



**THE ECONOMIC VALUE OF THE ENVIRONMENT:
CASES FROM SOUTH ASIA**

**ECONOMIC VALUATION OF THE MANGROVE ECOSYSTEM
ALONG THE KARACHI COASTAL AREAS**

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ECONOMIC VALUATION OF THE MANGROVE ECOSYSTEM ALONG THE KARACHI COASTAL AREAS

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ABSTRACT

The mangroves of the Indus River Delta in the Karachi, Pakistan coastal areas provide a wealth of goods and services to people who live and work among them. However, these products are not sold in established markets, so their economic importance goes unrecognized. As a result, the expansion of regional industry, agriculture, and population are permitted to threaten the sustainability of the mangrove ecosystems. This study describes the broad array of goods and services provided by the mangroves, and uses market data to estimate the economic value of a few of them. It then argues for the importance of more thorough mangrove valuation studies as a crucial input into policy decisions which will affect the viability of mangrove ecosystems in the future.

INTRODUCTION

This study focuses on economic valuation of the mangrove ecosystem along the Karachi coastal areas. The mangrove ecosystem of the Indus Delta coastal zone is a vital wetland area of great ecological and economic significance. The location of Pakistan's mangrove forests in a temperate zone is unique, as the tidal forests of most other countries are in tropical areas.

The mangroves of Pakistan occur mainly in the Indus Delta in the provinces of Sind and Baluchistan along the Arabian Sea coast. As recently as the early 1980s, mangroves grew all along the 240 km coastline, occupying an area estimated at 600,000 acres, approximately 40% of the entire tidal belt and 10% of the Indus Delta fan. At that time they were among the largest mangrove forests in the world and certainly the largest in an arid climate. The Indus Delta mangroves are dependent upon forest water discharges from the Indus River, as are other mangroves in deltaic regions of the world, because they grow better in low salinity water and soft alluvial substrate.

Mangrove ecosystems are complex, diverse and important. Their complexity and importance pertain not only to their role in the biosphere, but also to the broader sphere of human-mangrove interactions. Understanding their economic value is therefore important in the search for strategies to protect them.

ECONOMIC IMPORTANCE OF THE MANGROVE ECOSYSTEM

From an economic point of view, Pakistan's mangrove ecosystems are important for a variety of reasons. For countries like Pakistan, where population and economic pressures on the coastal zone are high, mangrove forests could be considered a primary natural resource. Not only are the forests themselves of direct value to the economy, but they also protect and sustain other key coastal resources.

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.

Many of the fish species which contribute to domestic and foreign consumption are directly harbored by the mangroves during a part of their life cycle, and they remain dependent on the mangrove food web throughout their life cycle. This is particularly the case with panarid shrimp, which comprise the most valuable commercial species in Pakistan.

The following tables list the direct and indirect uses of mangrove products.

Table 1 – Direct Products from Mangrove Forests	
Uses	Products
Fuel	Firewood for cooking, heating Firewood for smoking fish Firewood for smoking sheet rubber Firewood for burning bricks Charcoal Alcohol
Construction	Timber for scaffolds
Fishing	Timber for heavy construction (e.g., bridges) Railroad ties Mining pit props Deck pilings Beams and poles for buildings Flooring, paneling Boat building materials Fence posts Water pipes Chipboards Glues
Agriculture	Fodder Green manure
Paper Production	Paper of various kinds
Foods, Drugs and Beverages	Sugar Alcohol Cooking oil Vinegar Tea substitutes Fermented drinks Desert topping Condiments from bark Sweetmeats from propagules

	Vegetables from propagules, fruit or leaves Cigarette wrappers Medicines from bark, leaves and fruits
Household Items	Furniture Glue Hairdressing oil Tool handles Rice mortar Toys Matchsticks Incense
Textile and Leather Production	Synthetic fibres Dye for cloth Tannin for leather preservation
Other	Packing boxes

Table 2 - Indirect Products from Mangrove Forests	
Source	Product
Fish (many species)	Food Fertilizers
Crustaceans (prawns, shrimp, crabs)	Food
Mollusks (oysters, mussels, cockles)	Food
Bees	Honey Wax
Birds	Food Feathers Recreation (watching, hunting)
Mammals	Food Fur Recreation (watching, hunting)
Reptiles	Skins Food Recreation
Other Fauna (e.g., amphibians, insects)	Food Recreation

This wide range of products is the basis for the mangrove-dependent economies of many coastal peoples and contributes significantly to the national economy. Identifying the economic value of the marketed mangrove-based products is relatively straightforward. It is more difficult, however, to identify the economic contribution of those products which can be termed as free. These free goods and services would cost a tremendous amount of money if other resources were utilized in their place. Since this is usually not addressed, conventional accounting practices underestimate the total value of the mangrove resource.

FUNCTIONS OF THE MANGROVE ECOSYSTEM

Mangrove ecosystems provide a number of distinct services which are not sold or priced through the market:

- The presence of the species *Avicennia marina* along the shore ensures the firm and stable formation of shorelines and creeks. These trees serve the vital but almost unquantifiable function of protecting the coastline from wind and ocean currents. The location of Port Qasim, Pakistan's second largest port in the vicinity of the Korangi/Phitti creek system, may be attributed in large measure to the natural protection it gets from mangroves.
- The pollutants and waste discharge from industrial activities in and around Karachi find their way to the natural sink of the mangrove ecosystems. Karachi's ever-growing population generates a huge amount of domestic effluent which is also absorbed by the mangrove ecosystem.
- Coastal communities benefit from a host of products and services of the mangrove ecosystem. Fishing is the primary source of income for the majority of the fishermen residing in villages along the coast line and these fisheries depend upon mangroves for regeneration.
- The mangrove wood and leaves serve many purposes. They are used as fuel, as fodder for camels, cattle and goats, and to build houses and furniture.

DEGRADATION AND DEPLETION OF PAKISTAN'S MANGROVE ECOSYSTEMS

Deforestation and degradation are common among mangrove ecosystems all over the world. The increase in coastal population, together with rapid economic expansion, has brought about an increase in consumption of forest resources. Mangroves are under pressure to supply wood and other forest products. Pakistan's mangroves face serious threats which jeopardize their sustainability and their very existence.

Decreased Indus River Flow

Decreased flow in the Indus River is probably the most serious problem facing the mangroves of the Indus Delta. Mangroves occur in deltaic regions throughout the world because they grow better in low salinity water and soft alluvial substrate. Their productivity increases proportionately with the availability of freshwater. A decrease in freshwater supply means retardation in their growth.

There has been a continuous decrease in Indus River discharge ever since the creation of Pakistan some five decades ago. The population of the country was low and dispersed at that time. Since then, population has

increased steadily due to immigration from neighbouring India and to high birth rates. This has called for increased agriculture in the country. As a result, dams and barrages have been constructed to use the Indus water for irrigation, decreasing the river's discharge gradually over the years. Now only a trickle is available to the delta, except during monsoonal floods. Salinity has therefore increased dramatically in the deltaic region; at present a level of 40 parts per thousand or more is common in some mangrove areas. There exist no records of salinity in the area prior to the last few decades. However, it must have been appreciably lower, since rice was once cultivated in Keti Bunder in the vicinity of mangrove stands. Due to this hypersalinity, a decline in mangrove growth is now visible everywhere.

The upstream damming of the Indus River has also stopped the flow of much of the nutrient-rich alluvium. According to one estimate, 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.

The ideal solution to these problems would be to restore the normal flow of Indus river to the delta. However, this is not a practical option, when one considers the increasing demand for agriculture in the country. Recently, an Indus Water Accord by Government of Pakistan apportioned the use of Indus water between provinces and allowed only a meager amount of 10 million acre-feet to be discharged into the delta. This amount will be less than the 35 million acre-feet now available and much less than 150 million acre-feet available decades ago before the construction of the dams. Thus the situation is likely to worsen with time. The government may be prevailed upon to increase the amount to some extent. However, coastal scientists first need to determine the minimum freshwater required by the mangroves. Only then can one argue the case strongly with the authorities. Such studies would be an obvious undertaking for a coastal management program.

Grazing and Harvesting

Mangrove leaves are eaten by cattle and camels and are considered to be very nutritious. As many as 16,000 camels and 11,000 cattle may browse on mangroves in the Indus. The animals seem to have adjusted well to the diet. Mangroves are also harvested as fuel wood by local habitants at the rate of 173 kg of wood per month per household and 18,000 tons per year for the entire delta area (IUCN 1992). There is the problem of overfishing in the creeks, which is not only affecting the delta but also the coastal waters.

Harvesting may be as significant as hypersalinity in contributing to the decline of the mangrove ecosystems. In order to manage mangrove use properly, it is important to assess the damage caused to mangrove cover annually from this source. IUCN surveyed local consumption of mangrove wood for fuel in the Korangi Creek area (IUCN 1992) and the Sindh Forest Department surveyed the grazing and stall feeding by camels and cattle respectively in the delta region. Neither study provides quantitative estimates of rate of loss of mangrove cover over time attributable to such activities.

In any case, a number of strategies may be suggested to address these problems. Browsing by camels and stall feeding by cattle may either be completely stopped or allowed only within the sustainable yield. At present, the revenues collected from sale of mangrove products are minimal; they should be discouraged completely. Laws must be strictly implemented and poachers heavily fined. A two-month ban on fishing may be reintroduced to prevent declines in the fishery.

One solution to the problem is to provide alternate sources of fuel and fodder to the local inhabitants who now use the mangroves because they are cheap and easy to obtain. Provision of natural gas, which is cheap and plentiful in Pakistan, may be the best choice. Similarly, if local inhabitants are encouraged to go into professions other than fishing, it may improve the situation markedly.

Urbanization

The city of Karachi is constantly growing, both in population and in geographic area. Its population was estimated to be over 10 million in 1995. Pakistan's second largest port, Port Qasim, was recently established in the Korangi Creek area at the expense of thousands of acres of mangrove forest. Both the port and a nearby steel mill are supported by a new town, which houses people working in the two giant complexes. Thermal pollution and solid wastes originating from these sources are a direct threat to the mangroves. Dredging operations in the channels and creeks leading to the port, while needed for navigation, have a detrimental effect on the young seedlings and pneumatophores of mangroves as sediment cover cuts off their oxygen supply.

An immediate step to prevent further destruction of the mangrove vegetation must be to regulate coastal development in the area and restrict it to areas that will do the least harm. Coastal erosion can also be prevented by planting selected mangrove species on the banks. The dredged material must be disposed of far away from the mangroves, with experts on mangrove ecosystems consulted at every step.

Pollution

According to one estimate, there are more than 6,000 small and large-scale industrial units in the Karachi area, all of which discharge untreated effluent directly or indirectly into the Indus Delta. The major flow of industrial and domestic pollution comes through the Lyari River, whose spillway lies close to Karachi harbor. The other is the Malir River, spilling into Korangi Creek. Industrial pollutants include all types of heavy metals and hazardous chemicals. As many as 170 tanneries have also been established in Korangi, discharging heavy amounts of chromium into the nearby creeks. In addition, the steel mill is a source of iron pollution in the area. Agricultural pollutants including fertilizers, pesticides, and herbicides also make their way into the delta as the river collects these hazardous substances along its course through the country. Fertilizers result in eutrophication and are responsible for abnormal phytoplankton blooms resulting in high fish mortality. Organometallic compounds and chlorinated hydrocarbons are other toxic pollutants present in the Delta.

Oil may be the most serious threat to the mangroves. It physically covers the pneumatophores and prevents access of oxygen to the roots, thereby killing the plants by suffocation. Oil pollution in Karachi harbor and Korangi Creek area originates mostly in the sea. According to one estimate, some 20,000 tons of oil find their way to Pakistani beaches, harbors and fishing grounds annually. There are four major sources of this oil; near-shore bilge cleaning, leakage from vessels, accidental spills and refinery effluents.

The steel mill, Port Qasim, Korangi Power Plant, West Wharf Power Plant and Sindh Alkalies are also sources of thermal pollution in the area, and may collectively discharge some 1500 million cubic meter of warm water annually.

Organic pollution may not be too serious a problem for mangroves, as they can resist doses of domestic,

industrial and agricultural effluents. There are even suggestions to use them as bio-filters for land-based pollution entering into the sea. Domestic sewage seems to encourage the growth of mangroves because of its heavy load of nutrients and fresh water.

However, even though the different types of pollutants may not be affecting the mangrove growth, they are certainly toxic to animals living in the ecosystem and may, therefore, eventually destroy it. The only way to avoid this catastrophe is to treat the effluents before they enter the area. As yet, there are no treatment facilities for pollutants in the region, except for some domestic sewage treatment plants in the Karachi area. These are quite inadequate to handle the entire city's load, which includes more than 2000 tons of biological oxygen demand (BOD) per day.

An important aspect of combating pollution in the region is the regular monitoring of the levels of pollutants in the substrate and organisms of the area. Marine pollution is an international problem and, therefore, cooperation with international organizations may be sought to combat it.

Sea-Level Rise

The response of mangroves to the threat of sea-level rise depends on the balance between the rate of the rise and the rate of sedimentation or peat accumulation in the mangrove areas. If the former exceeds the latter, then the mangroves will retreat or disappear as they have on the Atlantic Ocean island of Bermuda. In Bermuda the local sea level had been rising at a rate of 28 cm/100 years whereas the rate of peat accumulation was only 8.5 to 10.6 cm/100 years. As a result, the mangroves perished. If, however, the rate of sea level rise equals the rate of sediment accumulation, then the mangroves can continue to flourish.

The recent estimate of sea level rise of 1.1 mm/year around Karachi between 1960 and 2000 is well below the average global rate. No meaningful estimates of sedimentation rates in the Indus Delta mangroves are available. However, due to continuous decrease in sediment loads of the Indus these rates must be small and it is likely that the mangrove forests of the Indus Delta will be overrun by the rising sea.

Socio-Economic Issues

Poverty, with its associated deprivations, seems to be the source of all socioeconomic problems along the coast, including the overexploitation of mangrove resources. The local dwellers, if provided with alternatives to fishing and harvesting mangroves, will tend not to overexploit the ecosystem. If these job opportunities are related to the mangrove ecosystem itself, they may not only prevent misuse but also guarantee continuous management of the mangroves by people who actually live beside them. Establishment of marine parks, ecotourism, mariculture facilities, and honey-bee farming are some of the alternatives that may be offered to the local people.

Mangrove areas in the delta which offer landforms unusually rich in wildlife could be treated as marine parks, completely protected from human interference. The objectives of such parks would be: 1) protection of the mangrove ecosystem along with its biodiversity, 2) research areas for scientists and 3) recreation and education for the public. The local people should be given priority for jobs in the parks since they live next to them.

However, caution is needed in introducing other economic uses of the mangroves, as their excessive and

indiscriminate use could overwhelm the ecosystem. The best policy is to use only the barren or less-populated areas for this purpose. In Pakistan, a certain proportion of barren areas 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.

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. 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 may underly the plight of deteriorating coastal ecosystems around the world. In the case of economically-important systems such as the mangroves of the Indus Delta, such ignorance is self defeating. Until recently these areas were 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 drastic cut in the Indus flow into the delta. Though educated people now seem to be better aware of the economic and ecological importance of mangroves, following a number of public fora and articles in the press, the villagers of the delta are not. Even today, they 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 fisheries.

ECONOMIC VALUATION OF MANGROVE ECOSYSTEM PRODUCTS

As we have seen, mangroves are a unique ecosystem which combine land, water, trees, animals and humans to provide multiple goods and services. They are also fragile ecosystems and the change of one part of the system may have profound effects on the rest. This interdependence of uses and production traditionally has been hard to communicate to policy makers, who see the mangroves as a low value resource to be exploited but not conserved. It is precisely because of this multiplicity of uses and interdependencies that a complete economic analysis is imperative in order to evaluate both the benefits and the costs of mangrove conservation.

Some of these goods and services are sold in markets where they have observable prices. Others are not marketed. They may be thought to have little or no value or their market value is difficult to quantify. The first category of goods and services often is referred to as pecuniary goods; that is, they can be exchanged and valued using existing market prices. The second category may be termed environmental materials or resources. These include such goods and services as the biological production of food that supports mangrove-dependent plant and animal species and the role of mangroves as nursery areas for finfish and shellfish. Although these goods and services are not priced, they still are valuable. The economic valuation of such goods and services presents many interesting challenges.

The environmental and resource economics literature illustrates a number of techniques that have been used to value such difficult-to-measure goods and services. For example, the value of mangroves in preventing storm damage can be calculated from an analysis of damage with and without the presence of mangroves. The value of damage prevented by retaining the mangrove barrier is an implicit valuation of one of the benefits of mangroves.

In this study, an attempt has been made to value some mangrove products used in the coastal villages along Korangi Creek, south-east of Karachi. We rely on secondary data available in the "Natural Resource Use Survey", Korangi / Phitti Creek, 1992, Volume I and II, by the Pakistan office of IUCN-The World Conservation Union. The time and resource constraints for this study do not allow a comprehensive natural resources survey of the mangroves of coastal areas of Pakistan. However, a rough estimation is done to put value to certain important goods available in the area.

The data available in the IUCN studies allow us to value two mangrove products, wood and fodder. The valuation uses the "market price" method and a simple exercise of multiplying the quantity consumed with the average market prices of the goods. Although some of these goods are traded in markets, these sales appear not to be recorded in the national income accounts.

The IUCN study interviewed users of mangrove wood and fodder to quantify the consumption level of these goods in the survey area. The respondents were from 100 households in four coastal villages in the Korangi Creek area. These four villages appear to include most of the population of the Indus Delta, according to the IUCN study, and therefore may represent the total use of the delta's mangroves. The table below provides estimated population and number of households in each village in 1992.

Village	Population 1992 (estimated)	Households 1992 (estimated)
Ibrahim Hydari	61,442	6,904
Chasma	7,303	769
Rehri	23,612	2,951
Lat Basti	2,898	326
TOTAL	95,255	10,950

Mangrove Wood as Fuel

Mangrove wood is the primary source of fuel in the four villages. While the data available from the survey are rough and contain some errors, they do provide useful information about the level of use of the wood and its economic value.

The study estimates total consumption of wood by the 10,950 households in the four villages at about 1,400,000 kg/month (p. 18). This is roughly consistent with its overall estimate of regional consumption per year at 18,000 tonnes (p. 12). These figures suggest that daily household use of mangrove wood is about 4.5 kg.¹ The study gives an average price of mangrove wood of 1.34 Rs. At this price, the total

¹ This figure is not consistent with the estimated daily household use of 7.7 kg/day given in Table 1.5 of the second volume of the study. Because the 7.7 kg/day figure cannot be reconciled with the other data and calculations in the

economic value of the fuelwood is about 22.5 million Rs per year.

If the value of marketed fuelwood is, in fact, not included in the national income accounts, this is the amount of economic activity which is omitted. If the value of marketed fuelwood is estimated in the accounts, then they only overlook the quantity collected directly by the households.

While the data are inexact, the survey does provide some information with which to estimate the amount collected by households. Among the 100 households surveyed, 76 purchase all of their wood, 20 collect all of their wood themselves, and 4 do some of each. If these figures are representative, then some 2,190 of the region's 10,950 households might be expected to collect all of their own wood. Those who collect wood appear to use it at a significantly higher rate than those who purchase it. The average collector for household use gathers 432 kg. per month, according to the survey. This means that 946,020 kg. are collected for individual use per month, or 11,352,240 kg. per year. Applying the market price to value the non-marketed wood, this comes to about 15.2 billion Rs per year which have been omitted from the income accounts.

Mangrove Leaves as Fodder

The leaves of the mangrove tree *Avicennia marina* are used for animal fodder by households in the Indus Delta. The residents of coastal areas purchase or collect mangrove leaves to feed domestic animals such as cattle, sheep and goats. The survey interviewed 92 households which kept domestic animals and used mangrove leaves as one source of fodder. On average, fodder consumption per animal unit was found to be 3.82 kg/day, of which 1.22 kg were mangrove leaves; thus mangroves represent some 32% of domestic animal feed.

The study indicates that total monthly consumption of fodder in delta comes to 535,650 kilos. Applying the ratio above of mangrove fodder to other sources of feed, this gives a monthly consumption of 171,000 kg of mangrove leaves, or 2,052,000 kg per year. The price of mangrove fodder averages Rs 1.25 per kilo, which allows us to estimate the annual value of the fodder provided by the mangroves at about Rs. 2,560,000. The data in the study do not let us estimate how much of this fodder is purchased rather than directly collected by the user. However, if in fact none of the marketed fodder is included in the national income accounts, then all of this should be added in to correctly reflect this service of the mangrove forests.

Mangrove Fishery Resources

Fishing is the primary economic activity and source of income for the coastal village communities. The fishing industry accounts for 0.8% of Pakistan's GDP, and is the country's sixth largest foreign exchange earner.

Data on the economic value of the mangrove-based fisheries in the Indus Delta area are not available. However, since employment and income in the region depends heavily on this resource, its contribution to the local economy is significant. Much of this contribution may already be included in the national income accounts; however it is important to be able to disaggregate it in order to identify the economic costs of any

report, we have used the 4.5 kg/day figure for our estimates.

degradation of the mangroves.

CONCLUSION

These indicative results from the valuation of a few services of the mangrove ecosystem suggest that this resource is of significant economic importance to the region and to the country as a whole. While our calculations are rough, they highlight the need for more research both on the physical productivity of the mangrove-dependent systems and on their contribution to the local economy. This must be complemented with further study of the impact of incremental changes in the ecosystems and their productivity due to decreased river flow, overuse, pollution, and other pressures. This information could lead to much better estimates of the values of the goods and services provided by the mangroves and their contribution to the regional and national economy.

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