Mangrove ecosystem and its impact on fisheries

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Introduction

Mangrove formation is a tropical phenomenon confined to tropical coastal areas, and sometimes extends to sub-tropical or slightly beyond. Areas where mangroves occur include estuaries and marine shorelines. In comparison with the tropical rainforest biome which contains thousands of tree species, mangrove forests are less in diversity. But the ecosystem these trees create provides a home for a great variety of other organisms. Mangrove forests form an interface between marine and terrestrial environment.

Mangroves fall into two groups according to their habitats in nature: true mangroves and mangrove associates. True mangroves refer to species that specifically grow in intertidal zones, while mangrove associates are capable of occurring in either littoral or terrestrial habitats. Mangrove formations depend on terrestrial and tidal waters for their nourishment and silt deposits from upland erosion as substrate for support. Mangrove is one of the most productive ecosystems and a natural renewable resource (Kathiresan, 2003). An inventory of the existing mangroves at the global scale indicates a total cover of about 18 million ha, inhabiting in 118 countries and territories in the tropical and subtropical regions (Spalding 1997). Mangroves of South and Southeast Asia are the most extensive and diverse systems comprising 42% of global mangroves. Indian mangroves make up 3.1% of the total global, 3rd largest in Asia (7%), after Indonesia (63%) and Bangladesh (8%). The Indian mangroves are distributed along the east (59.6%) and western (27%) coasts and the Andaman & Nicobar islands (13.3%), covering an area of about 4461 sq. km along the 7,500 km long Indian coastline.

Occurrence of Mangroves in Karnataka

Karnataka coastline extends over a length of 320.km with numerous river mouths, lagoons, bays, creeks, cliffs, sand dunes and long beaches. On account of the Western Ghats there are 14 rivers flowing from east to west. None of them takes its rise as much as 35 km beyond the peak of Western Ghats as these Ghats are not more than 80 km from the sea. The course of the rivers does not exceed 150 to 160 km. The rainfall of south west monsoon combined with the broken nature of the area is responsible for number of rivers and streams and also great volume of water in them during monsoon. Sometimes heavy rains cause flooding of rivers but they also deposit fertilizing silt. There are six estuaries with more than 70,000 ha water spread area and 8,000 ha of brackish water area.

Mangroves in Karnataka coast grow well on silty and clayey muds or mixtures of these soils. Often they form soft muddy substrates under the influence of tidal range where mud is deposited naturally. Under the canopy of mangrovephytes the substrate undergo physico-chemical alterations which determine the formation of zones within the habitat. The factors responsible for zonation are: frequency of flooding by tides, soil types based on structure, salinity, nutrient content, permeability and drainage, plant interaction, iron-influx-efflux regulatory mechanism and animal interaction. Along the Indian coast the estuarine area consists of Mangrove and their associates. There are 14 true Mangrove species of Karnataka belonging to 7 families (Table1).

The important estuarine areas where mangroves are present in Dakshina Kannada are Netravathi-Gurupur, Mulki-Pavanje, Udayavara-Pangala, Swarna-Sita-Kodi, Chakra-Haladi-Kollur, Baindur hole and

Shiroor hole while in Uttarakannda the mangroves are present in the Venkatapur, Sharavathi, Aghanashini, Gangavali and Kali river estuarine complexes. The coverage of mangrove area in Karnataka is reported as 6000 ha (GOI 1997).

Table 1 Mangrove species available in Karnataka

Sl. No.	Family	Species
1	Acanthaceae	*Acanthus ilicifolius*
2	Avicenniaceae	*Avicennia marina Avicennia officinalis*
3	Combretaceae	*Lumnitzera racemosa*
4	Euphorbiaceae	*Excoecaria agallocha*
5	Myrsinaceae	*Aegiceras corniculatum*
6	Rhizophoraceae	*Bruguiera cylindrica* *Bruguiera gymnorrhiza* *Kandelia candel* *Rhizophora apiculata* *Rhizophora mucronata* *Ceriops decandra*
7	Sonneratiaceae	*Sonneratia alba* *Sonneratia caseolaris*

Adaptation of Mangrove plants

Mangrove plants require a number of physiological adaptations to overcome the problems of anoxia, high salinity and frequent tidal inundation. Each species has its own solutions to these problems. Small environmental variations within a mangrove ecosystem may lead to greatly differing methods for coping with the environment. Adaptations concerning above-ground breathing roots are essential for gas exchange in saturated, non-porous soils depleted in oxygen. Roots are also adapted to support above ground mass by growing lateral support structure. Some of the modifications of mangrove plants are as follows

1. Stilt roots: It is an intricate network of branching areal roots up to 3 m above the ground. Their formation is mostly confined to *Rhizophora* species. The main purpose of these roots is to support the tree from severe strain by tides and wind.
2. Aerial roots: The flexible slender roots of uniform thickness descending from the lower branches of the crown of *Rhizophora* sp., they do not take root. These are also observed in *Avicennia* group.

Fig. 1 Root adaptation in *Rhizophora mucronata*

3. Plankbuttress: Columnar trunk of certain mangroves like *Bruguiera* and *Ceriops* have flanged or buttressed with short plate like protuberances, at the basal portion. This increases the surface area at the base of the trunk for increased aeration and also for the support of the trunk.

4. Surface roots: Exposure of roots on the muddy surface is not common among the certain mangrove taxa. In *Ceriops tagal* the plank buttresses, however extend into roots which are vertically flattened irregularly. Their exposure on high ground enables them to absorb sufficient oxygen.
5. Pneumatophores: The vertical outgrowth protruding above the surface from the horizontal cable root system just below the level of the mud. The different types are pencil like, geniculate or knee like, knobby or tuberous.
6. Vivipary–production of live young: This assist is rapid attachment to the muddy substratum.
7. Succulence: This is another common feature which is in response to the presence of chloride.

Importance of mangroves

Mangroves are highly productive components of the food web of coastal ecosystem. Detritus of plant material serves as the basis of food web and contributes to the good quality of mangrove habitat. Many commercial finfish and shell fish species depend on mangrove habitat for part of their life cycle. An analysis of the impact of mangrove plants on marine carbon inventories suggests that the mangroves account for more than 10% of the terrestrially derived dissolved organic carbon transported to the ocean, while they cover only 0.1% of the continents' surface.

The unique ecosystem found in the intricate mesh of mangrove roots offers a region for young organisms. In areas where roots are permanently submerged, the organisms they host include algae, barnacles, oysters, sponges and bryozoans, which all require a hard surface for anchoring while they filter feed. Shrimps and mud lobsters use the muddy bottoms as their home. Mangrove crabs mulch the mangrove leaves, adding nutrients to the soil for other bottom feeders. In at least some cases, export of carbon fixed in mangroves is important in coastal food web.

The dense network of mangroves protects adjacent high lands from erosion and damage. However, mangrove swamps' protective value is sometimes overstated. Wave energy is typically low in areas where mangroves grow, so their effect on erosion can only be measured over long periods (Massel *et al.* 1999). Their capacity to limit high-energy wave erosion is limited to events such as storm surges and tsunamis (Mazda *et al.* 2005). Erosion often occurs on the outer sides of bends in river channels that wind through mangroves, while new stands of mangroves are appearing on the inner sides where sediment is accruing.

The vegetation acts as filter trapping sediments and litter which enter with the run-off from the upland areas (Fig 2). The trapping of sediments helps maintain water clarity, a factor important to clam, oyster and phytoplankton productivity. The mangroves assimilate pollutants and recycle nutrients through various biochemical processes. Sediment meiofauna feed directly on mangrove detritus. The composition of the meiofaunal community changes during the process of litter decay, suggesting that the community is responding to chemical changes in the leaves (Gee and Somerfield, 1997). A number of factors can affect the rate of litter decomposition and rates of nutrient cycling. Litter decomposition rates vary among mangrove species. *Avicennia* leaves are thinner and have fewer types of tannin hence decompose faster than those of other species (Sivakumar and Kathiresan, 1990). *Avicennia* leaves also sink and begin to decompose immediately whereas the leaves of other species (*Sonneratia* and *Rhizophora*) may float for several days (Wafar et al., 1997). Many birds also utilize mangrove habitat for their feeding and breeding. Mangrove habitats have also become important for the purpose of aquaculture.

Impact of destruction of Mangrove habitat

Mangrove habitats of India have been facing tremendous threats due to indiscriminate exploitation of mangrove resources for multiple uses like fodder, fuel wood, timber for building material, alcohol, paper, charcoal and medicine (Upadhyay *et a*l. 2002). It is estimated that about 75% of mangroves in Karnataka state is lost due to expansion of cultivation, deforestation and encroachment activities. The development of ports, sand mining, sewage discharge, construction of bridges, expansion of roads (Fig. 3&4), disposal of non-biodegradable waste all this has taken a heavy toll on our coastal ecosystem and biodiversity. As more mangroves are destroyed the litter transported to the seaward side will increase. The total suspended solids in the estuarine area especially during monsoon will be higher.

Fig 2. A - Trapping of litter, B - Gastropods and oysters, C - benthic organisms, D - Avian diversity

Fig. 3. Destruction of mangroves in Mulki for cultivation purpose

Lime shells are being removed from mangrove habitat, thereby the bottom becomes deep and the receding tides move faster causing the bank erosion. The soil in mangrove region consists of those washed down from the Ghats as well as by the tidal accumulation from the sea. In texture the soil varies from drift sand to loam and stiff clays. The areas occupied by *Acrostichum aureum* an apparently salt tolerant fresh water fern is an indication of degradation of mangrove ecosystem. The inorganic constituents of Mangrove soils from different estuaries show considerable variability. This is due to topographic erosion and also human activity.

Once established, mangrove roots provide an oyster habitat and slow water flow, thereby enhancing sediment deposition in areas where it is already occurring. The fine, anoxic sediments under mangroves act as sinks for a variety of heavy (trace) metals which colloidal particles in the sediments scavenged from the water. Mangrove removal disturbs these underlying sediments, often creating problems of trace metal contamination of seawater and biota.

Fig 4. Development activities on Western Ghats which could influence erosion rate

Regeneration programme

Regeneration of mangroves has become increasingly important in recent years due to varied development activities. Below are some of the factors which need to be considered for successful regeneration.

1. In *Rhizophora* species November and December are the starting point for flower buds production; propagules start emerging from January and attain maturity in May/June.
2. *Bruguiera* species starts flowering in the months of October and November and the propagules are ready for propogation in the month of April/May. *Ceriops* and *Kandelia* start flowering after the fall of monsoon rains and the propagules mature in the months of April/May.
3. Spacing for various species ranges from 50 cm to 150 cm. *Rhizophora mucronata* is planted at 1.5m x 1.5m.
4. The oviparous fruits of *Sonneratia* reproduce by seeds. At maturity the fruits drop down and the seeds are released by disintegration of fruit wall.
5. Sediment texture, water quality, tidal variation and suitability of the mangrove species to the area selected for planting are to be considered.
6. Initial stages the plant requires fresh water and suitable temperature hence the ideal sowing season will be just before monsoon.

Conclusion

For successful regeneration an understanding of the mangrove soils is essential. The reasons for destruction of natural ecosystem diversity in the areas have to be ascertained. Proper spacing and diversity of mangroves have to be taken into consideration when any regeneration programme is conducted. Curbing deforestation may be more effective than reforestation. In the last decade, a study in Thailand found that the cost of restoring mangroves was US $946 per hectare, while the cost for protecting existing mangroves was only US $189 per hectare (Ramsar Secretariat, 2001). In India, the estimated values for different functions of Bhitarkanika mangrove (Orissa), such as nutrient retention was US$ 865 /ha/year, offshore fishery US$ 37.97/hr, inshore fishery US$ 1.9/hr, fry collection US$ 0.2/ h; and storm abatement US$ 116.28/household (Iftekhar, 2008).

Mangrove forests are increasingly recognized as a valuable source of revenue therefore it should be easier to entice those who benefit from mangroves to make payments for the ecosystem services that they generate (Lavieren *et al*., 2012). As mangrove forests store significant amounts of carbon and are threatened by the economic allure of conversion, they could be ideal targets for carbon financing. Such initiatives and investment funds provide new opportunities to better protect natural capital, benefit communities, and utilize cost-effective green technologies to address the challenges of climate change.

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