



UNITED NATIONS ENVIRONMENT PROGRAMME



*Environmental problems of
the marine and coastal area
of Bangladesh: National Report*

UNEP Regional Seas Reports and Studies No. 75

PREFACE

The Regional Seas Programme was initiated by UNEP in 1974. Since then the Governing Council of UNEP has repeatedly endorsed a regional approach to the control of marine pollution and the management of marine and coastal resources and has requested the development of regional action plans.

The Regional Seas Programme at present includes ten regions^{1/} and has over 120 coastal States participating in it. It is conceived as an action-oriented programme having concern not only for the consequences but also for the causes of environmental degradation and encompassing a comprehensive approach to controlling environmental problems through the management of marine and coastal areas. Each regional action plan is formulated according to the needs of the region as perceived by the Governments concerned. It is designed to link assessment of the quality of the marine environment and the causes of its deterioration with activities for the management and development of the marine and coastal environment. The action plans promote the parallel development of regional legal agreements and of action-oriented programme activities^{2/}.

In May 1982 the UNEP Governing Council adopted decision 10/20 requesting the Executive Director of UNEP "to enter into consultations with the concerned States of the South Asia Co-operative Environment Programme (SACEP) to ascertain their views regarding the conduct of a regional seas programme in the South Asian Seas".

In response to that request the Executive Director appointed a high level consultant to undertake a mission to the coastal States of SACEP in October/November 1982 and February 1983. The report of the consultant on his mission was transmitted to the Governments of the South Asian Seas region in May 1983, and the recommendations of the Executive Director were submitted to the Governing Council at its eleventh session.

By decision 11/7 of 24 May 1983, the UNEP Governing Council noted "the consultations carried out in accordance with Council decision 10/20 of 31 May 1982" and requested "the Executive Director to designate the South Asian Seas as a region to be included in the regional seas programme, in close collaboration with the South Asia Co-operative Environment Programme and Governments in the region, and to assist in the formulation of a plan of action for the environmental protection of the South Asian Seas".

^{1/} Mediterranean Region, Kuwait Action Plan Region, West and Central African Region, Wider Caribbean Region, East Asian Seas Region, South-East Pacific Region, South Pacific Region, Red Sea and Gulf of Aden Region, Eastern African Region and South Asian Seas Region.

^{2/} UNEP: Achievements and planned development of UNEP's Regional Seas Programme and comparable programmes sponsored by other bodies: UNEP Regional Seas Reports and Studies No. 1. UNEP, 1982.

As a first follow-up activity to decision 11/7 of the Governing Council, the Executive Director convened, in co-operation with the South Asia Co-operative Environment Programme (SACEP), a meeting of national focal points of the States of the region in order to seek their views on how to proceed in developing a comprehensive action plan for the protection and management of the marine and coastal environment of the South Asian Seas region (Bangkok, Thailand, 19-21 March 1984).

The meeting discussed the steps leading to the adoption of an action plan and reached a consensus on the items to be considered for further development of the action plan^{3/}.

The meeting recommended that the Governments, with the assistance of UNEP and other organizations as appropriate, should initiate the preparation of country reports reviewing their:

- national environmental problems defined as priority areas of regional concern;
- activities which may usefully be carried out under the action plan to resolve or mitigate these problems; and
- national institutional and manpower resources which are, or may be, involved in dealing with these problems, including the identification of the need to strengthen their capabilities.

It was also recommended that UNEP prepare in cooperation with SACEP, and other organizations as appropriate:

- a draft overview report, based on the country reports, reviewing the environmental problems of the region defined as priority areas;
- a document addressing the essential legislative aspects relevant to the action plan; and
- a draft action plan reflecting the conclusions of the country and regional reports.

The present document is the country report on environmental problems in Bangladesh prepared by experts designated by the Government of Bangladesh. The assistance of a consultant, A.H.V. Sarma, was provided to the Government of Bangladesh to facilitate the preparation of this report. The authors' contributions are gratefully acknowledged.

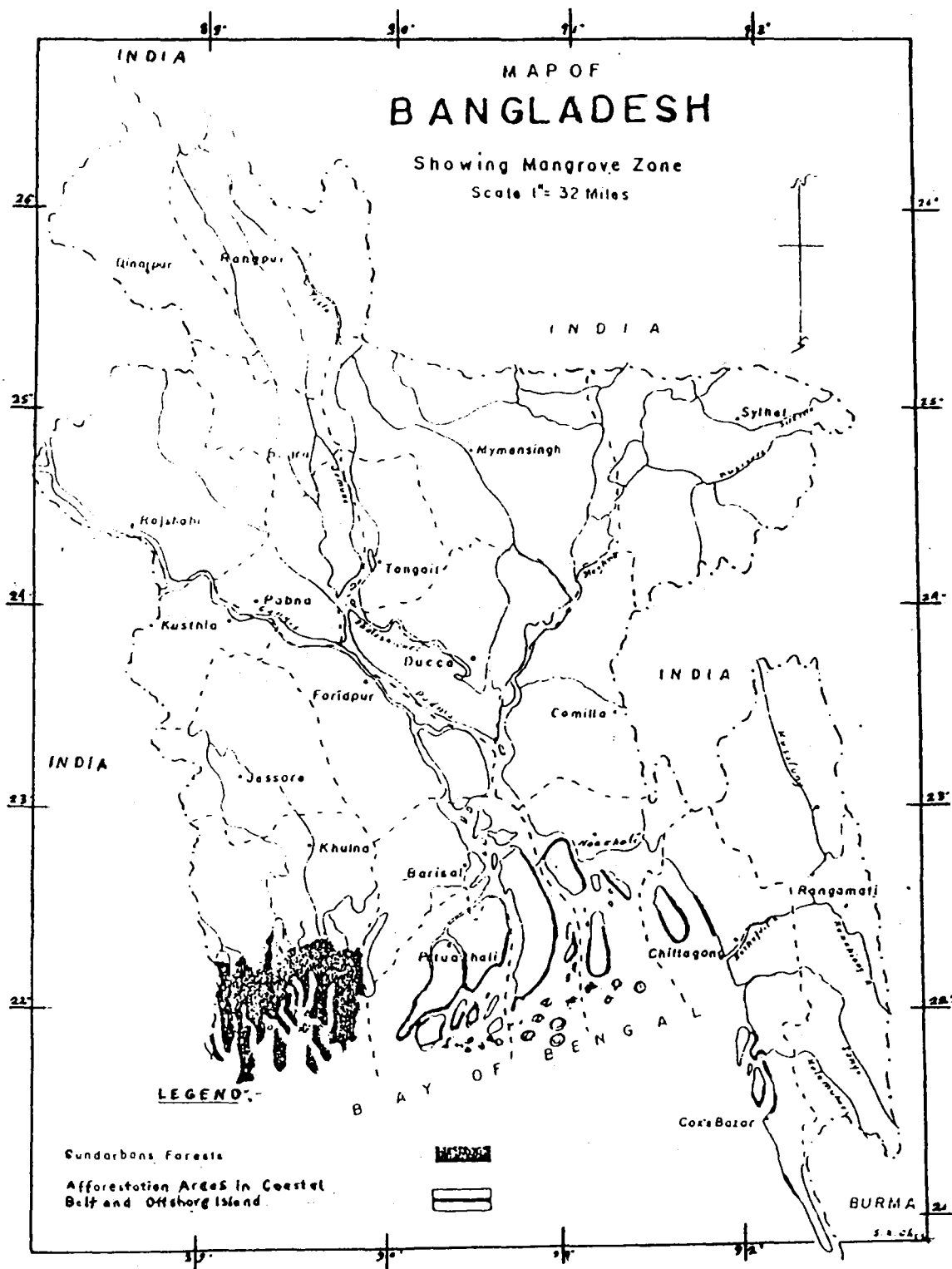
^{3/} Report of the meeting of national focal points on the development of an action plan for the protection and management of the South Asian Seas region, Bangkok, 19-21 March 1984 (UNEP/WG.105/5).

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Map showing distribution of mangroves and coastal afforestation areas in Bangladesh (FAO, 1982)

INTRODUCTION

With a population of over 80 million, Bangladesh is the most densely populated country in the world. The population density, according to the most recent estimates, is 615 persons per km² for the country as a whole and 1,063 persons per km² of arable land. The country is predominantly rural and the bulk of the population still live in some 71,000 villages with fewer than 7,000 people in each. The urban population constitutes less than 10 per cent of the total. Over half of the population suffers from malnutrition, while intestinal diseases and parasitic maladies such as malaria are commonly prevalent. Over-population is a major problem in the country and the need to control population growth (estimated at about 2.9 per cent per year) is urgent. Large and growing numbers of people exert increasing pressure on the limited resources of the country. Most of the arable land is under cultivation; forests are fast dwindling because of large agricultural expansion and the need for a fuelwood supply. Wildlife numbers have decreased considerably because of a shrinking habitat due to human encroachment. The country also suffers from harsh weather; heavy monsoon rains periodically cause floods and bring cyclones resulting in devastation to human settlements in the low-lying coastal areas and deltaic plains.

Geographically, Bangladesh can be divided into two principal areas: the low-lying deltaic alluvial plains which comprise the bulk of the country and the much smaller area of Chittagong hill tracks to the south-east. Bangladesh is a land of rivers which dominate the landscape, and most of the country is comprised of a triangular, nearly-level alluvial plain, much of it deltaic in nature and reputedly the largest delta in the world. The delta is cut up by three great river systems viz., the Ganges-Padma, the Brahmaputra-Jamuna and the Meghna. The rivers play a dominant role in both the economic and social life of the country.

The Bangladesh Plain, also called the Lower Gangetic Plain, lies between the Indian Foothills of Himalayas to the north and the Bay of Bengal to the south. In its lower reaches the deltaic area is composed of a large number of temporary, semi-permanent and permanent islands, locally called chars, formed by the network of rivers.

The land characteristics of the Bangladesh Plain, running from north to south, have been concisely described as 'old mud, new mud and marsh' (Nyrop, 1975). The Plain is also sometimes classified into old alluvium and new alluvium. The new alluvium, which occupies about three times the area of the old alluvium is economically more productive because it receives deposits of fertile soils carried by the rivers. The old alluvium consists of older alluvial deposits and is generally higher in elevation and less fertile than the new alluvium (Ahmed, 1976). The extreme southern reaches of the Plains, extending from the Indian border eastward to the Padma-Meghna estuary, consist of a forested, tidal-washed salt marsh region known as the Sunderbans, which is overgrown with mangrove forests, reputedly the largest single mangrove forest block in the world. No less than one-third of the total population of the country is, in one way or another, dependant upon the mangroves for their livelihood. The inland waterways constitute the most important means of navigation and communication throughout the country.

THE PHYSICAL ENVIRONMENT

Climate and seasons

The tropical monsoon climate of Bangladesh is characterised by high temperatures (about 8 months of the year), high summer rainfall, high humidity and relatively small temperature ranges. The three major seasons are: (a) hot humid summer season (March to June); (b) humid but cooler monsoon season with heavy rains (June to early October); and (c) winter season (October to March). Maximum temperatures during the summer range between 32-37°C with a daily temperature range not exceeding 12°C; the hottest month being April - May. The winter months are characterised by minimum temperatures of not less than 10°C and a daily temperature range of not more than 18°C. Humidity is high throughout the country for most of the year, the lower deltaic and the coastal regions being the most humid (Nyrop, 1975).

Rainfall is generally heavy but varies from about 1200 mm in the West to over 2500 mm in the south-eastern and northern regions. About two-third of this rainfall comes during the southwest Monsoon period. Variations in mean annual rainfall from year to year are only moderate. Excessive rains invariably cause flooding in the low-lying deltaic and coastal regions of Bangladesh, causing immeasurable hardships to the human settlements in those areas.

Wind patterns and cyclonic disturbances

Winds exercise an important influence on the weather in the country. The most destructive of the storm systems are the cyclones, often associated with the retreating monsoon winds in September-October, but which may also occur during November-December or in the premonsoon season, April-May. The cyclones strike mostly from the Bay of Bengal bringing torrential rains, and are frequently followed by tidal waves, which are particularly destructive in the coastal regions of the country. The worst cyclone of modern times occurred in November 1970, which was accompanied by a huge tidal flood taking a toll of over half a million human lives in addition to untold damage to property in the coastal region.

Waves, tides and ocean current regimes

The direct effect of the monsoon winds is to develop seasonal currents in opposite directions in the surface waters of the Bay of Bengal. The Southwest Monsoon tends to produce an easterly drift in the open waters of the Bay, together with a current setting northward and north-eastward along the east coast of India to the head of the Bay. The Northeast Monsoon tends to produce a westerly drift in the open waters of the Bay and a current setting south-westward and southward along the east coast of India from the head of the Bay. Owing, however, to the relatively small area of the Bay, and to the fact that, except on its southern side, it is entirely surrounded by land, two other factors influence the direction of the current. The resulting general circulation of the Bay is intricate and differs to a greater or lesser degree during every month of the year.

The currents show a considerable degree of variability, and they may sometimes even be setting in an opposite direction to the monsoon current or

in any haphazard direction. In either monsoon, the wind fluctuates considerably in strength and to some extent in direction, owing to variations in the distribution of atmospheric pressure. Other winds may also intervene for a time; in these are included the winds of depressions and cyclones. At the transition periods of the monsoons, the currents are even more variable.

The Southwest Monsoon wind is established all over the Bay in May, and gradually strengthens, the maximum strength being in July and August. The direct effect of the wind is to drive the waves across the Bay and along the east coast of India to the head of the Bay, and to pile it up on the eastern side. There is no exit for the accumulating water in the north-eastern part of the Bay: the head of water has, therefore, to be released by taking a westerly direction across the head of the Bay in exactly the opposite direction to the direct flow produced by the monsoon, which it begins to overcome when the accumulation of water reaches a sufficient amount. A counter-clockwise circulation then begins in the extreme north of the Bay; this occurs in July. This counter-clockwise circulation extends southwards and westward in subsequent months, still remaining centred at the head of the Bay, until in September it forms the predominant circulation of the whole of the Bay. The direct effect of the monsoon persists in the wide east-going movement of the southern part of this circulation, the whole being a balance struck between the east-going water and the returning west-going water.

Tides enter the Bay from the south through the Swatch of No Ground and the Burma trench has a semi-diurnal pulsation. The semi-diurnal type predominates all over Bangladesh water with slightly diurnal inequality.

River flows vary greatly with the season, the peak occurring during July/September. The tidal levels vary considerably in the river delta, and high-low water range variations between various localities depend on the interaction between tidal range and river discharge. The mean tidal range reaches 4.1 m at Sandwip and decreases upstream to 0.9 m at Noakhali. Due to this high range of tide and a comparatively high wave energy during the summer monsoon, the extension of the delta front is less rigid than in some other major deltas.

Salinity in the coastal area is primarily controlled by seasonal river discharge. Nevertheless, differences in salinity exist between coastal areas throughout the year. In the Sunderbans, low salinity water penetrates to the inland boundaries of the mangroves throughout the year, whereas in the Cox's Bazaar area salinity levels remain high all the year around. Other areas of the estuary exhibit greater inter-seasonal variations in salinity.

Soils, sands and sediments of the coastal zone

A detailed soil map of the country was compiled in 1970 based on the findings of the FAO/UNDP Soil Survey Project, Pakistan (FAO, 1971), and subsequently published in the FAO/UNESCO Soil Map of the World, Vol. VII (FAO/UNESCO, 1977).

The six dominant soil types occurring in Bangladesh are the following: Gleysols, Cambisols, Fluvisols, Nitosols, Histosols, and Acrisols. These soil types are given below in the order of their extent of occurrence:

Soil type	Area ('000 ha)	Percentage of total land area
Gleysol	7,492	67.47
Cambisol	2,218	15.54
Fluvisol	1,529	10.70
Nitosol	485	3.40
Histosol	355	2.49
Acrisol	57	0.40

Of these soil types Fluvisols are the true alluvial soils formed by deposition from the Ganges-Brahmaputra river complex. Fluvisols are heavily flooded every year and are the most highly productive soils of the region. Three types of Fluvisols are recognised, viz., calcaric, eutric and thionic. Calcaric Fluvisol, also known as calcareous alluvium, is spread over an area of 449,000 ha (3.1 per cent of the total land area) in the Ganges river flood plains. Eutric Fluvisol (also called non-calcareous alluvium) is found in an area of 542,000 ha (3.8 per cent) in the flood plains of the Brahmaputra river. Thionic Fluvisol, the mangrove soil (538,000 ha, 3.77 per cent of the total territory) is found in the Sunderbans region of the Ganges delta under the mangrove forests or on land cleared of such forests. Histosols are also extensive in the deep seasonal flooded area of the Ganges river basin and are under natural vegetation of tall reeds and grasses. Because of the alluvial origin of most of the soil types of Bangladesh, there is a scarcity of gravel and coarse aggregates in the country.

Ahmed (1976) classified the soils of Bangladesh into eight groups as follows: (a) hill soils; (b) red soils; (c) sandy soils of the rivers; (d) silt; (e) loam and loamy clay; (f) clay; (g) swampy soil of the inundated areas; and (h) saline or alkaline sandy soils in the inundated coastal areas.

The soils of the Sunderban swamps are derived from deltaic flat plain deposits and tidal wash deposits. The surface soil is a silty clayey loam overlying alternating layers of clay and sand. Soil fertility decreases from east to west and from north to south as is evidenced by the variation in the luxuriance of the mangrove vegetation (Chowdury, 1962). In the northern and eastern portions of the Sunderbans, the relatively high fertility is maintained by annual silting. High organic matter in the soils of the forest floor is due to the decomposition of leaves from the trees. The soils also have a high calcium content, which may be an important factor for the growth of the mangrove species.

Wetlands, swamps and saltflats

Being the largest deltaic estuary in the world, vast stretches of swamps and mudflats occur along the coastal region. The largest swamp is the Sunderbans along the south-west of the country, which is covered by the deltaic flood plain deposits as well as tidal mud deposits. The swamp is overgrown with 592,000 ha of mangrove forests, about 410,000 ha of which is land area. This is reportedly the largest single mangrove block in the world.

The mudflats and saltflats are constantly being formed at the mouth of the three river system because of heavy sedimentation. The high load of silt carried by the rivers when deposited form innumerable temporary flat highlands, called chars, which may either remain and even become permanent, or be eroded in the course of time. Depending upon the existing conditions, pioneering vegetation may invade these flats thereby increasing stability and land accretions. However, overgrazing by encroaching animals may destabilise the ecology of the islands triggering erosion and even the complete disappearance of the island in extreme cases.

Continental shelf and ocean floor characteristics

The entire territorial waters of Bangladesh is a shallow area that lies within the extensive eastern continental shelf of the Indian Sub-continent, and the only deep area is the narrow Swatch of No Ground, that stretches across into the Indian waters. The entire continental shelf in this region is covered with a thick layer of alluvial deposits, which are mostly clayey or loamy in character, brought down by the three river systems over geological times. No work has so far been done on the geology of these deposits. Certain oil exploring companies have undertaken seismic studies during their exploratory work for offshore oil, but the data is not available.

MARINE RESOURCES AND SPECIALISED ECOLOGICAL AREAS

Non-living (non-renewable) resources

The Territorial Waters and Maritime Zones Act of 1974 declares the resources of the continental shelf to include mineral and non-living resources. Under this Act the Government may make rules providing for, among other things, means to protect, use and exploit the resources of the Economic Zone and to regulate the exploration and exploitation of resources within the continental shelf.

Offshore oil and gas

There has so far been only very limited exploratory work for offshore oil and natural gas in the coastal waters of Bangladesh, and prospects of any commercial yields have not been very promising so far. The recent exploration has so far not yielded any encouraging results.

The Petroleum Act of 1974 states that persons carrying out petroleum operations are required, among other things, to: carry out operations in any area in a manner that does not interfere with navigation, fishing and conservation of resources of the sea and seabed; and consider factors connected with the ecology and environment. In particular, care is to be taken to control the flow and prevent the waste or escape in the exploitation area of either petroleum or water.

The Bangladesh Marine Pollution Control Ordinance, which is presently in the process of being promulgated, includes provisions on (a) discharge of oil or pollutants from offshore installations and seabed exploration and exploitation; and (b) installation of pollution-prevention and pollution-

combating equipment on ships and offshore installations. A National Oil Spill Contingency Plan has also been drafted with the assistance of the International Maritime Organization and is presently under consideration for promulgation by the Government.

Offshore minerals

Bangladesh is generally poor in mineral wealth and no explorations have so far been undertaken for any possible offshore deposits in the coastal waters of the country. However, the offshore island of St. Martin's, lying between 20° 37'N latitude and 92° 18'E longitude about 95 kilometers south of Cox's Bazaar and 80 kilometers north-west of Akyab in Burma, has been identified as a possible exploitable source of limestones. The coral deposits of the island are already being exploited on a small scale by the local population for the manufacture of lime.

Radioactive minerals have been found in heavy sand along the beaches south of Cox's Bazaar. Estimates place the resources at about 600 tons with a heavy mineral content of 10 - 30 per cent in the sand (Nyrop, 1975). Deposits of Monazite, Ilmenite, Rutile and Zircon are known to occur on certain beaches along the southwest coast, and banks of Monazite sand have been reported. However, the economic feasibility for their exploitation have not so far been worked out.

Limestone, silica sand and white clay are being mined from dry riverbeds in the deltaic region. In this process 1 - 1.5 m. of the surface overburden containing the mineral is extracted by the open pit mining technique and the pits are then refilled. No estimates are available of the quantity of the minerals extracted.

Water resources

Water resources and their development constitute a major problem in the country, because of too much water during certain seasons of the year and too little water during other periods. Coastal regions of the country, particularly the Sunderbans, are regularly inundated by the sea during high tides. Groundwater in these areas could attain salinity levels of 1200 parts per million (lppm) during the dry season (World Bank, 1972).

The groundwater table lies within about 10 m under the surface throughout most of the country. Groundwater hardness has been measured to be greater near the Ganges and its tributaries in the western parts of the country and lesser in the other regions. Iron content is quite high, sometimes reaching up to 50 mg per liter (Hussain & Arbuthnot, 1973).

An assessment of the water situation in the country in the early 1970s concluded that water resources may become inadequate in the future as a result of their increasing utilization for irrigation, industries, and other causes. Increasing water quality problems were also foreseen arising from higher bacterial counts and increasing alkalinity by seawater intrusion in the lower deltaic regions, as well as from increasing application of fertilizers and pesticides (Hussain & Arbuthnot, 1973).

Deltas of three large rivers, viz., Ganges-Padma, Brahmaputra-Jamuna and Meghna, which discharge into the Bay of Bengal, constitute the major part of the whole country. All the three rivers originate outside the country and

only 7.5 per cent of their total drainage area of 600,000 km² lie within the geographical boundaries of Bangladesh. The maximum and minimum discharges of these three major river systems are given below. The rivers attain peak flow in August and begin to decline thereafter to reach the lowest flow rates during the Summer months.

R I V E R	Discharge ('000 cusecs)*	
	Maximum	Minimum
Brahmaputra-Jamuna	2 - 3000	125 - 200
Ganges - Padma	2 - 3000	50 - 70
Meghna	500	3

*Cusec = Cubic foot per second; 1 cusec = 0.28 cubic meters

Construction materials

Construction materials are not extracted in the coastal areas. But silica sand, limestone and white clay are mined from the dry riverbeds in the deltaic areas. In this process, 1 - 1.5 m. of the surface overburden containing the minerals is extracted by simple open pit mining method. The pits are later partially refilled with sediments. No statistics are available on the quantities of minerals extracted. Limestone is used in the manufacture of lime, portland cement, paints and in the paper industry.

Other coastal resources

Sea-salt is manufactured in salt farms (Evaporation Pans) along the coastal area mostly as a small scale cottage industry. However, production is expensive and returns are poor because of the long humid rainy season.

Living (renewable) resources

In accordance with the regulations laid out in the Territorial Waters and Maritime Zones Act of 1974, the Government may, within those areas defined and declared as conservation zones, 'take measures it may deem appropriate including measures to protect the living resources of the sea from indiscriminate exploitation, depletion or destruction.' Under this Act, the Government may also make rules and take measures, among other things, to protect, use and exploit the resources of the Economic Zone, and take conservation measures to protect the living resources of the sea.

Seaweeds

Nurul-Islam (1976) studied the taxonomy of the more common seaweeds in the Bangladesh waters and reported that brown algae and green algae were the most predominant among them. The more common brown algae belong to the genera Colpomenia, Dictyota, Gelidium, Halimeda, Hydroclathrus, Padina and Sargassum. The more common green algae belong to the genera Caulerpa, Enteromorpha and Ulva.

The abundance, distribution and ecology of the seaweeds have not been studied so far. However, in view of the wide seasonal fluctuations in salinity levels, it should be expected that their growth is not luxurious in most of the area because of the adverse physiological conditions.

Fisheries

Fish represents the most easily augmentable source of protein in the country. Inland fisheries account for about 90 per cent of the total annual fish catch in Bangladesh, because of the deltaic nature of the country and the existence of vast stretches of natural inland water bodies. Fishing is the second most important economic activity engaging over 5 million persons.

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. At present, several small - to large-sized mechanized fishing vessels are being operated under these projects.

Total annual fish landings in the country during 1982 was of the order of 650,000 mt which was less than what it was 10 or 20 years ago mainly because of the drastic decrease in the inland fish catches since 1962. The growth of the marine fish production has not been sufficient to offset the decrease in the inland catches. A recent World Bank estimate says that the potential for increasing marine catch is rather limited and costly except in the nearshore areas (mainly shrimps).

Coastal aquaculture

Very little aquaculture is being practised in the country in a systematic manner, although several modern advanced technology techniques have been demonstrated in recent years. However, the traditional practise of 'trapping and holding' technique for enclosing and fattening shrimps is used in paddy fields in the coastal areas. The Government is aware of the vast potential for developing aquaculture in the coastal regions to boost the supply of protein in the country.

Other marine living resources

The coastal and offshore islands are often the breeding grounds of marine turtles, and both the adults and their eggs have been traditionally collected in large quantities mostly for local consumption. This has in recent times created a conservation problem for several species of marine turtles in the country.

Among other living resources, sponges and shells are common along the sandy south-eastern coast line, in such localities as St. Martin's Island. Fattah (1979) reported that collection of shells on a commercial scale by the local fishermen as well as souvenir collection by tourists have damaged certain areas of the coral reef, and felt that if this collection is allowed to continue uncontrolled, it could endanger the reef as a whole, creating conservation problems for the only coral reef of the country.

Ecosystems, habitats and specialised ecological areas

Bangladesh has the largest river delta in the world which is slowly increasing in area due to heavy sedimentation and land accretion. The coastal areas have vast stretches of mudflats, swamps and newly emerging islands, which are all specialized habitats of great ecological interest. Some of these are the Sunderbans swamps with the largest mangrove forest block in the world, and thousands of deltaic islands in the estuaries.

Seagrass beds

No information is available on the ecology, distribution and abundance of seagrasses in the waters of Bangladesh. Murul-Islam and Aziz (1980) reported one species of seagrass, Halodule uninervis, growing in the sandy littoral zone around St. Martin's Island.

Mangrove forests and swamps

The mangroves of the Sunderbans, reportedly the largest block of mangrove forests in the world, cover some 5,993 km² in the tidal plains (12.5 per cent of the total forests cover and 4.2 per cent of the total land area of the country), and consist of species adapted to low-lying clayey soils that are often flooded during high tides. Minor areas of mangrove forests also occur near Chittagong. About seven mangrove species occur in association in these forests, important and economic species being Heritiera fomes, Excoecaria agallocha and Sonneratia apetala, with mixed stands of Heritiera and Excoecaria being the basic type.

These forests are worked by a system of selective cutting and natural regeneration. There are deforestation problems in the mangrove swamps and over-exploitation of the forests for firewood and timber has resulted in the degradation of this important barrier against cyclones and tidal waves. Reforestation is now being undertaken in a systematic manner and mangrove species are planted extensively under coastal afforestation projects to protect embankments and new land accretions.

The Sunderbans is a very large mangrove forest with a complex ecology. The area is traversed from north to south by numerous large channels which represent former river arms in the delta, but with the eastward shift of the Ganges - Brahmaputra river system, there is only a relatively modest outflow of freshwater through the Sunderbans, which has further decreased in quantity in recent times with the diversions of the flow of these rivers. The forest becomes poorer and more open as one proceeds towards the sea or towards the west (Ahmad, 1966). The unique vegetation is classified under three zones: freshwater forest (north-eastern part), moderately saline forest (eastern part) and saltwater forest (western part, actually eastward extension of the Indian Sector of the Sunderbans).

In the freshwater areas, Heritiera fomes is the most important tree, followed by Excoecaria agallocha which increases in importance westwards. Other species in this zone are Xylocarpus moluccensis and Bruguiera cylindrica. Sonneratia apetala, S. caseolaris, Avicennia officinalis and Nipa fruticans are common on the banks of the waterways. In the moderately saline areas, H. fomes becomes smaller and less abundant, and X. moluccensis occurs in greater abundance. Rhizophora apiculata appears in the more saline areas to the southwest. In the more saline areas, the forest consists mainly of E. agallocha and Ceriops tagal with patches of Phoenix paludosa on drier

soil (Ahmad, 1966). Grasses, Oryza coarctata and Typha elephantica are relatively abundant in the Sunderbans due to the freshwater influence. The vegetation is classified into strata which are further divided into site classes according to the height of trees.

The Sunderban forest has been managed on a more or less scientific basis since the beginning of the century when minimum felling diameters were fixed. The felling cycle is now 20 years and the silvicultural system is of the 'selection-cum-improvement' type. This prescribes minimum diameters for all commercial species which vary between 11.8 cm and 56.3 cm depending on both the species and site quality class. Care is taken to avoid blanks and to ensure natural regeneration and improvement fellings remove trees interfering with the growth of others (Das, 1978). The average yield has been rather poor (about 1.9m² ha/yr for the last 20 years), and clear-felling and replanting are being undertaken on an experimental basis.

Excluding the improvement fellings, the sustained timber yield under the management plan is 200,000 m³ of Heritiera fomes and 170,000 m³ of Excoecaria agallocha. During 1957 - 1977, the average yield of forest products was as follows:

P R O D U C T	Q U A N T I T Y
Timber	322,000 m ³
Firewood	424,000 m ³
Thatch (roofing material)	81,600 t
Honey	177 t
Wax	49 t

Heritiera (Sundri) is used as telegraph and electricity poles, and for construction of houses and boats; branches are used for hardboard manufacture and as firewood. Excoecaria (Gewa) is used for the manufacture of newsprint paper, and in the boxwood and matchwood industries. Sonneratia apetala is used for manufacturing tea chests; Ceriops roxburghiana (Goran) is used for posts, construction of sheds and as firewood; and Xylocarpus (Carapa) abovata (Dhundal) is used in the pencil industry (Ahmed, 1976). Several industries in the Khulna district are based exclusively on the Sunderban mangroves and the employment generated is estimated at 317,000 including wood-cutters, fishermen, honey collectors and labourers in the wood industries.

Extensive coastal afforestation has been undertaken as a means of hastening land reclamation by stabilizing new land accretions and protecting embankments. Up to 1978, 24,400 ha of mangrove plantations had been established and the area under plantation is now being enlarged at a faster rate. Sonneratia apetala is the most favoured species for plantation establishment. The plants are raised in nurseries and transplanted when they reach a height of 32 - 60 cm. Other species used are Avicennia officinalis, Ceriops decandra, Bruguiera gymnorhiza, Excoecaria agallocha, Xylocarpus spp. and Nipa. Acacia arabica and other non-mangrove species are planted to stabilize embankments.

Occupying the basins of the north-eastern region below the Khasi hills, there are also about 275 km² of freshwater swamp forests dominated by Barringtonia acutangula and Trewia nudiflora, along with reeds and grasses such as Erianthus, Saccharum and Phragmites. These swamp forests are worked very little, and when they are, the trees appear pollarded.

Reputedly one-third of the population of the country is in one way or the other dependant upon the mangrove environment for their livelihood.

Coral reefs

The only known coral reef area in Bangladesh occurs around St. Martin's Island (20°37' N latitude and 92°18' E longitude) in the Bay of Bengal, about 95 km south of Cox's Bazaar and 80 km north-west of Akyab in Burma. Fatta (1979) stated that "It is believed that a submerged reef is present on the south and south-east of St. Martin's Island and in all probability this reef is the western extension of the one of Malaysian sea coast. This area appears to be rich in biological zones, but adequate survey work is yet to be carried out in this region". Despite some recent taxonomical studies, our knowledge of this coral reef is still very limited, and two scientific expeditions were organised to this island in recent years to study its flora, fauna and ecology. Fattah (1979) further stated that: "Over the last 20 years in the author's experience, the damage to the reef surrounding the island has increased yearly at an alarming rate. It is known that a portion of the area has now been totally destroyed!"

There is no information on the types of corals or their distribution at St. Martin's Island, but Fattah (1979) has summarized some of the human activities responsible for their deterioration. The problem of shell and coral collection appears to be acute and Fattah was of the opinion that commercial collection has been responsible for the drastic reduction of their population in the area. He also indicated that although commercial collection of ornamental fish, recreational pressures, and use of explosives to catch fish had not yet reached alarming proportions, these could become future problems unless adequate precautionary measures are taken to control commercial scale collection. He also suggested that strong measures should be taken to prevent the introduction of 'carbide bomb fishing' on the reef. In this method of fishing, explosives of different types, including dynamite, are thrown into the water near the reef edge and the killed or stunned fish are collected. This method not only kills the larval, juvenile and adult fish together with other marine organisms in the vicinity (including those species which have practically no commercial value), but also the coral growth in the area. The damaged reefs often do not recover to their original stage and are overgrown with seaweeds in the course of time.

Fattah (1979) also feels that industrial and agricultural wastes could pose problems to the coral reef. He states that "We still do not know about the effects of pollutants entering the country's river system on the environment of reef area surrounding St. Martin's Island..... It is suggested that no industry, small or big, should be allowed to dump pollutants in the Naff river area."

An ESCAP/SACEP review (1983) states that collection of shells and corals as souvenirs by tourists and sedimentation from freshwater runoff pose the major threat to the coral reefs around St. Martin's Island.

Island ecosystems

The three major river systems of Ganges-Padma, Brahmaputra-Jamuna and the Meghna and the numerous tributaries drain a vast area of the Indian sub-continent and the Himalayan mountains bringing with them enormous quantities of silt and sediment, which are deposited at the river mouths in the Bay of Bengal forming deltaic islands, many of which eventually become permanent with their progressive colonization by pioneering mangrove species, reeds, grasses and terrestrial vegetation. It has been estimated that 2-3 billion metric tons of silt is brought down by this river system, deposition of which has in recent times built new islands of over 4,000 km² mostly in the Padma-Meghna Estuary. Many of these islands are barely above mean sea level and could be seasonal, exposed only during periods of low sea level or 'move' seasonally (Nyrop. 1975). Salinity of the entire deltaic region seasonally fluctuates considerably ranging from freshwater immediately following the peak monsoon season to almost pure sea water during the inter-monsoon season.

Sand occurs along the sea face of the deltaic region, where the surge and turbulence prevent deposition of fine clay. Tides bring up quantities of sand from the ocean floor and deposit it on exposed coasts of sandbanks. This sand is then driven inland by strong winds that blow from the ocean. On the lee side of these sandbanks, tidal creeks establish and silt deposition begins finally establishing an island. Frequent flooding continually fertilizes the surface of this area by carrying away old soil and bringing in new soil, thus facilitating the establishment of pioneering vegetation.

The river network of the plains move generally from north to south but include large number of 'feeder' streams flowing from all directions, and distributaries from the large rivers in a unique profusion. Accurate study and description of this riverine labyrinth with its associated lakes, marshes and islands is practically impossible because of its magnitude and as the rivers continually change their courses annually and/or seasonally. In some cases, the streams die and others are born in a continuing process. Naturally, these geomorphological and hydrological changes also affect the pattern of formation of deltaic islands. Permanency of these islands is largely determined by the degree of success of their stabilization through the colonization by pioneering mangroves and other plants.

The western part of the delta between the Indian border and Madhumathi River (also called the old delta) consists of beds of dead and dying rivers and has been mostly reclaimed for agricultural purposes. The new delta, east of the Madhumathi River is being slowly built up by silt and mud from the swift-flowing rivers and seasonal floods, subject to frequent changes of deposit and erosion.

From the Padma-Meghna junction, the combined rivers spread out into the Bay of Bengal through one of the largest estuaries in the world. In this triangular estuary are a number of permanent islands, including many that surface only at low tide and many that are temporary or that shift in outline from time to time. Many of these are chars, land forms built up by silting that may become permanent or erode. The largest of the permanent islands in the area are, from east to west, Shabazpur, north Hatia, south Hatia and Sandwip.

There is only one coral island in the country, St. Martin's Island lying between 20°37'N latitude and 92°18'E longitude about 95 kilometers south

of Cox's Bazaar and 80 kilometers northwest of Akyab in Burma. The island group has a total area of about 15.5 square kilometers. The shores of the island are composed of calcareous sand and sandstones, fossiliferous conglomerates, shalebeds, coquina and loose calcium sand. Despite some recent taxonomical studies, present knowledge of the marine biology of the island is still very limited. Two scientific expeditions were organised in recent years to explore the flora, fauna and ecology. Fattah (1979) suggested that conservation measures are most urgently to be undertaken to save the reefs of this Island.

ENVIRONMENTAL ASSESSMENT OF MARINE POLLUTION

General aspects

The major water quality problem in the country at present is the quality of drinking water, which is generally high in bacterial content because of contamination by human waste matter. Water quality problems are also created because of increasing use of fertilizers and pesticides in agriculture, as well as inflow of untreated waste effluents from industries.

In accordance with the provisions laid out in the Territorial Waters and Maritime Zones Act of 1974, the Government may, within those areas declared as conservation zones, "take measures..... it may deem appropriate..... including measures to protect the living resources of the sea from indiscriminate exploitation, depletion or destruction." With regard to pollution, the Government may "with a view to preventing and controlling marine pollution and preserving the quality and ecological balance in the marine environment in the high seas adjacent to the Territorial Waters, take such measures as it may deem appropriate for the purpose."

Pollution from domestic sources

The townships and human settlements of Bangladesh do not have any domestic waste treatment facilities, and the effluents either directly or indirectly find their way into the water bodies. The unplanned growth and lack of proper waste disposal systems further aggravate the problem. No surveys have so far been conducted of the quantity and the quality of either domestic effluent or solid waste (garbage).

Disposal of solid waste is also a serious problem. The most common system presently adopted is to dump the wastes in the outskirts of townships usually as a landfill which becomes a breeding ground for house flies and mosquitoes. Such garbage also finds its way into the water bodies during the flood season. The Government has given due consideration to the potential for the use of organic wastes to produce bio-gas.

Uncontrolled flow of large quantities of domestic effluent sometimes makes the receiving water bodies eutrophic, and aquatic vegetation proliferates in such areas in great abundance. When the vegetation eventually dies and decays in large quantities, it makes the waters anoxic triggering a vicious cycle of its own. In extreme cases such a situation may even cause localised fish mortality.

Pollution from industrial sources

The industrial sector in the country is still in its developmental stage, and dumping of untreated toxic or non-toxic effluent into the rivers and other natural water bodies is often practised causing localised water quality problems. For example, effluents from industrial operations such as a petroleum refinery causes serious water quality problems in Karnaphuli river, so much so that it cannot be used as a source of water supply for the city of Chittagong. Textiles and chemical plants in the vicinity of Dhaka city affect the quality of surface water in the area, when their effluent are discharged untreated into streams especially during the low flow season. A survey conducted in the area yielded a maximum BOD₅ value of only 6.1 mg per liter in the city of Narayanganj, indicating the high level of organic activity in the natural waters.

Fattah (1979) pointed out that industrial and agricultural wastes could pose problems to the coral reefs of Bangladesh around St. Martin's Island. He stated that "We still do not know about the effects of pollutants entering the country's river system on the environment of the reef area surrounding St. Martin's Island..... It is suggested that no industries, small or big, should be allowed to dump pollutants in the Naaf river area."

Pollution from agrochemicals

Precise information on the use of fertilizers and pesticides in the country has not so far been compiled, but there are sufficient indications of their increasing application in agriculture. The Directorate of Fisheries of Bangladesh reports that increasing application of fertilizers and pesticides is affecting the spawning of freshwater fish in rice fields, and that pesticides are killing plankton and affecting their production in the water bodies.

A recent FAO estimate showed that over 3,000 tons of pesticides are annually distributed into the country. The survey reported that the most commonly applied pesticides are the following: Aldrin, Malathion, Toxaphene, Dithiocarbamate, Dinitro-compounds, Copper compounds, 2,4-D and miscellaneous rodenticides.

There are reports of inappropriate applications of both fertilizers and pesticides in the country which only accentuates the problem.

The 'Pesticide Rules', which were under consideration by the Government for promulgation in 1984, lay out the regulations and provisions for the import or formulation, registration, testing, packing, storage and transport, application and inspection for all types of pesticides in the country. A list of registered pesticides is appended to these Rules. The Government has also prepared a list of banned, prohibited or restricted pesticides. The banned pesticides include DDT, BHC, Endrin, Lindane, Parathion (Ethyl and Methyl), Telodrin, Methoxychlor, Disyston (granules), Thimet (granules), Solvigum and Sevidol Dieldrin, Heptachlor and Chlordane are allowed to be applied only against soil pests; and all mercurial compounds should be applied only against sugarcane pests.

Siltation and sedimentation

The silt load carried by the three river systems of Bangladesh is greater than that of any other river system in the world. The total annual sediment load of the river systems of Bangladesh has been estimated to be of the order of about 2.5 billion tons (Abbas, 1973). Of this total, the Brahmaputra river carries 1.7 billion tons and the Ganges 800 million tons annually.

As the silt-laden waters enter the estuaries, a brackish water interface is formed, slowing the flow of the streams and causing silt to be deposited along channel banks and on mud islands in the estuary. At some points, deposition is only temporary, because of changing water currents. At others, it continues and the emerging mudflat is colonised by pioneer grasses, particularly dhansi grass (*Oryza coarctata*). The pioneer plants increase stability and silt deposition. In the undisturbed state, the land surface rises, the periods of inundation shorten and soil salinity declines as the effect of rainwater leaching increases. In this less severe environment, the range of plant species broadens and eventually the mudflat becomes part of the main alluvial plain.

The demand for land often leads to the chars being used for grazing as soon as they have been colonised by suitable pioneer grass species. Heavy grazing of char lands can lead to a reversal of the succession to stable land by removing vegetation and by compacting the soil, causing an increase in sheet erosion.

By analysing the LANDSAT Imagery Data, an attempt was made to calculate net accumulation of land formed by the sedimentation process ongoing at the rate of 2.5 billion tons per year. 368 km² of land was accreted during the period 1972 - 1977; 436 km² of land eroded during the same period. Considering tidal conditions, net accretion lies between 3,210 and 3,600 ha of new land. Vast amounts of suspended sediments resulting from the surface runoff and land erosion is carried downstream by the rivers to the Bay of Bengal, where most of it apparently settles out as a result of flocculation, collects and often forms new offshore land. Tidal action resuspends most of this sediment and redistributes it along the coast line. As a result, gains in one area may be offset by losses in another area.

Oil pollution

There has not been any large scale oilspill catastrophe in the Bangladesh waters so far, and the only oil pollution in the water bodies of the country occurs from land sources, and from river-boats, launches and steamers. This has not so far produced much of a pollution hazard because of the more or less fast river currents. The level of oil derivatives in the rivers and the coastal waters has not so far been surveyed.

Localised oil pollution is said to be heavy in the vicinity of the Chittagong and Chalna Harbours. There has also been persistent reports of frequent sightings of oil slicks in the territorial waters of the country, and the upper Bay of Bengal, but these have not yet been scientifically documented.

An Oil Spill Contingency Plan has recently been drafted with the assistance of the International Maritime Organization (IMO). The plan is presently under consideration by the Government for adoption.

A Marine Pollution Control Ordinance has also been drafted and was in the final stages of promulgation in 1984. This Ordinance is expected to include, among other things, (a) provisions on discharge of oil and pollutants from ships, offshore installations, and seabed exploration and exploitation; (b) provisions for pollution-prevention and pollution-control equipment on ships and offshore installations; (c) provisions on transfer of oil or pollutants at sea; (d) provisions for installation of waste reception facilities at Ports and Harbours; and (e) appropriate enforcement machinery, including inspection and penalties for violations.

Microbial pollution

Because of the open latrine system in the country and the traditional means of human waste disposal, faecal contamination of the water bodies is of a high order. Coupled with the lack of potable water supply to most of the rural and urban population, this is the main cause for the high prevalence of diarrhoeal diseases and their high degree of contagiousness in the country. The Department of Environmental Pollution Control is presently undertaking periodic surveys of E.coli levels at its monitoring stations throughout the country, and coliform bacteria was recorded, sometimes in large numbers, in everyone of the water samples examined.

Environmental health

Health aspects

Affecting over 50 per cent of the population, malnutrition is said to be the underlying factor contributing to mortality and has been called the most important health problem in the country, because it renders its victims more susceptible to the effects of other ailments such as diarrhoeal diseases. Due to nutritional deficiencies of protein, Vitamins A and C and riboflavin; goiter, anemia, etc. are rampant. With the continuing population growth and deficiencies in food supply, malnutrition can be expected to remain a problem in Bangladesh for some time to come.

Statistical information on the prevalence of environmentally transmitted communicable diseases in the country is very limited. The most immediate causes of death are infectious diseases such as cholera, diarrhoeal diseases, tuberculosis, measles, and other bacterial and viral infections. Gastroenteritis compounded by malnutrition is thought to be the most common cause of sickness. Children under five are estimated to account for 40 per cent of all deaths. The prevalence of water-borne and faecal-related diseases underlines the urgent need for improving the water supply and sanitation systems.

Cholera, a major problem throughout Bangladesh, is endemic in the deltaic region, and appears to strike different parts of the country in a seasonal pattern. The disease is transmitted by water contaminated with human waste matter from disease-carrying individuals. Although the international centre for Diarrhoeal Disease Control and Cholera Research Institute have developed means to control the disease, the real key to contain its incidence is improved sanitation.

In 1974, WHO reported that of 71 million people at risk to malaria, 42.5 per cent were in the pre-maintenance phase, 46.5 per cent in consolidated phase and the rest (11 per cent) in attack phase. Except for residual pockets here and there, the disease steadily decreased in numbers of incidents as a result of a concerted mosquito-eradication programme since the mid-1960s. Filariasis, another mosquito-borne disease, is endemic to the northern region of the country and some 14 per cent of people examined in a recent survey in Dinajpur District were found to be infected. An estimated 100,000 people die annually from Pulmonary Tuberculosis and another 100,000 suffer from Leprosy.

The health care system consists of a centralised public system based on the concept of Rural Health Centres, scattered private services, such as community co-operative health insurance plans, individual physician care, and traditional services based on folk beliefs and herbal cures. The National Health Policy was started in the first Five Year Plan, 1973-78. It calls for the establishment of an integrated and comprehensive rural health care system with emphasis on the need to make low-cost health care available to the majority of the rural population and the need to attack communicable diseases on a broad comprehensive front, rather than through single, uni-purpose programmes.

Water supply and sanitation

The inadequacy of both water supply and sewerage systems is the chief factor preventing the improvement of the overall health status of the people in the country. Although water is plentiful in the country a good potable water supply is available only to a small fraction of the population, and even Dhaka, the capital, does not have a satisfactory supply of potable water. Domestic water supplies in about 30 townships which have piped water systems is derived mostly from wells. The majority of the population obtains its domestic water from hand-pumped tube wells or from surface ponds, tanks or from rivers.

A WHO survey conducted in 1976 estimated that about half of the rural population and less than one-fifth of the urban population have a reasonable access to relatively safe potable water. However, Loomis (1976) estimated that less than 10 per cent of the rural population effectively receives and/or uses potable water regularly either because of frequent breakdown of tube well pumps or the deep tradition of water use from a natural source such as rivers and lakes. As a result, unhealthy water is the primary cause of much of the diseases prevailing in the country. A UNICEF-assisted programme aims at improving the rural water supply situation by eventually providing one tube well for every 150 - 200 persons in rural areas throughout the country.

Dhaka the capital is the only settlement area, urban or rural with a sewerage system and according to WHO estimates only 5 per cent of the urban population is connected to the sewerage system. Urban households use pit privies and buckets as predominant waste disposal systems. Makeshift latrines are used for human waste disposal in the rural areas, and rivers and streams serve as waste removal systems. Solid wastes, like night soil are deposited on the outskirts of cities.

Other environmental aspects of coastal development,
resource exploitation and natural phenomena

Coastal tourism development

Coastal tourism development is still in its very initial stages mostly for lack of suitable beach resort areas for such development, and the only existing beach resorts are found along the south-eastern coast. The most famous beach resort in the country is in Cox's Bazaar. Indigenous tourists far outnumber the foreigners.

The most noticeable environmental concern so far from Coastal Tourism Development has been the increasing level of souvenir collection from the coral reefs around St. Martin's Island, located 95 km south of Cox's Bazaar, and the only coral reef in the country. Fattah (1979) concluded that although it has not yet reached alarming proportions, souvenir collection from the coral reef could pose a conservation problem in the future, if it is allowed to continue uncontrolled.

River discharges

The silt load carried by the three river systems is reputedly greater than that of any other river system in the world. In fact, the entire Gangetic delta comprising most of the land area of the country, was formed from such alluvial deposits over geological times. As the silt-laden waters enter the estuary, a brackish water interface is formed which slows the flow of the stream and causes silt to be deposited along the channel banks and mudflats forming temporary, semi-permanent or permanent islands locally called chars. The magnitude of the silt loads and the river flow rates during the peak and low flow seasons are discussed earlier.

Coastal erosion

Kabir, Pramanik and Choudhury (1979), estimated the net result of land accretion and erosion in the deltaic area as measured by the LANDSAT imagery during the 1972-77 period. They concluded that river bank erosion is negligible in the Sunderbans area mainly because of the coastal stabilization by the mangrove forests, but the eastern region between Tetulia River and Chittagong coast was very dynamic both from the sedimentation and erosion point of view. It was, however, observed that as soon as any newly formed land is colonized by pioneering species of grass, they are immediately invaded by grazing animals which upsets ecological succession, rendering the area unstable and prone to erosion thus starting a vicious circle.

Transport and other maritime activities

The national marine fleet consists of 30 foreign-going vessels with a total DWT of 388,040 tons of which 26 are dry cargo vessels, 2 are coasters and 2 lightering tankers. In addition, numerous rivercrafts, launches and steamers ply the waterways which are the main means of transportation and communication throughout the country. Several foreign cargo vessels and tankers also visit Chittagong, the major coastal harbour, and Dhaka, the major inland harbour. The waste oil, spillages and bilge washings from these vessels could be the main source of oil pollution in the waters of Bangladesh.

There is no specific legislation so far to deal with the control of marine pollution or oil pollution in the country. The Bangladesh Marine

Pollution Control Ordinance was drafted recently and was in the process of promulgation in 1984. The Ordinance is expected to include, among other things, provisions on discharge of oil and pollutants from ships, and for the installation of pollution-prevention and pollution-combating equipment on the ships.

Marine dumping

The Department of Environment Pollution Control (DEPC) has established water quality standards for drinking, recreation, fishing and other purposes, and the release of hazardous effluent from industrial and other landbased sources is presently controlled. DEPC is operating a network of monitoring stations through the country and is undertaking periodical surveys to check that the water quality is maintained.

There was no legislation so far to deal with the dumping of wastes from ships. To cover this gap, the Marine Pollution Control Ordinance has been drafted and was in the final stages of promulgation in 1984. The Ordinance is expected to include, among other things, (a) provisions on discharge of oil and pollutants from ships, offshore installations, and seabed exploration and exploitation; (b) provisions for pollution-prevention and pollution-control equipment on ships and offshore installations; (c) provisions on transfer of oil or pollutants at sea; (d) provision for installation of waste reception facilities at Ports and Harbours; and (e) appropriate enforcement machinery, including inspection and penalties for violations.

Overfishing and harmful fishing activities

Fishing has been undertaken traditionally by non-mechanised rivercrafts in the country. Mechanised fishing vessels have been introduced only in very recent years and are now being developed under projects assisted by the World Bank and the Asian Development Bank. Only limited scope has been recognised for the development of mechanised bottom-trawling or pelagic fisheries. The Government has also initiated joint fishing ventures with some neighbouring countries in recent years. It is estimated that there is still good scope for the development of fisheries.

No apparent signs whatsoever have so far been seen of over-fishing of any commercially important fishery in the waters of Bangladesh. However, research work is required for the location of breeding and spawning grounds, seasons and ecology of most of the economically important marine species of fish. Steps are also to be taken to protect their breeding and spawning grounds. Certain harmful fishing methods such as 'carbide bombing fishery' is prevalent in the country.

Red tides and mass mortalities

There has been no report of mass mortality from the waters of Bangladesh so far. The marine ecology, biota and fish populations in the waters of the coastal areas are predominantly regulated by the wild seasonal fluctuations in the salinity of waters during the monsoon and off-monsoon seasons (salinity fluctuations range between almost nil to 32 ppt).

Nazrul-Islam and Aziz (1975a) studied the phytoplankton in the waters of Bangladesh and reported 27 genera and 76 species belonging to diatoms, Dinophyceae and Blue-green algae. Diatoms predominated the flora (up to 99.5 per cent of the total by numbers) followed by Dinophyceae and Blue-green

algae. The most abundant diatom genera were Melosira, Laudera, Hemidiscus, Rhizosolenia, Chaetoceros and Eucampia, Chaetoceros contributing to the largest extent. Laudera is predominant during Summer, Hemidiscus during the monsoon, and Melosira during the post-monsoon months. The annual phytoplankton bloom peak occurs during the Summer months, but no 'red tides' have been reported so far from Bangladesh waters.

The same authors in another paper (1975b) studied the distribution of zooplankton in the same area. Eighteen species belonging to 18 genera were recorded. Copepods were the predominant organisms followed by Decapods, Cladocerans, Chaetognaths, Tintinnids, Nematodes and Coelenterates. Zooplankton peaks during late Summer and inverse relationship was noticed in its abundance with that of phytoplankton.

Souvenir collection

Souvenir collection is a problem only on the coral reefs around St. Martin's Island, where tourists collect shells, coral and other curios. Enterprising local fishermen also indulge in commercial collection of specimens for sale to the tourists. Fattah (1979) states that such collection appears to have damaged certain areas of the reefs. He felt that, although it has not yet reached alarming proportions, souvenir collection could create conservation problems in the future, if it is allowed to continue uncontrolled.

Water salinity

Salinity of both surface and ground water is a problem in Bangladesh and in the dry season sea water is carried up the river channels during the high tides. Salinity penetrates much further inland in the western than in the central and eastern regions of the delta where dry season river flows are greater. Control projects have been designed to prevent the intrusion of saline waters into portions of the coastal saline lands of over 16,500 km² along the Bay of Bengal. In the lower deltaic region, particularly in the south-west salt water intrusion prevents the use of groundwater for both domestic and agricultural purposes.

Natural calamities and coastal hazards

Flooding regularly affects some 6 million hectares of land in Bangladesh, 5.6 million hectares of which is cultivated land, causing damage to crops, property and human settlements estimated at about US\$ 25 million per year. Government programmes dealing with the water sector in Bangladesh have therefore concentrated particularly on tackling the flood problem, and most of the efforts of the Bangladesh Water Development Board have been directed at flood control. Catchment protection and soil conservation to reduce runoff and flood damage cannot be undertaken on a large scale in Bangladesh because most problem areas do not lie within its geographical territory, but in the Himalayan region. The construction of embankments has, therefore, been taken to be the most practical method for flood protection in the country, since a well managed system of embankments, functioning with sluices and regulators, interior drainage channels and major pumping plants can exclude exterior flood waters.

ENVIRONMENTAL MANAGEMENT AND PLANNING

National policies and strategies

The rationale behind the enactment of a national policy on the environment is to establish a commitment by the state to preserve and improve the environment and thereby the quality of human life, implying not only that environmental factors be kept in view in all activities, public or private, that may have a bearing upon the human environment, but also that the state shall initiate measures to improve the human environment and to rectify the environmental degradation that may be impairing the quality of life.

In declaring the policy the Government recognised that (a) conflicting demands generated by population growth, urbanisation, industrial expansion, rapid natural resource utilization and technological advances have resulted in a piecemeal concept of environmental protection; and that (b) such a concept is not conducive to the attainment of an ideal environmental situation where man and nature can thrive in harmony with one another. Therefore, there was an urgent need "to formulate an intensive, integrated programme of environmental protection that will bring about a concerted effort towards the protection of the entire spectrum of the environment through the requirement of environmental impact assessment."

The Bangladesh National Policy on the Environment is declared to (a) create, develop, maintain and improve conditions under which man and nature can thrive in productive and enjoyable harmony with each other; (b) fulfill the social, economic and other requirements of present and future generations of Bangladesh; and (c) ensure the attainment of an environmental quality that is conducive to a life of dignity and well-being.

Towards the achievement of the broad objective of this Policy, the department of Environmental Pollution Control is assigned the duties, among other things, to (a) monitor on a regular and systematic basis the quality of river, ground-, tap- and lake-water and to analyse them through laboratory tests and to file the findings with the concerned departments; (b) embark upon necessary corrective action to contain water contamination and pollution through executive/punitive action against agents of pollution, wide special powers vested by the Environmental Pollution Control Ordinance (1977); and (c) conduct bioassay experiments on popular species of fish in order to determine their tolerance level in presence of varying concentrations of industrial toxicants in rivers and lake waters.

In pursuing this policy, the Government was to take all measures to (a) recognise, discharge and fulfil responsibilities of each generation as trustees and guardians of the environment for succeeding generations, (b) assure the people of a safe, decent, healthy, productive and aesthetic environment; (c) encourage widest exploitation of the environment without degrading it or endangering human life health and safety, or creating conditions adverse to agriculture, commerce and industry; (d) preserve important historic and cultural aspects of Bangladesh; (e) attain a rationale and orderly balance between population and resource use; and (f) improve the utilization of renewable and non-renewable resources.

Legislative development

The legal system of Bangladesh is based on the English Common Law adopted from the British Colonial period. The 1972 Constitution of the country has since been amended in January 1975 and April 1977 to better reflect the Islamic character of the nation. Resource legislation, such as the laws covering the use of water and the Forest Act of 1927, was promulgated during the British rule and is still in force. Other legislation has been inherited from the State of Pakistan, of which Bangladesh was a province until its separation in 1972.

The Water Pollution Control Regulations were passed in 1970 with the objective of protection, preservation and conservation of the overall environment. The Regulations were subsequently amended in 1973 and promulgated as the Water Pollution Control Act. The major piece of legislation for pollution control in the country today is the Environmental Pollution Control Ordinance promulgated in 1977, which is a 13-article framework law that provides the basis for the regulation of pollution of all kinds, and covers all water bodies, including streams, coastal waters, tanks, lakes, ponds, reservoirs, marshes, water courses, waterways, wells, springs, irrigation systems, drainage systems and all other bodies or accumulations of water, surface or underground, natural, or public or private. The Ordinance established the policy-making Environmental Pollution Control Board and also set up the Pollution Control Cell to implement the policies of the Board, which subsequently became the Department of Environmental Pollution Control (DEPC).

The Director of DEPC is empowered to:

- a) require any person or commercial or industrial undertaking to adopt such measures, including construction, modification, extension or alteration of any disposal system as may be specified therein for the prevention, control and abatement of existing or potential pollution of the environment;
- b) require any person, or commercial or industrial undertaking to furnish such information as may be specified therein relating to wastes, sewerage system, or treatment works in any land or building owned or occupied by such person or undertaking; and
- c) require any person, or commercial or industrial undertaking to permit any officer named therein, to enter upon, inspect or search any land or building owned or occupied by such person or undertaking and to inspect and test any wastes, air, water, soil, plants and materials of disposal system found therein and to afford all reasonable opportunities to such officer for such inspection, search and test.

The orders are legally binding and penalty for failure to comply is a prison term of up to one year or a fine of up to 5,000 Taka (approx. US\$ 170 at the current rates) or both. Further fines may be imposed for every day on which the offence continues. However no cases have so far been adjudicated under this Ordinance and there is no Government lawyer exclusively charged with dealing with issues related to environmental matters.

The Environmental Pollution Control Ordinance also deals with safe and sanitary disposal of solid wastes and control of radioactive substances in the environment.

There is no specific legislation covering environmental impact assessment studies and such analysis is presently being conducted as a 'policy matter' (Hassan, 1978).

A National Environmental Protection Ordinance is in the process of preparation to replace the environmental legislation. This Ordinance is being designed to overcome the drawbacks of the existing environmental pollution control regulations and would basically incorporate amendments to the existing Environmental Pollution Control Ordinance.

For the management of natural resources such as forests, wildlife and mineral resources, separate legislation has been in force since earlier times (some of these laws have been inherited from the British era, such as the Mines Act of 1923 and Forest Act of 1927). These resource legislations are being implemented by the Departments or agencies dealing with these specific resources.

The Mines Act of 1923 does not contain any provisions for the disposal of mine tailings or wastes, and for the reclamation of abandoned mine land.

The Wildlife (Preservation) Order of 1973, which is an amendment of the Wildlife Preservation Act of 1927, lists three schedules of animals. Schedule 1 includes all animals which may be hunted with an ordinary hunting licence or with a special permit; the latter category covers mammals, reptiles and birds, population increase of which threatens the balance of nature of a particular locality or becomes a threat to public life. Schedule 2 includes animals for the possession, transport or import of live specimens, meat, trophies, skins, furs, horns, tusks, etc. of which a certificate of lawful possession is required. Schedule 3 covers protected species which are not to be hunted, killed or captured except in cases of scientific purpose or public safety.

The Territorial Waters and Maritime Zones Act of 1974 provides the definitions and declaration of: territorial waters - a contiguous zone to extend 6 miles (approx. 10 km) from the outer limits of the territorial waters; economic zone and conservation zone. The limits of the continental shelf are also defined and its resources are declared to include mineral and other non-living resources.

Within those areas declared as conservation zones, the Government may "take measures..... it may deem appropriate..... including measures to protect the living resources of the sea from indiscriminate exploitation, depletion or destruction." With regard to pollution, the Government may "with a view to preventing and controlling marine pollution and preserving the quality and ecological balance in the marine environment in the high seas adjacent to the territorial waters, take such measures as it may deem appropriate for the purpose."

Under this Act, the Government may formulate rules and regulations providing for, among other things: measures to protect use and exploit the resources of the economic zone; conservation measures to protect the living resources of the sea; measures regulating the exploration and exploitation of resources within the continental shelf; and measures designated to prevent and control marine pollution of the high seas. Offences against rules made under this Act may be punished with fines of up to 5,000 Taka (approx. US\$ 170 at the current conversation rates), or up to one year imprisonment or both.

The Petroleum Act of 1974 states that persons carrying out petroleum operations are required among other things to: carry out operations in any area in a manner that does not interfere with navigation, fishing and conservation of resources of the sea and seabed; and consider factors connected with the ecology and environment. In particular, care is to be taken to control the flow and prevent wastes to escape in the exploitation area of either petroleum or water.

The Bangladesh Marine Pollution Control Ordinance has been drafted and was in the final stages of promulgation in 1984. The Ordinance is expected to include, among other things, (a) provisions on discharge of oil and pollutants from ships, offshore installations, and seabed exploration and exploitation; (b) provisions for pollution-prevention and pollution-control equipment on ships and offshore installations; (c) provisions on transfer of oil or pollutants at sea; (d) provision for installation of waste reception facilities of Ports and Harbours; and (e) appropriate enforcement machinery, including inspection and penalties for violations.

The Pesticide Rules, which were under consideration by the Government for promulgation in 1984, lay out the regulations and provisions for the import or formulation, registration, testing, packing, storage and transport, application and inspection for all types of pesticides in the country. A list of registered pesticides is appended to these Rules. The Government has also prepared a list of banned, prohibited or restricted pesticides. The banned pesticides include DDT, BHC, Endrin, Lindane, Parathion (Ethyl and Methyl), Telodrin, Methoxychlor Disyston (granules), Thimet (granules), Solvigum and Sevidol; Dieldrin, Heptachlor and Chlordane are allowed to be applied only against soil pests; and all mercurial compounds should be applied only against sugarcane pests.

Bangladesh has become a signatory of the following international maritime conventions:

- a) International Convention for the Safety of Life at Sea (1960)
- b) International Convention on Regulation for the Prevention of Collisions at Sea (1972)
- c) International Convention on Load Lines (1966)
- d) International Convention on Passenger Ships (1961)
- e) International Conference on Space Requirements for Special Trade Passenger Ships (1973)

Considerations are also underway by the Government to accede to the following International Conventions:

- a) Convention for the Safety of Life at Sea (1974).
- b) Convention for the Prevention of Pollution of Sea by Oil (1954, with subsequent amendments).
- c) Convention on Tonnage Measurement of Ships (1969).
- d) Convention relating to Intervention on the High Seas in Case of Oil Pollution Casualties (1969).

- e) Convention on Standards of Training Certification and Watch-keeping for Seafarers (1978).

Institutional arrangements

With the promulgation of the Environmental Pollution Control Ordinance in 1977, the Department of Environmental Pollution Control (DEPC) has become the main governmental institution dealing with the entire sector of environmental pollution control and its management. The specific functions of DEPC as outlined in the Ordinance are (a) to formulate policies for the control, prevention and abatement of environmental pollution; and (b) to suggest measures for the implementation of its policies. It has also the function to co-ordinate inter-ministerial activities relating to the environment and to review and suggest improvements in environmental legislation. Among its concerns are all forms of pollution, including water, air and noise pollution as well as marine pollution.

DEPC is thus the executive policy-implementing agency of the Government and is headed by a Director, who is responsible for implementation of all projects duly approved by the Government and policies formulated for adopting measures for the same.

The Director may require any person, or commercial or industrial undertaking to adopt any measures for the prevention, control or abatement of pollution of the environment; to furnish any information relating to wastes, air pollutants, sewerage systems or treatment works; or to permit any person to enter upon, inspect or search any land, building or factory premises and to inspect and test any wastes, air pollutants, emissions, waters, soil, plants, materials or disposal systems.

The programmes of DEPC include a detailed survey of industries; compilation of monitoring data and water samples analysed in laboratories or in the field; bioassay tests to establish permissible concentrations of various toxic chemicals in industrial effluents; detailed river surveys for pollution abatement; establishment of water and air quality standards; and establishment of a data bank.

DEPC has its headquarters in Dhaka and has four divisional offices at Dhaka, Khulna, Chittagong and Bogra. Each divisional office is headed by a Deputy Director and is responsible for all activities in its area of jurisdiction. There is also a Chemical Laboratory to carry out routine chemical analysis, water quality surveys, pollution monitoring and other tests, including bioassay experiments on the effects of wastes and toxic chemicals on aquatic organisms.

Among the other agencies and departments dealing with environmental matters, the Bangladesh Water Development Board (BWDB) is one of the chief agencies concerned with mitigation and control of floods, and the utilization and development of water resources in the country. It is entrusted with the responsibility for solving problems related to the overflow of water during the monsoon and low flow during the post monsoon seasons including control of flood and ingress of saline water.

The Water Pollution Control Board is responsible for policies dealing with the control, prevention and abatement of water pollution. The Flood

Control and Water Resources Division of the Planning Commission is concerned with water resources planning, flood control problems and their appraisal, and formulation of national water and flood control policies. The Board is to frame schemes providing for (a) construction of dams, reservoirs and other works; (b) irrigation, embankment, drainage and bulk water supply to communities, and recreational use of water resources; (c) flood control including watershed management (d) prevention of salt water intrusion as well as reclamation of land; (e) maintenance, improvement and extension of channels for inland water transport, including dredging of navigation channels; and (f) regulation of channels to concentrate river flow for more efficient movement of water, silt, sand and sediments.

Environmental quality criteria and standards

In 1976, the Government of Bangladesh set up National Committees to establish water quality standards in the country with a view to conserve and enhance the overall quality of the aquatic environment. The existing standards adopted in the various countries vary in accordance with the financial situation of each country to provide for a waste treatment facility and the administrative machinery that may be required for effective implementation of the adopted standards.

Ever since the Water Pollution Control Project began its activities the urgent need for adopting appropriate water quality standards became evident. Keeping this in mind, the Committee concentrated its efforts to form national water quality standards adaptable to the existing conditions. Eventually, three different water quality standards were adopted depending upon their utility viz. (a) drinking purposes; (b) recreational purposes; and (c) fisheries. These standards were set keeping in view the specific physical, chemical and biological characteristics of water most suitable and safe from the human point of view for each type of use. The standards also provide for the maximum allowable concentration of toxic substances safe from the human consumption point of view.

The set water quality standards for drinking purposes are given below:

(a) Physical

Turbidity	25 units
Colour	30 units
Odour	Unobjectionable

(b) Chemical

Total Dissolved solids (TDS)	1,500 ppm
Chloride	600 ppm (up to 1,000 ppm in coastal areas where alternative water sources are not available)
Iron	1 ppm (max. 5 ppm) (up to 6 ppm in exceptional cases)
Manganese	0.5 ppm
Zinc	15 ppm

Copper	1.5 ppm
pH	6.5 - 9.2
SO ₄	400 ppm
Total Hardness (as CaCO ₃)	250 ppm (max. 450 ppm)
Fluoride	1 ppm (max. 2 ppm)
NO ₃	45 ppm (max. 50 ppm)
Phenolic substances (as Phenol)	0.002 ppm

(c) Bacteriological

The arithmetical mean numbers of coliform group organisms shall not exceed 4 per 100 ml of water sample throughout the year.

(d) Toxicological

Cyanide	0.2 ppm
Chromium (Hexavalent)	0.05 ppm
Lead	0.05 ppm

The water used for recreational purposes (bathing and swimming) has set standards of pH 7 - 10; total residual Chlorine 0.3 ppm; and high transparency values. These waters should also not have bacterial population in excess of 200 coliform colonies per 100 ml.

The standards for fishing water are as follows:

Dissolved Oxygen	4 ppm minimum
pH	Above 8.5 (below 6.8 may be lethal)
Temperature	20 - 32°C range throughout the year
Electrical Conductivity	800 x 10 ⁻⁶ mhos
Ammonia	3 ppm max.
Carbon dioxide	2 ppm max.

Environmental impact assessment approach

There is no specific legislation so far in the country to cover environmental impact assessment of development projects and such analysis is presently being conducted as a 'policy matter' (Hassan, 1978).

Environmental monitoring and surveillance

Since 1977, the Department of Environmental Pollution Control is conducting a survey of the types and numbers of industries discharging effluents into water bodies, as well as chemical analysis of the types and concentrations of insecticides and herbicides carried by the major rivers.

Water quality monitoring programme

DEPC operates a network of countrywide monitoring stations to determine

the type and degree of pollution of the water bodies. The main objective of this monitoring programme is to assess the magnitude of pollution in these water bodies and their long-range trends. These include the ten monitoring stations on the major rivers which were established during the Water Pollution Control Project in 1973. These are:

Station	Monitoring
1. Karnaphuli river (near Karnaphuli Paper Mills Complex)	Industrial Pollution
2. Sitalakhya river (near Narayanganj township)	Industrial Pollution
3. Buriganga river (near Chandnighat township)	Dhaka Water Supply
4. Balu river (near Tongi Bridge)	Industrial Pollution
5. Ganges river (near Hardinge Bridge)	River flow from India
6. Brahmaputra river (near Bahadurabad ferry)	River flow from India
7. Meghna river (near Bhairab Bazaar township)	River flow
8. Halda river (Chittagong Water Supply Intake)	Chittagong Water Supply
9. Rupsa river (near Khulna)	Industrial Pollution
10. Lower Ganges river (near Chandpur)	River Water Quality

Surveys conducted since 1975 show that Biochemical Oxygen Demand (BOD) in the Karnaphuli River, Buriganga river and Meghna river may increase to such high levels during the low flow season as to threaten the fish life in the area. E.coli bacterial populations are present in all the areas.

The countrywide water quality monitoring programme includes the following stations which are sampled periodically:

a) Rivers:

Jamuna (Bahadurabad ghat)
Padma (Hardin bridge, Pakshi)
Meghna (Ashuganj)
Karnaphuli (Karnaphuli Paper & Rayon Mills, Sadarghat terminal and T.S.P. Factory)
Sitalakh (Narayanganj, Ghorasal & Demra)
Buriganga (Hazaribagh, Chandni ghat)
Bhairab (Gowalpara ghat, Hospital ghat, Gilatola Bazaar & Charanhat ghat)
Rupsha (Rupsha ghat)
Halda (Mohora, Chittagong)
Balu (Tongi)
Surma (Sylhet)

b) Lakes:

Kaptai

c) Groundwater:

Tube well (Khulna)
Tube well (Barisal)
WASA tube well (Tejgaon)

d) City Water Supply:

Dhaka Water Supply Intake
Chittagong Water Supply Intake.

It has been proposed to establish in, addition, three monitoring stations for marine pollution control.

Coastal zone management plan and coastal land-use planning

A regional survey of legislation dealing with the coastal zones listed Bangladesh as "one of a large group of Asian Coastal States which do not have any significant coastal zone management through legislation" (Hassan, 1978).

There are legal provisions concerning land-use. Municipal Corporations, Upazilas and Statutory Bodies handle various aspects of land-use planning in the country.

In order to better protect life in coastal areas from cyclonic and tidal surges, the Forest Department began in 1966 a programme of planting mangroves outside the protective coastal embankments. The programme was based on evidence that the Sunderban natural mangrove forest provides some protection from wind and waves for the western coastal areas, and thus the expectation that planting of belts of mangroves would give a worthwhile degree of protection to other coastal areas. As the programme proceeded it became apparent that the plantations contributed to the acceleration of the land-accretion process and to the stabilisation of the char lands, with the ultimate potential of the land being sufficiently stabilised to be used for agricultural purposes.

The programme started in 1966 with annual plantings of about 325 hectares and over 30,000 ha had been planted by the end of that decade. Foresters look for evidence of adequate sedimentation and some degree of land stability as indicated by the growth of the pioneering Oryza grass. The mangrove species are then selected according to frequency of inundation and salinity. Mangrove plantations are subjected to thorough thinning about 9 years after establishment. About two-thirds of the planted trees are cut in order to allow the remaining trees to develop better. Eighty per cent of the fuelwood is distributed free to the neighbouring villages and the rest is marketed.

The programme is presently continued with financial assistance from the World Bank. Nowhere else has a mangrove afforestation programme been successfully undertaken on such a large scale.

Management of areas of special ecological interest

The areas of special interest to Bangladesh are the mangrove forests and swamps of the Sunderbans, deltaic islands and coral reefs of St. Martin's Island. The Sunderban mangroves are presently managed through (a) designation of reserve forests; (b) selective felling and cycling of felling; and (c) an extensive afforestation programme as discussed in detail earlier. Afforestation also stabilises deltaic islands through increased land accretion and prevention of erosion. However, action is necessary to prevent overgrazing of pioneering plants on newly formed islands by invading cattle, in order to prevent their ecological deterioration.

Steps are also being considered to manage the only coral reef of the country, located around St. Martin's Island, including its declaration as a marine park as has been repeatedly recommended in the past.

Oil spill contingency plan

An Oil Spill Contingency Plan has been drafted with the assistance of the International Maritime Organization (IMO), which is at present under consideration by the Government for adoption.

Conservation

Conservation of mangrove swamps and coral reefs

All forests in the country are state-owned and three basic categories are recognised depending on their legal status. Of these, the Sunderban mangroves fall under the category of Reserve Forests, where no individuals are allowed to hold any rights and all activities are managed under the authority and supervision of the Forest Department. There is scarcely any human habitation in the area and the Forest Department mans checkpoints wherever waterways enter the Reserve Forests.

The ESCAP/SACEP Symposium on Environmental Management of Mangrove, Coral and Island Ecosystems held in Dhaka on 21 - 25 August 1983 recommended that a Regional Mangrove Institute may be established in Bangladesh for conducting, co-ordinating and documenting mangrove research in countries of the South Asian

Region. The Mangrove Silvicultural Research Centre and Plantation Trial Unit of the Forest Department of Bangladesh could be used as the nucleus of this Institute.

The symposium underlined the need to make a study of the St. Martin's Island and to take measures to check human interference in order to ensure growth and conservation of the coral wealth. Establishment of marine parks as multiple use areas for recreation, research, education and conservation was suggested as possible measures for environmental management of the coral reefs. The symposium also recommended that the Bangladesh Government may consider the urgent need for environmental management measures for the coral reefs, including declaration of the area as a marine park. The first and second St. Martin's Island Scientific Expeditions organised in 1973 and 1979 also made several recommendations for the conservation of this coral reef.

The symposium also underlined the need for identification of ecosystem management and conservation strategies for protecting endangered and threatened ecosystems with special emphasis on traditional systems of management and institutional aspects, existing legislation and problems of their enforcement, need for establishment of national parks, reserves, etc. It noted that declaration of marine parks as multiple use areas with facilities for recreation, research and education in addition to preservation, might go a long way in the management of the coral reefs.

Coral reef management might ultimately be obtained only through the education of the public on their value and importance, and the need to prevent degradation. Endorsing the recommendations of the first and second St. Martin's Island Scientific Expeditions organised in 1973 and 1979, the symposium urged the Government to consider the declaration of the coral reef area as a marine park. This recommendation is presently under study for appropriate action by the Government of Bangladesh.

Protection of endangered and threatened species and habitats

Many species of wildlife in the country today occur in very restricted areas and the most obvious reason for this is the loss of habitat from human encroachment for agricultural and industrial activities or for settlements. Nothing is known about the damage to wildlife from pollution. Wild animals are widely hunted for their skins and furs which are easily available in the local market although laws banning the export of certain species exist. Over 5 per cent of the mammalian species in the country has been estimated to have become extinct over the last 100 years.

The mangroves are an important wildlife habitat of Bangladesh. The wildlife of the mangrove ecosystem of the country comprises about 400 species, including 8 species of amphibians, 50 species of reptilians, 260 species of birds and about 50 species of mammals. Of the species recorded from the mangrove ecosystems, one species each of frog, chelonian, crocodile, stork, sea-eagle, finfoot, oyster-catcher, flowerpecker, tiger and deer; two species each of herons, kingfishers and microchiropterans; three species of snakes and four species of dolphins and porpoises normally do not occur outside the Sunderbans. The crab-eating macaque occurs only in the mangrove formations of the Naaf river in the south-eastern part of Bangladesh.

There are nine species of wildlife in the Sunderbans which have been rated as 'endangered' and one as 'vulnerable' in the Red Data Book of IUCN

(International Union for Conservation of Nature and Natural Resources), whereas CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) included 17 species in its Schedule I and 7 in Schedule II, all of which occur in the mangrove ecosystems.

The royal bengal tiger or bagh (Panthera tigris) widely distributed throughout the country until the beginning of the century, is today found in limited numbers only in these swamps. The species is endangered because of human encroachment and habitat destruction, and a World Wildlife Fund-assisted project is underway for its conservation. Three Wildlife Sanctuaries covering a total area of 324 km² have been designated for their protection.

The spotted deer or chital (Axis axis) and the fishing cat (Felis viverrina) are very common in the marshy areas, river banks and swamps of the Sunderbans. The swamp deer (Cervus duvauceli) is also found in lesser numbers.

Among the birdlife, several species of kingfishers, storks, herons, bitterns, egrets, grebes, cormorants, snakebirds, hornbills, gulls and terns are found in the Sunderbans and in the coastal marshes both as residents and/or migrants. The red jungle fowl (Gallus gallus) and the pied hornbill (Anthracoceros malabaricus) are the most common species. Several species also nest in the Sunderbans.

Several species of poisonous seasnakes occur in the Sunderbans including Kerilla jerdoni, Hydrophis nigrocinctus and H. obscurus.

Sunderbans is the habitat for the mugger crocodile (Crocodilus palustris palustris), the snub-nosed crocodile (C. holustris) and the estuarine crocodile (C. porosus). The fish-eating Gangetic river-crocodile, gahrial or gavial (Gavialis gangeticus), once common in the Ganges and its tributaries is today decreasing in abundance. The mugger crocodile and the Gangetic river-crocodile are included in the List of Endangered and Threatened Wildlife and Plants of the U.S. Fish and Wildlife Service (1979), and the Bangladesh Wildlife (Preservation) Order of 1973 bans their hunting, killing or capture.

Several species of marine turtles occur in the coastal waters and on the coastal and offshore islands. Their eggs are collected in large numbers for local consumption. Several species of marine turtles, river terrapin and freshwater tortoises are on the endangered list for Bangladesh (Hussain, 1974). The following species are included in the List of Endangered and Threatened Wildlife and Plants of the U.S. Fish and Wildlife Service (1979): River terrapin (Batagur baska); Indian flat-shelled tortoise (Lissemys punctata punctata); Black soft-shelled tortoise (Trionyx nigricans); Peacock soft-shelled turtle (T. hurum); and Three-heeled Asian Turtle (Geomyda tricarinata).

The freshwater dolphin (Platanista gangetica) has been reported from all major rivers and tributaries in the country, while the Malay dolphin (Stenella malayana) is occasionally seen in the Sunderbans. The Indian Ocean pilot whale (Globicephala macrorhyncha) has been reported from the coastal waters of the Bay of Bengal (Hussain, 1974).

Under the Bangladesh Wildlife (Protection) Order of 1973 a large number of endangered and threatened species have been given protection in Bangladesh. Schedule 3 of this Order bans the hunting, killing or capture of 67 species of mammals, 22 species of reptiles and 465 species of birds. The

Schedule also includes all mammals, reptiles and birds which are in their immature stage or not fully grown except when they endanger public life; and all female animals when pregnant, suckling or accompanied by their young ones. However, hunting may be permitted under special circumstances, if the increase of any particular species is declared a threat to the balance of nature or it becomes a threat to the public as in the case of man-eating tigers or rogue elephants.

Marine fisheries

Aquatic life is said to be adversely affected by pollution and the Directorate of Fisheries is presently undertaking research on the extent of water pollution and its effects on fish life. The Directorate reports that increasing application of fertilizers and pesticides in agriculture is affecting the spawning of freshwater fish in paddy fields, and that pesticides are killing plankton and affecting their production in the water bodies.

The Directorate of Fisheries has also declared twenty-five fisheries as sanctuaries in order to allow for replenishment of fish populations in adjacent natural water bodies.

Marine parks, sanctuaries and protected areas

Articles 23 and 24 of the Bangladesh Wildlife (Preservation) Order of 1973, provide for the establishment of wildlife sanctuaries, national parks, game reserves or recreation parks. The Government, by notification in the official Gazette, can declare any area as a wildlife sanctuary, and the areas designated for wildlife management would cover about 8 per cent of the total land area of the country at present. Of these, the Royal Bengal Tiger Sanctuaries in the Sunderbans and the Crocodile Reserve in the Selagong river in the Sunderbans, along with some other selected areas, were taken up for development under the first five year plan (1973/74 - 1977/78).

Sunderbans East, Sunderbans West and Sunderbans South (in the Khulna district) are the three designated Royal Bengal Tiger Sanctuaries with areas of 54.4, 90.7 and 178.7 km² respectively. These sanctuaries are closed to hunting, shooting of birds and animals, and are generally to be set aside as undisturbed breeding grounds for the protection of wildlife and their habitat, including vegetation, soil and water. Public access is prohibited, and no exploitation of the forest is allowed except for reducing fire hazards, epidemic insect attacks, etc.

Similarly, hunting, killing and trapping of all species of crocodiles are prohibited in the Sunderbans sector of the Selagong river in order to protect their population and encourage multiplication.

International co-operation

Bangladesh has been co-operating with the various international and United Nations agencies in the field of environment and participating in their activities, conferences and meetings. The assistance of a number of these agencies was also utilised in the development and evolution of environmental concepts, strategies and policies in the country.

Several seminars and workshops were held in the country in co-operation with international agencies, particularly on environmental development and on promotion of environmental awareness and legislative development. Environmental Awareness seminars were also organised recently in collaboration with UNEP and UN/ESCAP. Special mention should be made of a national seminar on the Protection of Marine Environment and Related Ecosystems, which was held in Dhaka during 27-29 November 1979.

Bangladesh is a member of the South Asia Co-operative Environment Programme (SACEP) since its inception, and hosted a Regional Symposium on Environmental Management of Mangrove, Coral and Island Ecosystems in South Asia, which was held in Dhaka during 21-25 August 1983. The Government of Bangladesh also hosted the second meeting of the Governing Council of SACEP at Dhaka on 17 and 18 April, 1985.

Bangladesh has recently drafted an Oil Spill Contingency Programme with the assistance of the International Maritime Organization (IMO) which is presently under consideration by the Government for adoption. The country has become a signatory to five maritime conventions, and considerations are underway by the Government to accede to five additional international conventions.

Recognising the benefits of a regional programme, Bangladesh has extended its full support to the development of a South Asian Seas programme and was one of the sponsors of the resolution on developing this Regional Seas Programme at the 10th session of the Governing Council of UNEP.

Financial aspect of environmental management

A number of Government agencies and departments deal with planning of natural resource utilization and management which have clearcut environmental implications. It is, therefore, practically impossible to make a realistic estimate of the level of expenditure currently incurred for environmental management as a whole in the country. The total cost of the Department of Environmental Pollution Control's on-going water and air quality control programme alone amounts to US\$ 1 million under the current development programme.

ENVIRONMENTAL PROMOTION

Environmental information

The programmes of the Department of Environmental Pollution Control (DEPC) include, among other things, compilation of environmental information and monitoring data, and establishment of a Data Bank. As the central agency dealing with environmental matters in the country DEPC collects and collates all information dealing with environmental aspects of various ecosystems and resources of use to man or of interest to conservation. The information is then disseminated in an appropriate manner to the various departments and agencies dealing with the particular ecosystems and/or resources, to the various mass media, non-governmental organisations and other target groups. DEPC also publishes brochures, pamphlets and booklets to assist in the dissemination of such information.

All analytical data from the chemical laboratories of DEPC are similarly compiled and distributed to the agencies and departments concerned and are also published later in the form of Year Books. Text books are also being published to incorporate the environmental curricula for the schools.

Proceedings of the various meetings, seminars and conferences on various aspects of the environment (many of them organised in collaboration with United Nations agencies) have also been compiled and published including a volume on the marine environment and related ecosystems.

Considering the volume of data presently being accumulated, the Department is aware that it will soon become necessary to establish a Data Bank for systematic storage and retrieval of all environmental information and data. The matter is presently under consideration by the department.

Environmental education

Bangladesh attaches great importance to the development and training of manpower for managing environmental problems and issues. Environment is, therefore, incorporated in the educational curricula from the elementary school level onwards. Five Universities in the country offer courses on environmental sciences, some of which lay special emphasis on aquatic and marine sciences: Dhaka University, Chittagong University, Jahangirnagar University, Bangladesh Agricultural University and Bangladesh University of Engineering and Technology. The Institute of Environmental Research of the Dhaka University conducts research work on environmental aspects, and the Department of Zoology is studying the effects of water pollution on aquatic life. The Institute of Forestry attached to the Chittagong University has several research projects on mangrove ecology and mangrove management. The University also has a Department of Marine Biology which offers degree courses. Jahangirnagar University located in Dhaka offers degree courses in Environmental Science. The Bangladesh Agricultural University situated in Mymensingh has departments of Fishery Biology and Limnology. The Environmental Engineering Division of the Civil Engineering Department of the Bangladesh University of Engineering and Technology located in Dhaka offers undergraduate and post-graduate courses in water supply, urban and rural sanitation water pollution and its control, and waste treatment and disposal, in addition to conducting research in these fields. In addition to these educational institutions, organizations such as the Bangladesh Council of Scientific and Industrial Research also undertake research activities on environmental matters. The Directorate of Fisheries under the Ministry of Fisheries and Livestock also operates a marine biological laboratory.

As regards legal education specifically dealing with environmental issues, arrangements are being made to include environmental legislation in the syllabus of the Law School of Bangladesh.

Environmental awareness

Promotion of awareness has a particularly special significance in Bangladesh where the relatively low literacy figures clearly pinpoint the undesirable effects of hazardous environment and possible benefits that could accrue to the population from the prevention of environmental deterioration. The rural masses in the country share the concern for the betterment of the environment along with the Government and the planners.

DEPC has launched an extensive programme of popular education and promotion of awareness aimed at increasing local support and understanding through the distribution of literature (notices, brochures, pamphlets, booklets and newsletters) and other audiovisual means. For example, the rural population is being appraised of the hazards of environmental pollution through demonstrations of appropriate examples and case studies, as well as a large variety of printed material. Public response is also being measured by arranging national seminars, exhibitions, films, slide shows, field trips, excursions and press briefings. The World Environment Day is appropriately celebrated every year through slogans, posters, brochures, meetings and other publicity activities, including appropriate radio and television programmes aimed at improving environmental knowledge and public awareness.

Promotion of public awareness is a key point of emphasis of the environmental pollution control policy of the Government and this activity is further strengthened through the involvement of the non-governmental organizations (NGOs). The environmental NGOs of Bangladesh play a key role in this respect. These organizations frequently organise discussions, seminars and meetings as well as publish journals, newsletters, bulletins and booklets with particular emphasis on environmental matters of immediate concern to the society and the country. NGOs also actively take part in public debates through newspaper columns on issues of national environmental concern and interest.

The printed media of the press has been making special efforts on their own to promote environmental awareness among the public. For example, the Press Institute of Bangladesh in collaboration with UN/ESCAP jointly organised a workshop on environmental reporting for the mass media in order to demonstrate the viability of the press in promoting awareness of environmental issues and to discuss ways and means by which this could be achieved. A similar seminar on environmental awareness for the mass media was organised in 1979 jointly by DEPC, Press Institute of Bangladesh and UNEP.

Conclusions

It could undoubtedly be stated that the marine environment plays a crucial role in the economy of Bangladesh and the life of the people, and the environment is under stress because of increasing pressure from population growth and demand for resources. In view of the limited knowledge of this environment so far, there is an urgent need to strengthen research and surveys to fill existing information gaps in order to plan the environmental management for the future and promote national expertise in the field of environmental management. The country, therefore, stands to benefit from active participation in regional environmental projects for mutual exchange of information and expertise in tackling problems of common interest. Because of the fast increasing pollution problems and the promises a healthy marine environment holds for the future generations, the country has assigned importance to the protection and management of the marine environment and several steps have already been initiated in this direction. Under the circumstances, Bangladesh is very interested in the development of a South Asian Seas Programme. The country has already agreed to the priority areas agreed upon at the UNEP Meeting of National Focal Points on the Development of an Action Plan for the Protection and Management of the South Asian Seas Region, 19 - 21 March 1984 held in Bangkok.

The various activities and components that should be considered in the development of action plans and programmes in the above priority areas are listed below:

PRIORITIES FOR A REGIONAAL ACTION PLAN

Environmental Assessment

Survey and research

Objectives

Estimate the extent and status of useful marine resources and specialised marine ecosystems.

Evaluate the effects of exploitation and pollution on the marine environment and its resources.

Project component

Survey of the extent and present status of useful marine resources and specialised ecosystems.

Research on the effects of exploitation and pollution on the quality, quantity and sustenance of useful marine resources and specialised marine ecosystems.

Input needs

Training, with special emphasis on field and laboratory methodology and techniques (fellowships/group courses/study tours; national/regional/extra-regional; short-term/long-term).

Equipment for laboratory and field work.

Standardisation and intercalibration exercises.

Environmental pollution and problems

Objectives

Estimate extent of marine environmental problems and level of pollution, and their effects on the marine environment and its resources.

Project component

Environmental effects of marine pollution and maritime activities.

- a) Coastal erosion
- b) Coral and sand mining
- c) Oil pollution & marine dumping

Environmental effects of pollution from land-based activities.

- a) Sanitation, vectors and microbiol pollution
- b) Toxic harzardous wastes from industrial and agricultural sources
- c) Non-toxic wastes from domestic, industrial and agricultural sources
- d) Erosion of topsoil, siltation and sediment transport

Input needs

Same as previous

Regional discussions (conferences, workshops, etc.) for exchange of experiences and technology transfer.

Bilateral technical discussions on aspects of joint utilization of multi-national resources and control of trans-national pollution.

Environment management

Objectives

Identify how the problems could best be managed in an effective manner and prepare programmes for the same.

Provide any technical inputs necessary for the same

Project component

Environmental quality criteria and standards (effluent standards, water quality standards, etc.)

Waste treatment, utilization and recycling programme.

Coastal zone management and land-use planning.

Oil spill contingency plan.

Vector Control Programme.

Environmental impact assessment of projects.

Environmental quality monitoring network and surveillance programme.

Environmental conservation, i.e. marine parks and sanctuaries for endangered wild-life and aquatic species (aquatic birds, crocodiles, turtles mammals, etc.) and specialised marine ecosystems, mangrove forests and coral reefs.

Input needs

Regional discussions (Conferences, workshops, etc.) for exchange of information and technology transfer.

Study tours (regional/extra-regional).

Regional and international expertise.

Equipment for field work.

Legislative aspects

Objectives

Draft supplementary legislation for effective management of marine environment and its resources.

Identify measures for effective implementation of environmental legislation.

Project component

Adoption of supplementary legislation.

Adoption of measures for effective implementation of environmental legislation.

Modalities of institutional arrangements for effective implementation of environmental legislation and co-ordination of environmental management.

Input needs

Regional/sub-regional discussions on adoption of an oil spill contingency plan.

Bilateral discussions on legislative arrangements for management of transnational marine pollution.

Regional discussions on adoption/formulation of international/regional conventions/protocols/treaties dealing with conservation of marine environment and its resources.

Institutional aspects

Objectives

Propose modalities for institutional facilitation of legislative implementation and co-ordination of environmental management.

Project component

Development of institutional arrangements for effective implementation of environmental legislation and co-ordination of environmental management.

Input needs

Study tours to observe the working and efficiency of institutional set-ups for environmental management (regional/extra-regional).

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