

Mangrove Ecosystem Services: Indus Delta (PQA), Sindh

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Abstract

Mangroves of the Indus Delta are the world's fifth largest assemblage, and the largest in the arid zone. Mangroves of Indus delta (PQA) provide immense benefits, products and unrecognized regulatory services. Products of Direct Economic Value: Fish, Minerals and food. There are Products of Natural System (intangible) supplies of rich nutrients to support productivity. Coastal communities benefit in a multitude of ways from Mangrove ecosystems. Collectively, these benefits are known as ecosystem services. The ecological role of mangrove ecosystems in the Indus Deltaic area of Port Qasim Authority (PQA) is, economically and socially significant. The Mangroves are well known for their high biological productivity and their consequent importance provided to the coastal community in terms of services and products of direct and indirect value to the adjacent coastal waters. Mangrove Ecosystem services are regularly involved in the provisioning of food and services and the decomposition of organic wastes. They export organic matter, mainly in detritus form of leaf litter to the marine environment, thus providing a highly nutritious food source for themselves and for the Benthic and terrestrial animals found in the mangrove areas, as well as for those in neighboring estuarine and marine ecosystems. Apart from nutrient export, mangroves also contribute to offshore fisheries by acting as nurseries and shelters for many species of commercially important finfish and crustaceans. Degradation of Indus Deltaic mangrove in PQA would destabilize the economic potential and the livelihood of communities' which include services and benefits offered by the mangrove ecosystem. Rehabilitation and conservation of mangroves ecosystem in PQA is essential for sustained biological productivity in the region.

Keywords

Mangrove Ecosystem Services, Biological Productivity, Coastal Communities

1. Introduction

The present Indus Delta covers an area of about 263,000 hectares and is characterized by 16 major creeks and innumerable minor creeks, dominated by mud flats, and fringing mangroves. The coastal morphology is characterized by a network of tidal creeks and a number of small islands with sparse mangrove vegetation, mud banks, swamps, and lagoons formed because of changes in river courses. The Port Qasim Authority has administrative control over 64,000 ha of mangrove forests, mud flats and creeks, 4900 ha of land are above the high water mark

(+3.4 m.) [1]. The major land use of the area adjoining the site includes industrial zones and port areas. The numerous estuaries and creeks connecting to the sea which characterize the tidal delta and marshy mud flats, do not receive the same quantities of nutrients that they used to get in the past to support the growth of mangroves and aquatic life. PQA is part of the Indus Delta that currently supports one of the largest single mangrove ecosystems in the tropical coastal environments. In the Indus Delta mangrove ecosystem, eight species of mangroves have been reported. The *Avicenna marina* is the dominant species of the mangroves in the Indus Delta that grows on the northern and southern banks of the Phitti Creek. The Mangroves are highly nutritious food source for marine fauna. Mangroves provide a habitat and breeding ground for a variety of marine life, particularly fish, shrimps and crabs.

2. Study Area

The Karachi coastline between Korangi creek inlet and Kadiro Creek encompasses three islands; Bundal Island, Buddo Island and Khiprianwala Island and two large and deep openings towards the sea viz. Phitti Creek Mouth (Approach channel of Port Qasim) and the Kadiro Creek Mouth. The geographical location is given in **Figure 1**. The eastern coast has tidal creeks with mangrove and mudflats which are linked with a network of creeks of Indus Delta. The Port Qasim Authority consists of three major creeks systems, the Gharo Phitti Creek System: Gharo Creek, Kadiro Creek and Phitti Creek. All three are connected in a series starting from Gharo Creek at the north-eastern end to the Phitti Creek at the south-western end and located at 22.3 km from Karachi. This creek system is about 28 km long and its width ranges from 250 to 2500 m. The Korangi Creek and Kadiro Creeks are connected with it at the north-eastern end while it acts as main waterway connected with the open sea at the south-western end. The main channel of Port Bin Qasim lies in this creek system, which has been dredged to maintain a navigable depth of -11.3 meters.

The sampling location and coordinates in the PQA area for the observing the mangrove tree heights, densities and biodiversity sampling locations are given in **Table 1**.

3. Mangrove Ecosystem Services

Avicenna marina is the most dominant species. Other mangrove species in the deltaic region such as the *Cerriopstagal* occur in localized patches and there are a few plants of *Rhizophora mucronata*. All other species are rare and have disappeared from most part of the Delta due to adverse environmental conditions. The mangrove trees growing 200 - 300 m away from the creek (seawater) in the land ward direction show an overall decline in the height of the mangrove plantations. Destabilization of mangroves in the Indus Delta has been attributed to the progressive reduction in fresh water discharge over a period of many years. Historical records indicate that the distribution of mangroves in the Indus Delta has significantly changed during the past several hundred years

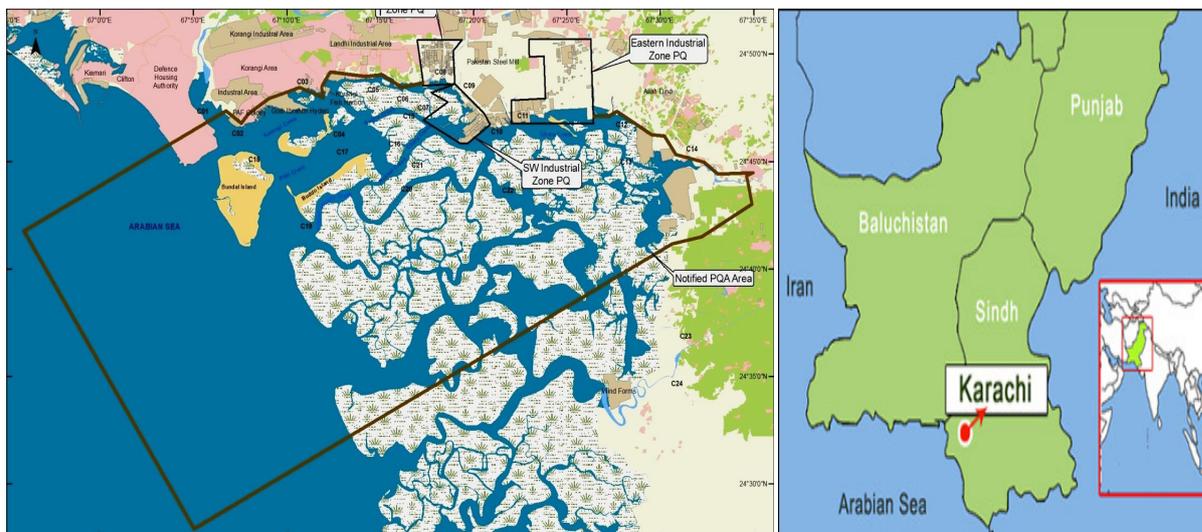


Figure 1. Geographical location and Study Area, Sought of Karachi Port Qasim Area, part of the Indus Delta, Sindh.

Table 1. Sampling stations and coordinates.

Station No	Latitude N	Longitude E
EC 1	24 48 37.8	67 14 57.2
EC 2	24 48 14.7	67 16 45.5
EC 3	24 46 12.6	67 25 19.4
EC 4	24 43 53.1	67 14 50.3
EC 5	24 43 45.9	67 21 13.2
EC 7	24 37 51.8	67 17 9.0
EC 11	24 46 23.9	67 12 50.7

with the shifting pattern of the river [2]. Until recently the Indus River had a largely river-dominated estuary but increased utilization of the river for agriculture etc. has resulted in discharge to the Arabian Sea only during the summer southwest monsoon. During remaining nine to ten months the Indus River has no estuary due to elimination of the river discharge [3]. As a result, the Indus delta mangrove ecosystem has been adversely affected. The mangroves are degrading rapidly caused by a number of factors such as cutting, browsing and by reduced silt laden river water. The mangrove forests which covered 263,000 ha in 1977 recessed to about 160,000 ha in 1990 [4], threatening the survival of the natural resources and thereby the livelihood of a large number of fisherman. The current mangrove cover in the Indus delta and the PQA shows an increase in mangrove forest by 3.17% from 94.18% (2005) to 97.35% in 2015 (2015 SPOTXS) (**Table 2**).

4. Nutrient Concentration

The standing stock of plant biomass represents the “natural capital” of the PQA ecosystem that is combined with nutrients, water, and abiotic components to maintain the existing biomass, and create new biomass essential for the well being of the Indus delta.

The nutrients including Phosphate, Nitrate, Nitrite and Ammonia play a vital role in the food chain of marine ecosystem in primary production of coastal and oceanic waters.

They support the growth of phytoplankton which serve as the food for zooplankton as well as larval stages and juveniles of fish and crustaceans, they also serve as food for filter feeders and benthic marine invertebrate (MBI). The Gharo/Phitti creek in PQA receive large quantities of nutrients as part of the sewage effluent and garbage that is disposed off in these creeks. Nutrients in the PQA do not appear to be limiting to primary productivity in the channels. If there is any limitation, it is due to water turbidity that restricted the photic zone. Higher concentrations of nutrients result in overproduction and subsequently leading towards exhaustion of dissolved oxygen in the seawater.

The Primary Productivity values from literature for the months of February, March, and June show relatively higher productivity rates for PQA area. The overall Productivity in the mangrove areas is reported to be high (365 - 780 gC/m²/year, [6], compared to coastal waters (50 - 200 gC/m²/year), which accounts for greater potential for fisheries yield in the PQA (64,000 ha) mangrove area (**Table 3**).

5. Mangroves Tree Heights and Densities

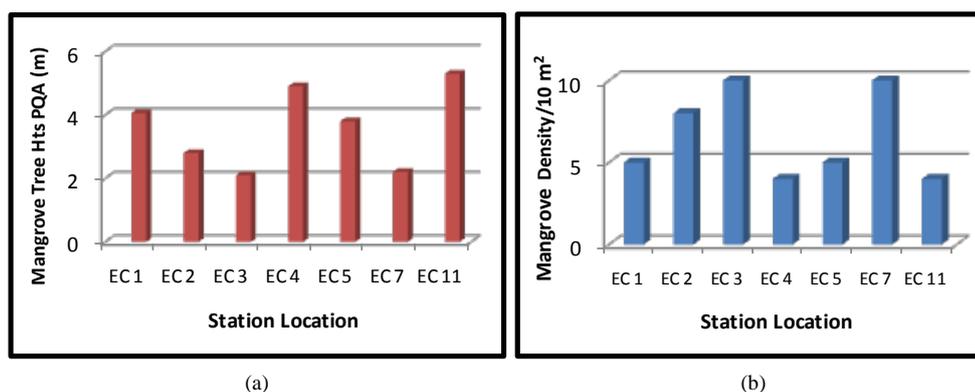
Despite their strategic importance, mangroves are among the most threatened and rapidly disappearing natural environments in the world. Mangroves are a valuable resource for many of the coastal villages. They are primarily used as a source of fuel and fodder and provide the feeding grounds for shrimp, besides protecting the land from erosion. The people have been overexploiting this resource over the years. IUCN has, in association with Sindh Forestry Department, initiated a program of mangrove conservation, replanting and sustainable management along the coastline of Rehri village, and CSR of PQA industrial area, for every mangrove tree felled, five mangrove sampling have to be planted (SEPA 2014) under the supervision of a third party (IUCN/WWF). Mean tree heights of *Avicenna marina* in PQA at seven randomly selected locations ranged from 2 - 6 m (**Figure 2(a)**). The mangroves density ranges 4 - 9/10 m² (**Figure 2(b)**). Data of mangrove tree height from seven locations

Table 2. The area summary of Mangrove forests along the coast of Pakistan based on SPOT XS data 2015 [5].

Region	Area in Hectares	Area in Acres	%
Karachi Harbour Area	985.5	2434.185	0.51585
Indus Deltaic Region & PQA	186000	459420	97.35984
MianiHor	3431.36	8475.459	1.796111
KalmatHor	194	497.18	0.101547
Jiwani	433	1069.51	0.2265
Total	191043.86	471896.334	100

Table 3. Primary productivity and Potential fish productivity in the PQA area.

Mean Primary Production	PQA Area m ²	Transfer efficiency (across two trophic levels)	Fish Production Biomass mtC/year
572.5 gC/m ² /year	6.4×10^8	$0.1 \times 0.1 = 0.01$	36,640 mtC/yr

**Figure 2.** (a) & (b) *Avicenna marina* tree heights and no of trees per 10 m² PQA.

was subject to ANOVA (**Table 4**). The results indicate significant difference ($p < 0.05$), between mangrove (*Avicenna marina*) tree heights.

The mangroves plants have a high biological productivity and are important to the nutrient budget of coastal waters. They export organic matter, mainly in detritus form (*i.e.* leaf litter) to the marine environment, thus providing a highly nutritious food source for marine fauna. Mangroves provide a habitat and breeding ground for a variety of marine life, particularly fish, shrimps and crabs. Since they act as nurseries and shelters for many species of commercially important finfish and crustaceans they are important for maintaining offshore fishery, as well as habitat for wildlife, such a loss would reduce available habitat for birds and juvenile fish, and the biodiversity of the local plants and benthic marine invertebrates.

6. Shannon Weiner Diversity Index

Shannon Weiner diversity index is a tool for measuring the health of the ecosystem. Benthic Marine Invertebrate sample at stations EC 4 (1.146) and EC 7 (1.0) show a relatively higher biodiversity of MBI in PQA (Diversity ranges from 0.1 - 3.0). The MBI species show a relatively even distribution at sampling stations EC 1 (0.841), EC 3 (0.898). The normal range for evenness (J') is from 0.1 to 1.0. PQA is a designated industrial area, creeks system are a disturbed due to industrial activity, and therefore both species diversity and species richness are relatively low (**Table 5**).

7. Employment and Living Conditions

PQA and its environs do not offer opportunities for employment and the population is primarily employed as

Table 4. Results of ANOVA on *Avicenna marina* (Mangrove heights) in PQA.

ANOVA				
<i>Avicenna marina</i> (Mangrove heights) in PQA				
	Sum of Squares	Mean Square	F	Sig.
Between Groups	48.407	8.068	8.566	0.000
Within Groups	26.372	0.942		
Total	74.779			

Table 5. Shannon Weiner Diversity Index in for marine benthic invertebrates PQA.

Index	EC 1	EC 2	EC 3	EC 4	EC 5	EC 7	EC 11
Shannon H' Log Base 10.	0.802	0.161	0.628	0.274	0.577	0.418	0.201
Shannon Hmax Log Base 10	0.954	0.778	0.699	1.146	0.903	1	0.699
Shannon J'	0.841	0.207	0.898	0.239	0.639	0.418	0.288

cheap unskilled labor force in the industrial areas of PQA. Agriculture is limited to subsistence farming due to scarcity of water. In Juma Goth and areas close to Cattle Colony there is extensive cultivation of vegetables using the effluent from the cattle yards. Livestock herding is not a healthy and reliable income generating option, and the few livestock holdings in the settlements are primarily for household and domestic use, a source of dairy consumables. Skilled labor is rare and the categories of skilled laborers are mostly drivers, welders, plumbers and electricians. Government service is rarely available.

The Settlements in the Korangi Creek area are fishermen, but the village dwellers are engaged in other low level occupations as well. The employment, and therefore the earnings for a large section of population in the area is variable, dependent on, fisheries, shrimp and crab fishing from inshore waters and collection of mangroves as fodder for domestic animal is the main source of income. However, a substantial segment of population is employed on deep-sea fishing boats.

8. Conclusion

The ecological role of mangrove ecosystems PQA is, economically and socially, highly significant. The Mangroves are well known for their high biological productivity and their consequent importance to the nutrient budget of adjacent coastal waters. They export organic matter, mainly in detritus form to the marine environment, thus providing a highly nutritious food source for themselves and for the Benthic and terrestrial animals found in the mangrove areas—as well as for those in neighboring estuarine and marine ecosystems. Thus, they support local and commercial fisheries yields. Apart from nutrient export, mangroves also contribute to offshore fisheries by acting as nurseries and shelters for many species of commercially important finfish and crustaceans. While a positive correlation between mangrove areas and fish productivity is acknowledged, the scientific information on this relationship is lacking.

Acknowledgements

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