra and the Meghna and is being extended towards south through a slow process of land accretion. The coastal mangrove afforestation has been taken up with a view to stabilizing the accreted lands, accelerating the accretion process and slowing down the process of erosion in the coastal areas. The establishment of a coastal forest belt would also provide a natural barrier along the coast to improve the coastal ecology and protect the coastal environment and lives against the wind and wave actions associated with the tropical cyclones and other natural phenomena.

In the Remote Sensing Component of the Mangrove Afforestation Project (Phase-II) the monitoring of the coastal afforestations has been performed by using satellite imagery and aerial photographs. Landsat MSS data of 1984 and Landsat TM data of 1987 and 1991 for selected regions have been used in the form of colour composite products. It is seen that the mangrove plantations are identifiable in 1984, 1987 and 1991 imagery and the increase in the plantation area is also clear in the imagery. However, the very new plantations are not recognizable in these imagery because of lower spectral response due to very low vegetative growth. Because of this reason the detailed mapping of the mangrove afforestation has been done through the use of aerial photographs and ground-truth data.

From the above-mentioned study using Landsat data of two different years (1984 and 1991) for selected regions, the process of accelerated accretion and stabilization of accreted lands due to coastal mangrove afforestations have been evidenced. The erosion process has been found to be active in the southern and western part of Urir Char during this period. This area had mangrove plantations. It is envisaged that the erosion process would have been more active if the mangrove plantations were not there. Some evidences of destruction of the plantations due to sand deposition were also found in the satellite imagery.

The aerial photographs of 1990 were interpreted to produce the plantation maps in the scale of 1:10,000 which is an up-date of the plantation map of the Phase-I. The maps prepared for Phase-II plantations contain the details of the progress of the plantations and the changes of the geomorphological features during the period of five years (1985-1990). The maps have been bound into 4 volumes; each volume corresponds to one individual Forest Division. The area of plantations have been estimated for each plantation centres and summarised in tabular form (Annexure-I).

The Forest Department of Bangladesh has played an encouraging role in the improvement of the coastal ecology and environment of the Bangladesh coastal region through this afforestation programme. The painstaking job of raising mangrove plantation in the coastal region has been done successfully. The natural calamities like the devastating cyclone of 29 April 1991, the deposition of sands in some of the plantation areas, erosional activities in the coast and the encroachment due to various human activities hindered the progress of the programme to a considerable extent. Inspite of the above-mentioned factors, success has been achieved in finally raising around 45,000 acres of plantation out of the planned area of 76,500 acres during this project period (Phase-II) which is about 60 percent of the planned area.

The objectives of the programme would be achieved successfully if appropriate measures are taken for the survival of the raised plantation. The maps produced by SPARRSO during this project (Phase-II) would help the Forest Department and the management/planning people maintain the raised plantations, plan the landuse of the stable lands, identify the areas suitable for fresh plantation i.e. prepare the future plantation plans and implement the future plantation activities.

The erosion and accretion information in the maps will help understand the coastal geomorphology and the effect of mangrove plantation on the geomorphologic processes of the Bangladesh coast.

The process of afforestation should be continued for the gradual improvement of the overall coastal environment of Bangladesh.

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ANNEXURE-I

Mangrove Afforestation Project
Phase-II
Survey Report of Yearwise Coastal Mangrove Plantation

Area in acres

Plantation Division	Range	Plantation Centre	Year of Planta-tion	Area as per FD's Planta-tion Journal	Condition of Surveyed Plantation Area by SPARRSO			Total Area Found by SPARRSO (Col. 6+7+8)	REMARKS
					Area Bearing Seedling	Blank Area	Erosion Area		
1	2	3	4	5	6	7	8		
Bhola	Kukri Mukri	Char Baikal	1985-86	200.00	79.30	115.76	-	195.06	Surveyed. Lower part was blank
			1986-87	250.00	86.43	157.20	-	243.63	Surveyed. Lower part was blank.
			1987-88	43.50	42.96	-	-	42.96	Surveyed. Scattered seedlings found. 3.50 acres of area was Golpata.
		Char Shafi	1985-86	70.00	-	70.00	-	70.00	Scattered seedlings found.
			1989-90	70.00	70.00	-	-	70.00	Only ocular survey was done. 50% area covered with thick Uri & Eli grass.
		East Dhal Char	1986-87	350.00	300.55	-	-	300.55	Surveyed. Erosion noticed.
			1987-88	2850.00	2238.63	537.30	-	2775.93	Surveyed. Some areas washed out. Some areas were newly planted.
		Char Jamir	1987-88	100.00	70.00	30.00	-	100.00	Lower part was blank. Condition of seedlings in the upper part was satisfactory.
		Char Hakim	1989-90	95.00	-	95.00	-	95.00	Non-mangrove plantation. Cyclone damage noticed. Only scattered seedlings were surviving.
		Char Dighal	1987-88	10.00	10.00	-	-	10.00	Golpata plantation.

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Plantation Division	Range	Plantation Centre	Year of Plantation	Area as per FD's Plantation Journal	Condition of Surveyed Plantation Area by SPARRSO			Total Area Found by SPARRSO (Col. 6+7+8)	REMARKS
					Area Bearing Seedling	Blank Area	Erosion Area		
1	2	3	4	5	6	7	8		
Bhola	Kukri-Mukri	Char Dighal	1989-90	80.00	60.00	20.00	-	80.00	The lower part of 40 acres area was blank and another 40 acres area was covered with thick Eli grass mixed with scattered seedlings.
		West Dhal Char	1988-89	300.00	126.01	138.88	-	264.89	Surveyed. Lower part was blank.
		Char Pataila	1989-90	05.00	05.00	-	-	05.00	Non-mangrove plantation.
	Monpura	Char Chiringa	1985-86	50.00	13.90	36.70	-	50.60	Surveyed. Washed out.
		Sonar Char	1985-86	880.00	371.36	130.00	378.64	880.00	Surveyed. Active erosion.
			1986-87	200.00	-	-	200.00	200.00	Complete erosion.
		Natun Char	1985-86	50.00	-	-	50.00	50.00	do
			1986-87	300.00	94.84	22.73	-	117.57	Surveyed.
			1987-88	500.00	350.38	-	-	350.38	do
		Char Patalia	1986-87	150.00	49.25	99.28	-	148.53	Surveyed. Heavily damaged by grazing.
		Char. Mojumdar	1986-87	300.00	-	-	300.00	300.00	Complete erosion.
		Char Pial	1986-87	100.00	112.80	-	-	112.80	Surveyed.
			1987-88	500.00	252.95	205.64	-	458.59	Surveyed. Washed out.

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Area in acres

Plantation Division	Range	Plantation Centre	Year of Planta-tion	Area as per FD's Planta-tion Journal	Condition of Surveyed Plantation Area by SPARRSO			Total Area Found by SPARRSO (Col. 6+7+8)	REMARKS
					Area Bearing Seedling	Blank Area	Erosion Area		
1	2	3	4	5	6	7	8		
Bhola	Monpura	South Sakuchia	1987-88	500.00	-	500.00	-	500.00	In the middle of the plantation block a new channel formed. 350 acres were non-mangove & the rest 200 acres were mangrove plantations.
		Embanbkment	1989-90	550.00	550.00	-	-	550.00	
	Char Fassion	Char	1985-86	100.00	-	100.00	-	100.00	Surveyed.
		Nizam	1986-87	100.00	-	100.00	-	100.00	do
			1987-88	1000.00	266.35	500.00	-	766.35	do
		Char.Sulaksmi	1985-86	140.00	-	140.00	-	140.00	Checked.
		Char Hassan	1986-87	100.00	-	100.00	-	100.00	do
			1987-88	150.00	-	150.00	-	150.00	do
		Kharchir Char	1986-87	200.00	62.79	-	137.21	200.00	Surveyed.
		Char Kachhapia	1987-88	100.00	33.56	58.24	-	91.80	do
	Char Fassion	Char Zahiruddin	1988-89	400.00	404.44	-	-	404.44	do
			1989-90	800.00	802.99	-	-	802.99	do
		Char Mohammad pur	1989-90	100.00	94.39	-	-	94.39	do

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Area in acres

Plantation Division	Range	Plantation Centre	Year of Plantation	Area as per FD's Plantation Journal	Condition of Surveyed Plantation Area by SPARRSO			Total Area Found by SPARRSO (Col. 6+7+8)	REMARKS
					Area Bearing Seedling	Blank Area	Erosion Area		
1	2	3	4	5	6	7	8		
Bhola	Char Fassion	Char Fakaria	1989-90	65.00	65.00	-	-	65.00	Non-mangrove plantations on embankment.
		Char Kalkini	1989-90	35.00	-	35.00	-	35.00	Cyclone damage (covered with shifting sand).
	Daulat Khan	Char Zahiruddin	1985-86	220.00	-	-	220.00	220.00	Complete erosion.
			1986-87	600.00	476.15	-	123.85	600.00	Surveyed.
			1987-88	500.00	403.94	-	96.06	500.00	Surveyed. Erosion noticed.
			1988-89	1300.00	1100.18	-	199.82	1300.00	do
			1989-90	450.00	458.94	-	-	458.94	Surveyed.
		Char Uril	1985-86	240.00	237.35	-	-	237.35	do
			1986-87	300.00	258.47	-	-	258.47	do
			1989-90	100.00	143.36	-	-	143.36	do
		Char Medua	1989-90	100.00	-	100.00	-	100.00	Complete erosion.
	Majher Char	Char Zahirul Islam	1985-86	100.00	-	73.04	-	73.04	Completely damaged.
		Char Nizamia	1986-87	50.00	-	25.95	-	25.95	do
			1987-88	02.00	02.00	-	-	02.00	Non- mangrove plantation in Tushkhali plantation centre (Golpata).
		Char Mizan	1987-88	38.00	24.75	-	-	24.75	Surveyed. Golpata plantation.
			1988-89	15.00	22.27	-	-	22.27	do
		Majher Char	1989-90	50.00	47.45	-	-	47.45	Surveyed. Non-mangrove plantation.
		Grand Total:		15858.50	9788.74	3540.72	1705.58	15035.04	

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					Area Bearing Seedling	Blank Area	Erosion Area		
1	2	3	4	5	6	7	8		
Chittagong	*Mirsharai*	*Baman*	*1986-87*	*240.00*	*241.00*	-	-	*241.00*	*Surveyed.*
		Sundar	1987-88	200.00	149.00	50.00	-	199.00	Surveyed. (50 acres-cyclone damage).
		Ichakhali	1985-86	800.00	734.00	-	66.00	800.00	Surveyed. Erosion noticed.
			1986-87	1560.00	1434.00	-	126.00	1560.00	do
			1987-88	900.00	302.00	600.00	-	902.00	Surveyed. 600 acres encroached.
			1988-89	250.00	218.00	6.00	24.00	248.00	Surveyed. (erosion noticed)
		Mogadia	1986-87	200.00	160.00	40.00	-	200.00	Surveyed. (40 acres-cyclone damage).
		Dhalkhali	1987-88	400.00	262.00	140.00	-	402.00	Surveyed. (140 acres-cyclone damage).
	Shita-kunda	Banshbaria	1988-89	100.00	31.00	70.00	-	101.00	Surveyed. (Cyclone damage).
			1989-90	125.00	27.00	100.00	-	127.00	do
	Head Qr.	Halishahar	1985-86	50.00	-	50.00	-	50.00	Ocular survey was done as the area was blank.
			1989-90	190.00	90.00	100.00	-	190.00	Checked. Cyclone damage noticed.
		Kattali	1985-86	50.00	-	50.00	-	50.00	Only ocular survey was done as the area was blank.
			1988-89	200.00	102.00	98.00	-	200.00	Checked. 50% area was blank.
		Sitalpur	1989-90	210.00	130.00	80.00	-	210.00	Checked. cyclone damage.
		Bandar	1989-90	80.00	-	80.00	-	80.00	Ocular survey was done as the area was blank and covered with shifting sand.
	Banskhali	Gondamara	1985-86	100.00	-	100.00	-	100.00	Checked and plotted.
			1986-87	338.00	-	338.00	-	338.00	do
		Ratanpur	1986-87	465.00	-	465.00	-	465.00	Surveyed.

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Area in acres

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					Area Bearing Seedling	Blank Area	Erosion Area		
1	2	3	4	5	6	7	8		
Chittagong	Chanua	Chanua	1986-87	70.00	-	70.00	-	70.00	Checked and plotted.
	Gorak-ghata	Gorakghata	1985-86	100.00	-	100.00	-	100.00	Checked and plotted. Failure due to public activity.
		Jhapua	1987-88	10.00	10.00	-	-	10.00	Plotted as per FD's plantation journal.
		Ghatibandha	1985-86	85.00	70.00	15.00	-	85.00	Checked. 15 acres of plantation damaged by sand deposition.
		Tejjyakata	1985-86	75.00	15.00	60.00	-	75.00	Checked, most of the area damaged by grazing.
		Baruakhali	1985-86	70.00	20.00	50.00	-	70.00	Checked. Most of the area was blank.
		Chaufaldandi	1985-86	50.00	-	50.00	-	50.00	Surveyed. The area was blank.
		Gomatali	1985-86	120.00	42.00	78.00	-	120.00	Surveyed. 30 acres damaged by wave action, 6 acres by cyclone and 42 acres leased out.
		Ambassya-khali	1988-89	250.00	125.00	125.00	-	250.00	Checked. Damaged due to cyclone.
		Matarbari	1989-90	255.00	125.00 (20+50+55)	130.00 (40+90)	-	255.00	do
	Charan-dwip	Shilkhali	1988-89	100.00	100.00	-	-	100.00	Checked and plotted.
			1989-90	25.00	25.00	-	-	25.00	do
	Kutubdia	Baraghup	1988-89	05.00	-	05.00	-	05.00	Damaged by cyclone.
			1989-90	10.00	-	10.00	-	10.00	do
		Kumirer-chara	1988-89	05.00	-	05.00	-	05.00	do
			1989-90	05.00	-	05.00	-	05.00	do
		Grand Total :		7693.00	4412.00	3070.00	216.00	7698.00	

Mangrove Afforestation Project
Phase-II
Survey Report of Yearwise Coastal Mangrove Plantation

Area in acres

Plantation Division	Range	Plantation Centre	Year of Plantation	Area as per FD's Plantation Journal	Condition of Surveyed Plantation Area by SPARRSO			Total Area Found by SPARRSO (Col. 6+7+8)	REMARKS
					Area Bearing Seedling	Blank Area	Erosion Area		
1	2	3	4	5	6	7	8		
Chittagong	Urir Char	Uttarchar	1985-86	600.00	350.00	250.00	-	600.00	Surveyed.
				375.00	-	375.00	-	375.00	do
				120.00	24.00	96.00	-	120.00	do
			1986-87	400.00	36.00	348.00	-	384.00	do
				350.00	190.00	55.00	-	245.00	do
			1987-88	1300.00	-	1009.00	291.00	1300.00	do
			1988-89	700.00	428.00	230.00	-	658.00	do
			1989-90	175.00	23.00	152.00	-	175.00	do
		Sadar	1986-87	1100.00	405.00	-	695.00	1100.00	do
			1987-88	300.00	-	-	300.00	300.00	do
				150.00	-	-	150.00	150.00	do
			1988-89	670.00	636.00	-	-	636.00	209 acres overlapped with 1984-85 plantation.
			1989-90	120.00	80.00	34.00	-	114.00	54 acres overlapped with 1984-85 plantation.
				350.00	-	350.00	-	350.00	Surveyed.
		Majer Char	1985-86	1105.00	768.00	-	337.00	1105.00	Partly surveyed.
			1986-87	577.00	533.00	-	44.00	577.00	do
			1987-88	500.00	393.00	67.00	-	460.00	do
			1988-89	140.00	-	125.00	15.00	140.00	Surveyed
				270.00	46.00	177.00	-	223.00	do
			1989-90	123.00	-	15.00	101.00	116.00	do
				132.00	25.00	111.00	-	136.00	do

Mangrove Afforestation Project
Phase-II
Survey Report of Yearwise Coastal Mangrove Plantation

Area in acres

Plantation Division	Range	Plantation Centre	Year of Plantation	Area as per FD's Plantation Journal	Condition of Surveyed Plantation Area by SPARRSO			Total Area Found by SPARRSO (Col. 6+7+8)	REMARKS
					Area Bearing Seedling	Blank Area	Erosion Area		
1	2	3	4	5	6	7	8		
Chittagong	Urir Char	Char Rafsan	1988-89	145.00	-	145.00	-	145.00	Checked. Washed out.
	Sandwip	Puber Char	1985-86	1300.00	-	1192.00	108.00	1300.00	Checked.
			1986-87	550.00	513.00	-	37.00	550.00	do
				150.00	133.00	-	17.00	150.00	do
	Sandwip	Puber Char	1987-88	750.00	258.00	292.00	200.00	750.00	Checked.
			1988-89	675.00	297.00	337.00	41.00	675.00	do
			1989-90	400.00	193.00	137.00	-	330.00	Surveyed.
			Grand Total:	13527.00	6499.00	4250.00	2415.00	13164.00	

Mangrove Afforestation Project
Phase-II
Survey Report of Yearwise Coastal Mangrove Plantation

Area in acres

Plantation Division	Range	Plantation Centre	Year of Plantation	Area as per FD's Plantation Journal	Condition of Surveyed Plantation Area by SPARRSO			Total Area Found by SPARRSO (Col. 6+7+8)	REMARKS
					Area Bearing Seedling	Blank Area	Erosion Area		
1	2	3	4	5	6	7	8		
Noakhali	Charbata	Banshkhali	1985-86	200.00	231.00	-	-	231.00	Surveyed.
			1987-88	288.00	212.00	96.00	-	308.00	do
		Char Majid	1986-87	680.00	685.00	-	-	685.00	do
			1987-88	1612.00	1210.00	412.00	-	1622.00	do
		Char Clark	1987-88	600.00	660.00	-	-	660.00	do
			1988-89	300.00	336.00	-	-	336.00	do
			1989-90	300.00	346.00	-	-	346.00	do
		Char Lakshmi	1985-86	50.00	26.00	27.00	-	53.00	do
	Companigonj	Gangchil	1985-86	105.00	107.00	-	-	107.00	do
			1986-87	600.00	605.00	-	-	605.00	do
		Char Elahi	1985-86	395.00	156.00	-	240.00	396.00	do
	Char Alauddin	Char Bonani	1986-87	120.00	131.00	-	-	131.00	do
			1988-89	40.00	45.00	-	-	45.00	do
		Char Lakshmi	1985-86	100.00	104.00	-	-	104.00	do
			1989-90	75.00	75.00	-	-	75.00	do
		Char Shahid	1989-90	150.00	48.00	102.00	-	150.00	do
		Char Noman	1985-86	500.00	505.00	-	-	505.00	do
			1987-88	450.00	454.00	-	-	454.00	do
			1988-89	160.00	161.00	-	-	161.00	do
			1989-90	225.00	225.00	-	-	225.00	do

Mangrove Afforestation Project
Phase-II
Survey Report of Yearwise Coastal Mangrove Plantation

Area in acres

Plantation Division	Range	Plantation Centre	Year of Plantation	Area as per FD's Plantation Journal	Condition of Surveyed Plantation Area by SPARRSO			Total Area Found by SPARRSO (Col. 6+7+8)	REMARKS
					Area Bearing Seedling	Blank Area	Erosion Area		
1	2	3	4	5	6	7	8		
Noakhali	Habibia	Bhuiyar Char	1985-86	415.00	274.00	145.00	-	419.00	Surveyed
			1986-87	500.00	505.00	-	-	505.00	do
			1987-88	640.00	650.00	-	-	650.00	do
			1988-89	400.00	408.00	-	-	408.00	do
			1989-90	100.00	102.00	-	-	102.00	do
		Banshkhali	1985-86	250.00	255.00	-	-	255.00	do
			1986-87	300.00	305.00	-	-	305.00	do
			1987-88	400.00	404.00	-	-	404.00	do
			1988-89	600.00	605.00	-	-	605.00	do
			1989-90	400.00	404.00	-	-	404.00	do
	Char Alaxander	Char Srijani	1985-86	500.00	500.00	-	-	500.00	do
			1986-87	800.00	804.00	-	-	804.00	do
			1987-88	1100.00	1104.00	-	-	1104.00	do
			1988-89	1000.00	1010.00	-	-	1010.00	do
			1989-90	700.00	702.00	-	-	702.00	do
		Char Khabir-uddin	1989-90	400.00	404.00	-	-	404.0	do
		Telir Char	1985-86	775.00	781.00	-	-	781.00	do
			1986-87	1100.00	910.00	-	200.00	1110.00	do
			1987-88	100.00	102.00	-	-	102.00	do
			1988-89	200.00	206.00	-	-	206.00	do
		Char Sagar	1985-86	580.00	586.00	-	-	586.00	do
			1986-87	330.00	333.00	-	-	333.00	do
			1987-88	90.00	94.00	-	-	94.00	do

Mangrove Afforestation Project
Phase-II
Survey Report of Yearwise Coastal Mangrove Plantation

Area in acres

Plantation Division	Range	Plantation Centre	Year of Planta-tion	Area as per FD's Planta-tion Journal	Condition of Surveyed Plantation Area by SPARRSO			Total Area Found by SPARRSO (Col. 6+7+8)	REMARKS
					Area Bearing Seedling	Blank Area	Erosion Area		
1	2	3	4	5	6	7	8		
Noakhali	Nalchira	Oskhali	1985-86	500.00	105.00	282.00	113.00	500.00	Checked and plotted as per FD's journal.
			1986-87	150.00	-	-	150.00	150.00	do
		Char Nurul Islam	1985-86	200.00	101.00	-	99.00	200.00	do
			1986-87	100.00	26.00	-	74.00	100.00	do
		Char Bari	1985-86	158.00	100.00	58.00	-	158.00	Surveyed.
			1986-87	42.00	-	29.00	13.00	42.00	do
			1987-88	100.00	52.00	18.00	-	70.00	do
	Nalchira	Char Piya	1985-86	460.00	252.00	141.00	53.00	446.00	Surveyed.
			1986-87	800.00	159.00	535.00	106.00	800.00	Surveyed & partly plotted.
		Ghasiar Char	1986-87	190.00	175.00	15.00	-	190.00	Surveyed.
			1987-88	1000.00	727.00	273.00	-	1000.00	do
		Char Jonak	1985-86	1100.00	653.00	7.00	440.00	1100.00	Checked and plotted as per FD's journal.
			1986-87	660.00	425.00	110.00	125.00	660.00	do
			1987-88	150.00	81.00	69.00	-	150.00	do
			1989-90	440.00	310.00	40.00	-	350.00	Surveyed.
		Char Alvi	1987-88	250.00	-	170.00	80.00	250.00	Checked and plotted as Per FD's journal.
	Jahajmara	Kamlar Char	1985-86	100.00	28.00	72.00	-	100.00	do
			1986-87	80.00	-	80.00	-	80.00	do
			1987-88	260.00	-	196.00	64.00	260.00	do
		Char Kalam	1985-86	800.00	-	800.00	-	800.00	do

Mangrove Afforestation Project
Phase-II
Survey Report of Yearwise Coastal Mangrove Plantation

Area in acres

Plantation Division	Range	Plantation Centre	Year of Plantation	Area as per FD's Plantation Journal	Condition of Surveyed Plantation Area by SPARRSO			Total Area Found by SPARRSO (Col. 6+7+8)	REMARKS
					Area Bearing Seedling	Blank Area	Erosion Area		
1	2	3	4	5	6	7	8		
Noakhali	Jahajmara	Kamlar Char	1986-87	100.00	-	100.00	-	100.00	Checked and plotted as FD's journal.
		Char Rawshan	1987-88	100.00	-	100.00	-	100.00	do
		Char Baha-uddin	1985-86	550.00	80.00	470.00	-	550.00	do
			1986-87	520.00	6.00	514.00	-	520.00	do
			1989-90	50.00	45.00	-	-	45.00	Surveyed.
	Sagaria	Char Alim	1985-86	500.00	-	500.00	-	500.00	Checked. Plantations washed out. Deep channel has been formed where water remains even at the peak low tide.
			1986-87	50.00	-	50.00	-	50.00	Checked. Plantations washed out. Deep channel has been formed where water remains even at the peak low tide.
			1987-88	50.00	-	50.00	-	50.00	do
		Char Awal	1985-86	50.00	-	50.00	-	50.00	Checked.
			1986-87	250.00	-	250.00	-	250.00	do
		Char Rehania	1985-86	250.00	-	250.00	-	250.00	do
			1986-87	100.00	-	100.00	-	100.00	do
		Grand Total :		28700.00	21094.00	5966.00	1902.00	28962.00	

AREA STATEMENT
MANGROVE AFFORESTATION PROJECT, PHASE-II
1985-90

Area in acres

Plantation Division	Range	Plantation Centre	Year of Plantation	Area as per FD's Plantation Journal	Condition of Surveyed Plantation Area by SPARRSO			Total Area Found by SPARRSO (Col. 6+7+8)	REMARKS
					Area Bearing Seedling	Blank Area	Erosion Area		
1	2	3	4	5	6	7	8		
Patuakhali	Patharghata	Lathimara	1985-86	150.00	113.00	34.00	-	147.00	Surveyed.
			1986-87	80.00	-	81.00	-	81.00	do
		Harinbaria	1985-86	200.00	137.00	48.00	-	185.00	do
			1986-87	50.00	50.00	-	-	50.00	do
			1987-88	25.00	20.00	-	-	20.00	do
		Kumirmara	1986-87	500.00	-	500.00	-	500.00	Checked.
			1987-88	305.00	214.00	86.00	-	300.00	Surveyed.
		Gazi Mahmud	1988-89	300.00	300.00	-	-	300.00	Checked.
		Dhulua	1988-89	200.00	177.00	-	-	177.00	Surveyed.
	Amtali	Paliatali	1987-88	150.00	-	150.00	-	150.00	Checked.
		Char Raushan	1985-86	200.00	-	200.00	-	200.00	Plotted as it is.
			1986-87	200.00	-	200.00	-	200.00	do
			1987-88	70.00	-	70.00	-	70.00	do
		Nidrar Char	1987-88	30.00	-	30.00	-	30.00	do
	Mohipur	Char Habib	1985-86	50.00	50.00	-	-	50.00	Checked.
			1986-87	100.00	-	100.00	-	100.00	Plotted as it is.
			1987-88	100.00	-	100.00	-	100.00	do
		Char Khalid	1985-86	200.00	-	200.00	-	200.00	do
			1986-87	200.00	-	200.00	-	200.00	do
			1987-88	300.00	-	-	300.00	300.00	Checked.
		Nishanbaria	1989-90	150.00	150.00	-	-	150.00	do
	Galachipa	Agunmukha	1985-86	100.00	65.00	35.00	-	100.00	do
			1986-87	300.00	40.00	-	-	40.00	Surveyed.
			1987-88	250.00	104.00	122.00	14.00	240.00	do

AREA STATEMENT
MANGROVE AFFORESTATION PROJECT, PHASE-II
1985-90

Area in acres

Plantation Division	Range	Plantation Centre	Year of Plantation	Area as per FD's Plantation Journal	Condition of Surveyed Plantation Area by SPARRSO			Total Area Found by SPARRSO (Col. 6+7+8)	REMARKS
					Area Bearing Seedling	Blank Area	Erosion Area		
1	2	3	4	5	6	7	8		
Patuakhali	Calachipa	Khankanipara	1985-86	100.00	30.00	70.00	-	100.00	Checked.
			1986-87	30.00	-	30.00	-	30.00	do
	Galachipa	Ganyipara	1987-88	-	-	100.00	-	100.00	do
		Char Lakshmi	1985-86	50.00	-	50.00	-	50.00	do
		Char Talukdar	1985-86	50.00	40.00	-	-	40.00	Surveyed.
			1986-87	100.00	-	100.00	-	100.00	Checked.
			1988-89	25.00	-	25.00	-	25.00	do
		Char Hare	1987-88	50.00	-	50.00	-	50.00	do
		Char Ashabaria	1985-86	175.00	165.00	-	-	165.00	Surveyed.
			1987-88	100.00	111.00	-	-	111.00	do
			1988-89	25.00	-	25.00	-	25.00	Checked.
		Ghashir Char	1985-86	150.00	150.00	-	-	150.00	do
			1986-87	300.00	300.00	-	-	300.00	do
			1987-88	70.00	-	70.00	-	70.00	do
			1988-89	45.00	45.00	-	-	45.00	do
		New Later Char	1988-89	100.00	-	-	100.00	100.00	do
		Char Bogla	1988-89	50.00	-	50.00	-	50.00	do
		Char Nutan Bangla	1985-86	225.00	226.00	-	-	226.00	Surveyed.
			1986-87	100.00	-	69.00	31.00	100.00	Checked.
			1987-88	200.00	61.00	50.00	92.00	203.00	Surveyed.

AREA STATEMENT
MANGROVE AFFORESTATION PROJECT, PHASE-II
1985-90

Area in acres

Plantation Division	Range	Plantation Centre	Year of Plantation	Area as per FD's Plantation Journal	Condition of Surveyed Plantation Area by SPARRSO			Total Area Found by SPARRSO (Col. 6+7+8)	REMARKS
					Area Bearing Seedling	Blank Area	Erosion Area		
1	2	3	4	5	6	7	8		
Patuakhali	Char Momtaz	Sonar Char	1985-86	50.00	47.00	-	-	47.00	Surveyed.
			1987-88	420.00	-	420.00	-	420.00	Checked.
			1989-90	100.00	-	55.00	-	55.00	Surveyed.
		Nayar Char	1985-86	100.00	-	100.00	-	100.00	do
			1986-87	70.00	-	70.00	-	70.00	do
			1987-88	70.00	-	70.00	-	70.00	do
			1988-89	150.00	-	150.00	-	150.00	do
		Char Taposhi	1985-86	500.00	308.00	180.00	-	488.00	do
			1986-87	300.00	93.00	236.00	-	329.00	do
			1987-88	200.00	31.00	146.00	-	177.00	do
			1988-89	100.00	-	100.00	-	100.00	do
			1989-90	100.00	-	100.00	-	100.00	do
		Char Habir	1985-86	100.00	-	-	100.00	100.00	do
		Ander Char	1986-87	300.00	19.00	281.00	-	300.00	do
			1988-89	100.00	-	100.00	-	100.00	do
		Char Banani	1985-86	150.00	-	150.00	-	150.00	Checked.
			1986-87	150.00	-	139.00	11.00	150.00	do
			1988-89	175.00	-	65.00	110.00	175.00	do
		Char Baslin	1986-87	50.00	9.00	3.00	38.00	50.00	do
		Char Buslum	1985-86	25.00	5.00	6.00	14.00	25.00	do
		Char Bangla	1985-86	25.00	30.00	-	-	30.00	Surveyed.
			1986-87	50.00	50.00	-	-	50.00	Checked.

AREA STATEMENT
MANGROVE AFFORESTATION PROJECT, PHASE-II
1985-90

Area in acres

Plantation Division	Range	Plantation Centre	Year of Plantation	Area as per FD's Plantation Journal	Condition of Surveyed Plantation Area by SPARRSO			Total Area Found by SPARRSO (Col. 6+7+8)	REMARKS
					Area Bearing Seedling	Blank Area	Erosion Area		
1	2	3	4	5	6	7	8		
Patuakhali	Char Momtaz	Char Sonar Bangla	1985-86	200.00	198.00	-	-	198.00	Surveyed.
			1986-87	50.00	26.00	-	-	26.00	do
			1987-88	30.00	17.00	-	-	17.00	do
			1988-89	100.00	21.00	-	-	21.00	do
	Dashmina	Char Hadi	1985-86	200.00	-	200.00	-	200.00	Checked.
			1986-87	100.00	-	100.00	-	100.00	do
			1987-88	30.00	-	30.00	-	30.00	do
		Total Plantation :		10250.00	3405.00	5546.00	810.00	9761.00	

Project Personnel*

Mr. A.K.M. Fariduddin Bhuiyan, Chief Scientific Officer and Project Director
Mr. M.A. Jabbar, Chief Scientific Officer
Dr. D.A. Quadir, "
Mr. Nazmul Hoque, Principal Scientific Officer
Mr. Abdul Halim Howlader, "
Mr. A. Gafoor, "
Dr. Abdul Mannan Sardar, "
Mr. Atiar Rahman, "
Mr. Abul Kalam, "
Mr. Nizam-ur-Rahman, "
Mr. Jinnahtul Islam, "
Dr. Abdus Shahid, "
Mr. Delwar Hossain, "
Mr. M.A. Jalil, Senior Engineer (upto 2-11-91)
Mr. Omar Hayat Akhond, Senior Engineer
Mr. Refat Zaman, Senior Engineer (upto 20-05-91)
Mr. Ahmed Sayeed, Senior Scientific Officer
Mr. Golam Rahman, "
Mr. T.I.M. Tugril Hossain, "
Mr. Mozammel Hoque Sarkar, Assistant Engineer
Mr. Shafiqul Alam, Scientific Officer (upto 19-9-90)
Mrs. Afroza Nasrin Ahmed, Scientific Officer
Mr. Prabir Kumar Biswas, Research Fellow
Mr. Abdul Mannan, "
Mr. Syed Mehdi Hasan, "
Mrs. Nilufar Chowdhury , Cartographer

The logistics, administrative and technical support was provided by the Administration, Finance and the Technical staff of SPARRSO and the project.

* **Dr. M.A.H. Pramanik** was the Project Director (upto 27-04-91)