CHAPTER 1
INTRODUCTION

Chapter 1
Introduction

1.1 Review of Literature

Mangrove is an important coastal ecosystem and has been studied extensively for its ecological and economic values. Some of the works related to the present study are given here. Asornkoae and Sanit (1993) in their work "Ecology and Management of Mangroves" have covered some major all aspects of mangroves like historical back ground, definition, distribution of mangroves in the world, flora and fauna associated with mangrove ecosystem. Importance of mangroves in the coastal environment and socio-economic aspects of mangrove ecosystem has been dealt by Sanegar et.al. (1993) by giving emphasis on global status of mangrove ecosystems.

Mastaller and Michal (1997) have revealed comprehensive information regarding the mangrove ecosystem as the forgotten forest between land and sea. General account of flora and fauna of mangrove swamps and forest in the Indo-West Pacific region is covered by Macanae (1968). Information on the mangrove and mangrove forest of Bangladesh is given by Das and Siddiqui (1985). While general account of the mangrove fauna of Andaman and Nicobar Islands is presented by Das and Dev Roy (1989). Detail study of mangroves in India was done by Blasco (1975) in which information on the mangrove ecosystem on the east coast is given in detail.

Information on the status of mangrove, flora and fauna of mangroves and measures being taken for its conservation in India is given in the reports of the Ministry of Environment and Forest , Govt. of India (MoEF 1987, 1989). Status of mangroves on East Godawari region studied by Sidhu (1963). Kumar (2000) gave Current status of mangroves in Andaman. Upadhyay et.al. (2002) in "Current Science" gave information on Human mangrove conflicts.

Mangrove ecosystems on the west coast of India is well studied by Untawale (1980). Diverse information on the mangrove ecosystems in Maharashtra is compiled and presented in the book "The Mangroves"(ed. Bhosale L.J. 1986). Chaphekar and

Deshmukh (1996) have commented on the changing status of mangroves in Maharashtra. Untawale et.al.(2000) have contributed a well balanced account on the mangroves in their article "Prioritisation of potential sites for mangrove biodiversity in India". First detail account on the avifauna of the mangroves on the west coast, around Ratnagiri, Maharashtra, was done by Samant (1986). Giri (2003) gave information on status of marine turtles in Maharashtra.

1.2 Coastal Ecosystems

Biodiversity means variability among the living organisms from all the sources including terrestrial, coastal and other aquatic ecosystems and complexes of which they are part; this includes diversity within species, between species and of ecosystem.

The world's wealth of the biodiversity is found in highly divers marine and coastal habitats. There are about 30 million species of living organisms estimated on the earth. Marine biodiversity is known to be one of the richest among all the living ecosystems. There is a rich marine biota in different parts of the oceans, from the surface to the deepest parts and from the estuarine region to the offshore regimes. The ocean water can support life from the microscopic bacteria to the gigantic whale. As compared to the information available on terrestrial biodiversity much less information is available on the marine biota.(Untawale et. al. 2000)

Marine biodiversity has been classified into two sectors i.e. coastal and offshore. The coastal areas are shallow and cover the ecosystems like estuaries, near shore and inter tidal areas where strand flora and mangroves are available. The intertidal and subtidal regions also harbour the biota like marine algae, seagrasses, corals and associated flora and fauna. Coastal ecosystem is a storehouse of variety of flora and fauna with great ecological and economical importance.

Macnae (1968) has given a general account of the fauna of mangroves in the Indo- West Pacific region. The tropical marine ecosystems of the Indian subcontinent harbour a large number of species belonging to various habitats that include mangrove swamps, estuaries, lagoons, muddy sandy/rocky shores, and oceanic islands.

There is a definite food chain present in the oceanic system. The famous "Trophic Prism" indicates intimate and intricate relationship among the primary, secondary and tertiary levels. At the same time, different ecosystems are interdependent but self-sufficient. Various biological, biochemical and reproductive process of a complex nature supports numerous life forms in the ocean. (Untawale et.al. 2000)

Marine fauna comprises of several phyla, orders, classes, families, genera and species in the coastal as well as offshore environment. It is practically difficult at this stage to enlist various species family wise. These faunal complex elements therefore are indicated as separate groups like zooplankton, benthos, corals, fishes, amphibians, reptiles, birds, mammals, etc.

According to scientific data available, there are 23 groups of faunal elements, which have been reported, from the Indian coastline. Various ecosystems are contributed to faunal elements that are near to the coasts. Following are few of them, coral ecosystem, sand dune ecosystems, benthic ecosystem, mangrove ecosystem etc.

1.3 Coral Ecosystem

Coral reefs are known to be the most diversified and productive ecosystem among all the marine ecosystems of the tropic zones (Wells, 1988). Many corals are very beautiful, colourful and attractive to human being. Coral reefs are of direct economic importance due to their direct and indirect organic resource. Coral reefs are also exploited for their beautiful associated fauna such as molluscs and fishes. Coral reefs are very fragile ecosystems and are easily destroyed by silting, dredging and over exploitation as a result of coastal human activities.

1.4 Sand dune Ecosystem

This is situated in the supra-tidal region. It does not have direct contact with seawater, however, the sand from the marine origin is accumulated as a result of currents, waves and winds. These open dunes are habituated by a special sand dune flora, which binds the sand and controls it's movement it has typical zonation like pioneer (with herbs) and back shore (with trees). At climatic climax stage when it is well preserved and managed, this ecosystem functions as an effective shelter belt

which minimises the coastal erosion and also the impact of cyclonic winds. (Untawale, 1980; Desai and Untawale, 2002).

1.5 Benthic Ecosystem

The benthic biota, which is attached to the substratum, consists of marine algae, seagrasses, and varieties of the faunal elements. The juvenile form of this biota may be free floating. The marine benthic biota different tidal inundation levels and also substrata. Hence these are distributed from the supra-tidal fringe to the subtidal areas.

Since these static biotic elements are not in position to migrate, these are affected by the changes in coastal regions like temperature, tidal waters, pollution and siltation. The benthic biota also binds, holds the substratum, increases the biological productivity and enhances the interaction at the trophic level.

1.6 Mangrove Ecosystem

Imagine a tree so well adapted to shoreline conditions that its roots can filter salt water. These trees, known as mangroves, have a unique system of stilt like roots, which protect coastlines from storms and filter sediments that would otherwise smother sea grasses and corals. Leaves falling from the canopy form the basis of an incredibly productive food chain, with detritus directly and indirectly nourishing thousands of life forms.

Mangrove is an assemblage of different flowering plants that can grow in saline or brackish water along the estuaries, on deltas, backwaters creeks etc. Mangrove ecosystem is one of the most productive natural ecosystems on the earth with great economical significance. It is widely believed that mangrove forests developed first in the Indo-Malaysian region and then spread to other regions of the tropics. This region is, therefore considered as the cradle of evolution for mangrove vegetation. (Krishnamurthy, 1993)

Mangroves once covered 3/4 of the world's tropical coastlines, often in conjunction with coral reefs. Asia contains most of the world's mangroves with 46%, followed by America with 35% and Africa with 17% (MAP, 1990). Mangroves either

exclude or excrete silt from their tissues, and have special upright roots which "breathe" in stagnant shallows. Some species produce spike like seedlings, which drop off the parent and land upright in the mud, ready to grow.

Historically mangrove ecosystems have been sites of human settlement throughout the tropics, especially in the India-Pacific region. This is understandable since mangroves dominate in sheltered locations, offer extensive navigable channels for boats and provided early settlers with an abundant source of building materials, fuelwood, thatching, bark (a source of tannin), medicines, etc., as well as excellent gathering, hunting and fishing environments for food.

1.6.1 Importance of Mangroves

Mangrove forest serves as a link between terrestrial and marine ecosystems. The energy flows from land to the sea and enrichment due to the detritus formation makes marine ecosystems rich in relation to the primary and secondary production and helps as a diverse micro habitat for wildlife such as mammals, reptiles, amphibians, birds, insects and micro-organisms.

The mangrove ecosystems also contribute to the economy of the coastal zone. Timber is one of the biggest resources obtained from mangroves. Other products such as honey, tannins, charcoal etc is also extracted from mangrove forests. In recent years charcoal has been exploited as a commercial product. Various mangrove plant species can be use used for charcoal making. (Untawale et..al., 2000)

The wide variety of traditional products from mangroves utilised by coastal communities has been well documented by Hamilton and Snedaker,(1984); Chan and Salleh, (1987). Many of these activities still continue, and include collection of thatching material (Nypa), gathering of shells to produce lime and wild honey collection (in the Sundarbans especially). While early coastal settlers enjoyed great self-sufficiency in this way, and some human communities still live in an integrated way within mangrove environments, commercial exploitation of mangrove resources, especially for timber and fuelwood, developed rapidly to supply the growing needs of urban populations. Even among traditional communities, increasing population pressure on coastal resources has inevitably led to a gradual degradation of mangroves as more and more forest has been cut to satisfy local timber and fuelwood needs.

Traditionally the mangroves of India and Bangladesh have been exploited for timber and fuelwood, bark tannin, animal fodder, native medicines and food (fish, shellfish, honey, wild animals). Population pressure has greatly increased the rate of exploitation, leading to degradation of the remaining forests at an alarming rate. In Bangladesh, where an estimated 300,000 wood and thatch cutters, honey collectors, and fishermen are directly dependent on the Sundarbans, the area of pure Sundri (*Heretiera fomes* -the main economic timber species) is reported to have shrunk from 31.6 to 21.0% between 1959 and 1983 (Chaffey, Miller and Sandom, 1985).

In the Bangladesh Sundarbans, timber yields, principally of *Heritiera fomes* (Sundri) and *Excoecaria agallocha* (gewa), have exceeded 300,000 cubic metres annually (FAO, 1982), representing a major source of wood in a country poorly endowed with other forest types. Elsewhere, by far the greatest use of mangrove wood is for fuel, especially charcoal because of the exceptional slow-burning properties of the wood of *Rhizophora* species.

Mangrove honey is an important economic product extracted from the Sundarbans. Although impossible to quantify, hunting also remains a significant activity in the Sunderbans and in many other areas in Asia where mangroves are still extensive. Unfortunately, this extends beyond hunting to support local food needs, into the poaching of rare and endangered species for sale as skins and stuffed specimens for tourist markets (Nuruzzaman, 1993). To a limited degree native medicines and miscellaneous plant extracts (e.g. a fish poison is obtained from the *Derris* plant) and food items are still collected from mangrove forests (Chan and Salleh, 1987). The exploitation and value of aquatic products from mangrove ecosystems is, however, of far greater significance today, as described below.

Mangrove wood is still an important source of domestic fuel for coastal villages. Firewood is obtained from small sized trees. Smaller quantity is burnt as insects' repellents. Poles are used mainly for foundation piling, scaffolding and fish traps. In Matang, Malaysia, some 2000 ha of mangroves are thinned for the production of 3-4 million poles every year. In Indonesia, mangrove produces

approximately 1,70,000 poles per year. In another countries, the extraction of mangrove woods for poles is limited.

Tannin is a mangrove product that has a variety of uses, such as in the manufacture of ink, plastic and glue. It is also used for dyeing fishing nets and leathers. Tannin is extracted from the bark of mangrove trees. Another traditional use of mangrove is as medicines. Certain species of mangroves contain active substances that has power to care various ailments. However, these traditional medicinal plants have not received the support of scientific investigation and experiments.

Some of the fishing equipment used by mangrove dwellers is made from mangrove wood. Mangrove poles made from *Rhizophora* and *Bruguiera* spp. are used for crab traps. The mangrove forest is a good site for raising bees. Untawale (1987) reported that bee keeping is popular in mangroves of India and 120 metric tons of honey is produced every year. *Avicennia, Ceriops* and *Excaecaria* communities are good for this purpose. (Aksornkoae and Sanit 1993).

At first sight, the scope for recreational use of mangrove ecosystems may appear to be limited, but it is in fact an important aspect of the management of mangroves in Australia (boating and recreational angling). There is also some developing country examples. In Thailand there is considerable value attached to the mangroves in Phangna Bay as a component of the bay's environment which tourists from Phuket can visit in pleasure boats. In some of the Caribbean islands, fringing mangroves are regarded as important indirectly to tourism as they act as sediment traps, thereby protecting the adjacent coral reefs from siltation - the tourist economy of these islands being strongly dependent on the attractiveness of their reef environments.

It is also probable that mangroves will feature in future as one of the tropical environments attractive to the growing developments in eco-tourism. Boat trips through mangrove ecosystems are easy to organise and elevated walkways can be built for easy access to the forest environment. Walkways constructed by the Royal Thai Forest Department in a forest reserve area within the Ranong mangrove

ecosystem have proved to be highly successful for research and educational activities involving large groups of people (Macintosh, et al, 1992).

In suitable areas, this concept is readily adaptable to make it attractive to a wider audience through eco-tourism; consequently the latter should be included as part of coastal zone planning where it is considered to have potential. However, eco-tourism must be clearly distinguished from tourism in its general context, the latter having had a history usually associated with negative impacts on mangroves.

The soils of the mangrove forest are considered to be marginal for agricultural production due their saline and anaerobic environment. However, this can be improved through drainage improvement, limiting, control of the water table and fertilisation. The major use of mangrove reclaimed land is for the establishment of cash crop plantations such as coconut and oil palm.(MoEF,1989).

1.6.2 Mangrove Biodiversity

The mangrove ecosystems are rich in biodiversity and known to harbour wide variety of plants (193 sp), fishes (397 sp), crabs (259 sp), molluscs (256 sp), 450 types of insects and more than 250 other associated species. Mangrove ecosystem has perhaps the highest level of productivity among natural ecosystems, and it performs several ecological services. (Upadhyay et. al. 2002)

Saenger et al. (1983) provided a summary of the types of reserves, including mangroves, designated by different countries. Traditionally, mangroves and other tropical wetlands have not been considered particularly rich in species, especially in comparison to the extremely high biodiversity found in coral reefs and rainforests. In conservation terms however, this view is counter-balanced by the extremely high abundance and productivity of certain wetland plant and animal species. These characteristics of mangroves make them important for other wildlife, specifically:

1 As dry season refuge and subsequently as sources for re-colonisation of surrounding habitats,
2 As feeding grounds for resident and migrant wildlife,
3 As breeding and nursery grounds,
4 As a link between terrestrial and marine ecosystems.

The abundance of wildlife probably attracted early natural history enthusiasts (and hunters) to the estuaries, islands and lagoons habitually used by nesting and over-wintering waterfowl. Consequently, the significance of mangroves and associated habitats is much better appreciated for birds than any other group of wildlife, and a number of conservation initiatives have focused on their protection. In Indonesia, endangered species associated with mangroves include the milky stork and lesser adjutant stork, while mangrove mudflats serve as feeding areas for huge numbers of migratory water birds, including rare species (Silvius, 1987). In Mauritania, the tidal flats of the Banc d'Arguin National Park provide a wintering site for some 3 million shorebirds every year (IUCN 1990).

Several reef and oceanic species, including shrimp, depend on mangrove habitats during various stages of their life cycles. Species such as the endangered olive Ridley turtle, the white breasted sea eagle, the tree climbing fish, the proboscis monkey, the dugong, and even the Bengal tiger use mangrove forests in their daily lives (MAP, 1990, Subramania and Krishnamurthy, 1990).

Prawn fries require copper for their body fluid during development and thus mangrove soils provide an excellent source for this mineral (Subramania et al., 1990). In the United States, half of the commercial marine fisheries are dependent on coastal wetlands for spawning and as nurseries (Mathias and Moyle, 1992).

Of the species studied in one mangrove community in Belize, 10 percent of the crustaceans were previously unrecorded, and 20- 30 percent of the microbes, algae, sponges and worms may also have been new to science (Feller and Rutzler, 1996).

The shallow mangrove waters, abundance of food, and absence of predators are ideal for young organisms to thrive. Underneath the mangroves, soft soils provide an excellent habitat for burrowing prawns and other mud dwellers. The nutrient humic layer provides food for the herbivores found in the mangroves. Through continuous tidal movements, these nutrients also supply species in surrounding estuaries and coral reefs. This release of excess nutrients is essential for resources such as oysters.

About 80 species of true mangrove trees/shrubs are recognised, of which around 50-60 species make a significant contribution to the structure of mangrove forests. Species diversity is much higher in the Southeast Asian region, where approximately two-thirds of all species are found, while approximately 15 species occur in Africa and 10 in the Americas. The trees of several genera are valuable for timber or fuelwood, especially *Rhizophora* species which occur in all three regions. Although mangroves thrive best along sheltered humid tropical coastlines where alluvial sediments can accumulate as a substratum for mangrove colonisation, mangroves also occur as fringes or patches in carbonate sediments along small island shores, as in the Caribbean (Ellison, 1993).

It is more recent research that has highlighted the other species of conservation concern for which mangroves are an important ecosystem. Moreover, as research has continued, examination of the large range of niches available for use (a three dimensional space in the terrestrial realm like a normal forest, and a three dimensional in an aquatic one, linked by a highly dynamic inter-tidal zone), has revealed greater biodiversity than was originally expected. Lopez et al. (1988) provided a summary of invertebrate species associated with mangroves and benthic habitats adjacent to mangroves.

Viewed in isolation, the mangrove itself is still of only moderate significance, but it assumes far great importance when its fundamental ecological linkages with other habitats are taken into account. Thus a great number and variety of birds, mammals, fish and invertebrates utilise mangroves during at least one part of their life cycle.

Those species of greatest conservation concern that are associated with mangroves have been reviewed by Saenger et al. (1983). Of 21 crocodile species recognised by CITES, seven are endangered and of these, three inhabit mangrove dominated environments. For example, Silvius (1987) mentions that conversion of riverine mangroves in Indonesia will further reduce the habitat available to three already endangered species in Indonesia: *Crocodilus porosus*, *C. novaeguineae* and *Tomistoma schelegelii.*

Large mammals are especially vulnerable to human intervention because of their need for large forest ranges and their value to poachers. In West Africa, the Caribbean, southern USA and northern Latin America, manatees have been brought close to extinction in many areas by hunting and other disturbance (IUCN 1990). Quiet tidal creeks where overhanging prop roots give production from predators are thought to be especially important for calving and nursery areas for these creatures.

In Thailand the leaf monkey, *Presbytis cristata* and in Malaysia and Indonesia, the proboscis monkey *Nasalis larvatus*, are both vulnerable species which inhabit mangroves (IUCN 1990), while the Malayan sun bear and the tapir are similarly threatened by forest destruction (Silvius, 1987).

In India and Bangladesh, the relative isolation of the Sundarbans mangroves have made them the largest remaining habitat of the Bengal tiger *Panthera tigris.* However, human population pressure is perhaps the greatest threat to conservation of mangrove wildlife. Major international efforts have contributed to some conservation success with the Bengal tiger, but habitat degradation in the Sundarbans is a slow time bomb, which ultimately will be just as lethal for the tiger as the hunter's bullet. Fourteen species of mammal have already disappeared from Bangladesh in the past 20-25 years (Nuruzzaman, 1993).

About 50% of India's mangrove resource is found in the Ganges delta of West Bengal (Sundarbans) and comprises more than 20 species, whereas at similar latitudes on the arid west coast (Gujarat) only about 12% of the total resource and nine species occur. (Chavan and Untawale, 1993).

In India mangrove occur in various habitats such as delta, estuarine, backwater and sheltered-insular bay types. Deltas are found along the East Coast. The great river deltas, such as those of the Ganga, Bramhputra (Sundarbans, West bengal), Mahanadi and Bhitarkanika (Orissa), Godavari and Krishna (Andhra Pradesh) Pichvaram and Gulf of Manar (Tamil Nadu coast) are mangrove formation along the east coast. Total area of mangrove including Andaman and Nicobar is approximately 7,00,000 hectors, i.e. about 82%. On the west coast however, the estuary display fringing growth where 18% of the area is covered under mangrove. This includes Gujrat, Maharashtra, Goa and Karnataka.

Maharashtra coast lies between $15^0 43'$ to $20^0 00$ N latitude and $72^0 49'$ to $77^0 41'$ longitude. The coast line lies about 720 km long and as identified by numerous river, mouths, creeks small bays, headland promotaries, cliffs etc. The coast broaded to the east by Western Ghats. Beyond which there is a plateau. In Maharashtra Vengurla, Achra, Deogad and Vijaydurg in Sindhudurg district, Shirgaon and Bhatye in Ratnagiri district, Veldur, Kundalika, Revdanda and Shrivardha in Raigad district and Mumbra, Diwa, Vaitarna river, Vasai and Manori creek in Thane district are the major sites having good mangrove area. (Untawale, et.al. 2000)

Mangrove forests emphases a variety of plants including trees, epiphytes, lianas and algae. Almost all are evergreen, possessing similar physiological and structural adaptations and are salt tolerant. These are diversified group of trees and shrubs. There are 59 mangrove species belonging to 41 genera and 29 families present along the Indian coast. The west coast harbours 33 species, whereas 47 species are present along the east coast. Out of the species found on the west coast, Maharashtra has the maximum i.e 30 sp, followed by Gujatat 23 sp., Karnatak 20 sp., Goa 19 sp. and Kerala 12 sp. (Wafar and Untawale, 2000)

Geomorphology, environmental and hydrological conditions are mainly responsible for the distribution of mangroves. Apart from physical conditions such as soil type, rainfall, tidal inundation's and fluctuations, salinity gradients and biotic factors are also important. Polyhaline and mesohaline zones (salinity 5-30%) shelter many mangrove species. The oligohaline zone (salinity 0.05-5%) supports limited species such as *Kandelia candal, Sonneretia casiolaris* and *Acrostichum aureum.*

The east coast mangrove vegetation is comprised of 47 species with almost 70% of the total mangrove cover in India. The maximum number of 27 species has been reported from the Mahanadi delta. Mangrove species like *Avicennia* sp. and *Aegiceras majus* are dominant along the Godavari, Krishana and Cauvery delta. *Ceriops decandra* and *Sonneratia apetala* are dominant in the Mahanadi delta. The dominant flora of Gangetic Sundarbans delta comprises of species like *Exoecaria agallocha*, *Heritiera fomes* and *Xylocarpus moluccensis*. Mangrove species like *Nypa*, *Xylocarpus*, *Heretiera* and *Acanthus ebracteatus* are found on the east coast only.

Among the west coast states, Maharashtra has the most diversified mangrove flora composed of 19 species, followed by Goa and Karnataka. Gujrat despite having large mangrove coverage of 37,000 ha. Displays poor assemblage of 9 species. *Avicennia alba, A. marina A. offincinalis, Rhizophora mucronata, R. apiculata, Acanthus illicifolius, Sonneretia alba, S. apelata* are the dominant species along the west coast.

Shrubby vegetation including *Acanthus illicifolius, Avicenia marina, Salicornia brachiata and Seuda sp.* occurs above the high tide mark. Due to the deforestation as well as development activities and domestic exploitation, species of *Nypa* and *Xylocarpus* have become extinct from the west coast, Where as other species like *Ceriops tagal*, *Lumnitzera racemosa*, *Sonneratia apetala* are found only in certain areas. A very distinct discontinuous, distribution of mangrove plants has been observed along both the coasts of India due to various factors. (Untawale, 1987)

Mangrove forests support population of considerable size and variety from almost all phyla ranging from simple protozoa to birds, reptiles and mammals. These animals spend at least a part, if not all of their lives within ecosystem. Four major families of shrimps, four predominant families of crabs and molluscs are commonly present in mangrove. Fishes use mangrove water as nursery grounds, permanent habitats, or breeding grounds (Aksornkoae and Sanit, 1993).

Monkolprasit et al. (1983) classified mangrove fish into four groups, true residents, partial residents, tidal visitors, and seasonal visitors. Various other animals

also make mangrove forests their home. McNeely and Lekakul (1976) surveyed vertebrates and found 35 species of mammals, including monkeys, otters, wild cats, bats, wild boar, and deer. Way (1977) recorded 25 species of reptiles- snakes, iguanas, turtles, and alligators. The diversity of fauna with in the mangroves is high due to ample food resources and a wide range of microhabitats. Chapman (1975) recorded six types of microhabitats in the mangrove forests as soil surface, soil interior, tide pools, small canals, fallen logs and tree canopy.

The mangrove ecosystems are ideal sanctuaries for avi-fauna. According to Saenger et.al.(1983) the total list of the mangrove bird species in each of the main biogeographic regions includes from 150-250 species. Mangrove forest provides good shelter, food, breeding ground, for the resident and migratory birds. Das and Siddiqi (1985) compiled the information on the wild life species such as mammals, reptiles, amphibians and birds found in Sundarbans.

Das and Dev Roy (1989) gave the general account of mangrove fauna of Andaman and Nicobar Islands. About 177 species of birds are found in mangrove forest of India. A total of 121 bird species were recorded from the mangroves of west coast, out of these, 66 are resident and local migrants, 24 true migrants, 28 resident with migratory populations and only three 3 are vagrant or occasional strays. (Samant, 1986). All over the world, 65 mangrove bird species have been listed as endangered or vulnerable.

One of the most fascinating features of the Indian biodiversity is its mammalian fauna. Most of the workers use the term 'marine mammal' to include members of five different mammalian groups viz. cetaceans (whales, dolphins, and porpoises), sirenians (manatees and dugongs), pinnipeds (sea lions, walruses, and seals), marine and sea otters and the polar bears. Many species of wild and domestic mammals are directly or indirectly associated with mangroves in India.

Marine reptiles of India include turtles, crocodiles and sea snakes. Of the 12 living turtle families, only 2 families are marine which include 8 species, of which, 5 are found along the Indian coastline viz. *Dermochelys coriacea* (leather back sea turtle), *Chelonia mydas* (green turtle), *Eretmochelys imbricata* (Hawksbill), *Caretta*

caretta (Loggerhead sea turtle) and *Lepidochelys olivacea* (Olive Redley). Three species of crocodiles are found in the subcontinent viz. saltwater crocodile (*Crocodylus porosus*) mugger (*Crocodylus palustirs*) and Gharial (*Gavialis gangeticus*). There are about 20 species of sea snakes reported from India.

India offers a diverse of marine habitats which range from coral reefs, islands, backwaters, swamps, lagoons, mangroves along its coastline. Considering such a vast diversity of habitats, it is no wonder that it offers home for about 1200 species of birds.

About 176 species, contained in 106 genera, 39 families and 11 orders are endemic to Indian subcontinent. Many of them are spillovers to Pakistan, Nepal, Bhutan, Bangladesh, Myanmar and Sri Lanka. Many species are recital and 50 species and 11 genera are endemic to India exclusively. Besides, 106 endemic species of the subcontinent also occur in India (Saha, 1998). Kathiresan and Rajendran, (2000) have given account of floral and faunal species from mangroves in India as follows

Table No 1.1 Floral and faunal species reported from the mangroves of India

Fauna	Number of species
Mammals	56
Reptiles	42
Birds	378
Amphibians	22
Total no. faunal of species	1442
Total no. of floral and faunal Species	1854

A diversified mammalian and reptilian fauna is observed from mangroves of India The Royal Bengal Tiger is one of the endangered species that lives in Sundarbans area. This is the only locality in the world where the tiger shares aquatic and terrestrial food web. Some of the common animals found in mangrove swamps are the monitor lizard (*Varanus salvator*) estuarine crocodile (*Crocodylus porosus*),

Redley Turtle (*Lipidochalys olivacea*). Various species of monkeys, otters, deer, foxes, wild pigs and fishing cats. Along the West Coast, the marsh crocodile (*Crocodilus palustris*) is confirmed only in the Goa mangroves. Among the reptiles 21 snakes, 4 lizards, 5 turtles, 1 crocodile species recorded from the Maharashtra coast. (Deshmukh, 1994).

The coast waters of Maharashtra are known to harbour different species of marine turtles, porpoises i.e. fin-less black porpoise, *Neomeris phocaenoides*, and the common dolphin *Delhinus delphis*. Found near estuaries, backwaters and mangroves in shallow waters. Occasionally drifted and stranded whales are also reported from this region.

1. 6. 3 Present Status of Mangroves

Mangroves are mainly restricted to the tropics, because of their requirements for higher atmospheric and water temperature, but occasionally but some mangrove formation are also found in subtropical areas, particularly in Japan (Oyama, 1950) and New Zealand (Steenis, 1962) (Walsh, 1974) divided the geographical distribution of mangroves vegetation into two main areas: the Indo Pacific region and the region of Western Africa and the Americas. The Indo Pacific region includes East Africa, the red sea, India, Southeast Asia, Southern Japan, The Philippines, Australia, New Zealand and the South Pacific Archipelago, as far as east as Samoa. The West African region includes the Atlantic coasts of Africa and the Americas, the Pacific coast of tropical America and the Galapagos islands.

Most tropical countries were originally covered with mangrove vegetation. The total mangrove cover of the world is about 1,81,000 sq. km. (Spalding et.al 1997). Walsh (1974) suggested five basics requirements for the extensive mangrove development.: 1) tropical temperature 2) fine-grained alluvium, 3) shores free for strong wave and tidal action , 4) salt water and 5) large tidal range. These five important environmental factors can influence the occurrence and size of mangrove, the species composition, and species zonation other structural characteristics and the functions of the ecosystem itself.

Mangroves are available in approximately 117 countries, covering an area of 190,000 to 240,000 km^2. Countries like Indonesia, Nigeria, and Australia have the

largest mangrove areas. Table 1.2 shows mangrove area in different countries from Asia , Africa and America.

Table 1.2 Mangroves in different countries in the world

Asia	Area in (ha) *	Africa	Area in (ha) **	America	Area in (ha) ***
Australia	1,162,000	Angola	50,000	Belize	75,000
Bangladesh	410,000	Benin	3,000	Brazil	2,500,000
Burma	812,000	Cameroon	273,000	Colombia	307,000
Brunei	7,000	Gabon	250,000	Costa Rica	19,000
Fiji	20,000	Guinea	260,000	Cuba	448,000
India	96,000	Guinea Bissau	260,000	Dominican Rep.	9,000
Indonesia	2,500,000	Gambia	60,000	El. Salvador	36,000
Kampuchea	10,000	Kenya	45,000	Ecuador	196,000
Malaysia	674,000	Liberia	40,000	French Guyana	150,000
Pakistan	345,000	Mauritania	Few ha.	Haiti	18,000
Papua (New Guinea)	553,000	Madagascar	320,700	Honduras	145,000
Philippines	240,000	Mozambique	85,000	Jamaica	7,000
Sri Lanka	4,000	Senegal	440,000	Martinique	2,000
Thailand	288,000	Sierra Leone	100,000	Mexico	660,000
Vietnam	320,000	Nigeria	973,000	Nicaragua	60,000
Total	**7,441,000**	Tanzania	96,000	Panama	486,000
		Zaire	20,000	Peru	28,000
		Total	**3,258,000**	Surinam	115,000
				Trinidad & Tobago	4,000
				U.S.A.	178,000
				Venezuela	260,000
				Total	**5,831,000**

Grand Total 1,65,30,000 ha. (1,65,300 sq. km.)

(*) Wacharakitty(1983), (**) Saenger et.al (1983), (***) FAO (1981)

Huge areas of mangrove have been lost from Southeast Asia due to wood extraction, conversion to agriculture or salt production, coastal industrialisation and urbanisation and, conversion to coastal aquaculture. Recently, shrimp farming has been blamed for large-scale losses in several countries, notably Thailand, Indonesia and the Philippines. Estimates of the mangrove areas destroyed for different purposes in Thailand reveal the relative importance of aquaculture as a cause of mangrove destruction since 1980, but a greater total loss of almost 70,000 ha prior to 1980 due mainly to agriculture and coastal infrastructure developments. The total mangrove resource in Thailand has shrunk from an estimated 368,100 ha in 1961 (FAO, 1982) to 196,643 ha in 1986-87 (Aksornkoeae, 1993).

The continued exploitation of mangroves world-wide has led to habitat loss, change in species composition, loss of biodiversity and shifts in dominance and survival ability. Now about half of the mangroves world over have been destroyed. The Indian mangrove biodiversity is also reasonably high. The increase in the biotic pressure on mangroves in India has been mainly due to land use changes and on account of multiple uses such as for fodder, fuel wood fibre, timber, alcohol, paper, charcoal, medicine etc.

In India and Bangladesh, the largest mangroves in Asia, large areas of the inland mangroves have been converted to agriculture, mainly for paddy fields or salt production. Shrimp farming represents a relatively new form of coastal land use, which is a further threat. Jagtap et al (1993) cite an overall area loss of mangrove in India of 34% between 1975 and 1990-91, which is equivalent to 148,500 ha,

Top-dyeing of mangrove species 'Sundri' as well as over-cutting is blamed for this situation, but the die-back problem seems to be associated with increased salinity arising at least partly from large scale diversion of freshwater - an indirect form of human impact on the Sundarbans mangroves. Khulna District of Bangladesh, plodder rice fields ('ger') are flooded with brackish water in the dry season months for shrimp culture, then a rice crop is grown in the wet season when the field can be flushed with freshwater (e.g. Nuruzzaman, 1993). For economic reasons associated with the high price of shrimp, such partial or complete switches from rice farming to aquaculture are putting further pressure on the remaining mangroves.

In Asia large tracts of back mangroves were cleared initially for agriculture, especially rice farming (reviewed by FAO, 1982). Other suitable crops include coconut and oil palm and even pineapple. Rice farming can be successful on mangrove soils in the wet season, although yields are only moderate.

However, in many such areas the soils are alluvial in origin and have acid sulphate or potential acid sulphate characteristics which lead to a rapid reduction in rice production within a few years (due to acidity, iron and aluminium toxicity and lack of available nutrients), after which they are abandoned. These soil problems can be countered by the use of lime and fertilisers, but it may not be economically viable to do so. For example, fertilised potentially acid sulphate soils in the eastern region of the Bangkok plain produced 1,940 kg/ha, whereas yields from non acidic mangrove soils in the western region reached 3,000 to 4,000 kg/ha (cited by FAO, 1982).

Salt water intrusion is another problem which can destroy coastal rice crops; this is a frequent occurrence in central Vietnam, for example, due to high waves generated by typhoons. Conversion of mangroves to rice agriculture is not common in South America (Snedaker et al. 1986). In many parts of Asia the environmental and economic limitations of coastal rice farming have been overcome by alternating the rearing of shrimp with a rice crop in the same field, or by converting completely to shrimp farming. However, conversion of mangrove area for fish farms has been proved to be environmentally detrimental on the long time scale with reference to local ecology. Therefore recently the Supreme Court of India has legally banned fish farming on the East Coast.

In addition to the physical loss of mangroves through coastal industrialisation, there are also concerns over environmental effects from pollution. Burns et al (1993) note that there were 157 major oil spills in tropical seas between 1974 and 1990. Deep mud coastal habitats may take 20 years or more to recover from the toxic effects of such oil spills.

According to some estimates the mangrove forest cover in India has reduced from 6000 km^2 in 1953 to 3000 km^2 in 1989. According another estimate these forests

now occupy an area of about 4871-km^2 area. In Maharashtra alone since 1995, 47-km^2 mangrove forest is lost. Along the West Coast alone, almost 40% mangrove area has been converted into agricultural and urban development. Our understanding of natural processes in this vulnerable and fragile ecosystem is far from adequate. Environmental awareness, proper management plans and greater thrust on ecological research on mangrove ecosystems may help us to save and restore these unique ecosystems. (Upadhyay et.al. 2000) Table 1.3 gives state wise distribution of mangroves in India.

Table No. 1. 3 State wise Distribution of Mangroves in India

State/U. Territory	*(1987) Sq. Km	**(1993) Sq. Km	***(1997) Sq. Km
West Bangal	4200	1619	2123
Andaman & Nicobar	1190	770	966
Maharashtra	330	138	124
Gujarat	260	1166	991
Andhra Pradesh	200	480	383
Tamil Nadu	150	90	21
Orrisa	150	187	211
Karnataka	60	19	3
Goa	200	5	5
Kerala	Sparse	Sparse	Nil
Total	**6740**	**4474**	**4827**

(Note: The values of the area has been rounded to the nearest 10 sq. km.)

*Govt. of India, (1987),** Nayak (1993),***Forest Survey of India (1997)

The table shows that there has been steady decline in the mangrove cover in the country. In Maharashtra alone over the period of past twenty years from 1987 to 1997 the mangroves have declined from 330 sq. km to 124 sq km (i.e. 62.43 %). This decline is a result of agriculture expansion and plantations in the rural areas and reclamation for developmental activities, urbanisation and industrial growth in urban and semi-urban areas.

In Maharashtra, conversion of mangrove area into agriculture land is going on with the help of state government's Kharland Department. In all coastal districts, there are offices of this department for converting coastal saline lands into agriculture land. Embankments (bunds) are basically constructed to prevent erosion and seawater intrusion in agriculture lands in Sindhudurg, Ratnagiri, Raigad, and Thane districts. In Most cases these bunds have been constructed on mangrove lands. In Mumbai, housing and road construction is the root cause for decline in the mangrove ecosystem by clear cutting and land reclamation in mangroves.

However, still some good but fragmented patches of mangroves are observed in Maharashtra along Achara, Deogad, and Vijaydurg in Sindhudurg district, Purnagad and Ratnagiri in Ratnagiri district, Kundalika in Raigadh district and Mubra- Diwa in Thane district. They provide shelter a great array of biodiversity of unique flora and fauna. These mangroves also function as sanctuary for a large diversity of local and migratory wildlife including birds.

As it is well known the mangrove are ecologically important as nourishing grounds for different species of brackish water fish. Many of the commercially useful species of fish spend part of their life cycle in the adjoining estuaries in mangroves. Organic and inorganic matter is the primary source of food for molluscs and shellfish such as crabs, shrimps, and prawns. The larval and juvenile forms of fish and prawn feed on this detritus in the estuaries. The mangroves provide roosting and breeding grounds for variety of birds such as egrets, ibis, herons, kites, harriers, cormorants etc. and reptiles and mammals. As per revised classification of forest types of India by Champion and Seth (1968), the mangrove forest fall under the type 4B/Ts1, Ts2.

In Maharashtra the coast is degrading rapidly due to severe and diverse anthropogenic activities. Population increases with increased demands for and misuse of resources leading to poverty is one of the main causes of mangrove degradation. Some of causes of the present status of mangrove in Maharashtra are as follows.

1 Biotic pressure for firewood near human habitations.
2 Construction of bunds for reclamation of saline lands for agriculture purpose
3 Industrialisation resulting into uncontrolled toxic pollution.
4 The reduction in fresh water inflow in estuaries
5 Potential threat due to man made natural hazards like oil pollution, toxic waste,
6 Sea level rise, cyclones and geotectonic changes damaging mangroves.

In order to understand current status of mangroves and the biodiversity supported by them, the present study is undertaken. Due to time and resource constrains only the four higher vertebrate taxa namely amphibians, reptiles, birds, and mammals were chosen as indicators of biodiversity richness.

Overall 30 mangrove sites, along the entire coast of Maharashtra in the four districts, were considered for the present study to review the current status of mangroves. It is observed that almost all mangrove ecosystems are declining in quality and expanse at much faster rate than expected. The local people seem to be still unaware of the environmental economic importance of mangroves. The governmental efforts for mangrove conservation, if any, are non-coordinated, inadequate, counterproductive, non effective, and far from satisfactory.
