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Constrains on mangrove forests and conservation projects in Pakistan

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Abstract Mangroves forests are facing serious stresses which jeopardize their sustainability and their existence in Pakistan. Theses coastal forests are found in the Indus delta in Sindh and the coastal areas of Sonmiani, Kalmat and Gawatar bay in Balochistan. A significant reduction in the fresh water supply and increased marine water pollution in from industries as well as over harvesting of mangroves and fishes by the local peoples, sedimentation, population stress and coastal erosion are usually considered to be the immediate causes of mangrove loss in Pakistan. Various Projects have been under taken in the past and in current scenario to conserve the resources of mangrove areas. Strong planning with the collaboration of the local institutes at the grass-root levels will be helpful to strengthen their capacity and to achieve the targets easily, and they will also help in achieving the conservation goals in a sustainable manner. It is predictable that large-scale plantation of this mangroves species in these areas would increase the resources in coastal areas, resulting economic benefit to the local people.

Keywords Conservation · Mangrove · Balochistan · Pakistan · Coastal forest

Introduction

The coastline of Pakistan is 1,050 km long and 40–50 km wide shared by the provinces of Sindh (350 km) and Balochistan (800 km). In the Sindh province (mainly in Badin and Thatta districts), mangroves are found in the Indus Delta which occupies approximately 600,000 ha extending from Korangi Creek in the north to Sir Creek in the South (FSMP 1992).The mangrove forests lie between 24° 10′ and 25° 37′ latitude North and 61o 38′ and 68° 10′ longitude east. Indus Delta comprises 17 major creeks, numerous minor creeks and extensive mudflats and constitutes 97% of total mangrove forests found in Pakistan (Amjad and Jusoff 2007). The Balochistan coast extends from the Hub River to the border of Iran and is formed by five bays beginning at Sonmiani Bay and ending at Gwader Bay. Mangrove forests are found in three different patches, Miani Hor, Kalmat Khor and Gwader bay with total area of about 7,500 ha in Balochistan (Saifullah and Rasool 1995; Mirza et al. 1988). The three pockets of mangroves areas:

Miani Hor: 95 km from Karachi, the lagoon covers an area of 7,471 ha
Kalmat Khor: 315 km from Karachi, the lagoon covers an area of 10,216 ha
Gawatar Bay: 515 km from Karachi, the bay covers an area of 26,316 ha

This area is equal to 3% of total mangrove forests in Pakistan (Figs. 1 and 2).

Miani Hor is a swampy lagoon on the coast in the Lasbela district where the climate is very arid, with less than 200 mm of rain a year. The sources of fresh water for Miani Hor are the seasonal run-off rivers of Porali and Windor. The nearest river to the other lagoon, Kalmat Khor, is the Basol River, which runs 15 km east of Khor. Gawatar, the third site, is an open bay with a mouth almost as wide as its length. Its freshwater source is the Dasht River, the largest seasonal river of Baluchistan. Miani Hor mangrove species are *R.mucronata, Ceriops tagal,* and *A. marina*. It is

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Fig. 1 A satellite view of the Indus Delta Mangroves

the only area in Pakistan where the first two species are growing naturally. The other two pockets, Kalmat Khor and Gawatar Bay, support only *A. marina*.

Nearly 95% of the mangroves located in the Indus Delta are of the species *Avicennia marina*. Small patches of *Ceriops roxburghiana* (Rhizophora family) and *Aegicerias corniculata* (Myrinaceal family) are found near the mouth of the Indus at Keti Bunder. Two species of family Rhizophora i.e. *R.mucronata* and *Ceriops tagal*, , are also present due to some replantation work. The Indus Delta is believed to have had eight species, most of which are now extinct in Pakistan.

Mangrove forest ecosystem is not only a direct value to the economy, but it also protects and sustains other key coastal resources. From an economic point of view, mangrove forests are important for a variety of reasons in Pakistan, where population and economic pressures on the coastal zone are high. These forests are a pool of biodiversity supporting many forms of plants and animal life, providing habitat, shelter and breeding region for an economically important marine life and migratory birds, protecting coastline and sea ports from erosion due to wave wash and siltation, provide fuel wood and fodder for domestic livestock of the local communities.

The two most widespread uses of mangrove wood are fuel and construction. The harvest of mangrove trees for fuelwood is widespread throughout the coastal area of Pakistan. Many common mangrove tree species like *Rhizophora*, produce wood which is dense, hard and often rich in tannins (FAO 1994) that burns long and hot, and so is highly attractive for making charcoal or consuming directly as firewood (Bhattacharyya 1990; Ewel et al. 1998a; Walters 2005a; Dahdouh-Guebas et al. 2006). The qualities of strength and durability also make mangrove wood well-suited for use in construction (Kairo et al. 2002; Walters 2005a). Yet, the typically short and contorted growth form of tree stems renders them of limited value for large, commercial-sized lumber. Therefore, construction wood from mangroves is thus limitedmostly to domestic consumption and sale of small-size posts to targeted local and regional markets. Fronds from the mangrove "nipa" are particularly valued in Southeast Asia for use in roofing and as thatch in walls and floor mats, posts, beams, fencing and fish traps/weirs by coastal communities (Alvarez-Leon 1993; Rasolofo 1997; Ewel et al. 1998a; Semesi 1998; Primavera et al. 2004; Walters 2004; Walters 2005a). Mangrove wood is also used in some countries for building boats, furniture, wharf pilings, telegraph poles, construction scaffolding, railway girders and mine timbers (Mainoya et al. 1986; Adegbehin 1993; Primavera et al. 2004; Lopez-Hoffman et al. 2006) and wood fiber such as rayon and paper, traditional medicines and toxicants (Bandaranayake 2002) and as habitats for honey bees and hunted wildlife.

Non-timber forest products are also known as important economic resources, particularly to rural, costal communities (Vedeld et al. 2004). The majority of people in or near by mangrove belts, derive their main income from fishing and related activities. The direct harvest of mangrove wood and plants is occasionally a full-time occupation, but rely mostly on non timber products to meet subsistence needs is an important income supplement for costal communities (Glaser 2003; Walters 2005a; Lopez-Hoffman et al. 2006; Rönnbäck et al. 2007).

Mangroves forests play a significant role in assimilate sewage water wastes, heavy metals from industrial plants, reduce the intensity of cyclones and protect seaports from cyclones. These forests also provide livelihood to a coastal population of more than 100,000 people, and serving as laboratory for marine research (Amjad and Jusoff 2007).

Mangroves, seagrass beds, unvegetated shallows, and coral reefs collectively form integrated ecosystems of high productivity (Yanez-Arancibia et al. 1993; Ogden 1997; Rönnbäck 1999), therefore, mangroves indirectly support fish species that never enter mangrove environment. Mangrove belts also support aquaculture operations by providing seed, broodstock and feed inputs (Rönnbäck 1999; Naylor et al. 2000). Theses costal forests function as nursery grounds for the early life stages of aquaculture species like penaeid shrimps, mangrove mudcrabs, sea-perch, snapper, grouper, milkfish, etc. (Primavera 1998; Walton et al. 2006; Cannicci et al. 2008; Nagelkerken et al. 2008).

Pakistan is a major shrimp producing country, and a net exporter of shrimps, lobsters, crabs, mollusks, and fish and

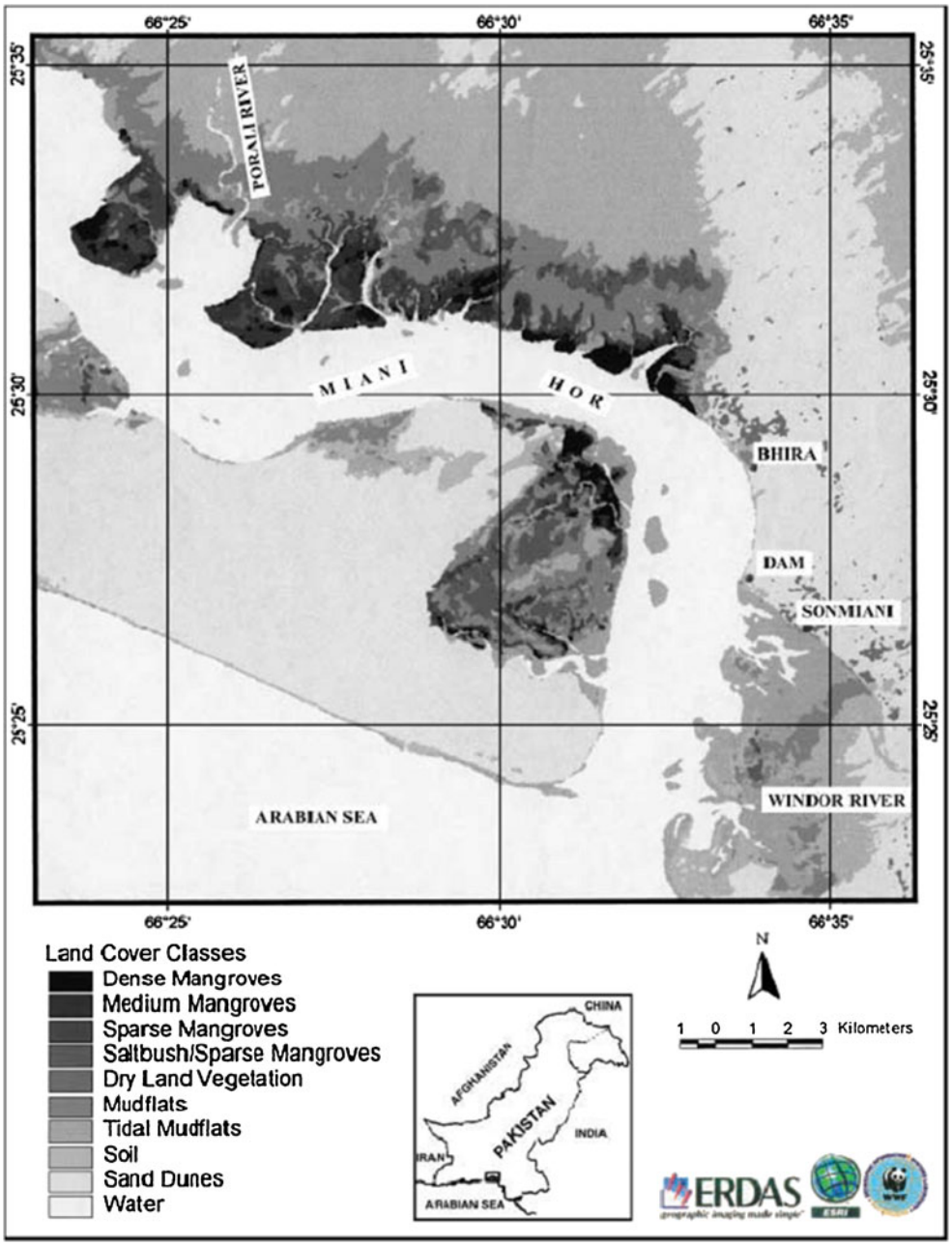

Fig. 2 Mangrove distribution at Miani Hor, Balochistan. A classification of Landsat TM satellite imagery was used to map the extent and density of mangrove cover

fishing products. Mangrove forests are the breeding grounds of shrimps, prawns and other exportable species of fish that fetch millions in foreign exchange for dollar-starved Pakistan. The annual shrimp catch for the past three decades was 25,541metric tons. Despite their importance, the mangrove forestation areas in Pakistan face many economic and ecological pressures.

A- major constrains on mangrove forests

Mangrove deforestation and degradation are common all over the world. There has been considerable loss of mangrove cover in Pakistan in last 50 years (Memon 2005). Mangrove forests are under serious threats due to a variety of factors which directly or indirectly influence on mangrove plantations in Pakistan. These factors have exposed this complex ecosystem to severe environmental and socio-ecomomic stresses in the form of loss of habitat and biodiversity, decline in fish productivity and social problems for coastal communities.

Reduction in fresh water and silt

Coastal mangrove forest belt in Pakistan have been seriously degraded over the last 50 years as a result of

freshwater diversion for agriculture, industrial and urban water pollution, and over-fishing. These proximate causes are largely driven by national policies that have favored agriculture and industry over the coastal regions.

Existing estimates show that mangroves cover approximately 129,000 ha in the Indus Delta and about 3,000 ha on the Baluchistan Coast in the Miani Hor, Kalmat Khor, and Gawatar Bay areas. The Indus Delta therefore supports 97% of the total mangrove forest while the three pockets on the Baluchistan Coast support the remaining 3%. The loss of mangrove species over the last 50 years is highly consistent with the reduction of fresh water and silt supplies to the Indus Delta.

Reduction in the flow of fresh water to the Indus Delta from 140 to 40 million acre feet (maf) over the last 50 years has created two problems. First, the salinity of the sea water has increased to 50 ppt, which is damaging to mangrove growth. Second, the flow of alluvium–the fine gained nutrient-rich soil brought by the rivers during their course through the fertile plains–has declined from 160 to 60 million tons per year.

Secondly, the effect of freshwater diversion is serious by reductions in silt flow resulting from damming upstream. Dams and diversionary barrages affect bed load and transport of suspended sediments during the flood season by capturing the material and preventing its uniform dispersal over mangrove areas. As a result, the surviving Indus Delta mangroves are sparse and stunted.

Along the Baluchistan Coast, Sonmiani is the only area where the three mangrove species occur naturally. At other locations on the Baluchistan Coast, namely Kalmat (Pasni) and Jiwani (Gawatar Bay), only *A. marina* is present. Estimates revalied a little change in the total area under mangroves between 1990 and 1998, the qualitative decline from dense to normal and/or sparse cover is very evident.

Mangrove development is best in areas that have significant freshwater run-off. Although the freshwater requirement of mangroves has not been established, however Sindh Forest Department suggested that an average flow of 1 cusec (28 liters/second) of fresh water for each 100 acres is required for healthy growth. It is also unclear whether this is a constant need throughout the year or whether occasional supplies, as might be expected during large natural riverine floods, are sufficient (IUCN 1988).

Based on the estimated water requirement, about 6.8 maf fresh water is required annulay for healthy magrove forest. But at present, it is clearly shows that, as a result of freshwater scarcity over time, mangrove cover has been reduced both qualitatively and quantitatively. The survival of *A. marina* in the Delta, which has a higher tolerance for salinity, and the gradual extinction of other species that are less resistant to higher salinity levels indicate the increased levels of salinity in the Indus Delta.

The loss of five mangrove species, stunted growth of mangroves, and the analysis of plant pathology under these conditions provide sufficient evidence to show that reductions in freshwater supplies in Indus Delta during the last 40 years.

The Indus Delta mangroves are one of mangrove forests in deltaic regions of the world, because these grow better in low salinity water and soft alluvial substrate. In these areas with out or low alluvium deposited are mostly muddy substrates and no inundated channels or creeks. These areas support thin, relatively sparse mono specific stands of mangroves. The upstream damming of the Indus River has stopped the flow of much of the nutrient-rich alluvium. Previously, it was estimated that annual alluvial flow has decreased from 200 million tons in 1955 to a current flow of less than 50 million tons at the Kotri. Lack of sediment also affects the mangroves negatively (Khalil 1999). A reduction in fluvial discharge causes in increased salinity of seawater, which reportedly prevents fruiting, and causes senescence of immature flowers and buds (Qureshi 1993). It is estimated that mangrove cover has decreased by 15% in past 20 years due to reduction in Indus discharge (IUCN 1988).

The continuous reduction in fresh water is resulting in increase sea water burden that cause changes in the geomorphology of the mangrove habitat and nutrient balance of the ecosystem. It is estimated that the sea water intrusion has taken place up to 67 km resulting in not only damaging terrestrial ecosystem in deltaic region but also affecting adversely the agricultural fields and other habitats (Amjad et al. 2007). Interiors of the deltaic islands, the village of Keti Bunder showed dramatic evidence of surface salt accumulation and corrosive deterioration of domestic structures (effects of hypersalinity) that presumably led to the connected partial collapse of the fishing industry (Snedaker 1984). The survival of salt-tolerant *Avicennia marina* in the Delta provides another evidence of higher levels of salinity in and around the mangrove forests.

Another threat to mangrove forests is the steadily filling of forest cover with silt and sand by erosion (Alizai et al. 1988). In Balochistan, Porali River is hardly discharging any water into the mangrove lagoon because its water supplies now are used for human consumption. Moreover absence of any significant rainfall in this area has converted Porali River into a river of sand (Hussain 1998). Huge quantities of sand and silt are carried by the wind and deposited into mangrove area, which is already incompletely flushed by seawater. Therfor regular silt and sand depostion cause hindrence in water flusing. Occasional flow of turbid streams and runoff into the lagoon (Alizai et al. 1988) also make worse the situation.

Global warming

Asia has 42% of the world's mangroves, followed by 21% in Africa, 15% in North and Central America, 12% in Oceania and 11% in South America. Many factors including global warming, affecting the mangrove ecosystem all over the world. The universal phenomenon of sea level rise is attributed to global warming. Pakistan has been included in the list of ten countries most vulnerable to the impacts of rising sea levels. Indus Delta mangroves, one of the largest tracts of arid mangroves in the world, used to cover an approximate area of 2, 50,000 to 2, 83,000 ha till early 1980s but the area dropped drastically to 1, 60,000 ha in 1990s. A recent study by WWF-Pakistan (2006) has estimated the existing cover of the Indus delta mangroves around 73,000 ha. Qureshi (1993) has estimated a land loss of about 1,700 km2 in the Indus Delta due to sea encroachment over the last half century. Sea-level rise may cause stronger wave action, higher tides, and greater probability of flow, all of which may cause coastal erosion and depletion of mangrove cover, aggravating current patterns of physical damage. This serious hazard to mangrove ecosystem is destructive if coupled with reduce silt deposition. It is estimated that mangroves with significant discharge from the land can maintain themselves by accumulating deposited silt with sea level rise as high as 2.5 mm/year.

Water pollution

Mangrove cover areas in Pakistan are threatened because of over-exploitation, pollution, and a decline in fluvial discharge into the Indus delta (Ansari 1987; IUCN 1988; Qureshi 1993). Rapid urbanization in costal areas is accompanied by weak urban planning has resulted in generation of domestic and industrial effluents without emphasis on safe or environmentally friendly approaches to its disposal (Amjad et al. 2007). Industrial waste contains toxic pollutants like heavy metals, salt fertilizers and biocides residues. These pollutants cause bioaccumulation of toxic compounds and eutrophication.

On the other hand, organic pollutants increase overall biomass in the form of algal blooms, which exerts pressure or stress on mangrove seedlings. These algal blooms grow abundantly and cover the seedlings stopping their growth partially or completely and causing mortality on large scale.

The other serious class of pollution is oil discharged by the ships stopping over at Karachi harbour. It is estimated that about 37,000 tons of industrial waste is being dumped yearly in the coastal environment of Karachi whereas, 20,000 tons of oil finds its way to beaches and harbours and the fishing grounds of Karachi annually (WWF-Pakistan 2006). Oil seepage in the mangroves areas causes a number of environmental impacts, including the interruption of fresh water flow, alteration in the flow of tidal sea water to the mangrove, and, in the forest itself, the alteration of drainage patterns, vegetation and soil and general instability in the mangrove areas.

Costal erosion

Mangrove forests provide a useful cover for coastal edges and protect the land from stormy winds and wave action. The cutting of entire trees for obtaining wood for construction houses and other purposes by local community has also resulted in soil erosion of the mangrove habitat. Once the forest cover is removed, the edge is exposed and erosion starts, which in due course of time results in submerged soft mud flats causing problems in fishing and easy rowing of boats. Soil erosion is another significant source of siltaion in the mangrove areas. Costal erosion caused by waves and tidal current is also considered as a result of human activities. Once the vegetation cover is removed, the edge is exposed and erosion starts. Erosion forces gradually lead to the loss of seaward young mangrove growth. Further more, construction of dam and barrages on Indus River leads to decrease water supplies that making the mangrove vegetation less vigorous and stunted. This has resulted in heavy erosion in adjoining mangrove islands.

Erosion of creeks

The meandering of small creeks and channels is also one of the causes of natural reduction in mangrove ecosystem in Pakistan. This natural process results in habitat changes because some of the areas are cut-off from regular flood waters, while the others receive additional soil deposits, resulting in creation of high lying areas. The erosion of creek banks destroys woody vegetation cover on these banks. This phenomenon is chiefly evident along creeks near the sea where tidal movement is very high. It is expected that in the next 10 years, new developments in tourism sector will open in areas adjacent to coast and including mangrove areas. The creeks represent an important source for recreation, water sports and eco-tourism for Karachi city, which has relatively few such resources nearby. Such developments will change the relationship of the local people with the mangroves.

Over harvesting of fish

An emerging over harvesting of fish resources by coastal established communities is another cause of mangrove cover degradation. The major shrimp grounds in Sindh are located in southern coast of Karachi coast to offshore of the

River Indus. The other important shrimp fishing grounds are Gaddani-Sonmiani, located on the Baluchistan coast, and is influenced by Hub River discharges into the sea. Small catches are also landed at Pasni Gwater area (Sultana 2006). Fish harvesting in costal areas largely provoked by increased pressure for exports. These human activities have exposed this complex ecosystem to severe environmental and social stresses in the form of loss of habitat and biodiversity, decline in fish productivity and social problems for coastal population.

Fuel wood, fodder harvesting and cattle grazing

Overgrazing, browsing and lopping activities put considerable stress on the mangrove stands. In many studies, it is reviled that small-scale cutting cause localized structural disturbances that create relatively small gaps in the forest canopy. The creation of such gaps can alter micro environmental conditions within the forest (Ewel et al. 1998b; Allen et al. 2000; Pinzon et al. 2003; Walters 2005b).

Avicennia marina (Timer) is a predominant mangrove species in costal areas of Pakistan. Timer leaves are regularly being used as fodder for animals and fuel wood by local communities in and around the coastal mangroves. Cattle are allowed to graze in good mangrove cover areas, especially camels are at times taken to uninhabited mangrove forests for grazing in Pakistan as also very common practice in India, Persian Gulf region and Indonesia (Qasim 1998). On the other hand, the use of mangroves fuel wood is directly related to the population of the people living in the coastal zone. As a result of increased population and poor ecomomic infrastructure, usage of mangrove wood for fuel has increased in costal area. The diagnostic survey of Indus delta shows that 25% of households depend on mangrove wood for cooking & heating purpose (Amjad et al. 2007). The increasing effects of such selective cutting on a forest include reduced adult tree density, canopy height and canopy closure (Walters 2005b; Hauff et al. 2006; Lopez-Hoffman et al. 2006).

Heavily effected forest areas are some times characterized by few species of trees, manifest a clearly "bushy" appearance. Promising damage by selective wood cutting may result in a net increase of dead wood in the forest (Allen et al. 2000). Although, in some locations, local people intentionally use deadwood for fuel and thereby reduce levels of naturally occurring deadwood (Walters 2005a). Therefore, these human activities cause change in forest configuration, composition and micro-climate that can effect significantly on establishment of mangrove seedlings (Bosire et al. 2003, 2006) and for resident marine and terrestrial animals (Bosire et al. 2004, 2005a, b; Crona et al. 2006; Crona and Rönnbäck 2007).

Rapid increase of population

The increase in coastal communities and rapid economic expansion has brought about an increase in consumption of forest resources in Pakistan. The human population in and around mangrove forests on the coastle area is estimated to be about 1.2 million in Pakistan. In the Indus Delta, nearly 900,000 reside and 300,000 on the Baluchistan Coast. The number of households are estimated to be about 140,000 in the Indus Delta and 30,000 on the Baluchistan Coast. Over 90% of the costal communities are directly or indirectly engaged in fishing activities, where as only a few people work for government departments (fisheries, electricity and education) or are involved in trade. High returns associated with fishing is significat factor for rapid population growth. On average, the population in the coastal areas has been growing at a rate of 6 to 8% annually over the last 10 years. Migrants from other areas of the country, Bangladesh, and Burma, who come mostly to the Indus Delta, have contributed to this growth. Over the last decade, concern has grown over the ways in which human activities have altered the mangrove ecosystems of Pakistan.

The population of the area further rises momentarily during the fishing season, when working forces from other parts of the country come to the area for earning livelihood through fishing. Therefore, these communities establishment are directly dependent on coastal resources, especially fisheries and mangrove forests.

Mangrove shifting and export

In the recent years a new stress has been imposed in the locality. During the fruiting season hundreds and thousands of propagules are taken away from Miani Hor (Balochistan) to Indus Delta region (Sindh), where they are transplanted for reforestation (Rasool 1996, 1997). Moreover, they are also exported to the Middle East for the same purpose. All these activities are seriously affecting the seed bank and reproductive potential of the mangroves of the area. The lagoon of Miani Hor may be treated as a natural nursery ground of the three species and, therefore, be declared, as a reserved area.

Socio-economic problems

Poverty, land shortage and increasing populations are main problems in coastal areas, associated deprivations of these fectors, are the major source of all socio-economic problems, including the overexploitation of mangrove resources.

Timber and non-timber forest products are recognized as important economic resources, particularly to rural, marginalized communities (Vedeld et al. 2004). Coastal

communities are characterized chronic poverty and significant dependence on the harvest of marine and coastal resources for their livelihood (Kunstadter et al. 1986). In Pakistan, majority of people living in or near mangrove areas derive their principal income from fishing and related activities that cause stress on the mangrove resources directly. On the other hand, the land mafia is jeopardising precious mangrove forests that not only provide breading grounds for fish, but also hold immense aesthetic value. According to Pakistan fisherfolk Forum (PFF) influential locals enjoyed the support of the land mafia and government functionaries occupied a wide area of beaches for commercial purposes. Law enforcing agencies protect natural habitats like the mangroves because these provide cover against natural disasterslike cyclones and tsunamis.

Alternatives to fishing and harvesting mangroves stratigies to local communities can stop overexploit of mangrove ecosystem. Job opportunities related to the mangrove ecosystem may not only prevent misuse but also guarantee continuous management of the mangroves by people who actually live beside them. Like other countries, establishment of marine parks, ecotourism, mariculture facilities, and honey-bee farming are some of the alternatives that may be offered to the local communities. The best policy should be to use barren or less populated areas for some immediate projects. In Pakistan, a certain proportion of less populated area may be used for pond culture of shrimps. This could be economically viable not only covering the management expenses, but also provide job opportunities for the local people.

Mangroves and aquaculture are not necessarily incompatible. However, the culture of seaweeds, mollusks and fish in cages in sub tidal waterways is both compatible with mangroves and amenable to small-scale, family-level operations (Primavera 1993, 1995). But there remains a need for mangrove-friendly aquaculture technology in the intertidal forest or swamp that does not require clearing of the trees. Development of such technology is on two levels: (a) silvofisheries or aquasilviculture where the lowdensity culture of crabs and fish is integrated with mangroves and (b) mangrove filters where adjacent mangrove stands are used to absorb effluents from high-density shrimp and fish culture ponds (Primavera 2000; Primavera et al. 2007). Modern versions of integrated forestry–fisheries–aquaculture can be studied in the traditional gei wai ponds in Hong Kong, mangrove–shrimp ponds in Vietnam, aquasilviculture in the Philippines, and silvofisheries in Indonesia (Primavera 2000). In recent past, the Southeast Asian Fisheries Development Center Aquaculture Department has figure out guidelines for sustainable aquaculture in mangrove ecosystems (Bagarinao and Primavera 2005).

Apiculture, or honey-bee farming, is a venture which would have beneficial effects for the mangroves as it encourages cross pollination. Mangrove forests are noted for high quality honey production and India and Bangladesh are major producers of mangrove honey. This profession needs little investment and may be ideal for the local people as a side occupation. The product is a renewable resource and is non-perishable.

Lack of public awareness

Lack of public awareness about ecological and environmental issues is the one of the causes of deteriorating coastal ecosystems around the world. Mangroves forests are economically-important systems in costal areas of Pakistan, ignorance to this ecosystem is self defeating. At present, these areas are considered wastelands with nothing to offer to mankind. If their importance had been realized by planners and policy makers at an early stage, perhaps there would not have been such a severe cut in the Indus flow into the delta. However educated people now seem to be better aware of the economic and ecological importance of coastal mangroves, following a number of public discussions and articles in the press. But the local villagers believe that mangroves would never perish no matter how much they are harvested. They are also ignorant of the relationship between the mangroves and the other marine life.

The coastal mangroves have now been greatly reduced and represent a fraction of their earlier luxuriance. If the Indus waters are further harnessed and the dry period at the mouth of the Indus is lengthened from the present 2 to 3 months, present heavy development pressure on the coastal areas continues and domestic and industrial pollution continues unchecked, it is possible that the mangrove forests will largely disappear in the next 15 to 20 years.

B-mangrove conservation strategies

Mangrove forests haves a great economic and ecological significance in coastal areas of Pakistan. Local communities use them as fodder, fuel and for house construction while land has been cleared for developmental activities on the coast. The Indus Delta is believed to have more or less eight manrgove species in the past. However, now only four species have been left. Approximately 95% of the mangroves located in the Indus Delta comprise the species *Avicennia marina*. Very small patches of *Ceriops tagal* and *Aegiceras corniculatum* are found near the mouth of the Indus at Keti Bunder (Saifullah et al. 1994). *Rizophora mucronata* and *Ceriops tagal* have been introduced in the Indus delta through replantation work. Miani Hor (Balochistan) is the only area in Pakistan where three species of mangrove *Avicennia marina*, *Rhizophora mucronata* and *Ceriops tagal* occur naturally. The mangrove

forest in Miani Hor is spread over an area of about 2,500 ha, which represents 42% of total cover of mangrove forest in Balochistan. The mangrove forests have vital economic importance in sustaining the productivity of inshore and offshore fisheries. They provide shelter and nurseries for commercial fishery species and some coastal species such as shrimps. Pakistan's thriving shrimp fishery, which almost entirely depends upon the mangrove ecosystem, earns some US $100 million annually. The global area of mangroves, some 150,000 square kilometers, is equivalent to the area of Suriname or half area of the Philippines. Mangroves—forests straddling land and sea—are believed to generate up to $9,000 per hectare, a strong argument in favour of mangrove management, protection and restoration. Therefore, a broad range approaches are needed for the restoration of the mangrove ecosystem. The approach, which was applied generally in the project implementation, was based on integrated conservation and development (ICD) principles, whereby the local development needs were linked with various conservation initiatives.

Over view of previous projects

The mangrove area is a region of Pakistan that has been overlooked in government planning and decision making. The set up the country's irrigation infrastructure, the development of its fisheries and the growth of the coastal population have all, from an ecological standpoint, had devastating effects on this area. However, this is an area of critical ecological and socioeconomic importance for Pakistan. Attempts have been made in the past to conserve the resources of mangrove fprests; however, most have been relegated to old files.

- The first real protection came to mangrove area when 344 870 ha was transferred from the Sindh Board of Revenue to the Sindh Forest Department and declared Protected Forest under the Forestry Act of 1927. These forests, minus the 64 000 ha given to the Port Qasim Authority in 1973, are still legally protected even as harvesting and camel grazing continue. The only protection, which the marine resources are accorded, is the 2 month fishing ban on shrimp from mid-may to mid-July, during the time of recruitment. However this is not followed by all local people (35% observed closure period in 1987) because there is no alternative income sources for fisherman during this period (imposed in 1983). And a ban on trawlers fishing within the mangroves also not enforced due to a lack of enforcement of legislation.
- Under the UNDP/ UNESCO Regional Mangrove Project on Research and Training for Asia Pacific (1982–1988), a national Mangrove Committee (NATMANCOM) was constituted in Pakistan in 1985. In March 1986, an International Conference was held in Karachi on Biology of Arabian Sea under the auspices of Karachi University. Substantial support was given to NATMANCOM as the organization in the field of mangroves to develop a conservation strategy for mangrove ecosystem in Pakistan. Various proposals have not been accepted because of they have largely been the initiatives of individual departments and were not supported by others.
- The Korangi-Ecosystem project initiated in 1991 was IUCNP's (The World Conservation Union) first field project. Working in collaboration with Sindh forest department and the Port Qasim Authority, Over 6,000 hectares were replanted in Korangi-Phitti creek areas. The important part of this work was to develop some innovative planting techniques which are being adapted within Pakistan and evenoutside Pakistan in Persian Gulf and Red Sea areas.
- Sindh Forest Department (SFD) carried out a long term World Bank mangrove rehabilitation project entitled "Environmental Protection and Resource Management ". This project commenced in 1991 in the Indus Delta and was completed in 1997. Under the SFD established mangrove plantation on 16,000 ha. Community plantations were raised in Keti Bunder and Shah Bunder on 300 ha. Research studies were undertaken on socio economic conditions of coastal population in the Indus Delta Silvicultural of Indus Delta mangroves and coastal and marine fisheries in Sindh.
- In 1992, WWF and the Sindh Wildlife Management Board developed a project to determine park feasibility in mangrove areas. However, this project was postponed due to the law and order situation in Sindh. In, 1994 the government was considering a proposal for a coastal national park. The concept of a biosphere reserve is being discussed by IUCN an alternative because of its flexible nature in allowing for conservation and sustainable development and its integrated approach. IUCN's coastal ecosystem unit (CEU) began working alongside the Sindh Forest department initiative in the early 1990's.
- In May 1994, IUCN in collaboration with Port Qasim Authority and the Sindh Forest and Wildlife Department, held an International workshop on the subject for various stakeholders. In October 1994, the National Institute of Oceanography, a department of the Ministry of Science and Technology GOP, organized an International workshop on integrated coastal zone management. Several resolutions were made about how to best proceed; however, there was no real follow-up, again due to a lack of political will and funding.

- Some mangrove conservation initiatives have been taken by the IUCN with a grant from the International Society for Mangrove Ecosystem (ISME) at Miani Hor but due to lack of follow- up the results were not promising (Vannucci 1995). In 1994, the World Wide Fund for Nature (WWF)—Pakistan with the cooperation of the University of Karachi conducted a preliminary survey of the area to describe the status of the mangroves of Balochistan. The study (Saifullah and Rasool 1995) indicated some potential sites for a reforestation programme. In 1995, WWF initiated a reforestation programme and one nursery of 10,000 mangrove saplings was established.
- In 1996, WWF Pakistan with the financial assistance of DGIS -WWF started a mangrove project entitled "Conservation of Mangrove Forests at the coastal areas of Balochistan and Sindh" for 5 years (September 1996 to August 2001). The main objective of the project was to rehabilitate the degraded areas and to bring the area under local sustainable management. Different multi-sectoral approaches were applied in this project. Under this project, in Miani Hor, Balochistan 150 ha of degraded areas was planted against the target of 140 ha. The planting works was carried out with participation of coastal communities, Community Based Organization (CBOs) in those areas. In addition, the CBO trained by WWF planted 50 ha under a separate project funded by Small Grants Program of the Ministry of Environment, Government of Pakistan in the same area of Miani Hor for DGIS—WWF. The project was completed in 2001.
- The Asian Development Bank in partnership with IUCN, with a technical assistance grant from the Japan Support Fund implemented the Regional Technical Assistance project (October 2001—June 2003) "Coastal and Marine Resources Management and Poverty Reduction in South Asia". Pakistan, Maldives, Srilanka and India participated in this project. During this project, different field activities and studies were undertaken to pilot test some of the recommended approaches. In Korangi Creek system the sustainable mangrove forestry was initiated. According to work plan, 135 hectares of degraded mangrove forests in Korangi High Priority Area (HPAs) were successfully replanted, using two mangrove species i.e. *Avicennia marina* and *Rhizophora mucronata*. A 70,000 container plant nursery was established to carry out the restocking of both the old and new plantations. Field training programmes of nursery and planting techniques was conducted for the community in coastal villages as a part of the suitable mangrove forestry.
- As a follow up of the World Bank project, Government of Sindh sanctioned two mangrove rehabilitation projects in the Indus delta. Coastal Ecosystem Unit also implemented the mangrove rehabilitation component of Balochistan Programme Office funded by Royal Netherlands Embassy. So far over 1,000 hectares were planted on four sites of Balochistan coast namely Miani Hor, Hingol national park Estuary, Pushkan Bay and Gawater Bay. A network of container plants mangrove nurseries had been established along the coast. Additionally, the community development programme was attempting an attitudinal and behavioral change among the communities through education and awareness raising. All the stakeholders were trained to play an active role in involving communities for sustainable management of mangroves in particular and sustainable use of coastal resources in general. The project replanted over 2,000 hectares of degraded mangroves areas by pit/ trench sowing to assist in natural regeneration. The project was complete in 2007.
- In 2009, IUCN-Pakistan (with initiative support of the Ministry of Environment) carried out a task to plant 10,000 mangrove saplings in Ibrahim Hyderi and Rehri village (Korangi creek-Sindh) and Jiwani along the coast of Balochistan.
- Under Sindh Coastal Community Development Project (CCDP), Wildlife and forest Department has raised 300,000 nursery plants and mangrove plantation over an area of 1,000 hectors during planting season (2008–2009) in Taluka Keti Bandar and Shah Bandar. Mangrove planting work had been done with active participation of costal communities.

Current conservation projects

Exploitation of mangroves forests resources has occurred over a long period of time in Pakistan. Recognition of their value as forest resources is a relatively recent phenomenon and there has been virtually no scientific management of mangroves in sub-continent in the past. Local people harvest timber, fuel wood and other mangroves resources in random and irregular manner. However, mangrove exploitation by villager for local use, did not pose a major threat to the existence of these forest. Current projects are major part of the mangrove conservation programm in Pakistan.

- Sindh Coastal Community Development Project (SCCDP): IUNC has lounch this project to improve the sustainable livelihood of the poor inhabitants of eight coastal talukas of Thatta and Badin districts. SCCDP is being implemented in Badin and Thatta districts of Sindh province, Pakistan. The Project is working towards increasing income, access to public

services and capacity of local communities (who are mostly agriculturalists and fishermen) to manage the natural resource base on which they live. The Project also strives to improve conditions of coastal mangrove forestry and fisheries, as well as improve coastal zone management. The cross cutting themes being addressed are gender, climate change and disaster risk reduction.

- IUCN Project 2010: IUCN, International Union for Conservation of Nature, Pakistan and Barclays Bank entered into a partnership on September, 2010. Under this agreement IUCN Pakistan will raise a mangroves plantation of over 25 hectares along the Karachi coast. The area selected for plantation is densely populated and highly degraded over a period of time due to over exploitation and neglect. Besides, creating a green belt the plantation will also constitute a barrier to protect communities from coastal calamities. The assertion that mangroves forests play a significant role in combating natural and man-made hazards in coastal zones is well established. They acted as a first natural defense line against the killer waves in the recent Asian Tsunami and cyclones in South East Asia. IUCN began its efforts to restore degraded mangroves forests in Pakistan in the early nineties and these efforts are still ongoing. For several years restoration was carried out in Sindh and Balochistan and over 30,000 hectares have been restored and restocked. Under this afforestation programme many exotic and indigenous species have been re-planted on an experimental basis through out the coast. Through the Mangroves for the Future (MFF) programme IUCN has been building on a history of coastal management interventions in tsunami affected countries, especially heeding the call to continue the momentum and partnerships generated by the immediate post-tsunami response. This initiative will thus be linked to MFF.
- Plantation of Jatropha and Mangroves at District Thatta, Sindh: WWf-Pakistan is running this project with the support of American Electric Supply (AES).
- In Balochistan, A joint project is being carried out with the collaboration of CBOs, WWF-Pakistan and Balochistan Forest Department. The main objects of this project is to increase in the area of forest through mangrove plantation, introduction of alternate resources for fuel wood and fodder like FEST, Sustainable management for better water consumption.

'The mangrove stands in costal areas of Pakistan are less complex than those of favourable regions of the world and are comparable only to stressed dwarf forests (Pool et al. 1977; Martinez et al. 1979; Lahmann et al. 1987). This may be attributed to the scarcity of fresh water, exploitation of mangroves and increased rate of siltaion in the lagoon. Direct and indirect factors are seriously affecting the seed bank and reproductive potential of the mangroves in Pakistan. If this problem is not looked after soon the mangroves will disappear. During the implementation phase different agencies have developed a link between local-level development activities and conservation initiatives. Strong planning with the collaboration of the local institutes at the grass-root levels will be helpful to strengthen their capacity and to achieve the targets easily, and they will also help in achieving the conservation goals in a sustainable manner. Working with the government officials is always time consuming but regular follow- up and close links result in their active involvement. Technology development at the grass-root level also helps to achieve goals. Monitoring and follow-up is very necessary and should start in the early phase of any long-term project. There are a number of strategies to address this problem, but the most effective and immediate solution is perhaps periodic dredging of the mangroves.

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