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Implications of Mangrove Wetland in Socio-environmental Sector: Experiences from Southeast Coast of Chittagong, Bangladesh

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ABSTRACT : Wetlands perform various functions of vital socio-ecological significance playing fundamental role in moderating monsoon tidal floods and coastal protection and generate goods and products such as fish and forest resources. The depletion of mangroves is a cause of serious environmental and economic concern to many developing countries. Problems of sustainability of mangrove ecosystems are not only technical but also socio-economic. Functions played by mangrove wetlands are of fundamental importance for society. The present study aims to identify the challenges of the mangrove wetlands of Southeast coast of Chittagong, their uses and socio-economic influence on local people, and the value of ecosystem services, and to suggest how to conserve this ecosystem in a more equitable way.

Keywords : Mangrove, Wetland, Socio-environment, Southeast coast, Bangladesh

Abbreviations : Ecosystem service value = ESV, Household = HH, Set Bag Net= SBN

INTRODUCTION

Wetlands perform key ecosystem functions that maintain the ecological integrity of the wetland ecosystems (Smith et al., 1995). They provide wildlife habitat, recharge ground water and deep aquifers, recycle nutrients, ameliorate downstream flooding and protect water quality and produce biomass (Brinson et al., 1995; Ullah et al., 2005). The level of a function performed by a wetland is the result of its biotic and abiotic structural characteristics as well as their interactions (Taylor et al., 1990). Among the wetland ecosystem, mangrove wetlands along with sea grass and salt marsh habitats are the most productive ecosystem in the world in terms of the quantity of vegetation production closely linked to the high production rates of associated fisheries (Hena et al., 2007). Mangrove also designates the marine tidal forest that includes trees, shrubs, palms, epiphytes and ferns (Tomlinson, 1986). The high productivity of mangrove ecosystems means that they provide ample food supplies to maintain a complex food chain. They therefore provide fertile habitats and nursery grounds for many wild species of commercial importance, including shellfish and fish. Thus, the ecosystem service value is high. The southeast coastal area of Bangladesh is characterized by both natural and planted forest. Recognition of the protective role of natural mangroves, the Sundarbans, inspired the government to start a coastal afforestation program in 1966 to strengthen coastal protection. Four Coastal Afforestation Divisions were established to administer the program. the primary objective was to mitigate the catastrophic effects of cyclones and storm surges by this planted natural barrier (Siddiqi, 2001); however, other objectives were added later, namely timber production, the conservation and stabilization of newly accreted lands, the acceleration of accretion (with the ultimate aim of transferring a large part of this land to agriculture), the creation of employment opportunities for coastal communities; and the development of suitable habitat for wildlife and aquatic species (Canonizado, 1999). At first, the plantation was restricted to a few major

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species. Later, all the commercially valuable mangrove species were tested (Siddiqi et al., 1993) particularly in the southeast coast of Chittagong but of these only two species, keora (*Sonneratia apetala* Buch.—Ham) and baen (*Avicennia officinalis* L.) demonstrated good performance. As pioneer species in mangrove succession, they can grow well on newly accreted areas with regular inundation (Das and Siddiqi, 1985). However, there are many challenges to mangrove wetlands, including anthropogenic ones. The mangrove forest found in the wetlands helps to prevent natural calamities such as Tsunami. In addition, wetlands are a source of recreation, timber and other natural products for commercial use (Hossain et al., 2007). Though, recognition of the environmental, social and economic impacts associated with the decline and degradation of mangroves are now being addressed through legislative, management, conservation and rehabilitation efforts aimed at mitigating the negative impacts of development on mangrove ecosystems, most of those works were focused on the single largest natural mangrove forest of the world "sundarban" at the southwest parts of Bangladesh. In contrast, less effort has been made on the southeast coastal mangrove ecosystem of Bangladesh over the last decade to address above issues. So this study was undertaken to ascertain those issues in this planted stands dominated southeast coastal mangrove ecosystem of Bangladesh.

MATERIALS AND METHODS

Study areas

Bangladesh Forest Department has four forest divisions namely Chittagong, Patuakhali, Bhola and Noakhali while Chittagong forest division represents the five districts in southeast. A deliberate sampling method was used to distinguish Chittagong and Cox'sBazar district from the surrounding five districts of the southeast coastal Bangladesh. Sample sites Teknaf, and Mirarsharai in Southeast Chittagong were selected for the study because of the availability and accessibility of mangrove forest. Teknaf is the most southern or south-eastern coastal subdistrict under the Cox'sBazar district of Bangladesh., occupying an area of about 388 sq km between latitude $21^0 10'$ N and $20^0 40'$ and longitude $92^0 05'$ E and $92^0 25'$ E (Figure 1). This is the only place of Bangladesh which is connected with Myanmar by a small river called Naaf River of Bangladesh. Mirsharai Upazila (Chittagong district) with an area of 482.88 km^2, is bounded by Tripura State of India, Chhagalnaiya and Feni sadar Upazilas on the north, Sitakunda and Sandwip Upazilas on the south, Fatikchhari Upazila on the east, Sonagazi and Companiganj (Noakhali) Upazilas on the west and located at 22°46.3′N and 91°34.5′E. (Figure 1)

Methods

The study aims to generate baseline data on the mangroves and wetlands of Southeast Chittagong and to review the pattern of resource use in the wetlands in terms of sustainable utilization of resources. This demands an interdisciplinary approach with components of socio-economic, biodiversity, and cartographic appraisal of the landscape units in different localities. Owing to this, the methods of investigation adopted in the present study range from household surveys, a review of the literature, foot surveys of biodiversity studies, and ecosystem value analysis. Data was collected through semi-structured questionnaires and interviews with people from different walks of life – aged people, fisherman and other stakeholders. A preliminary socioeconomic survey was carried out to ascertain the important socioeconomic parameters of the study areas and to select the respondents for detailed study. A detailed survey was conducted to obtain data regarding mangrove products and goods, cost of labor, etc. However, determination of ecosystem service value (ESV) values are actually static snapshots of a biosphere that is a complex, dynamic system whereas building regional and global models of the linked ecological economic system aimed at a better understanding of both the complex dynamics of physical/biological processes and the value of these processes to human well-being. As the attributes of ecosystem values (benefits of wetlands) may vary at different regional levels,

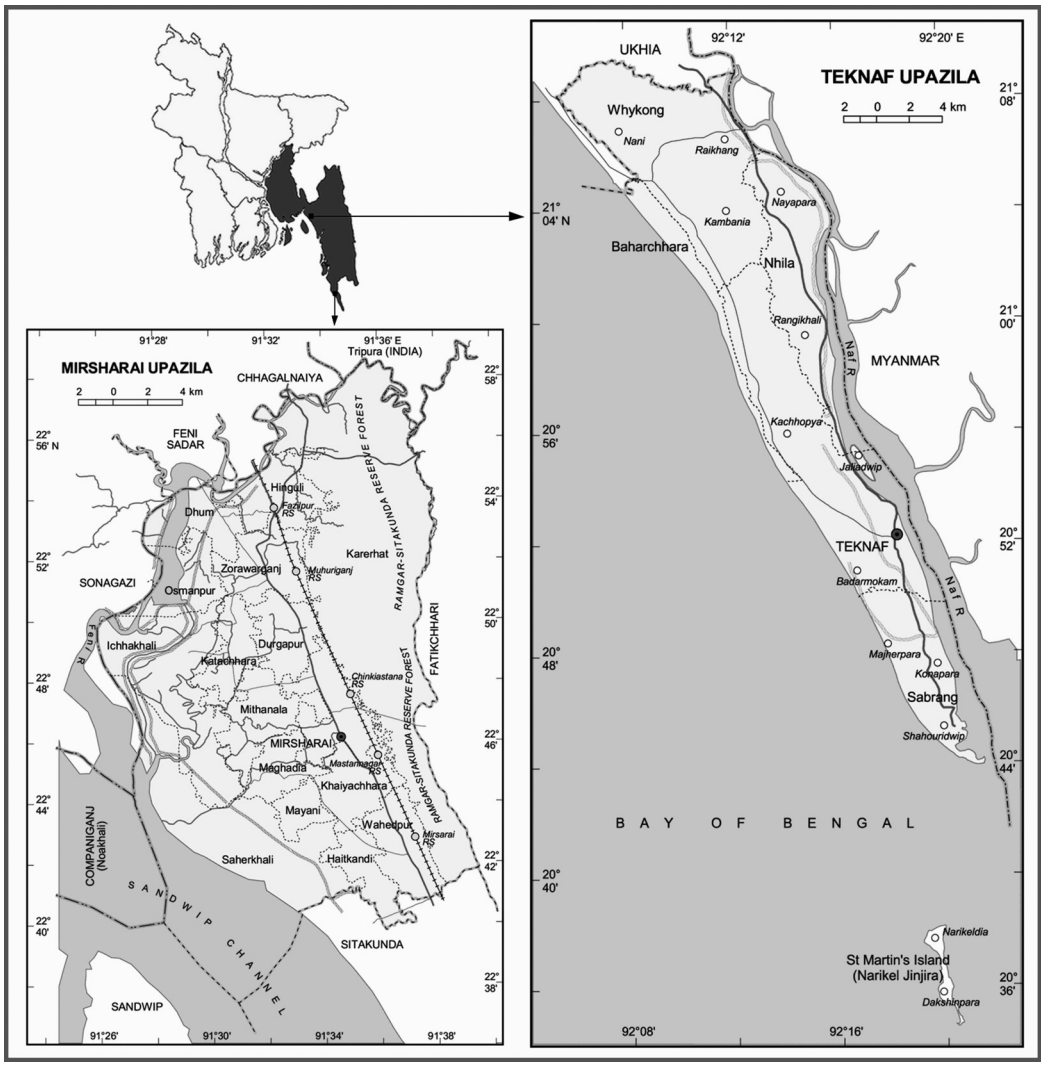

Fig 1. Map of the study area

an extensive literature study (Groot, 1987; Turner, 1988; Turner, 1991; Groot, 1992; Siddiqi et al., 1993; Daily., 1997; Chowdhury et al., 2009) and foot surveys on the studied areas were made to recognize the service value of southeast coastal mangrove wetland of Chittagong. Thereafter, the method of Costanza et al., (1997) was followed to determine ESV where key theory was considered as, "either directly or indirectly, on attempts to estimate the 'willingness-to-pay' of individuals for ecosystem services." The essence of the ecosystem value approach is to estimate values as subtractions from or additions to income that leave people equally economically satisfied with or without a change in the services provided by the mangrove ecosystem. Challenges and suggestions for sustainable developments are listed from the data.

A household (HH) survey as part of assessing the importance of wetland-related activities in the occupational pattern of the areas were conducted in 80 (40 HHs in each study area) randomly selected houses belonging to the two Upazila. A multistage random sampling method was applied to locate the villages and households for the study within the Upazila as the primary and ultimate sampling units, respectively. Criteria used for selection were: proximity to the backwaters, type of soil (whether representing typical wetland alluvium, sand or silt), geomorphic features and features of vegetation of wetlands. Details of occupation, social and organizational affiliations, basic amenities, access to the basic resources, and the

preferred mode of developmental input and participation of individuals in the people's movement were collected.

RESULTS AND DISCUSSION

The extent of mangrove forest in Southeast Bangladesh from Cox'sBazar to Chittagong district is nearly 6632 ha (Chowdhury et al., 2009, Mahmood, 2009). Chittagong district has the major share of it. A large number of plants and animals depend on mangrove wetlands as their habitat. The dominant mangrove species are *Sonneratia apetala, Avicennia alba, A. officinalis, Acanthus ilicifolius*, *S. lucida*, and *Nypa fruticans while* other mangrove species include *Excoecaria agallocha, Ceriops roxburghii* and *Bruguiera gymnorhiza.* There are also found *Phoenix paludosa* a small straight and slender palm some times forms pure and dense stands along river banks or as under growth in sparsely wooded areas. The banks of Naaf river estuary are covered in a dense growth of *Oryza coaretata*. The lowlands on the west bank of the river are under cultivation; the hills of the Teknaf Peninsula are covered in tropical wet evergreen and semi-evergreen forest. A wide variety of waterfowl population characterized these mangrove wetlands including 81 species, of which 341 are migratory. There are 160 different species of fishes in the wetlands. The mangrove wetlands have strong linkages with the coastal environment and agriculture and are considered important areas for sustenance of the coastal communities. The stability of the functioning of these ecosystems depends on climate stability and coastal processes. Even a minor change in the global temperature and climate of the area would have a major bearing on the coastal wetlands and also on land-and water-based activities in the region. Most of the true mangroves are medicinally and economically important. Coastal communities are involved in artisanal fishing, turtle egg collection, coastal aquaculture, shrimp fry collection, firewood collection, timber collection, fishing pole, fishing float, mollusc shell collection, medicinal use, salt production and crab collection, etc. The respondents identified 12 mangrove resource user groups in southeast Chittagong coasts. The percentage

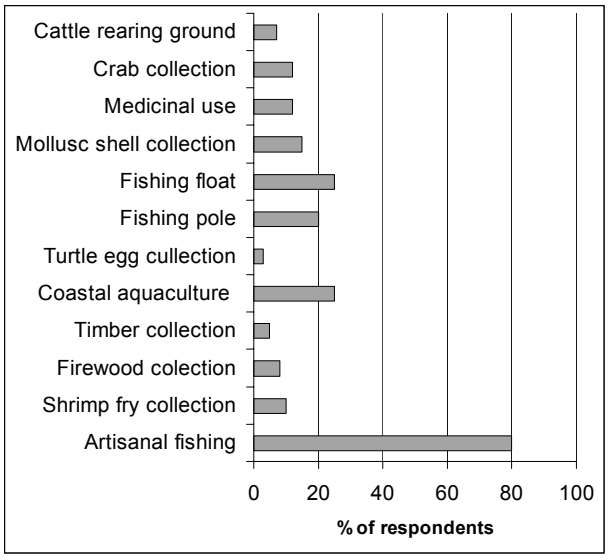

Fig. 2. Benefits sharing among the stakeholders from southeast coastal mangrove ecosystem of Chittagong

of benefit of stakeholders from the mangrove wetlands is given in Figure 2.

Socio-economic influence on local people

The Teknaf Peninsula has a population of 15,2557 whereas population of Mirsharai Upazila is 32,5712. Sample studies were carried out in different parts of the two places of study. Sample analysis was done on 200 people, of whom 110 were males and 90 females. Out of a total of 130 earning individuals, 90 were males and 40 were females. There are about 15 people who own the land in the Teknaf Peninsula area. Fishing is the major profession of the local people though some were involved in cultivation until a decade ago. Increase in salinity, land reclamation and profit loss are the main reasons for giving up cultivation. The stakeholders of this area can now be classified into following major groups:

Fishermen

There are about 2000 fishermen in the studied areas. Rented and self owned boats are used for fishing. Two persons use a single boat. Rent for the boats varies from Taka 400−500 for one month. The best season for fishing

is December to June. Each fisherman can earn about Taka 80 to 120 per day. A trap called a *pedal*, which is made of ribs of the leaves of coconut palm, is also used for fishing. It is mainly women who use these traps in shallow areas. Some fishers also use two types of nets i.e. Gill net and Set Bag Net (SBN). During the peak season (usually 4 months) they use Gill net for Hilsha fishing. During the lean season SBN is used for fishing Bombay duck and shrimp. A small number of fishers also use long line and conventional fishing gear for fishing. However, barrier net locally known as Char jal is also widely used to catch fish and contribute significantly on the livelihood of local fishermen. To set up barrier net net fencing is made by bamboo poles and become submerged in the water during high tide. Bamboo poles are stuck in the shore of the intertidal area adjacent to wetlands during low tide and the net are kept attached with these poles. During the high tide at first the water is let to enter, after 2 to 2.30 hours of the high tide the fishermen pick up the upper portion of the net and make a fence. When the low tide started all the species inside the fence become trapped. When it is extremely low tide then the fishermen used to harvest the fish, shrimp and crab.

In some cases, women make small mud enclosures in the shallow areas, and use the traps during ebbs to trap shrimps by rolling the *pedal*. Some old fishermen revealed the above-mentioned facts. According to these fishermen, destruction of mangroves has reduced the availability of fishes considerably. The price of the prawn varies from Taka 50−150 per kg. Generally, the prawn catching sites are open to all fishermen to fish but in some places, a particular area belongs to some fishermen as their inherited property. The fact is managed by local influential leaders and organization.

Those involved in mollusc and turtle egg collection and processing

More than 40 families are involved in this. Mostly clams (*Meretrix* sp) are collected from the wetlands near to mangroves. One *thella* (Portable small pot made by bamboo) costs Taka 20. Clam mining is done from January to June. There is good demand for clams, and they are transported to Cox'sBazar and Chittagong for further processing and industrial purposes. Shells can be mined throughout the year. There is a boiler owned by a family in Teknaf where the shells are made into lime powder which is used for the treatment of industrial waste. Lime powder is used for whitewashing the houses. Some local people explained the details. In the Teknaf Peninsula, Oliver ridely turtle (*Lepidochelys olivacea*) is dominant in mangrove vegetated areas, the green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricate*) and leatherback (*Dermochelys coriacea*) turtle nests are rarely found. Local people collect eggs from the nearby beach and sell to the visitors, local market at BDT 200-380 per hundred eggs (1 US$= 70 BDT)

Crab catchers

Ring nets tied with chicken legs are used for crab (*Scylla serrata*) catching. The season for crab catching is from December to May. The crab catchers get a good catch at night though due o security problems most of the crab-catcher do their jobs at day light. Currently, about 25 small boats and around 65 peoples are involved in crab catching. Generally, two persons go in a boat. Three to four crabs are caught in a ring net. A good catch is available during high tide. The price of the crab varies according to its size where the large-sized one costs BDT 200 kg^{-1}. The ordinary type will cost BDT 50 kg^{-1}. Each boat can catch 2−6 kg in a day. Each fisherman can earn BDT 1500 to 2500 in a month. The best catch is available near the mangrove area. The mud crab (*S. serrata*) is harvested on an increasing scale from the Mirarsharai area and is currently a lucrative business due to international demand. The quantity of crabs brought to the market has nearly doubled in the last 5 years. The potential of crab fishery seems promising. Along with graded crabs juvenile crabs also exploited enormously Graded crabs are sold, juvenile crabs are retained for own consumption. One of the major problem is local fishermen indiscriminately catch the

crabs irrespective of size, or whether it is a breeding population; and this has a great bearing on the future stocks of the species. It is therefore imperative that the community is educated on alternative methods of exploiting crabs without interfering with the adult population and the future stocks of the species. One of the ways of doing this is by introducing crab cultures in mangrove areas, where gravid females are collected from the wild, induced to spawn, and introduced to culture pens after a certain stage of their growth. Crab farming has net benefits to the local community through direct employment, as well as a source of income through the sale of the adults.

Other uses

Buffalo, cow and goat are allowed to graze in mangrove areas as the *Avicenna* species form cheap and nutritive feed for the animals mostly found to see Mirarsharai area. Local residents use mangrove twigs as their favorite firewood because of its easy access and good quality as it produce high heat without generating smoke. The mangrove wood with high content of tannin is also used as timber for its durability. The local people have been used mangrove extracts as indigenous medicine; for example, *Avicennia* species have tonic effect while *Sonneratia* species also used to produce beverage. Extract of mangroves are regarded as a good potential for human treatments including disease like AIDS (Kathiresan, 2000)

Ecosystem service value

The services of ecological systems and the natural capital are critical to the functioning of the Earth's life-support system contributing human welfare, both directly and indirectly, and therefore represent part of the total economic value of the planet (Costanza *et al*., 1997). Among the ecological systems, global wetlands are called "the nursery of much life" because they are one of the most valuable resources for life on earth. They are the source of nutrition and habitation for many species. Wetlands are the world's most productive acres for nutrition in the food web, and are particularly efficient converters of solar energy. The plants present in the wetlands convert sunlight into plant material and produce oxygen as a by-product. This production is an integral part of the interdependent system of a food web. The benefits of wetlands are many and recognized service value for this study are : (1) ecosystem function; (2) fish and shellfish habitat; (3) waterfowl and other birds' habitat; (4) wildlife habitat; (5) pollution filtration; (6) protection against natural disasters particularly Cyclone and Tsunami; (7) heavy metal removal; (8) oxygen production; (9) nutrient production and recycling; (10) chemical pollution absorption; (11) aquatic production; (12) microclimate regulation; (13) world climate (ozone layer) regulation; (14) flood control; (15) wave damage protection; (16) erosion control; (17) groundwater and recharge supply; (18) energy source; (19) livestock grazing; (20) fishing; (21) fertilizer industry; (22) hunting and trapping; (23) recreation; (24) preservation of the genetic inventory; (25) aesthetics, and (26) scientific research (Zhao et al., 2004). From this list of areas that wetlands affect, it is no wonder that global wetlands play a vital role in the earth's ecosystem. By analyzing all the factors related to the ecosystem, the service value is calculated (Table 1) as per the method of Costanza et al., (1997). As Southeast Bangladesh has a total of 6,632 ha of mangrove wetlands, the ecosystem service value per year can be calculated as 11850x6632 = 78,58,9200 US $. Approximately, it is equal to BDT 550 crores, 12 lakhs and 44 thousands. (1 US $= 70 BDT)

Challenges to mangrove wetlands

According to the respondents, the challenges to mangrove wetlands are: (1) over exploitation of mangrove resources (45%) (2) Wetland reclamation is often carried out illegally due to the shortage of land in and around cities, which increases the risk of urban encroachment and squatting in marginal mangrove areas (21%). (3) Mangroves may also be reduced by actions ranging from the construction of water-based recreational or residential facilities, such as canal estates, to the conversion of nat-

Table 1. Ecosystem service values of mangrove wetlands (in US $·ha^{-1}·year^{-1}).

Services	Value
1. Ecosystem function in terms of dry matter·ha^{-1}·year^{-1}	150
2. Fish and shellfish habitat	2500
3. Protection against cyclone and wave damage	2000
4. Waterfowl and other birds' habitat	1000
5. Wildlife habitat	800
6. Pollution filtration	260
7. Heavy metal removal	150
8. Oxygen production (20 kg·ha^{-1})	40
9. Nutrient production and recycling	450
10. Chemical pollution absorption	350
11. Aquatic production	300
12. Microclimate regulation	1000
13. World climate regulation	100
14. Flood control	500
15. Erosion control	1200
16. Groundwater and recharge supply	40
17. Energy source	100
18. Livestock grazing	60
19. Fishing	150
20. Fertilizer industry	50
21. Recreation and aesthetics	500
22. Preservation of gene pool	100
23. Scientific research	50
Total	11,850

ural ponds for aquaculture (24%) (4) Expansion of ship breaking industries are being regarded as a major cause of rapid destruction of mangrove wetlands (particularly Chittagong coastal area) (31%) (5) In addition, mangrove areas are also lost through indirect actions, often carried out upstream in a catchments area, which impact on the quantity or quality of water supply to the site (2%).

Wetland management

There is clearly a need to utilize wetland and mangrove resources on a sustainable basis, to reduce the levels of conversion to other land uses, and declare certain mangrove areas, especially those with pristine resources, as conservation and preservation zones (Blasco, 1977). These general objectives of resource conservation and mangrove land allocation should be properly spelt out in mangrove development plans to sustain the benefits of the resource over a long period of time and for a greater number of people. The wetland ecosystem is a complex and open ecosystem. It is composed of various interrelated elements in the land/sea interface zone and is further intertwined with other natural systems in the coastal zone such as corals, sea grasses, coastal fisheries and beach vegetation (Finlayson and Moser, 1991). It is imperative; therefore, that wetland management should be pursued in an integrated manner and not in isolation from other sectoral developmental objectives; for example, fisheries, the coastal zone, forestry and other national, regional and site-specific development objectives. This approach should result in optimal multi-purpose or multiple uses of mangrove resources that can be sustained over time without degrading the ecosystem.

Suggestions for sustainable development

In each of the study areas people depend on mangrove wetlands for fishing, clam collection, crab collection, natural shrimp farming, medicinal plants and many other uses. A participatory management strategy is suggested to get maximum benefit by conserving the wetland. The results show that mangrove wetlands form a highly valuable ecosystem. There is clearly a need to utilize wetland and mangrove resources on a sustainable basis, to reduce the levels of conversion to other land uses, and declare certain mangrove areas, especially those with pristine resources, as conservation and preservation zones. These general objectives of resource conservation and mangrove land allocation should be properly spelt out in mangrove development plans to sustain the benefits of the resource over a long period of time and for a greater number of people. The following suggestions may be adopted for management of the mangrove wetlands of southeast Chittagong: (1) Coastal structure in the proximity of mangrove areas should be designed in such a manner as to avoid excess

sedimentation or erosion. Upstream structures should be made keeping in mind that landslide in the catchment area, construction of dams, etc., may be hazardous to mangroves by causing decrease or total stoppage of fresh water inputs or by burying the mangrove seedlings under excess silt. The hydrographic and topographic patterns should not be altered while planning strategies for marine or brackish water cultures: if manipulations must be carried out, care should be taken to ensure continuity of tidal flushing and to avoid stagnancy of water. (2) Mangroves are highly productive and function as nurseries or feeding grounds for a variety of marine life. Therefore, preserve the undisturbed virgin areas and avoid dumping dredged material, sewage and industrial wastes there. (3) An inventory should be taken of the resources that can be made available locally and an assessment should be made of their optimum potential output. A continuous monitoring of the ecosystems' reaction to the extraction of forest and fishery products should be maintained since the pace of regeneration rates of the ecosystem varies with season, site and biotic influences. (4) Non-destructive aquaculture practices should be encouraged such as small sea level or above sea level ponds for agri-aquaculture, keeping mangroves intact. Locate aquaculture ponds behind or landwards from the mangroves, rather than inside them. Sylvi-aquacultural practices are the most sound types of exploitation and management of resources. (5) Small residential houses should be constructed on stilts without damaging the forest. (6) Extraction processes for timber and other products should not be damaging to the ecosystem. (7) Only partial extraction or clear extraction in parallel alternate rows leaving behind the saplings for regeneration should be adopted on a large scale. (8) Replanting of plant species should be done wherever on the sites the natural re-growth is insufficient. (9) Ecotourism can be promoted to provide job opportunities for local people without disturbing the ecosystem.

CONCLUSION

The Southeast coast of Bangladesh is blessed with both natural and planted mangrove resources which have tangible (e.g., timber, fuelwood, fruit etc.) and intangible values (e.g., shelterbelt, tourist spots, biodiversity, feeding and breeding ground for fishes, wildlife habitat etc) contributing significantly in the livelihood of the local peoples both directly and indirectly. However, particularly several anthropogenic threats are the major part to give proper attention for the good management and sustainable use of these valuable resources. Plantations of mangroves and develop forestry practices to establish new generation mangrove plantations along the southeast coast of Chittagong can be also a good option for the government and steps should have been taken accordingly.

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