18. Mangrove ecosystem- importance, identification and threats in Karnataka

Dr. Bindu Sulochanan

Marine Biodiversity and Environment Management Division

ICAR-Central Marine Fisheries Research Institute, Mangalore Regional Centre

Introduction

Coastal habitat like mangroves, seagrass, coral reefs, and estuaries are intricately linked to fisheries, and their conservation is essential for maintaining the health of our oceans and the livelihoods of communities that depend on them. They support small-scale, commercial and recreational fisheries in India and are a vital source of income for millions of people. They provide humans with multiple benefits, a stable climate, air, water, food and materials in addition to protection from disaster and disease. Mangrove species contain a wide variety of chemical compounds that could be used as drugs for many epidemic diseases (Behbahani et al., 2018).

Like other coastal ecosystems, naturally dynamic conditions resulting from weather patterns drive riverine, estuarine, and coastal hydrogeomorphology and ultimately the spatial pattern of marine macrophytes mangroves (Lugo and Snedaker, 1974) seagrasses and seaweeds. The coastal vegetation, which grows under different conditions are varied consisting mainly of marine algae or seaweeds, seagrasses, mangroves and sand dune vegetation, which grows on a sandy zone beyond the highest high tide level. Loss of any of these habitats can destabilize bottom sediments formerly protected from water, wind and tidal erosion by the sheltering and binding abilities of macrophyte colonies. Such changes also exert pressures on fish congregation and benthic invertebrates (Fig. 1).

Fig. 1 Benthic fauna-bivalves and polychaetes observed in mangrove ecosystem

Mangroves are salt-tolerant and distributed along coastlines, lagoons, estuaries, rivers or deltas in over 120 tropical and subtropical nations and forms less than 1 percent of all tropical forest. In 2020 it was estimated that mangroves areal extent is 14.8 million ha (FAO, 2023). Mangrove coverage in the nations Indonesia, Brazil, Nigeria, Mexico and Australia accounts for 47 percent in the world (FAO, 2020). Mangroves provide nursery grounds for numerous fish species, protect shorelines from erosion, and support biodiversity. There are many birds which breed, feed and take shelter along the mangrove ecosystem (Fig.2). Marine-estuarine

species- adults spawn offshore, produce eggs which disperse in water columns for varying lengths of time. The eggs then develop planktonic larvae, which move or are carried by current into an inshore estuarine region where mangroves protect and are also the feeding ground. The length of time spent varies between species, region and also depends on environmental factors. The sub adults or adults migrate varying distances out of the estuary e.g *Penaeus merguiensis, sea mullet (Mugil cephalus)* Whiting *(sillago sp) and* flathead *(Platycephalus spp).*

Nitrogen, phosphorus, potassium, magnesium, oxygen, hydrogen, carbon, sulfur, and iron supply relative to the catchment area influences the growth of these macrophytes. Heavily populated coastlines in the region also make these macrophytes vulnerable to anthropogenic disturbances such as those to the landscape (channelization, impoundment), those on soil or water properties (eutrophication, pollution), or those on species (vegetation planting/removal, burning, introduction of invasive species). Indian mangroves cover an area of approximately 4,975km^2 which is approximately 3% of the mangrove vegetation in South Asia (ISFR,2019). Approximately 57% of these areas are located along the east coast of the Indian mainland, 23% along the west coast, and 20% in the Andaman and Nicobar Islands (Venkataraman and Wafar, 2005). It is estimated that mangroves store 12 billion metric tons of carbon dioxide worldwide and when these systems are damaged, they emit their stored carbon back into the atmosphere, where it contributes to climate change (Cawood 2023). In India the ecosystem services of mangroves are region specific due to their diverse nature, which includes tourism, water filtration; it is estimated that 2 to 5 hectares of mangroves may treat effluents of 1 ha of aquaculture, supports more than 3000 species of fishes, regulates climate; as carbon storage potential is 3-5 times higher than that of the tropical forest, supports livelihood of 120 million people directly or indirectly, is a source of fuel and timber and offers coastal protection.

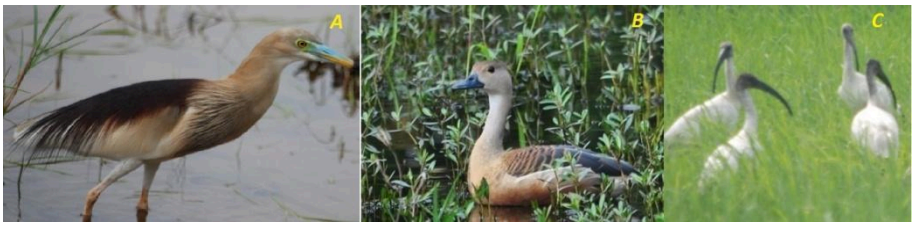

Fig. 2 A) Indian Pond-Heron *Ardeola grayii* (Breeding plumage), B) Ruddy Shelduck *Tadorna ferruginea* and C) *Oriental white ibis* (*Threskiornis melanocephalus*).

Mangrove diversity in Karnataka

The mangroves diversity varies according to the ecosystem depending largely on the climate, salinity, topography, also the structure and composition of soil of the area. In very high saline areas patches of dwarf and tree having irregular and distorted growth patterns can be observed while favourable conditions for certain species forests with canopies exceeding 40 m in height (FAO, 2007) can be observed as in the Sundarbans. The perennial rivers Ganges, the Meghna and the Brahmaputra of India and Bangladesh, bring with it rich nutrients and forms the Sundarbans delta. In arid zones, the diversity is often limited and irregular canopy can be observed as in Karnataka where nutrient flow occurs mainly during monsoon. These

mangroves still play a major role in the ecosystem as well as for the economy of the local people.

Rao and Suresh (2001) and Chandran et al. (2012) have reported the occurrence and distribution of eumangrove species such as *Rhizophora mucronata* (Fig.3a&b), *R. apiculata*, *Acanthus ilicifolius*, *Avicennia alba*, *A. marina*, *A. officinalis*, *Bruguiera cylindrica*, *B. gymnorhiza*, *Lumnitzera racemosa*, *Excoecaria agallocha*, *Kandelia candel*, *Sonneratia alba*, *S.caseolaris*, *Aegiceras corniculatum* and *Ceriops decandra* along the estuaries of Karnataka.

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.Litter decomposition rates vary among mangrove species. *Avicennia* leaves are thinner and have fewer tannins hence decompose faster than those of other species. *Avicennia* leaves also sink and begin to decompose immediately whereas the leaves of other species (*Sonneratia* and *Rhizophora)* may float for several days.

Fig. 3a *Acanthus ilicifolius* (A) *B.gymnorrhzia* (B) *Sonneratia alba* (C) *S. caseolaris* (D)

Fig. 3b *Rhizophora apiculata* (A) *Avicennia officinalis*(B) *Avicennia marina*(C)

Mangrove morphological adaptations

Though mangrove species diversity is less compared to that of rainforest, their ability to adapt to adverse conditions in the intertidal zone is what makes them unique. Morphological adaptations of mangroves to survive the tidal variations include aerial roots, salt excretion glands and vivipary of seeds. The aerial roots assist in respiration and anchorage especially in waterlogged soils and enhance the plants ability to adapt to salinity changes in the ecosystem (excess salt is excluded by the roots and leaves); propagules are also adapted to tidal dispersal by seed vivipary and excellent methods of nutrient retention.

Functional attributes

1. Breathing roots aid to survive in anaerobic conditions
2. Viviparous propagules are buoyant
3. Salt glands to remove excess salt
4. Supporting roots vary in structure to adapt to the changing salinity regime
   High intracellular salt concentration

Types of roots

Around the mangrove tree trunk there is a barrier of roots which support the diverse fauna of the ecosystem. Some mangrove species have pencil-like peg or cylindrical roots of varied lengths that grow above the ground and Rhizophora species have roots which resemble legs and are sometimes referred to locally as walking trees (Fig.4). Some common names of mangrove trees are given in Table1. The dense network of mangroves protects adjacent highlands from erosion and damage. Their capacity to limit high-energy wave erosion is limited to events such as storm surges and tsunamis. 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. Field guide to identify different mangrove species is given in Table 2.

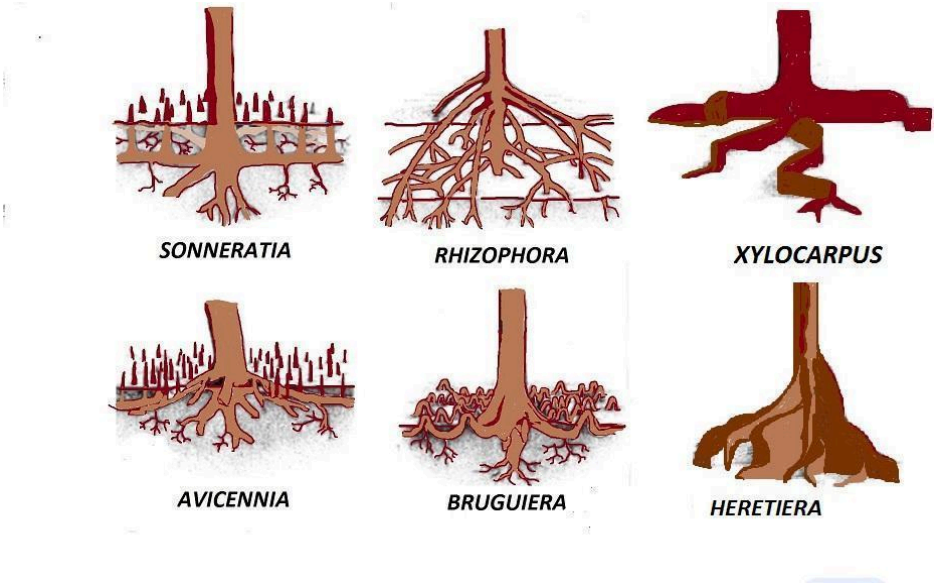

Fig. 4 Root pattern difference in mangroves

Table 1. Common names of some mangrove species observed in Karnataka

Mangrove	Common name
Acanthus ilicifolius	Sea holly
Lumnitzera racemosa	White flower back mangrove
Excoecaria agallocha	Blind your eyes, milky mangrove
Aegiceras corniculatum	River mangrove
Bruguiera cylindrica	Black mangrove
Bruguiera gymnorrhiza	Large leafed orange mangrove/oriental mangrove
Ceriops decandra	Chiru kandal
Kandelia candel	Kandla
Rhizophora apiculata	Red mangrove
Rhizophora mucronata	Looproot mangrove
Sonneratia alba	Mangrove apple
Avicennia alba	Api Api Putih
Avicennia marina	Indian white mangroves
Avicennia officinalis	Indian mangrove

Table 2. Field guide to identify different species of mangroves

Sl No:	Family	Species	Key features
1	**Acanthaceae**	*Acanthus ilicifolius* L.	Pneumatophores rarely present, A woody shrub, with somewhat green succulent branches, Holly-leaves perennial spike with white to mauve flowers. Pair of stipular spines at the base of leaves and also a pair of bracteoles beneath each flower

2	**Combretaceae**	*Lumnitzera racemosa* Wild.	Pneumatophores absent, Leaves clustered at the end of branches, alternate leaves have notched apex bearing a small gland/Hydathode, white flowers in short axillary racemes , Multi-stemmed to columnar trunk
3	**Euphorbiaceae**	*Excoecaria agallocha* L**.**	Exudes milky latex, abaxial surface of leaves with greyish scales. Bark with longitudinal roes of lenticels, Knobby serpentine root system, with white lenticels on the knobs acting like pneumatophores
4	**Myrsinaceae**	*Aegiceras corniculatum*	Pneumatophores absent, Multi-stemmed or columnar trunk, Flowers stalkes, several in number, fruits cylindrical, curved and acute 3 cm long and 0.5 cm dia
5	**Rhizophoraceae**	*Bruguiera cylindrica* (Roxb.)Wight.	Geniculate pneumatophores, cable roots, Flowers not solitary in axis Peduncles 3 flowered
6	**Rhizophoraceae**	*Bruguiera gymnorhiza* Merr.	Geniculate pneumatophores, cable roots, Flowers solitary in axil, Petals with 3-4 hairs at the top, viviparous fruit, 10-25cm long, leaf scars 3, distinct, usually horse-shoe shaped vascular bundles
7	**Rhizophoraceae**	*Ceriops decandra* (Griff.)Ding Hou.	Pneumatophores curiously shaped, feeding roots, cable roots and anchoring roots present, stem flanged or buttressed with short plate like protruberances. Petals divided into fringe like lobes. Fruits with spreading calyx lobes. Hypotocyl club shaped, angular to 30 cm long.
8	**Rhizophoraceae**	*Kandelia candel* (L.) Druce.	Pneumatophores absent, tree bushy form with aeriel roots in close assembly from stem and branches, white flowers in axillary pendunculate, dichotomously branched cymes. Fruit 1 celled, 1 seeded grit with the persistent reflexed calyx lobes. Propagule viviparous, bark reddish brown
9	**Rhizophoraceae**	*Rhizophora apiculata* BL.	Pneumatophores absent, multiple leaf scar, Branching stilt roots, cyme with 2 sessile, flowers on thick peduncles

			under leaf or the leaf with or without black dot, Fruits like an inverted pear, hypocotyl curved at the apex
10	**Rhizophoraceae**	*Rhizophora mucronata* Poir.	Pneumatophores absent, multiple leaf scar, leaves ending with apiculum. Branching stilt roots, Flowers in recurved stalk, style is absent or very short
11	**Sonneratiaceae**	*Sonneratia alba* J. Smith	Pneumatophores present, feeding roots, cable roots and anchoring roots present, stipules absent in leaf, branches swollen at nodes, readily breaking. Flowers large 6-8 oblong sepal lobes. Stamens numerous, long
12	**Sonneratiaceae**	*Sonneratia caseolaris* (L.) Engl.	Pneumatophores present, feeding roots, cable roots and anchoring roots present, leaves have at the tip hydathodes, Flakeybark, brownish in colour
13	**Verbenaceae**	*Avicennia alba* Bl.	Pneumatophores 15-20 cm long, tree height 10m-15m, bark grey, leaf dark green or black shining above, flower 3-6 mm, yellow, fragrant, arranged in axillary or terminal spikes, peduncle 2.5-3.5cm long branched. Fruits compressed capsule ovoid or ellipsoid slightly curved at the apex. Seed solitary.
14	**Verbenaceae**	*Avicennia marina* (Forsk.) Vierh.	Pencil like pneumatophores feeding roots, cable roots and anchoring roots present, Gnarled spreading tree, leaves grey dense hairy on abaxial surface. Fruit velvety like, an unopened almond in shape, not acuminate or beaked at the tip.
15	**Verbenaceae**	*Avicennia officinalis* L.	Pneumatophores plenty tree height 8m. salt excreting glands on leaf. Flower 1cm long, fruit green almond shaped

Mangrove species and salinity tolerance

India has a diverse range of mangrove species, and their salinity tolerance varies. Table 3 gives the salinity tolerance of some species of mangroves found in the west and east coast of India. Different populations of the same species may exhibit varying levels of salinity

tolerance as environmental conditions of temperature, humidity, and tidal influences can affect a species' salinity tolerance.

Table 3 Salinity tolerance of mangrove species

Species	Salinity tolerance
Avicennia officinalis	Highly tolerant of high salinity up to 45 ppt
Rhizophora mucronata	Moderately tolerant of high salinity up to 35 ppt
Bruguiera gymnorrhiza	Tolerant of moderate salinity (up to 25 ppt)
Ceriops tagal	Tolerant of low to moderate salinity up to 25 ppt
Sonneratia apetala	Tolerant of low salinity (up to 15 ppt)
Aegiceras corniculatum	Highly tolerant of high salinity (up to 40 ppt)
Excoecaria agallocha	Moderately tolerant of high salinity (up to 30 ppt)

Threats for mangrove ecosystem

Along Karnataka Coast it was observed that mangroves prefer silty and clayey soils or mixtures of these soils. Monsoon brings with it large amount of clay, silt and sand from upstream catchment areas especially due to the present rapid land use changes. There are 22 Urban agglomerations and 1044 villages along Karnataka coastline of 320 km. Increasing sea level has resulted in decreasing beach width and inundation and erosion of river banks. Climate change impacts, receding shoreline and rapid change in land use plan, dumping of solid and liquid waste (Fig. 5) are some of the factors influencing the water and soil quality and there by impacting the diversity of mangroves in the estuaries of Karnataka.

Fig. 5 Threats to the ecosystem observed in Karnataka A Cutting of mangroves B Dumping solid waste C Sand mining

Sand mining and upstream land use changes have significantly altered the flow of sediment into the estuaries. Hence, when the tide dominates, during reduced runoff the sand gets deposited naturally inside the estuarine area form the seaside thereby narrowing the bar mouth opening. During monsoon when water flows from the rivers this results in transportation of sediment towards the sea and adjacent beaches. The mixing of waters creates a diverse environment, supporting a wide range of marine life and hence the tidal cycles and currents play a major role in the sustenance of mangroves and its associated fauna and flora.

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Suggested Reading

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