Mangrove Forest in India

Mangrove forests are one of the most productive and bio diverse wetlands on earth. Yet, these unique coastal tropical forests are among the most threatened habitats in the world. They may be disappearing more quickly than inland tropical reinforests, and so far, with little public notice. Growing in the inter-tidal areas and estuary mouths between land and sea, mangroves provide critical habitat for a diverse marine and terrestrial flora and fauna. Healthy mangrove forests are key to a healthy marine ecology.

Mangroves are marine tidal forests and they are most luxuriant around the mouths of large rivers and in sheltered bays and are found mainly in tropical countries where annual rainfall is fairly high. Mangrove plants include trees, shrubs, ferns and palms. These plants are found in the tropics and sub-tropics on riverbanks and along coastlines, being unusually adapted to anaerobic conditions of both salt and fresh water environments. These plants have adapted to muddy, shifting, saline conditions. They produce stilt roots, which project above the mud and water in order to absorb oxygen. Mangrove plants form communities which help to stabilize banks and coastlines and become home to many types of animals.

However, in many areas of the world, mangrove deforestation contributing to fisheries declines, degradation of clean water supplies and salinisation of coastal soils, erosion, and land subsidence, as well as the release of carbon dioxide into the atmosphere. In fact, mangrove forests fix more carbon dioxide per unit area than phytoplankton in tropical oceans. Mangrove forests once covered ¾ of the coastlines of tropical and sub-tropical countries. Today less than 50% remain, and of this remaining forest, over 50% is degraded and not in good form. There needs be greater protection on primary or high quality mangrove sites knowing that the total remaining area will continue to decrease. Many factors contribute to mangrove forest loss, including the charcoal and timber industries, urban growth pressures, and mounting pollution problems. However, one of the most recent and significant causes of mangrove forest loss in the past decade has been the consumer demand for luxury shrimp, or “prawns”, and the corresponding expansion of destructive production methods of export-oriented industrial shrimp aquaculture. Vast tracts of mangrove forests have been cleared to make way for the establishment of coastal shrimp farm facilities.

MANAGEMENT OF MANGROVES IN INDIA

In India, mangroves occur on the West Coast, on the East Coast and on Andaman and Nicobar Islands, but in many places they are highly degraded. According to the Government of India (1987), India lost 40 percent of its mangrove area in the last century. The National Remote Sensing Agency (NRSA) recorded a decline of 7000 ha of mangroves in India within the six-year period from 1975 to 1981. In Andaman and Nicobar Islands about 22 400 ha of mangroves were lost between 1987 and 1997.

Table I

Area distribution of mangroves in India (thousand ha)

State/Union territory	Government of India, 1987	Government of India, 1997
West Bengal (Sunderbans)	420	212.3
Andaman and Nicobar Islands	119	96.6
Maharashtra	33	12.4
Gujarat	26	99.1
Andhra Pradesh	20	38.3
Tamil Nadu	15	2.1
Orissa	15	21.1
Karnataka	6	0.3
Goa	20	0.5
Kerala	Sparse	Nil
Total	674	482.7

India has a long tradition of mangrove forest management. The Sunderbans mangroves, located in the Bay of Bengal (partly in India and partly in Bangladesh), were the first mangroves in the world to be put under scientific management.

Other mangroves of the East Coast are found in the deltas of the Godavari, Krishna Mahanadi and Kollidam rivers and in smaller patches along the coast. The area's first management plan was implemented in 1892 (Chaudhuri and Choudhury, 1994).

More recently, the concern of the Government of India for the conservation of forests and wildlife was clearly demonstrated by a 1976 amendment to the Indian Constitution, which states that it shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife. Recognizing the importance of mangroves, the Government of India set up the National Mangrove Committee in the Ministry of Environment and Forests in 1976 to advise the government about mangrove conservation and development. In its first meeting, the panel, which consists of scientists, research scholars and experts on the mangrove ecosystem, emphasized the need to conduct a survey of the extent of existing mangrove areas within the country. The government subsequently introduced a scheme for mangrove conservation and protection, consisting of:

- Identification of selected mangrove areas for conservation;
- Preparation of a management plan;
- Promotion of research;
- Adoption of a multidisciplinary approach involving state governments, universities, research institutions and local organizations,

In 1979, the National Mangrove Committee recommended areas for research and development and for management of the mangroves, which included the following:

- Nationwide mapping of the mangrove areas, preferably by remote sensing techniques coupled with land surveys, and time series to assess the rate of degradation of the ecosystems;
- Quantitative surveys of areas, climatic regime, rate of growth of forest trees and seasonal variations of environmental parameters;
- Assessment of suitable sites for reserve forests; Conservation programmes;
- Afforestation of degraded mangrove areas;
- Study of management methods, the ecology of mangroves, their flora and fauna, their microbiology and the biochemistry of organic matter and sediments.

On the basis of the National Mangrove Committee's recommendation, 15 mangrove areas were identified for conservation. The Government of India has provided guidance and financial assistance to states and Union Territories for the preparation and implementation of Management Action Plans for the conservation and development of these mangrove ecosystems. Most of these plans are now being implemented. The plans broadly cover survey and demarcation, natural regeneration in selected areas, afforestation, protection measures, fencing and awareness programmes.

The government also supports research by academic institutions for development of mangrove ecosystems on a sound ecological basis. The National Forest Policy. 1988 lists effective conservation and management of natural forest ecosystems (including the mangrove ecosystem) as a priority area for forestry research.

The Environment (Protection) Act, 1986 has had a crucial role in the conservation and management of mangrove ecosystems. It declares a Coastal Regulation Zone in which industrial and other activities such as discharge of untreated water and effluents, dumping of waste, land reclamation and bunding is restricted in order to protect the coastal environment. Coastal stretches are classified into four categories, and mangroves are included in the most ecologically sensitive category.

Sundarban Forest:

Geographical location of Sundarban lies south-east of Calcutta in the 24-Paraganas District of West Bengal and forms part of the Gangetic Delta, which borders on the Bay of Bengal. Consists of Matla, Goashaba, Chhotahardi, Mayadwip, Chamta, Gona and Baghmara forest blocks, which are bounded by the Matla/Bidya and Haribhanga/Raimangal rivers to the east and west, respectively. The northern boundary is buffered by Netidhopani and Chandkhali forest blocks. $21^{o}31'$-$21^{o}53'$ N,$88^{o}37'$-$89^{o}09'$E. Altitude Ranges from sea level to 10m at the most.

The Sundarbans, covering some 10,000 sq.km. of mangrove forest and water (of which some 40% is in India and the rest in Bangladesh), is part of the world's largest delta (80,000 sq. km.) formed from sediments deposited by three great rivers, the Ganges, Brahmaputra and Meghna, which coverge on the Bengal Basin. The whole Sundarbans area is intersected by an intricate network of interconnecting waterways, of which the larger channels are often a mile or more in widthand run in a north-south direction. These waterways, apart from the Baleswar River on the eastern edge of the Bangladesh Sundarbans, now carrylittle freshwater as they are mostly cut off from the Ganges, the outflow of which has shifted from the Hooghly-Bhagirathi channels progressively eastwards since the seventeenth century (Seidensticker and Hai, 1983). This is due to subsidence of the Bengal Basin and a gradual eastward tilting of the overlying crust. In the Indian Sundarbans, the western portion receives some freshwater through the Bhagirathi-Hooghly river system but that portion designated as the tiger reserve is essentially land-locked, its rivers having become almost completely cut off from the main freshwater sources over the last 600 years (Sanyal and Bal, 1986), thus waterways in the tiger reserve are maintained largely by the diurnal tidal flow, the average rise and fall being about 2.15m on the coast and up to 5.68m on Sagar Island (Lahiri, 1973).

Tidal waves are a regular phenomenon and may be up to 7.5m high. The land is constantly being changed, moulded and shaped by the action of the tides, with erosion processes more prominent along estuaries and deposition processes along the banks of inner estuarine waterways influenced by the accelerated discharge of silt from seawater (Sanyal and Bal, 1986). About half of the Sundarbans is under water (Lahiri, 1973) and the rest of the landscape is characterized by low-lying alluvial islands and mud banks, with sandy beaches and dunes along the coast. As with the rest of the Bengal Plain, alluvial deposits are geologically very recent and deep, sediment of just the last few million years being as much as 1,000m thick (Seidensticker and Hai, 1983). The subsoil consists of alternate layers of clay and sand, gradually changing into shales and sandstone. The soil is clayey loam down to a depth of 1.1-1.4m and thereafter stiff black clay. It is alkaline due to an excess of sodium chloride (Lahiri, 1973).

Rainfall is heavy and humidity high (80% on average) due to proximity of the Bay of Bengal. The monsoon usually lasts from mid-June until mid-September, after which fair weather prevails until mid-March. The mean annual rainfall recorded at the observatory on the nearby Island of Sagar was 2002mm in 1937-1946, that for Jhingakhali Station in the northern part of the reserved forests was 1920mm in 1970-1972. Mean annual maximum and minimum temperatures recorded at the latter was 34^{o}C and 20^{o}C, respectively. Prevailing wind is from the north and north-east from October to mid-March, although January and February are calm. Violent south-west prevails from mid-March to September. Storms are common in May and October-November, sometimes developing into cyclones which are usually accompanied by tidal waves and cause much loss of life and damage to property and the forests (Lahiri, 1973). Meteorological data for

1955-1960 are presented by Mukherjee (1975). There are meteorological stations at Haldi, Jhingakhali and Sajnakhali.

The entire mangrove forest extends over an area of 4,262 sq.km. of which 2,320 sq.km. is forest and the rest is water (Mukherjee, 1975), and is called Sundarban owing to the dominance of the tree species Heritiera fomes, locally known as 'sundari' because of its elegance (Jain and Sastry, 1983).

This march Vegetation consists of elements of the Malayan Peninsular and Polynesian regions, together with some Indo-Chinese, Ethiopian and a few of the New World. It is not found elsewhere except in a small part of the Mahanadi and Godavari deltas to the south-west and the Bay Islands (Mukherjee, 1975). Prain (1903) lists 334 species found in the Sundarbans. Champion (1936) classified the Sundarbans as moist tropical seral forest, comprising beach forest and tidal forests. The latter are subdivided into four types, of which only low mangrove forest and salt-water **Heritiera** forests occur within Indian territory. Beach forest occurs on coastal islands comprising low sand-dunes which, together with lime formed from disintegrating shells and salt, give rise to a pronounced xerophytic habitat despite the high rainfall. Sand-dunes are partially covered with spear-grass, behind which are creepers and shrubs or trees, such as jhao **Tamarix troupli,** palita **Erythrina variegate** and **kulsi Aegiceras comiculatus**. Salt-water **Heritiera** forest (6-11m high), a low salinity vegetation type, occurs between the Raimangal and Matla rivers, where freshwater flows from the lchamati River into the Raimangal River. Characteristic species include garjan Rhizophora sp., kankra Bruguera gymnorhiza, goran Ceriops sp., and been Avicennia officinalis Heritiera fomes is scattered over areas of higher elevation, along with keora sonneratia apetala, gengwa Excoecaria agallocha, dhundul Carapa obovata and the date palm or hental Phoenix paludosa. The golpata palm Nipa fruticans is reatively uncommon but occurs on wet mud-banks along the creeks. Low mangrove forest (3-6m high) occurs between Matla and Muriganga, to the west of the National park and tiger reserve, this area being devoid of freshwater because its rivers are cut off from the ramifications of the Hooghly in the north. Soft mud, which is submerged by the tides, supports a dense forest,very similar in composition to salt-water Heritiera forest except that sundari and golpata are virtualyu absent. Goran and been are the commonest trees, occupying extensive areas but only growing up to 2m. Clusters of hental are very common. Certain forest tracts on low-lying islands were cleared some two hundred years ago and gradually claimed for cultivation. Various trees and other plants were introduced, including some exotics (Mukherji) 1975; also see Lahiri, 1975; Jain and Sastry, 1983). In a more recent examination of the composition and structure of the mangrove vegetation, 69 plant species are identified (Calcutta University, 1987). This report also includes inventories of algae, phytoplankton and fun. The following table I presents the fractions represented by forest and other land types in the Sundarban.

Table 2

(Source : Forest Resources Management Project 1998 (modified))

Type	**Area (km^2)**	**Percent**
Forest area	3997	66
Sandbars, grass, bare ground	115	2
Rivers	1905	32
Total SRF (of which 1397 km^2 represented by 3 wildlife sanctuaries)	6017	100

The Sewri Mangrove Park:

The Sewri Mangrove Park was declared a protected area by the Mumbai Port Trust on January 15,1996. This park consists of 15 acres of mangroves in the mudflats between Sewri and Trombay. The MPT has undertaken to protect this area from any new construction or dredging activity. It will also attempt to influence the chemical industries along the coastline to check air and water pollution by reinforcing effluent control measures. The Trust also plans to protect the park from residents of nearby areas who cut down the trees for fuel, as well as from unscrupulous developers who remove sand from the area , thereby weakening the grip of anchor roots.

Mangroves are essential to the ecology of the coast and the island. They provide fertile ground for fish to feed and breed in and nurture a large variety of birds. It is estimated that 800 species of birds either live in, or visit these swamps. In 1994 Flamingoes returned to mudflats after forty years. Seven species of mangroves have been identified in this area. The Bombay Nutural History Society (BNHS) helps the MPT to replant barren areas inside the reserve. This project is expected to cost about Rs. 500,000. In addition, biodiversity studies will be carried out using satellite imagery in addition to older techniques like forest inventory.

Similar efforts have been made to replant mangroves in Vikhroli-Ghatkopar in the early 90s. This was done BNHS and the Soonabai Phirojsha Godrej Foundation.. The BMC also has plans for replanting mangroves in the Thane creek region.

SITUATION IN GOA;

Out of Goa's total land area of 370000ha, the mangrove area is 500 ha having declined sharply from a recorded 20 000 ha in 1987. Some 178 ha of the best mangrove area at Chorao, Goa has been declared as Reserved Forest under the Indian Forest Act, 1927 to protect and conserve the mangrove forests. Subsequently, in 1988, this area was declared a bird sanctuary under the Wildlife (Protection) Act, 1972. Afforestation work to restore degraded mangrove areas started in Goa ion 1985-1986; by the end of 1996-1997 the programme had covered 876 ha (Forest Department of Goa statistics).

In 1988, The Government of Goa formed a State Level Steering Committee to oversee the development of the mangrove forest. In 1990, the State Government set up Multidisciplinary Project Formulation Team to facilitate the preparation of a Comprehensive Action Plan for the development of the mangrove ecosystem. The same year, the government decided that no construction or development would be allowed in the area earmarked by the Forest Department for mangrove conservation, and declared that 15 mangrove species should not be felled for a period of ten years. A five-year Mangrove Management Plan for Goa was prepared in 1991-1992 and implemented with financial assistance from the Government of India, and 100 ha of mangroves were planted each year as planned. A second five-year Management Plan is currently under implementation.

SITUATION IN ANDAMAN AND NICOBAR ISLANDS;

Andaman and Nicobar Islands comprise 572 islands in the Bay of Bengal, with a total area of about 825 000 ha. The coastline is about 1 962 km. The area under mangroves is 96 600 ha (Government of India, 1997). The Middle Andaman Islands comprise an area of 99 800 ha, of which 23 400 ha or 23.4 percent are covered with mangroves (Environment and Forest Department records).
In the past, fuel wood and poles were extracted from mangroves on a small scale to meet local demand including, in addition to household use, the fuelling of a power station at Port Blair, three major plywood industries and the governments steam vessels. Limited extraction did not cause any damage to the government mangrove forests, but in the revenue areas (areas managed in such a way as to allow local people to benefit from extraction of forest products) the destruction of mangroves is conspicuous. Some areas have been reclaimed for agriculture and settlements (Andaman and Nicobar Islands Environment and Forest Department, 1997). Since 1987, as a result of growing awareness regarding the conservation of mangroves, the Andaman and Nicobar Administration has banned extraction of mangrove wood. The plywood industries, power station and government steam vessels have since switched over to diesel.

The strategy adopted in Andaman and Nicobar Islands for the conservation and management of mangrove forests is as follows:

- Full protection of mangrove flora and fauna by banning the extraction of mangrove wood from government forests;
- Identification of potential mangrove areas for declaration as national parks and sanctuaries;
- Restoration of degraded and critical mangrove areas by planting of suitable species;
- Identification of endangered mangrove species and full protection for their rehabilitation;
- Checking encroachment, destruction and reclamation of mangrove areas;
- Monitoring changes in mangrove area, floristic and faunal composition and physiography;

- Raising awareness among the pubic on the importance of mangroves and the need for their preservation;
- Protection measures to keep vigil on possible destruction of mangroves.

MANGROVE CONSERVATION AND MANAGEMENT ISSUES:

Most of the challenges to mangrove forests observed in Goa and the Middle Andamans are also relevant to other parts of India. These include both natural hazards and destructive human activities. However, the gravity of the problems varies from area to area.

Natural hazards: The natural threats to mangroves observed in Goa and the Middle Andaman islands include the following:

- Cyclones, typhoons and strong wave action (Naskar and Mandal, 1999), especially in the geographically vulnerable Andaman and Nicobar Islands;
- Browsing and trampling by wildlife (e.g. deer, which are numerous in the Middle Andamans) and livestock (goats, buffaloes and cows), which are often left to graze freely, especially in areas close to human habitation;
- Infestation by barnacles which attach to young seedlings, interfering with respiration and photosynthesis and delaying seedling growth (Hong, 1996);
- Damage by oysters to the young leaves and plumules of Rhizophora and Ceriops plants;
- Crabs, which attack young seedlings, girdle the root collars and eat the fleshy tissues of the propagules- a serious problem in the Middle Andamans, although not noticed in Goa;
- Gastropods that eat young leaves and flowers of mangroves, a big problem in Middle Andamans;
- Insect pests such as wood borers, caterpillars (which eat the mangrove follage and damage the wood as well) (Naskar and Mandal, 1999) and beetles;
- Weeds such as Acrostichum aureum and Acanthus species, which often occupy deforested mangrove areas and restrict the re growth of economic mangrove tree species;
- Drying and mortality of mangrove trees (e.g. approximately 1 ha of Bruguiera trees at Shoal Bay in South Andamans; 50 ha of Avicennka trees at Tarmugli Island; big patches of mangroves at Baludera in the Middle Andaman Islands).

IMPACT OF SHRIMP CULTURE ON MANGROVES:

The fast development of the shrimp sector required the conversion of flat, coastal lands to shrimp ponds. Part of the shrimp pond construction took place in mangroves, and shrimp aquaculture has been an important cause of the conversion of mangroves in India in the last decade (Lakshmana Rao, Mahapatra andSubba Rao, 1994; Holmgren, 1994; Alagarswami, 1995; Krishnamoorthy, 1995; James, 1999). A recent survey by the

aquaculture sector found that about 5 percent of the shrimp acquaculture farms in India have been constructed in former mangrove area (ADB/NACA, 1998) (Table 3). Mangrove conversion has been undertaken by both small-scale extensive farms and by larger-scale semi-intensive and intensive farms (Vivekanandan, Muralidharan and Subha Rao, 1997; ADB/NACA, 1998).

Table 3.

Prior land use of shrimp farms (%)

Production system	Mangroves	Inter-tidal wetland	Rice farming land	Other, including fallow land
Traditional and extensive	3	20	32	45
Semi-intensive	7	8	5	80
Total [a]	5	14	18	63

A 966 farms, with a total surface of 3 560 ha. Source: ADB/NACA, 1998.

In order to determine the significance of the destruction of mangroves by aquaculture in relation to other factors having an impact on mangrove ecosystems, a case study has been carried out for the Godavari delta; Andhra Pradesh, by the Andhra Pradesh Remote Sensing Application Centre. The results of the classification of the images are presented in Table 4.

From the remote sensing images it is apparent that in the Godavari delta area, about 14 percent of the aquaculture farms have been constructed on mangrove lands. Shrimp aquaculture is responsible for about 80 percent of the conversion of mangrove land. Shrimp ponds are often located in sparse mangrove forests (see Maps). The decrease in the area of sparse mangrove cover is partly reversed by the convesion of dense into sparse mangroves, probably through fuel-wood collection and grazing.

Table 4.

The impact of shrimp aquaculture in the Godavari delta (ha)						
Land use	Land use area			Converted to shrimp farms		
	1989	1997	1999	1987-1997	1997-1999	1989-1999
Crop land				4 543	2 324	6 903
Fallow land				3149	1327	4497
Dense mangrove	16 586	15 987	15 318	433	471	1 137
Sparse mangrove	4530	3786	3199	604	666	1030
Total mangrove	21 116	19 773	18 517	1 037	1 37	2 167
Other				2 281	1 493	3 714
Aquafarms	2 006	13 032	19 239			
Total				17281	6251	17281
Sources: Remote Sensing Images from the Andhra Pradesh Remote Sensing Application Centre, 1999						

The rate of conversion of mangroves into shrimp ponds increased in the period 1997 to 1999, suggesting that shrimp pond construction started in fallow and crop lands, but then encroached on mangroves in the absence of suitable fallow land. Policy regulations banning the conversion of mangroves to shrimp ponds and the protected status of the Godavari forest have not been able to prevent the conversion of mangroves into shrimp ponds.

Comparison of land use and land cover in the Godavari delta in 1989 and in 1999, showing the encroachment of shrimp farms on mangrove land.

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