COASTAL ENVIRONMENTAL MANAGEMENT PLAN FOR BANGLADESH

Volume One: Summary

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INTRODUCTION

1. Bangladesh is an extraordinarily rich country in terms of land, water, climate and people. It is also an equally poor country in terms of efficiency of utilization of these resources, in terms of investment of surplus in dynamic, sustainable development and in terms of mobilization of the vast majority of the people in the process of development.

2. This wealth and this poverty are reflected in the environmental stress affecting Bangladesh today. On the one hand, the nation enjoys a beautiful coastal environment productive in fish, forests and crops, while, on the other hand, poverty is on the increase: nutritional levels are falling, wood fuel and food are now in short supply and consumption of fish is declining. On the one hand, shrimp exports are booming, shipping and industrial activity are growing and Dhaka exhibits signs of wealth unimaginable 15 years ago; on the other hand, rivers have become cesspools and shipping lanes sewers, forests have in many cases become scrub and bush, soils have become waterlogged and saline and the once rich variety of fish life has dwindled irretrievably. Such contrasting and conflicting development-environment scenarios have been boldly painted in a unique effort jointly undertaken by ESCAP and the Government of Bangladesh through the development of the Coastal Environmental Management Plan (CEMP) and the audio-visual module entitled “The precious wetlands of Bangladesh”. The map on page 3 shows the location of the CEMP study area.

3. This summary report is basically divided into three parts, namely, a brief analysis of the development-environment linkage in the context of Bangladesh, the findings of the study and a set of recommendations endorsed by an Interministerial Symposium on CEMP held at Dhaka in June 1987.

I. DEVELOPMENT-ENVIRONMENT LINKAGE

4. In trying to establish the linkage between development and the environment in Bangladesh, at least two vicious circles can be identified. Pauperization of the masses increases their pressure on the environment: in order to survive, the poor are forced to cut fruit trees for cooking fuel, to over-fish for sustenance and to settle on fragile and unconsolidated land prone to cyclonic devastation. They undercut their children’s chances, spend their children’s patrimony and starve their children of nourishment. Poverty makes the poor relentless enemies of the environment.
5. The second vicious circle involves development: the projects, programmes, schemes, technologies and management institutions that turn human labour into economic growth. Very often such development undermines the long-term sustainability of resources, and since resource availability is the very basis of development, such development is ultimately self-defeating. If resources are wasted and ruined, development is slowed down and may even be halted.

6. In the past, in promoting environmental protection and management efforts in the countries of the ESCAP region, the United Nations has frequently encountered such questions as: Why should the poor developing countries worry about environmental degradation when they have other priority areas of concern? In other words, environmental protection and management is considered by many to be a luxury only to be enjoyed by the rich countries. Unfortunately, however, if the situation was examined carefully, the opposite conclusion would be drawn. If Bangladesh were rich, it could get away with a greater degree of environmental degradation. It could denude its forests and import wood from elsewhere, it could move its most dangerous industries to other countries, it could export pollution with impunity and it could afford to import the protein-rich food and feed needed for its population and livestock. But Bangladesh, of course, is at the other end of that environmental/resources flow. Unless, therefore, it wishes to undercut its children’s chances and spend its children’s patrimony, it should pay due attention to the problem of environmental management now.

7. The CEMP report makes it clear that there can be no separation of environment from development — of poverty from exploitation. It emphasizes that unplanned and uncontrolled projects harm the environment and harm sustained development. It constantly returns to the theme that sustainability is the key, and for sustainability there must be broad-based involvement by all.

8. Sustainability in turn implies that a project should not lead to irreversible environmental impacts. It implies caution in the face of uncertainty, and it implies the necessity of long-term and multisectoral planning based on the knowledge and wisdom of all people involved in the development process.

9. Broad-based involvement implies the necessity of focusing on the needs of the poor, not the greed of the rich, to bring them into the development process as winners and not losers. Thus, for example, the CEMP report has focused on the village environmental aspects of sanitation and biomass, on land-settlement policies and on the need for collective management of water and land resources. It is critical of short-sighted “development” that spews out toxic chemicals, chews up corals, rapes forests and engorges itself on the profits to be made from overexploiting fisheries.
Map of the study area

MAP OF BANGLADESH
Showing the location of the study area

Legend:
- - - - Tidal limit line.
+ + + + Line showing the salinity limit of 1,000 micro-mhos (approx. 6.76 ppt)

Three broad regions of the Bangladesh coastal area.

Study area.
10. Although the CEMP report presents an alarming picture of environmental trends, there is room for some encouragement as well. Against the destruction of the east coast’s mangrove forests can be set the conservation of the Sundarbans. Against a decline in the Sundarbans’ stock of trees can be set our knowledge of that decline and some preliminary, though insufficient, steps that have been taken to arrest the decline. Against the salinization and drainage congestion of the coastal embankments can be set the opportunity offered by the shrimp boom to reinvest profits and mobilize collective efforts to improve water management significantly.

II. FINDINGS OF THE STUDY

A. The coastal environment

11. Bangladesh has an area of about 144,000 square kilometres and a population of more than 100 million. It is situated in the north-eastern part of the South Asian subcontinent and has a vast sea area to the south in the Bay of Bengal. The coastal area of Bangladesh, comprising the complex delta of the Ganges-Brahmaputra-Meghna (GBM) river system, has immense resources with great potential for development. While flowing through Bangladesh on its way to the Bay of Bengal, the river system, carries an estimated annual sediment load of 2.4 billion tons. These sediments are subjected to coastal dynamic processes generated mainly by river flow, tide and wind actions, leading to accretion and erosion in the coastal area of Bangladesh.

12. The coastal morphology of Bangladesh is characterized by:

(a) A vast network of rivers;

(b) An enormous discharge of river water heavily laden with sediments, both suspended and bed load;

(c) A large number of islands in between the channels;

(d) The Swatch of No Ground (a submarine canyon) running NE-SW partially across the continental shelf about 24 km south of the Bangladesh coast;

(e) A funnel-shaped and shallow northern Bay of Bengal, to the north of which the coastal area of Bangladesh is located;

(f) Strong tidal and wind actions;

(g) Tropical cyclones and their associated storm surges.
13. These factors act in complicated ways to bring about geomorphological changes in the Bangladesh coast. The entire coast is about 710 km long and can be broadly divided into three distinct geomorphological regions: the eastern, central and western regions.

14. The eastern coastline extending from the Big Feni River to Badar Mokam (southern tip of the mainland) along Chittagong is regular and unbroken and is protected along the sea by mud flats and submerged sands. The famous Cox's Bazar sand beach about 145 km long is part of the coastline.

15. The central region runs east from the Tetulia River to the Big Feni River estuary and includes the mouth of the combined GBM rivers. As a result, the region is characterized by heavy sediment input, formation of chars (new lands) and bank erosion.

16. The location of erosion and accretion is dependent on the directional flow of the river currents and the tides. Sites of considerable activity include the northern and southern tips of Hatiya and Sandwip islands.

17. The western region covers the Bangladesh coastline westward from the Tetulia River to the international border (with India) located at the Hariabhanga River. This is a stable region and is mostly covered with dense mangrove forests which lessen the bank erosion. Accretion does not occur much in this region.

18. Available maps for different periods suggest massive changes in the coastline over the last 200 years. Two basic influences on the coastline are exerted by the sediment carried by the GBM system and the action of tides. The net result of these and other factors is an approximate net accretion of 35.6 sq km of land per year. New land has been formed south of Hatiya, Manpura and Bhola islands as well as near Char Clark, Char Balua and Uria Char on the Noakhali coast. Erosion is taking place mostly in the north-eastern part of Bhola, the northern part of Hatiya and the north-western part of Sandwip.

19. Geologically, the Bengal basin is an active tectonic region. According to one report, the land in the Noakhali region, has been uplifted by some 150 cm in recent times. At the same time, the Quaternary sediments along the coast, which may be as thick as 3,000 m, show indications of large-scale subsidence caused by compaction of recent sediments and possibly by structural downwarping.

20. Tectonic activity and land subsidence, combined with the greenhouse effect caused by the depletion of the ozone layer, large-scale defor-
estation and increased burning of fossil fuels and aided by a lower rate of sediment deposition due to the construction of dams, dikes, etc., may, according to one estimate, cause a relative rise in the sea level and inundate 40-45 per cent of the present area of Bangladesh, displacing up to 30 million people by the year 2050.

21. The Chittagong region is geologically different from the rest of the coast. The plains in the coast have been formed mainly by piedmont alluvial deposits transported from the Chittagong Hills by local streams and rivers.

22. Coastal Bangladesh is typified by the general tropical climate of the country with the predominance of the monsoon during June-September, cooler, rainless periods during October-February and a hot and humid summer during March-June. The mean annual rainfall varies from 150 cm in the west in the Khulna region to over 380 cm south of Cox's Bazar. Cyclonic storms are an important feature of the coastal climate and occur during both the monsoon and pre- and post-monsoon periods. The latter are the most destructive type. Some examples of these are the May 1985 Urir Char cyclone, the November 1970 cyclone, the great cyclone of 1919, the Bakarganj cyclone of 1876 and the Barisal cyclone of 1584.

23. Storm winds move at speeds of up to 240 km per hour and cause widespread damage. The most devastating element is storm surges 3 to 6 m high, which can theoretically be as high as 7.5 m.

24. The soils of the coast, as stated earlier, are generally sediment deposits of the GBM and other rivers. Such soils are fertile, but salinity intrusion, both normal and that during cyclones, offsets part of the fertility. One third or the arable land can be classified as saline in the coastal zone, with Khulna and Patuakhali being the most affected regions.

25. Land use in the coastal region can be classified into two broad categories, natural and human. The mangroves in the Khulna region and in patches along the Chittagong coast are part of the natural forest vegetation. Much of the rest of the land is used for agriculture, where the cropping pattern is dictated by various factors including salinity. A major factor in controlling salinity in the past was massive investment in the construction of coastal embankment. Recently, however, the spread of shrimp cultivation has resulted in a weakening of the system through breaches in and lack of repair of the embankments. Apart from agriculture, another important land use is artificial afforestation carried out by the Forestry Department.
B. Mangrove forests

1. Location and vegetational composition

26. In the eastern part of the coast located within the Cox’s Bazar district there is a small patch of forest (about 7,500 ha) known as the Chakaria Sundarban occupying the central part of the delta of the Matamahuri River. The vegetation consists of salt-water halophytes with an abundance of *Dalbergia spinosa* and *Algialitis rotundifolia*. There are only about 20 species of trees and none attains a height of 12 m. (*Avicennia tomentosa*) is the commonest of the larger trees. *Keora (Sonneratia apatata)* is prominent on the sea front and river banks while, on higher grounds, *sundri (Heritiera fomes)* is the dominant species.

27. A strip of the bank of the River Naf contains a small patch of mangrove vegetation consisting mainly of *gewa (Excoecaria agallocha)* and *Ceriops noxburghiana*). Near Teknaf, Jhaliardwip Island is covered by a beautiful *keora* forest of over 300 ha and is a habitat of crabeating monkeys.

28. West of the GBM delta lies the most important mangrove forest, the Sundarbans. This is the largest mangrove forest in the world in one patch and covers a total area of 571,508 ha, of which about 170,000 ha consists of rivers, channels and other watercourses. Out of a land area of 401,600 ha, 395,500 ha is occupied by forest and the remaining 6,100 ha is scrub jungle, grassland or bare ground.

29. The Sundarbans receive large volumes of fresh water from inland rivers flowing from the north and saline water from tidal incursions from the sea. The fresh water is charged with alluvium which contains plant nutrients and this, together with the salinity of the tidal water, is a major factor affecting the forest ecosystem. The numerous rivers and streams which dissect the Sundarbans in a north-south direction are or were distributaries of the Ganges. These rivers partially combine to form the five main estuaries which provide the major points of ingress for saline-water intrusion. The crucial problem in the present-day Sundarbans is that only two of them, the Baleshwar and Passur systems, have direct connections to the Ganges and thus to an uninterrupted source of fresh water.

30. Because of the salinity to which the vegetation has to be adapted, the forest flora are not rich in species. They are dominated by *sundri (Heritiera fomes), gewa (Excoecaria agallocha), goran (Ceriops decandra)* and *keora (Sonneratia apatata)*. There are about 25 other species which are common but considerably less frequent in their occurrence.

31. In general, the forest in the northern and eastern parts of the Sundarbans, which are better supplied with fresh water, is floristically richer than that in the south and west.
Three ecological zones within the Sundarbans differentiated according to salinity and species composition have been recognized. The fresh-water zone consists of all the forest to the north and east of an imaginary line drawn from the Kopotakha Forest Station at the northern boundary to the mouth of the Katka Khal on the sea face. The Moderately saline zone lies to the west of this line but east of the Malancha River. The forest west of the Malancha River is the salt-water zone. The respective characteristic species are sundri (*H. fomes*), gewa (*E. agallocha*) and goran (*C. decandra*). In every zone, however, there are both pure and mixed stands of various proportions of species. The vegetation which colonizes newly accreted land does not fit exclusively into any of the three main ecological zones. Once land has accreted to a stage where it can support woody vegetation, stands of keora (*S. apatula*) develop.

2. **Mangrove resources and their management**

The Sundarbans have been under some form of management since 1875 and most of the forests were declared reserve forests in 1879. Up to 1985, there were a total of seven working plans or revisions of working plans. The most comprehensive plan and the one that remains a definitive record of many aspects of the Sundarbans was that compiled by Curtis for the period 1931-1951.

The major and latest inventory of the forest since that by Curtis was compiled by the Land Resources Development Centre of the United Kingdom in 1983 and 1984 based on aerial survey and ground mapping. The results include estimates, in respect of the main species, of number of stems per hectare, mean volume per hectare and total standing volume. The results also include an assessment of the regeneration status in the forest.

The principal finding of the inventory is that the standing volume of the two main commercial species, sundri and gewa, has declined since the previous inventory 20 years ago. The volume of sundri has decreased by 40 per cent since 1959 and that of gewa by 45 per cent. The reduction of stock is mainly due to:

(a) Rates of removal in excess of allowable rates, especially for fuelwood;

(b) High level of removal (36 per cent or more in the case of sundri) of immature stems;

(c) Increased incidence of top-dying of sundri, which can be attributed to increased salinity;
(d) Overestimation in 1959 of the rate of increment of sundri and gewa, particularly the latter.

36. The mangroves support a wide range of mammals, birds, amphibia, reptiles and crustacea. Certain of the animal species in the Sundarbans, including the Royal Bengal Tiger and estuarine crocodile, are internationally recognized as being in danger of extinction.

37. Thirty-two mammal species are known to occur or to have occurred in the Sundarbans, but of these no less than four major species, the Javan rhinoceros (*Rhinoceros sondaicus*), wild buffalo (*Bubalus huybalis*), swamp deer (*Cervus duvauceli*) and hog deer (*Axis porcinus*) have become extinct since the beginning of the century. The following are rough population estimates of the larger terrestrial mammals at present:

<table>
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<th>Species</th>
<th>Population</th>
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<tr>
<td>Spotted deer</td>
<td>80,000</td>
</tr>
<tr>
<td>Wild boar</td>
<td>20,000</td>
</tr>
<tr>
<td>Tiger</td>
<td>350</td>
</tr>
<tr>
<td>Rhesus macaque</td>
<td>40,000</td>
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<tr>
<td>Otter</td>
<td>20,000</td>
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38. The deer particularly are hunted and trapped illegally for meat and skins. The tigers are endangered not only because of their small number, but also because their complete isolation prevents genetic interchange between them and other populations.

39. Incomplete estimates record 186 species of birds in the Sundarbans. They provide an immense service to neighbouring cultivation by feeding on insects which often cause considerable damage to crops.

40. About 35 reptile species and 8 species of frogs and toads have been recorded in the Sundarbans. Of these, the mugger or marsh crocodile (*Crocodylus palustris*) is now extinct, while the salt-water crocodile, three species of lizards and the rock python (*Python molurus*) may soon be no more owing to illegal and overexploitation.

41. There are reported to be over 120 species of fish commonly caught in the Sundarbans. Crustacea account for by far the largest proportion of animal biomass, with an estimated 40,000 metric tons of fiddler crabs and 100,000 metric tons of mud-crabs. There is also a considerable harvest of shrimps, prawns and lobsters.

42. The primary productivity of the mangrove forests is manifest in the accumulation of biomass (wood, roots, leaves, etc.). Leaves, which are continually being shed by plants, undergo decomposition and result in particulate organic matter (POM) and dissolved organic matter (DOM) that enter the estuarine ecosystem.
43. The POM, which consists of small particles, is consumed by larval and juvenile organisms that use the mangrove habitat as a nursery and feeding ground. The DOM, which consists of a wide range of soluble organic compounds, is consumed by filter feeders (oysters and mussels) that are common in the nearshore environment and that retain the phyto, nauno and micro plankton which need DOM to synthesize organic matter. In addition, any organic matter that is transported seaward is flocculated by the increasing salinity. The flocculated organic matter (FOM) becomes a substrate for benthic feeders and scavengers.

44. The algae, planktons, benthos and micro fauna are essential features of the mangrove ecosystem and they determine to a large extent the variety, quality and quantity of fish, shrimp and other crustacea.

45. The mangroves in Bangladesh are under ecological stress, which is sometimes quite severe in nature. The recent inventory has revealed that there has been depletion in the stocking of the Sundarbans and has confirmed the top-dying of sundri (H. fomes) trees in certain localities. The depletion of stocking is attributed to overexploitation and to top-dying of Heritiera. The apparent deterioration in the composition of the flora may be partly due to increased salinity.

46. The Chakaria Sundarban faces problems of a more severe nature. This forest was reserved in 1903. Management practices involve restricted exploitation and limited grazing. In the past, these restrictions were observed mostly in the breach. The depletion of the Chakaria Sundarban mangroves has accelerated since the late 1970s as a result of the conversion of forests into shrimp farms. So far, more than 3,000 ha have been allotted to private individuals for shrimp cultivation, accounting for close to half the forest land.

47. At this stage, mention should be made of the coastal afforestation efforts by the forestry authorities. Afforestation in the coastal area commenced on a modest scale in 1966 with the planting of seedlings on the slopes of embankments of the Water Development Board. The success of these plantations led to a more ambitious programme in the newly accreted land with several objectives, including protection of land from erosion, creation of shelterbelts to protect life and property inland from tidal bores and creation of an environment for wildlife, fishes and other estuarine and marine fauna. Up to 1985, more than 76,000 ha were planted, 40,000 ha of which were afforested between 1981 and 1985. Species used in coastal afforestation are keora (S. apatata), baen (Avicennia officinalis) and sadda baen (A. alba). Kankra (Bruguiera gymnorrhiza) has been planted to a limited extent. Other species include (Acacia arabica and A. catechu in higher land along embankments and golpatta (Nypa fruticans) in new accretions and lower areas of embankments.
3. *Production and management of the Sundarbans*

48. An understanding of the Sundarban production system demands first an understanding of the relationship between tree species and salinity level or ecological zones. As stated earlier, sundri is predominant in the fresh-water zone, goran in the salt-water zone and gewa in between. For the present, sundri reigns supreme in terms of areal coverage whether as pure forest (20 per cent of the area) or as mixed ones (30 per cent as dominant and about 10 per cent as second dominant, total 40 per cent of the area). In terms of merchantable volume, sundri accounts for nearly two thirds of the total of 10.6 million m³. The next two in importance are gewa (17 per cent) and keora (4 per cent).

49. Sundri is naturally the major timber that is harvested. Other species cut for timber or wood are baen, kandra, dhundul and keora. Gewa is cut mainly for use as pulpwod in newsprint mills and matchwood in match factories. Fuelwood is one major product. Usually the upper parts of trees felled for timber are exploited as fuelwood, while goran is felled particularly for this purpose.

50. The output of round timber is growing at nearly 11 per cent per annum and the estimated present output is likely to be 200,000 m³. The extraction of industrial round wood (gewa) has moved up at a rate of nearly 9 per cent per annum. However, during 1984-1985 and 1985-1986, the rate of extraction was more than double that for the 11 years from 1973/74 to 1983/84, in spite of clear recommendations that overexploitation should be stopped.

51. Fuelwood harvesting has increased faster than that of other woods, namely, by 13 per cent. The wood is marketed over a large part of Bangladesh.

52. The major animal product harvested from the Sundarbans is fish, of which over 120 species are caught. The major species are hilsa and shrimp. During the recent past, the average catch was around 9,000 tons.

53. The exploitation of resources from the Sundarbans is managed through a system of auction, licences and permits on the basis of work plans. Timber harvesting is through bidding at auctions. The implicit or explicit royalty rates per unit of output bear little relationship to market prices. The ratio of market price to royalty rate varies from a minimum of 4:1 (in case of sundri round wood) to 40:1 (for sundri fuelwood) and 136:1 (for prawns). The quasi-rent to be reaped in each case is thus staggeringly high.

54. Total revenue from the royalties in recent years was 150 million taka or more. Of this, sundri timber alone accounted for nearly 80 per cent.
55. A considerable level of employment has been maintained within the Sundarbans. Employment is also generated by the industrial processing of raw materials derived from the forest. The probable direct employment offered by the Sundarbans is likely to be in the range of 500,000-600,000 people for at least half of the year. Formal industrial sector employment is likely to be of the order of 10,000. One should also include probably 90-95 per cent of the boatmakers in Khulna, Barisal and Jessore, the bulk of the labourers engaged in roof thatching and those in furniture making.

56. Most of the employment goes to poor people with low wages, probably lower even than those for agricultural labourers. Fishermen, however, are probably better off than most other labourers.

57. The ecological stress in the Sundarbans has already been referred to above. Overexploitation, whether because of population pressure, poverty, management inefficiency or simply greed, may deplete the largest mangrove forest (in on patch in the world to such an extent that it may no longer be classified as a forest. Such a future is likely to have an effect on the economy not only because forest products will no longer be exploited and the people employed in their extraction, processing and trade will have to look for practically non-existent alternative employment elsewhere, but also because agriculture, the mainstay of the economy, will suffer to a considerable extent as a drier climate sets in and as the nutrient-recycling function of the mangroves disappears.

C. Fisheries

58. Perhaps no sector illustrates the Bangladesh environmental dilemma more clearly than fisheries. Environmental changes induced by development projects in other sectors are major threats to the fishery sector; yet, ironically, the fishery sector itself is now expanding with scant regard for its own environmental impact.

59. In the coastal areas, the natural nursery and grazing grounds of many marine and estuarine fishes and prawns have been eliminated by the coastal embankments. The expansion of shrimp cultivation is threatening mangroves and increasing soil salinity, while the exploitation of marine fishes may have reached the limit of the sustainable harvest.

1. Shrimp culture

60. Currently, brackish-water shrimp/fish aquaculture is practised mainly in Khulna but also in the district of Cox's Bazar along the Chittagong coast. In the Khulna region, the cropping pattern is brackish-water shrimp culture in the dry months followed by a crop of a local variety of transplanted *aman* rice in the wet months from July-August to November-
December on the same land. In some areas, shrimp is grown as a single crop. In Cox’s Bazar, shrimp is followed by salt production, which takes place during the sunny period from December to April.

61. When shrimp is the only crop in a field, the preparation of shrimp ghers (enclosures) is taken up in December or January. Harvesting usually begins in the first week of April, by which time individual shrimps have attained an average heads-on weight of 35 g.

62. During July and August, when the water inside the ghers and the adjacent water becomes less saline or fresh, post-larvae of giant fresh-water prawns (golds chingree: Macrobrachium rosenbergii) are stocked. Fin fishes too enter the gher. By October-November, all the fresh-water shrimp and all the fin fishes are completely harvested.

63. When shrimp culture is followed by rice, one crop of local transplanted rice is grown between July and November following the crop of shrimp. For this, saline water from the inundated fields within the ghers is drained out by the end of July. Thereafter, rain water is allowed to accumulate and is drained out to remove salinity in the soil for paddy cultivation. However, as the water in the paddy fields is fresh, M. rosenbergii (golds chingree) and other fin fishes are also released and later harvested.

64. By 1985, a total of nearly 67,000 ha were under shrimp cultivation in the Khulna (46,000 ha) and Chittagong (21,000 ha) regions, representing around 8.5 and 3.3 per cent of the land in the regions, respectively. Some 2,400 farms were involved.

65. Shrimp yields at present are low and vary by locality from around 50 kg/ha of \textit{P. monodon} (bagda chingree, the most sought-after variety) in the Chittagong region to nearly 160 kg/ha in Satkhira. Even such low yields have allowed Bangladesh to earn an increasing amount by way of exports. In 1975/76, export earnings from shrimp were a mere Tk 145 million, rising to about Tk 550 million by 1980/81, when explosive growth began. By 1985/86, the value of exported shrimp increased to over Tk 2.7 billion. Semi-intensive technology can raise the average yield to 500-600 kg/ha or more, implying a truly staggering level of possible export earnings and a great incentive for those who can to get on the bandwagon.

66. Given the nature of the present institutional framework in shrimp farming, such growth will be a mixed blessing at best since the environmental costs and social tensions will rise, offsetting part, if not all, of the gain. The irony is that many of these costs are avoidable.

67. The available evidence indicates that shrimp culture is done on relatively large tracts of land owned by people ranging from large landow-
ners to very small farmers. The following types of ownership/control are observed:

(a) Single or household operation on own land;
(b) Single control but with hired labour (on own or rented land);
(c) Many owners, all or most of whom control and participate in cultivation;
(d) Small number of owners and local people carrying out shrimp culture on land which is partly theirs and partly rented;
(e) Shrimp culture basically controlled by outsiders.

68. Two points have been observed about such ownership and/or control. These are that the average size of the farms increases from (a) to (e) and that, although (c) is the most frequently observed type of arrangement (nearly half of all farmers), the farm area under them is only about a third of the total. However, while outsiders may operate only about 20 per cent of the farms, they control 43 per cent of the area. This is one source of social tension in the shrimp culture zone.

69. The second source of tension is the way the income distribution takes place. On the face of it, everybody gains. The available evidence indicates that, on average, the leaseholder (who rents land for shrimp farming) gets about a third of the income and the landowner (from whom the land is leased) receives about 30 per cent, while the sharecropper (to whom the leaseholder entrusts the responsibility for rice farming after shrimps are harvested) obtains a quarter. Wage labour receives just about 10 per cent. Upon close examination of these figures, one cannot but express serious concern.

70. Take the landowners first. They receive nearly Tk 5,000 as rent per ha of land rented out to shrimp farmers. And the landowners are in many cases small and medium-sized ones. As the rent is fixed, an increasing income situation worsens their relative position. Worse than this, however, may be the fact that, as the shrimp farmers are in general influential people, they may not always pay their rental to the landowners.

71. The third source of social friction is that shrimp farming requires about 20-22 per cent less labour than t. aman. But two further points need to be kept in mind. In shrimp farming, nearly all labour is hired while in rice farming the corresponding figure may be no more than 70-80 per cent of total labour. Again, while threshing and husking of paddy used to generate employment for women, mostly from within the farm, that has now been replaced by women deheaders and women fry catchers and
sellers. Thus, on the whole, it is difficult to judge whether labour has gained or lost in terms of employment. Practically all the evidence suggests that the average labour earning per day has gone up owing to shrimp culture.

72. All these are short-term phenomena and in the long term several ills-effects of shrimp farming are likely to be felt unless some of the trends are corrected immediately. First, the lure of high income is inducing shrimp farmers, particularly the large ones, to illegally force small landowners to lease their land for shrimp culture (by forcing saline water into their fields) and also to encroach upon mangrove forest land whether legally or illegally, thus initiating a process of self-destruction by breaking the food chain from detritus to shrimp in those forests. If the mangroves vanish, shrimps including many others shall vanish too.

73. Secondly, the rice yield may not so far have been affected in shrimp fields. But over time, there will be an accumulation of salt, lowering paddy yield and forcing the landowner to lease the land permanently to shrimp farmers. There will be a loss in paddy production and an increase in social tension.

74. Thirdly, the present low-yielding technology is partially responsible for the extensive method of shrimp cultivation. At least a semi-intensive technology should be encouraged so that the inducement for legal or illegal seizure of land is lessened.

75. Shrimp farming is giving rise to other environmental problems, which include loss of grazing land, loss of sources of fresh water and a fall in tree cover owing to the rise in salinity.

2. Marine fisheries

76. Information on the marine fishery resources of Bangladesh is as yet incomplete. Various surveys done over the last 20 years or so indicate that the size of the maximum harvestable annual stock is around 175,000 tons. The present catch is of similar magnitude or more and is rising at nearly 11 per cent per annum. Thus, Bangladesh may have started over-fishing, a process which is likely to have a profound and adverse impact on the environment and long-term development of the country. Shrimp catches, however, are probably still within environmentally tolerable limits.

77. Two types of issues are relevant in the present context: first, the technology of production and second the organization of production and the way the two mesh with each other.

78. Small-scale marine fisheries account for the bulk (85 per cent) of the fish catch and about half of the shrimp catch. Among small-scale fisheries,
there are non-mechanized (75 per cent or more) and mechanized boats (25 per cent). Nearly 185,000-190,000 fishermen are involved, about 112,000 (60 per cent) of them in primary production. There were some 75 trawlers in 1983/84, with the number decreasing to 45 by 1985/86.

79. In both trawlers and mechanized fishing boats, the initial investments needed are high and are beyond the reach of professional fishermen, who are usually poor and landless. In both cases, capital investments are made to procure trawlers/mechanized boats by entrepreneurs and investors with influence and money. Fishermen work under them as wage labourers.

80. In the case of fishing with non-mechanized boats and when mechanized boats are owned by fishermen, elaborate institutional mechanisms ensure that everybody from the owner of the boat to the fishermen, be the highly skilled or semi-skilled, receive a more or less fair share of the proceeds from the catch. In cases where the boats and trawlers are owned by entrepreneurs and investors, not bound by such social customs, the fishermen end up with relatively much lower income.

81. Provided that the maximum sustainable harvest is as mentioned earlier, continued mechanization and the ownership of boats passing to investors from outside the community may have environmentally, socially and economically disastrous consequences. Environmental disruption will follow from increased over-fishing due to mechanization. This will lower the income and employment of already poor fishermen in non-mechanized boats as these cannot go to the deep seas. Of course, there will be a short-term bonanza for the owners of mechanized boats, mostly outsiders, as their boats can prowl the deep seas and come back laden with fish. However, over-fishing will disrupt the environmental chain in the Bay of Bengal with as yet unknown consequences.

82. The nutritional and health consequences may also be adverse, although it is difficult to assess to what degree, but certainly more severe in the coastal areas, leading to lowered protein and iodine intake.

D. Land and water development projects

1. Coastal embankments

83. To protect the land in the coastal area, which was subjected to regular or periodic incursions of saline water, the construction of small dikes or embankments has been practised since the seventeenth century. During recent times, in 1967, the Government took up an organized programme of construction under the coastal embankment project (CEP), which consists of a large number of polders, to control flooding, in which sluices are provided to facilitate drainage from inside empoldered land.
Phase I of CEP, which is now complete, consists of 92 polders with about 400 km of embankments and 780 sluices and protects nearly 1 million hectares of land.

84. The original purpose of CEP was to increase agricultural production by providing flood protection and drainage facilities. Therefore, the principal benefits occurring would be an increase in crop yield due to salinity reduction, an increase in cropping intensity as a result of flood protection and a decrease in fallow and idle lands. Crop yields have increased two- to threefold and there is no longer any idle land inside the polders. However, the actual benefit from the project has been far below the potential. This is mainly because CEP has no water management component. Further, the distribution of benefits from the project has been rather unequal and the inequality increases over time. The construction of CEP, of course, had little to do with such inequitable distribution, which is rather governed by the existing pattern of land ownership.

85. The recent phenomenon of shrimp cultivation inside the polders, while boosting the national economy, has created a serious controversy owing to environmental and ecological considerations. It has also given rise to a number of problems and conflicts between rice farmers and shrimp cultivators. The major problem of the CEP are:

(a) Embankments have deteriorated and may be breached or overtopped by cyclonic storm surges;

(b) Absence of irrigation facilities;

(c) Embankment cutting by farmers to obtain irrigation water;

(d) Inadequate drainage provisions;

(e) Siltation of rivers, rendering sluices inoperative;

(f) Shrimp farming is in conflict with agricultural practices;

(g) HYV rice suitable for the coastal area has not been developed yet;

(h) Absence of farmers' organization and lack of credit facilities.

86. To rehabilitate the polders, assist the poor and enable them to derive benefits from CEP, a pilot project has been undertaken and completed. The pilot project was carried out in polder 22, which is located in the semi-saline zone and is a small polder consisting of 1,500 ha of land. The investigations established that improved water management together with the introduction of HYV or "local improved varieties" would increase
the yield substantially. The construction of irrigation inlets resolves not only irrigation problems in the *aman* season but also eliminates the cutting of embankments by farmers. Unscientific methods of shrimp farming, which are currently affecting areas beyond the shrimp farms by spillage of saline water, are the major cause of conflict. Further effects of shrimp cultivation on agriculture, soil salinity and the flora and fauna of the area will be very damaging in the long run. However, in the semi-saline zone the conflict is more social in nature. The attainment of full benefits from CEP is dependent on two related factors: the availability of water for irrigation and the salinity of soil and water. It is possible to manage land use in the polder in an environmentally sounder manner. In order to achieve this, the study recommends action research on improvement of shrimp cultivation and shrimp farm management practices, improvement of water management through construction of pipe inlets and formation of users' groups, and establishment of pilot farms for the introduction of advanced agricultural practices.

2. Cross-dams

87. The Bangladesh Water Development Board (BWDB) constructed two cross-dams in the Meghna estuary in 1957 and 1964 across the channel between Noakhali on the mainland and Ramgati Island, which have resulted in the accretion of new land, estimated to amount to 80,000 ha. These lands are now being fully used for agriculture.

88. The islands of Hatiya and Sandwip are currently facing severe problems of erosion, especially in their northern ends. To prevent such erosion from taking place in the north of Sandwip and also to facilitate the accretion of a vast tract of land from the bay (about 23,000 ha), a cross-dam is being proposed to connect Sandwip Island and the Noakhali mainland. The feasibility study of the cross-dam project anticipated no increase in erosional activity in other locations in the estuary. However, since the area is dynamically active, careful monitoring of the new tidal regime is recommended. The feasibility study also evaluated the ecological and environmental aspects of the cross-dam and found them to be of minimal consequence.

89. Through the land reclamation project (LRP), the BWDB also proposes to take up a number of cross-dam projects in the estuary, namely, Manpura-Goalia cross-dams, Hatiya south cross-dam, Hatiya north cross-dam, etc. LRP has also taken up studies for optimum land and water development in newly accreted land through a pilot research plot and pilot polder. It has also conducted studies to try out various methods to accelerate the accretion of land along the coast. The role of mangrove forests in land accretion and the stabilization of newly formed land needs to properly assessed through action research.
3. Salinity

90. Recently, owing to a reduction in the upland fresh-water supply in the south-western part of the coastal area as a result of diversion and withdrawal of the Ganges flow at an upstream location, the advancement of the saline front in the dry months has become a matter of alarm and concern. The salinity equilibrium in the Meghna estuary has also been disturbed on account of the same reduction of flow as water is being utilized upstream. In planning water development projects in the country, the limiting condition will be the maximum diversion that may be made without resulting in a saline intrusion in the Meghna estuary as well as in the Khulna region. An in-depth study to establish and predict the fresh-water/saline-water interaction is now essential for this purpose. Mathematical modelling exercises are recommended.

4. Navigability

91. Inland navigation has always been a principal means of transport, especially in the coastal region. During last 15-20 years, considerable and rapid deterioration has taken place in the river system and navigation routes through massive siltation, instability of rivers and closure of channels for flood control purposes. The coastal embankment project has seriously hampered the local riveting transport system and has been identified as the cause of siltation in the Mongla Port area. To evaluate the siltation and erosion rates of the rivers in the coastal areas, regular hydraulic surveys are needed at selected locations.

E. Biocides

92. No systematic study has been made to assess the concentration of agro-chemical residues in the coastal water and their effect on the environment. Analysis of limited data indicates some effects of very low levels of nitrate and phosphate pollution. At present, about 20 insecticides, 18 fungicides and 2 rodenticides are being used in Bangladesh. Among the organochlorine types of synthetic organic insecticides, aldrin, dieldrin, endrin and heptachlor are common in Bangladesh. Following the ban on DDT in developed countries, Bangladesh has also taken similar steps but its indiscriminate use in Bangladesh in the 1960s for the malaria eradication programme has resulted in high-level concentration in humans compared with those in Western countries. Each year, flood water inundates about one third of the total area of the country and carries the agro-chemical residues into the river system for final discharge at the coast. Systematic monitoring and assessment of the use of biocides in the country as a whole as well as over the entire river basin is therefore necessary to understand the effects on the coastal region and to protect it.
F. Environmental health and sanitation

1. Water supply

93. The water in 81,000 ponds scattered over the coastal belt is the main source of water supply for domestic consumption in the rural areas. The quality of water is the major constraint in water supply. Salt-water intrusion in surface and ground waters, especially in the dry season, is the major problem. Brackish water is available within 0 to 2.5 m below ground surface. Pockets and lenses of fresh water are available and are tapped by hand tubewells. The quality of the water is acceptable from the bacteriological point of view, but chlorides, iron and hardness are present in excess of the internationally acceptable limits.

94. For public water supply in the townships, the Department of Public Health Engineering (DPHE) pumps water from deep aquifers (between 150 and 350 m). Piped water supply is available only in a few major urban centres. The total number of deep tubewells was about 8,500 in June 1986; they supplied drinking water to about 40 per cent of the population. DPHE has been installing a large number of hand pumps to tap water from shallow aquifers. Rain-water harvesting is practised on a limited scale, mainly on offshore islands. Owing to the unequal distribution of rainfall throughout the year, a system completely based on rain water requires large reservoirs; the potential of rain water as a supplementary water source is very good, however. Water consumption as well as the use of tubewell water for drinking purposes is strongly related to the socio-economic condition of the household, with wealthier families owning private hand pumps.

2. Coastal sanitation

95. In the municipal areas, the traditional sanitation practice prevails, in which night soil collected in buckets is removed by manual labourers. In 1985, some 9 per cent of the urban population used this method. A more common latrine is an elevated enclosure along streams, rivers, ponds or over a shallow pit where the faecal matter is either washed away or decomposes on its own. A majority of the population, however, use open places, bushes and the sides of embankments and rivers to relieve themselves. As such, sanitation in the coastal region needs attention and improvement.

96. With UNICEF assistance, DPHE is popularizing the use of pour-flush pit latrines with water-sealed pans. The Local Government Engineering Bureau has taken up a low-cost sanitation programme for municipal areas, while Chittagong Municipality has undertaken a massive programme for water-sealed latrines for Chittagong on an urgent basis.
3. Present health situation

97. The general health situation in the coastal area is not different from that of rest of the country. The infant mortality rate is 110 per 1,000 live births. Malnutrition is believed to affect over 80 per cent of infants and young children and 25 per cent of them are grossly malnourished. The most common diseases are diarrhoea, dysentery, typhoid, tetanus, respiratory tract infections, tuberculosis, whooping cough, malaria, scabies, worm infections and night blindness. The occurrence of diarrhoea in the coastal region is higher, however, because of the scarcity of safe water, improper sanitation practices and lack of knowledge of personal hygiene.

G. Biomass crisis

98. Bangladesh is at present going through a rural energy and biomass crisis. Although much of the forest land, including mangroves, is in the coastal areas, this zone too suffers from the same problems.

99. Apart from food, the energy equivalent of the rest of the biomass supply comes to about 256 PJ per year in the coastal districts. Of this, about 30 per cent each is used as fuel and fodder while a significant amount (17 per cent) is wasted.

100. Agricultural residue is the most important source of biomass. Nearly one half of such residues are used as fodder. In the case of forestry, whether village or State-owned, most residues (up to 72 per cent in the case of the former) are utilized as fuel.

101. Biomass fuels are used mainly for cooking, whether measured in physical or energy units (nearly 88 per cent — rural and urban combined). The other major use is for parboiling (8 per cent).

102. Nearly 60 per cent of the biomass fuel comes from agricultural residues while village forests and animal residues contribute 17-18 per cent and 10-11 per cent respectively.

103. The total consumption of biomass fuel (8.1 million tons or 111 PJ) is about a third more than its apparent supply. As supply and demand (including stocks) must balance, the obvious implication is that there is a problem with one estimate or another. Deeper probing narrows the focus to the supply from the reserve forest, which is problematic, and indicates actual removals far in excess (probably by a factor of three) of the estimated figure based on official data. Corroborating evidence from other government reports shows that such may indeed be the case.
H. Industrial and marine pollution

1. Industrial pollution

104. While industrialization in Bangladesh is still at the emerging level, problems of industrial pollution are quite prominent. To promote the process of industrialization, Bangladesh welcomes the establishment of industries, and transnationals have taken up the opportunity of a total lack of enforced industrial and marine pollution regulations to exploit natural resources like fuels, minerals, timber, fish and leather at the cost of damage to the environment. Primary and heavily polluting industries like the steel, non-ferrous metals, fertilizers, pesticides, asbestos, cement, toxic chemicals, pharmaceuticals and leather industries have taken this opportunity.

105. Nearly 144 industries in eight industrial zones of Chittagong, namely, Kalurghat, Nashirabad/Sholoshahar, Patenga, Kaptai, Bhatiari, Barabkunda and Fauzderhat, situated on the bank of the Karnaphuli River or on the coast, discharge their untreated toxic wastes directly into the river or the bay. Among the polluting industries in those areas are tanneries, textile/cotton mills, an oil refinery, a TSP plant, a steel mill, a paper mill and rayon complex, cement factories, detergent plants, and pesticide, paint and dye manufacturing plants. None of these industries have any existing or planned pollution treatment facility. The effluent generated daily from these industries is huge in quantity and contains both degradable and persistent organic and inorganic wates and toxic metallic compounds and chemicals.

106. Khulna is another fast-growing industrial centre in the coastal region. Nearly 165 industries are located in three industrial zones, namely, Rupsa, Khalisipur and Shiromony. Among the polluting industries are a new sprint mill, jute mills, fish processing units, hardboard mills and wood processing plants. The effluent from these industries is discharged into the Bairyub-Rupsa River system and none of them have any waste treatment plant.

2. Marine pollution by municipal wastes

107. The townships and human settlements in the coastal areas discharge untreated effluents directly into the rivers. The populous cities of Chittagong and Khulna have poor sanitary conditions and it is common practice to dump all garbage and wastes into the rivers. The major channels which carry sewage and wastes reverse their flows at high tide and spread into the coastal city areas, causing pathogenic microbial pollution and serious health hazards.
3. Marine pollution by oil

Nearly 1,000 ships and 40-50 oil tankers in Chittagong Port and nearly 500 ships at Mongla Port are handled annually. Moreover, numerous river craft and launches ply along waterways and discharge waste oil, spillages and bilge washings. These are the main sources of pollution of the marine environment. Spillage of crude oil and its derivatives, discharge of ballast water and water used for washing the cargo tanks or oil tanks, discharge of untreated bilge-water and sewage from ships, and disposal of bottom sludges of residual heavy oil and other lubricants and engine oil are causing severe pollution of the water in the coastal reaches and marine environment.

4. Pollution load estimation

The total pollution load as biodegradable organics in sewage and industrial wastes dumped into the River Karnaphuli in terms of kg of BOD/day has been estimated as 40,000 to 45,000. The BOD level in the river water is found to vary from 0.7 to 38 ppm in certain locations with an average of 3.0 ppm. Although the average BOD level is still within acceptable limits, the high value of BOD in the industrial effluents is serious. By the year 2000, the population will increase several times and the level of industrialization is expected to rise. As a result, the enormous amount of sewage that will be generated will cause severe pollution problems in its ultimate disposal sink — the Karnaphuli and the estuary.

A few potentially toxic persistent organic compounds from chemical and pharmaceutical industries are dumped into the river. A careful study to assess residue levels should be started soon. As the indiscriminate use of pesticides is increasing, assessment of pesticide residues is also imperative. Currently about 4,000 tons of pesticides are used in the country annually and about 25 per cent of them may reach coastal water. Insoluble inorganic pollutants are also present at levels higher than those acceptable internationally. Level of mercury, lead, chromium, arsenic, cadmium and iron are very high. The level of chromium in tannery waste near tannery waste outfalls in Chittagong is as high as 200 ppm (as against a 0.05 ppm standard allowable limit). Near the ship-breaking yard, the content of ammonia and iron are much higher than the allowable range. The estimate of crude spillage at Chittagong is about 6,000 metric tons per year, while about 240,000 gal/yr of bilge-water is dumped into the river. Crude oil residue and wash water from the refinery have been estimated to be about 50,000 tons per/year. The Sundarbans are now in danger because of chronic spillages of oil in the Mongla Port area. There is always a possibility of accidental oil spillage from oil tankers, through which the ecosystem of the Sundarbans may suffer irreversible damage. The effects of industrial effluents on the mangrove ecosystem are not yet
clearly understood. Recently, the mortality of trees in the Sundarbans has been on the increase owing to unfavourable conditions (including changes in salinity levels). A conservative estimate made by the Forestry Department showed that Bangladesh had sustained a financial loss of $100 million owing to the loss of 1,440,000 cubic metres of timber caused by the death of sundri alone since 1976.

111. To combat the effects of any major oil spillage in the Bay of Bengal, or the Andaman Sea, contingency plans have been evolved delineating responsibilities for the operational response by various agencies. These plans have not yet been promulgated by the Government. The development and enforcement of marine and port pollution control legislation is essential for proper management and protection of the coastal environment. But appropriate legislation in this regard has yet to be developed in Bangladesh. The very fast rate of increase in the level of all sources and types of pollutants calls for immediate regulatory measures.

I. Tourism

112. Bangladesh has no significant tourist industry. Although the nation has what are reputed to be the world's longest sand beach and the world's largest area of contiguous mangrove forest — both almost completely unspoiled by tourists — few tourists stop in Bangladesh. The country's international reputation and cultural conservatism are not attractive to those seeking the "good life".

113. As a consequence, tourism in Bangladesh means, and for some time will continue to mean, domestic tourism, and this implies Cox's Bazar. This is not to deny the possibility of limited international tourism to see the Royal Bengal Tiger in the Sundarbans or to visit the beaches and islands of the south-east coast. It is rather to emphasize that, for the time being, such tourism can be expected to be minor and easily controlled.

114. A focus on the Cox's Bazar district quickly uncovers a host of environmental crises that strongly impact, or could impact on tourism. are crises created or at least exacerbated by tourism, and some threaten the growth and quality of tourism. In rough order of priority, they may be enumerated as follows:

(a) Destruction of the ecology of St. Martin's Island;

(b) Water pollution from oil, industrial and municipal wastes and shrimp processing;

(c) Elimination of shells, turtles and other wildlife;
RECOMMENDATIONS

115. An interministerial symposium was held at Dhaka on 3-4 June 1987 on the Coastal Environment Management Plan for Bangladesh. The symposium discussed the integrated report which has been summarized above. The symposium was inaugurated by the Honourable Minister for Planning, Air Vice Marshal (R) A.K. Khondaker, while the Honourable Minister for Agriculture, Mirza Ruhul Amin, attended as the Special Guest. The symposium was attended by 42 representatives of various relevant ministries and implementing agencies. After two days of deliberations, the participants endorsed a set of conclusions and recommendations for the management of the environment in the coastal region of Bangladesh which had been presented to it by the ESCAP secretariat, with appropriate revisions and modifications.

116. The recommendation of the study can be grouped into four broad categories. These are:

(a) Programmes to create public awareness about and to ensure people's participation in environmental management;

(b) Action to strengthen administrative and regulatory machineries and measures;

(c) Priority programmes for further investigation, action research and monitoring of the environmental aspects of development;

(d) Investment projects with the objective of promoting economic development while conserving or enhancing ecosystem productivity and environmental quality.

A. Public awareness and people's participation

117. Creation of public awareness about the problem of environmental degradation caused by unco-ordinated development efforts of various sorts and unrestricted private activities is a major task that has to be taken up in all earnest.

118. The press, radio, television and cinema can play a very important role in this regard. Particular emphasis should be given to the interdependence of the preservation of environmental quality and the development of the economy and people's welfare.
119. Furthermore, people’s participation needs to be ensured for the greater benefit of all. This is particularly true in the case of resources exploitation in the Sundarbans and fishing, shrimp culture and water management in the coastal area.

B. Administrative and regulatory actions

1. Environmental policy and planning

120. The fundamental principles of the State policy of Bangladesh should duly recognize the environmental and ecological principles underlying development activities. All development plans should integrate environmental considerations into the planning, design and implementation of all development programmes and projects. Furthermore, there is a need for the Government to enunciate clearly its policies with respect to certain key environmental issues, which include: (a) overexploitation of the Sundarbans, (b) industrial and marine pollution and (c) wildlife.

121. An environmental planning unit should be established within the planning commission which would review environmental impact assessment studies of projects and certify compliance of development with environmental sustainability in accordance with project analysis suitably modified to integrate ecological and environmental considerations with more conventional ones.

122. A task force should be set up by the Planning Commission to review and suggest measures for the preservation of environmental quality. It should examine proposals to improve administrative authority manpower and logistics in the existing relevant institutions like the Department of Environment Pollution Control; recommend the establishment of new agencies, organizations or cells, if necessary; delineate priority areas of environmental stress and pollution for immediate intervention; and suggest measures for a legal framework for environmental protection and its application.

123. Apart from general administrative and regulatory measures, action plans which relate to various ecosystems on the coast need to be initiated, both in general and specifically.

124. A general area of concern is the problem of oil spills. Before disaster strikes, Bangladesh needs an oil spill contingency plan with the requisite equipment and training facilities. Marine pollution control legislation should be enacted and strictly enforced, particularly in and around the port of Chalna, where an oil-spill clean-up operation would be virtually impossible.
2. Preservation of critical areas

125. The Sundarban wildlife needs protected areas, free from human interference. Small areas have been delineated in the past, but they are insufficient and there are indications that human activities occur within these areas. Several wildlife studies have strongly recommended the expansion of wildlife sanctuaries and their protection; these recommendations should be implemented without delay.

126. The Chakaria and Teknaf mangrove forests have nearly all been destroyed. There remains a glimmer of hope, however, that as awareness increases of the value of mangroves for the shrimp-fish business and the supply of fuelwood and other tree products, some parts of these east coast mangrove forests can be saved and managed for the national benefit.

127. St. Martin's the only coral island in Bangladesh and is a unique natural resource under tremendous pressure from immigration, livestock, tourism, coral exploitation, shell and turtle destruction and vegetation overcutting.

128. On the basis of further studies and investigations, an action programme for the sustainable ecological management of the Sundarbans, including wildlife sanctuaries, the Chakaria and Teknaf mangroves, St. Martins Island and other critical coastal areas, should be developed and implemented. The government should enact legislation (wherever appropriate) and ensure its strict enforcement.

3. Forestry Department

129. Four range offices and 14 field stations having inadequate manpower, transport, communications and patrol equipment make it virtually impossible for the Department to implement the administrative and regulatory decisions of the Government in the Sundarbans. Therefore, it is recommended that the Forestry Department should be adequately strengthened if it is to perform its task of monitoring and controlling logging operations and other forest extraction activities.

4. Financial resources for environmental ecological rehabilitation

130. On the basis of the "polluter pays" principle, the Government should impose fines for effluent discharge on industries and ships adding to marine pollution in the coastal waters of Bangladesh with a view to stopping it once for all.

131. The Government should also periodically review the royalties for extraction of forest products, fine violators of wildlife laws and levy a
national parks fee on tourists visiting the Sundarbans and St. Martin’s Island.

132. Finally, ways and means should be explored for investment in polder improvement, for which some form of duty might be levied on shrimp culture and income. The exact form of such a duty, particularly the specific situation where it can be imposed, needs to be carefully studied and worked out.

C. Studies, research and monitoring

133. Throughout the discussions in the symposium, areas for further studies, investigation and monitoring were identified. Such work should be carried out by the various research and academic institutions within the country in close collaboration with the relevant government ministries and agencies.

134. Studies may be classified on the basis of whether they refer to the coastal zone in general or to specific ecosystems within the area. Further, these may be either scientific or socio-economic. Following are some of the priority areas for research, studies, investigation and monitoring.

1. Land-use planning

135. Land-use planning may refer to both macro planning regarding the area specificity of various ecosystems or micro planning within them. At the macro level, planning is needed especially for activities which compete for the same land, more specifically crop agriculture, livestock, shrimp and biomass (particularly trees). Further, the area delimitations for other ecosystems like the Sundarban, Chakaria and Teknaf mangroves and St. Martin’s Island must be clearly spelt out.

136. Micro land-use planning refers to that within each ecosystem. Water and land management on a polder-by-polder basis, the use of newly accreted land, land management on St. Martin’s Island, etc., fall under this category.

2. Mangrove research

137. Bangladesh needs focused action research to help to halt the deterioration of the Sundarbans and an integrated resources management plan. Some of the priority areas are as follows:

(a) A full-scale, international effort needs to be mounted to diagnose the causes of the sundri top-dying process and develop an approach to counter the problem;
(b) Plantation trials of indigenous and exotic species of mangroves to reforest degraded areas and also to increase stock;

(c) Assessment of a sustainable yield of fish from the Sundarbans;

(d) Monitoring of forest stocks to revise management plans;

(e) Socio-economic study of the Sundarbans;

(f) Other mangrove research needs:
   (i) Improved honey technology;
   (ii) Grass production;
   (iii) Nipa-to-alcohol;
   (iv) Wildlife dynamics.

3. Study of inter-polder hydraulic interactions for polder rehabilitation

138. Before huge sums of money are spent on polder rehabilitation only to find that the situation has not improved or has worsened, a clearer understanding of inter-polder hydraulic interactions is required. This could be done most effectively through mathematical modelling. Furthermore, environmental changes in the south-west, from decreases in freshwater in-flow, tectonic shifts or any other phenomena, need to be better understood and continuously monitored.

4. Noakhali-Sandwip cross-dam

139. Bangladesh constructed cross-dams in the past, resulting in the accretion of vast areas of land. The experience should be reviewed and evaluated to be used as a guide for the present, especially with regard to the appropriate use of the accreted land.

140. Given the magnitude of this project, there should be continuous monitoring of the impact if and when construction is initiated. A comprehensive review should be made of the Netherlands experts' conclusions regarding the role of coastal afforestation, the rate of land settlement, impacts on migratory birds and fish (hilsha) and effects on the erosion of Bhola and other islands. Furthermore, a mathematical modelling study should be conducted of the possible effects of the cross-dam on the outer anchorage of Chittagong Port.

141. With reference to paragraph 139, there is a clear need for a full social and economic evaluation of the earlier experiences to arrive at a socially optimum land-use plan.
5. *Coast-specific farming systems*

142. The coast has a tendency to be ignored in agricultural research. This neglect needs to be redressed, taking into account the farming systems needs of farmers in saline and semi-saline areas. Priority areas of agricultural research in coastal areas should focus on:

(a) Salt-tolerant varietal improvement;

(b) Salt-tolerant fodder grasses;

(c) Salt-water/fresh-water shrimp aquaculture;

(d) Agro-forestry;

(e) Soil fertility maintenance strategies.

It should be mentioned, however, that the importance of such research depends on the macro land-use plan and its emphasis on agriculture vis-à-vis livestock, forestry, fishery, etc. This aspect needs more attention.

6. *Fish*

143. A long-term effort should be undertaken to assess stocks and optimum sustainable yields of fish in different environments (e.g., marine, coastal, estuarine, Sundarban) and of different species. Some efforts are in progress and should be continued. Other studies that are required include:

(a) Population dynamics and habitat requirements of major species of fish;

(b) Socio-economic issues related to fishing, fish processing and marketing and fishermen, with particular attention to the role of technology.

7. *Biomass*

144. There are various programmes and projects on social and community forestry in the country, including the coastal areas. Research is needed to ascertain their effectiveness in solving the problem of biomass supply.

145. Production and distribution of biomass, particularly tree biomass, should feature in any micro land-use planning in newly accreted land and polders.
8. Pollution

146. The problem of industrial and urban pollution is fast becoming worse. Monitoring industrial and urban pollution in coastal areas and the environmental impacts of pollution on the health of the people in and around the major seaports has become a priority area for research.

9. Tourism

147. The preparation of a master plan for the development of tourism in Cox’s Bazar needs to be taken up keeping in view the growth in tourism, preservation of the quality of the coastal environment, minimization of pollution and land-use conflicts, and a proper legislative and administrative framework.

D. Investment projects

148. Various investment projects should be undertaken as a follow-up of studies and recommendations. These might be as follows:

1. Mangrove management

149. Two types of investment projects related to mangroves may be called for. First the Government should actively consider setting up an integrated mangrove research institute to co-ordinate and integrate research on mangroves. Second, the intended integrated resources management plan may give rise to various proposals for investment which may include replanting in denuded areas, expansion of wildlife sanctuaries, strengthening the institutional capabilities of the Forestry Department and credit facilities for people employed in the Sundarbans.

2. Water management

150. Further pilot polder projects should be launched to improve water management for multiple uses. Uniform monitoring and evaluation across polders needs to be carried out for comparison purposes. These projects need to include funds for structural improvements, farming systems research and demonstration and farmer-group organization.

3. Coastal water supply

151. Based on upazilla-level hydrogeological mapping, a coastal water supply scheme needs to be launched with the goal of equal access by all to safe water. Pilot projects on the development of sand filters, infiltration galleries and rain-water collection should be launched to determine
their cost-effectiveness, leading to a large-scale programme to transfer these technologies to the coastal areas, if found economically and socially attractive. Mature technologies like deep and shallow tubewells can be installed simultaneously in those areas where they are the most cost-effective alternatives.

4. Social forestry

152. The rural energy crisis can best be solved through a large, community-based social forestry scheme. Emphasis needs to be on community involvement, group management of plantation areas, private and cooperative nurseries and agro-forestry (for crops, livestock, fuels and income). Furthermore, an integral component of such an action programme should be the development and dissemination, on a wide scale, of more fuel-efficient cooking stoves. It is understood that there are programmes in operation along the lines suggested. These should continue and be expanded and modified if necessary.

153. As a measure to alleviate rural poverty, a programme should be set up to encourage the active participation of the poor people in development activities with a view to better management of the coastal environment. As suggested earlier, group credit to poor people engaged in the exploitation of natural resources in the Sundarbans and other mangrove areas might go a long way in this regard. Similarly, land management in the newly accreted land should attach high priority to the collective use of land. In the case of water management, land-use planning on a polder-by-polder basis should lead to the following:

(a) Groups formed by hydrological units;

(b) Integrated working of the farm units (shrimp ponds or paddy fields);

(c) Group access to credit;

(d) Group management of ponds and beels for higher production.
The Park has two species of *Rhizophora* and four species of *Bruguiera*.

- *Rhizophora apiculata*
- *Rhizophora mucronata*
- *Bruguiera parviflora*
- *Bruguiera cylindrica*
- *Bruguiera sexangular*
- *Bruguiera gymnorrhiza*

**Verbenaceae**

The mangrove species of the family Verbenaceae is represented by the genus *Avicennia*. *Avicennia* is characterised by the presence of pencil like pneumatophores. They also have flowers that are small and yellow in colour. The roots grow in the seed while still on the tree; however it does not come out of the seed until after it has fallen to the ground.

The Park has three species of *Avicennia*.

- *Avicennia marina*
- *Avicennia alba*
- *Avicennia officinalis*

**Sonneratiaceae**

The mangrove species of the family Sonneratiaceae is the genus *Sonneratia*. This genus has pneumatophores, and a six lobed starlike calyx which is persistent (does not drop off). The styles is also persistent and the big flowers open at dusk with petals and stamens falling at dawn.

The Park has two species of *Sonneratia*.

- *Sonneratia alba*
- *Sonneratia caseolaris*

**Euphorbiaceae**

The mangrove genus of this family is *Excoecaria*. It belongs to the rubber family and is easily distinguished from the other genera as this is the only one which has latex. The flowers are minute and spiked. Male and female flowers are found separately and all the flower parts are in threes (3 sepals, 3 stamens, 3 styles, 3 chambered ovary, and three lobed capsule).

The park has only one species of *Excoecaria*.

- *Excoecaria agallocha*
One of the major ecosystems of Kuala Selangor Nature Park is the Mangrove Forest. The mangroves play an important role in the ecology of the area and hence enhances and sustains the economic activities of Kuala Selangor District.

Where conservation is concerned, the mangrove in an important element of the Park and, for the State of Selangor. The smooth otter, silvered leaf monkey, leopard cat, Lesser Adjutant Stork and the mangrove butterfly are directly dependent on the mangroves for their survival. Some of these animals are already on the endangered list.

Ecologically, mangroves play an important role in the prevention of soil erosion caused by the flow of the river and by the activity of tides. The detritus formed by the decaying of dead leaves enables the mangroves to continually supply nutrients to the micro-organisms, shellfish, molluscs, etc. These in turn become food for larger predators. The mangroves also act as a spawning and breeding ground for crabs, worms, shellfish, molluscs, etc.

In the local economy, mangroves have been a major source of fuel in the form of fire wood and charcoal. The poles are used for buildings and for construction piling. Fishermen and locals use them for tannin extraction and in traditional medicine. The fishing industry, which is more productive on the west coast, is directly linked with the presence of mangrove along the whole coast.

This brochure provides information on what mangroves are and how to identify the genera present in the Park.

Mangroves are a community of plants which have adapted themselves to survive in a salt water environment. These plants differ greatly in their phylogenetic make-up as they come from different, unrelated plant families but share similar adaptive characteristics. Mangroves prefer and grow better in protected estuaries, as very few plants are able to grow in these environments; and thus therefore, there is minimum competition for survival.

This environment however creates some adverse conditions for which the species have developed adaptations which characterise them as mangrove plants. The adverse conditions that restrict plant growth are:

1. The salt content of the sea water.
2. The anaerobic condition of the soil which deprives the roots of air (oxygen).
3. The tidal action which washes away their seeds.

Different families of mangrove plants have evolved specific means of overcoming these problems. By identifying these characters, we can easily recognise the families and then the genera and species.

Adaptations

1. High salt content.

All plants take in water and minerals through the process of osmosis. This poses a problem in saline conditions as salt is also taken in with water. Thus, the plants must have a way of getting rid of the excess salt. The plant *Avicennia* has developed salt glands which excrete the excess salt. On the other hand the plant *Excoecaria* stores the salt in older leaves. These leaves are then shed by the plant. This type of plant is also capable of excluding the intake of salt with the use of special filtration cells. The plant *Rhizophora* can also exclude salt through this method.

2. Lack of air (oxygen).

Like all parts of the plant, roots need oxygen to survive. Due to the accumulation of mud, high water table, and constant tidal flooding sufficient air is not available to the roots. This condition is defined as an anaerobic soil condition. To overcome this, plants like *Avicennia*, *Sonneratia* and *Excoecaria* have developed breathing roots or pneumatophores. These roots contain a large section of aerenchyma cells, which are capable of storing air. They also have minute openings called lenticels for gaseous exchange to occur. In the above mentioned plants, the pneumatophores are thin pencil like vertical projections coming out from the cable root.

*Bruguierea* roots also have the same kind of cells and structure but their shape is like a knee. Thus, they are named knee roots. *Rhizophora* lack pneumatophores but their stilts, or prop roots have many aerenchyma cells for air retention.

3. Vivipary

This is a condition which mangrove plants have developed to ensure that their seeds are not washed away by the tides before they have a chance to germinate and become seedlings. Vivipary is when the seeds mature and the radicle develop while the fruit is still on the tree. When the condition is right, the spear shaped seedling detaches and pierces into the soft mud, thus anchoring the seedling firmly. By this method, the seeds have a high rate of becoming trees. Plants like the *Rhizophora* and *Bruguierea* have this adaptation. *Avicennia* has a tiny hook at the end of the seed which helps in attachment. It hooks itself to the breathing roots or to the soft mud.

Kuala Selangor Nature Park has 12 species of Mangrove plants and the following can be used as a guide to identify them.

The 12 plants come under 4 families and 5 genera namely:

<table>
<thead>
<tr>
<th>Family</th>
<th>Genera</th>
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<tbody>
<tr>
<td>a. Rhizophoraceae</td>
<td><em>Rhizophora</em> : <em>Bruguierea</em></td>
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<tr>
<td>b. Verbenaceae</td>
<td><em>Avicennia</em></td>
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<td>c. Sonneratiae</td>
<td><em>Sonneratia</em></td>
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<tr>
<td>d. Euphorbiaceae</td>
<td><em>Excoecaria</em></td>
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*Rhizophoraceae*

The main characteristic of the mangrove species of the family Rhizophoraceae is the true vivipary nature of their seeds. Two genera is found in the Park, namely *Rhizophora* and *Bruguierea*. One is *Rhizophora* and the other *Bruguierea*. For quick and simple identification between these genera, the following table is helpful.

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<th>Roots</th>
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<td>stilts</td>
<td>4 lobed</td>
<td>long and thick</td>
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<tr>
<td>knee roots</td>
<td>8-16 lobed</td>
<td>short and thin</td>
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<td>more than 30cm</td>
<td>less than 15cm</td>
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