Marine Protected Area Needs in the South Asian Seas Region Volume 1: Bangladesh

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1. General Description: Bangladesh

1.1.1. Geography

Area:	144,054 km^2;
Coastline:	710 kilometres;
EEZ:	76,800 km^2;
Territorial waters:	12 miles.
Population:	110 million.

Bangladesh lies between latitudes 20° 34'N and 26°38'N and longitudes 88°01'E and 92°41 'E. It is bounded by India to the west and north, by India and Myanmar to the east, and by the Bay of Bengal to the south. It lies at the junction of the Indian and Malayan sub-regions of the Indo-malayan zoogeographic realm.

1.1.2. Climate

A subtropical monsoonal climate prevails. From December to February, the climate is mild and dry, with minimum temperatures varying from about 7.2°C to 12.8°C and maximum temperatures from 23.9°C to 31. 10°. The winds are northeasterly at the beginning of winter but become northwesterly by the end. The monsoon season is preceded and followed by periods of thunderstorms from March to early May and from October to November. May is the hottest month and temperatures may reach 40°C. Temperatures during the monsoon season usually reach a maximum of about 37°C, but temperatures in excess of 40°C have been recorded. Relative humidity ranges from about 75% in February and March to 85-90% from June to September (ESCAP, 1988; Mahtab, 1992; Scott, 1989).

The heavy southwest monsoon rains begin in early June and continue to mid-October; they account for about 80% of the total annual rainfall. Highest rainfall occurs in northern Sylhet and in the Chittagong area, lowest in the north and west of the country. During the period 1976-1985, the annual rainfall varied from a minimum of 1,180 mm at Jessore in 1976 to a maximum 4,785 mm at Sylhet in 1983. According to Mahtab (1989), annual rainfall varies from a mean of 1,250 mm in the west to 6,000 mm in the northeast, and the average is 1,500-3,000 mm.

Cyclones are frequent and often followed by destructive wave surges and extreme high tides, affecting the economic development of some 18,130 krn^2 of the coastal region (Rahman, 1983). Around 12 to 13 tropical storms are recorded each year in the Bay of Bengal, about half of these attain cyclonic strength, and around three or four affect India and Bangladesh. They are most severe in spring and autumn, usually forming in the south-eastern part of the Bay of Bengal and moving northerly or northwesterly, often turning northeasterly or easterly towards the east coast of the country. They cause problems through flooding from heavy rainfall, storm surges (particularly damaging because of gently shelving estuarine shores) and strong winds (ESCAP, 1988; Mahtab, 1989).

1.1.3 Coastal and off-shore topography

The northern part of the Bay of Bengal is narrow and funnel shaped serving to concentrate wave energy from storm centres to the south. The continental shelf has an area of about 69,000 km^2 (Sivasubramaniam, 1985) partially bisected by the Swatch of No Ground, a submarine canyon, 100-100 m deep, which lies 24 km off Hannghata and runs away from the coast in a south-westerly direction. The Burma Trench, a more extensive submarine canyon extends northwards from the Sunda Trench, parallel to the coast (ESCAP, 1988).

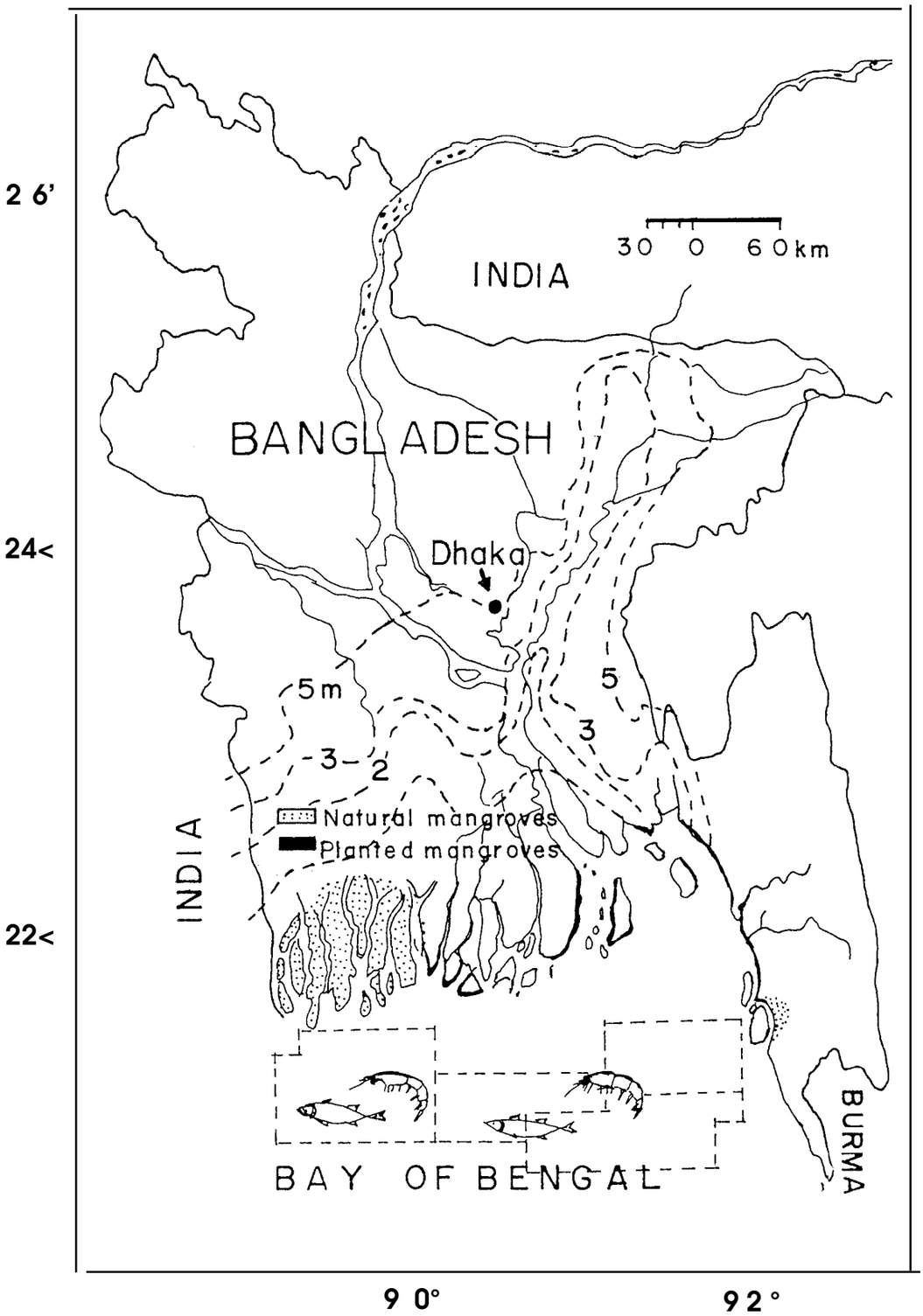
Most of the country lies within 10 m above mean sea level, (Figure 1) and the extensive coastline extends for some 710 km (excluding major indentations) from the Indian border in the west to the border with Myanmar in the southeast. The coastal area encompasses the regions of Cox's Bazar, Chittagong, Noakhali, Barisal, Patuakhzali and Khulna and includes some 2.5 million ha of coastal tidal lands (Bashirdlah *et al.,* 1989). The coastal morphology is characterized by a vast network of rivers; an enormous discharge of river water heavily laden with sediments; a large number of distributary channels; numerous off-shore sand/mud bars and temporary islands; strong tidal and wind action; tropical storms and associated wave surges.

The coastline is dominated by three major river systems; the Ganges-Padma; the Brahmaputra-Jamuna; and, the Surma-Meghna, which unite with several smaller rivers in Bangladesh to form the largest deltaic system in the world. The floodplains and coastal mangrove swamps of this delta cover almost one-third of the total area of the country. At its estuary the largest of the rivers, the Meghna, carries the joint flow of the Padma, the Meghna and the Dhaleswari rivers. The coastal zone can be broadly divided into three somewhat different regions: the Sundarbans swamps in the west; the area around the delta and mouth of the Meghna in the centre; and, the Chittagong-Cox's Bazar sandy coast in the east.

The western region includes the numerous low-lying islands and vast mangrove swamps of the Sundarbans which extend westward from the Tetulia River to the Indian border. The mangroves of the Bangladesh Sundarbans consist of a forested, tidal saline swamp. Together with the Indian Sundarbans, they makeup the single largest contiguous block of mangrove forest in the world. This area is intersected by a complex network of waterways with larger channels often more than a mile in width. The river estuaries tend to be long and straight as a result of the tidal influence. Sediments are transported almost directly south into the Swatch of No Ground, but numerous **chars** (temporary, sediment islands) are also formed around the Meghna estuary.

The central region runs from the Tetulia to the Big Feni River estuary and includes the mouth of the Meghna river. The older, inland sections of the delta, in the north, are comparatively high with sandy soils; the lower central parts are subject to extensive flooding every rainy season; and, the accreting coastal zone is subject to regular tidal inundation. The off-shore environment is characterized by heavy sediment input and this is the most dynamic region, with much active accretion and erosion. The coastline is broken and consists of a series of subaqueous bars and **chars** formed from sediment deposition. The general flow of water is still westward towards the Swatch of No Ground so that erosion occurs mainly on the eastern side of islands and sedimentation on their western sides. The larger islands (Hatiya, Manpura, Shahbazpur) thus appear to bend westwards. In the north-eastern corner of the Bay of Bengal, erosion occurs on

Figure 1.
Bangladesh, showing the extent of low-lying land, natural and planted mangrove areas, and the four major fishing grounds of the Exclusive Economic Zone
(Based on Hussain, 1982; Mahmood, 1986; WHOI, 1986)



the northern sides of islands and deposition on the southern sides.

The eastern region comprises the much smaller estuarine systems of the Chittagong-Cox's Bazar Coast (Chakaria Sundarbans and Naaf Estuary, Karnaphuli, Sangu, Matarnuhuri) from the Big Feni River to Badar Mokam. The coast is regular, unbroken and protected by mud flats and submerged sands. A continuous sand beach runs from Cox's Bazar to Badar Mokam, for about 145 km. There is a single coral island, Jinjiradwip, off the extreme southern tip of the country and several larger islands to the north. In this region the coastline runs parallel to a series of low forested hill ranges and valleys running north to south.

Bangladesh is unique in that the influence of the sea is felt for a very long distance inland. Tidal floodplains occur over an enormous area in the southern part of the Ganges, in the lower Padma floodplain and in parts of the Chittagong coastal plain. The rivers deposit very fine sand and silt as narrow levees in their floodplain reaches. The Ganges tidal floodplain encompasses the Khulna, Barisal, Patukhali and Chittagong Districts and a detailed account of the whole area is given in Scott (1989). Much of the floodplain lies far inland but even here cultivation is limited by the extent to which saltwater from the tidal inflow is flushed out by the freshwater outflow.

Soil characteristics of the coastal region and topographical changes to the Bangladesh coastline are discussed in ES CAP (1988) which provides relevant references. LANDSAT imagery and other satellite data are being used by Government to determine current rates and areas of accretion and erosion.

1.1.4. Oceanographic features

The Bay of Bengal has an unusually large seasonal fluctuation in mean sea level; the average level in March is about 94 cm lower than in September. The dominant semi-diurnal tidal range increases as one passes from the Indian border towards the Meghna estuary where it reaches a maximum (5 m), decreasing as one moves further eastwards along the Chittagong coast. North of Sandwip the spring tidal range can exceed 6 m at equinoxes because of the shallowness and funnel effect of the Hatiya River (ESCAP, 1988). In the Sundarbans, the tidal pattern is semi-diurnal with a maximum amplitude of 3 m during spring tides.

Salinities vary widely at different sites and at different times of year. In general, salinity increases from east to west and from north to south, and is highest from February to April when freshwater inflow is at its lowest. Coastal water salinity falls abruptly in June with the onset of the rainy season (Scott, 1989).

2. Marine and Coastal Ecosystems

2.1.1. Mangroves

Mangroves comprise over half the remaining natural forest in Bangladesh and according to Saenger *et al.* (1983), the total extent of mangrove forest is 405,000 ha. Hutchings and Saengar (1987) give a figure of 417,013 ha while Scott (1989) gives a figure of 610,000 ha for mangroves and estuaries and Mahtab (1989) gives a total figure of 600,000 ha. Their distribution within the country has also been described by Pramanik (1983) and Shahid (1985).

The most important area is the Sundarbans where mangroves are variously stated to cover 407,313 ha (Scott, 1989), 395,500 ha (Mahtab, 1989) or 599,300 ha (UNEP, 1986; 1987). The total area of the entire Sundarbans is about 1,000,000 ha, 60% of which lies in Bangladesh, and the rest in India. The total area of the Bangladesh Sundarbans, including channels and creeks, is said to cover 577,100 ha (Scott, 1989) or 401,600 ha (Mahtab, 1989). ESCAP (1988) gives a different set of figures, taken from a forest inventory of the Sundarbans carried out by the ODA/Land Resources Development Centre 1983-84 (Chaffery *et al.*, 1985)). The Bangladesh Space Research and Remote Sensing Organization (SPARRSO) has prepared detailed maps of the mangrove resources for the Forest Department (SPARRSO, 1986a; 1986b).

The structure and composition of the Sundarbans forest is maintained by a strong salinity gradient from the relatively freshwater environment of the northeast to the highly saline environment of the southwest (Saenger et *al.*, 1983). The area is intersected by a complex network of **khals** or rivers varying in width from a few metres to several kilometres. Until recently, all the rivers were connected with the Ganges but as the main course of the Ganges has migrated eastwards many of the western rivers have been cutoff. The River Baleswar in the east is now the main freshwater supply to the Sundarbans. Trees reach a height of up to 20 m, but the main canopy is at about 10 m. Detailed descriptions of the Sundarbans are available in several publications including ES CAP (1988), WCMC (1989) and Scott (1989).

Smaller areas of mangrove are found in the Chakaria Sundarbans, near Cox's Bazar, where mangroves formerly covered 20,000 ha. Large tracts have been cleared for shrimp ponds and other forms of aquiculture (Mahmood, 1986; 1990a). According to ESCAP (1988), there are now around 7,500 ha of forest occupying the central part of the delta of the Matamuhuri River. There are only about 20 species of tree and none reaches over 12 m in height; *Avicennia tomentosa is* the commonest of the larger species. Further details are given in ESCAP (1988) and Karim & Khan (1980). According to ESCAP (1988) a small strip (1,800 ha) of mangrove consisting of scattered *Excoecaria agallocha* and *Ceriops roxburghiana,* occurs along the banks and estuarine islands of the Naaf River. Jhaliardwip Island near Teknaf is covered with **keora,** *Sonneratia apetala* forest and supports a population of crab-eating monkeys. Other small off-shore islands such as Sonadia support some mangroves. According to Mahtab (1989) an additional 0.36 million ha of mangrove have been planted since 1966 in the coastal areas of Noakhali, Chittagong, Patuakjali and Barisal.

The mangrove forests of Bangladesh have a very diverse flora; over 330 plant species have been recorded in the Sundarbans alone. The dominant species are *Heritiera fornes, Excoecaria agallocha, Sonneratiaapetala, Avicennia ofjicinalis,Amoora cucullata,Xylocarpus moluccensis, X. obovata, Ficus retusa, Aegiceras corniculatum, Ceriops decandra, Acanthus ilicijolius, Acrostichum aureum, Phoenixpaludosa and Nypa fruticans.* Creepers irclude; *Entadapursaetha* and *Derris sinuata;* grasses include; *Phragmites karka, Imperata cylindrical* and *Typha elephantine.* The Department of Zoology at the University of Dhaka has carried out a number of faunal studies.

2.1.2. Marshes and Wetlands

Most of Bangladesh is composed of the deltas of three major river systems, namely the Ganges, Brahmaputra and Meghnarivers which flow into the Bay of Bengal. Numerous large and small tributaries and distributaries criss-cross this country. All the river systems have extensive flood plains along both banks of their courses. The total area of the floodplains was estimated in the past at 6,300,723 ha of which 814,114 ha have been permanently drained and are protected by flood defenses leaving 5,486,609 ha at the end of 1985 (Anon., 1985a; MPO, 1987). These flood plains remain inundated to varying depths (0.3 to more than 1.8 m) during the monsoon seasons.

Vast areas of the low-lying alluvial plains between the rivers are flooded during the rainy season, and the flood waters remain for a minimum of two, to a maximum of five months. As the floods recede, the exposed land is used for cultivation of rice, jute and other crops. Cultivation of rice is a major activity in and around the Ganges-Brahmaputra floodplain and Haor Basin. Low-lying lands under private ownership are used almost exclusively for this purpose and the state-owned margins of **beds, baors, haors** and rivers are often leased on an annual basis for paddy cultivation. During the dry season, large numbers of domestic livestock, "mainly cattle and buffalo, are allowed to graze in the marshes, and the aquatic vegetation is harvested to provide fodder during the monsoon. In recent years, wetlands have also been used for rearing domestic ducks, and aquatic plants have been collected for use as fertilizers (Scott, 1989). Agricultural land use and the limitations imposed by flooding and salt water intrusion are briefly described in UNDP/FAO (1988), ESCAP (1988) and Mahtab (1992).

The floodplains also include numerous permanent and seasonal freshwater lakes and marshes known as: **beds ,** oxbow lakes; **baors,** saucer shaped depressions of marsh vegetation; and, **haors,** bowl shaped water bodies lying between river levees. **Haors are** flooded every year during the monsoon and most retain some water throughout the dry season. They are found in eastern Mymensingh and Sylhet, in a region known as the Haor Basin. These water bodies are extensively utilised for fish production (Anon., 1985 b). A **baor** is an oxbow lake or other wetland formed in a dead arm of a river, and ranging in size from about 50 ha to 1,300 ha, most retain water throughout the year. All are situated in the moribund delta of the Ganges in Kushtia, Jessore and Faridupur. Beels are usually saucer-like depressions most of which become overgrown with marsh vegetation during the dry season, although a few dry out completely. There are over a thousand **beels** in the country, the greatest concentrations being in the main delta region and in the Haor Basin. There are very few in the Chittagong region where most of them contain water only in the rainy season.

Kaptai, the largest man-made freshwater body in Bangladesh is also the largest in South-East Asia (Fernando, 1980). Although primarily created for hydro-electric power generation it contributes significantly to the production of freshwater fish, flood control and agriculture (ARG, 1986). This reservoir covers an area of about 58,300 ha and has a mean depth of 9 metres.

In addition the country has 1,288,222 man-made ponds and reservoirs which together makeup a total area of 146,890 ha (BFRSS, 1986). Listings of the finfish, shrimps and other aquatic living resources of these water bodies are provided by Hussain (1971), Kibria (1983), Fugler (1984), Rahman (1989) and Begum *et al.,* (1989). The rivers, **haors, baors** and beels support a very rich fish fauna including many commercially important species such as *Labeo rohita, Labeo calbasu, Labeo genius, Catla catla, Cirrhinus mrigala, Wallago attu, Mystus aor, Mystus tengra, Mystus vittatus, Puntius spp., Channa spp., Anabas testudinetts, Clarius batrachus, Heteropnuestes fossilis, Notopterus spp.,* and *Hilsa spp.* Some 120 species in 34 families have been recorded from the estuaries of the Bay of Bengal (DS/ST, 1980).

At the southern extremity of the country, all the rivers empty into the Bay of Bengal as estuaries and along the coast are around 25,000 km^2 of tidally inundated land which used to be important nursery areas for fish and shrimps. A substantial proportion of this area has been diked or converted to shrimp ponds in the south-eastern and western regions of Bangladesh. A review of the published literature on estuarine and near-shore areas has been compiled by Mahmood & Das (1987) based on the work of the Institute of Marine Sciences of the University of Chittagong.

2.1.3. Coral **Reefs**

The only known coral reef in Bangladesh occurs on the west, south and east shores of Jinjiradwip (St. Martin's Island). Coral boulders are scattered over the island (Hoque *et al.,* 1989). Scientific knowledge of the area is still very limited (UNEP/IUCN, 1988), although expeditions to the island took place in 1973 and 1979 (UNEP, 1986; 1987). Very recently Mahmood & Haider (1992) recorded 13 genera of corals from 6 families in the waters around this island *(Stylocoeniella, Pocillopora, Stylophora, Madracis, Anacropora, Acropora, Astropora, Porites, Pavona, Favia, Favites, Goniastrea,* and *Montastrea).*

2.1.4. **Seagrasses and algal communities**

There appears to be no information on the existence of any major seagrass beds. *Halodule univervis* has been reported from the sandy littoral zone around Jinjiradwip (Islam, 1980). Some of the more common seaweeds in Bangladesh waters aredescribed by Islam (1976). It is thought that the large seasonal fluctuations in salinity may mean that conditions are not suitable for seaweeds.

2.1.5. Beaches

Most beaches in the south-central and southeastern regions are backed by *Casuarina* plantations or agricultural lands. A 145 km stretch of beach runs from Cox's Bazar to the tip of the Teknaf Peninsula. Das (1989a) describes a 6 km section of the main beach at Cox's Bazar. There

are also sandy beaches at Teknaf, Potenga (near Chittagong) on Jinjiradwip and other offshore islands.

2.1.6. Islands

The lower reaches of the delta include a large number of temporary, semi-permanent and permanent islands called chars, formed by the network of distributaries. New islands are constantly being formed along the coast where easily eroded sands collect to form banks and chars, sub-aerial sands are blown into coastal dunes above the high water mark. Mudflats form in the lee of the dunes and eventually become overlain with sand and covered in grasses. The alluvial deposits are very deep and the soil of these islands is a silty clay loam with alternate layers of clay, silt and sand. The surface is usually clay except on the seaward side of the islands where there are sandy beaches (UNEP, 1986; 1987).

In the extreme southeast of the region, there is a small coral island, Jindiradwip (St Martin's Island) (20037 'N, 92018' E), about 6 km^2, lying 13 km from the southeast mainland coast and 95 km south of Cox's Bazaar. A number of larger islands lie off the Chittagong-Cox's Bazar coast, including Kutubdia (16 x 4 miles) the flora of which is described by Huq (1986); Maheshkhali (252 sq.mi.) the flora of which is described by Huq & Khan (1984) although the island is now largely deforested (Anon, 1990); and, Sonadia (c. 7 sq. mi.) which is connected at low tide to Maheshkhali and has mangroves and sand dunes. The flora of Sonadia is described by Khan *et al.,* (1977)). Further information on these islands is given in Miah & Islam (1983).

3. Economic Aspects of Marine and Coastal Resource Use

3.1.1. . Fisheries

The Exclusive Economic Zone (EEZ) of Bangladesh encompasses an area of around 76,800 km² which forms an important potential source of fish and shellfish (Shafi & Quddus, 1982). Information on the hydrology of the shelf sea is provided by Saetre (1981) and the hydrology is dominated by the outflow from the river systems which has a significant effect on the demersal and pelagic fish species. Penn (1982a) estimated that the potential production of demersal finfish and shrimpin Bangladesh off-shore waters was of the order of 10,000 to 20,000 tonnes an d2,000 to 4,000 tonnes respectively. Further details and the results of previous surveys are provided in Penn (1982a; 1982b) A listing of commercially important fish and shrimp species is provided in Hussain (1982).

In 1983, export earnings from fishing ranked third after jute and jute products, and amounted to 7.2% of the country's total export earnings (Scott, 1989). According to Bashirullah *et al.*, (1989), coastal and inland fishing is second only to agriculture in economic importance. The importance of fish and fisheries to the economy, diet and nutrition, employment, export and cultural life of Bangladesh is reviewed in some detail by Ali (1990). Fish ranks next to rice as a staple food providing about 80% of daily per *capita* animal protein in the diet. The fisheries sector contributes nearly 6% to Gross Domestic Product and around 12% to export sector earnings. The fisheries sub-sector is a major source of employment providing full-time employment to around 2 million and part-time employment to a further 10 million people.

The main activity in the coastal wetlands is fishing, which is practiced under a system of lease/ auction from Government or Government agencies. Marine landings increased from 100,000 tons in 1976 to 130,000 tons in 1981. The total harvest of finfish, crustaceans and frogs in Bangladesh is now estimated at about 675,000-725,000 tonnes per year. In the Sundarbans, 158,000 people were engaged in fishing over the period 1971-1983 and the average number of boats employed was 54,000. Fishermen come from as far away as Chittagong, bringing their boats and households and establishing temporary encampments along the coast. Fishery production in this area has increased from 640 mt in 1971/72 to 14,000 mt in 1982/1983. The average annual yield over this 12-year period was 7,160 mt although ESCAP (1988) gives figures of about 9,999 tons. The main catches are hilsa and prawns, the former for local consumption, the latter for export. The estuaries and shelf waters are very rich in prawns and shrimps, notably *Macrobrachium, Penaeus, Metapenaeus, Parapenaeopsis* and *Palaemon.*

Fishing is also an important activity in the Chakaria Sundarbans (Scott, 1989). Brackish water fisheries for prawns and hilsa in the Cox's Bazar region are described in Ahmed (1981; 1984). ESCAP (1988) described the traditional **gher** fisheries for fish and shrimp, involving enclosing tidal water bodies with earth embankments.

At present, a relatively small proportion (19%) of total fisheries production comes from coastal and marine habitats. 64% comes from the riverine fisheries, 15% from small freshwater bodies, 1% from large freshwater bodies, and 1% from brackish water ponds.

The Bay of Bengal is considered as potentially a very rich fishery because of the nutrient input from the rivers (ESCAP, 1988). Hussain (1982) records more than 475 fish species in 133 families, about 10 species of marine shrimps of commercial importance, about 108 species of shellfish, molluscs and crabs and two species of lobsters from this area. Surveys of the three main fishing grounds illustrated in figure 1 (South Patches, Middle Ground, Swatch of No Ground), covering 14,000 km^2, have been carried out by international agencies (Shahidullah, 1983; ESCAP, 1988).

Penn (1982a; 1982b) provides assessments of fishery stocks in the early 1980s. A discussion of stock assessment and sustainable yield is given in ESCAP (1988). Annual catches are composed of pelagic fish (38%), demersal fish (48%) and shellfish (14%). Demersal production is possibly close to its optimal yield and has recently declined. Shrimp production is also close to its maximum yield if not beyond it while the status of pelagic stocks is not known (Sivasubramaniam, 1985). Overall, there has been an increase introduction (Sivasubramaniam, 1985) but this is not equalling the decline in inland catches (UNEP, 1986; 1987).

HiIsa hilsa is the dominant species in the fishery of Bangladesh, making up 30% of the country's total fish production and employing over 1.5 million people. 140,000 mt are produced from the sea and 90,000 mt from estuaries since hilsa is an anadromous species that migrates between rivers and the open sea (Anon., 1987). Sivasubramaniam, estimated that in 1985150,000 mt were produced, of which 50% was from the sea. Additional information is given in Dunn (1982) ESCAP (1988) and Raja (1985). Marine catches of hilsa have shown a significant increase in production but river production has decreased (Sivasubramaniam, 1985).

Small-scale subsistence and artisanal fisheries contribute 90% of total marine catches which accounts for the lack of accurate statistics. A 1967/68 survey revealed that there were 29,000 marine fishing households and 42,000 active marine fishermen, 72% of whom are based in the Chittagong region.

A World Bank report suggests that the potential for increased marine catches is limited and costly except for shrimp in near-shore areas (UNEP, 1985; 1986; 1987). There has been a recent increase in trawlers for shrimp and finfish, but joint fishery ventures with Kuwait and Thailand ceased in 1980 because of decreasing catch rates and uneconomic operations (Sivasubramaniam, 1985). Further information is available in Shahidullah (1986) and Sivasubramaniam (1985); many of these studies have been carried out under the Bay of Bengal Programme (BOBP, 1985).

3.1.2. Aquiculture

The Government is actively encouraging shrimp culture, and major aquiculture schemes have been developed in recent years in the Chakana Sundarbans and Moheshkhali area in Cox's Bazar. Total estimated area of shrimp ponds is 90,000-115,000 (Scott, 1989). Chowdhury (1986) and Islam (1983) review the aquiculture industry; Mahmood & Khan (1980) describe

aquiculture in the Bakkhali estuary and around Cox's Bazar. FAO/SIDA has supported a demonstration farm at Satkhira (FAO, 1985) and training courses to improve culture techniques such as selective stocking, pest control screening, and nursery pond construction. The Asian Development Bank is financing a large Aquiculture Development Project (ADB, 1985) and further information and additional references are provided in ESCAP (1988).

Although freshwater pond culture of shrimps has been practised for centuries, brackish water pond culture is a more recent development and is proving highly lucrative. The areas of such brackish water ponds have increased from less than 20,000 ha to 70,000 ha in 1985 when they were predicted to cover more than 90,000 ha by 1990. The third 5-year Plan attaches high priority to the development of the industry and by the end of the Plan period, it is expected that shrimp production will reach 34,000 mt of which 60% will be for export (Bashrullah *et al.*, 1989). According to Mahtab (1989), the total export value of shrimps for the years 1983-88 was US$140 million.

Penaeus monodon, the tiger shrimp is the most economically important species in the Bay of Bengal. Tiger shrimp seed is collected from estuaries and the shallow coastal region with consequent destruction of populations of these and other species (Mahmood, 1990b). In 1986, over three billion post larvae were collected of which around 40% died because of improper handling and inadequate transport. Demand is likely to increase and supplies decrease because of over-collection of seed and heavy trawler fishing of adults. Only one hatchery has been established to date.

Penaeus monodon is cultured in four ways (Bashirullah *et al.,* 1989):

a. In the Chittagong-Cox's Bazar region, salt producers use the salt pans in the monsoon season for subsistence fishing and the harvesting of shrimp and finfish.

b. Low-lying areas within and outside the coastal embankment and in the mangrove areas of Cox's Bazar district are used for combined shrimp and finfish culture.

c. In the Khulna region, about 50% of the shrimp farms inyolve 'bheri' culture - an area is impounded by earthen dykes with access to tidal waters; fish and shrimp are cultured from January to July and rice for the rest of the year.

d. Shrimp monoculture was initiated in 1985 because of the good export market; pond sizes average 8-200 ha in size.

3.1.3. Mangrove exploitation

The mangrove reserve of the Sundarbans is of great economic importance to Bangladesh, providing a livelihood for some 300,000 people at certain seasons of the year. The mangroves are exploited for a wide range of forest products, in particular timber, pulpwood and firewood, and wood for making matches, hardboard and pallets. The main timbers are *Heritiera fomes,* **sundri** the most commercially valuable which makes up 64% of the total merchantable value according to Mahtab (1989) and *Excoecaria agallocha* and *Sonneratia apetala. The* fronds of

Nypa fruticans are used for thatching, and those of *Phoenix paludosa* for making house walls. Large quantities of honey and beeswax are gathered from wild bees' nests (a total of 232 mt of honey and wax in 1983), and mollusc shells are collected for the production of lime for consumption with betel nut (Saenger *et al.*, 1983; Scott, 1989). ESCAP (1988) provides a detailed account of timber production and other resource utilization in the Sunderbans.

The forests are worked by a system of selective cutting and natural regeneration, involving a 20 year cutting cycle for the main species (Chowdhury, 1968; ESCAP, 1988). The economic resources of the Sunderbans are described in Ahmad (1984), Islam & Khan (1988) and Munshi (1985) while Shahid (1985) and Mahmood (1991) have assessed the relationship between mangrove forest and fishing grounds.

3.1.4. Coastal tourism

Despite having one of the world's longest beaches and one of the largest contiguous areas of mangrove forest, there is no significant international tourist industry. There are four areas of potential tourism development:

1) Khulna, favourably sited for reaching several points of interest including the Sundarbans;

2) Kuakata, at the south of Patuakhali region, with a sandy beach and access to the Sundarbans:

3) Chittagong, with scenic and cultural interest, beaches at Fauzdarhat and Patenga; and,

4) Cox's Bazarthe most frequented tourist spot, with beaches, cultural interest and access to the islands of Moheshkali (beaches and fishing villages), Sonadia (uninhabited), Jinjiradwip (coral reef) and the village of Teknaf.

Cox's Bazar, the only place currently visited purely for tourism, is described in some detail in ESCAP (1988). Tourism is being developed at Teknaf and there are a few visitors to Potenga, near Chittagong-Cox's Bazar (Das, 1989a). Domestic tourism far outweighs international tourism and turbidity of the water is one major deterrent in the development of international coastal tourism.

Some of the wetlands have considerable potential for tourism, and provide excellent opportunities for scientific research and conservation education (Scott, 1989). Lack of facilities and inaccessibility mean that the Sundarbans are still rarely visited but there is some special interest tourism between October and May (Scott, 1989; Talukder, 1984).

3.1.5. Coastal agriculture

Bangladesh has a very long history of human settlement and agriculture. It is one of the most densely populated countries in the world (615 people km^2 of arable land (UNEP, 1986; 1987), and the population continues to increase at about 2.6-2.970 per annum. Mahtab (1989) provides a detailed discussion of population growth and predicts a density of 1,160 km^2 by the year 2000.

The coastal region had an estimated population of 10 million in the early 1980s (Rahman, 1983). As a result, land is a scarce commodity, and national policy has therefore always aimed at its full utilization. The extent of government owned lands (khas land) is decreasing year by year as they are transferred to private ownership. Thus most of the haors and beels have now been sold or leased to private individuals for cultivation during the dry season (Scott, 1989). As fast as new chars are formed, poor farmers rush to settle on them, despite their vulnerability to storms and flooding.

4. Conservation Issues and Problems

4.1. Habitat Degradation and Destruction

4.1.1. Mangroves

Conservation problems in the Sundarbans have been discussed in numerous publications and summaries with references include ESCAP (1988) and WCMC (1989). The Sundarban mangroves have been in a state of progressive deterioration since the 1970s (Saenger *et al.*, 1983). Their ecology is changing as a result of reduced inflow of freshwater during the dry season. Up to 40% of the dry season flow of the Ganges has been diverted upstream following the completion of the Farraka Barrage in India in 1974. Only the Baleswar and Passur rivers and their distributaries now have a direct connection to the Ganges and thus the freshwater supply is interrupted. The other rivers only receive freshwater from local catchments and are very susceptible to dry season reduction in stream flow and to tidal intrusions of salt water. This has caused increasing salinization, which affects and in some areas has prevented the natural regeneration of mangroves. There has also been localised die-back of *Heritiera fomes*, which is likely to be replaced with *Excoecaria agallocha* (Scott, 1989). Although new mangrove rapidly accretes, changes in the hydrodynamics of the Ganges River through further damming could be a threat (Davie, 1991)

Over-exploitation is also a major problem in the Sundarbans. It is thought that *H. fomes* may have declined by 40% since 1959 and E. *agallocha* by *45%.* More areas are being cut on a shorter rotation (Scott, 1989). Additional problems are agricultural encroachment and illegal hunting.

In the Chakaria Sundarbans, large areas of mangrove forest are being cleared for the construction of shrimp ponds (ESCAP, 1988; Mahmood, 1986; Bashirullah *et al.*, 1989) and 8,500 ha are no longer productive. ‘Giant-deep’ ponds, created by blocking-off tidal channels and distributaries of the Matamohuri River by cross dams, have had a particularly serious impact. Rapid deforestation in the Matahohuri catchment area has increased siltation which is compounded by the building of embankments for shrimp ponds. Much of the mangrove in the Naaf Estuary has also been converted to shrimp ponds (Scott, 1989).

Mangroves will be particularly vulnerable to sea level rise, and will probably be killed by the increased salinities rather than inundation (Mahtab, 1989).

4.1.2. Coral Reefs

Around Jinjiradwip, parts of the reef are said to be completely destroyed due to shell and coral collection, but it is possible that domestic and industrial effluents, dynamite fishing and recreational pressure have added to the problem (Fattah, 1979). There is some small-scale exploitation of coral for lime production (Scott, 1989).

4.1.3. Sea level rise and coastal defence

Up to one third of the country floods each year during the monsoon. Mahtab (1989) gives figures of 18% or 26,000 km^2 in normal years and 52,000 Krn^2 in severe years. Flooding is most severe when the peak flows on the Ganges and Brahmaputra coincide. Much of the coastal land is vulnerable to storm surge floods around 3,280 km^2 in the southeast, 4,450 km^2 in the south-central, and 1,350 km^2 in the south-west. Such floods can penetrate up to 150 km inland through the Tetulia and Meghna estuaries and up to 50 km through the Biskhali and Buriswar estuaries. Flooding has become more frequent and devastating in recent years; in 1988, 75% (89,900km^2) of the country flooded, with accompanying cyclones (Mahtab, 1989). Hundreds of thousands of people have been killed in these floods.

The adverse impacts of sea level rise could theoretically be countered in Bangladesh by enhanced deposition of the high silt loads brought down by rivers. These deposit some 2.5 billion tons of silt in the delta and Bay of Bengal which should result in accretion of land towards the south. This is said to have increased but it is a rather slow and erratic process (Haq, 1989). According to Mahtab (1989), there was net accretion of about 110 km^z between 1972/73 and 1979 in the region south of Bhola, Shahbazpur, Manpura and Hatia Islands, but elsewhere accretion has been accompanied by erosion. Milliman *et al.*, (1989) conclude that the coast has not prograded significantly over the last 200 years as siltation is counteracted by subsidence of the land. Furthermore, much of the sediment maybe deposited in deep water or in the Swatch of No Ground.

A considerable amount of land was reclaimed in the late 1950s and early 60s (500-600 mi^2,) and it is now proposed to increase this by reclaiming the area between Hatiya and Sandwip islands. This project, the Noakhali-Sandwip Cross Dam Project, will reclaim 20,000 ha of intertidal mudflat. It has been calculated that as much as 800 square miles could be reclaimed in 15 to 20 years although this will have a number of impacts such as alteration of navigation routes (Haq, 1989). ESCAP (1988) gives further information on the impact of reclamation projects on wildfowl and fisheries.

The effect of rising sea level, due to global warming will be particularly serious (WHOI, 1986) and it has been suggested that by the year 2,040, Bangladesh could have lost more than 31,000 km^2 to the Bay of Bengal (Choudhury, 1989). Mahtab (1989) calculates that with a one metre rise in sea level, 22,889 km^2 or 15.8% of the total area of the country would be flooded (65% of greater Khulna, 99% of Barisal, 100% of Patuakhali, 44% of Noakhali and 1270 of Faridpur). This represents 14.05% of the main cultivated areas and 28.93% of forested land and some 10 million people would be affected. Milliman *et al.*, (1989) outline the difficulty of making predictions, given that the amount of land subsidence is not known - they predict that sea level rise in this country could be anything between 13 and 209 cm by 2050, the worst estimates causing loss of about 18% of the land. They point out that increasing groundwater extraction will increase rates of subsidence and thus vulnerability to flooding, and emphasize that loss of mangroves will increase erosion and storm damage.

Increasing salinity will be one of the immediate impacts of sea level rise, and this is already a problem due to changes in freshwater outflow. In the dry season, it affects agriculture, human

freshwater resources and industry. About 1.4 million ha already have saline soils or are subject to saltwater flooding (Mahtab, 1989).

The Government has embarked on an extensive Coastal Embankment Project involving construction of coastal embankments and river dams to protect the country from periodic cyclones and flooding (UNDP, 1989). Although of value in the short-term to the human population, this is causing ecological damage in terms of loss of coastal tidal plain habitat and damage to fish and shrimp nursery grounds (Bashirullah *etal.,* 1989) .Embankments can have a significant impact on fisheries, impeding the movement of newly hatched shrimp and fish from rivers and estuaries into the floodplain as the monsoon floods rise, and similarly preventing their return for breeding when the floods fall (Bingham, 1989). There is also a proposal for a new sea port at Hatiya Island (Scott, 1989) and numerous publications relating to hydrology, flooding and siltation, include those of Coleman (1969), Curray & Moore (197 1), Matin (1985) and Nishat & Hague (1985).

4.1.4. Overfishing

The intensity of fishing is very high, and in many areas stocks are being depleted. In the larger beels, fishing is controlled by the Fisheries Department and is usually limited to once in three years, but in practice the regulations are ignored and fishing is carried out every year (Scott, 1989).

There has been a significant decline in fish availability since the 1970s although shrimp exports have increased. Fisheries decline is considered to be due to destruction of fish habitats, pesticide use and industrial pollution and loss of mangroves. Coastal embankments have prevented flooding of intertidal areas which previously provided nursery areas, and have damaged a number of the traditional brackish water fisheries (ESCAP, 1988; Basirullah *et al.,* 1989). Flood control measures and drainage projects have removed 1.2 million ha of floodlands from fishery production (Siddiquie, 1986). The majority of species inhabiting the rivers and estuaries are adapted to a pattern of flooding in the monsoon season followed by a distinct dry season hence they are adversely affected by regulation of water flow.

4.1.5. Pollution

Oil pollution is a potential threat in the Sundarbans and could be especially damaging to aquatic fauna and seabirds. Sources of oil pollution are potentially the port at Mongla on the north edge of the mangroves and the numerous large shipping vessels which pass through the Sundarbans each day via the north-east shipping route (ESCAP, 1988); Scott, 1989).

4.1.6. Coastal tourism

Although insignificant at present compared with other countries, the impact of tourism is already being felt at Cox's Bazar where hotels are being built close to the beach and use of the beach by tourists is disturbing turtles. Shells from Jinjiradwip, Sonadia and other areas are being sold to tourists (Das, 1989b). A variety of other problems associated with tourism or which would inhibit the development of tourism are discussed in ES CAP (1988).

4.2. Species of Conservation Concern

In the following paragraphs species listed by IUCN (1990) as globally threatened are considered individually. Other species, including those considered threatened regionally or nationally are discussed in the general paragraphs. Status categories follow the IUCN definitions namely: endangered (E); vulnerable (V); rare (R); indeterminate (I); insufficiently known (K); threatened (T) and commercially threatened (CT).

4.2.1. Mammals

Platanista gangetica, Ganges river dolphin (V)
This protected species is common in all major rivers in the Ganges-Brahmaputra floodplains, the Sundarbans and around Hatiya Island (Scott, 1989) and reportedly enters tidal waters. Estimates for population size are not available. The status of this species is considered precarious because of dam and barrage construction and the use of agrochemicals.

Orcaela brevirostris, Irrawaddy dolphin (K)
Reported to occur in the Ganges and Bay of Bengal and maybe accidentally trapped in nets. No further information relevant to Bangladesh is available (Klinowska, 1992).

Other cetaceans:
Other cetaceans probably occur within Bangladesh waters although there is little information available. The only species definitely known to occur are: the rough-toothed dolphin, *Steno bredanensis;* the Indo-Pacific hump-back dolphin, *Sousa chinensis;* the spotted dolphin, *Stenella attenuata;* and, the finless porpoise, *Neophocaenaphocaenoides. The* latter species is protected according to Klinowska (1992). All Indian Ocean coastal populations of *Stenella attenuata and Sousa chinensis are* considered at risk (Perrin, 1989), the latter partly because its distribution is closely correlated with mangroves. The common dolphin, Delphinus *delphis;* the blue whale, *Balaenoptera musculus;* and, the minke whale, *B. acutorostrata are* protected but it is not known if they occur.

Panthera tigris, Bengal tiger (E)
This species occurs in the Sundarbans and is protected and regarded as a ‘national asset’.

Aonyx cinerea, oriental small-clawed otter (K)
Common in the Sundarbans, Char Kukri-Mukri and around Hatiya Island (Scott, 1989).

Lutra perspicillata, smooth-coated otter (K)
Common in the Ganges-Brahmaputra floodplains and Sundarbans where the population is estimated at 20,000 (Scott, 1989).

Elephas maximas, Asian elephant (E)
Occurs on the Tekinaf Peninsula (Khan, 1985b).

Dugong dugon, dugong (V)
No resident populations of this species are known from Bangladesh waters but individuals stray into the area from the north coast of Myanmar (Thornback & Jenkins, 1982). Haque (1976) reported a sighting of an animal thought to be a dugong at Moiscal Channel, near Cox's Bazar.

Other mammals:
Threatened mammals (Thornback & Jenkins, 1982) which previously occurred in the Sundarbans and are thought to have recently gone extinct include: *Canis lupus,* wolf; *Bos gaurus,* Gaur; and *Rhinoceros unicornis,* the Asian rhinoceros. The latter species was last seen in the Chittagong Hill Tracts around 1973 (Scott, 1989). *Bubalus bubalis, the* water buffalo is also believed to have recently become extinct in the Sundarbans (Scott, 1989). Spotted deer are found mainly in the northeastern Sundarbans and the population is believed to be declining (ESCAP, 1988). No information on the coastal distribution of *Cuaon alpinus,* the Asiatic wild dog (V) and *Panthera pardus, the* leopard (I) is available.

A population of the crab-eating macaque, *A4acaca fascicularis* was recently found in the extreme southeast of the Teknaaf Peninsula, where it is restricted to tidal-mangrove forest along the Naaf River and on Jhaliardwip Island. This population represents the western most extension of the species range and the animals may migrate between Myanmar and Bangladesh. The species is threatened by habitat destruction and is of national conservation concern. The rhesus macaque, *Macaca mulatta* has its largest and healthiest population (88,000-126,000 individuals) in the Bangladesh Sundarbans (Eudey, 1987).

4.1.2. Birds

Pelecanus philippensis, spot-billed pelican.
Reported to occur in Char Kukri-Mukri and the Sundarbans (Scott, 1989) but not listed for Bangladesh by Collar and Andrew (1988).

Leptoptilos javanicus, lesser adjutant (V)
Widespread in Bangladesh but fast disappearing (Collar and Andrews, 1988). Fairly common resident in Sundarbans with a total population of about 100; breeds August-December in mangroves. Several pairs also nest in the mangroves of the Teknaf Peninsula (Scott, 1989).

Leptoptilos dubius, greater adjutant (E)
Reported extinct in Bangladesh (Collar and Andrew, 1988), but one pair has recently been found nesting in the Teknaf Peninsula area (Scott, 1989).

Haliaeetus leucorphus, Pallas's fishing eagle (R)
Two pairs nest in the Sundarbans (Scott, 1989) but the species is rapidly declining (Sarker, 1985a; Sarker & Iqbal, 1985; Collar& Andrew, 1988).

Haliaeetus leucogaster, the white-bellied sea eagle
Not considered globally threatened this species has been surveyed in the Sundarbans where the population is considered by Sarker (1985b) to be threatened.

Heliopais personata, masked finfoot (V)
Resident in Sundarbans mangroves and maybe commoner than records suggest (Scott, 1989).

Tringa guttifer, spotted greenshank (I)
Winters rarely (Collar and Andrew, 1988),

Other birds:
About 150 species of waterfowl have been recorded, but over 70 of these are now rare and several have not been reported for many years. Common wetland species include: *Tachybaptus rujicollis, Phalacrocoraxniger,* a variety of herons *andegrets, Anastomus oscitans, Leptoptilos javanicus, Threskiornismelanocephalus,* several ducks, *notablyDendrocygnajavanica, Nettapus coromandelianus* and *Anas acuta;* and species such as *Amaurornis phoenicurus, Gallicrex cinerea, Porphyrio porphyrio, Fulica atra, Hydrophasianus chirurgus, Metopidius indicus,* and a wide variety of shorebirds (Forest Department, 1974; 1976; Husain & Sarker, 1984; Husain *et al.,* 1983; Karpowicz, 1985; Khan, 1986b; Maltby, 1986; Millin,1987; Rashid, In press; Rashid & Khan, 1987; Rashid & Scott In press; Sarker, 1985a; 1986; Sarkeret *al.,* 1984; Sarker & Sarker, 1985a; 1986; Savage, 1970; Savage& Abdulali, 1970; Scott&Poole, 1989; Van der Ven, 1987).

There is little information on sea birds although the Sundarbans are an important staging and wintering area for gulls and terns (Scott, 1989).

4.2.4. **Reptiles**

Batagur baska, Batagur river terrapin (E)
A significant breeding population of this species was discovered in 1982 (Scott, 1989) which only occurs in one river system in the Sunderbans (Khan, 1982c). According to IUCN/SSC (1989), the species occurs in the Mongla and Passur Rivers and a turtle recorded from creeks near the sea in the Teknaf region is thought to be of this species (Das, 1989b).

Aspideretes (Trionyx) nigricans, dark soft-shell turtle (R)
Around 300 individuals of this species remain (Khan, 1980; 1982c). It is endemic to an artificial pond at Nasirabad, 4 miles north-east of Chittagong and therefore is not strictly coastal. The natural habitat and distribution of this species are not known (Groombridge, 1982; IUCN/SSC, 1989; Das, 1989b).

Other freshwater turtles of concern in the Ganges Delta are *Geoclemys hamiltonii, Kachuga kachuga, Chitra indica* and *Pelochelys bibroni* (IUCN/SSC, 1989).

Caretta caretta, loggerhead turtle (V)
Occurs off the Sundarbans and St Martins (Scott, 1989) this species is reported to nest at Katka, Supati, Nilkamal, Bubla and Putney, islands off the southern Sundarbans (Khan, 1986a), although Groombridge (1985) reports no nesting.

Chelonia mydas, green turtle (E)
Nesting is common (Khan, 1982a) or fairly common (Sarker & Sarker, 1985b); some nesting

on mainland beaches and a regular visitor to Jinjiradwip where it nests October-February (Khan, 1985a; Rashid, 1986a). Also reported to nest at Katka, Supati, Nilkamal, Dubla and Putney, islands off the southern Sundarbans (Khan, 1986a). Relatively more abundant than *Lepidochelys olivacea* although Das (1989a) maintains the latter is more abundant. A reported nesting in the Sundarbans needs confirmation (Groombridge & Luxmoore, 1989).

Eretmochelys imbricata, hawksbill turtle (E)
Uncommon (Khan, 1982a; Sarker & Sarker, 1985 b). Occasionally nests on Jinjiradwip (Rashid, 1986a). Nests at Katka, Supati, Nilkamal, Dubla and Putney, islands off the southern Sundarbans (Khan, 1986a).

Lepidochelys olivacea, olive ridley turtle (E)
Das (1989a) considers this the commonest and most widespread species in Bangladesh. It nests at Katka, Supati, Nilkamal, Dubla and Putney, islands off the southern Sundarbans (Khan, 1986a; Rashid, 1987), and is considered to be the commonest of the three species nesting on Jinjiradwip (Ahmed *et al.,* 1986; Khan, 1985a; Rashid, 1986a). The species has been reported from the Teknaf Peninsula (Das, 1989a) and possibly as nesting on an island 10 km southwest of the Sundarbans (Whitaker, 1982a).

Dermochelys coriacea, leatherback turtle (E)
Occurs off Jinjiradwip (Scott, 1989).

Sea turtle eggs are collected for local consumption only by minority groups, such as tribal communities in the Chittagong-Cox's Bazar region but this occurs fairly widely, especially on Jinjiradwip where turtles are also taken for their meat and carapaces. There is no international trade and turtles are not protected (Das, 1989b; Groombridge & Luxmoore, 1989; Rashid, 1986b). Terrapins are threatened by uncontrolled exploitation.

Crocodylus palustris, mugger (V)
Thought to be extinct in the wild although a few individuals could still survive in the northern part of the Sundarbans. A small feral population is maintained at Khan Jahan Ali Shrine Tank in Bagerhat, Khulna (Groombridge, 1982; Scott, 1989).

Crocodylus porosus, estuarine or salt-water crocodile (E)
The only surviving population (less than 200 individuals) is in the southern part of the Sundarbans in an area of 78,000 ha. This species is under pressure from illegal hunting for the skin trade. Rivers known to support this species are Balleshwar, Bhola, Sela, Katka, Ambaria Ghat, other tributaries of the Pusur, Bhadra and part of the Sibsa; although formerly the species occurred in most rivers. It had disappeared from Chakaria Sunderbans by the 1950s. The population is considered important internationally as it is fairly well protected (Groombridge, 1982).

Gavialis gangeticus, the gavial (E)
Five individuals of this species were reported along the Padma between Godagari and Sardah in 1984/85 (Rashid & Khan, 1986) and a few are known to survive between Tista and Nagarbari on the Jamuna. The total population is estimated at less than 20. Nesting may have occurred in

the late 1970s on accreting islands (Char Dia Khidirpur, Char Mukhterput) in the Padma area near the border with India (Khan, 1982b; Scott, 1989).

Python molurus, Indian python (V)
This species is declining in the Sundarbans due to illegal hunting and habitat disturbance (Scott, 1989).

Other reptiles:
Three species of *Varanus* occur in coastal areas: *V. bengalensis* which occurs throughout the country, and is estimated at around 100,000 individuals; *V. j7avescens with* an estimated population of around 100,000 individuals; *and V.salvator,* a coastal species with around 40,000 individuals. All occur in Char Kukri-Mukri S. and the Sundarbans (Scott, 1989). *V. salvatorhas* the most restricted distribution, found only in the Sundarban mangroves and other habitats in the coastal strip fringing the Bay of Bengal including the Chittagong-Cox's Bazar area and offshore islands such as Jinjiradwip. It may formerly have ranged further inland and is now locally extinct in the Chakaria Sundarbans. All three species are collected illegally for the skin trade and *V. salvator is* threatened by habitat disturbance (Luxmoore & Groombridge, In press; Khan, 1988).

4.2.4. **Amphibians**

The Green Frog, *Rana hexadactjda* has declined as a result of commercial exploitation in the Sundarbans despite a ban on catching it in the breeding season (Scott, 1989).

5. Environmental and Conservation Legislation

Territorial Waters and Maritime Zones Act. 1974
This act covers the protection, use and exploitation of the resources of the EEZ and provides for regulation of resource use within the continental shelf. Conservation zones may be established to protect marine resources from indiscriminate exploitation, depletion or destruction.

Forest Act. 1927 (amended as the Forest (Amendment) Ordinance. 19891
This act established the Forest Department and allows for establishment and management of Forest Reserves. The new legislation declares a total ban on logging and increases punishment for offenders (Anon., 1990).

East Beruzal State Acquisition and Tenancy Act. 1950 (Act XXVIII of 19511

Bamzladesh Wildlife @reservation) Order. 1973
Promulgated under Presidential Order No. 23 in March 1973 and subsequently enacted and amended as the Bangladesh Wildlife (Preservation) (Amendment) Act, 1974 this provides for the establishment of national parks, wildlife sanctuaries and game reserves, and for the establishment of a Wildlife Advisory Board. Speciesprotected under this *actincludeBalaenoptera musculus, Balaenoptera acutorostrata, Platanistagangetica, Delphinus delphis, Neophocaena phocaenoides, Elephas maximus, Macaca fascicularis, Aonyx cinerea, Lutra perspicillata, Panthera tigris, Panthera pardus, Pelecanus philippensis,* several sea birds, *Leptoptilos dubius, Leptoptilus javanicus, Tringa gutti$era, Haliaeetus leucoryphus,* and the reptiles *Trionyx nigricans, Crocodylus palustris, Crocodylus porosus, Gavialis gangeticus* and three *Varanus* species.

Haor Development Board Ordinance (Ordinance No, IX of 1977)

Bangladesh Fisheries Development Corporation Ordinance, 1973

Ordinance Concerning the Protection and Conservation of Fish. 1982

Marine Fisheries Ordinance 1983
Provides for the establishment of marine reserves for fauna and flora, covering all aquatic animals and requires the licensing of all fishing vessels, domestic and foreign; the total number of trawlers is limited to 40, there are controls on their structure, and recommendations for mesh size and size limits for shrimp have been drawn up. No regulations protect small-scale fisheries.

Marine Fisheries Rules. 1983

Protection and Conservation of Fish Rules. 1985

East Bend Protection and Conservation of Fish Act, 1950 (East Bengal Act XVIII]

Petroleum Act, 1974
Provides for control of spillages and interference with natural resources and the environment.

Bangladesh Marine Pollution Control Ordinance
Provides for oil pollution controls

Water Pollution Control (Amendment) Order 1973

Environment Pollution Control Ordinance 1977
Covers all types of environmental pollution.

6. Institutional Infrastructure

6.1.1. Governmental and Semi-governmental Organizations

Forest Department. Ministry of Environment and Forests.
Previously the Directorate of Forestry of the Ministry of Agriculture and Forestry renamed in 1989

Responsible for the management of forest exploitation including the Sundarbans; reafforestation; protection of wildlife; and management of protected areas. In 1973, a Wildlife Circle was established within the Department of Agriculture and Forestry, with specific responsibility for wildlife matters. This was headed by the Conservator of Forests (Wildlife), with responsibility directly to the Chief Conservator of Forests. The Circle was abolished in June 1983, allegedly in the interests of economy. The post of Conservator of Forests (Administration and Wildlife) remains, but the incumbent has many other administrative duties unrelated to wildlife. Following its general down-grading within the Forest Department, wildlife conservation has become the theoretical responsibility of the various Divisional Forest Officers. A Wildlife Advisory Board was set up in 1977 under the Chairmanship of the Minister of Agriculture. The Board is supposed to approve important management decisions and directives, and attempt to create a comprehensive nation-wide system of protected areas, but it has been relatively inactive in recent years. A Task Force was set up under the Ministry of Agriculture in 1985 to make recommendations for improvement in environmental management.

Directorate of Fisheries. Ministry of Fisheries and Livestock.
Responsible for fisheries protection, marine fisheries, marine turtles, coastal aquiculture (but licensing of fishing vessels is controlled by a different ministry).

Bangladesh Fisheries Development Corporation. Ministry of Fisheries and Livestock.
Responsible for capture fisheries and marketing.

Department of Science and Technology of the Ministry of Education.
Responsible for all marine affairs including coastal zone management.

Bangladesh Water Development Board. Ministry of Irrigation and Water Resources
Responsible for irrigation, drainage and flood control for agriculture.

Ministry of Civil Aviation and Tourism
Administers tourism through the Bangladesh Parjatan Corporation.

Revenue Department. Ministry of Land Administration and Land Reforms
Controls the exploitation of Government lands including rivers, haors, baors and beels. The Deputy Commissioners are the principal executives in the District Administrations, the Additional Deputy Commissioners (Revenue) collect revenue from fishing leases and tempo-

rary leases for the cultivation of wetlands during the dry season and allocate and distribute lands, and lease fishing rights to private individuals.

Directorate of Environmental Pollution Control, Ministry of Local Government, Rural Development and Cooperatives
With the EPCB, jointly responsible for formulating environmental policy and recommending improvements in environmental legislation to the Ministry of Planning.

Bandadesh Wildlife Advisory Board
The Board advises the Government and makes recommendations regarding the conservation of wildlife.

Environmental Pollution Control Board (EPCB\
Established in 1977; assists in formulating environmental policy and makes recommendations concerning environmental legislation.

Survey Department and Space Research and Remote Sensing Organization (SPARRSO\
The national mapping agency.

Upazilla Councils
Responsible for the management of fisheries in water bodies of less than eight hectares in area.

Natural History Department, Bangladesh National Museum.

6.1.2. Non-governmental Organizations

Society for Conservation of Nature and Environment C3CONE\
Concerned with environmental education, creation of awareness to conservation problems among the public in general, and environmental pollution. Publishes a "Bulletin" with financial assistance from the Science and Technology Division of the Ministry of Education. Fifty-one Youth Science Clubs and organizations, scattered throughout the country, are associate members of SCONE.

Bandadesh Wildlife and Nature Cobservation Society
Formerly the wildlife Preservation Society, founded in 1972; the Vice-Chairman is the ICBP Representative of Bangladesh.

Wildlife Society of Bangladesh
Based at the Department of Zoology, Dhaka University, and organizes seminars, educational programmed and field trips for students. Publishes a "Wildlife Newsletter" in English and "Paribesh Parikrama" in the local Bangla language.

Barwladesh Bird Preservation Society
Based at the Department of Zoology, Dhaka University.

Nature Conservation Movemen[
A newly formed organization, established to promote nature conservation, research and education. The Movement is initially focusing on wetlands, coastal and offshore islands, and reptiles.

Polli Unnavan Sangstha (POUSH]
Protection and improvement of the environment.

Coastal Area Resource Development Management Association (CARDMA)
Organized a conference on the greenhouse effect and coastal areas of Bangladesh in March 1989.

6.1.3. Universities

University of Dhaka
University of Rajshahi
University of Chittagong, Institute of Marine Sciences
Bangladesh Agricultural University
The Islamic University (Kustia District)
Jahangimagar University; Institute of Life Sciences, Centre for Nature Studies
Cox's Bazar Marine Laboratory, Fishery Research Institute

7. Conservation and Environmental Management Actions

7.1.1. Current research

ESCAP (1988) contains references to a large number of government and scientific reports, particularly on fisheries, mangroves, and coastal engineering. Several national bodies and many visiting scientists have carried out research in the Sundarbans, and this region has now been well documented particularly with regard to vegetation cover by the Forest Department, the University of Dhaka and by some international agencies (Blower, 1985; Chaffey et *al.*, 1985). There is little information on the fish and fisheries and their status in the mangrove estuaries of the Sundarbans. Rabanal (1984) made a rapid inventory of the fishery and provides a general list of shrimp and finfish species in the area. He also recommended further research to formulate a rational policy for integrated management of this natural mangrove ecosystem. SPARSSO, the remote sensing agency, has been involved in much of the coastal research (SPARSSO, 1986a; 1986b).

The Directorate of Fisheries of Bangladesh and the Bangladesh Fisheries Development Corporation are undertaking projects to develop coastal marine fisheries in the Bay of Bengal with financial assistance from the International Bank for Resource Development and the Asian Development Bank. A twenty year fishery development plan was drawn up in 1984 (Marr, 1984) while Tsai & Ali (1984) provide a fishery management plan for carp. A number of projects are underway through the Bay of Bengal Programme.

Following the 1988 floods, numerous reports were produced by development agencies (UNDP, USAID, JICA (Japan), France) with proposals for flood control ranging from extensive embanking of rivers (4,000 km) to minimal embanking but emphasis on adjustment of people to live with the flooding, focusing on traditional lifestyles. The World Bank is now the umbrella, coordinating agency for a 5-year action plan which will take an intermediate path involving some embankment, but with a major focus on the environment, fisheries and the need for EIAs (Bingham, 1989). Development projects having an effect on the coastal area, in particular activities connected with the Ganges and Brahmaputra Rivers, need monitoring-in liaison with Nepal and India as many projects affecting Bangladesh take place in other countries.

7.1.2. Coastal zone management

In 1986a study was initiated with the support of ESCAP involving a team of national experts and expatriate consultants to prepare a coastal environmental management plan. The draft report was presented to an inter-ministerial symposium on coastal environmental management in Dhaka in 1987, and the final report has been published (ESCAP, 1988). There is also an accompanying audio-visual module entitled ‘Precious Wetland of Bangladesh’. The report contains a number of recommendations although it is not known what steps are being taken to

implement these. The coastal zone is stressed as a consequence of intensive land use combined with episodic natural events (Khan & Karim, 1982).

7.1.3. Existing protected areas

(Sarker & Huq, 1985; IUCN, 1987)

1. Char Kukri-Mukri Forest Reserve and Wildlife Sanctuary (40 ha): The island of Char Kukri-Mukri covers 2,500 ha; all mangrove forest is included within the Forest Reserve and the best mangrove in the Wildlife Sanctuary. There is no mangrove exploitation. The island also has extensive intertidal mudflats and a plantation of 1,500 ha in the interior (Scott, 1989). Site accounts in WCMC (1989) and Scott (1989).

2. Sundarbans Forest Reserve (571,508 ha, ESCAP, 1988) and east Wildlife Sanctuary (5,439 ha), south Wildlife Sanctuary (17,878 ha) and west Wildlife Sanctuary (9,069 ha): Within the Forest Reserve, entry and harvesting of forest products is subject to permits issued by the Forest Department; although hunting permits can be issued in theory, in practise they are not. Management includes the planting or replanting of mangroves (see below). The Wildlife Sanctuaries were established in 1977; all logging is prohibited within these and only fishing and collection of minor forest products is permitted (Scott, 1989).

3. Chakaria Sundarbans Forest Reserve: In the 1920s, about 18,200 ha of mangroves had the status of Forest Reserve, but this is ineffective and almost all the mangrove has been cleared or severely degraded as a result of expansion of shrimp farming (Mahmood, 1986; 1990a); data sheet in Scott (1989) but not considered a protected area by WCMC (1989).

4. Teknaf Game Reserve lies close to important coastal areas of the Teknaf Peninsula and Naaf Estuary and is described in Scott (1989).

Bangladesh has a national committee in connection with UNESCO's MAB programme but there are no biosphere reserves. It joined the World Heritage Convention in August 1983 but there are no coastal World Heritage Sites. Parts of the Indian Sunderbans were declared a World Heritage Site in 1987.

Bangladesh become a party to the Ramsar Convention in 1992 and nominated the Sundarbans mangrove forests as a Ramsar site.

7.1.4. Mangrove management and protection

A management regime for mangroves was established in the Sundarbans in 1984 and is based on selective logging and stand improvement principles with a 20 year logging cycle. Minimum diameters for commercial species vary between 11.8 cm and 56.3 cm depending on species and site quality class (UNEP, 1986; 1987). The historical management of the Sundarban mangroves is described in ESCAP (1988); Salter (1984) and WCMC (1989) provide further information. *Nypa is* harvested on a 3 year cycle (Davie, 1991).

The government has undertaken a large-scale planting programme, the Coastal Afforestation Programme, to protect the coastline from storm damage. Operated by the Forest Department, 24,400 ha had been planted by 1978 (UNEP, 1986; 1987) and a further 25,000 ha were planted in 1983 (Saenger *et al.,* 1983). There were then plans to plant a further 40,000 ha in the 1990s (Scott, 1989). (ESCAP (1988) gives figures of 11,000 ha replantedby 1976, 40,000 ha by 1980 and 37,000 by 1985; the total area available for replanting is 91,000 ha. Most of Nijhum Dweep, parts of Ghasiar Char and Char Bhata have been planted. National importance has been given to this programme of afforestation of intertidal lands with *Avicenia* and *Sonneratia* spp., since 1971, and more than 100,00 ha are now involved, the project having recently been supported by the World Bank (Davie, 1991). According to UNEP (1986), *Sonneratia apetala is* the most favoured species for planting. Seedlings are raised in nurseries and transplanted when they reach a height of 32-60 cm. The plantations are thinned after 5-7 years and harvested after 15-20 years. A variety of other species such as *Bruguiera gymnorhiza* and *Nypa fruticans are also* used and non-mangrove species such as *Acacia arabica are* planted to stabilise embankments (UNEP, 1986; 1987). The resulting new lands are for coastal protection, as a forest resource, for wildlife habitat, fisheries and ultimately as agricultural land for rice production. Further information is provided in SPARRSO (1986b).

7.1.5. Erosion and flood control

In the early 1960s, some 4,800 km of embankments were constructed by the East Pakistan Water and Power Development Authority, enclosing about 133,600 ha of coastal land. This involved closing tidal channels which had deleterious effects on fisheries, drainage and navigation and increased river siltation while decreasing siltation in low lying areas (ESCAP, 1988). The Coastal Embankment Project, covering 13,000 km^2, now protects almost all the low-lying coastal plain other than the Sundarbans against tidal flooding, saline water intrusion and river flooding. There have also been a number of other projects in flood control (eg. Anon., 1981) and the 1984/85 Delta Development Project in Khulna which involved the construction of the two cross-dams in the Meghna estuary in 1957 and 1964. A Cyclone Protection Project is underway with EC funding in the lower delta, involving the rebuilding of coastal defences.

7.1.6. Conservation

Conservation efforts began in 1966, prior to independence, when the Government of Pakistan invited the World Wildlife Fund (now the World Wide Fund for Nature) to assess the status of its wildlife and recommend measures to arrest deterioration and promote wildlife tourism. Two international expeditions were mounted and several areas were investigated, including wet-lands in the Haor Basin and the Sundarbans. The Government was urged to appoint its own Wildlife Enquiry Committee to follow up this work. The Committee was established in 1968, and by 1970 had drafted a report. Considerable progress was made with the establishment of protected areas, and several research projects were undertaken (eg. Olivier, 1979), particularly in the Sundarbans, where some 78,000 ha of the Katka and Nilkamal forests were notified as a Tiger Sanctuary (Scott, 1989).

Following the War of Liberation an ambitious programme of wildlife management was developed. A scheme entitled “Development of Wildlife Management and Game Reserve” was

incorporated in the country's First Five Year Plan. This proposed the establishment of numerous national parks, wildlife sanctuaries and recreation parks covering some 8910 of the country. Several reserves were established, but the scheme was much reduced in later plans and little further progress has been made. A conservation programme covering fifty-one wetland areas has been drawn up by the Government, but economic constraints have severely hampered progress, and the wetlands remain poorly protected.

The very low priority apparently now accorded by the Government to wildlife conservation in Bangladesh is reflected in the recent abolition of the Wildlife Circle, the reassignment of staff to normal duties, the lack of any separate financial provision within the Forest Department's budget and the relative inactivity of the Wildlife Advisory Board.

There has been a great increase in interest in nature conservation in the non-governmental sector, particularly in the last decade. A small number of wildlife enthusiasts founded the Wildlife Preservation Society (now Wildlife and Nature Conservation Society) in 1972, and actively participated in the formulation of the Bangladesh Wildlife Preservation (Amendment) Act of 1973. Since then, several other non-governmental conservation bodies have been established to promote the study of the fauna and flora of Bangladesh and to raise public awareness of conservation issues.

A national conservation strategy is being developed (BARC, 1987) and Environmental Impact Assessments are now mandatory. Bangladesh is a party to the Convention on the International Trade in Endangered Species (CITES).

8. Recommendations for Future Action

8.1.1. Proposed protected areas

1. Jinjiradwip and Jinjira reefs (St Martin's I.) are proposed as a marine national park (Khan, 1985a) on account of the coral reef, and the importance of the area as wintering ground for wildfowl and nesting site for marine turtles (Khan, 1985; UNEP, 1987; Rashid, 1986a). A detailed description, with map, and recommendations for management is given in ESCAP (1988) while the flora is described in Khan eta)., (1984) and a site account is found in Scott (1989).

2. Hatiya Island, Nijhum Dweep, Ghasiar Char, Char Bhata and mudflats on north-west and south-east coasts are recommended as waterfowl conservation areas. Top priority should be accorded to the establishment of a conservation area at Nijhum Dweep before illegal encroachment causes further damage (Rashid, In press). A site account is provided in Scott (1989).

3. Naaf Estuary islands: some of these were to be declared Game Reserves, but regulations were never implemented and the islands continue to be exploited. The planned reserves should be implemented and protection should extend to include all other islands and some of the tidal mudflats at Shahpurdwip, Teknaf, Muchoni and Whykeong (Scott, 1989). In Anon (1990), it is recommended that the small remaining stand of mangrove in the Chakaria Sundarbans, with its troop of crab-eating macaques be protected, as this area encompasses the entire range of this species in the country (Eudey, 1987).

4. Sunda.rbans: numerous recommendations have been made for improved protection; Seidensticker & Hai (1983) produced a working plan emphasizing protection of the tiger; Blower (1985) and Khan (1986) produced recommendations emphasizing sustainable exploitation, expansion of the Wildlife Sanctuaries and establishment of a National Park. IUCN/SSC (1989) emphasizes the importance of the Sundarbans and Ganges delta for a number of small turtle species and makes recommendations for their conservation.

5. The Ganges-Brahmaputra Floodplain is also considered a high priority for some form of protection (Scott, 1989).

8.1.2. Species protection

Das (1989s) makes a number of recommendations for improving marine turtle protection including; provision of legal protection, protection of nesting beaches and establishment of hatcheries. General recommendations for other turtles and tortoises are given in Das (1989b) although none of these species seem to be specific to the coast.

A proposal has been drawn up for the establishment of a central crocodile hatchery and nursery and for four model crocodile demonstration ranches; these would be mainly for C. *porosus* and G. *gangeticus* (Whitaker, 1982b). However, by 1985 no steps had been taken to implement this; a study of wild populations should be carried out first. Improved protection in the field and captive breeding efforts are urgently required in the case of *Gavialisgangeticus* (Khan, 1985b).

In the case of *Platanista gangetica* major requirements include a detailed survey of its distribution and abundance, increased public awareness and regional co-operation in providing protection. Research centres could be established at the Universities of Chittagong (Karnaphuli R.) and Mymensingh (Ganges) as recommended by Perrin & Brownell, (1989) and Perrin, (1989).

8.1.3. Mangrove conservation and management

ESCAP (1988) summarizes the recommendations made by Chaffey *et al.*, (1985) which cover anumberof aspects of mangrove management including management specific to the Sundarbans, coastal reafforestation, management specific to the Chakaria mangroves (based on recommendations made by a 1986 UNESCO mission, and those in the Working Plan of Cox's BazarForest Division, 1968), wildlife, fishing, apiculture and pollution. Bashurullah *et al.*, (1989) recommend the promotion of intensive shrimp aquiculture to limit mangrove destruction; the planting of mangroves to separate ponds; improved management and public education. Rabanal (1984) recommends planting mangrove buffer strips 100 m wide along the coast and banks of main waterway and 30-50 m wide along secondary tributaries.

8.1.4. Other recommendations

A National Oil Spill Contingency Plan has been drafted with assistance of the IMO (UNEP, 1986) following a 1980 IMO mission but has not yet been promulgated. A Marine Pollution Control Ordinance was drafted in 1984; appropriate legislation should therefore be implemented (ESCAP, 1988). ESCAP (1988) also provides a number of other general policy recommendations for pollution control.

A number of general recommendations are made in ES CAP (1988), the emphasis being on the management of Jinjiradwip. ESCAP (1988) also gives recommendations covering all aspects: institutional, legal, research, monitoring. A Bangladesh Fisheries Resource Unit is possibly to be established in Stirling, UK.

General recommendations are also given in ESCAP (1988) and in Mahtab (1989), which emphasises the need to control salinisation in the Sundarbans and the development of projects that will encourage land formation. Training in all disciplines and at all levels is considered a very high priority

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