Longliners in a mangrove-fringed creek in Bangladesh at lowtide.

Bangladesh

by

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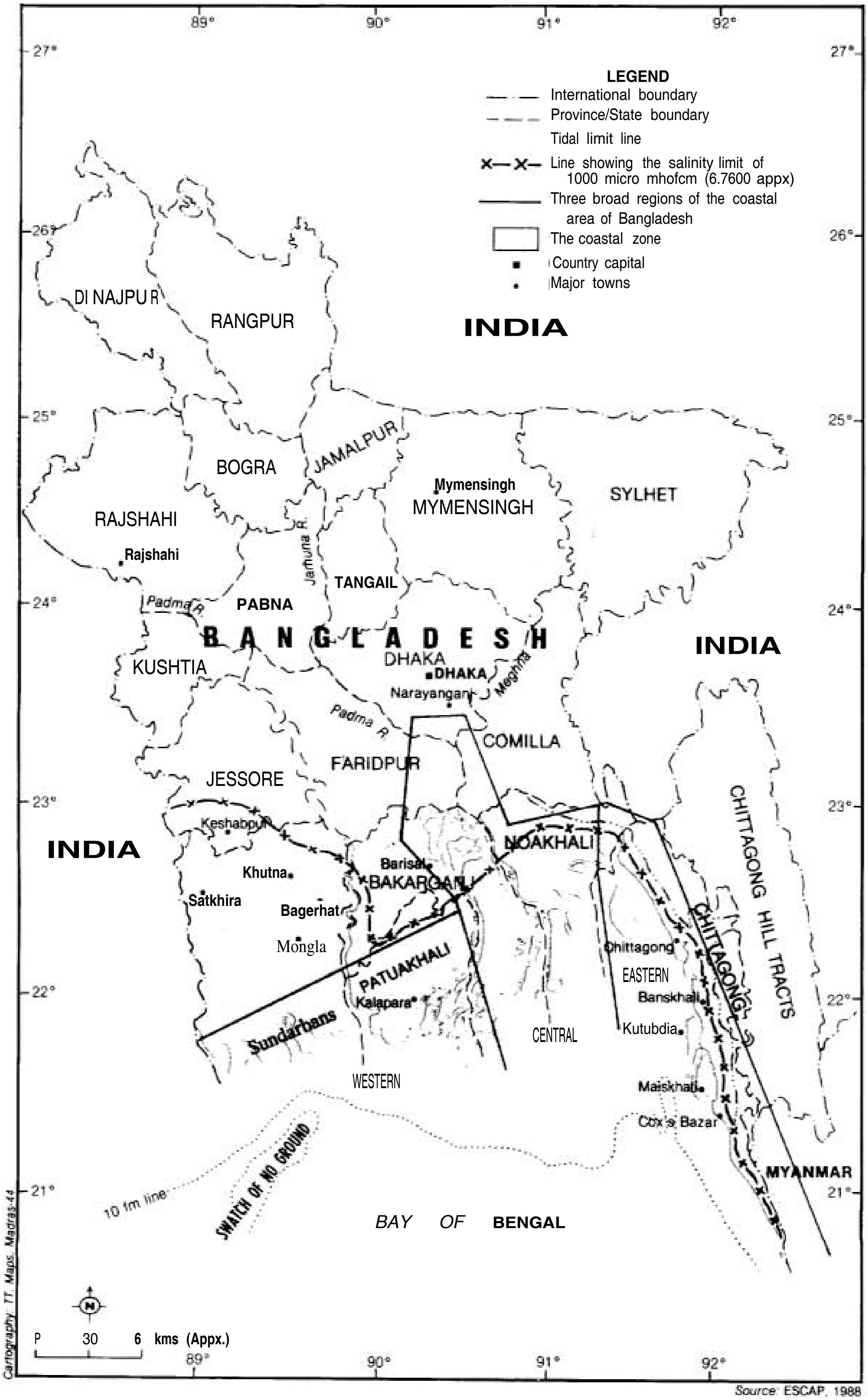
Fig. 14. Map of Bangladesh showing the limit of salt penetration in the coastal zone



Source: ESCAP, 1988

24. INTRODUCTION

Bangladesh has a land area of 144,054 km^2 and a population of over 110 million. Land-locked on three sides, it is in the South alone that it has a coastline, the Bay of Bengal washing this southern border. Geographically, Bangladesh lies at the junction of the Indian and Malayan subregions of the Indo-Malayan realm. Most of the country is low-lying, about ten metres above mean sea level.

Fish is the most accessible animal protein for the majority of the population. It is, therefore, vital that the aquatic environment be used in a sustainable manner, and that the resource base is not damaged or destroyed. Unfortunately, however, the inland capture fishery is jeopardized by natural and man-made environmental changes as well as by increased pollution from different sources. There are also indications that natural and man-induced transformation, including land-based industrial pollution, from cities as well as coastal areas, is affecting coastal habitats and, probably, the marine environment as a whole. Unfortunately research in this line is meagre. Following the recent world trends, however, the Bangladesh authorities have recently pinpointed environmental concerns and pollution as sensitive problem areas to be redressed on a national level.

This study attempts to extend baseline information on environmental threats to the coastal zone, the offshore marine fisheries and the environment. The research is based on scanty published and unpublished data collected from different sources.

25. GENERAL FACTS

The Bangladesh coastline extends 710 kms (excluding major indentations) along the northern edge of the Bay of Bengal, from the mouth of the Naaf River in the southeast, to the mouth of the Raimangal River in the southwest. In the dry season, the salt water limit follows an irregular line (Khan and Karim, 1982). Its width varies from less than 2 km, bordering some parts of the Cox's Bazar coastline, to as much as 50 km inland in the districts of Khulna and Satkhira (Figure 14, see facing page). During the monsoon season, floodwater pushes the salinity limit to near the coast, except in the districts of Khulna and Satkhira, where seasonal salinity variations are small. According to Pramanik, 1984, the coast of Bangladesh can be classified into three distinct regions on the basis of geomorphological conditions:

- The eastern region, from Big Feni River to Badar Mokam (southern tip of the mainland);
- The central region, from Tetulia River to the Big Feni River estuary, including the mouth of the Meghna River; and
- The western region, covering the coastline from the Tetulia River to the international border at Hariabhanga River.

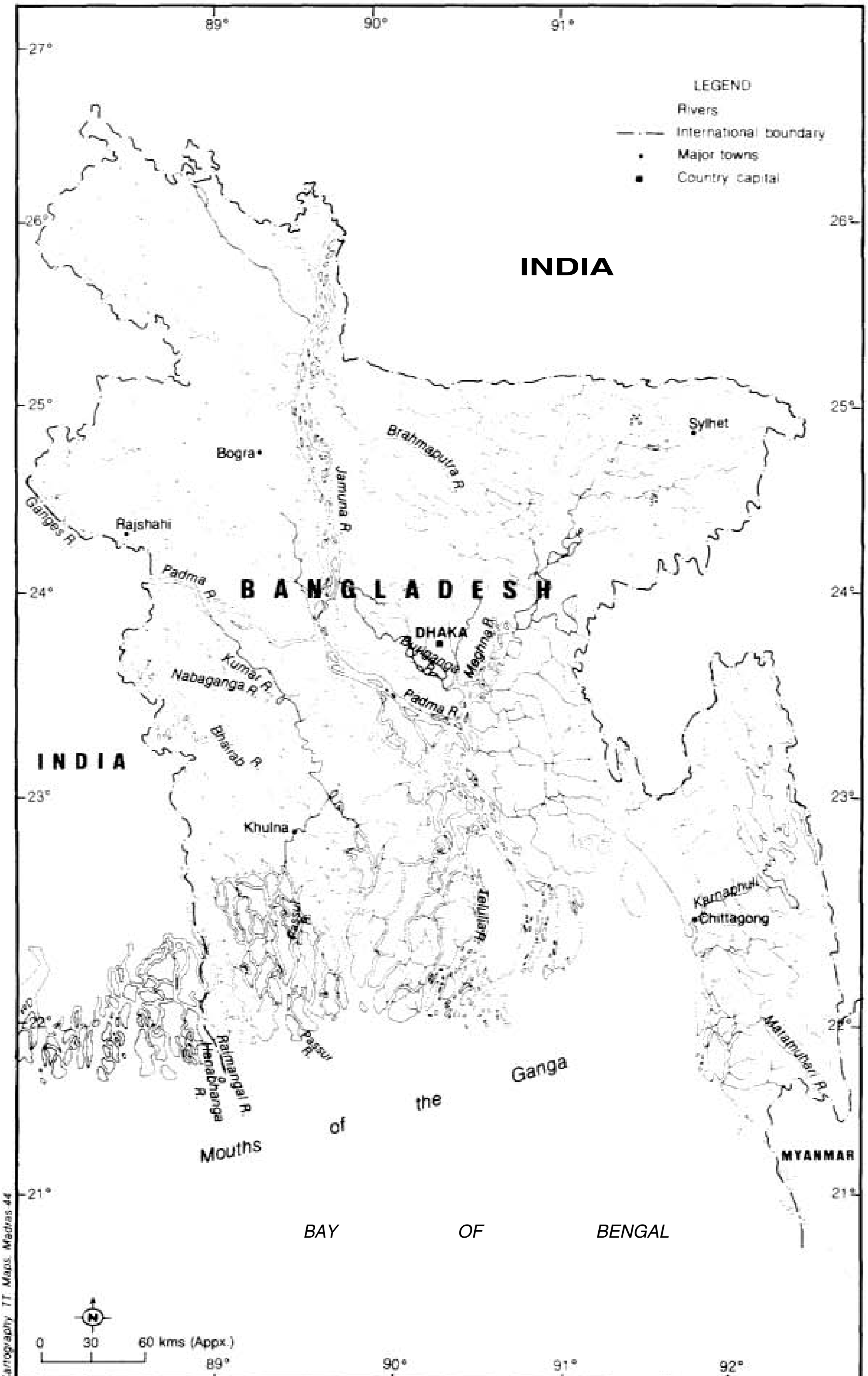
The coast for the most part is on the cyclonic tracks which form over the Bay of Bengal and suffers almost annually from severe damage caused by storms (Ali, 1979, 1980) and tidal waves. The Meghna estuary, in fact, acts as a funnel which draws the cyclones in.

The coastal zone of Bangladesh enjoys a tropical maritime climate. Its four distinct seasonal weather patterns, which are principally governed by the Southwest and Northeast Monsoons, are:

- The dry winter season, from December to February;
- The transition period, from March to May (pre-monsoon);
- The rainy season, from June to September; and
- The second transition period, between October and November (post-monsoon).

Normally about eighty to ninety per cent of the annual rainfall is confined to the monsoon months (June-September).

Fig. 15. River systems of Bangladesh



Source: Bangladesh in Maps, University of Dhaka, March, 1981

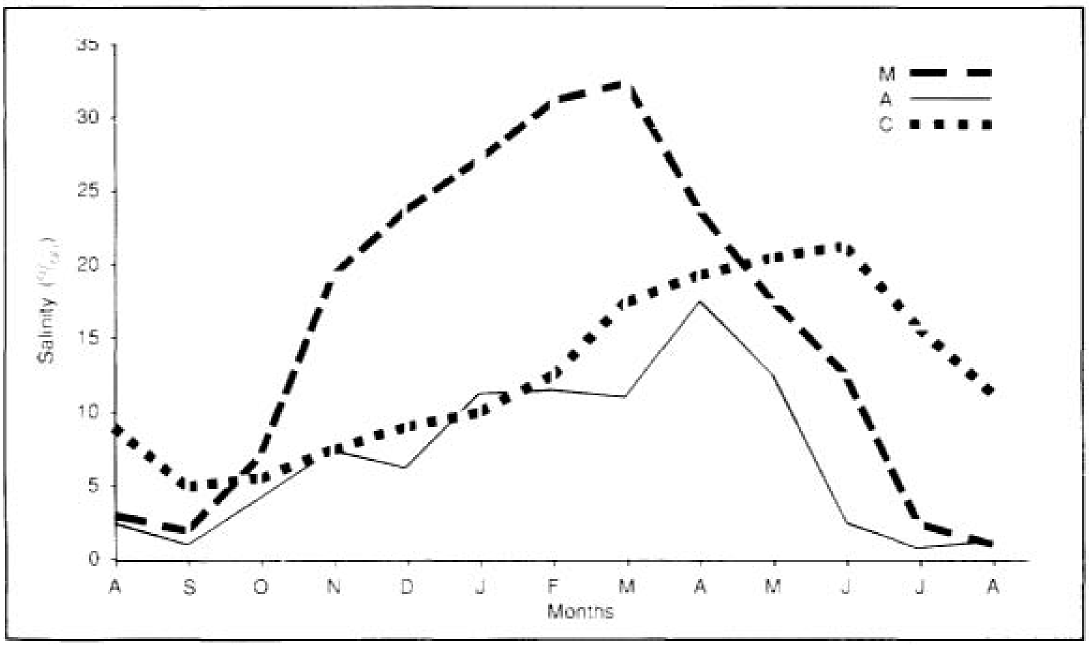
26. *MARINE HABITA TS*

26.1 *Estuaries*

Bangladesh's entire coastline is intercepted by an intricate network of interconnecting waterways, varying in width from a few metres to several kilometres. These generally run in a north to south direction (see Figure 15, facing page), Some of the world's biggest rivers, such as the Ganga, Brahmaputra, Meghna and Karnaphuli enter the Bay of Bengal through this estuarine system.

Although intensive estuarine studies have not yet been carried out, several authors have highlighted some interesting aspects of the Bangladesh estuarine system. (Mahmood and Ahmed 1976; Salam, 1976; Quader, 1976; Khair, 1976; Mohi, 1977; Das, 1977; Amin and Mahmood, 1979; Das and Das, 1980; Mahmood and Khan, 1980; Hakim *et al.,* 1981; Paul, 1981; Islam, 1982; Haque, 1983; Hossain, 1983; Mahmood, 1984 and Mahmood *et al.,* 1985). The principal feature in estuarine hydrology is the presence of a prolonged low saline regime every year, mostly during the monsoon and post-monsoon seasons (see Figure 16).

Fig. 16. Monthly variation of salinity (August 1982 August 1983) in the estuaries of Matamuhari River at Chakaria Chittagong (M) the Andhermanik River at Khepupara. Patuakhali (A), and the Coxali River at Satkhira, Khulna (C).



Note. Reconstructed after Mahmood 1986

A semi-diurnal tide is typical of Bangladesh's coastal waters, with a range of approximately three metres during the spring tide season. The mean tide level, however, is not constant throughout the year as it undergoes changes that vary with latitude and hydrography (Patullo, 1963). The Bay of Bengal has, possibly, the largest such variations known on earth. These large mean tide fluctuations have an important bearing on the overall geomorphology of the coastal area. The average level in March, for instance, is 94 cms below the average levels found in September – the month with the highest tides (Smith, 1982).

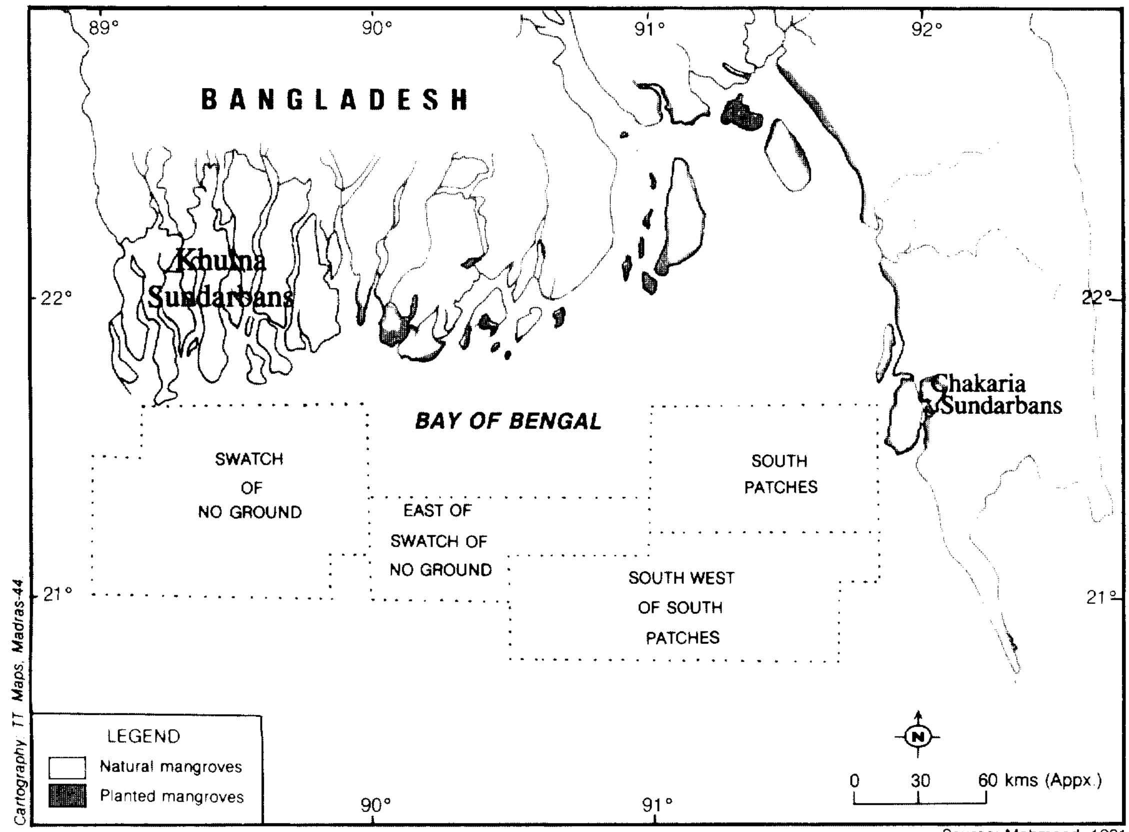
Estuarine plankton communities have also been studied (Salam, 1976; Islam, 1981; Islam, 1982; Haque, 1983; Elias, 1983; Mohi, 1977; Zafar and Mahmood, 1989; Mahmood, l990b). Until now, benthic estuarine fauna did not receive adequate attention. Only one investigation, in relation to pollution in the Karnaphuli estuary, was undertaken by Hossain 1983 (further described under 29.5: Municipal wastes).

26.2 *Mangroves*

Mangroves, locally known as *sundarban* or *peraban,* play a vital role in the national economy of Bangladesh. Besides being a source of different renewable resources, they also serve as buffer zones against the cyclones and tidal surges. The Bangladesh coast supports about 587,400 ha of natural mangroves (Mahmood, 1986) and a further 100,000 ha of planted mangroves.

The densest mangroves block, the Sundarbans (beautiful forest), is situated in the southwest (Figure 17), mostly in Khulna District, where it covers 577,040 ha (FAO. 1984), one third of this area is tidal channels. It is not only the largest single forest resource in the country, but also the largest single compact mangrove resource in the world.

Fig. 17. Showing distribution of mangroves in the coastal area of Bangaladesh and the offshore fishing grounds



Source: Mahmood, 1991

The Sundarbans represent a complex estuarine ecosystem, dominated by dense forest cover and subject to periodical tidal inundations. The structure and composition of the Sundarbans are maintained by a strong salinity gradient extending from the freshwater environment of the northeast to the saline environment of the southwest (Saengar *et a!.,* 1983). In mangrove areas, trees reach a height of upto 20 m, but the main canopy is at about 10 m.

The Chakaria Sundarbans, situated in the Matamuhari River delta in the Cox's Bazar District, is another mangrove tract. It has an area of 8,540 ha and has recently been degraded (Karim and Khan, 1980). Another mangrove forest area is a narrow belt fringing the Naaf River estuary and the offshore islands. It occupies roughly 1,800 ha.

Mangrove plantations in the different coastal districts of Bangladesh (particularly in the central region) are a recent but important attempt to improve the nation's forest cover. Afforestation in the coastal areas commenced on a modest scale in 1966, with the planting of seedlings on the slopes of embankments under the jurisdiction of the Water Development Boards (ESCAP, 1988). The success of the planting has led to other coastal afforestation programmes, with World Bank assistance, from 1980. These have the following objectives:

- To accelerate the process of siltation and stabilization of soil;

- To create forest buffer belts to protect inland life and property from extreme events, like cyclones and tidal surges;
- To create urgently needed resources to add to the national wealth;
- To create job opportunities for rural communities; and
- To create a healthy environment for wildlife, fish and other fauna.

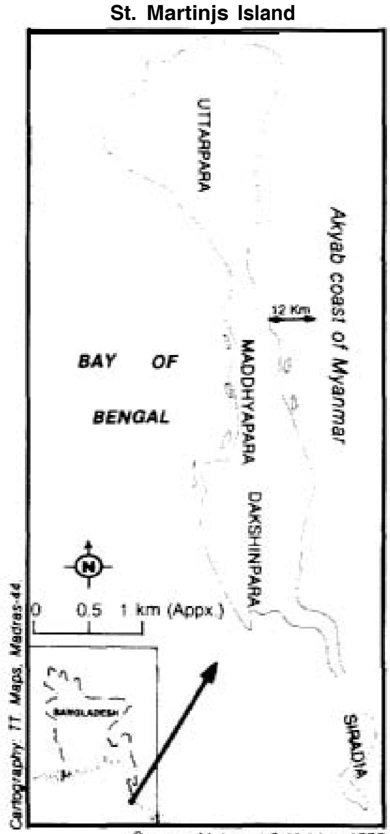
Afforestation attempts in some areas *(e.g.* Patharghata in Pat uakhali, Kukrimukri in Barisal and south Hatia in Noakhali) led to faster stable formations around the nucleus forest. From 1966, when plantation programmes commenced, to date, mangroves have been raised in about 100,000 ha. along the coast (Katebi and Habib, 1988).

The natural Sundarbans vegetation is composed of halophytic tree species dominated by *Sundri (Heritierafomes), Gewa (Excoecaria agallocha), Goran (Ceriops decandra)* and *Keora (Sonneratia apetala).* In the coastal afforestation areas, the most widely planted species are *Keora (Sonneratia apetala), Bayen (A vicennia officinalis), Sada Bayen (A. alba)* and *Kankra (Burguiere gyrnnori:a).* Other species include *Acacia arabica* and *A. catechu* in the higher lands (along the coastal embankments) and Golpata *(Nypafruticans)* in new accretions and lower areas along the embankments.

The densely forested swampy islands are the home of a variety of animals, ranging from large mammals, including tiger, deer and monkeys, to innumerable mud crabs, which, although common at the water's edge, can also be found throughout the intertidal zones. The Sundarbans harbour a number of species classified by the World Wide Fund for Nature and the International Union for Conservation and Natural Resources as endangered species. Its vast network is inhabited by at least four species of dolphins, the salt water crocodile *Crocodyluspoposus* and many other reptiles, several amphibians and numerous species of shell and finfish.

The mangroves are exploited for a wide range of forest products, such as sawn timber, fuelwood and wood for making pulp, safety matches, hardboard and bailing board. *Golpata* (Nypafruticans), *Hental (Phoenix paludosa)* leaves and *Hudo* (tiger fern) are also used as thatching materials. Considerable occupational levels have been maintained within the Sundarbans. Employment, in fact, is also generated by the industrial processing of raw materials derived from the forest. The probable direct employment is likely to be in the range of a minimum of 500,000 - 600,000 people during one half of the year, whilst the organized industrial sector employment is likely to be of the order 10,000.

Fig. 18. Geographical location of St. Martinjs Island



Source Mahmod & Haider, 1992

The four major animal products obtained from the Sundarbans are fish, honey, bees-wax and mollusc shells. Many small-scale or subsistence capture fisheries also exist in the mangrove estuaries. Unfortunately, records of these are scant. However, about 200,000 people are engaged in these fisheries and their annual average catch is about 7200 t, representing approximately one per cent of the yearly total national capture fisheries production.

26.3 *Coral reefs*

St. Martin's Island is the only coral reef island in Bangladesh. Locally known as Jinjiradwip, this gradually decaying island (Anwar, 1988) is about 10 km south of the mainland (Figure 18). It is about 8 km long in an approximate north-south direction and has a maximum width of 1.6 km (in the north). Its area is a little over 7.5 km^2 (Haque et al., 1979).

There is little information on Bangladeshi offshore coral. A recent study (Haider and Mahmood, 1992) records four species of the genus *Acropora (A. pulchra, A. horrida, A. humilis* and *A. variabifis)* from the neritic waters of St. Martin's Island. Besides this genus, coral of ten more genera, namel *y Stylocoeniella, Pocillopora, Stylophora, Porites, Pavona, Favia, Favites, Pseudosiderastrea, Goniastrea* and *Monstastrea,* under six families, have been recorded (Mahmood and Haider, 1992)

26.4 *Seagrass*

Information on the existence of seagrass beds is also lacking. Nevertheless, *Halodule uninervis* has been reported from the sandy littoral zone around St. Martin's Island (Islam, 1980). Usually, in Bangladesh, the seafronts of newly-formed islands *(chars)* as well as some low-lying coastal areas are often carpeted with seagrass.

26.5 *Beaches*

Most beaches on the coast of Bangladesh are either sandy or muddy and are backed by either Casuarina plantations or agricultural lands. A long sandy beach, about 145 kms in length, runs from Cox's Bazar to the tip of the Teknaf Peninsula. There are also beaches at Patenga (near Chittagong), Banskhali, Kuakata (Patuakhali) and on offshore islands like Kutubdia, Maiskhali and St. Martin's Island (Jinjiradwip).

26.6 *Islands*

The river system, which carries an enormous quantity of silt, empties through the coastal zone into the Bay of Bengal and results in the formation of a large number of temporary and permanent islands called *chars*. Almost all the islands are deltaic in origin — except Maiskhali and St. Martin's Island. About 30 per cent of Maiskhali's total area (653 km^2) is occupied by hills covered with mixed evergreen forest, but this is now, largely, degraded. Sandwip and Kutubdia are large islands lying off the Chittagong coast. The flora found in these islands has been described by Huq and Khan (1984) and Huq (1986).

26.7 *Offshore waters*

Following its declaration in 1979 of an Exclusive Economic Zone (EEZ), with a 200 nautical mile limit, Bangladesh now avails of a sizable offshore area in the Bay of Bengal. More than 120,000 km^2 is under national economic and management jurisdiction (Sada, 1991). Moreover, during the Law of the Sea Convention, 1982, Bangladesh established rights over an area within a 200-350 nautical mile limit (Nizam, pers. comm.). This entitles the country to maintain exclusive rights over the abiotic resources within this limit.

The oceanography of the Bay of Bengal, particularly that of Bangladesh's offshore waters, is dominated by three main factors (Lamboeuf, 1987):

- Wind direction;
- Precipitations, as a consequence of the tropical monsoons, prevailing in the region; and River discharge, also related to the monsoons, but intensified by the fact that major river systems in India, Bangladesh and Myanmar empty into the Bay of Bengal.

These factors have a strong influence on the marine environment, affecting water circulation, salinity, turbidity, productivity and the nature of bottom. Fish distribution and migration are, in turn, influenced by these reactions.

The Southwest Monsoon, characterized by a hot humid air mass blowing from the Bay of Bengal from May through August/September, is responsible for roughly 80 per cent of the total annual rainfall in Bangladesh. The Northeast Monsoon blows from November through March/April, drawing cool, dry air from the continental areas. Between these two monsoons, that is, during the transition periods, winds are unstable and change direction, often causing cyclones.

The seasonal changes to the Northeast and Southwest Monsoons bring about a complete reversal of surface current patterns in the Bay of Bengal. They become clockwise from January to July and counter-clockwise from August to December, following the direction of wind.

Three of the main subcontinent's rivers — the Ganga, Brahmaputra and Meghna — drain vast areas of India, Bangladesh, Nepal and the Himalayas. These rivers and their tributaries, converging in Bangladesh, carry aapproximately 85 per cent of the total water volume which is flushed from the country into the Bay of Bengal. The discharges show distinct seasonal fluctuations, with extreme values reaching 195,000 m^3/s in the monsoon period, obviously as a result of melting snow precipitation in the Himalaya. The rivers clearly supply a huge quantity of water (some 1100 km^3 annually) which dilutes the surface waters of the northern part of the Bay. These can plummet as low as riverine water conditions during the post-monsoonic season (September and October), and come near to estuarine conditions prevailing in January through June.

During flooding, the rivers also transport massive amounts of suspended sediment loads — of the order of 13 million t/day — into the Bay of Bengal, Most of the suspended sediment (80-90 per cent) is transported during the monsoon season. This is calculated at some 1500 million t of which only a small portion is deposited on to the flood plains or in the lower delta; most of it is flushed out towards the deeper parts of the Bay (Eysink, 1983).

27. FISHERY RESOURCES

The fisheries sector (both inland and marine) plays a vital role in the national economy in terms' of income-generation, employment opportunities and nutrition. It contributes roughly 80 per cent to the national animal protein intake, nearly 6 per cent to the Gross Domestic Product (GDP) and more than 12 per cent of the total export earnings (Sada, 1991).

27.1 The estuarine and nearshore fishery

Traditionally, coastal and riverine fishermen, accustomed to using traditional sail and small, mechanized boats (9-14 m long with 15-45 HP diesel engines), are active in this fishery. Set bagnets, gillnets and seines are the main fishing gear (Mahmood and Chowdury, 1989). Fishing efforts are restricted to estuaries and shallow coastal waters, upto about 30 m. The fish biodiversity here is mainly exploited by small-scale or subsistence level fisherfolk. Data on the estuarine and neritic water fisheries is scarce; however, about 95 per cent of Bangladesh's marine fishery production is contributed by this sector.

Until now, bagda shrimp, ***Penaeus monodon*** post-larvae, are the only fry used to stock the coastal brackishwater ponds. Recently, however, with demand increases, intense and widescale macro-zooplankton fishing has also been undertaken in the estuaries and nearshore waters. Mahmood (1986), and Funegaard (1986), have described the gear and methods used in such fishing efforts and have also discussed the procedures of sorting ***bagda*** PL from the mixed zooplankton catches.

21.2 The offshore fishery

Offshore trawl fishing, a relatively new development in Bangladesh, gained momentum from 1974. Marine fish production from offshore trawling during the last few years has been 4,000-12,000 t a year (Sada, 1991). It is noteworthy that these production figures do not represent actual catches in offshore waters. Large quantities of finfish caught (35,000-40,000 t/year) are shrimp by-catch, for which offshore trawler fleets are responsible. These are discarded as trash fish at the catching points, and only quality finfish (a very small fraction) are retained. In 1988-89, penaeid shrimp, the most lucrative item in commercial fishing, contributed only 5000 t in a total catch from the marine sector of 233,281 t, including catches from brackishwaters (Sada, 1991). Thus, as much as 90-95 per cent of the national Bangladesh marine fishery production is due to the traditional sector; that is, artisanal fisheries operating in estuaries and neritic waters, as mentioned earlier. The principal fish species are ***Hilsa*** (shad), Bombay Duck, ribbonfish, Round Scad, Spanish Mackerel, catfish, threadfin, croaker, pomfret, eel, Red Snapper, grunter, shark, ray and shrimp. Taxonomic details of commercially important fish and shrimp are given in Hussain (1971, 1984) and Howlader (1976).

Since 1958, a number of surveys have been conducted in the shelf area of Bangladesh by different international and bilateral agencies (Shahidullah, 1986). Several fishing grounds were identified, but it appears that greater attention was paid to demersal resources, particularly finfish. The standing stock of finfish has in three recent surveys been estimated as being 160,000 t (Saetre, 1981), 152,000 t (Khan, 1983) and 157,000 t (Lamboeuf, 1987). Several reports indicate standing penaeid shrimp stock, but these contain substantial estimate variations, ranging between 1000 and 9000 t (Khan and Haque, 1988). Apart from shrimp, pelagic resources, such as tuna, mackerel, sardine and cephalopods etc., are still untapped in Bangladesh's offshore waters. Neither has the standing stock been assessed. Minor quantities of these resources are, however, caught as Hilsa by-catch by the drift gillnetters active in the neritic and coastal waters upto depths of 30 metres.

The marine pelagic resources of Bangladesh are tuna and tuna-like fish, sardine, herring, shad, scad and the so-called unconventional marine resources, including shark and cephalopods (Begum and Ahsanullah, 1986; Huq, 1987; Ahmed, 1990 and Sada, 1991). A tentative taxonomic list is given by Mahmood and Khan (1992).

27.3 Culture fishery

Frozen food is next to jute and jute goods in national exports. It contributes about 14 per cent of Bangladesh's foreign exchange earnings. About 85 per cent of the freezing industry's production is shrimp (Sobhan, 1990). A significant portion (about 24 per cent) of this originates from coastal brackishwater aquaculture which, favoured by climate and several physical factors, is growing at a rapid pace in Bangladesh. But this growth also poses environmental challenges and socioeconomic concerns.

Shrimp farming in bheries, *ghers* or *ghonas* (that is, areas impounded by dykes) in the coastal area is traditional practice. But the rapid expansion in the coastal brackishwater areas in recent years has led to an exponential increase in production, the 1987-88 production figures of 17,889 t being eight times higher than the 1982-83 (2200 t) figures. The coastal shrimp farming area has increased from about 20,000 ha in 1980 (Mahmood and Chowdhury, 1989) to about 115,000 ha at present. Shrimp yields from the coastal aquaculture ponds are, however, very low: about 120 kg/ha/year.

The shrimp farms are primarily located in Bagerhat (29%), Satkhira (19%), Khulna (19%) and Cox's Bazar (31%). In addition, there are about 422 ha in Keshabpur Upazila of Jessore, 43 ha in Kalapara Upazilla of Patuakhali, and 87 ha in Anowara and Banskhali Upazillas of Chittagong. The average farm is about 28 ha in extent.

Four traditional styles are followed in shrimp farming (Mahmood, 1988): Salt production together with shrimp and finfish culture; round the year shrimp and finfish culture; *bheri* culture; and monoculture of *bagda* shrimp *(Penaeus monodon)*. The indiscriminate expansion of this farming, instead of planned development ensuring extensive, semi-intensive or intensive farming, has given rise to many socioeconomic and environmental problems in coastal areas (Mahmood, 195lb).

28. ENDANGERING THE MARINE HABITATS

Environmental concerns, such as pollution, ecological imbalance, environmental protection etc., are comparatively new concepts in Bangladesh. As environmental concerns became accepted worldwide, Bangladesh too became more aware of the degradation caused by natural and man-made pollution and the necessity for proper environment conservation if sustainable development was to be reached. Marine environment was no exception. National experts, development planners and government authorities first became conscious of the dangers to the marine environment in 1979, when a national seminar on 'Protection of the Marine Environment and the Related Ecosystem' was held in Dhaka under the joint sponsorship of UN/ESCAP, the Swedish Environment Protection Service (SEPS) and the National Department of Environment Pollution Control (which has now been renamed the Department of Environment).

Floor control dykes and river dams have also affected the marine fishries ecosystem (EPWAPDA, 1960; BWDB, 1978). Furthermore, the irrational expansion of coastal shrimp farming at the cost of mangrove forests (Mahmood, 1986, 1991b) and overfishing (Mahmood, 1990a) has exacerbated an already precarious situation. Overall ecological degradation, reduced tidal plains and damage to the habitual nursery grounds as well as the natural fishery stocks has been the immediate result. (Bhouyain, 1983; Bashirullah et *al.,* 1989; Ali, 1989: IUCN, 1991a). The consequences of pollutants, periodic cyclones, tidal surges and the long-term effects of sea level rise due to the global greenhouse effect are likely concerns in the long-term.

28.1 Water resources development activities

Water resources development projects, like the Flood Control and Drainage (FCD) and Flood Control, Drainage and Irrigation (FCDI) programmes, closures across rivers, obstruction of water for irrigation, diversion of channels etc. have been implemented in Bangladesh from the early 1960s to make the country flood-free as well as to increase food grain production. But these projects, though proving beneficial to food grain production and providing protection from periodic floods and cyclones, have produced adverse effects on the aquatic ecosystem, affecting the production both in terms of quantity and species diversity. The effects can be seen in freshwater as well as brackishwater fisheries in inland open water habitats, such as estuaries, rivers, canals, flood plains and *beels* (deep depressions), which become components of a single, integrated fishery production system during the monsoon (wet) season (Ali, 1989; IUCN, 1991a).

Upto the end of the Third Five-Year Plan period (June, 1990), about 3.36 million ha of flood plains that used to get inundated were protected by FDC with over 7000 km of embankment and other constructions. Thirtyone per cent of the total flood-protected area is now under the Coastal Embankment Project (CEP), located in the estuarine and coastal areas. The CEP includes about 3700 kms of embankments and 900 hydraulic sluices to prevent shallow saline water flooding and protect the area from tidal surges (MPO, 1985).

These embankments and other obstructions, however, have reduced the flood plains and inhibited fish movement and migration for breeding and feeding. It has been estimated that nearly 815,000 ha of flood plains had been removed from the openwater fishery production system until 1985, and a further 2 million ha of currently flood-prone land would be rendered flood-free by the year 2005. Thus, by the year 2000, an estimated 110,000 t of fish harvest may be lost every year (MPO, 1985). This includes not only the freshwater catch (e.g. carp), but also the estuarine and marine euryhaline species (e.g. mullet, *Hilsa* etc.) as well as freshwater prawn (e.g. the giant freshwater prawn) which live in both environments during the different phases of their life cycles. However, extensive studies are yet to be done to quantify the irreversible loss to this sector.

The impacts of the different projects on brackishwater fisheries are summarized below:

CHANDPUR FCDI PROJECT

Polders to a total extent of 555 km^2 have been created with high embankments in the project area. The South Dakatia River and associated water bodies within the project area were also cut off from the remainder of the open-water system by the project structures. The embankments and blockage of the South Dakatia River had the following impact (MPO, 1987b):

- Overall fish production within the project area declined by 35 per cent within two years of project implementation;
- A commercially high-value giant freshwater prawn species *(Macrobrachium rosenbergii),* found in the river before the project, was soon replaced by low-value, smaller-sized prawn *(i.e. Macrobrachium lammarrei* and others); and
- A fishery based on 18 fish species of tidal or estuarine origin, which used to inhabit the South Dakatia River has disappeared with the fish being prevented from entering the river by the project regulators (IUCN, 1991a). Among the species are *Hilsa ilisha, Pangasiuspangasius, Rhinomugil corsula, Glossogobius giuris, Doryichthys cuncalus, Oryzias melanostigma, A waous stamineus, Corica soborna, Sicamugil cascasia, Leiognathus equulus, Gobiopterus chuno, Odontamblyopus rubicundus, Pseudapocryptes lanceolatus, Trypauchen vagina, Setipinnaphasa, Macrognathus aculeatus,* the first three named being the most commercially important species in Bangladesh.

MUHURY PROJECT

This FCDI project encompasses 6980 km^2 in the Feni (old Noakhali) and Chittagong Districts. A cross dam, completed in February 1985, altered the physical, chemical and biological characteristics of the aquatic environment of the Feni River system. Now, backwaters remain fresh throughout the year, as the seasonal movement of the 'salt wedge' has been restricted. Nursery grounds of species requiring a brackishwater regime for their juvenile development have, thus, been destroyed during the dry season. Downstream of the dam, the Feni River estuary has also undergone drastic changes with increase in salinity. The dam prevents upstream *Hilsa* migration (for reproduction) from the estuary; it has also eliminated the commercial *Hilsa* fishery in the Feni River above the dam. Before the completion of the dam, this fishery in the upper reaches of the river was estimated at being about 500 t valued at Taka 10 million* (IUCN, 1991a).

COASTAL EMBANKMENTS

In the southern districts of Bangladesh, the low-lying lands on both sides of the tidal rivers and canals have traditionally been inundated by brackishwater during high tides. Such inundated areas act as temporary nursery and feeding grounds for the larvae and juveniles of many estuarine and marine shrimp and finfish. From the 1960s, embankments constructed to protect the land from saline water inundation have permanently eliminated these nurseries and feeding grounds for marine and estuarine fish as well as shrimp. The construction of coastal embankments also brought to an end the traditional practice of brackishwater shrimp and fish culture during dry months and alternated in the wet season with rice cultivation in the Khulna region, particularly in Sathkira District. Brackishwater shrimp and fish farming is now being undertaken by cutting the embankments, which makes the polders especially vulnerable to cyclones. This practice has also given rise to conflicts in respect of land use rights (Nuruzzaman, 1990; IUCN, 1991a).

RIVER CLOSURES AND BARRAGES

River closures and barrages across rivers obstruct upstream and downstream fish and prawn migration and thereby inhibit or disrupt their reproduction and sustenance. For example, the closure of the Kumar River, both at its source from the Rivers Kaliganga and Nabaganga, under the Ganges-Kobadak project, has cut off *Hilsa* migration from the sea *via* the Nabaganga River to the Padma River through the Kumar River. As a consequence, the *Hilsa* fishery of moderate magnitude that existed in the Kumar River is no more. The *Hilsa* fishery in the Ganges River, both in Bangladesh and India, has declined due to blockages of its upstream migration path by the Farakka Barrage (Jhingran, 1983; MPO, 1986). Jhingran (1983) reported that after the completion of the Farakka Barrage in 1973, *Hiisa* availability declined by 99 per cent.

Plans for the construction of barrages across the Ganges and Brahmaputra Rivers within Bangladesh for water diversion are in the pipeline. Such schemes would eliminate the spawning migration of anadromous and catadromous fish and prawns. It is also anticipated that the *Hilsa* population would not only decrease in the rivers but also in the sea. In addition, the catadromous migration of giant freshwater prawn *(M. rosenbergii)* and other such species would be detrimentally affected by the barrages — their breeding and return migratory patterns at risk.

28.2 Destruction of mangrove forests

Bangladesh's 687,000 ha of mangroves protect the coast from storm surges and cyclones and provide habitats and nurseries to numerous wildlife and fishery resources. Many small-scale or subsistence capture fisheries exist in the mangrove estuaries and swamps.

Unfortunately, the mangroves, overexploited by an increasing population growth and greater demand for forest products, are at a point of severe depletion. Ecological changes caused by biotic and edaphic factors as well as the horizontal expansion of shrimp farming has further exacerbated the situation.

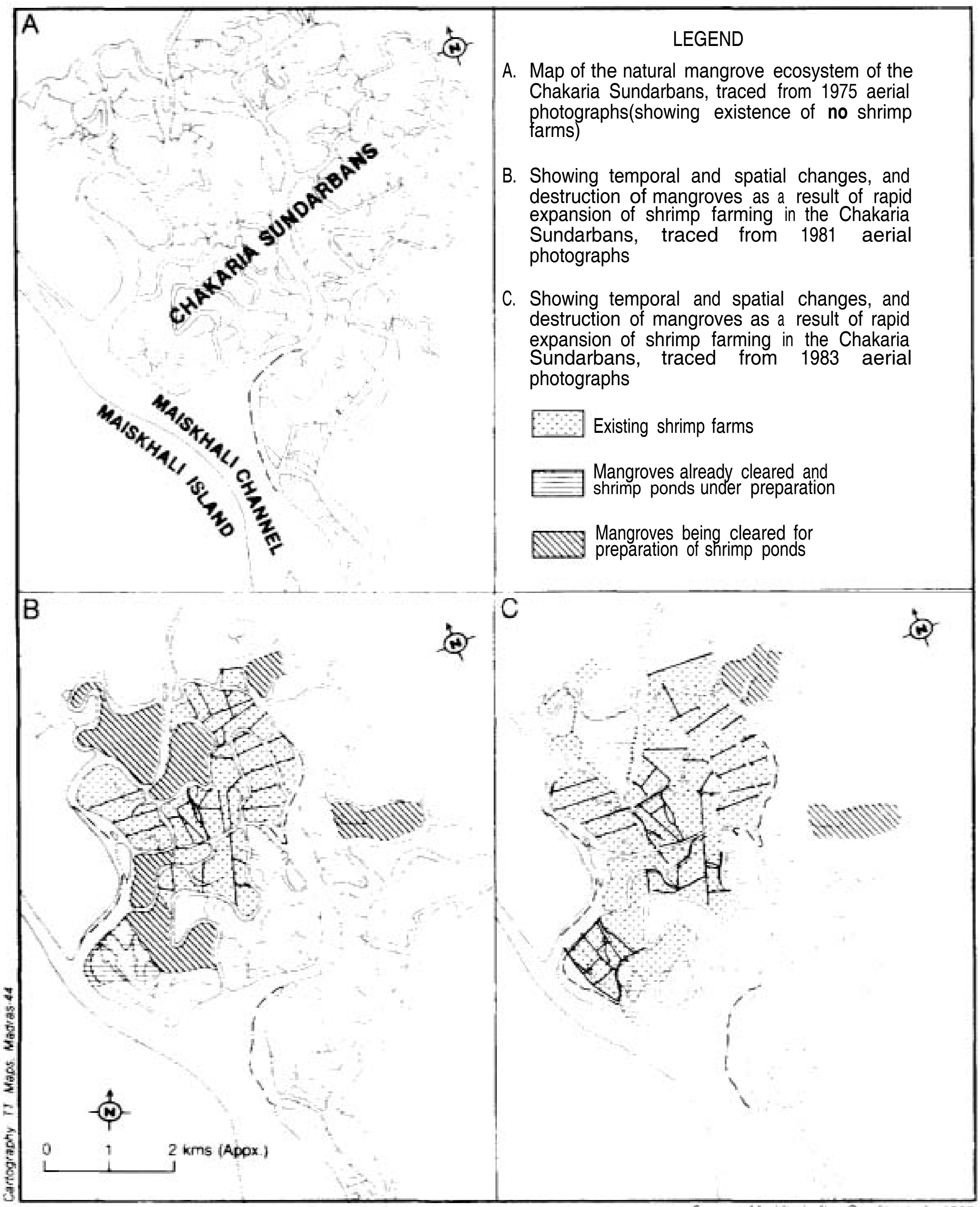
It is estimated that the standing volume of the two main commercial species of the Sundarbans *(Sundri — Heritiera fomes* — and *Gewa — Excoecaria agallocha)* declined by 40-50 per cent between 1959 and 1983. This has been due to a local salinity increase as a consequence of the reduced river

* US $ 1 = Tk 32 appx.

flows, following the completion of dams, barrages and embankments, as well as over-felling. Many areas within the Khulna, Barisal, Patuakhali and Chittagong Districts that once were covered by mangrove forests have since been given over to other land usage. Today, the Khulna and Chakaria Sundarbans are the only two compact mangrove tracts left intact (see Figure 17 on p. 82).

Natural calamities, such as cyclones and tidal waves, cause some damage to these forests along the sea. Spotted deer and other animals are also destructive agents (Khan and Karim, 1982). But the worst form of destruction in the Chakaria Sundarbans, located in the Matamuhari River estuary in Chittagong District, has been as a result of irrational and unplanned shrimp farming expansion since the late 1970s. Once the Chakaria Sundarbans were covered by dense mangroves and 8,510 ha enjoyed the status of a forest reserve (Katebi and Habib, 1988). After 1977, more than 50 per cent of the mangroves were cleared for preparation of shrimp ponds (see Figure 19). Now only a small patch of forest remains in the interior as a testament to the past (Mahmood, 1991b).

Fig. 19. The expansion of shrimp farming in the Chakaria Sundarbans



Source: Modified after Quader et al., 1986

Recently, the small fringe of natural mangroves on the bank of the Naaf River and the beautiful ***Keora (Sonneratia apetala)*** forest on Jaliardwip Island have also been cleared for conversion to shrimp ponds. The southern part of the Khulna region comprises the Sundarbans reserve, where shrimp farming is not permitted, but, recently, a few fish and shrimp farms have been established on the borders of the reserve (FAO, 1984) and encroachment is likely before long.

Mahmood (1990b) has described the ecological importance of the Matamuhari estuary of Chakaria after a recent investigation. Penn (1983) indicated that the highly productive fisheries found in the coastal and offshore waters of Bangladesh might be linked with mangrove proliferation on the shoreline. Rich fishing grounds in shelf areas (Hussain, 1992) are usually found off dense coastal mangrove forests (see Figure 17 on p, 82). The degradation of these mangrove ecosystems would have adverse effects on the nurseries and feeding grounds for marine and freshwater fish and shrimp as well as on the nearshore and offshore fisheries. If the present trend continues, it is bound to lead to a reduction in offshore stocks of shrimp and other finfish.

28.3 Overfishing

Small-scale and artisanal fisherfolk operating in estuaries and neritic waters have been overexploiting shrimp post-larvae, juveniles and pre-adults as well as finfish to meet the increasing demands of export and a burgeoning population (Ahmed, 1981 and 1984; Mahmood, 1990a).

AKTISANAL FISHERY

According to a frame survey in 1984-85, the coastal and estuarine fishing population includes 70,000 households and 124,000 fishermen spread over 869 villages in Greater Chittagong (i.e. Cox's Bazaar and Chittagong), Noakhali, Barisal, Patuakhali and Khulna Districts (Jahan, 1992). The fishery resources are exploited by traditional craft and motorired boats which operate marine and estuarinc set bagnets (SBN), the ***behundi jal,*** gillnets, trammelnets, longlines etc.

Among these gear, the estuarine SRN is the most popular. The SBN fishery is distributed throughout the country, active in channels, estuaries and tributaries and wherever else the brackishuater environment prevails. The SBNs are operated from less than five metres to an approximate twenty-metre zone in neritic waters. This is a very effective gear; it catches juveniles and under-sized shrimp and finfish as well as planktonic shrimp — ***Acetes*** spp. it has, however, been identified as a risk to overall biological sustenance (Ahmed, 1981 and 1984; Khan, 1992). At the cod end, its mesh sire varies from 5 to 18 mm.

Other fisheries have a limited distribution. The marine SRN is operated only during the dry season and only in certain areas, such as Sonadia Island, Dubla Island and Mohipur. The trammelnet is operated only in the neritic waters of Teknaf and Cox's Bazar. Further descriptions on this sectoral fishery have been given by Bennett and Alam (1992), Chowdhury (1992), Huq (1992), Islam (1992), Jahan (1992), Khan (1992) and Quayum (1992).

SHRIMP SEED COLLECTION

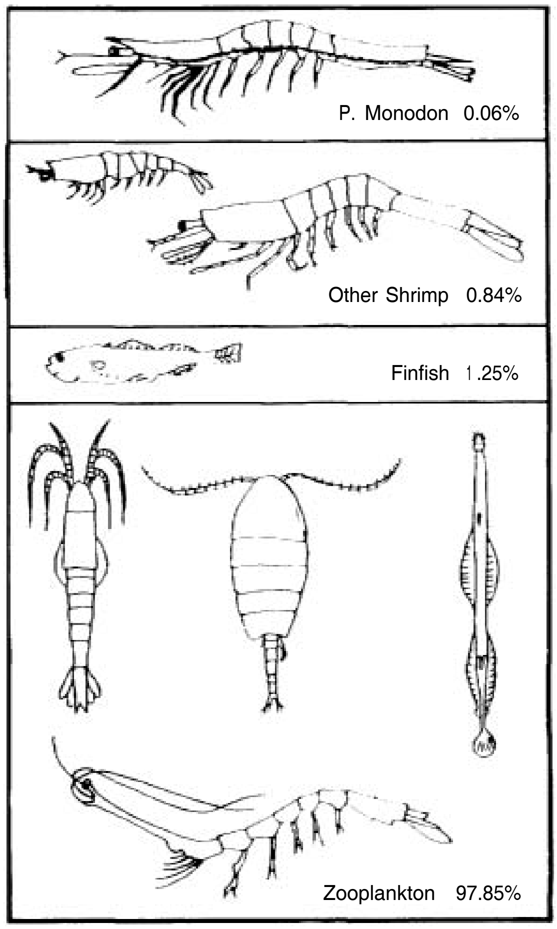
The rapid expansion of the coastal aquaculture areas in Bangladesh, coupled with the recent trend towards shrimp monoculture, has resulted in a tremendous demand for the seed of tiger shrimp, ***Penaeus monodon.*** But with the paucity of shrimp hatcheries, collecting P. monodon post-larvae (PL) from estuaries and nearshore waters has attracted thousands of coastal fisherfolk, causing immense destruction of nontarget species and damage to nursing grounds. Mahmood (1990a) has estimated the total fry collectors to be about 75,000 during peak periods, between mid-February and mid-March. But there are also estimates double that and more (BOBP, 1990).

In general, marine shrimp and many fish commonly follow a diadromous life cycle involving migration between the sea and the estuary. As a part of this cycle, the post-larvae are carried by the tide (planktonic migration) towards the shallow, estuarine mangrove areas of Satkhira, Khulna and Chakaria, as well as to nearshore waters of the southern and south-eastern part of the country — the Kutubdia, Banskhali, Maishali, Cox's Bazar and Teknaf coasts. In most of these areas, fry collector\ catch the wild fry by Set bagnets and pushnets made of nylon mosquito mesh.

In this collection, the catch is sorted out on the river banks or the coastal dykes after each half-hour haul. Besides *P. monodon* **PL** *(bagda* shrimp fry), the catch includes plenty of other zooplanktons. After the *P. monodon* PL are carefully separated, the remaining zooplankton, including post-larvae of other shrimp and finfish, are indifferently discarded (Mahmood, 1989). Thus, great loss is caused at the planktonic stage itself to other valuable resources. Figure 20 shows the average distribution of *P. monodon* post-larvae and that of other organisms. In order to capture a single *bagda* shrimp fry, 14 other shrimp and 21 finfish post-larvae as well as over 1600 other zooplankton are wasted! Alam (1990), in similar research undertaken along the Cox's Bazar and Teknaf coasts, found that for the capture of each *bagda* fry, about 21 post-larvae of other shrimp and 31 of finfish as well as 47 of other zooplankton were destroyed. Alam explained that "the dissimilarity with the findings of Mahmood 1990a, might be due to the mesh size variation of the net".

This colossal loss of shrimp and finfish resources at the planktonic stage is bound to have adverse effects on the off-shore and inland stocks. Funegaard (1986) noted that the daily catch of *P. monodon* fry in 1986 was one-tenth of what it was four Years earlier when 2000 fry/net/day were caught. Today, fry collectors and local fisherfolk repeatedly mention the decreasing abundance of shrimp and finfish fry.

Fig. 20. Average distribution (in percentage(of post-larvae of *Penaeus monodon,* other shrimp and finfish, and all other zooplankton in the estuaries of Bangladesh



Source Mahmood, 1990)

Mass-fry collection is also proving a threat to the coastal ecosystem, causing damage to the nursing grounds of many species, and to newly planted mangroves as well as the reserve forests (Saikat, 1992). As most of the seed-collectors are illiterate and not environmentally conscious, they are not aware of the ultimate effects of their actions. This situation, therefore, calls for immediate control measures to regulate shrimp seed-collection in the coastal waters and the establishment of hatcheries to meet the growing demand of fry for Bangladesh's coastal shrimp farming sector.

29. *MARINE POLLUTION*

Water pollution has been endemic in Bangladesh for a long time, and has become widespread in recent years. All kinds of waste – either in solid or liquid form – are dumped into the water, resulting in the deterioration of the aquatic environment.

The numerous rivers and their tributaries that criss-cross the country carry pollutants from the whole drainage area, including upstream areas in India, Nepal, Bhutan and China. Most of the pollutants are in sediment form, municipal and industrial wastes, agrochemical residues and pollutant discharges from ships and boats **(EPC,** 1980; Bhouyain, 1983; Hossain, 1989). Although this pollution has existed over the years, information regarding the nature of pollutants and the damage they cause to marine fisheries and other resources is very scant (WPCP, 1975; EPC, 1980; Quader, 1976; Paul, 1981; Bhouyain, 1979; 1983; Hossain, 1983; Islam and Hossain, 1986; UNEP, 1986; Jalal, 1988; Hossain *et al.,* 1988; ESCAP, 1988; Hossain, 1989; DOE, 1990; Sengupta *et al.,* 1990; IUCN, 1991, a, b, c).

29.1 Industrial cen tres

Bangladesh is not an industrialized country. Even so, the gradual growth of industry in recent years has resulted in a serious problem of environmental pollution. The considerable discharge of untreated industrial effluents has led to the degrading of the aquatic and marine ecosystems of Bangladesh and has had an impact on fisheries.

The Department of Environment had by 1986 identified 903 polluting industries under 13 categories (see table below). These were estimated to have increased to over 1200 by 1990-91 (IUCN, 1991c) and have increased still further by now.

Categorywise distribution of the polluting industries of Bangladesh

Industry	Number	Industry	*Number*
Textiles	298	Chemicals	23
Tanneries	176	Sugar mills	16
Pharmaceuticals	166	Paper and Pulp	5
jute	92	Fertilizers	5
Iron and steel mills	57	Distilleries	3
Rubber and Plastic	34	Cement	3
Insecticides and Pesticides	25	TOTAL	903

All these industries as well as fish processing plants (see Figure 21 on facing page) have been established on the banks of canals, rivers, tributaries, estuaries etc. They directly or indirectly discharge their untreated liquid and solid wastes into the water bodies and the wastes eventually find their way into the Bay of Bengal.

The polluting industries of the country are mainly concentrated in five major industrial zones (IUCN, 1991c). These zones are discussed below.

DHAKA MUNICIPALITY

It includes the Tejgaon industrial area (housing about 150 industries, mainly food, textile, pharmaceutical and metal industries), Hazaribagh (having about 160 small- and medium- sized tanneries), and Demra, Tongi and Joydebpur, all with industries primarily associated with textile manufacture. All these industries discharge their untreated wastes into nearby open drains, canals, floodplains etc., or directly into the Buriganga River.

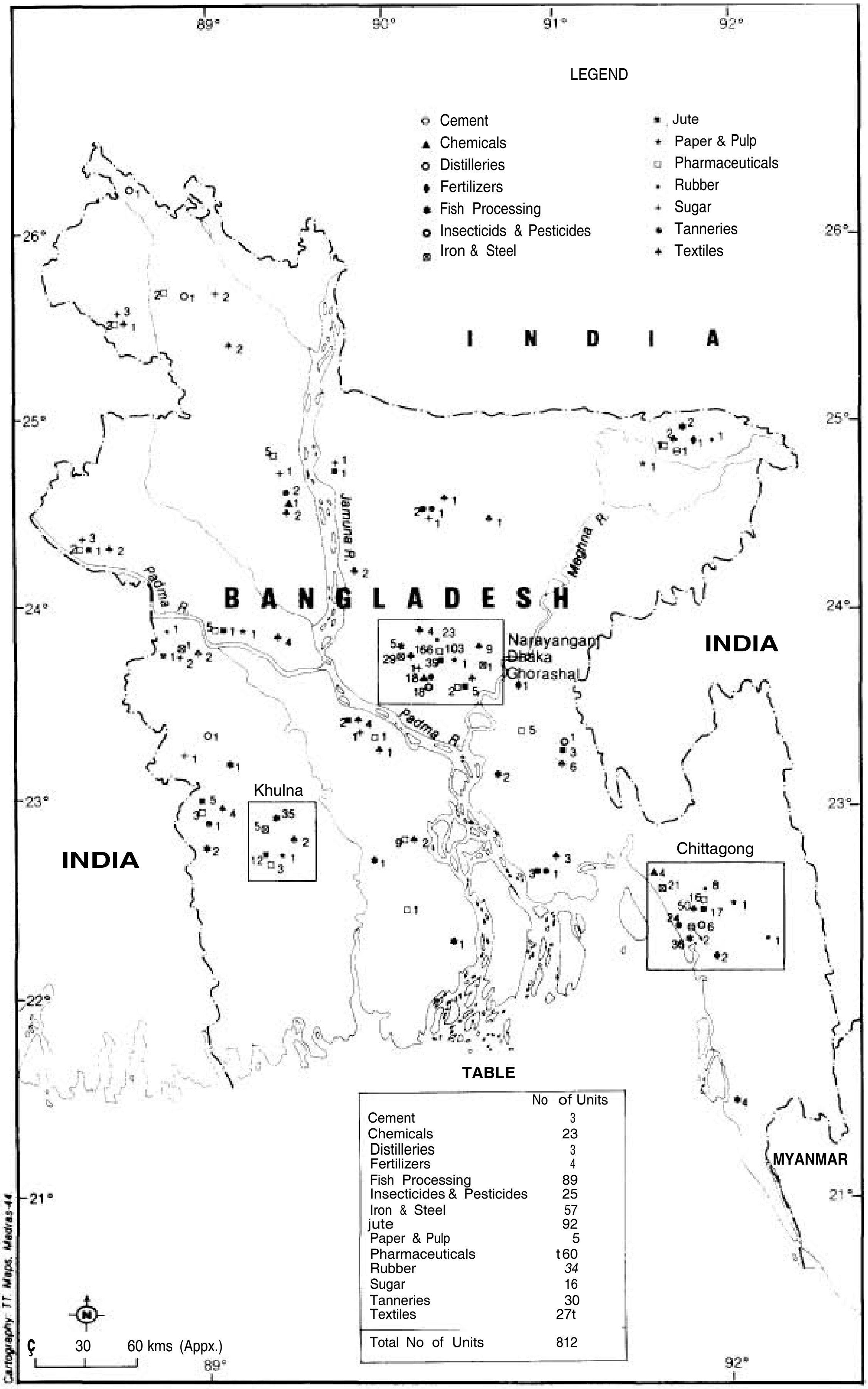
CHITTAGONG

There are about 150 industries, mainly textile mills, tanneries and chemical plants, in the eight industrial zones of Chittagong, namely Kalurghat, Nasirabad/Sholashahar, Patenga, Kaptai, Bhatiari, Barabkunda and Fauzdarhat, situated on the bank of the Karnaphuli River and along the coast of the Bay of Bengal. All these units discharge degradable and persistent organic and inorganic wastes as well as toxic metallic components directly into the Karnaphuli or the Bay; none have any existing or planned pollution treatment facilities (ESCAP, 1988). The second largest urea plant in the country has recently been established on the south bank of the Karnaphuli River. It has provision for treatment facilities, but the plant is reported to still contribute to river pollution (Hossain, 1992).

KHULNA

There are 165 industries located in the Rupsa, Khalispur and Shiromony industrial zones of Khulna. These discharge wastes into the Bhariab-Rupsa river system (Jalal, 1988: ESCAP, 1988), which opens into the Bay of Bengal. In addition, several match factories, the Khulna shipyard and fish processing units in the Rupsa industrial area discharge their effluents into the Rupsa River. A newsprint mill, a hardboard mill, a power station, some jute mills and some steel mills in the Khalispur industrial belt also discharge their untreated wastes into the Bhairab River.

Fig. 21. Location of industries (with total numbers) in Bangladesh under different categories



TABLE

	No of Units
Cement	3
Chemicals	23
Distilleries	3
Fertilizers	4
Fish Processing	89
Insecticides & Pesticides	25
Iron & Steel	57
jute	92
Paper & Pulp	5
Pharmaceuticals	t60
Rubber	34
Sugar	16
Tanneries	30
Textiles	27t
Total No of Units	812

Liquid waste characteristics of a typical urea plant

Measuring parameters	*Dora obtained*	*Measuring parameters*	*Dataa obtained*
Temperature	40°C	Ammonia	300 ppm
Flow	600-800 m^3 hr	TDS	8600 ppm
pH	9.12	Chromate	22 ppm
urea	2500 ppm	COD	150 ppm

Source Khair (1988)

Water quality in the Sitalakkhya River due to discharge of urea effluents

Parameter	*Sampling Location*	*Period*										
		10/88	*11/88*	*12/88*	*1/89*	*2/89*	*3/89*	*4/89*	*5/89*	*6/89*	*7/89*	*10/89*
E C	River	182	442	350	265	26'	297	220	280	219	70	76
[micromhos)	Dram	580	830	1075	1450	1400	890	580	600	510	498	890
Ammonia	River	–	–	3	2	I	I	0	0	I	3	
(mg/l)	Drain	49	61	33	18	20	21	22	14	8	14	

Soure NEMP D O E (1988-89) citd in IUCN, 1991c

Water quality in the Karnaphuli River due to discharge of urea effluents

Parameters	*Value in the river*	*Value in effluent*	*Parameters*	*Value in the river*	*Value in effluent*
				mg /litre	
Temperature (°C)	34	23	Total hardneo	133	1176
Total suspended solids (mg/l)	52	39	Ca-hardness	49	282
Total dissolved solids (mg/l)	443	294	Dissolved oxygen	4.6	5.8
Secchi depth(cm)	–	42	Ammonia	155	1.6
E.C (micromhos cm)	571	8133	Nitrate	66.1	4 5
pH	8.5	7.6	Nitrite	49.8	3 3
Total slksliniyy(mg/ l)	139	Pl	Phosphate	0.55	0 18
Salinity (gm l)	0.56	4.00	BOD	118	6
Chloride (gm l)	0 36	2 28	COD	571	68

Source Hossain (1992)