CHAPTER 4: MANGROVE VEGETATION

4.1 DEFINITION

Mangroves are woody plants that grow at the interface between land and sea in tropical and sub-tropical latitudes. These plants, and the associated microbes, fungi, plants, and animals, constitute the mangrove forest community or mangal. The mangal and its associated abiotic factors constitute the mangrove ecosystem. The term "*mangrove*" has often been referred to both the plants and the forest community. To overcome this confusion, Macnae (1968) has proposed that "*mangal*" should refer to the forest community while "*mangroves*" should refer to the individual plant species. Duke (1992) defined a mangrove as, "...a tree, shrub, palm or ground fern, generally exceeding one half meter in height, and which normally grows above mean sea level in the intertidal zone of marine coastal environments, or estuarine margins." While this definition is generally accepted most workers believe that ground ferns should be considered mangrove associates rather than true mangroves. Mangrove forests are sometimes called "tidal forests", "coastal woodlands", or "oceanic rain forests" (Kathiresan & Bingham, 2001).

The word mangrove has evolved from the Portuguese word "mangue" and the English word "grove". The Dutch use "*vloedbosschen*" for the mangrove community and "*mangrove*" for the individual trees. It is believed that all the above words originated from the Malaysian word, "*manggi-manggi*" meaning "above the soil" (Kathiresan & Bingham, 2001).

Mangrove forests are among the world's most productive ecosystems. They grow at the interface between land and sea in tropical and sub-tropical latitudes where they exist in conditions of high salinity, extreme tides, strong winds, high temperatures and muddy, anaerobic soils. They are an extraordinary ecotonal forest community, which occur in inter-tidal estuarine regions, sheltered coastlines and creeks. There may be no other group of plants with such highly developed morphological and physiological adaptations to extreme conditions. Because of their environment, mangroves are necessarily tolerant of high salt levels and have mechanisms to take up water despite strong osmotic potentials.

Some also take up salts, but excrete them through specialized glands in the leaves. Others transfer salts into senescent leaves or store them in the bark or the wood. Still others simply become increasingly conservative in their water use as water salinity increases. Morphological specializations include profuse lateral roots that anchor the trees in the loose sediments, exposed aerial roots for gas exchange and viviparous water-dispersed propagules.

Mangroves create unique ecological environments that host rich assemblages of species. The muddy or sandy sediments of the mangrove habitat are home to a variety of epibenthic, infaunal, and meiofaunal invertebrates. Channels within the mangrove habitat support communities of phytoplankton, zooplankton, and fish. It plays a special role as nursery habitat for juveniles of fish whose adults occupy other habitats (e.g., coral reefs, seagrass beds, near-shore waters)

The submerged mangrove roots, trunks and branches that are surrounded by loose sediments are islands of habitat that may attract rich epifaunal communities including bacteria, fungi, macroalgae, and invertebrates. The aerial roots, trunks, leaves and branches host other groups of organisms. A number of crab species live among the roots, on the trunks or even forage in the canopy. Insects, reptiles, amphibians, birds and mammals thrive in the habitat and contribute to its unique character.

Living at the interface between land and sea, mangroves are well adapted to deal with natural stressors (e.g., temperature, salinity, anoxia, UV). However, because they live close to their tolerance limits, they may be particularly sensitive to disturbances like those created by human activities. Industrial effluents have contributed to heavy metal contamination in the sediments. Oil from spills and from petroleum production has flowed into many mangrove forests. These activities have had significant negative effects on the mangroves.

Mangroves and mangrove ecosystems have been studied extensively but remain poorly understood. With continuing degradation and destruction of mangroves, there is a critical need to understand them better. Aspects of mangrove biology have been treated in several reviews. Tomlinson (1986) described the basic botany of mangroves. Snedaker and Snedaker (1984) reviewed earlier mangrove research and made recommendations for further research. An overview of tropical mangrove community ecology, based primarily on Australian work, can be found in Robertson and Alongi (1992). Li and Lee (1997) reviewed much of the Chinese mangrove literature published between 1950 and 1995. Ellison and Farnsworth (2000) have recently published a general review of mangrove ecology. Kathiresan and Bingham (2001) have reviewed the biology of mangroves recently.

4.2 DIVERSITY IN MANGROVES

It is not possible to set a simple set of rules to account for the diversity of vegetation types within the broad generic concept of the mangrove habitat and so we have contrasted vegetation types distinguished by differing habitats but made up of only one species. This lack of uniformity is in fact a measure of the plasticity of mangroves and their ability to colonize an enormous range of habitats. Instability and change are consistent characters of the habitat. The most consistent feature of this habitat is the vegetation, which is easily recognizable as there are very few species. Just as a mangrove habitat is difficult to delimit in its transition to terrestrial and other offshore communities, it becomes rather arbitrary to determine the floristic limits of the group of plants that should be included in an account of mangroves. Several workers have given differing lists of species that should be included in an enumeration of mangroves. Tomlinson (1986) has put the number of mangrove species (including hybrids) at approximately 54, while Duke (1992) puts this number at 70. Tomlinson has defined mangroves as any woody, tropical halophyte that is an obligate inhabitant of the mangal and divided mangroves into the following major groups

1. Major elements of mangrove
2. Minor elements of mangrove
3. Mangrove associates.

The characters possessed by the major elements are enumerated in table 4.1. Among all the criteria listed, complete fidelity to the mangrove environment is most important. The minor elements of the mangrove habitat are distinguished by their inability to form a conspicuous element of the vegetation. They occupy peripheral habitats and only rarely form pure communities. Mangrove associates are rarely inhabitants of strict mangrove communities and occur mostly in transitional vegetation.

Table 4.1 Characteristic features of Major elements of a Mangrove habitat

Features of major elements of mangal (Tomlinson 1986)
1. Complete fidelity to the mangrove environment; i.e. they occur only in this habitat and do not extend into terrestrial communities
2. A major role in the structure of the community and the ability to form pure stands
3. Morphological specialization that adapts them to their environment
4. Some physiological mechanism for salt exclusion so that they can grow in sea water
5. Taxonomic isolation from terrestrial relatives. Strict mangroves are separated from their relatives at least at the generic level

4.3 FACTORS AFFECTING THE MANGROVE HABITAT

Due to their position along coastlines, mangrove formations are constantly controlled by marine and terrestrial factors such as local climate, geomorphology, salinity and other edaphic characteristics. These, together with the distance from the sea, the frequency and duration of inundation and tidal dynamics govern to a great extent the local distribution of species and their succession.

Best development of mangroves are found at locations with deep, well aerated soils, rich in organic matter and low in sand, usually in estuaries. The inland extent of mangroves depends on the morphology of the soil in addition to the above factors. Forests can vary in size from a few clusters of small trees or shrubs to extensive areas with well-developed stands. The world's greatest contiguous mangrove area is the Sundarbans situated in the Bay of Bengal, which covers a total land area of approximately 6,60,000 hectares.

There are several factors influencing the mangrove ecosystem, they are.

4.3.1 CLIMATE

Mangrove forests are found in three climatic divisions viz., (a) the equatorial zone approximately between 10° N and 10° S, (b) the tropical summer rainfall zone, north and south of the equatorial zone, to approximately 25°-30° N and S, partly in sub tropical dry zone of the deserts and (c) partly in warm temperate climates that do not have really cold winters and only on the eastern border of the continents in this zone. The factors under climate are

4.3.1.1 Light

Light is vital for photosynthesis and growth processes of green plants. It also affects the respiration, transpiration, physiology and physical structure of the plants. Light intensity, quality and duration are factors known to be important to plants. In general, mangrove plants are long-day plants and require high intensity of full sunlight (Macnae, 1968; Du, 1962). This makes tropical coastal zones an ideal habitat. The range of light intensity, which is optimal for the growth of mangrove species, is 3,000-3,800 Kcal/m^2/day (Aksornkoae, 1993).

4.3.1.2 Temperature

Temperature is of importance to physiological processes such as photosynthesis and respiration. However, there is little evidence of the relationship between temperature variation and the growth of plants in mangroves. Hutchings and Saenger (1987) carried out a study in Australia and found that *Avicennia marina* sprouted fresh leaves at temperatures of 18-20°C and observed that the higher the temperature, the lower the rate of new leaf production. For *Rhizophora stylosa, Ceriops* sp., *Excoecaria agallocha* and *Lumnitzera* spp., the highest rate of fresh leaf production occurred at 26-28°C. In general, the appropriate temperature for fresh leaf production of mangroves is the average temperature of the tropical zone, which is the best habitat for mangroves

4.3.1.3 Winds and Storms

Wind has a number of effects on the mangrove ecosystem. Not the least of these is the influence of wind on waves and currents in coastal areas, which cause coastal erosion and changes in mangrove structure. Plants often depend on winds as agents of pollination and seed dissemination. Wind can also increase evapo-transpiration of plants. Strong winds are capable of impeding plant growth and causing abnormal physiological characteristics.

4.3.1.4 Rainfall

The amount, duration and distribution of rainfall are important factors determining the development and distribution of plants and animals. In addition, rainfall affects other environmental factors such as air and water temperatures, salinity of surface and groundwater, which, in turn, affect the survival of mangrove species. Normally, mangroves thrive in areas with a range of 1,500-3,000 mm of annual rainfall. However, they can also be found in areas with rainfall as high as 4,000 mm per year distributed over a period of 8-10 months in a year.

4.3.2 GEOMORPHOLOGY

Mangroves generally dominate coastal zones with mudflats and tidal estuarine deltas. Topography is an important factor affecting the characteristics of mangrove structure, especially species composition, species distribution and the size and extent of mangrove forest. Along the submerged shoreline, mangroves form a narrow fringe. Larger areas of mangrove occur on larger coastal plains such as in Brazil. Characteristics of coastal plains, such as area, extent and location, are related to tidal inundation, sedimentation, and sediment characteristics. Mudflats and estuaries influenced by streams or rivers are generally associated with fertile mangrove areas supporting a vast diversity of plants and animals (as is seen in the Sundarbans forest in Bangladesh and India).

4.3.3 TIDES

In coastal areas, tides determine the zonation of plant and animal communities found within the mangroves. Tidal duration has a great influence on salinity changes in mangrove areas. Salinity of water is high during high tide and decreases during low tides. Moreover, water salinity varies during spring and neap tides. During spring tides, highly saline water intrudes further into the mangrove areas than during neap tides. Changes in water salinity due to tides is one of the factors limiting species distribution in mangroves, especially horizontal distribution. Tides also contribute to the exchange of mass between fresh water and salt water and thereby affect the vertical distribution of mangrove organisms. Tidal duration has similar effects on species distribution, vegetative structure and functions of mangrove ecosystems. Mangrove forests influenced by diurnal tides differ in structure and fertility from mangroves affected by semi-diurnal tides and those affected by mixed tides. Watson (1928) studied the existence and distribution of plants in mangroves of Malaysia and found that species composition and distribution in inundated areas differed according to duration of tides and frequency of inundation. Tidal range between high and low tides, or the intertidal zone, is a factor that affects, in particular, the root systems of mangroves. Prop roots of *Rhizophora* sp. in mangrove areas with a wide tidal range extend far above the soil surface, while those with a narrow tidal range of water have significantly lower roots.

4.3.4 WAVES AND CURRENTS

Waves in coastal areas are mostly created by wind. Coastal waves are important because they can cause coastal erosion and suspension of sediment. At sandy or muddy beaches, waves carry particles of sand and sediment out to the sea. Larger or coarser particles will precipitate, accumulate and form a sandy beach or sand bar. Most currents occur in association with tides, winds and waves. There are many types of currents in mangroves, such as, currents which flow along the rivers, straits or water channels; coastal currents which move along the coastlines during high and low tides; surface currents which move following the force of water mass, containing water with different temperature, salinity, depth and tidal duration; and currents below the surface which move the sediment by the force of water mass. Waves and currents in mangroves can directly or indirectly change the structural characteristics and functions of the mangrove ecosystem. They have a direct influence on distribution of plant species, for example, plants in the Rhizophoraceae family have seedlings which are carried to distant areas along the coast by waves and currents. Indirectly, waves and currents affect coastal sedimentation and formation of sand bars or sand dunes at river mouths. These areas can eventually be covered by mangroves. Therefore, in several coastal areas where there is an accumulation of sediments, the mangroves expand as the accreted land increases. Waves and currents not only influence the distribution and formation of mangroves, but also the survival of aquatic organisms, through transportation of nutrients from mangrove areas to the open sea.

4.3.5 SALINITY

Salinity and interstitial water salinity are important to growth rate, survival rate, and zonation of mangrove species. It affects the productivity and growth of mangrove forests (Sylla et al., 1996; Twilley and Chen, 1998). It can also strongly influence competitive interactions among species (Ukpong, 1995; Ukpong and Areola, 1995; Cardona and Botero, 1998). The distributions of plant species within the mangal, in many cases, can be explained primarily by salinity gradients (Ukpong, 1994; Ball, 1998).

In general, mangrove vegetation is more luxuriant in lower salinities (Kathiresan et al., 1996a). However, low salinity associated with long periods of flooding contributes to mangrove degradation through reduced cell turgor and decreased respiration (Triwilaida and Intari, 1990). In mangals with strong riverine input, the combined effects of evaporation and transpiration may remove much of the fresh water entering the system (Simpson *et al.,* 1997). The plants must, therefore, have some salinity tolerance. True mangroves (e.g., *Avicennia* spp. and *Rhizophora* spp.) tolerate higher salinity than do non-mangroves, but tolerance also varies among the true mangroves. For example, *Rhizophora mucronata* seedlings do better in salinities of 30 g l^{-1}, but *R. apiculata* do better at 15 g l^{-1} (Kathiresan and Thangam, 1990a; Kathiresan *et al.*, 1996b). *Sonneratia alba* grows in waters between 5 and 50 % seawater, but *S. lanceolata* only tolerates salinities up to 5% seawater (Ball and Pidsley, 1995). Mangrove seedlings require low salinity (S.M. Smith *et al.*, 1996), but their salt tolerance increases as they grow (Bhosale, 1994).

Short periods of high salinity may trigger events in the mangrove life history. For instance, high salinity at the end of dry period, followed by an extended rainy period controls establishment of *Rhizophora* seedlings (Rico-Gray and Palacios-

Rios, 1996b). Chronic high salinity, however, is always detrimental to the mangroves. Hypersalinity stunts tree growth in *A. marina* stands (Selvam *et al.*, 1991), reduces biomass in hydroponically grown *Bruguiera gymnorrhiza* (Naidoo, 1990), and causes denaturing of terminal buds in *Rhizophora mangle* seedlings (Koch and Snedaker, 1997). Saline interstitial water reduces leaf area, increases leaf sap osmotic pressure, increases the leaf area/weight ratio and decreases total N, K, and P (Medina *et al.*, 1995). Simple salinity fluctuations also have significant negative effects on photosynthesis and growth (Lin and Sternberg, 1993).

Extremely high salt concentrations in the groundwater of tropical salt flats are responsible for the complete absence of macrophytes (including mangroves). There are often very sharp changes in groundwater salt concentrations at the interface between salt flats and mangroves, suggesting that the mangroves are modifying the salinity of the groundwater (Ridd and Sam, 1996). Models of groundwater flow show that human activity hundreds of kilometers inland can destroy vast mangrove areas by changing groundwater flow and modifying salinity levels (Tack and Polk, 1997). The zonation of most mangrove animals is affected by that of the plant communities (Macnae, 1968). Variations in species composition and distribution of aquatic organisms due to salinity are dependent upon the osmotic adaptation of each organism.

4.4 GLOBAL DISTRIBUTION OF MANGROVES

Mangroves are distributed around the globe and occur in 112 countries and territories (Spalding, 1997). They dominate approximately 75 % of the world's coastline. Mangroves are largely restricted to latitudes between 30° north and 30° south. Northern extensions of this limit occur in Japan (31°22'N) and Bermuda (32°20'N); southern extensions are in New Zealand (38°03'S), Australia (38°45'S) and on the east coast of South Africa 32°59'S; Spalding, 1997). The mangrove extents are depicted in Plate 4.1.

The global coverage of mangroves has been variously estimated at 10 million hectares (Bunt, 1992), 14-15 million hectares (Schwamborn and Saint-Paul, 1996), 16.7 million hectares (Aksornkoae, 1993) and 24 million hectares (Twilley

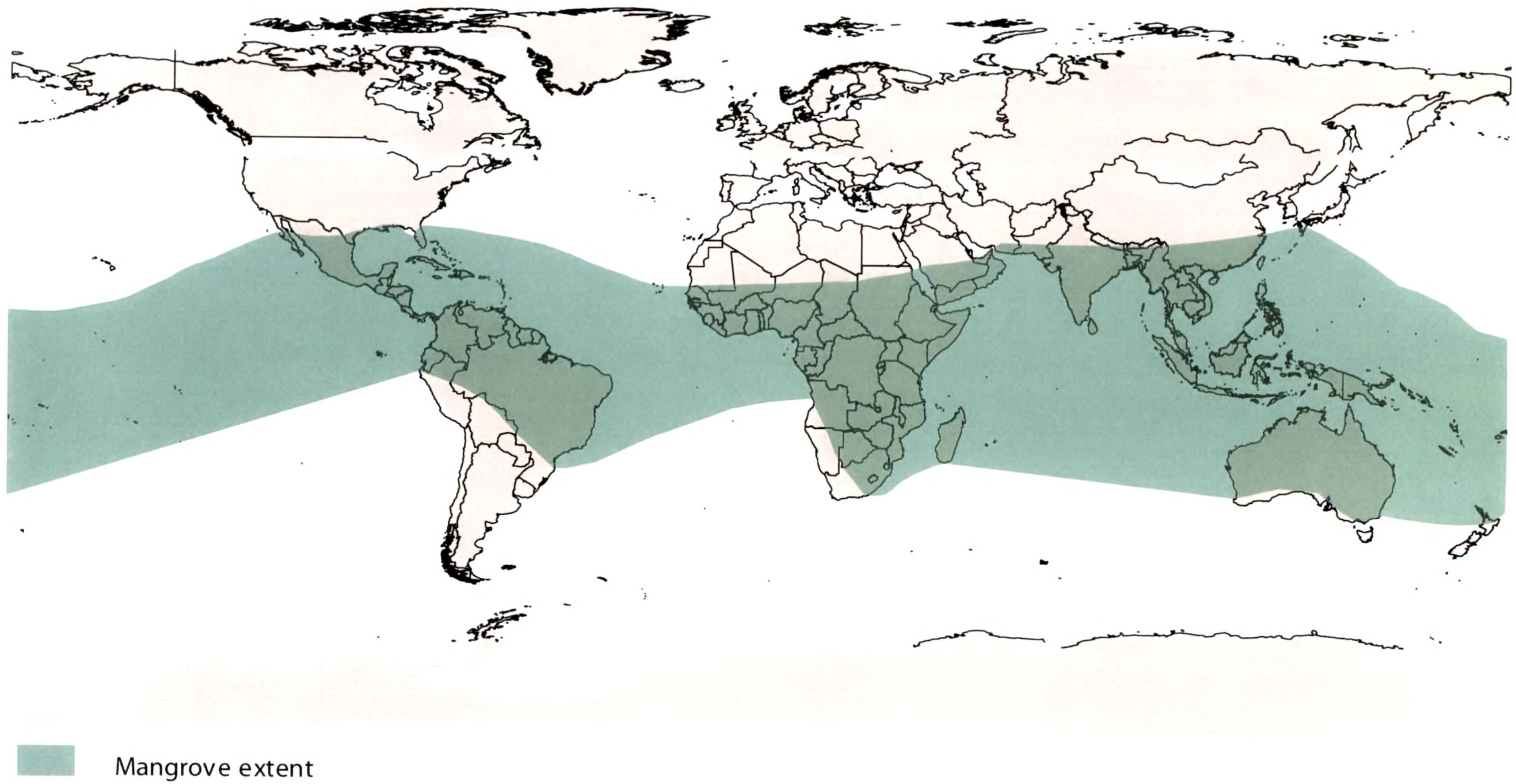


Plate 4.1 Global Distribution of mangroves (after Spalding, 1997)

et al., 1992). The best available estimate for global mangrove coverage has been given in the world mangrove atlas and this figure stands at just above 18 million hectares (Spalding, 1997). The estimates of mangrove areas in different regions of the world has been given in table 4.2.

Table 4.2 Areal coverage of mangrove forests

Region	Mangrove Area (Sq. Km)	Percent
South and South east Asia	75,172	41.4
The Americas	47,096	27.1
West Africa	27,995	15.4
Australasia	18,788	10.4
East Africa and the Middle East	10,348	5.7
Total	**181,399**	**100**

Most mangroves are found in the south and Southeast Asian regions with Indonesia alone accounting for 23 percent of the world's total. Just four countries (Indonesia, Brazil, Australia and Nigeria) have some 43 percent of the world's mangroves. The mangrove areas for the top eight countries in the world has been given in table 4.3

Table 4.3 Area of Mangroves in top 8 countries

Country	Area (sq. km)	Percent of World total
Indonesia	42,550	23.5
Brazil	13,400	7.3
Australia	11,500	6.3
Nigeria	10,515	5.8
Cuba	7,848	4.3
India	6,700	3.7
Malaysia	6,424	3.5
Bangladesh	5,767	3.2
Other Countries	76,697	42.3

A study of global mangrove distribution shows that there are two main centers of diversity and that they have very distinct floristic inventories in both size and composition. A graphical distribution of the mangroves has been given in fig 4.1 while the two groups have been described below,

Eastern Group: (essentially the eastern hemisphere) This group includes east Africa, India, Southeast Asia, Australia and Western Pacific. The total number of true mangrove species in this area is 40.

Western Group: (essentially the western hemisphere) This group includes West Africa, Atlantic South America, the Caribbean, Florida, Central America and the Pacific North and South America. The total number of true mangrove species in this area is only 8.

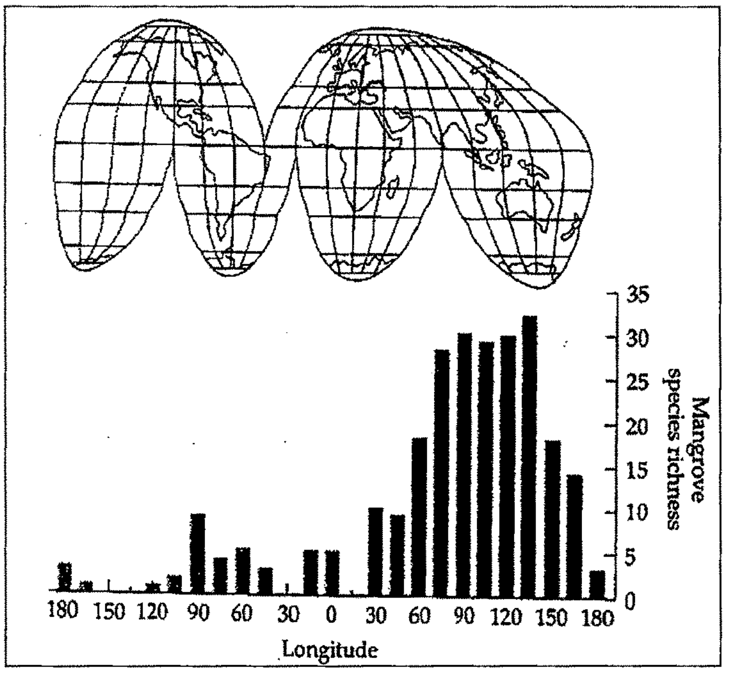


Fig 4.1. A map of the world showing mangrove distribution as well as gradients of species richness illustrating the biodiversity anomaly (adapted from Ellison & Farnsworth, 2001)

The widespread occurrence of mangrove vegetation and the floristic divergence between the 'old' and the 'new' world mangroves can only be explained by geological events. The composition of the modern mangrove flora at any one location while subject to present day climatic and geographical conditions, is largely relict (Tomlinson, 1986; Duke, 1995). The present distribution of individual mangrove species must be seen against the background of plate tectonics and continental drift.

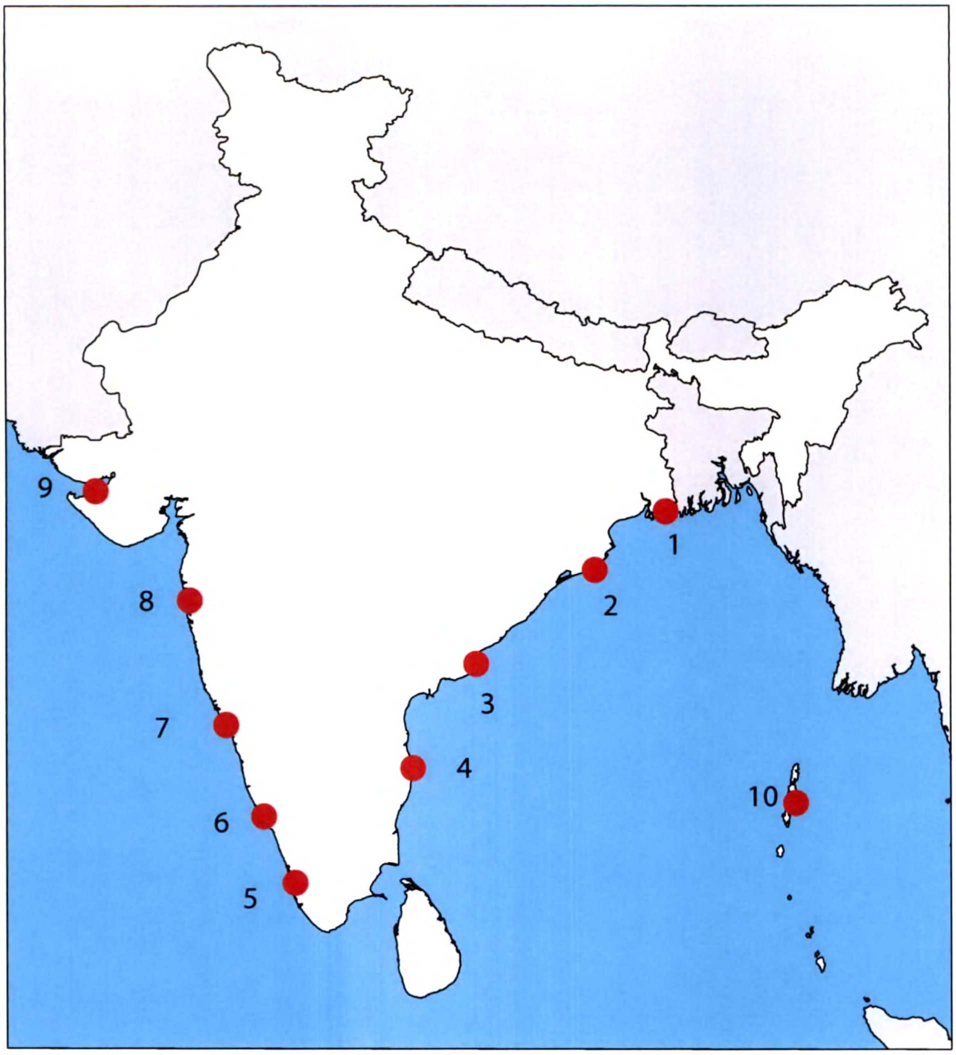
4.5 MANGROVE DISTRIBUTION IN INDIA

Mangroves are distributed along the deltas, estuaries, back-waters, bay islands, lagoons and coral Islands found along the 7,500 km long Indian coast. They are distributed along all maritime states of India except the union territory of Lakshadweep (Plate 4.2). The floral diversity of mangroves in India comprises 65 species which include major elements, minor elements and mangrove associates. They fall under 31 families and 59 genera (Banerjee & Ghosh, 1998). The first account of the Indian Mangroves is found in *Hortus Malabaricus* of H. van Rheede tat Drankenstein. This book on the flora of Malabar that gives detailed information on the mangroves of the region is also the first published account of mangroves in the world making India the pioneer in Mangrove research. However the mangroves of India did not receive adequate and sufficient attention till the late decades of the past century. This is despite the fact that about 4 % of the world mangroves still occur in India. There is also a great disparity in the extent of investigations in the different regions of India. The mangal formations of West Bengal, Tamil Nadu, Goa and Andhra Pradesh have been well studied on several aspects while the mangal formations in the other states have received little attention on aspects other than extent and floral diversity.

The mangroves in India are divided into three major zones

1. Mangroves of the eastern coast
2. Mangroves of the western coast
3. Mangroves of the Andaman and Nicobar Islands

Mangroves along the east coast of India are found on the deltaic coasts of the major rivers flowing into the Bay of Bengal like the Brahmaputra-Ganga, Mahanadi, Bhramani-Bhaitrani, Krishna, Godavari and Cauveri rivers. These provide the ideal conditions for mangrove growth and hence the east coast has a much higher diversity of mangrove species. Along the west coast no major riverine estuaries are present except the Kori Creek of the former Indus deltaic



Sr. No.	AREA
1.	**West Bengal**: Sundarbans, Subarnekha
2.	**Orissa**: Bhitarkanika, Mahanadi delta
3.	**Andhra Pradesh**: Godavari & Krishna delta
4.	**Tamil Nadu**: Pichavaram
5.	**Kerala**: Veli
6.	**Karnataka**: Coondapoor
7.	**Goa**: Chorao Is., Mandovi & Zuari estuary
8.	**Maharashtra**: Bombay, Vijaydurg & Devgadh creeks
9.	**Gujarat**: Gulf of Kachchh, Kori Creek
10.	**Andaman & Nicobar Islands**: Mayabandar, Shoal Bay, Porlob Jig

Plate 4.2 Major Mangrove Regions of India

system. As a result mangroves along the west coast are confined to narrow creeks, backwaters and islands. The diversity of mangrove species is also much lower on the western coast. The Andaman and Nicobar Islands harbour some of the best-developed mangrove vegetation in India and are the least disturbed of all Indian mangrove formations on account of their remoteness and inaccessibility. The detailed distribution of mangroves, major areas, the dominant component species and the major ecological factors affecting them for the various coastal states of India has been given below in table 4.4

4.6 MANGROVES IN GUJARAT

The mangroves in Gujarat are mostly confined to the Kori Creek and Sir Creek (the Indus Delta region) and the Gulf of Kachchh. Though they are also found in the Gulf of Khambhat and along the coast of Southern Saurashtra, they occur in these places as small patches and are mostly sparsely distributed.

Several authors have earlier worked on the vegetation diversity of the Saurashtra and Kachchh areas. Most of them have concentrated on the terrestrial vegetation of the region and have placed little emphasis on the coastal vegetation. A few of them have described the mangrove species and their distribution in the region. Cooke (1903, 1904, 1905) has given a list of the species of mangroves found in the Presidency of Bombay. Among all the species in the family Rhizophoraceae, he has indicated the presence of the genus *Rhizophora* in the study area by giving the distribution of the plant as from Sind to Kanara. He has not mentioned the specific presence on any other genera of mangroves to be in the study area. In his work Blatter (1908) has mentioned the presence of *Avicennia* along the northern shore of the Gulf of Kachchh. He has not studied the vegetation on the southern shore of the Gulf. Santapau (1950) just made a passing reference to the presence of *Avicennia alba* along the coast of Jodiya, however, in his 'Flora of Saurashtra' published in (1962) he has indicated the presence of *Rhizophora mucronata* and *Bruguiera gymnorrhiza* along Navlakhi creek *R. mucronata* was also reported from Dwarka. Kulkarni (1959a) has reported the use of pods and leaves of *Avicennia* by the domestic animals of the region. Blasco (1975) has reported that *Avicennia marina* var. *acutissima* was the most important woody

Table 4.4 The Status of Major Mangrove forests in India (compiled from various sources)

Sr. No.	State	Major Mangrove Areas	Area (sq. km.)		Major Mangrove Species	Major Remarks
			FSI (1999)	SAC (1992)		
1.	West Bengal	Sundarbans, Subarnekha	2,125	1,434	*Rhizophora apiculata, R. mucronata, Ceriops decandra, Bruguiera cylindrica, B. parviflora, B. gymnorrhiza, Kandelia candel, Avicennia alba, A. marina, A. officinalis, Aegiceras corniculatum, Xylocarpus granatum.*	• High tidal amplitude • High frequency of storms • High demographic pressure • Tectonic movement
2.	Gujarat	Kori Creek, Gulf of Kachchh, Gulf of Khambhat	1031	1052	*A. marina, A. officinalis, A. alba, R. mucronata, C. tagal, C. corniculatum*	• Climate not favorable • No freshwater influence • Severe industrial pressure. • Low in diversity and of short height.
3.	Andaman & Nicobar Islands	Austin Strait, Porlob Jig, Wandoor, Maya Bandar, Havelock Island, Shoal Bay, Katchal.	966	770	*R. mucronata, R. apiculata, C. tagal, B. gymnorrhiza, B. parviflora, X. granatum, Sonneratia alba, S. caseolaris, A. corniculatum, A. officinalis, Lumnitzera racemosa, Excoecaria agallocha, Nypa fruticans* and *Phoenix paludosa.*	• Least disturbed of the Indian mangroves. • Very luxuriant growth with height of upto 20 m. • High diversity • Low demographic pressure
4.	Andhra Pradesh	Godavari delta, Coringa, Kakinada Bay, Krishna Delta	397	330	*S.alba, S. apetala, A. marina, R. mucronata, R. apiculata, B. gymnorrhiza, C. decandra, X. granatum, L. racemosa, E. agallocha, Porteresia coarctata and Myriostachya wightiana.*	• Habitat destruction due to aquaculture, agriculture and pollution.

Sr. No.	State	Major Mangrove Areas	Area (sq. km.) FSI (1999)	SAC (1992)	Major Mangrove Species	Major Remarks
5.	Orissa	Mahanadi delta, Brahmani-Bhaitrani delta, Balasore coast.	215	193	*R. mucronata, C. decandra, C. tagal, B. cylindrica, B. parviflora, B. gymnorrhiza, K. candel, A. alba, A. marina, A. officinalis, A. corniculatum, X. granatum.*	• Habitat alternation for agricultural systems • Impact of development of port facilities
6.	Maharashtra	Bombay, Vijaydurg, Devgadh creek.	108	143	*A. alba, A. officinalis, A. marina, R. mucronata, A. corniculatum, B. gymnorrhiza, S. apetala, S. alba, L. racemosa, E. agallocha, A. illicifolius.*	• Fringing the banks of creeks.
7.	Tamil Nadu	Pichavaram, Muttupet, Tuticorin, Chatram	21	30	*A. marina, R. apiculata, R. mucronata, B. cylindrical, C. decandra, S. apetala*	• High demographic pressure • Hydrological change
8.	Karnataka	Coondapur, Mulki, Sita-swarna, Chakra-Haldi-Kolluru riverine complexes	3	13	*R. apiculata, C. tagal, K. candel, A. alba, E. agallocha, Cynometra* sp., *S. caseolaris*	• Small patches. • In patches along minor tidal creeks and rivers • Habitat destruction due to aquaculture development
9.	Goa	Mandovi and Zuari estuary, Cambarjua canal, Chorao island	5	5	*R. mucronata, S. alba, A. officinalis, R. apiculata, S. caseolaris, K. candel, B. parviflora, B. gymnorrhiza, A. corniculatum, E. agallocha, A. illicifolius.*	• Under high demographic pressures
10.	Kerala	Kumargom, Dharmadom, Chateri, Veli	0	-	*A. officinalis, R. mucronata, R. apiculata, B. gymnorrhiza*	• Extensive replacement by coconut plantation

species of mangrove of the region. He has also described the mangroves of the region as open scrubby type. Chavan (1985) had indicated the presence of *Bruguiera* along with *Avicennia*, *Rhizophora* and *Ceriops* on the islands on the Jamnagar coast like Pirotan. He has also mentioned the presence of *Sonneratia apetala* on the coastal stretch of Jamnagar. He had noted that the species of *Bruguiera* and *Aegiceras* were becoming rare in the area. Untawale and Wafar (1988) have reported the presence of *Avicennia marina, A. officinalis, Bruguiera parviflora, B. gymnorrhiza, R. mucronata, R. apiculata, Aegiceras corniculatum* and *Sonneratia apetala* from Pirotan and its surroundings. They have also reported the presence of *Ceriops* spp. along the coast between Okhamandal and Dhani. Naik *et al.* in (1991) had indicated the presence of *Avicennia* and *Rhizophora* on the islands of Pirotan. Singh (2000) has reported the presence of four species of *Avicennia*, *Rhizophora mucronata, Ceriops tagal* and *Aegiceros corniculatum* in the area while mentioning that two species, *Bruguiera gymnorrhiza* and *Sonneratia apetala* have not been found in recent surveys in the region. In an earlier study Singh (1994) had reported the presence of *Bruguiera* on the island of Pirotan. Except for Singh (2000), there has been no dedicated work on the mangrove flora of the region. He has however not worked on the mangrove associates and the halophytes in the region. The information available from all these sources have been enumerated in a concise form in table 4.5

Table 4.5 Past Reports of true mangroves of the Gulf of Kachchh

Sr. No.	Author	Species Present along South Gulf of Kachchh Coast	Species Specifically Present in Study area	Remarks
1.	Cooke (1903, 1904 and 1905)	*Rhizophora mucronata,* *R. conjugata*	-	The distribution has been given to be between Sind and Kanra. The distribution of any other mangrove specifically in the study area has not been given
2.	Blatter (1908)	*Avicennia alba*	-	The plant diversity on the Kachchh coast of the Gulf has been studied.
3.	Santapau (1950)	*Avicennia alba*	-	The presence of the species has been reported from Jodiya, which is to the west of the study area.
4.	Santapau (1962)	*Rhizophora mucronata, Bruguiera gymnorrhiza*	-	Both the species have been reported from Navlakhi while the first one has also been reported from Dwarka
5.	Rao and Shanware (1967)	*Avicennia marina* var. *acutissima*	-	This species has been reported to be occurring all over the Gulf.
6.	Blasco (1975)	*Avicennia marina* var. *acutissima*	*A. marina* var. *acutissma*	This species has been stated to be the dominant one in the study area
7.	Chavan (1985)	*Avicennia marina* var. *acutissma, A officinalis, Rhizophora mucronata, Bruguiera gymnorrhiza, Ceriops tagal, Aegiceras corniculatum, Sonneratia apetala*	*A. marina* var. *acutissma, A officinalis, Rhizophora mucronata, Bruguiera gymnorrhiza, Ceriops tagal, Aegiceras corniculatum*	*Bruguiera* and *Aegiceras* have been reported to become rare in the study area
8.	Anon (1987)	*Avicennia, Rhizophora mucronata, R. conjugata, Ceriops candolleana*	*Rhizophora mucronata, Ceriops candolleana*	The distribution has been given on the authority of Waheed (1957) and Kulkurni (1957). The mangroves of the Gulf have been described as scrubby.

Sr. No.	Author	Species Present along South Gulf of Kachchh Coast	Species Specifically Present in Study area	Remarks
9.	Bole and Pathak (1988)	*Avicennia marina, A. officinalis, Aegiceras cornulicatum, Bruguiera conjugata,*	*Avicennia officinalis*	*Aegiceras* has been reported from the Navlakhi creek and the northern parts of Saurastra. Both species of *Avicennia* have been reported from all over the coast.
10.	Untawale and Wafar (1988)	*Avicennia marina, A. officinalis, Bruguiera parviflora, B. gymnorrhiza, R. mucronata, R. apiculata, Aegiceras corniculatum, Sonneratia apetala* and *Ceriops candolleana*	*Avicennia marina, A. officinalis, Bruguiera parviflora, B. gymnorrhiza, R. mucronata, R. apiculata, Aegiceras corniculatum* and *Sonneratia apetala*	Mangrove species from both the North and South coasts of the Gulf have been given. They have reported that due to overexploitation the mangroves of the study area have become shrubby.
11.	Singh (2000)	*Avicennia marina, A. officinalis, A. marina, Ceriops tagal, Rhizophora mucronata, Aegiceras corniculatum,*	*Avicennia marina, A. officinalis, A. marina, Ceriops tagal, Rhizophora mucronata, Aegiceras corniculatum,*	He has not found the presence of *Bruguiera* and *Sonneratia* in the study area as well as other areas in the gulf of Kachchh

Table 4.5 Past Reports of true mangroves of the Gulf of Kachchh