

PAKISTAN: MANGROVES

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Coastal mangrove ecosystems 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 and that have given high priority to exports.

Pakistan is largely arid and semi-arid, receiving less than 250 mm annual rainfall, with the driest regions receiving less than 125 mm of rain annually. It has a diverse landscape, with high mountain systems, fragile watershed areas, alluvial plains, coastal mangroves, and dune deserts. The flora and fauna are mainly Palaerctic and Indomalayan. Forests cover approximately 4.58 million ha (5.7 percent) in Pakistan. (Government of Pakistan, 1996) Of these, 0.132 million ha (less than 3 percent) are coastal mangrove forests. Pakistan is divided into 18 habitat types, among them mangrove forests, which occur mainly in the Indus Delta and in a few patches westward along the Baluchistan Coast.

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, Kalamat Khor, and Gawatar Bay areas. The Indus Delta therefore supports 97 percent of the total mangrove forest (37 percent of the Delta area) while the three pockets on the Baluchistan Coast support the remaining 3 percent (varying from 8 percent of the total area in Gawatar Bay to 21 percent in Kalamat Khor and 25 percent in Miani Hor).

There has been considerable qualitative and quantitative loss of mangrove forest in Pakistan over the last 50 years. A significant reduction in the river water supply and increased marine water pollution in the Indus Delta as well as overharvesting of mangroves by the local communities, sedimentation, and coastal erosion are generally considered to be the proximate causes of this loss. Another threat is emerging in the form of overharvesting of fish resources, largely provoked by increased pressure for exports with little or no consideration for the existing environmental laws and regulations. Policies and decisions made at the national and international levels have determined these proximate causes.

This study investigates the root causes of biodiversity loss in the mangrove ecosystem using the mangrove forests as the primary indicator of ecosystem health and the fish resources as a secondary indicator. Through the analysis, links have been established among factors at the local, national, and international levels to unveil the pattern in which various causes affect the ecosystem. The conceptual models prepared for this purpose were developed with the help of a detailed household survey of coastal communities and intertemporal images of mangrove forests using Landsat digital techniques. The analysis and comparative framework led to the development of policy recommendations and provide a research agenda for future work related to biodiversity loss in the mangrove ecosystem.

SITE DESCRIPTION

The Indus Delta covers approximately 600,000 ha with a coastline of 250 km, bordering the city of Karachi in the northwest. The Indus Delta is comprised of 17 major creeks, numerous minor creeks, extensive areas of mudflats, and 129,000 ha of mangrove forests. The dense forests are mostly located in the pockets created by the creeks. The source of fresh water is the perennial river, Indus, that flows through the Delta before reaching the Arabian Sea. The

Indus Delta shelf is 150-km wide and receives scanty rainfall during the monsoon season. The average wind speed during these months varies from 12 km to 35 km.

Figure 12.1 *Coast of Pakistan*

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

The 800-km long Baluchistan coastline, running along the North Arabian Sea, includes lagoons, bays, alluvial plains, mudflats, cliffs, beaches, and marine terraces. The continental shelf of Baluchistan is only 40 km wide and the exposed coast is subject to intense wave action. Mangroves occur in relatively protected lagoons and bays. The three pockets of mangroves occur at the following locations:

Miani Hor:	95 km from Karachi, the lagoon covers an area of 7,471 ha
Kalimat 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

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

The Indus Delta and the Baluchistan Coast possess 12 varieties of halophytes and 3 varieties of algae. Common and important marine organisms include shrimps (3 species), oysters (4 species), gastropods (8 species), and crabs (3 species). Mud skipper, thread fin, pomfret, mullet, palla, and dolphin are also present. Endangered Green and Olive Ridley turtles are found in the vicinity of the mangroves in the Sandspit area (Sindh). According to estimates, 90 percent of the commercially important marine species spend at least a part of their life cycle among the mangroves, linking the mangrove forests inextricably with the biodiversity of the entire ecosystem.

The human population in and around mangrove forests on the coast of Pakistan is estimated to be about 1.2 million. Nearly 900,000 reside in the Indus Delta and 300,000 on the Baluchistan Coast. The number of households is estimated to be about 140,000 in the Indus Delta and 30,000 on the Baluchistan Coast. Over 90 percent of the population is directly or indirectly engaged in fishing. High returns associated with fishing are causing rapid population growth. On average, the population in the coastal areas has been growing at a rate of 6 to 8 percent annually over the last ten 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. Freshwater scarcity due to upstream diversions of river flows for agriculture, water pollution, overgrazing, cutting for fuelwood and timber, and unsustainable fishing levels are seen as the main factors associated with biodiversity loss in the mangrove forests on the coasts of Sindh and Baluchistan. The rate of degradation of mangrove forests in the Indus Delta has been estimated at 6 percent between 1980 and 1995. At present, only 15 percent of mangroves here are considered healthy. (Thompson and Tirmizi, 1995)

RESEARCH METHODOLOGY

This study focuses on four issues that contribute to biodiversity loss in the mangrove ecosystem. The analysis was divided into four modules which were studied in a local, national, and international context. The four modules were investigated with the following objectives, keeping in view the relevant disciplines of economics, sociology, hydrology, and environmental studies:

1. scarcity of fresh water and silt in the coastal belt: To investigate the causes of scarcity of fresh water in the coastal areas and its impact on mangrove ecosystems, which required an assessment of demand for water, water rights and policies, the legal framework and its implementation, and associated political constraints.
2. pollution resulting from industrialization and port activities: To assess the impact of pollution and land clearance in the coastal area on mangrove forests. National and international policies, institutional effectiveness in maintaining and improving environmental conditions, and political factors were examined.
3. overharvesting of mangrove forests and fish resources: To ascertain the extent of human pressure on mangrove forests and fish resources; to determine the relative importance of overharvesting of mangroves and fish resources; and to identify economic, social, and institutional factors causing such changes.
4. geophysical factors: To identify the geophysical factors affecting the mangrove ecosystem.

In order to determine the extent of biodiversity loss, the study selected quantitative and qualitative change in mangrove cover as the primary indicator and the quantitative and varietal change in fish resources as the secondary indicator. The study presents an estimation of biodiversity loss by comparing the mangrove cover over a period of eight years using Landsat images for two of the project sites, Indus Delta and Sonmiani in Baluchistan. Given a dearth of scientifically comparable information on mangrove cover across time, the intertemporal Landsat digital images provide comparable data to ascertain the loss of cover during the period 1990 to 1998 (see Annex for Landsat data).

Main proximate causes of biodiversity loss were identified, and an initial conceptual model as well as individual models for the four main issues were developed. The actual impact on the biodiversity of the mangrove ecosystem was then investigated to assess the importance of each module, followed by an analysis of the module from the local to the national and international levels and applied to the two sites (Indus Delta and Baluchistan Coast), to assess its

relevance in a comparative framework. Based on the analysis and the comparative framework, future projections were made for biodiversity in these sites. The conceptual model was then revised accordingly.

Figure 12.2 *Schematic Chart Highlighting Different Factors Contributing Toward Biodiversity Loss*

After visiting the sites, reviewing the literature, and holding initial discussions with the major stakeholders, household-level information was collected from different sites in both the regions. Using the information gathered from initial visits, two questionnaires, one for the household and one for the village, were designed. Questionnaire designers made an effort not to ask any question directly that might be sensitive for the respondents. Questions were asked about demography, occupation, accessibility of services, mobility, fishing and other economic activities, perceptions about and use of mangroves, use of camels and, finally, assets and income flows. A total of 198 households were interviewed in 14 locations. Of these, 125 were interviewed in the Indus Delta and 73 in Baluchistan. Twenty-four village-level questionnaires were administered.

During the course of the study, lack of scientific information and a poor information database were major constraints. For most of the issues covered, a first-hand data sample had to be generated and then extrapolated to the whole area. To provide a causative explanation of biodiversity loss, the local, national, and international levels had to be linked. Thorough understanding of these linkages would require a more in-depth analysis, since there are various intervening layers, which the available time and financial resources did not allow. In addition, the impact of the various causes could not be tested through scientific means and experimentation. Hence, a large part of the analysis was necessarily based on qualitative assessments rather than on quantitative data.

SCARCITY OF FRESH WATER

LOCAL CONTEXT

Biological Aspects: 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 detrimental 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 million to 60 million tons per year. Figure 12.3 highlights the proximate and root causes of scarcity of fresh water in the coastal areas.

The effect of freshwater diversion is aggravated by reductions in silt flow resulting from damming upstream. During the past 50 years, 3 large storage dams and 20 barrages were built which divert river water for agricultural use. 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.

Figure 12.3 *Scarcity of Fresh Water*

Reports show eight different species of mangrove in the Indus Delta through the 1950s. However, at present, only three species of mangrove exist in the Delta, with *Avicennia marina* accounting for about 95 percent of the mangroves. The other two species, *Ceriops tagal* and *Aegiceros corniculatum*, are restricted to localized patches, which indicates ecological stress. 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. There is no evidence of other species at these locations. In addition to the loss of species, there has been a consistent decline in mangrove cover in the Indus Delta and Sonmiani (Baluchistan). Though the estimates show 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 scientifically, one estimate prepared by Sindh Forest Department suggests that an average flow of 1 cusec (28 liters/second) of fresh water for each 100 acres is required for healthy growth. However, it is 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, 1993).

Based on the estimated water requirement per unit of land and the Landsat estimates on area under mangrove cover together with area under mudflats (land that is potentially suitable for mangroves), the annual requirement for fresh water is about 6.8 maf. Since water releases for the Delta are made at Kotri (Hyderabad), which is about 100 miles from the mouth of the Delta, the conveyance losses (about 40 percent of the total) were also added to the net requirement of 6.8 maf. In gross terms, the requirements for water release from the Delta at Kotri, for healthy mangrove cover, are in the neighborhood of 9.5 maf. This is close to the 10.0 maf currently allocated in the Water Accord.

The above discussion clearly shows that, as a result of freshwater scarcity over time, mangrove cover has been reduced both qualitatively and quantitatively. In addition, 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.

Socioeconomic Aspects: The coastal areas of the country lack basic amenities such as drinking water, fuel sources, and road infrastructure. Over time, the coastal population has grown as a result of increased returns from fishing, despite the poor physical infrastructure. Consequently, the demand for fresh water for household consumption has increased several fold. Local authorities have not assessed the household demand for water, causing the meager water supplies from seasonal rivers on the Baluchistan Coast, in particular, to be under pressure due to population growth.

The status of local governments has not been clearly defined in Pakistan. These governments are dominated by local feudal structures, and the role of local communities in assessing their water needs has remained extremely weak. Local political representation has not been effective in resolving the issue. These tendencies are not unexpected given that the feudal structure prevailing at the regional and national levels restricts participation by the end-users in local development activities.

The loss of five mangrove species from the Indus Delta during the last 40 years, stunted growth of mangroves, and the analysis of plant pathology under these conditions provide sufficient evidence to show that reductions in freshwater supplies in future may further reduce the genetic diversity of mangroves in the area. Such changes will have significant effects on the biodiversity of the mangrove ecosystem. Fish resources may be depleted in the process. In order to survive, the mangroves may also shift inland toward areas with more fresh water, causing loss of land.

NATIONAL CONTEXT

Agriculture is the leading sector of Pakistan's economy. Over two-thirds of the population live in rural areas and depend mostly on agriculture for their livelihood. Being arid, the country continually faces scarce surface water supplies, and irrigation water is considered the life blood of the economy.

Efforts to increase agricultural exports to support the growing industrial sector and to ensure adequate food supplies for the rapidly growing population focus on irrigation water supplies. Therefore, three large storage dams and over 20 barrages were constructed to use the Indus water for irrigation, greatly reducing the flow to the Delta over the last 40 years, both in terms of the total amount of water and its annual distribution. In addition, feudal-style landowners, backed by economic and political power, have managed to procure and maintain huge public subsidies on irrigation water. In addition to capital subsidies on irrigation projects, there is a massive recurring subsidy on irrigation water covering nearly 60 percent of the operation and maintenance costs of the country's irrigation systems. Consequently, water-use efficiency in the Indus Basin has remained low. According to a National Conservation Strategy (NCS) report, only 30 percent of the total of 200 maf of water—available in an average year through all sources—is applied to farmers' fields. As a result of these huge subsidies, neither the farmers nor the irrigation authorities have any incentive to use irrigation water more efficiently.

In the water management process at the national level, coastal areas are neglected. Allocations for the coastal areas are determined after accounting for all other needs. While the Water Accord of 1990 does guarantee 10 maf for the Delta, this allocation is not based on any scientific or need-based assessment and could be subject to further reduction in the wake of greater shortfalls in the system. Over the past 50 years, all additional requirements for irrigation water have been met through increased diversion of water upstream, thereby reducing the flows to the Delta.

At the irrigation-system level, because of the failure to improve water-use efficiency, any additional cultivation of land reduces the flow downstream. Since the government has not succeeded in establishing a water market, due to

the pressure from the agricultural lobby, inefficiencies in the use of water are likely to continue. International agencies such as the World Bank and IMF have heavily stressed the need to reduce the water subsidy and establish a water market. However, since the agricultural lobby dominates the assemblies in the country, these pressures have been ignored.

It is quite evident that, unless appropriate policy measures are taken to increase water-use efficiency, population growth and increased demand for irrigation water will continue creating shortages in the Indus Delta. Adequate supplies of fresh water and silt to the Delta region are critical for the health of mangroves and the region's biodiversity. Any reduction will restrict the mangroves in performing their vital role as primary producers in the ecosystem.

The problem of reduced flow of fresh water to coastal areas is most pertinent to the Indus Delta because of the larger variations in the total availability in the river system and increased diversions upstream for agricultural uses. Here, the root cause appears to be at the national level where water use and allocation policies are made with political biases and remain largely devoid of the economic measures required to conserve water resources.

POLLUTION AND LAND CLEARANCE

LOCAL CONTEXT

Pollution of the marine environment is another proximate cause of biodiversity loss in the coastal areas of Pakistan. Three areas in the coastal region of the Indus Delta are significantly polluted: Keti Bunder (to the south near Sir Creek), the metropolitan center (Karachi, Port Qasim, and Rehri), and the coastline in the west (extending from Sonmiani to Jiwani). The loss of mangrove species during the last 50 years, besides being consistent with the reduced supply of fresh water to the Delta, is also consistent with the increased volume of untreated wastewater discharges from industries and the city of Karachi and its vicinity. In addition, land clearance for the construction of new sea ports, extension of existing sea ports, and establishment of industrial units near the coast has also contributed to the depletion of mangrove cover, particularly in the northern part of the Delta. These factors have not yet affected the mangrove cover on the Baluchistan Coast.

One of the direct and major causes of pollution in the Indus Delta is the industrialization-cum-trade-led urbanization in and around Karachi (Figure 12.4), where more than half of the industrial units and over 70 percent of the country's international trade are based. Being the biggest and only natural seaport, Karachi has attracted investments from all over the country. The situation thus created is largely an outcome of the national industrial policies that have emphasized centralized growth for industrialization. With improved infrastructure, Karachi was rapidly transformed into one of the largest cities in the world. Rapid migration to the city raised its population growth rate to over 6 percent annually. Rapid urbanization was accompanied by weak urban planning. The centralized industrialization approach was not accompanied by requisite urban development strategies. As a result, the generation of domestic and industrial effluents could not be assessed nor was the rapid population growth rate in Karachi taken into account. Correspondingly, there was no emphasis on safe or environmentally friendly approaches to the disposal of municipal and industrial wastes. Over time, pollution has affected the coastal areas of the Indus Delta, causing stunted growth of mangroves and biodiversity loss in the marine ecosystem.

Figure 12.4 *Pollution and Land Clearance*

Industrialization, in addition to indirectly increasing pollution by promoting urbanization and therefore increasing domestic waste, also directly increases pollution. Due to the lack of efficient production and post-production technologies and processes in the industrial sector, environmental problems, particularly marine pollution, have worsened as a result of an increased supply of untreated industrial effluent and pose a constant threat to biodiversity. Effluents from tanneries, including lead and mercury, are among the most harmful to marine life.

Due to the poor standard of living, local communities eagerly anticipate all types of development activities, without understanding the long-term adverse effects on themselves or their environment. For example, the development of a new seaport or establishment of an industrial complex is normally welcomed by the local communities since these developments offer employment opportunities. More often than not, the communities are unaware of the detrimental impacts of such development activities on the marine ecosystem and, consequently, on their fishing and other natural resource-based income and use. Unless the ineffective and non-participatory approach followed so far is changed, the social cost of land clearance and polluting industries will continue to rise and the environment will continue to suffer.

Based on past trends, one can easily ascertain the long-term environmental consequences of existing industrial pressures in and around Karachi and of the ineffectiveness of the environmental policy framework. A continuation of the present trend will cause more stunted growth of mangroves, and the biodiversity of mangrove areas will be eroded. Given the inelastic supply of land in Karachi, future economic growth will require reclamation of land from the sea at the cost of removal of mangroves. Unless this cost is correctly valued to capture long-term effects on the sustenance of coastal areas, the trend is likely to continue and biodiversity will suffer irreversible losses. Although this analysis is most relevant to the Indus Delta, this trend will eventually affect the Baluchistan Coast too. The Sonmiani region is likely to be affected earlier than any other region on the Baluchistan Coast because of its close proximity to the industrial complex planned at Hub.

NATIONAL CONTEXT

Local public institutions in Pakistan have not been accorded autonomy to design and implement policies or mobilize resources on their own. Rather, these institutions have historically remained dependent on meager grants from provincial or federal governments. At the national level, ministries of commerce and trade, finance, and urban and environmental affairs do not have coherent decision-making procedures for urban planning. The lack of coordination among local institutions or departments and among related ministries and departments aggravates the problems of urbanization.

Since domestic industries have long been protected from foreign competition because import-substitution policies were followed until 1988, they are uncompetitive and inefficient. A study of 48 manufacturing units from Pakistan found that the value added of nearly half of the units was negative when measured at world prices. Industrialization in Pakistan depended on a steady inflow of foreign aid and paid little or no attention to environmental costs. To support expansion of the volume of trade, a new port was established at Bin Qasim. The dredging of port channels was carried out with a complete lack of adherence to international dredging laws. Not only was land cleared for the port facilities, but the dredged material was dumped on mangrove forest. Although in recent years, the policies of donors have shifted toward a more favorable environmental bias, the considerable damage to environment and ecosystems caused by earlier national and international policies will take decades to remedy.

The federal government approved a National Conservation Strategy in 1991. This strategy formed the basis for the Pakistan Environmental Protection Act of 1995 (revised in 1996), which covers issues related to marine pollution and conservation of biodiversity in addition to air, water, and soil pollution, and handling of hazardous wastes. In order to exercise the powers and functions established by the Act, the government established the Pakistan Environmental Protection Agency (PEPA) and created the Pakistan Environmental Protection Council (PEPC), with the Prime Minister as its chairperson, to approve national environmental policies. Similarly, each provincial government established an Environmental Protection Agency (EPA) to exercise the powers and functions delegated to them by the PEPA.

With a top-heavy institutional structure, the PEPC requires a minimum of 15 non-government officials as members out of a total of 41. These non-officials, however, are appointed by the federal government. Although such non-officials may represent different sectors of society, given their low proportion in the PEPC and their nomination by the government, it is not likely that they will exert significant pressure to ensure that environmental issues are better understood and political biases are minimized. This lack of representation reflects a major deficiency in the country's current institutional structure for environmental protection.

National Environmental Quality Standards (NEQS), also established under the 1995 Act to cover all sectors of the economy, have remained largely unenforced as anticipated. Government agencies responsible for enforcing the NEQS are understaffed, under-equipped, and unprepared. They are, therefore, unable to fulfill their roles of carrying out environmental impact assessments, monitoring, or enforcement. The industrialists, on the other hand, do not share responsibility for improving or protecting the environment and have made virtually no attempt at recovery of by-products or minimization of wastes. The NEQS have, therefore, had minimal success in reducing pollution.

Since the largest sea ports in the country, one at Karachi and the other nearby at Bin Qasim, as well as a number of industrial units are located in the Indus Delta, the issues of pollution and land clearance are currently relevant to the Indus Delta only. The untreated and unregulated industrial effluent thrown into the Delta will continue to be a major threat for mangroves and fish.

INTERNATIONAL CONTEXT

Increased pressures from the World Bank and the IMF for structural reforms do not explicitly emphasize the need for reform of centralized growth strategies. Rather, they stress liberalization of the fiscal, tax, and trade structure,

reduction in public expenditure, and incentives for private investments in order to move toward a market-based economy. However, the government has responded by a hastening toward increasing production levels with emphasis on the expansion of existing industrial and trading centers, largely ignoring associated environmental issues.

With increased sea trade, the probability of oil spills increases. These accidental spills pose a great threat to marine life and mangrove estuaries. Available safety measures are insufficient to check and control such oil spills. A lack of coordination among the relevant ministries and departments at the national and provincial levels prevents them from taking safety measures to protect the environment from such hazards.

Such circumstances are in part a reflection of the inefficiency of the bureaucracy and also an outcome of the strong emphasis on international trade by international agencies. GATT, to which Pakistan has been a party since 1964, and the newly established WTO restrict government use of trade policies to protect the environment. The effects of incentives (or disincentives) from international agreements and policies on national and local decisions are often far-reaching. However, there is no simple and straightforward link between the WTO's policies and the government's poor environmental performance. A detailed institutional analysis is required to unfold the layers of factors between these levels. Nevertheless, the prescriptions for increased trade will continue posing threats to the marine environment through increased pollution and land clearance until environmental issues are correctly understood and effective remedial measures are enforced.

On the whole, it appears that, whereas the WTO is facilitating significant expansion in world trade, coverage of the associated environmental concerns is in a stage of transition if not infancy. At present, short-term gains may be achieved by WTO-member countries by ignoring long-term environmental losses. Since environmental effects cannot be confined within national boundaries, it is likely that incompatibility between the WTO and multilateral environmental agreements may create environmental as well as political conflicts.

OVERHARVESTING OF MANGROVES AND FISH RESOURCES

LOCAL CONTEXT

Overharvesting mangroves and fish by coastal communities is a third cause of mangrove cover degradation. It is, however, difficult to determine the extent of damage due to use by local communities.

Mangroves: Earlier studies covering specific locations in the Delta and on the Baluchistan Coast have reported logging of mangroves for fuel and timber at an increasing scale. Some studies have also highlighted the effect of camel browsing. However, empirical work has been confined to specific locations. The economic rationale behind the overharvesting of mangroves rests with the scarcity of fuel alternatives at a comparable or lower price. Figure 12.5 shows the causal links among factors at different levels for the overharvesting of mangroves. As a consequence of increased population and poor physical infrastructure, demand for mangrove wood for fuel increased at the local level. Lack of alternate fuelwood aggravated the problem. Alternatives, such as kerosene oil or natural gas, are either not available or too expensive for the local communities.

In order to understand the links among the factors mentioned above and to establish the trends with regard to overharvesting of mangroves and fish resources by the local communities, a household survey was carried out in the Indus Delta and Baluchistan Coast. The data show that 46 percent of the 125 households interviewed in the Indus Delta use mangrove wood as fuel. In case of Baluchistan, 22 percent of the 73 households reported use of mangroves. Overall, 37 percent of the total 198 households reported use of mangrove wood. The proportion of households using mangrove wood for fuel declines with the increase in distance to mangrove forests.

Mangrove forests have remained a source of fuel, timber, and fodder for coastal communities in almost all estuaries. Because of their remoteness, resident communities have always had a stake in maintaining the forest. Logging and cutting have, therefore, remained within safe limits. However, these communities remain unaware of the greater role mangroves play in their own lives by maintaining diversity of biological resources in the marine environment and protecting coasts from erosion. This can be linked to the failure of society to increase the awareness of such communities about the greater role of mangroves.

Camel browsing in the mangrove forest is extremely harmful to the growth and regeneration of mangroves. Ineffective control over the forest by the relevant departments allows this degradation to continue. However, the impact of camels is limited to certain pockets in the dense forest of the Indus Delta, and the associated threats to mangroves have tended to be insignificant given a decline in the camel population in coastal areas. The decline in the camel population has been caused by both a reduction in camel exports to the Middle East and an increase in the relative profitability of cattle and buffalo over camels. Domestic ownership of camels is now very low with only 31 households out of 198 keeping camels. On average, one household had one camel. This implies that the impact of camels is limited to particular locations.

Figure 12.5 *Overharvesting of Mangroves*

Despite the fact that, in certain areas, cutting is prohibited and the Forest Department has taken over control of the forest, easy access to mangrove forests has led to surplus cutting of mangroves for commercial purposes in some locations, as at Keti Bunder. Here again, the relative price structure that makes mangrove wood cheaper than other wood (Rs. 60 per 40 kg as against Rs. 80-100 per 40 kg) causes surplus cutting. Although commercial cutting is limited to certain areas, the weak implementation of laws prohibiting this activity has long-term implications for the management of mangroves. On the whole, however, the dependence of local communities on mangroves for fuel and fodder is not great enough to pose a serious threat of overharvesting.

Fishing: In addition to the overharvesting of mangroves, overharvesting of fish resources was also investigated. A set of causal factors and relationships is presented in Figure 12.6. In-migration to the communities in the coastal areas and increased pressure on mangroves for fuel and fodder, which accelerated during the period 1970 to 1985, was accompanied by increased pressure on fisheries. Over time, due to migration of communities belonging to other tribes, races, and nationalities to the coastal areas, the level of community cohesiveness has declined. As a result, communities have become socially stratified and their capacity to undertake appropriate measures to reduce

environmental degradation has been curtailed. The internal equilibrium between growth and consumption of mangroves and other marine products has been disturbed.

The survey data indicate reductions in the catch of different fish species in the Indus Delta and Baluchistan Coast over the last five years, as reported by the locals. In the Indus Delta, 92 households out of 125 responded to this issue. Of the 92 households, only 6 reported no change in fish catch. Similarly in Baluchistan, 64 out of 73 responded. Only one household reported no change in fish catch.

The above shows a qualitative assessment of reduction in fish catch. These qualitative assessments based on the perceptions of fishermen at various locations provide first-hand information that is consistent with the general impression gathered during initial site visits and meetings with various stakeholders.

Published data on fish catch was not used because a significant part of catch is not reported by the fishermen. However, the official statistics published by the government tend to confirm the overharvesting of fish resources (Government of Pakistan, 1996). Between 1985 and 1995, the total number of marine boats increased 74 percent in the Indus Delta, from 7,717 to 13,448. On the Baluchistan Coast, they increased 84 percent, from 2,698 to 4,970. Since marine fishing in Pakistan is carried out within a 50-mile range of the coast, the massive increase in the number of boats indicates significant pressure on in-shore fishing resources.

Increased pressure on fisheries is caused by a number of factors. First, the coastal area is largely undeveloped in Pakistan. The traditional profession of the locals is fishing. With the rapid increase in coastal population, 6 to 8 percent annually over the last ten years, along with extremely poor physical infrastructure, these regions could not offer new alternatives for income generation. Lack of the basic infrastructure needed to attract investments to non-traditional ventures or development of fishing has been a binding constraint on social and economic development.

Figure 12.6 *Overharvesting of Fish Resources*

Second, higher returns from fishing emerged at the same time as coastal population growth, resulting primarily from the government's strategy to boost exports. Increased investments from abroad along with increased international emphasis on trade were instrumental in shaping national policies.

Third, the higher returns from fishing promoted further significant in-migration from within the country as well as from abroad, further increasing pressure on fish resources. In the process, local communities became more and more heterogeneous in their ethnic and tribal characteristics, and their cohesiveness started declining, exerting additional pressure on fishing, as respect for traditional rules and sustainable practices were replaced by profit-seeking due to the increased competition and community heterogeneity. New settlers in the coastal areas increased damage to the local environment by propagating the use of illegal small-mesh fishing nets to further enhance the financial returns from fishing. After some initial resistance and hesitance in using illegal nets, the local fishermen also joined in.

The household survey data show 168 households, out of a total of 198, involved in fishing. For nearly 85 percent, fishing is their main source of income. On the whole, average earnings per household per annum were nearly three times the average income in rural Pakistan. Hence, in a relative context, these areas do not suffer from financial poverty but suffer from great social poverty, notably the lack of social amenities, and therefore have a poorer standard of living than other rural areas.

The Indus Delta is suffering population pressure from three sources—local population growth, migrants from within the country, and migrants from outside the country—while only local population growth and in-migration from within the country have pressured the Baluchistan Coast so far.

The Indus Delta reports loss of a larger number of fish species during the last five years (1993-1998) in relation to the Baluchistan Coast. The use of illegal fishing nets seems quite widespread in the Indus Delta whereas on the Baluchistan Coast, they are used only in Sonmiani, which is close to the Indus Delta. The use of these nets has reached the Baluchistan Coast only recently. Widespread use of illegal nets demonstrates ineffective implementation of fishing laws at the local and provincial levels. The Fisheries Department is not implementing other fishing laws, including a ban on in-shore fishing of certain species, further promoting overharvesting.

It appears that overharvesting fish resources is a bigger threat to biodiversity than the overharvesting mangroves. Overharvesting fish resources is increasing in both the regions. The higher income possibilities from fishing and total disregard of fishing laws is leading to the extinction of certain fish species. There is an urgent need for effective implementation of existing laws related to both fishing and migration to coastal areas for the effective control of harvesting of fish.

NATIONAL CONTEXT

Overharvesting mangroves is a result of negligence in the development of Pakistan's coastal areas. Lack of basic amenities has, in certain locations, left no alternative to the use of mangrove wood for fuel.

Responsibility for protecting mangrove forests has lain with the Forest Department since the late 1950s, but only very recently has this department shown any interest in conservation of these forests. A mere expansion of responsibilities, without the requisite resources, will not help the Forest Department implement the existing laws. For example, one forest guard alone is given an area of 20,000 to 25,000 acres of mangroves to monitor. At the national level, weak environmental groups coupled with a general lack of political will to control deforestation allow weak implementation of laws to continue. These environmental groups receive inadequate support from international bodies and NGOs, while the absence of strong conditionalities related to environmental protection in larger economic and financial agreements does not promote political will on the part of the government to control deforestation.

Inter-departmental jurisdictional conflicts have created barriers to improving forest laws, particularly those related to the marine environment. The Indus Delta region has been divided among three authorities, namely the Sindh Forest Department, the Bin Qasim Port Authority, and the Land Revenue Department. As a result, mangrove forests within

the jurisdiction of each department are being protected in different ways. For example, the Bin Qasim Port Authority has declared mangrove forest within its control as protected area. But improper dredging of port areas by the Authority itself has included clearing of mangroves. The Land Revenue Department has not developed any plan for the conservation of its forests.

Given the high returns associated with fishing and a general lack of implementation of fishing laws as well as migration laws, the issue of overharvesting of fish is likely to escalate in future and may affect the entire coastal belt. The increased pressure on fisheries from the local population indicates a lack of other income alternatives, which is itself a reflection of poor infrastructure. Coastal area development is not a priority for the government, due to the absence of strong political representation of the local area at the national level. Poor infrastructure has made the area unattractive to investors who could help in the diversification of local economic activities.

Emphasis on the expansion of exports, given increasing trade imbalances, has been supported by rapid devaluation of the rupee in relation to major currencies. Devaluation has led to rapid increases in the local price of shrimp and other fish. Since fisheries are treated as a sub-sector of agriculture, which enjoys total exemption from direct taxes in Pakistan, it remains extremely attractive financially for fishing communities to expand fish catch at all cost and to ignore the environmental consequences.

INTERNATIONAL CONTEXT

International trade agreements, including tariff reforms, and greater emphasis by international organizations on the expansion of world trade have jointly created opportunities for exports. These agreements do not address the long-run sustainability of the coastal environment. As a result, increased export of fish is likely to cause depletion of fish species and biodiversity.

Since the major argument presented by the government for the devaluation of the rupee is to boost exports as well as to reduce exchange rate controls (which fulfills the requirements of the structural adjustment program and is consistent with the emphasis on increased trade), it is not surprising that international agreements do not address overharvesting of fish resources and degradation of marine environment.

It is interesting to note that most member countries of WTO are also signatories to multilateral environmental agreements, and the number and scope of these agreements grew significantly during the 1980s and the first half of 1990s. The failure to achieve compatibility between the agreements under WTO and environmental agreements appears to be a binding constraint in linking trade and environment under WTO. Thus it seems that the trade sanctions envisaged under environmental agreements have become difficult for the WTO to adopt.

GEOPHYSICAL

LOCAL CONTEXT

Geophysical factors affecting the mangrove ecosystems include existing problems and the threat of global warming. Figure 12.7 describes the proximate and root causes of geophysical changes in the coastal region.

The Indus Delta exists because the deposition of sediments transported by the Indus in the past has been greater than erosion by the sea. Sediment transport is basically a function of river discharge. As a result of reduced sediment flows, the Delta is now retreating. The damaging effects of floods in the coastal regions are caused in part by the lack of infrastructure for flood control at the local and provincial levels. On the Baluchistan Coast, this problem is

very serious and largely a result of strong wave action and coastal current patterns (Mirza, et al, 1988). The coastline is open and hence subject to strong wave action.

Global warming will cause changes in weather patterns at the micro- or local-level. Sea-level rise may cause stronger wave action, higher tides, and greater probability of surges, all of which may cause coastal erosion and depletion of mangroves, aggravating current patterns of physical damage.

Figure 12.7 *Geophysical Changes*

NATIONAL AND INTERNATIONAL CONTEXT

Pakistan has been included in the list of ten countries most vulnerable to the impacts of rising sea levels. Qureshi (1989) has estimated a land loss of about 1,700 km² in the Indus Delta due to sea encroachment over the last half century. Along the Baluchistan Coast, historical records show that sea encroachment destroyed several towns and villages. The lack of focus on the coastal area development at the national level has given rise to issues related to coastal protection. National flood control and coastal protection measures are virtually non-existent. At the international level, global warming, a cumulative impact of worldwide industrialization as emissions of greenhouse gases cause depletion of the ozone layer, poses a regional threat. The advances made since the Rio Summit in 1992 to address this problem are encouraging, but stricter implementation of the agreements is required.

CONCLUSIONS

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. The survival of salt-tolerant *Avicennia marina* in the Delta provides evidence of higher levels of salinity in and around the mangrove forests. The comparative Landsat picture (see Annex) of mangrove cover in the Delta also suggests quantitative and qualitative decline of mangroves over the last two decades. Although the Water Accord of 1990 guarantees a minimum of 10 maf of water annually for the Delta, the high public subsidies to irrigation water for agriculture upstream provide negative incentives for the conservation of water resources. In the event of any significant water shortage, the Delta is likely to receive a smaller quantity. If the mangroves are to be conserved effectively, a larger water supply has to be assured. This would require improved water-use efficiency in the upstream areas.

The root cause of the reduced supply of fresh water to the Indus Delta is found at the national level. The decision to apportion and/or divert water supplies for upstream uses only takes agricultural needs into account. The strong agricultural lobby has managed to procure various government subsidies on a sustained basis since most of the elected officials are feudal landowners who benefit directly from the subsidies. An efficient water market has not been allowed to develop. National policies have aimed at increasing agricultural growth by increasing crop area and water supply instead of focusing on higher productivity and efficient water usage, despite the fact that 40 percent of irrigation water is wasted.

The loss of mangrove species is also consistent with the increases in volume of untreated industrial and domestic wastewater discharges from Karachi and its vicinity. Since domestic industries were consistently protected from foreign competition, they are noncompetitive and production and post-production technologies and processes are inefficient. Moreover, the dredging of port channels is carried out with a total disregard for international dredging laws. The increased level of marine pollution in the Delta at present, which is likely to spread to Sonmiani in Baluchistan, has stunted mangrove growth, and marine pollution poses a constant threat to biodiversity.

The government agencies responsible for enforcing NEQS are understaffed and under-equipped. The general public and the industrialists, on the other hand, show no desire to share the responsibility for improving or protecting the environment. The ineffectiveness of EPAs in controlling marine pollution will continue to contribute to environmental degradation. Instead of changing the environmental laws, efforts are needed to increase local participation in the PEPC if the effectiveness of EPAs is to be improved.

The household data show that most households are directly or indirectly linked with fishing. Because of relatively high incomes, by national standards, from fishing, the area does not suffer from financial poverty relative to other rural areas in the country. However, there is widespread social poverty as a result of the lack of social amenities.

Household fuel consumption patterns show that nearly two-thirds of the resident communities do not use mangroves at all. This indicates that pressure on mangroves for fuel is low and, given the high returns from fishing, it is likely that people will shift to non-traditional fuel sources as they become more affordable. Though the overharvesting of mangroves is a serious problem in selected areas, it is not a major threat in terms of impact on the entire mangrove area. This refutes the commonly held notion that overharvesting by the local communities is the biggest threat to the mangroves.

Overharvesting of fish resources emerged as a very important factor for biodiversity loss in the mangrove ecosystems. Over-fishing results in the extinction of certain fish species, causing changes in the biodiversity of mangrove forests where local fish species spend at least a part of their life cycle. In the rural household survey, over 95 percent of households reported a loss of fish species over the last five years. The overharvesting of fish resources is primarily caused by improved financial returns resulting from increased export demand and opportunities. Factors contributing to this phenomenon include use of fishing nets of illegal specifications and poor control by the relevant authorities, including the Fisheries Department, as well as changes in economic policies.

The root causes of degradation of mangrove forests seem to stem, at the national level, from industrial, trade, and conservation policies. Industrial policies favor centralized growth with implicit and explicit subsidies promoting inefficient production technologies and leading to increased marine pollution. Trade policies, marked by tariff reductions and influenced by international prescriptions, emphasize export expansion to reduce trade deficits and revenue gaps. On the conservation side, overharvesting of fish resources in shallow waters indicate a complete disregard for the existing environmental protection laws. Tax and water pricing policies have promoted inefficient water use. Due to the lack of environmental assessment of these policies, biodiversity loss in the mangrove ecosystem has neither been understood nor given due attention.

Understanding the economic rationale for the conservation of mangrove forests requires that the entire problem be viewed from a broader perspective. The costs of degradation must be weighed simultaneously with the benefits of resource use. Mangrove protection will require a comprehensive planning effort with integration of the relevant ministries or departments and the local communities. Further research efforts would be extremely helpful in designing a comprehensive plan to conserve biodiversity in mangrove forests.

Figure 12.8 *Revised Conceptual Model*

RECOMMENDATIONS

The following recommendations are made based on the analysis carried out for this study:

- Environmental impact assessments should be carried out by EPAs on a regular basis and published officially to strengthen the mandated efforts to increase public awareness about environment and promotion of research.
- Given the extent of overharvesting of fish resources, close coordination should be maintained between fishermen and fisheries departments to ensure implementation of existing fishing laws, particularly those related to illegal fishing nets.
- Effective policy actions at the national level are needed to check the influx of migrants promoting the use of illegal fishing nets and exerting pressures on the marine environment through overharvesting of fish resources.
- Based on discussions with the personnel of the Forest Department and local community members, reforms need to be formulated to promote cooperation between the Department and coastal communities in order to ensure effective protection and conservation of mangroves.
- Qualitative assessment of the status of the fishing communities indicates the need for a vocational training program for fishermen to help them develop their resources in a manner conducive to the protection of marine environment.
- The levels of income from fishing are promising for the development of financial markets in coastal areas. Development of financial markets would help mobilize household savings and provide credit to develop off-shore fishing capacity, which would reduce pressure from in-shore fishing. In the initial period, provision of subsidized credit may be instrumental in reducing overharvesting of fish resources, particularly shrimp.
- Given the variations in the availability of water in the river system of Pakistan in the past, it is highly likely that such variations may cause further reductions in the flow toward the Delta despite the guarantee of 10 maf in the Water Accord. The only viable option left is to increase the efficiency of water use at the system and farm

levels in order to minimize increases in diversions upstream and to ensure an adequate supply of fresh water to the Delta.

- Changes in the legal structure of the PEPC are needed in order to include non-appointed members in the Council, and to ensure an adequate balance between officials and non-officials for better understanding of environmental issues and for effective implementation of laws.
- In order to avoid conflict of interest and for strict compliance with the International Dredging Convention to which Pakistan is a signatory, dredging operations need to be monitored by agencies like EPAs instead of port authorities.
- Appraisal of foreign investments, particularly those directly or indirectly affecting the mangrove ecosystem, should account for the full costs of environmental degradation they may cause.
- For a pragmatic solution to the increased water pollution in the marine environment, a restructuring of NEQS is needed so that polluters' ability to pay the associated costs and the technological constraints are taken into account.
- A process of stakeholder dialogue needs to be initiated to effectively address the causes of biodiversity loss and provide an open forum for discussion of the role and constraints of the various stakeholders. Such dialogue would play a role both in information dissemination and consensus-building. It would help bridge the information gaps that are currently present among the important actors and lead to viable and agreed-upon steps for improving the environmental situation.
- In the light of the complexities associated with the issue of biodiversity in marine ecosystems and the scientific information generated so far, in-depth scientific studies on the following issues should be conducted:
 1. the adaptive behavior of mangroves in Indus Delta and Baluchistan Coast in the face of the technical, socioeconomic, and environmental changes in the coastal areas;
 2. fresh water requirements of mangroves in terms of quantity and distribution;
 3. the "willingness to pay" for alternate sources of fuel for household consumption on the part of coastal communities; and
 4. institutional factors, from local to international levels, and the causality among various layers of institutional mechanisms that affect biodiversity in the mangrove ecosystem.

Annex: Landsat Data

Figure 12.9 *Mangrove & Landforms in Indus Delta (01 February 1990, Landsat TM Image)*

Figure 12.10 *Mangrove & Landforms in Indus Delta (07 February 1998, Landsat TM Image)*

Figure 12.11 *Mangrove and Landforms in Sonmiani Bay (12 march 1990, Landsat TM image)*

Figure 12.12 *Mangrove & Landforms in Indus Delta (05 February 1998, Landsat TM Image)*

