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A review on the present status and management of mangrove wetland habitat resources in Bangladesh with emphasis on mangrove fisheries and aquaculture

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Abstract

The mangrove forest of Bangladesh, the largest continuous mangrove bulk, is one of the most important features of the coastal area of the country. The existence of the mangrove has increased the values of other coastal and marine resources such as the coastal and marine fisheries by increasing productivity and supporting a wide biological diversity. The deltaic mangrove of Bangladesh is ecologically different from the other, mostly nondeltaic mangroves of the world and is unique also in its floral and faunal assemblage; therefore, a number of endangered plants and animals that are extinct from other parts of the world, are existing in Bangladesh mangrove. However, the mangrove has been under intensive pressure of exploitation for the last few decades which, in addition to direct clearance and conversion have placed the mangrove under extreme threat. Shrimp farming is the most destructive form of resource use the mangrove has been converted to, which contributed significantly to mangrove destruction with a corresponding loss of biological resources. Concerns have been raised among the ecologists, biologists, managers and policy makers since the early 1990s; deliberate destruction of mangrove and unplanned development of coastal aquaculture particularly shrimp aquaculture have been put under extreme criticism and the sustainability has been questioned. The present status of the mangrove resources including mangrove fisheries and aquaculture and management practices have been reviewed in this paper; impacts of different forms of human interventions and resource use have also been discussed. It is suggested that the management options and the policy aspects should be critically reviewed and amended accordingly; beneficiaries and stakeholders at all levels of resource exploitation must take part and contribute to conservation and management. An immediate need for mangrove conservation has been identified.

Introduction

Mangrove forest is one of the primary features of the coastlines throughout the tropics and subtropics of the world and, locally known as 'Sundarbans', mangroves in Bangladesh is one of the major important coastal habitats and a major component of the vegetative cover in the coastal region. Substantial areas of mangrove forests are found in Bangladesh, Cambodia, India, Indonesia, Malaysia, Myanmar, New Guinea, Pakistan, Philippines, Thailand, Vietnam, and in the West India (Fig. 1). The Sundarbans mangrove forest is located in the Gangetic delta (Ganges-Brahmaputra-Meghna) of India and Bangladesh, is the largest single chunk of continuous mangrove forest in the world (Gittings & Akonda, 1982; Chaudhury & Naithani, 1985; Hussain & Acharya, 1994), covering an area of 10 000 km^2 of which 62% fall within the territory of Bangladesh, covering an area of 6500 km^2 (FAO, 2003) (Fig. 1). At one time, mangrove forest in Bangladesh was

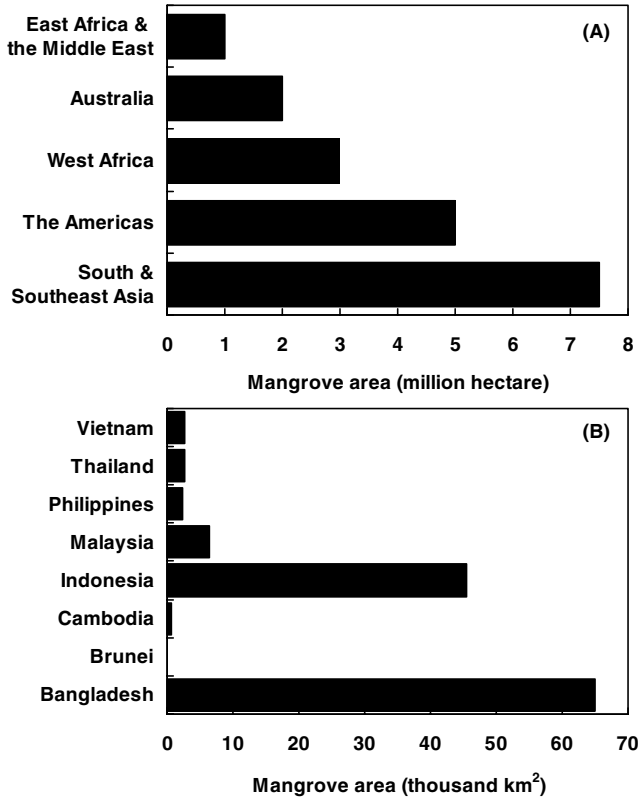

Figure 1. Relative proportions of mangrove coverage. (A) Global distribution of mangrove forests with the South and Southeast Asia having the largest mangrove area (Kathiresan & Bingham, 2001). (B) Distribution of Asian mangrove showing the largest area in Bangladesh (FAO, 2003).

distributed along much of the coastal belt of the southwestern region, but is now confined to the Sundarban reserve forest and offshore islands (Fig. 2). In the eighteenth century, before the process of land reclamation began, the total area of the forests including the Indian part was 16 700 km^2. Being the source of a variety of renewable resources, mangroves are playing significant role in the local coastal economy and livelihood of the people, in the national economic development and also in the global environmental balance. Baran & Hambrey (1998) described the major features of the estuarine environment including the dependence of coastal resources on estuarine and mangrove environment and also highlighted why mangroves are a particular case of an estuarine environment. The ecological significance of mangrove forests has now been universally recognized. Forests in Bangladesh cover an approximate area of 577 000 hectares (Hussain & Acharya, 1994) which stand for about 17% of the total area of the country (Das & Siddiqi, 1985), of which 401 600 hectares are land forests and the remaining 175 600 hectares are temporarily or permanently inundated by water in the form of rivers, canals or tidal floodlands. The mangrove is one of the three major forest types of Bangladesh and one of the most important features of the coastal areas comprising about 50% of the productive forests of Bangladesh (FAO, 1981, 1993).

Mangroves in Bangladesh have two major regional distributions. The first and the largest of which is the southwest region covering greater Khulna District, namely, the Sundarbans mangrove forest and the other is the southeast region covering greater Chittagong District, namely, the Chakaria Sundarbans. The mangrove forest is very rich in biotic diversity supporting around 330

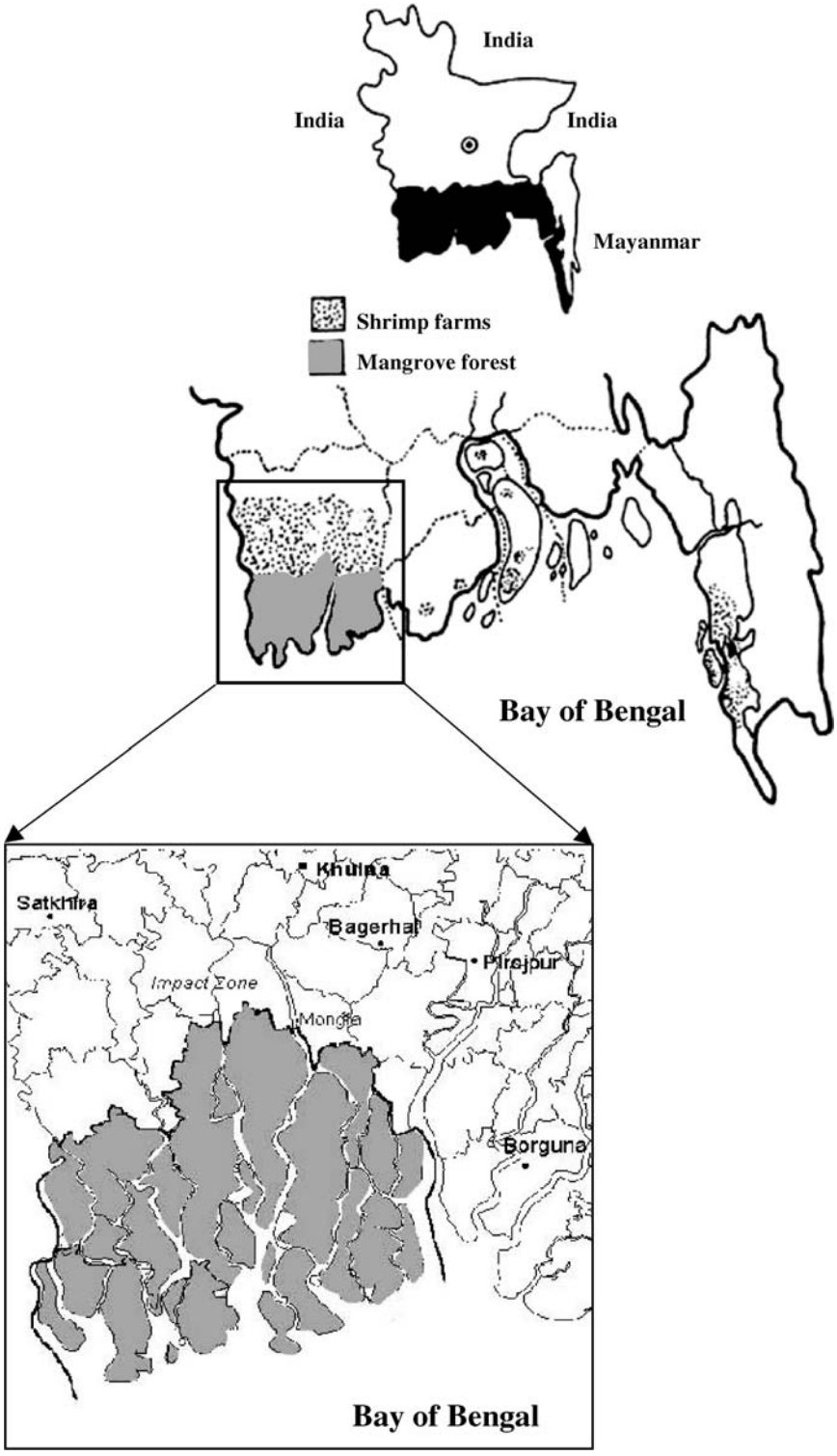

Figure 2. Map showing the mangrove forest and associated coastal areas of the Bay of Bengal, Bangladesh.

species of plants, as many as 400 species of fishes, about 40 species of shrimps and other crustaceans, 35 species of reptiles, over 270 species of birds, and 42 species of mammals (Hussain & Acharya, 1994). Besides, the Sundarbans is the largest single remaining habitat of the famous Royal Bengal Tiger (*Panthera tigris*) and estuarine crocodile (*Crocodylus porosus*). A large number of threatened and endangered species are still found in the Sundarbans mangrove areas, which are not available in other parts of the country.

The Sundarbans mangrove forest is used as the basis for various commercial and subsistence activities. About 10 million people of the coastal regions are dependent directly or indirectly on the mangrove for a variety of purposes such as agriculture, fishing, cattle rearing, human settlement, collection of housing materials, fuelwood and human foods and employment opportunities in forestry practices. Along with the subsistence fishing by numerous small fishermen, large-scale export-oriented aquaculture industries have been developed in the coastal areas of Bangladesh for the last few decades, using the mangrove as the basic productive unit. Thus, the mangrove is playing a very significant role in uplifting the coastal regional as well as the national economy.

Although mangroves are exploited for human interests from time immemorial, conversion of mangroves for different land use purposes is almost a new phenomenon. With increase in population pressure, the dependence of man on forests for various purposes has been intensified. In recent years, the exploitation and conversion of the forestlands have reached such a level that irreversible changes in the natural balance of the ecosystem have taken place, resulting in serious loss of sustenance. Among others, shrimp farming is one of the major and perhaps the most detrimental activity the mangroves have been converted to. Shrimp culture by removing mangroves in Bangladesh expanded so rapidly during the past two decades that concerns on the possible detrimental effects became obvious. Hopefully, plans and policies are currently being formulated and implemented with a view to conserve and protect the mangrove resources and to ensure sustainable resource use and management.

This paper reviews the present status of the mangrove resources and the main forms of coastal resource use with special emphasis on mangrove fisheries and aquaculture. The paper also discusses existing management practices and policy aspects, legislative and institutional issues as well as the impacts of various form of resource use and, finally, suggests options for better management and probable modes of rehabilitation of the exploited resources.

Physical characteristics

The Sundarbans is part of the world's largest delta (100 000 km^2) formed from sediments deposited by three great rivers, the Ganges, Brahmaputra and Meghna, which converge on the Bengal Basin (Seidensticker & Hai, 1983). The land is moulded by tidal action, resulting in a distinctive physiography. The soil is a silty clay loam with alternate layers of clay, silt and sand. The surface is clay except on the seaward side of islands in the coastal limits, where sandy beaches occur. The pH averages 8.0 (Christensen, 1984). The Sundarbans mangrove forest is intersected by an elaborate network of rivers, channels and creeks; innumerable small canals drain the land at the ebb. These waterways are of varying width and length and occupy a substantial part of the forest. Of the total area of the Bangladesh Sundarbans almost 62% is land and the rest water (Christensen, 1984). Generally, the rivers flow north to south and are connected with a number of side channels that connect two rivers and facilitate exchange of waters. The larger rivers, passing through the forest join together, forming estuaries at the confluence where they meet near the sea. The surface water flow in the rivers of the Sundarbans mainly comes from the Ganges-Padma River Systems through Garai-Madhumati Rivers and from the lower Meghna through the Swarupkati-Kocha Rivers. The other source of surface water flow in the rivers is the runoff from the local catchment area.

The Sundarbans mangrove forest is located south of the Tropic of Cancer and at the northwest of the Bay of Bengal (21° 30′–22° 30 ′N, 89° 12′–90° 18′ E). The four main seasons are pre-monsoon (March–May), monsoon (June–September), post-monsoon (October–November) and the dry winter season (December–February). Each of the seasons has its distinct characteristic features which influ-

ence mangrove ecology. The area inundated by tidal water increases and, due to increasing maritime influence, the salinity of river water also reaches a maximum during the post-monsoon season because of its characteristic southern winds, high temperature and higher evaporation rates with occasional heavy thunderstorms. The monsoon brings high rainfall and cloudy cover resulting in a rise in water levels and increased sediment loads in upper catchment areas. Very low or no tidal inundation resulting in a dry, exposed period is characteristic of the winter season.

Rainfall is heavy and humidity high (80%) due to the proximity of the Bay of Bengal; about 80% of the rainfall is in the monsoon. Mean annual rainfall varies from about 1800 mm at the north of the Sundarbans to 2790 mm on the coast. There is a 6-month dry season during which evapotranspiration exceeds precipitation. Conditions are most saline in February–April, the depletion of soil moisture being coupled with reduced freshwater flow from upstream. Temperatures rise from daily minima of 2–4 °C in winter to a maximum of about 43 °C in March and may exceed 32 °C in the monsoon. Storms are common in May and October–November and may develop into cyclones, usually accompanied by tidal waves of up to 7.5 m high (Seidensticker & Hai, 1983). Climatic data for Khulna are summarized by Christensen (1984); annual changes in temperature, rainfall, humidity and evaporation have been shown in Figure 3.

The Sundarbans is a low-lying deltaic swamp drained by a network of small creeks, which flow into the main watercourses on the ebb-flow of the tide. These are, in some instances, eroded by the tide to form saucer-shaped depressions in which there may be standing water. For about seven months of the year, from November to May, potential evaporation exceeds precipitation by nearly 500 mm. For more than half of the year, therefore, the vegetation is heavily dependent on soil–water, which is recharged largely by tidal intrusion and the reduced overflow. During this period of precipitation deficit, soil salinity temporarily increases. The forest receives large volumes of freshwater from inland rivers and of saline waters from the twice-daily tidal inundation from the sea, creating in the mangrove forests an open

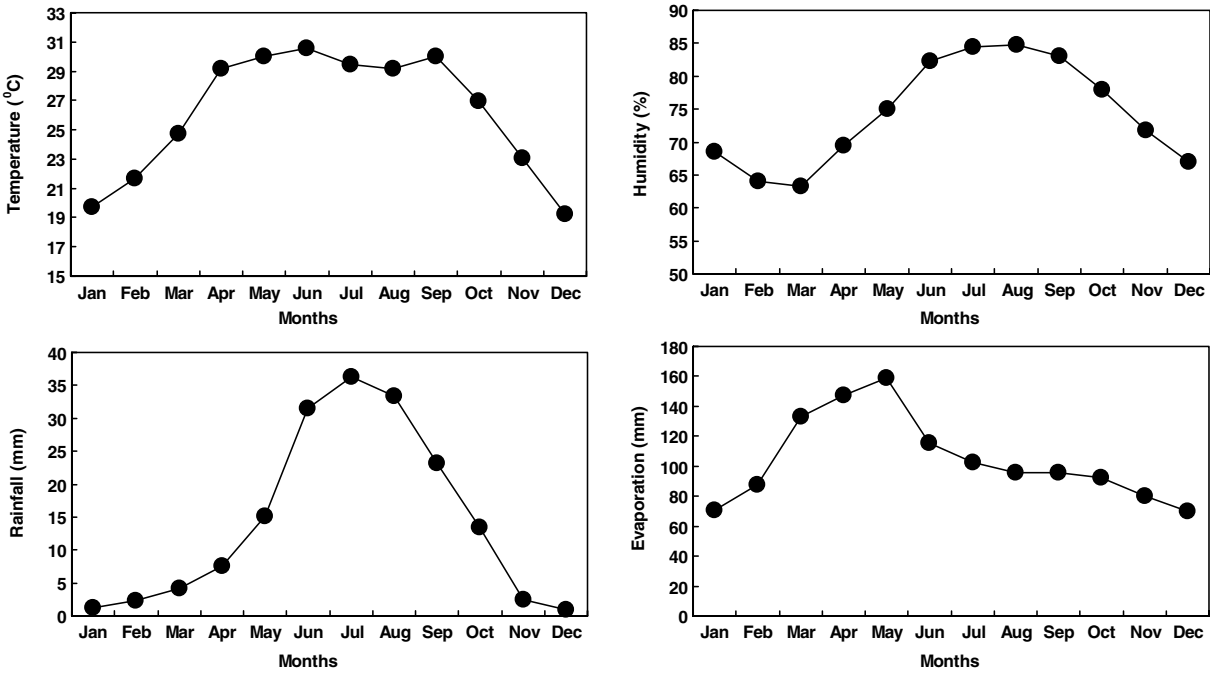

Figure 3. Seasonal patterns in some of the meteorological parameters of the Sundarban mangrove forest of Bangladesh (Islam, 2003).

ecological system. The freshwater charged with alluvium that contains plant nutrients and which, together with the salinity of the tidal water, is a major factor affecting the forest ecosystem. The relative contributions from the two sources of water are not constant throughout the year. The bulk of the freshwater reaches the forest in the monsoon season. During the dry season the freshwater flow decreases progressively, resulting in a prolonged saline condition which persists until the freshwater flow increases again. Mangroves are vegetated tidelands and function as a nutrient producer, water purifier, nutrient and sediment trap, storm barrier, shore stabilizer, aesthetic attraction, energy storage unit, transportation networks nursery and feeding grounds of many major coastal and ocean fisheries.

Mangrove flora

The study of the floral diversity of the Sundarbans is limited to a group of commercially important species and few others. The forest supports a diverse plant genetic stock including timber species, wild relatives of cultivated plants and a number of endemic species. While most of the mangroves in other parts of the world are characterized by members of the Rhizophoraceae, Avicenniaceae, and Lagancullariaceae, the mangroves of Bangladesh are dominated by the Streculiaceae and Euphorbiaceae. The mangroves of the Sundarbans are unique when compared to non-deltaic coastal mangrove forest; the reason for this difference is the large freshwater influence in the north-eastern part and the elevated level of the ground surface. Sunduri (*Heritiera fomes*) and Gewa (*Excoecaria agallocha*) are the dominant species, occurring in suitable localities along the coast. Unlike former times, Rhizophoraceae are now of minor importance. Inventory of the Sundarbans shows that there has been a change in favour of mixed *Heritiera fomes* and *Excoecaria agallocha* at the expense of pure *Heritiera fomes* forest. A further important change which the forest has undergone is a reduction in canopy density. In 1959, 78% of the forest had a canopy closure of 75% or more; now only 65% of the forest has canopy closure of 70% or more. Current inventory also shows that approximately 70% of *Heritiera fomes* stems are moderately or severely affected by topdying.

Seidensticker and Hai (1983) report a total of 334 plant species, representing 245 genera. The natural mangroves are halophytic, two-storied woodland, seldom exceeding 10 m in height with the notable exception of Sunduri (*Heritiera fomes*) and Keora (*Sonneratia apetala*) and Bean (*Avicennia officinalis*). Stem diameters are generally less than 30–40 cm at breast height although few species attain diameter up to about 1 m. Among the dicotyledonous plants, the tree species are represented by 30 genera under 22 families. Rhizophoraceae is represented by all the known four genera and at least six species. Avicenniaceae is represented by three species, Meliaceae by three species, Combretaceae by two species and Sonneratiaceae by two species. Among the tree species, *E. agallocha* and *H. fomes* are found as the most common species. The shrubs and scandent shrubs are represented by 12 species belonging to 11 genera under 7 families. The forest is also abundant in climbers and epiphytes. At least 11 species belonging to 6 families have so far been identified. The monocotolydenous herbs are represented by Graminae, Palmae, and Pendanaceae. Besides, the rooted plants, the swamp forest species also include the epiphytic parasitic flora that live in the rooted trees and do not come into contact with forest floor. The epiphytes include *Hoya parasitica*, *Dischidia numularia*, 13 species belonging to the family Orchidaceae, 7 epiphytic ferns, *Lycopodium* and *Psilotum*. Like the epiphytes, woody species parasitic on tree crowns are also found to some extent. One of the most important non-wood forest products is *Nypa fruticans* leaf.

Several reports suggest that a number of plant species in the mangrove forest are endangered to some extents. The changing composition of the forest is a clear manifestation of the uniqueness of its ecological condition and the management regime. *Heritiera fomes* is not an endangered species but the dominance of the species as a forest type is threatened and reflects the changing health of the ecosystem, particularly due to reduced supply of freshwater. The decline in growth of many freshwater loving plants such as *Nypa fruticans* has also been noted. Previous reports mentioned at least four common species of the genus *Bruguiera* but only one species, *B. parviflora* is found in the Sundarbans today. *Lumnitzera racemosa* and *Barringtonia* spp. are also very limited in the

present forest composition. Except for the commercially important species the remaining species are subjected to unregulated felling practices. Some of these species, particularly *Cynometra*, *Amoora cuculata* and *Rhizophora* spp. are threatened due to such unregulated felling.

Mangrove fauna

The mangrove forest provides a unique ecosystem and extensive habitats for a wide variety of faunal species. The Sundarbans is a very high quality wildlife conservation area of regional and international importance. Many authors have studied and given lists of the wildlife assemblages of the Sundarbans (Hendrichs, 1975; Mukherjee, 1975; Khan, 1982; Hussain et al., 1983; Sanyal, 1983, 1987; Khan, 1986, 1987; Seidensticker & Hai, 1983). The international importance of the Sundarbans as an essentially long-term wildlife habitat has also been documented (Gittins & Akonda, 1982; Seidensticker, 1986, 1987). Several studies (Seidenstiker & Hai, 1983; Blower, 1985a, b; Khan, 1986) reported that the mangroves of Bangladesh support at least 120 species of commercially important fishes, 290 species of birds, 42 species of mammals, 35 reptiles, and 8 species of amphibians. The mangroves also support a large number of species, which are now extinct elsewhere in the country. These include 2 amphibians, 14 reptiles, 25 birds, and 5 mammals (Sarker & Sarker, 1986; Sarker, 1993).

The Sundarbans is the only remaining habitat in the lower Bengal Basin for a variety of faunal species. The presence of 49 mammal species has been documented. Of these, no less than five spectacular species, namely Javan rhinoceros *Rhinoceros sondaicus*, water buffalo *Bubalus bubalis*, swamp deer *Cervus duvauceli*, gaur *Bos frontalis* and probably hog deer *Axis porcinus* have become locally extirpated since the beginning of this century (Salter, 1984). The Sundarbans of Bangladesh and India support one of the largest populations of tiger *Panthera tigris*, Spotted deer *Cervus axis*, and wild boar *Sus scrofa*, smooth-coated otter *Lutra perspicillata*, three species of wild cat, *Felis bengalensis*, *F. chaus* and *F. viverrina*, and Ganges River dolphin *Platanista gangetica*, which occurs in some of the larger waterways. Species accounts and a check-list are given by Salter (1984).

A total of 315 species of bird have been recorded (Hussain & Acharya, 1994), including about 95 species of waterfowl (Scott, 1989) and 38 species of raptors (Sarker, 1985a, b). Among the many which may be readily seen by the visitor are no less than nine species of kingfisher, including brown-winged and stork-billed kingfishers, *Pelargopsis amauropterus* and *P. capensis*, respectively; the magnificent white-bellied sea-eagle *Haliaeetus leucogaster* which, at a density of one individual per 53.1 km of waterways (Sarker, 1985a), is quite common; also the much rarer grey-headed fish eagle *Ichthyophaga ichthyaetus*, Pallas's fish-eagle *Haliaeetus leucoryphus* and several other raptors. Herons, egrets, storks, sandpipers, whimbrel, curlew and numerous other waders are to be seen along the muddy banks and on the chars or sandbanks which become exposed during the dry season. There are many species of gulls and terns, especially along the coast and the larger waterways. Apart from those species particularly associated with the sea and wetlands, there is also a considerable variety of forest birds such as woodpeckers, barbets, shrikes, drongos, mynahs, minivets, babblers and many others (Salter, 1984). Scott (1989) gives further details of the avifauna.

Some 53 reptile species and eight of amphibians have been recorded (Hussain & Acharya, 1994). Of these mugger *Crocodylus palustris* is now extinct, probably as a result of past over-exploitation. Estuarine crocodile *C. porosus* still survives but its numbers have been greatly depleted through hunting and trapping for skins. There are also three species of monitor, *Varanus bengalensis*, *V. flavescens* and *V. salvator*, and Indian *python Python molurus*. Four species of marine turtle have been recorded from the area, olive ridley *Lepidochelys olivacea* being the most abundant. Green turtle *Chelonia mydas* is rare due to excessive fishing, while loggerhead *Caretta caretta* and hawksbill *Eretmochelys imbricata* are not common although there have been some reported on the beaches (Hussain & Acharya, 1994). River terrapin *Batagur baska* is also present. The eighteen recorded snake species include king cobra *Ophiophagus hannah* and spectacled cobra *Naja naja*, three vipers and six sea-snakes (Salter, 1984).

Mangrove fish and related fauna

Plankton

Algal flora is one of the most poorly studied components of the mangrove ecosystem. Algae can be seen attached to the pneumatophores, stilt roots, tree trunks and on the mud floor. Mangrove algae can also be found in some areas forming red, brown or green mats on intertidal mud flats. Due to muddy shorelines and low saline conditions, typical euryhaline benthic marine algae are negligible in the region. Although not complete, so far, 34 species of phytoplankton have been listed (Islam, 1973; Hussain & Acharya, 1994). Belonging to the families Volvocaceae, Palmelaceae, Ulvaceae, Cladephoraceae, Zygnemaceae, and Codiaceae, the Division Chlorophyta is represented by 9 species under 6 genera. Division Cyanophyta is represented by 16 species under 9 genera belonging to the families Chroococcaceae, Oscillatoriaceae, Nostocaceae, and Rivulariaceae. Bacillariophyta is represented by 16 genera and 35 species and the Euglenophyta is represented by 2 genera consisting of 2 species. It was observed that most of the members of Bacillariophyta and Cyanophyta occur in abundance in the lower littoral zone. The distribution and abundance of algae in the mangrove areas are greatly influenced by the ecological characteristics, particularly the mixing of saline and freshwater resulting in salinity fluctuation and the silt carried by rivers.

The complex mangrove ecosystems are highly suitable to support very complex food chains and for organisms of all trophic levels and niches to occur. The mangroves of Bangladesh are extraordinarily rich in zooplankton production. Thirteen major taxa of zooplankton namely, Copepods, Amphipodes, Mysids, Acetes, Chaetognaths, Polychaetes, Lucifers, Hydromedusae, Shrimp larvae, Fin fish larvae, Crab larvae, Squilla, and Horseshoe crab larvae were found to occur in this region. Mahmood (1985) recorded 23 species of ichthyoplankton dominated by *Glossogobius giuris*, *Odontablyopsus rubiundus*, *Mugil* spp. etc.

Fish fauna

The fishery resources are one of the primary concerns in the Sundarbans mangrove ecosystem. The fishery resources are characterized by a very high degree of endemism and diversity. The number of fish species available in the Sundarbans and their taxonomic status have been described among others by Rahman (1975, 1989) with varying degrees of accuracy. According to Hussain and Acharya (1994) the mangrove waters support 53 species of pelagic fish belonging to 27 families and 124 species under 49 families of demersal fish. However, this number is expected to be as high as 400 species using the mangrove swamps in various ways. Diadromous species such as *Pangasius pangasius*, *Hilsa ilisha*, *Lates calcarifer* are common in the low saline zone. The moderately saltwater zones are dominated by *Hilsa ilisha*, *Pomadasys hasta*, Polynemus spp., *Coilia* spp., *Johnius* spp. etc. The highly saline zones are likely to support species such as *Harpodon nehereus*, *Trichiurus savala*, *Setipinna* spp., *Pampus* spp., *Sardinella* spp., *Salar* spp. etc. Considerable seasonal changes also occur in the quality and quantity of fish fauna in the region.

Over 120 species of fish are reported to be commonly caught by commercial fishermen in the Sundarbans (Seidensticker & Hai, 1983). According to Mukherjee (1975) only brackish water species and marine forms are found in the Indian Sundarbans, freshwater species being totally absent. This may be assumed to apply also to the Bangladesh Sundarbans, except possibly in the eastern portion where there is freshwater in Baleswar River. Mention should also be made of mud-skippers or gobies which occur in large numbers and are a characteristic feature of mangrove swamps.

Non-fish organisms

Besides the large number of fish species, the mangroves also support many nonpiscine species of very high degree of commercial value. These include 24 species of shrimps belonging to 5 families, 7 crab species under 3 families, 2 species of gastropods, 6 species of Pelecypods, 8 species of lobsters and 3 species of turtles (Hussain & Acharya, 1994; Blower, 1985a, b). Being a transitional zone between freshwater and seawater the mangrove serves as a seasonal habitat for many freshwater and marine species and, as such, is richer than either of the two in terms of its biological genetic resources. Many species, both freshwater

and marine, are dependent on the mangroves for their nursery areas.

Crustacea account for by far the largest proportion of animal biomass, with an estimated 40 million kilograms of fiddler crabs and 100 million kilograms of mud crabs (Hendrichs, 1975). The nutrient-rich waters of the Sundarbans also yield a considerable harvest of shrimps, prawns and lobsters. The area supports a varied insect population including large numbers of honey bees, honey and beeswax being among the economically important products. The insect life of the Sundarbans has been little studied.

Mangrove forest and fisheries

There are two basic types of capture fisheries in the mangrove areas, namely, inshore fishery and offshore fishery. Usually small boats fishing in relatively shallow waters, ranging in depths from 2 to 8 m constitute the inshore fishery. Various types of gears are used by artisanal and commercial fishermen and about one-third of annual fish production in the mangrove areas is attributable to inshore fishery. The offshore fishery covers estuarine and coastal waters. Among different types of fishing gears used by the fishermen, the most common ones are 'behundi jal' (set bag net), 'ilisha jal' (hilsa gill net), and long line.

In addition to commercial fishing, another important fishing activity that has gained considerable attention throughout the past two decades is 'shrimp fry fishery', the collection of shrimp fry from mangrove estuaries and nearshore waters of the Bay of Bengal. Until recently, wild post-larvae (PL) of tiger prawn (Penaeus monodon) were the only source of fry for stocking the coastal brackish water ponds of Bangladesh. Following increasing demand, intense and widespread fishing of fry is being practiced in the estuaries and creeks along the coast. The total shrimp fry caught during the peak period between mid-February and mid-March in three coastal districts, namely, Satkhira, Khulna, and Cox's Bazar was estimated to be 75 000 post-larvae in 1990 which was increased as much as 1453 million in 1993 (Chantarasri, 1994). Over 100 000 fishermen were reported to engage in fry collection.

The importance of mangrove ecosystems to coastal fisheries has been described among others by Pauly (1985), Twilley et al. (1996), Baran & Hambrey (1998) and Kathiresan & Bingham (2001). Yanez-Arancibia et al. (1985), in the Gulf of Mexico, have shown a clear positive correlation between commercial finfish catches and the total area of mangroves. Similarly, positive correlations of mangrove were reported by De Graaf & Xuan (1997) with finfish catches, by Martosubroto & Naamin (1977) with annual catch of prawns, by Paw & Chua (1989) with penaeid shrimp catch and by Staples et al. (1985) with the annual catch of banana prawn. Pauly & Ingles (1986) showed that most of the variance of the MSY of penaeids could be explained by a combination of area of mangrove habitats and latitude. This implies that a certain minimum mangrove area is necessary for a high production, a point also noted by Pauly & Ingles (1986) who suggest that the impact of destruction of a mangrove area might be greater if this area is small and residual.

Conversion of mangrove into aquaculture

Many areas of coastal districts such as Khulna, Barisal, Patuakhali, Bagerhat, Chittagong, and Cox's Bazar were once ornamented with dense mangrove vegetation, but, in the course of time, mangroves over large areas have been cleared and converted to other land uses. In the southeast part in the delta of Matamuhuri River, one of the oldest mangrove forests of the subcontinent, the 'Chakaria Sundarbans' had an area of 18 200 ha which was dramatically reduced to 5446 ha as consequence of human intervention such as salt production and shrimp cultivation in the last two decades. The Chakaria Sundarbans typical of the southwestern mangrove forests in terms of growth, with unique dense vegetation of what is locally known as 'Chulia Kanta' (*Dalbergia spinosa*) and 'Nunia Kanta' (*Aegialitis rotundifolia*). Now, virtually no compact mangrove forest is found in these areas except some sporadic vegetation.

The ecology of coastal areas and the climatic condition of Bangladesh are extremely suitable for shrimp culture with a very low production costs. Shrimp culture is mostly practiced in low-lying tidal flats within Bangladesh Water Development

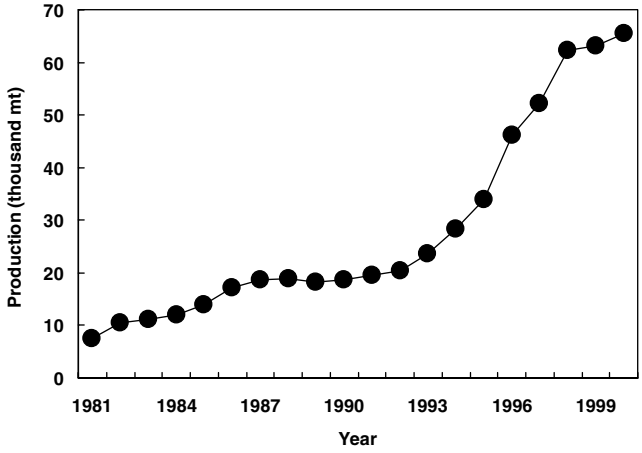

Figure 4. Showing a steady rise in the production of cultured shrimp over the last two decades, indicating an expansion in shrimp farming areas (DOF, 2001).

Board (BWDB) polders. The polders were originally constructed to prevent the land from brackish water inundation and to use the reclaimed land for agriculture.

Shrimp culture in Bangladesh started to expand in 1970s and, as a source of immediate economic gain, shrimp farming has expanded steadily over the last two decades (Fig. 4). According to survey result of 1982–1983, the area under shrimp culture was 52 000 ha, which has increased to about 0.11 million ha by 1995. About 75% of this land is located in Khulna, Bagerhat and Satkhira districts in the south and the rest in the Cox's Bazar district in the southeastern region of the country (DOF, 1999). From the early eighties, the government of Bangladesh has been endeavoring to improve the traditional culture practices.

The development shrimp farming took place in a speculating and traditional manner. Because of unscientific management, water quality problems are common in almost all farms in each year, which are further compounded by higher stocking density which results from the intention of getting more production. However, at the end, very poor production with respect to the total input is experienced by most producers. Frequent occurrence of disease and mortality of shrimps is another consequence of poor water quality. Shrimp culture techniques existing at present in Bangladesh and its environmental and socio-economic have been described by many authors (Karim & Aftabuzzaman, 1997; Deb, 1998; Islam, 2003).

Along with the shrimps that are introduced by trapping during watering of the ghers, a number of finfish species are also introduced and raised with shrimps. At the end of the culture period, large quantities of different species of finfishes are harvested. The major fish types are *Mystus*, *Wallago*, *Pangasius*, *Glossogobius*, *Liza* etc. At present, commercial culture of several species of finfishes and one crab species is being carried out on a small-scale. The major species cultured are *Lates calcarifer*, *Liza cascasia*, *L. ologolepis*, and *L. tade* among the finfishes and *Scylla serrata* (the mud crab) among the crab species. However, development of suitable culture technologies for these species and some others is under trial.

Utilization of mangrove vegetation

Heritiera fomes is the principal timber species in Bangladesh. This plant along with some others, namely, *Xylocarpus mekongensis* and *Bruguiera sexangula* are highly priced construction material and are exported to distant markets. *Ceriops decandra*, *Phoenix paludosa*, *Sonneratia apetala*, and *Avicennia officinalis*, are extensively used as poles for construction of the hunts. *Nypa fruticans*, *Typhia elephantina* and *Saccharum cylindricum* are used for thatching and roofing. Among these, the leaves of *Nypa fruticans* (Nipa) are used extensively throughout the country. The timbers are used among other purposes for boat building and

bridge construction. Various household items and agricultural implement are made from mangrove materials. Some products like mats, baskets etc. are sold in distant markets.

The Sundarbans mangrove forest is the largest source of timber, firewood, fuelwood and other forest products. *E. agallocha* is used as raw materials in the paper and match industry. Annual coupes are laid out each year and pulpwood is extracted under a selection system where all trees above 20 cm diameter at breast height are extracted. The two major fuel wood species in the mangroves are *Heritiera fomes* and *Ceriops decandra*. The trimmed parts of these two species, originated during harvesting of timber are separated for use as fuel. Some healthy trees below the exploitable diameter are also removed to use as fuel during thinning of congested and dense stands. However most of the fuelwood harvested commercially from the mangrove is transported to the towns.

The mangroves are the main source of honey and wax. The Sundarbans possesses numerous species of trees that produce abundant nectar and pollen and these floral resource are used by the giant honey bee (*Apis dorsata*). An estimated amount of 200 metric tones of honey and 55 metric tonnes of wax are collected annually from the forest (Das & Siddiqui, 1985). Local people are seasonally engaged in honey collection. The value of mangrove-marketed products can be expressed in economic terms. However, the free services like protection, accretion and land stabilization provided by the mangroves are difficult to quantify in economic terms.

Impacts of mangrove exploitations

Environmental impacts

Destruction of the mangrove forests has been occurring for a very long time and the total mangrove forest in Bangladesh today is less than half the size it was two centuries ago. Many authors have reported that removal of mangrove for shrimp farming is responsible for rapid and irreversible environmental changes, some of which are so severe that the shrimp culture itself is under threat. Most shrimp farming in Southeast Asia has occurred or still takes place on reclaimed mangrove forests.

Although there are still many of the more traditional style aquaculture farms in production, the dominant trend during the past decade has seen most farms built as either semi-intensive or intensive operations. Unfortunately, a number of climatic, environment and monetary factors make the shrimp farmers follow the principle of adapting short-cut ways for profit making and, therefore, farmers have been moving to even greater levels of intensification and, as the extensive style has given way to intensification and industrialization, the degree and extent of environmental damage intensifies too.

Modern shrimp farming is clearly unsustainable ecologically because its operational requirements vastly exceed the carrying capacity of surrounding ecosystems. The environmental pressures from industrialized shrimp farms have impacts well beyond the boundaries of the immediate site itself. For instance, studies have shown that a one hectare (2.5 acres) semi-intensive shrimp culture system producing about 4000 kg of shrimp annually requires the productive and assimilative capacity of between 38 and 189 hectares of natural ecosystem per year. Higher intensity farming operations require even greater levels of support from the surrounding environment. Such systems are extremely inefficient from an ecological energy standpoint, using approximately 295 Joules of ecological work in order to produce just one Joule of edible shrimp (Mahmood, 1986; Larrson et al., 1994; Mahmood et al., 1994; Deb, 1998).

The shrimp culture industry is mostly dependent on wild sources for fry. Fry catching has become such a profitable business that thousands of poor landless and unemployed coastal people are engaged along the coastline for catching tiger shrimp fry from the nearshore waters of the Bay of Bengal. The catch includes different types of marine, estuarine and freshwater shrimps and prawns, crabs and mollusks, and a wide variety finfish and zooplankton. A large number of young shrimps and fishes are destroyed before attaining biologically sustainable size due to intensive fishing pressure. The overexploitation has been reported to result in decreasing the availability of shrimp fry from year to year and posing disastrous impacts on artisanal and commercial fisheries

(Deb, 1998). Besides, most of the semi-intensive shrimp farms depend on fishmeal-based pelleted feeds which will lead to even greater fishing pressure globally as demand for fishmeal increases with increase in area and intensity of shrimp farming. This contributes to the already unsustainable fishing pressure that is pushing many fisheries in the developing coastal countries into quite serious declines.

It is reported that the target species, the tiger shrimp, P. monodon constitutes only a very small portion of the total catch. Consequently, huge mortality and loss of other species have been reported for every single P. monodon post-larvae collected from the wild. Hoq et al. (2001) reported that 12–551 post-larvae of other shrimps, 5–152 finfish larvae and 26–1636 macrozooplankton are wasted during the collection of a single P. monodon PL in major rivers of the mangrove forest in Bangladesh. Karim (1986) and Kamal (2000) suggested that *P. monodon* post-larvae constitute at most 1% of the total collection in Bangladesh, amounting 1–3 billion/year. Therefore, the remaining 99% would count about 99–297 billion. Recent report shows that more than 100 000 collectors were engaged in this activity with a total loss of about 180 000 million other aquatic organisms in Bangladesh (Kamal, 2000). Clearly, the shrimp fry fishery posed serious impacts on the regional biodiversity and aquatic community structure not only by directly killing a vast number of the fish and shrimp species but also by reducing the food availability of other organisms such as aquatic birds, reptiles linked through the food web.

The sustainability of the practice of harvesting wild PL has been questioned, in particular as the aquaculture industry has expanded and the demand for post-larvae has increased over the past two decades. Begum & Nazmul (2002) stated that the overall survival from the egg stage to recruitment is highly density dependent; they suggested that if density-dependence occurs after the PL stage, then the harvesting of PL would have little effect on recruitment and if density-dependence occurs before the PL stage, then PL harvesting would have a direct and proportional effect on recruitment and fishery yield. Based on the comparison of growth rate and corresponding economic value of the PL between those left in the wild (to be harvested by capture fisheries) and those collected for aquaculture rearing (6.0 g and 0.01 US$/PL for those left in the wild vs. 0.38 g and 0.0025 US$/PL collected for aquaculture rearing), they concluded that PL harvesting is not intrinsically irrational or wasteful. However, this conclusion was not based on practical time-series data on the stock size, recruitment pattern and the level at which wild shrimp fry can be exploited without affecting the original wild stock. The authors also ignored the ecological importance of the fishery as well as the loss of other fishery resources associated with shrimp fry collection. Such comment is, therefore, under extreme criticism while shrimp fry fishery itself is in a steadily declining trend. Hoq et al. (2001) reported that the abundance of P. monodon PL was significantly reduced from 1992 to 1999 and the shrimp fry fishery is responsible for declining other important fisheries such as Hilsa fishery and crab fishery in coastal Bangladesh.

Mangrove removal is associated with coastal erosion, change in sedimentation pattern and shoreline configuration. Massive destruction of mangroves in the southeastern part (the Chakaria Sundarbans) of Bangladesh since 1982 in the name of 'improvement of shrimp culture technology' was patronized by the 'Asian Development Bank' (ADB) and the World Bank (Deb, 1998). Huge areas of mangrove forests were cleared for shrimp farming. Rapid deforestation has led to increase in both the discharge rate and sediment load of the river resulting in increasing siltation of the distributary channels of the delta.

Massive clearance of large areas of mangroves has resulted in reduction of natural production of fish and shrimp larvae that use mangrove for feeding, breeding, and nursery grounds. Therefore, at present, shrimp seeds are not sufficiently available for stocking and this situation, compounded by unavailability of enough hatchery produced seed has resulted empty and abandoned farms. According to FAO/NACA (1995), because of largescale destruction of mangroves for shrimp culture, the natural breeding grounds have been lost to a great extent. The clearing of mangroves resulted in an increased vulnerability to cyclones and tidal waves. The conversion of mangrove forests would not appear to be economic if the potential yields were compared with the combined yields of the forests and traditional fisheries, which are now both lost.

Mangrove soils developed from seawater sediments contain high sulfides, which occur in the form of iron sulfides (FeS and FeS_2). Under conditions of severe acidity, solubility of aluminium, iron, and manganese increases and these may cause phytotoxicity, unavailability of nutrients and reduction in soil fertility. Deb (1998) reported the effects of high concentrations of aluminium and high acidity on shrimp farms constructed through mangrove cut. Potential acidity causes severe stress and deaths of fish and shrimps have been reported due to gill clogging by ferric hydroxide resulting from pyritic soils through complex ecological processes. Because of the growing toxicity, a number of agricultural and aquacultural farms are left abandoned at present.

Mangrove forests have been playing a very important role as a protecting wall against the devastating cyclones and tidal surges by deflecting and reducing energy. It has been reported that the southeastern coastal zone of Bangladesh with fewer mangroves had been more vulnerable than that of southwestern zone with more mangroves. Inundation of large areas with water for shrimp farming has led to intrusion of salts in the surrounding soils resulting in salinization of soil and altering soil chemistry. Long time inundation of lands does not allow other cropping and prevents free nitrogen fixation and mineralization and soil fertility reduces within few years (Rahman, 1993). Continuous inundation also posed tremendous impacts on the underground water of the coastal districts of Bangladesh.

Underground water is used to reduce the salinity of water at the early stage of culture period. Intensive culture systems also need water exchange at a rate of 10–50% of the pond volume each day. This water demand places a tremendous burden on local ground water supplies, rapidly depleting local freshwater resources. Huge amounts of water are used for this purpose in each cycle of culture resulting in lowering in underground water table and consequently drying of wells. In the coastal areas of the country, loss in crop production, freshwater crisis, loss of fodder as consequences of salinity intrusion are common.

It has been reported that only 17% of the feeds supplied to the shrimp farms become harvestable tissues and the rest (83%) is lost and find way into the water in various forms of wastes (Primavera, 1994; Deb, 1998). As a result, the waters discharged from the shrimp farms are extraordinarily high in organic loads from dissolved and particulate organic matters in the form of detritus and unused feeds, metabolites, various forms of toxic and hazardous chemicals, fertilizers, feces, microbes etc. The volume of wastes occurs at a very high amount when the ponds are dried for complete harvesting of the crop. The nutrients and organic loads in shrimp pond effluents are potential sources of detrimental effects on the receiving waters such as reduction in dissolved oxygen, production of hazardous gases and off-odors through microbial decomposition, hypernutrification and eutrophication, higher rate of sedimentation resulting in altering primary and secondary productivity, changes in benthic community structure etc. The wastewater is discharged directly to the surrounding waters.

The higher intensification requires regular fertilization and supplemental feeding to stimulate higher growth. In addition, a wide variety of other chemicals such as herbicides, pesticides, lime, antibiotics, preservatives, disinfectants are used in shrimp farms. It is supposed that some of these chemicals particularly the antibiotics and some persistent ones might lead to the proliferation of resistant pathogens complicating further disease treatment and due to the residual effects of the persistent chemicals, they get deposited through various food chains in different animals even in man.

Facing scarcity of wild shrimp seeds, substantial amounts of shrimp fry were imported from other countries. There is evidence that shrimp pathogens have been widely disseminated through introduction and transfer of shrimp fry. The 'Infectious Hypodermal Hematopoietic Necrosis Virus (IHHNV)' is suspected of being spread from its natural range on the Pacific Coast of Latin America to the Middle East and Asia through transshipment of infected shrimps (Deb, 1998). The 'Monodon Baculovirus' (MBV) disease is also suspected to spread from the same source (Lightner et al., 1989). The serious outbreak of disease in the shrimp ponds of Bangladesh since mid 1990s hints to the danger of importing shrimp fry.

Socio-economic impacts

Although shrimp industry tries to promote itself as a boon to the local economies, it is largely only a relatively few investors that have received the lion's share of benefits, while large portions of society, particularly the rural poor, have become disenfranchised and marginalized into severely degraded environments. Repeated claims have revealed that the ownership and the tenurial processes of shrimp culture ponds are handled by the socially advantaged groups of people who are sufficiently powerful and have access to the necessary capitals and credits and these groups usually gain the benefits (Deb, 1998). It is very interesting and surprising that despite the involvement of internationally reputed organizations like ADB and World Bank in the policy making and implementation, the original objectives of various national and international efforts for improvement of shrimp culture are not met in most instances. The land use patterns, and leasing and sub-leasing systems in the coastal regions of Bangladesh have resulted in a chain of tenurial hierarchy. Competition between traditional fishermen and family (peasant) farmers, and entrepreneurial shrimp farmers for the use of good quality land, coastal fisheries habitats like mangroves, and other critical areas along the coastline increases.

The transformation of multiple-use coastal resource system into a privately owned single-purpose use deprives the coastal communities of their traditional resource use rights who have been using the resource in question for generations. This has also been reported from many other tropical countries (Balley, 1988). The expropriation further aggravates the livelihood of the vast majority of desperately poor coastal communities, which, can be quoted after Deb (1998) as 'As observed in the aquatic trophic structure, predatory ''big fishes'' of the society engulf the benefits of ''small'' social creatures'. The traditional patron-client relationship among the local rich and poor in the form of inter-linkages of various exchanges is being gradually reputed to such an extent that the poor are either migrating out of the area, or forced to accept a demeaning life style.

It is said that shrimp play a significant role in providing animal protein to the people. But, in fact, this seems to be not true. The coastal people have never had the opportunity to taste the tiger shrimp. Most of the coastal people do not have the buying capacity of the costly shrimps, which are processed and exported abroad. However, low quality and diseased shrimps discarded from the processing plants are sometimes sold to the local markets.

Modern shrimp farming is capital rather than labor intensive and, therefore, results in labor utility discrimination and provides limited employment opportunities for coastal residents and most of those are typically poorly paid seasonal and non-skilled jobs, offering no long-term job security. It has been reported that shrimp farming displaces more jobs than it creates. Again, the leaseholders from outside generally do not trust the local laborers and rather hire workforce from their own localities. The unemployment problem being very acute in the coastal areas and such bias against local laborers is a source of discontent among them. As a result, people are forced either to migrate to the urban areas compounding the already complex environmental and social conditions of the urban areas or to resort to destructive fishing or improper methods of husbandry in order to extract livelihoods from the coastal areas.

In the coastal areas, the poor are becoming economically more and more vulnerable due to shrimp culture. Livestock and trees are important private resources which save the poor in overcoming vulnerabilities. In the shrimp farming areas, common grazing grounds have been converted to shrimp ghers (large ponds) and owners do not allow the cattle to pass over the dikes, thus the grazing areas are restricted (the results of such restrictions on the livestock and plant will be discussed in the next section). The depressions and canals, earlier used by the poor fishermen for their livelihoods have been turned into shrimp ponds. In the remaining canals virtually no fish are available due to discharge of the shrimp farm effluents containing toxic chemicals and hazardous substances and to overfishing by the fry catchers. Fishing by cast nets around shrimp culture areas has virtually been banned for security reasons of the shrimp farms. All these have resulted in extremely damaging effects on local food security.

Economic and social marginalization is not the end of the sufferings of the ill-fated poor. The coastal paddy farmers very frequently fall in victim in the hand of shrimp farm owners. There are

growing conflicts among the shrimp farm owners and paddy cultivators in the coastal areas, which frequently end up through tragic bloodshedding incidents and even deaths. The ultimate consequence of such conflicts further marginalizes the victims and the local administrative bodies have been reported to favor the powerful owners. There are also enough incidents of murders through clashes among the farm owners themselves on the issues of territorial disputes and occupying lands forcefully. The shrimp farm owners hire professional terrorists to fight with local peoples when disputes reach climax.

The biodiversity impacts of mangrove utilization are profound on the wild fish stock. It has been reported that about 12 species of fish are considered as endangered or threatened due to their gradual disappearance as a result of change or conversion of habitats (FAO/NACA, 1995). Although precise information regarding the effects of import of shrimp fry from other countries on the native genetic stock are not available, there are many evidences that introduced genetic material often has a lower reproductive successes. The data on the reduction in plant and animal biodiversity and production in the coastal residential areas due to shrimp culture are very frustrating as well as alarming. It has been shown that during 1986–1989, total production of cows and buffalos have been declined by 47% and yield by 25%; mortality of chicken is very high due to higher salinity resulted from salinity intrusion; poultry production declined by 36% in shrimp culture areas (Deb, 1998). Poultry farming have become difficult due to reduced natural food and degrading economy of the rural people which does not permit them to buy feeds for the poultry. Productions of other green crops along with paddy have been reduced to a great extent. Significant reduction in the fruit trees such as coconut, mango, jackfruit, bettlenut etc. have been reported from both Cox's Bazar and Khulna regions. Most of the fewer trees still remaining are almost fruitless even in the season (Deb, 1998).

Worldwide, rural community people affected by the encroachment of shrimp farmers have started striking back at aquaculture owners. Shrimp farming is now meeting with significant resistance by local communities to its further expansion. Protests have centered on issues of pollution, takeover of lands, access to water resources, destruction of mangroves, and the deterioration of surrounding soil and water quality. Sometimes violent clashes occur, some ending in beatings and even death for some protesters. In one incident in Bangladesh two villagers lost their lives, one of them killed by a bomb attack arranged by shrimp-farm owners. Similar protests have been reported in other shrimp producing countries such as Ecuador, India, and Honduras.

Habitat restoration and conservation

The Sundarbans mangrove forest of Bangladesh is most likely to be changed directly or indirectly by human activities and a priority question in conservation planning is what to expect from the Sunderbans in the future. It is very difficult or almost impossible to rehabilitate a mangrove forest to its original state once it is destroyed severely or completely. This is because the changes that the ecosystem undergoes and the conditions under which the natural mangrove vegetation flourish are hardly likely to restore. However, like some other countries, some efforts and strategies have been made in Bangladesh and, hopefully, many authors have reported the Sundarbans as the most important area left for the long-term survival of many forms of wildlife because the area is large enough to support a large effective population size (Seidensticker, 1986, 1987; Tilson & Seal, 1987).

Although mangroves are exploited for a diverse array of purposes, the practice of afforestation in the mangrove areas is almost recent. Information regarding the nursery raising and planting techniques for mangrove species still are not adequate and complete (Siddiqi & Khan, 1996). However, to some extent, afforestation with mangrove species have been standardized and are implemented with varying degrees of success in sites which have not been too badly degraded (Siddiqi et al., 1993).

The program of afforestation in Bangladesh was initiated in 1966, and up to 1990 and an area of 0.12 million hectares had been brought under plantations which have substantially increased the total area of mangrove during the early 1990s (Fig. 5). Primarily, the plantation was restricted to the commercially important species. Virtually, all the commercially important species have been

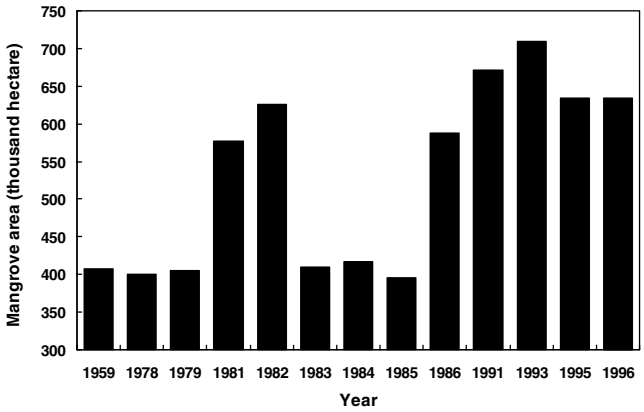

Figure 5. Changes in the total areas of mangrove in Bangladesh over the last few decades.

tried in the coastal belt of Bangladesh, but, among them, only two species, namely, *Sonneratia apetala* and *Avicennia officinalis* showed better performance constituting about 90% of the plantations (Siddiqi et al., 1993). Consequently, being the major planting species, more information on the nursery techniques on these two species are available in comparison to the other species. At present, trials with all the commercially important plant species are being carried out with the objectives of accelerating the process of siltation and stabilization of soil, creating forest shelterbelts to protect life and property of inland from tidal bores, creating an urgently needed resource to add to the national wealth, creating job opportunities for the rural communities, and creating an environment for wildlife, fishes and other estuarine and marine fauna.

Species used in coastal afforestation include *Sonneratia apetala*, *Avicennia officinalis*, *Rhizophora gymnorhiza* and *Casuarina equisetifolia* (MOEF, 1996, 1998; Haque, 1999). For plantation in the mangrove areas, species that produce long tapering propagules are usually desirable because they are more likely to propagate easily and flourish naturally. But, plantations with such species have been difficult, particularly in cases where soils have become badly desiccated and hard; similarly, in areas where pan formation has taken place below the soil surface, plantations with species which have long roots have been difficult (Hussain & Acharya, 1994). However, different types of approaches and their alternatives are employed to overcome these difficulties.

Annual planting continuously increased and reached a peak of 22 800 ha in 1985, of which coastal plantations were about 10 000 ha (MOEF 1993a). Recent inventories and estimates generally note that 20–30% of all plantations established during the last 30 years no longer exist. Officially, the reported total plantation area in the country in 1990 was 332 000 ha of which 113 000 ha were in coastal regions (MOEF, 1993b).

The Forestry Master Plan (1993) suggested two scenarios. The first one proposed an annual planting target of about 18 000 ha during 1993–2002 and 21 000 ha during 2003–2012 (MOEF, 1993b). However, use of quality planting material, site preparation and post-establishment maintenance has not been given adequate attention. Due to budgetary and legal constraints adequate protection of plantations from fire, grazing, illegal removal and encroachment has not been provided (MOEF, 1993b). The second scenario emphasizes on the development of wildlife sanctuaries; consequently, three areas of the Sundarbans Forest Division have been declared wildlife sanctuaries. However, the total area of these sanctuaries is not sufficient to provide long-term protection to the wildlife of the forest.

Planning and policy aspects

The first management plan for the Sundarbans was formulated in 1893 for a period of 6 years. The Sundarbans was declared a reserve forest in 1875–1876, under the forest act of 1855. The Pakistan

portion of the Sundarbans became under Forest Division after the partition of India in 1947. The Sundarbans is now administered by the Bangladesh Forest Department under the Ministry of Environment and Forest. To regulate the activities within the forest and to ensure sustainable resource use from the forests, several policies have been formulated, amended, modified and improved over years.

After the liberation the first National Forestry Policy of the Government of Bangladesh was formulated in July, 1979. Since then, efforts have been made to orient the policies to meet current need, particularly as they relate to the rapid depletion of forestry resources owing to numerous socio-economic factors. As part of this, the Government has formulated another and the latest National Forestry Policy (1994) for a period of 20 years. The objectives and the major policies have been summarized below (Hussain & Acharya, 1994; ADB/UNDP, 1995; FAO/UNDP, 1998).

The national forestry policy

To meet the basic needs of the present and future generations and also to ensure greater contribution of the forestry sector in the economic development, about 20% of the total area of the country will be afforested under this policy by taking up various afforestation programs. Side by side, fallow lands (lands not useful for the purpose of agriculture) hinter lands and in other possible areas, Government sponsored afforestation programs will be implemented. Moreover, appropriate measures will be taken to encourage afforestation on private land and technical support and services regarding the production of forest crops have to be ensured. The major policies are as follows:

- By creating employment opportunities, strengthening the rural and national economy, the scope for poverty alleviation and trees and forest based rural development sectors will be extended and consolidated.
- Biodiversity of the existing degraded forests will be enriched by conserving the remaining natural habitat of birds and other animals.
- Agricultural sector will be strengthened by extending assistance to the sectors related with forest development, especially by conserving the land and the water resources.
- National responsibilities and commitments will be fulfilled by implementing various international efforts and government ratified agreements relating to global warming, desertification and control of trade and commerce of wild birds and animals.
- Through the participation of the local people, illegal occupation of the forest lands, illegal tree felling and hunting of the wild animals will be prevented.
- Effective use and utilization of the forest goods at various stages of processing will be encouraged, and Implementation of the afforestation programs, on both public and private lands will be provided with encouragement and assistance.
- Forest shall be carefully preserved and scientifically managed.
- Attempts will be made to bring about 20% of the country's land under the afforestation programs.
- Private initiatives will be encouraged to implement the programs.
- Attempts will be made to increase the amount of protected area by 10% of the reserved forest land by the year 2015.
- Multiple use of forest, water and fish of the Sundarbans through management will be ensured keeping the bio-environment of the area intact.
- Keeping in view the ecology, the management of the forest lands will be brought under profit oriented business.
- Inaccessible areas as slopes of the hills, fragile watersheds, swamps etc. will be identified and kept as protected forests. Modern technology shall be employed for extraction and utilization of the forest produce.
- Emphasis will be given to the forest based industries to ensure effective utilization of the forest raw materials and profit oriented management systems under the free market economy;
- Rules and procedures regarding forest produce in the country will be simplified and made up-to-date.
- Reserved forest cannot be used for non forest purposes without the permission of the Head of the Government.

- Women will be encouraged to participate in homestead and farm forestry, and participatory afforestation programs.
- Fund from different donors will be used to promote private forestry organization and such programs like training, technical and financial support will be imparted at an increasing rate.
- Timber resource to be increased by establishing large scale plantation.
- Ecotourism, related to forest and wildlife, is recognized as forestry related activity, which will be promoted taking into consideration the carrying capacity of the nature.
- Forest Department will be strengthened in order to achieve the goals and objectives.
- Research, education and training will be organized to meet the scientific, technological and administrative needs of the country.
- Laws, rules and regulations relating to the forestry sector will be amended and, if necessary, new laws and rules will be promulgated in consonance with goals and objectives of the National Policy.

Legislation and regulation

The broad principles for forest management in Bangladesh are encapsulated in the Forest Act 1927 (amended in 1989). This Act consolidates the laws relating to forests, the transit of forest produces and the duty leviable on timber and other forest produce. It also makes provision for the government to declare any forest or wasteland as reserved forests, village forests or protected forests. Reserved forests prohibit a variety of activities, including agricultural clearing, cattle grazing, fuelwood collection and harvesting of most forest products. Protected forests provide a lesser degree of regulation in that these activities may be carried out under license. Rights to government forests may also be assigned to communities as village forests. More recently, the Forest Law of 1993 has been enacted to provide a legal basis for implementing forest management practices envisaged under the Forestry Sector Master Plan. A variety of specific forestry, environment and land acts have been formulated, having substantial impacts on forest management. These include: the State Acquisition and Tenancy (SAT) Act, 1950; the Acquisition of Wasteland Act, 1950; the Bangladesh Private Forest Act (PFA), 1959; and the Bangladesh Wildlife (Preservation) (Amendment) Act, 1974.

The Government of Bangladesh launched a Master Plan for Forestry Development in 1990 in an effort to counter ongoing deforestation and forest degradation. The objectives of the Master Plan are to optimize the contribution of forest resources for environmental stability and economic and social development. The Plan covers a 20 year period 1993–2013, and has been incorporated into the country's Fifth National Five Year Plan (1995–2000). As a first step in implementing the Master Plan a new national forest policy was promulgated in October 1994. Three sets of programs were formulated under this policy: people-oriented programs, production directed programs, and institutional strengthening programs. In 1994, a National Environmental Management Plan was also prepared. The main forest-related provisions of this plan are for participatory management of plantations and natural forests.

Forest act

The Sundarbans mangrove forest was declared as 'Reserve Forest' in 1875–1876 under the first Forest Act of the then British India. This act, virtually, transferred the ownership and all the rights of the forest to the government through the Department of Forest and restricted privileges of the public in the forest. The act empowered the Forest Department to permit or prohibit all activities and also made the department responsible for formulating and implementing management plans. The act contains 86 sections of which 25 are concerned with reservation, 10 with protection, 1 with village forests, 6 with transit of forest produce, 7 with drift timber, 24 with penalties and procedures, and the remaining 13 with miscellanea. The important features of this act with respect to mangrove are as follows:

- All rights or claims over the forest have been settled at the time of reservation of the Sundarbans and the grant of any new right to individuals or communities is prohibited.

- Any activity within the Reserve Forests of Sundarbans, unless permitted by the Forest Department, is prohibited.
- Any kind of violation in the Sundarbans Reserve Forest may result in court cases with fine or rigorous imprisonment, or both.
- Any offense may be compounded by the Forest Department upon realization of the fine.
- Without any warrant, the Forest Official can arrest anyone for violation of the Forest Act.
- The Forest Department is also empowered to regulate the watercourses within the Sundarbans.
- The Forest Department is also empowered to regulate the rivers with regard to transit to and transportation of timber and other forest produce.

Wildlife act

In order to strengthen the power of the Forest Department with regard to conservation of wildlife, the Wildlife Act was promulgated in 1973. The act has 48 sections, 18 of which relate to procedures regarding the disposal of offenses and claims, 2 to framing of rules, 7 to export, import and possession and the remaining 21 relate to various other aspects of wildlife. The major features of the act are:

- The forest officials are empowered to prosecute violators for emphatically protecting the wildlife.
- Hunting of wildlife is restricted only to certain species.
- Hunting and trapping of any of the threatened or endangered species is prohibited.
- Possession of specified wildlife materials requires certificates from the Forest Department.
- Upon realization of fine, some of the offenses can be compounded by higher officials.
- Man-eating tigers cannot be killed without permission from the Chief Warden.
- Forest Officials can arrest anyone for violating the provisions of the act.

Brick burning act

Fuelwood was once used extensively for manufacturing bricks. The Brick Burning Act was promulgated in 1991 to regulate the use of fuelwood in brick manufacturing plants. Heritiera fomes and Ceriops decandra are considered high quality fuelwood for brick burning and were in high demand for this purpose. At present, a limited quantity of fuelwood is allowed but use of coal fuel in brick burning is strongly recommended.

Sundarbans forest transit rules

The Forest Transit Rules formulated in 1906 and revised in 1969 are in action till now. There are 15 rules 6 of which are concerned with details of working, 7 with permit issuance, 2 with licensing of boats used in transportation of the forest produce. The important features of the rules are:

- Prohibition of cutting or converting timber without a pass.
- Prohibition of transit of forest produces without a valid transit document.
- Any permit issued for collection of any forest produce must contain specific information about what type of produce to be collected, where to be collected, and when the collection would have been completed.
- The boat used in the transportation of the forest produce must have a valid Boat License Certificate (BLC).
- Any forest produce on transit from the forest will pass through one of the 16 notified Forest Revenue Stations located on the banks of the rivers on the boundary of the forest.

Felling and cutting rules

These rules focused mainly on those purposes for which trees are most likely to be collected such as for use as firewood and on those species which are most likely to be destroyed such as Ceriops decandra and Nypa fruticans. Besides the rules and regulations, the government has made several agreements with the industries, which are dependent on the forest for raw materials. The industries are newsprint mills, match factory, hard board mills etc. which require huge quantities of *Excoecaria agallocha*, Heritiera fomes, and *Cynometra ramiflora*. Upon the agreement, the government has decided to reduce the annual supply of these woods, but on a regular

basis, which, on one hand, ensures regular supply of the raw materials to the industries, and help conserving the resources on the other.

Institutional issues

In view to maintain the ecological balance and to develop the resource for sustainable utilization, the Government of Bangladesh has formulated and established different management policies and action plans. At the same time, various non-government organizations (NGOs) and private organizations have engaged themselves in research, management and development processes. The Government also provides institutional, infrastructural and legal support to encourage participation of such organizations. Moreover, International organizations such as CIDA, AIDAB, USAID, JSPS, UNDP, UNESCO, FAO, ADB, and World Bank have sponsored research programs on mangrove ecosystems and various development activities.

The FAO/SIDA Bay of Bengal Program (BOBP), First Aquaculture Development Project (ADB), Shrimp Culture Project (IDA), Second Aquaculture Development Project (ADB), Third Fisheries Project (World Bank) have all contributed along with the national policy making and funding in the improvement of shrimp culture in Bangladesh. The currently operating Fourth Fisheries Project funded by the World Bank also has its component for promotion of shrimp aquaculture.

Status and trends in forest management

Scientific forest management and conservation in Bangladesh has a history of more than a century. Forest management in the country naturally encompassed the various silvicultural and management techniques developed under British colonial era. The strictly ecological approach to forest management has foundered in more recent years in the face of rapidly mounting population pressures and poverty-driven demands for additional agricultural lands. Consequently, the focus of forest management has moved quite rapidly toward a community-based approach. This approach recognizes that effective forest management in conditions of intense population pressure requires community participation in planning and implementation.

The Sundarbans mangrove forest has a distinct forest management history. The area was mapped as early as 1764, soon after proprietary rights were obtained by the East India Company in 1757. The first Forest Management Division with jurisdiction over the Sundarbans was established in 1869 and the first management plan was introduced in 1892.

Current management objectives

The Master Plan for Forestry Development stipulates that forest resources should be managed in an ecologically sustainable manner to ensure species diversification and continuous improvement of environmental conditions. State-owned forests, comprising natural forests, hill plantations and Sal (*Shorea robusta*) plantations are used to produce forest products, except for reserved forests, which are set aside to conserve soil and water resources, and for the maintenance of biodiversity. Commercial management of forests is expected to be profit oriented. The Master Plan aims at rehabilitating denuded or encroached forest areas using participatory approaches. The Master Plan recommends a strategy incorporating six key points for forest management:

- Enhancing environmental preservation and conservation;
- Introducing rational forest land use;
- Increasing public participation and benefits from resource management;
- Expanding the resource base;
- Improving management practices; and
- Undertaking efficient resource allocation.
- Forest management plans.

The shift toward participatory forestry means that new plans, with significantly altered management prescriptions, will be required. This planning process is, however, very much in its infancy. Nonetheless, efforts to involve stakeholders in forest planning are being made in Bangladesh. Workshops and seminars have been arranged at divisional levels to enable 'grass roots' views to be expressed and to share local experiences in forest planning. Forests managed for production pur-

poses comprise around 550 000 hectares, conservation forests constitute 220 000 hectares, while forests for coastal protection, most notably the Sundarbans area, cover 350 000 hectares. The Sundarbans Reserved Forest is the focus of several conservation efforts, including an FAO-executed project, which helped draw up an integrated resource management plan for the area. The planwas published in 1998 and has objectives: to produce a plan for integrated resource management designed to enhance the supply of wood and non-wood products; to conserve and manage aquatic and terrestrial wildlife resources; to study the potential for mobilizing and assisting people's participation in income- and employment generating activities in the area (with particular focus on disadvantaged groups); to develop the tourism and recreational potential of Bangladesh's forests; and to enhance the protective role of forests against cyclones, soil erosion and tidal surges. In mangrove forests the principal silvicultural system is 'Selection cum Improvement'. This system involves selection of individual trees and small coupes for commercial felling, based on specified diameter limits. Diseased and undesirable species are also felled, to promote growth of more valuable species.

Mangrove management problems

The problems associated with management of the mangrove resources are many and varied. These problems are closely related to the rapid destruction of the mangroves, conversion of mangroves to aquaculture and other forms of land uses and other related impacts. In defining the management problems of mangroves it is better to identify the root causes of the problems rather than to look at the most dramatic forms of alteration of the mangrove system alone. Identification of the problems associated with the mangrove must also take into account the social, economic and other related events particularly when the development issues are concerned. Some of the major problems concerning mangrove resources management and development are listed below.

The management agencies are formed on the basis of economic sectors giving major consideration on economic benefit from the resources. The complex biophysical mechanisms occurring in the ecosystems and their relations with the management are rarely considered. Consequently, persons with sufficient knowledge on the ecological basis of mangrove management and development are ignored from the overall management systems.

Mangroves are very complex ecosystems formed by interactions between land, water, flora and fauna. But the country's management policies are such that, in most cases, management policies are formulated separately for each individual unit by the authorities concerned. In most instances, there is no coordination between different sectors, and their policies are conflicting. The need for a quite different management strategy for mangrove forests rather than managing separately each unit has not yet been realized. As a result, effective exploitation, management and conservation of mangrove resources are far away.

Many of the mangrove development policies cannot be successfully implemented due to various reasons. Corruption at different levels of management systems, illegal felling of trees, poaching of woods are some of the major constraints in successful implementation of development projects. There are frequent claims that the law enforcing agencies and the management bodies themselves are sometimes engaged with the illegal actions. If this situation prevails, virtually, no policy, rule or regulation could contribute to the development of the resources.

Although the mangrove lands are under the ownership of the state the accessibility of the general people is not always regulated properly. People even engage themselves with agricultural activities within the restricted areas. Implementation of development policies is hindered to a great extent by shortage of manpower for official management, including monitoring, evaluation, supervision etc. As in other Asian nations, there is a general shortage of resource management expertise in proportion to the scale and rate of development related pressures in Bangladesh.

Although the management history of the mangrove is quite old, yet, management strategies based on logical and scientific basis have not been developed. Sufficient research efforts have not yet been paid to find out effective management policies. Although the forest management system of the Sundarbans has focused on the sustained production of forest products the management

systems has not taken into account the mechanisms to maintain best achievable ecosystem function (Clark, 1974).

Poor management policies, weak organizational and legal efforts and, above all, the population pressure have subjected the mangrove forests to massive destruction. Destruction of mangrove resources in Bangladesh is so high that irreversible long-term changes have taken place in the ecosystem affecting the balance and sustenance of the system. There is an annual loss of some 1500 ha of natural forest which is more than compensated for by an annual plantation establishment of about 18 000 ha. For the sectoral economic interest, traditional patterns of use of forest by the local people have been restricted to a great extent, which, appeared as threat to the poor rural economy of the country.

Any sector without a reliable guideline can be treated as a boat without a helm. The need for a basic guideline for mangrove resources is now fully recognized to overcome the problems of unplanned destruction. Most of the people in the rural areas of Bangladesh are poor and illiterate. They do not have the knowledge of any biophysical or socio-economic event of the mangroves and are not aware of even their own legal rights. As a result, very often they are deprived and, when they get chance, they exploit the resources in an irrational way.

Best practice recommendations

The principal challenges for Bangladesh arise from intense population pressures on meagre and stressed forest resources. Nearly half the country's population is living below the poverty line and there is, consequently, severe conflict between environmental protection and enhancement objectives on one hand, and economic development and poverty eradication objectives on the other. The overriding imperative is to balance social, economic and environmental goals to avoid ecological disaster. In this context, the key issues for forestry are to bring forests under environmentally sound management, while also enhancing their economic productivity.

Problems regarding the exploitation, management and development of the mangroves in Bangladesh are many and varied as well as complex. To ensure sustainable resource use and development of the mangrove resource, a well-coordinated and complete management plan is the first need for the mangrove of Bangladesh. The plan should be formulated on the basis of a clear understanding of the mangrove systems including the factors affecting it and the impacts of different forms of resource use on the system rather than considering the forest as merely a collection of trees. The plan should also consider the social and economic conditions of the people directly or indirectly associated with the mangrove forests. Sustainable development requires, among others, an integrated decision making process, a political system that secures effective citizen participation, an economic system that generates surpluses on a sustained basis, a social system that provides solution to the tensions arising from disharmonious development, a production system that respects the obligation to preserve the ecological base, and an administrative system that is flexible and has the capacity for self-correction (Deb, 1998).

Regular and up-to-date data of the forest and other related resources should be available of the authority. For this, a continuous and effective program of resource assessment of the mangrove should be formulated and implemented. Intensive and exhaustive research should be undertaken to study the basic functional systems of the mangrove ecology and the factors affecting the system. This will help finding out all possible way of mangrove utilization as well as developing models for optimizing and integrating multiple use of resources without causing any temporary or permanent damage to the system. The research should be conducted on the basis of a multi-disciplinary approach, ensuring participation of all the related disciplines.

A national institute for multi-disciplinary research on mangroves should be established. This institute, along with research programs, may take the responsibilities for formulation of management plans and conservation strategies. Bangladesh is also suitable for establishment of a Regional Mangrove Research Institute. Establishment of such institute could be helpful in disseminating and exchanging research findings amongst the regional countries as well as sharing benefits from the experience of other countries. Intensive studies should be conducted on the environmental impact of different forms of resource use, which must take into consideration the socio-economics of the mangroves.

Conversion of mangroves to aquaculture or any other land use should proceed with extreme caution and must be followed by the environmental and socio-economic impact assessment, considering the probable damage to the resources because of such conversions. All conversion programs should be carefully evaluated both ecologically and socio-economically. For promotion of recreational and tourism activity in the mangrove areas, 'Mangrove national Parks' and 'Virgin Jungle Reserves' can be established, which can help developing public awareness. Experience can be shared from other mangrove-dominated countries like Malaysia or Thailand.

A 'National Mangrove Committee' should be established which will be responsible for all aspects of mangrove utilization, conservation, research and management. To facilitate the development of an integrated management plan, there should have regular communication and exchange of data among groups, which actively support sustainable use of mangroves.

For the fisheries and aquaculture sector, there should have clear understanding of the fisheries implication of the mangrove forests. Studies should be conducted on the biology and life history as well as on the potential benefits that could be obtained from the mangrove fisheries resources without affecting the long-term sustenance. Emphasis should be given on technical and financial assistance, which stimulates more efficient use of existing resources rather than that, which encourages further destruction and degradation. The experts should look forward to stimulate the development of such kinds of aquaculture in mangrove, which are compatible with the mangrove forests or to the probable alternative sites outside the mangrove areas for establishment of aquaculture industries.

The population pressure and the economic situation of the country is such that there will be a continuing pressure on the forest resources of the country in the form of settlement, farming activities, cattle grazing etc. which could lead to serious consequences. The experts and authorities should, therefore, look forward to alternative sources and patterns of land use.

In Bangladesh, a realistic national policy for shrimp cultivation is yet to be formulated. The Government should formulate a complete and compatible guideline for brackish water aquaculture particularly for shrimp culture which must provide specification on all aspects of shrimp farming activities including the types and amounts of drugs and chemicals that can be used in the farms, the effluent discharge, import of shrimp fry, catching of fry from the wild stock etc. Such a policy should ensure regular and sufficient institutional supervision and monitoring of the operational procedures, application of the impact assessment, and implementation of the regulatory measures. The guideline should necessarily include an appropriate land use pattern to resolve the socio-economic conflicts. The Government should strictly regulate the import of the banned poisonous 'dirty dozen' and other chemicals of the 'red group' from other countries through back doors.

For large-scale production of shrimp seeds, it is extremely important to establish commercially viable hatcheries to support the shrimp industries of Bangladesh. This will play a great role in enhancing production by reducing the problems originated from import of fry as well as to conserve the biodiversity by reducing dependence on the wild stock for fry. By the side of the government, the non-government organizations (NGOs) and the private sectors could play a significant role in this process. The government should provide infrastructural and legal support to the NGOs and private sectors to encourage hatchery establishment. Development of nursery and larval rearing techniques and facilities for regular monitoring of water quality are also of considerable importance. It is also important to ensure regular supply of quality shrimp feeds at low cost.

Destruction of mangroves in the name of shrimp farming must be banned. To protect the resources from destruction, participatory approaches including the local people could be effective. To help promote the development of the brackish water aquaculture, bank financing should be extended to the private entrepreneurs.

Conclusion

The beneficial influence of mangrove forests is not limited to the immediate geographical area in which they grow. They exert balancing ecological influences that are felt far beyond their immediate

boundaries. Although exploitation of mangroves for a long time and large-scale conversion of mangroves to aquaculture and other forms of resources have caused serious consequences, it is not impossible to rehabilitate the resources if proper attention is paid and effective management programs is formulated and practiced. A number of reports suggest that the mangrove Sundarbans of Bangladesh has been under a simple, easy-to-implement management regime which was installed more than a hundred years ago. The management regime has ensured sustainability and if the management practices are followed properly, this will ensure maintenance of the stands in stable condition for an indefinite period of time.

Bangladesh is as rich in terms of its natural resources as it is poor in terms of its inadequate resource utilization and mobilization of its large human population to productive and development purposes. Therefore, Bangladesh has to give a new look to its natural resources particularly to the coastal resources of how they can be used for sustainable social and economic development of the country.

In old days, there was very poor knowledge on mangroves, and the forests were exploited without any scientific background, not considering the future implication of the exploitation. However, in recent days, knowledge of different aspects of the mangrove resources has increased greatly and mangrove resource conservation, management and development have been paid considerable national and international attention. It has been fully realized and recognized in recent times that we are dependent to a great extent on the mangrove forests and they must be conserved for our own interests.

Destruction of mangrove for coastal farming is now a global problem that has created considerable debate worldwide and need proper attention and immediate action. The numbers of shrimp producing and consuming nations are very few. These relatively few countries should provide a clear field of action on specific demands. The governments of these producing and consuming countries have a fundamental responsibility to enact legislation and enforce regulations to protect coastal and marine environments from destructive aquaculture practices. The multilateral development agencies such as the World Bank and the UN Food and Agriculture Organization, along with various national foreign aid programs, which have promoted and/or helped finance the destructive shrimp farming industry must review and amend their policies in this field, and redirect their support into rectifying the damage done.

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