MARINE BIODIVERSITY CONSERVATION AND MANAGEMENT

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II. THE MANGROVES - IMPORTANCE, CONSERVATION AND MANAGEMENT

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The role of mangroves in nature and their ecological significance have been realised of late and the Government, scientific Institutions and Universities are paying increasing attention to the biology, conservation and management of mangrove areas.

INTRODUCTION

Mangroves are termed as 'Tropical tidal wet lands' with typical vegetations distributed along the border of the sea and lagoons reaching up to the edges of the rivers to the point where the water is saline and growing in swampy soils covered by the saline water during high tides. The mangroves dominate almost one-quarter of world's tropical coastline. When conditions are favourable, they may form extensive and productive forests protecting the coastline. Mangrove ecosystem serves as the reservoir of species of plants and animals associated together.

The mangrove swamps and forests are more diverse and luxurient in the Indo-Pacific region. The mangroves of India have received inadequate and insufficient attention in the past. Most of the mangroves are on the verge of disappearance due to overexploitation. No sustainable effort has been made to study them in a comprehensive manner. In the early sixties, the mangrove area of India was estimated as to extend about 6,81, 976 ha including the adjacent mud-flats and brackishwater system (Sidhu, 1963). Later, during eighties, the mangrove area of India has been estimated as 3,56, 500 ha (Saenger *et al.* 1983) and in nineties 4,37, 900 ha (Anon, 1992) which includes the mangroves of Andaman and Nicobar islands also.

There has been increasing awareness among the scientific community that the mangrove biotope is an important component of the

tropical ecosystem. The role of mangroves in nature and their ecological significance have been realised of late and the Government, scientific Institutions and Universities are paying increasing attention to the biology, conservation and management of mangrove areas. Apart from the economic uses of its resources, the mangroves are potential grounds for coastal aquaculture. It is generally recognised that mangrove areas form the breeding and nursery grounds for the larvae and juveniles of many commercially important species of prawns and fishes. The high productivity resulting from mangrove litterfall supports a host of detritus feeding animals such as amphipods, mysids, harpacticoids, molluscs, crabs and larvae of prawns and fishes. The mangrove vegetation and associated creeks and channels provide habitats to these organisms especially in their critical stages of life-history. The role of the mangrove forests in stabilizing the shoreline or coastal bed is well known. The important role played by the mangrove forest and swamps in the production of detritus, dissolved organic matter and recycling of nutrients is being increasingly realised.

As an example, the contribution made by the Pichavaram mangrove ecosystem in Tamil Nadu to the adjoining Bay of Bengal may be cited. This ecosystem exports an equivalent of 3,786 tonnes/yr as litter out of its estimated litter production of 6,310 tonnes/yr. Within the ecosystem the leaf litter alone amounts to about 750 tonnes/ha/yr (Muniyandi, 1985). Further, it is known that the sediment microbial population is about 7 fold greater than that of the littoral zone in the adjoining Bay of Bengal. The suspended particulate matter in the waters of Pichavaram is higher by more than 20 times than of seawater. Further, the silicate concentration is 10 times more, the nitrate 4 times greater and inorganic phosphate 20 times greater than the adjacent seawater. Likewise, photosynthetic pigments and primary production rates are also very high when compared to the seawater.

DISTRIBUTION OF INDIAN MANGROVES

The world's total mangrove area which spans over 30 countries including those for the various island nations is about 1,00,000 sq. km (Deshmukh and Balaji, 1994). The total area of the Indian mangroves

is estimated at 6,81,976 hectares of which nearly 45% occurs in Sunderbans and the islands in the Bay of Bengal (Blasco, 1975, 1977). Other important mangroves are Killai and Pichavaram in Tamil Nadu, that of Kerala, Karnataka, Gulf of Kutch and Andaman & Nicobar Islands. The Andaman-Nicobar Islands contain some of the least disturbed and best preserved mangroves. According to Quereshi (1957), the Andaman-Nicobar Islands have about 1,190 sq. km area of mangroves. Here, the forests are gregarious type, dominated by single species. The Sunderbans formed in the vast delta complex of the Ganga and Brahmaputra river systems are usually described as the largest single natural mangrove block having an area of 4,170 sq. km in W. Bengal (Anon, 1987).

It is noteworthy that today, in Kerala, there is no dense mangrove forest in spite of its generally very heavy rainfall as compared to the other States of the west coast of India. It is contrary to the general rule that the maximum development of mangroves is in the regions with heavy rainfall. Tidal currents and freshwater supply influence the physico-chemical factors in the mangrove estuarine systems to govern the distribution and zonation of the mangrove species, of which temperature and salinity of the ecosystem appear to be important factors.

Regional distribution of mangroves in India

State	*Locality*	*Area in ha*
W. Bengal	Delta system of Ganges	4,18,888
Orissa	Mouth of Mahanadi	12,000
Andhra Pradesh	a) Mouth of Godavari	13,304
	b) Mouth of Krishna	5,120
Tamil Nadu	Cauvery delta	2,640
Maharashtra	Bombay region	62,208
Gujarat	Saurashtra and Kutch	52,616
Andaman-Nicobar Islands	Bay of Bengal	1,15,200
	Total	**6,81,976**

(After Sidhu, 1963)

VEGETATION

On the basis of the height of the vegetation, 3 categories of forest stratification can be observed in a normal mangrove ecosystem. The widest trunk with spreading crown is found in species of *Sonneratia* and *Avicennia* and less spreading crown found in the species of *Bruguiera* and *Rhizophora* which constitute the top canopy of the forest. The second category is contributed by shrubs and small trees represented by the species of *Aegeceros, Excoeccaria* and *Ceriops.* The third one is occupied by small shrubs and ferns such as species of *Acanthus, Aegiolitis* and *Acrostichum.*

Globally, mangrove ecosystems are thought to contain about sixty species of true mangrove trees and shrubs and more than twenty additional species frequently associated with the mangrove flora. They exhibit a remarkable capacity for salt tolerance and hence they are physiological halophytes. The leaves possess halophilous properties with thick cuticle, large mucilage cells etc. The formation of butress and stilt roots and vertical pneumatophores are characteristic adaptations. The composition of the mangrove species changes with depth, salinity, wave action, inter-tidal exposure etc.

Diversity in the structural formation and zonation of mangrove forests can be witnessed along the latitudinal gradients and probably also along the longitudinal gradients that reflect climatic, especially rainfall gradients. Across the latitudinal gradients, air temperature and across the longitudinal gradients, water and soil fertility appear to be the most important factors in determining the growth patterns of the mangrove populations.

BENTHIC FLORA AND FAUNA

Mangrove systems are among the most productive natural ecosystems on earth. The sources of primary productivity are the mangrove vegetation themselves, algal colonies associated with the mangrove root surfaces and the moist forest floor and the phytoplankton communities in the associated bay and lagoons. Algae observed in the inter-tidal regions of mangroves are very rich and diverse in both

quality and quantity. The benthic algae of the mud surface are represented by the green filamentous species of *Enteromorpha, Rhizoclonium, Monostroma* and *Ulva.*

The mangrove environment provides living space for a dependent biota of more than two thousand species of flora and fauna of resident, semiresident or migratory mode of life. The mangrove associated fauna, being a composite of terrestrial, estuarine and marine organisms, constituting representatives of almost all invertebrate Phyla and fishes have to face numerous interactions between animals of terrestrial and aquatic biotopes. As such, the mangrove fauna with its lower species diversity but with relatively large number of individuals is highly characteristic in nature.

The primary food source for aquatic organisms in most mangrove dominated estuaries occurs in the form of particulate organic matter (detritus) derived chiefly from the decomposition of mangrove litterfall. The annual litterfall normally ranges from 10,000 to 14,000 kg dry weight per hectare. An additional source of nutrition is provided by dissolved organic compounds of mangrove origin. The predators feed on the detritus feeders and form important food source for both aquatic as well as terrestrial wild life in addition to forming food resource for human beings.

FAUNAL ASSEMBLAGE

In general, the fauna of mangroves constitute insects, crustaceans, molluscs, fishes, snakes, crocodiles, birds, monkeys and some other mammals. Very few studies are made with respect to plant-animal interactions. It is estimated that insects consume about 20-25% of available leaf tissues (Deshmukh and Balaji, 1994). The mangrove waters are rich in detritus providing a highly potential area for fishing. The major fishery sources in these waters are detritivorous species of fishes, crustaceans and molluscs. Krishnamurty (1983) has estimated the yield of mangrove-cum-estuarine dependent fisheries of India to the tune of 30,000 tonnes of crustaceans per annum. Roughly about 60% of India's coastal marine fish species are dependent on the mangrove estuarine complex. Some of the most common fishes of man-

groves are species of *Liza, Mugil, Lates, Polynemus, Ilisha* and *Etroplus*. Prawns are represented by the species of *Penaeus* and *Metapenaeus* while crab resource is mainly of *Scylla serrata*. The molluscan forms of mangrove waters are species of *Crassostrea, Meretrix, Telescopium* and *Cerethedia*. The major gears used for fishing are stake-nets, cast-nets and hand-picking in the mangrove areas.

ECOLOGICAL FEATURES

There are 5 important factors that influence mangroves, namely, temperature, salinity, tides, rainfall and winds; each having its own effect. Temperature influences the development and survival of the mangroves in the early stages. Salinity determines the distribution and zonation of the species within the ecosystem since each species has got its salinity tolerance. Tides act jointly with salinity in the dispersion and zonation; and the tidal amplitude determines the landward extension of the mangroves. Rainfall is important in the zonation of mangroves on flat coasts and the productivity of the mangrove ecosystem is related to the frequency and volume of freshwater supply by rainfall. Wind is important in regulating the seasonality of litterfall which is the major pathway of energy from terrestrial to aquatic system.

Mangroves colonize on a variety of substrata that include silty and clayey mud, calcareous mud, quartz sand, calcareous sand or mixture of these. Occasionally they may colonize coastal coral reef as well as cracks and hollows of rocky substrata. They prefer sediments that have been brought by rainwater or transported by tidal currents. The mangrove soils are generally slightly acidic. The anaerobic condition in the soil helps sulphate reducing bacteria to produce Hydrogen sulphide. The characteristic black or grey colour of the soil is due to reduction of ferric compounds to ferrous sulphides (Deshmukh and Balaji, 1994).

In general, atmospheric mean temperature of most of the mangrove habitats in the Bay of Bengal varies from 29-33°C while surface soil temperature ranges from 30-34°C and surface water temperature from 28-33°C. Salinity of mangroves fluctuates considerably ranging from 3 to 33 ppt in landward and creek waters; and in the bay it varies from 25 to 35 ppt. The pH of the water fluctuates from 6.5 to 8.0 and

dissolved oxygen content is usually very low ranging from 1.7 to 3.8 mg/l. However in the seaside, it may reach even 10 mg/l (Deshmukh and Balaji, 1994).

The primary productivity of the mangrove waters is very high. Gopinathan and Rajagopalan (1983) have reviewed the productivity of the Andaman-Nicobar mangroves. According to Nair and Gopinathan (1983), the primary productivity rate ranges from 0.2 to 0.8 g C/m^3/ day in the Northern Andamans, slightly higher values from 0.5 to 1.0 g C/m^3/day in the shallow mud flats and mangroves of Car-Nicobar and higher productivity rates from 2.0 to 3.6 g C/m^3/day in and around the mangroves of Port Blair.

ENVIRONMENTAL IMPACT

In recent years, the mangrove environment is getting polluted with different kinds of effluents and other contaminants from the factories and industrial wastes. Heavy metals pose a serious problem due to their environmental persistence and toxicity to aquatic organisms even at a lower concentration. Hence, it is very important to monitor the heavy metal pollution by taking suitable managerial measures to protect the valuable mangrove resources.

Increasing human pressure for domestic needs and development of industries has virtually destroyed large areas of virgin mangroves all over the world. Reclamation of mangroves for housing, agriculture and salt evaporation site, grazing of cattle, removal for fuel, sewage discharge with high BOD, discharge of industrial effluents and excessive release of pesticides and aquaculture practices have threatened most of the mangroves and some are in the verge of extinction. These degraded areas need to be restocked and fresh mud-flats need to be afforested with suitable mangroves. Silvicultural techniques like regeneration, restoration and afforestation of mangroves can be the only answer to these problems.

ECONOMIC IMPORTANCE

Like any other types of forests, mangroves form the national wealth of a nation. Timber produced from mangroves is of great value.

Wood of *Rhizophora* is used for boat-building which is resistant to termites and boring animals. Mangrove trees are used as fuel wood or for charcoal. Mangroves were the main source of tannin industry once but now gradually replaced by synthetic tannin. A black dye is also extracted from the bark of mangrove trees. Seeds of *Cerebra odolum* is poisonous and fish poisons are extracted from it.

Mangroves are good breeding and nursery grounds for a variety of prawns and fishes. It provides nutrition for various organisms through recycling of plant and animal remains. Of course, mangroves give protection to the coastline and minimise the disaster due to cyclones. Aquaculture practices in the mangrove sites of many countries are flourishing even now. Protection of bird sanctuaries (eg. Vimalavanam and Mangalvanam) and endangered species of wildlife (crocodiles and tigers) are the other important aspects of mangroves.

Mangrove ecosystems, with their variety of subhabitats, offer a range of recreational opportunities such as boating, hunting, bird watching, wild life observation, education trips for specimen collections, photography etc. Apart from these, fishery activities (culture and capture) in many coastal regions of the tropics are highly dependent upon mangrove dominated estuaries.

AQUACULTURE IN MANGROVES

Aquaculture in mangroves signifies a case of necessity rather than suitability. In specific cases of aquaculture in the mangrove ecosystem, economic and social benefits may outweight management problems. A major part of the primary production enters the mangrove food-web as dead organic matter or detritus which is either utilized within the mangrove ecosystem or transported into the adjoining water body in a degraded form and the estuaries and backwaters fringed by mangroves have long been used for rearing or fattening of bivalves, prawns and fin-fishes.

Mangrove swamps found in the coastal areas of Indo-Pacific regions are suitable for the culture of finfishes, molluscs and crustaceans. The mud crab *Scylla serrata* is an important inhabitant in the sub-tidal and inter-tidal regions of mangrove estuaries and creeks. Extensive farming of the mud crab is practiced in Philippines, Malaysia, Thailand and Taiwan

using wild juveniles. In India, nonavailability of adequate juveniles for stocking is the major problem since reliable hatchery techniques have not been established. Prawn culture in mangroves is about a century old; and holding and trapping system of marine prawn cultivation is still in practice in southeast Asian countries. Although several prawn species enter the mangrove swamps, the most commonly cultured species are the tiger prawn *(Penaeus monodon)* the banana prawn *(P. merguensis)* and white prawn *(P. indicus)*

Finfish resources are abundant in mangrove creeks and estuaries. The milkfish *Chanos chanos,* mullets like *Mugil and Liza,* mudskippers, predatory fishes like grouper, sea-bass and cat fish are found suitable for the culture in mangroves. Edible species of oysters, clams and gastropods are the cultivable molluscan groups in mangroves. Edible seaweeds such as species of *Gracilaria, Ulva* and *Caulerpa* occuring in the nearby areas of mangroves have excellent farming potential in unused mangrove associated waters.

CONSERVATION AND MANAGEMENT

In India, mangroves are under pressure due to increasing population, development of ports, salt pan and aquaculture, dumping of industrial wastes and effluents, development of fertilizer plants and exploration for petrochemical activities. Conversion of mangrove area for agriculture and residential purposes is also leading to loss of this important ecosystem. Based on the above observations, a concerted and co-ordinated effort is necessary to undertake management measures to conserve these natural resources. With a view to preventing further destruction of mangrove forests, for sustained improvement and utilization of mangrove resources and to conserve and enhance biological diversity, it is felt that an integrated approach is required. The conservation of the existing mangrove resources is the first step towards achieving this goal.

Poor management decisions and practices have severe and direct social, economic and ecological impacts on mangroves. Both overexploitation and conversion activities can result in severe socio-economic consequences for coastal people and their regional economics.

Sustainable use is a theme of prime importance in approaches for better utilization of the resources. There are basically three options for the management of mangroves. The first option is 'preservation' of the ecosystem in the natural state and the second is 'utilization' of the system to extract various goods and services on a sustainable basis. The third option is the 'conversion' or destruction of the natural ecosystem for other uses such as agriculture or aquaculture or housing development. It is important to recognise that all these three options have related costs and benefits. Since these management options are mutually exclusive, a frame work is needed for evaluating the alternatives and economic analysis has a role to play in this process to minimise the costs and maximise the benefits.

The Centre for Research on Sustainable Agriculture and Rural Development (CRSARD) of the M.S. Swaminathan Research Foundation, Madras, initiated in 1991, a project with financial assistance from the International Tropical Timber Organisation (ITTO), Yokohama, Japan, for the establishment of a global net-work for the conservation and sustainable utilization of mangrove forest genetic resources. The main objectives of this project are a) maintenance of genetic diversity of species represented at local and biogeographic regional scales b) training Managers of mangrove forest genetic resources on genetic conservation, evaluation and sustainable utilization and c) development of information and communication systems (Deshmukh and Balaji, 1994).

A National Committee on Wetlands, Mangroves and Coral Reefs, constituted in 1993 by the Ministry of Environment and Forests, recommended the following areas for research and development as well as management of mangrove environment:

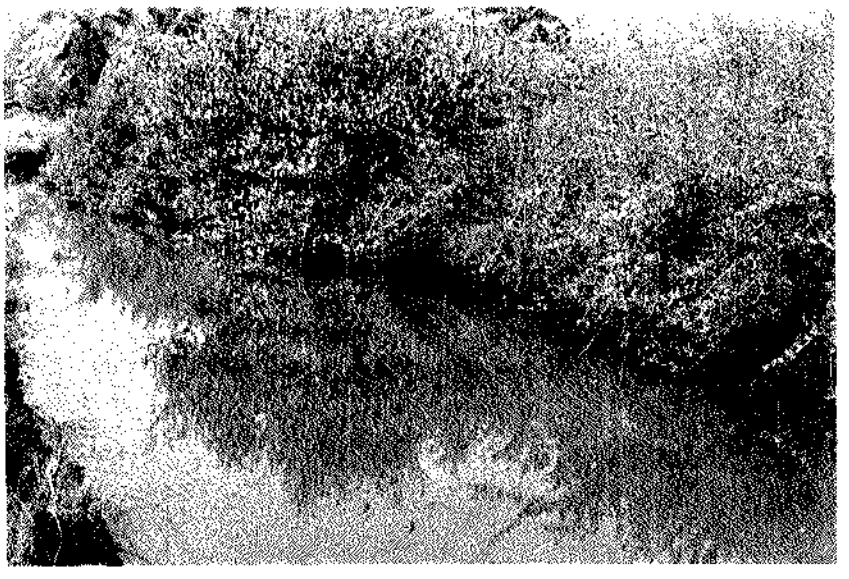
a) Nationwide mapping of the mangrove areas, preferably by Remote Sensing Technology, coupled with land surveys. (Time series should be made to make an assessment of the role of degradation of the ecosystem).

b) The mangrove forests should be surveyed quantitatively for area, climatic region, rate of growth of forest trees and seasonal variation of environmental parameters.

Mangrove vegitation in Vypeen Island, Cochin

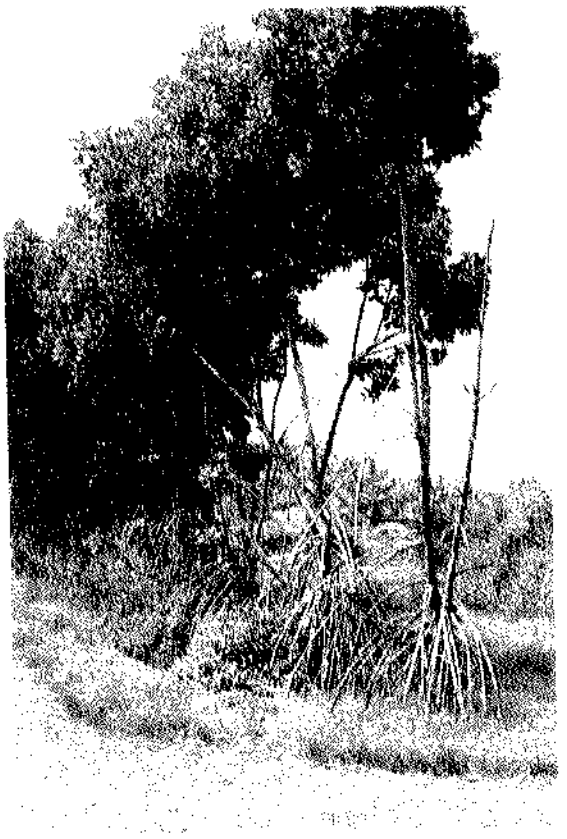
Clearing of mangrove trees for construction purposes

Excoecaria agallocha mixing with *Cerebra odollum* and *Aegiceras corniculatum*



Avicennia officinalis mixed with *Clerodendron*

Acanthus ilicifolius and *Rhizophora mucronata*



Rhizophora mucronata with Stilt roots

c) Afforestation of degraded mangroves and management of mangrove forests.

d) Assessment of suitable sites for the 'Reserve Forests' and its conservation programme.

e) Floral, faunal and microbiological role and ecological studies.

Action Plan and Strategies

The aspects which need immediate attention in evolving the framework of conservation and management action plan and the strategies are:

a) Full protection to the mangrove flora and fauna by banning mangrove exploitation from government forests.

b) Identification of potential mangrove areas for declaring as 'Reserve' or 'National Park' and sanctuaries.

c) Application of mangroves in the islands. For this, a few nurseries have been established and efforts are underway to plant suitable areas with mangroves.

d) Awareness among the public on the importance of mangrove ecosystem and the need for its preservation by educating the coastal people.

e) Protection measures to keep vigil on possible destruction of mangroves.

Research Priorities

There are about 14 major centres in India, engaged in mangrove research. The important R & D programmes are on survey and distribution, Remote Sensing, ecology, fisheries, aquaculture, physiology, productivity, pollution, afforestation, management and wildlife. Research priorities in mangrove ecosystem towards the conservation and sustainable management of resources can be summarised as follows:

1. Estimation of total extent, rate of change and the quality of mangrove ecosystem by a combination of mapping methods using Remote Sensing, aerial photography, field survey for ground truthing and Geographical Information System.

2. Examination of floristic composition of as many diverse mangrove communities as possible in different climatic and biogeographic regions. This will provide information on species distribution, population sizes of common, rare and endangered species.

3. Selection of suitable species for reforestation and their planting techniques.

4. A resource survey of all utilities and service rendered by keeping the mangrove ecosystem as opposed to its removal for alternate land use such as aquaculture etc.

5. Based on above surveys, initiation of research into afforestation with appropriate species fulfilling the environmental protection needs.

6. A comparative study of population genetic structure, breeding system, vegetation and reproductive phenology of selected species for conservation of their genetic diversity.