World Heritage Sites

Protected Areas and World Heritage

THE SUNDARBANS
BANGLADESH

The Sundarbans lie across the outer deltas of the Ganges, Brahmaputra and Meghna rivers. At 10,000 sq.km, it forms the largest estuarine mangrove forest in the world, 40% in India, 60% in Bangladesh. The adjacent World Heritage sites in India and Bangladesh cover just over a quarter of the area. The forest is composed of small forested islands and mudflats intersected by an intricate network of tidal waterways. It exemplifies the ecological processes of monsoon rain flooding, delta formation, tidal influence and plant colonisation.The area has a wide range of rare fauna, including the Bengal tiger, estuarine crocodile and many reptiles and birds. The devastation caused by Cyclone Sidr, especially to the forest in Bangladesh, emphasised how important mangrove forests, flood refuges and an early warning system are to protection of the coastal population.

COUNTRY
Bangladesh

NAME
The Sundarbans

NATURAL WORLD HERITAGE SITE
1997: The Sundarbans in Bangladesh inscribed on the World Heritage List under Natural Criteria ix, x

STATEMENT OF OUTSTANDING UNIVERSAL VALUE [pending]
The UNESCO World Heritage Committee issued the following statement at the time of inscription:

Justification for Inscription
The Committee inscribed the site under criteria (ix) and (x) as one of the largest remaining areas of mangroves in the world, which supports an exceptional biodiversity with a wide range of flora and fauna, including the Bengal Tiger and provides a significant example of on-going ecological processes (monsoon rains, flooding, delta formation, tidal influence and plant colonisation).

INTERNATIONAL DESIGNATION
1992: The Sundarbans Reserved Forest in Bangladesh designated a Wetland of International Importance under the Ramsar Convention (601,700 ha).

IUCN MANAGEMENT CATEGORY
IV Managed Nature Reserve

BIOGEOGRAPHICAL PROVINCE
Bengalian Rainforest (4.3.1)

GEOGRAPHICAL LOCATION
The Sundarbans mangrove forest lies among the creeks and distributaries of the Ganges and Meghna (Bramaputra) river deltas. The Bangladeshi site lies 2-300 km south-southwest of Dhaka between the Raimangal and Harinbhanga (Baleswar) rivers between 21°30' to 22°30'N and 89°12' to 90°18'E. Its South Sanctuary adjoins the Indian section of the forest.

DATES AND HISTORY OF ESTABLISHMENT

1875: The entire forest in the Twenty-four Paraganas, Khulna and Backergunje districts made a protected forest reserve under the Indian Forest Act of 1865. Much of the area was later leased out by the government for cultivation;

1926: The boundaries of the remaining protected forests were fixed by Notification 4457-For. Those in the Basirhat Division of the district were declared reserved forests in 1928 under Notification.15340-For and those in Namkhana Division in 1943 under Notification 7737-For;

1977: The separate Sundarbans South (17,878 ha), Sundarbans West (9,069 ha), and Sundarbans East (5,439 ha) Wildlife Sanctuaries established under the Bangladesh Wildlife (Preservation) (Amendment) Act of 1974;

1996: Each sanctuary extended to its present area.

LAND TENURE

Owned by the Government of Bangladesh. Management is by the National Forest Department.

AREAS

139,500 ha. The total area of both World Heritage sites is 272,510 ha.

Bangladesh:	Sundarbans West Wildlife Sanctuary	71,502 ha
	Sundarbans South Wildlife Sanctuary	36,790 ha
	Sundarbans East Wildlife Sanctuary	31,227 ha

The West and adjoining South Sanctuaries adjoin the Indian National Park.

ALTITUDE

Sea level to 3m at most,

PHYSICAL FEATURES

The Sundarbans are part of the world's largest delta, formed from the sediments brought down by three great rivers, the Ganges, Brahmaputra and Meghna, which converge on the Bengal Basin. The forest extends over some 200 islands, separated by 15 major distributary rivers flowing north-south, and 400 interconnected tidal estuaries, creeks and canals. It forms an impenetrable saltwater swamp reaching 100-130km inland, which supports the largest tidal mangrove forest in the world, covering 10,200 sq. km. Of this 595,500ha (59.3%) are in Bangladesh and 426,200ha (42.5%) in India, 232,000ha of which is land. The landscape is one of low-lying forested alluvial islands, 56 on the Indian side, mudbanks with sandy beaches, and dunes along the coast. The area is approximately three-fifths of the 16,700 sq.km that existed 200 years ago having been cleared and converted to agriculture, especially in India (Hussain & Archarya, 1994). The forest swamp, extensively embanked and empoldered, is an essential buffer for inland areas against the ravages of frequent cyclones from the Bay of Bengal. The nutrient-rich waters also provide the most important nursery for shrimps and spawning grounds for crustaceans and fish along the whole coast of eastern India.

The landscape is dynamic, constantly moulded and altered by tidal action, with erosion along estuaries and deposition along the banks of inner creeks augmented by the discharge of silt from seawater (Sanyal & Bal, 1986). The wider rivers of this intricate network of waterways are over two kilometres wide, run north-south and tend to be long and straight. They are maintained largely by the two diurnal flow tides and ebb tides over a tidal range of 3-5m up to 8m, together with the erosion-resistance of the clay and silt of their banks (Ghosh & Mandal, 1989). Innumerable small channels drain the land at each ebb but major coastal deposition occurs primarily in Bangladesh. There is a deep submarine canyon-head depression on the eastern Bengal shelf which forms a sediment trap where sedimentation increases. The way that waves diverge over the delta undersea, especially during monsoon gales, largely depends on the changing deep wave fields accompanying them which are affected by this trough. Flood currents deflect waves more to the east, ebb currents deflect them more to the west, and are important in the redistribution of river-borne sediments along the coast (Ghosh & Mandal, 1989; Michels *et al*., 1998). On the coast, easily eroded sands collect at the river mouths forming banks which are blown into dunes above high-water level by strong south-west monsoon winds. Finer silts are washed out into the Bay of Bengal and where they are protected from wave action, form mud flats in the lee of the dunes. These become overlain with sand from the dunes, and develop into grassy flats. This island-building process continues for as long as the area on the windward side is exposed to wave action. With the formation of the next island further out, silt begins to accumulate along the shore of the

island and sand is blown or washed away (Seidensticker & Hai, 1983). This process is most evident in the Bangladesh section of the coast.

The Sundarbans in Bangladesh are dissected by seven main north-south-flowing rivers, from the Rainagal, a branch of the Hariabhanga to the Baleswar, a mouth of the Meghna. These waterways, apart from the Baleswar River on the eastern edge of the East Sanctuary, now carry little fresh water as they are mostly cut off from the Ganges, the freshwater outflow of which over 400 years has shifted progressively eastwards from the Bhagirathi-Hooghly channels (Seidensticker & Hai, 1983). This shift is due to tectonic subsidence of the Bengal Basin during the 10th-12th centuries, and the continuing gradual eastward tilting of the underlying crust. Where the forest in India remains relatively stable and essentially land-locked, with rivers almost completely cut off from the main freshwater sources and therefore salt, the southeastern corner in Bangladesh is subsiding and is an area of active sedimentary deposition (Sanyal & Bal, 1986). The average salinity of water and soils therefore decreases markedly from west to east (Islam, 1973). The area has three main hydrological zones: brackish, moderately saline and saline, which influence the types of vegetation which dominate each. As with the rest of the Bengal Plain, the alluvial deposits are geologically very recent but deep, sediments of just the last few million years being as much as 1,000m thick (Seidensticker & Hai, 1983). The subsoil consists of alternate layers of sand and silty clay loam down to a depth of 1.1-1.4m and thereafter stiff black clay, gradually changing into shales and sandstone. The soils are saline, chiefly an alkaline clay with an excess of salt except on the seaward side of islands at the coastal limits, where sandy beaches occur (Lahiri, 1973). The pH ranges from 5.6 to 8.0 (Christensen, 1984). By comparison with the drier western Sundarbans the surface soil in the east is fertile silt loam, very suitable for tree growth (Choudhury, 1968).

CLIMATE

The climate is humid sub-tropical, tempered by the sea. Temperatures rise from daily minima of 2-4°C in winter to over 32°C during the monsoon and a maximum around 43°C in March. The mean annual maxima and minima recorded at the Jhingakhali meteorological station were 34°C and 20°C respectively. Rainfall is heavy and the humidity averages 70-80% due to the nearness of the Bay of Bengal. The mean annual rainfall varies from about 1,800mm at Khulna, and 1,920mm at Jhingakali north of the Sundarbans, to 2002mm recorded at the observatory on the western coastal island of Sagar and 2,790mm on the Bangladesh coast. 80% of the rain falls during the monsoon between mid-June and October, purging saline soils of their salt. From then to mid March the weather is dry until mid-March, a period when evapotranspiration exceeds precipitation. During the monsoon over half the Sundarbans is submerged under water. Conditions are most saline in February to April, when the depletion of soil moisture occurs at the same time as freshwater flows from upstream are reduced. From 1983 to 2003 the annual sea level rise was 3.14cm compared with the world average of 2cm and the outer islands began to erode away. A 25cm rise in sea level would destroy 40% of the Sundarbans, and a 45cm rise by the end of the 21st century would destroy 75% (Colette, 2007). Rising sea levels also increase saltwater intrusion into aquifers.

The prevailing wind is from the north and northeast from October to mid-March, although January and February are calm. However, violent southwesterlies prevail from mid-March to September. Storms, funnelled up the shallow upper Bay of Bengal, are common in May and from October to November, sometimes developing into cyclones which can be accompanied by storm surges up to 7.5m high, causing enormous loss of life, damage to property and forests, as in 1970 and 1991. The effects on India of the 2004 tsunami, and of the mid-year monsoon floods and cyclone Sidr were less drastic than in Bangladesh. There the effects of the 2004 tsunami were very bad and those of the July and September monsoon floods and cyclone Sidr in November 2007, disastrous on a huge scale. The strongest effects were felt between the Passur and Baleswar rivers in the East Sanctuary. Cyclonic winds reached 220 kph with a 6.5m storm surge which took over 5,000 lives, affected up to twelve million people in the area, and damaged or destroyed some one million homes, livestock, rice fields, forests and the fishing industry (Bangladesh Forest Department, 2008; Indian Water Portal Blog, 2007). Such storms vividly emphasise the protective function of the coastal forest but also the vulnerability of the Sundarbans to the effects of climate change.

VEGETATION

Mangrove swamp forest extends over half of the Sundarbans, the rest being largely brackish and salt water. The name comes from the dominant *sundari* tree *Heritiera fomes*, so called because of its elegance, and from *ban,* forest (Jain & Sastry, 1983). The vegetation consists of Malayan Peninsular and Polynesian elements, with some Indo-Chinese and Ethiopian elements, even a few from the New

World. It is found nowhere else except in small parts of the Mahanadi and Godaveri deltas to the southwest and in the Bay Islands (Mukherjee, 1975). The mangrove flora of the Sundarbans, which contains 27 species, is unique in comparison with non-deltaic coastal mangrove forests. Unlike these, the Rhizophoraceae and Avicenneaceae are of only minor importance: most of the genera are from the Sterculiaceae and Euphorbiaceae (Hussain & Acharya, 1994). The dominant species are *sundari Heritiera fomes*, *gewa Exoecaria agallocha*, *goran Ceriops decandra* and *keora Sonneratia apetala*. The *sundari* dominate where the soil water is relatively fresh, especially in the northeast, and on higher ground, and forms 60% of the commercially useful timber. The reason for the difference is the strong influence of freshwater. *Excoecaria agallocha* dominates the zone of moderately saline soils; and *Ceriops decandra*, the saline soils. Other mangrove species include *garjan* or red mangrove *Rhizophora mangle*, *R. mucronata* and *R. apiculata*, *kankra Bruguiera gymnorhiza*, and *baen* or Indian mangrove *Avicennia officinalis*.

The Sundarbans are classified as moist tropical seral forest, comprised of a mosaic succession of four types of tidal forest communities: low mangrove forest, tree mangrove forest, salt-water *Heritiera* forest and freshwater *Heritiera* swamp forest, now much cleared for settlement. The pioneer vegetation on newly accreted sites is *Sonneratia apetala*, followed by *Avicennia officinalis.* The *golpata* or nypa palm *Nypa fruticans* grows on levee banks, especially if they are well established. As the ground rises with soil deposition, *Exoecaria agallocha* comes to dominate, and when the land is only occasionally flooded, *Heritiera.* Beach forest occurs on coastal islands of low very xerophytic sand-dunes due to the lime from disintegrating shells and salt. The sand dunes are partially covered with spear-grass *Imperata cylindrica*, with behind them, creepers and shrubs or trees such as *jhao Tamarix troupii*, *palita Erythrina variegata* and *kulsi Aegiceras corniculatus*. Wild rice *Oryza coarctata*, *Nypa* and speargrass *Imperata cylindrica* are prevalent on mud flats (Khan, 1986) The large stands of *Sonneratia*, which colonises new mudbanks, provide important wildlife habitat (R.Salter, pers. comm., 1987). Though mangrove forests are not very diverse, there are many climbers, creepers, algal and fungal species on the forest floor. Prain (1903) described the flora of the mangrove forest of the Ganges-Brahmaputra delta, recording 245 genera and 334 species of plant as did Seidensticker & Hai in 1983 in the Bangladesh section, listing the principal woody and herbaceous species. Chaffey & Sandom (1985) also give a detailed list of trees and shrubs in the Bangladesh section and Islam (1973) gives an account of the mangrove algal flora.

All four types of tidal forest are found here. Sundarbans West is in the salt-water zone, which supports a dense understory of *Ceriops*, with sparse *Exoecaria* and intermittent patches of hantal palm *Phoenix paludosa* on drier ground, riverbanks and levees. *Carapa obovata*, *Bruguiera* and *passur Xylocarpus mekongensis* grow sporadically throughout the area. Sundarbans South where there is the greatest seasonal variation in salinity levels has relatively longer periods of moderate salinity where *Exoecaria* is the dominant tree, often mixed with *Heritiera*, frequently associated with a dense understory of *Ceriops* and some *Xylocarpus*. Sundarbans East where freshwater and sundari predominate, has some *Exoecaria* and *Xylocarpus*, with *Bruguiera* in areas of more frequent flooding. The *Nypa fruticans* palm growing along the creeks on wet mud-banks is widespread along drainage lines. There is an understory of *shingra Cynometra ramiflora* where soils are drier, *amur Amoora cucullata* in wetter areas and *Ceriops* in saline soils.

FAUNA

The Sundarbans is the only remaining habitat in the lower Bengal Basin with a great variety of fauna. 49 mammal species have been recorded, 45% of the Bangladeshi total. The Sundarbans support one of the subcontinent's largest populations of tiger, the Bengal tiger *Panthera tigris tigris* (EN), known for its swimming and man-eating. According to the WWF Tiger Programme in 2007 the area may now shelter about 350 tigers in the Bangladeshi section and an estimated 250 on the Indian side, though an IUCN Species Survival Commission study suggested that the latter may be fewer than 100 (UNESCO, 2002), and a report in 2011 from the National Tiger Conservation Authority cited a total of 70 in the Indian Tiger Reserve (Anon, 2011). Its high density relative to the availability of prey, and the number of encounters with local people in the Tiger Reserve are probably the reasons for its habit of man-eating (Hendrichs, 1975; Chakrabarti, 1986a). The only primate is rhesus macaque *Macaca mulatta*, considered to number about 68,200, based on a survey by Khan (1986). The smooth-coated otter, *Lutrogale perspicillata* (VU), which may number 20,000 (Hendrichs, 1975), is domesticated by fishermen to drive fish into their nets (Seidensticker & Hai, 1983). Other mammals include leopard cat *Prionailurus bengalensis* and jungle cat *Felis chaus.* Chital or Indian spotted deer *Cervus axis*, estimates of which vary between 52,600 (Khan, 1986) and 80,000 (Rahman, n.d.), and wild boar *Sus scrofa*, estimated at 20,000 (Hendrichs, 1975), are the principal prey of the tiger, together with macaques, crabs and fish. Aquatic mammals include the Ganges river dolphin *Platanista gangetica* (EN), Indo-Pacific hump-backed dolphin *Sousa*

chinensis, Irrawaddy dolphin *Orcaella brevirostris* (VU) and finless porpoise *Neophocaena phocaenoides* (VU) (Mukherjee, 1975). Species accounts and a check-list are given by Salter (1984).

Several of the larger species are now locally extinct due to agricultural reclamation and the increase in soil salinity during the 20th century. They include Javan rhinoceros *Rhinoceros sondaicus* (CR), Indian rhinoceros *Rhinoceros unicornis* (VU), Indian water buffalo *Bubalus arnee* (EN) last recorded in 1885, swamp deer *Rucervus duvaucelii* (VU), plentiful until the early 20th century, and Indian muntjac *Muntiacus muntjak*, last seen on Haliday Island in the late 1970s (Sanyal, 1983), gaur *Bos gaurus* (VU), and hog deer *Axis porcinus* (EN). Gharial *Gavialis gangeticus* (CR), mugger *Crocodylus palustris* (VU) and narrow-headed softshell turtle *Chitra indica* (EN) also became locally extinct last century (Salter, 1984; Sanyal,n.d.). Mukherjee (1975) gives an extensive account of the vertebrate and invertebrate fauna. Later inventories have been compiled by Sanyal (n.d.) and Calcutta University (1987).

The bird-life of the Sundarbans waterways is varied and colourful. A total of 315 species (39.5% of the national total) has been recorded, of which 84 are migratory (Hussain & Acharya, 1994), including about 95 species of waterfowl (Scott, 1989), 38 species of raptors and two pheasants (Sarker, 1985). Four of the rarer species are the greater and lesser adjutant storks *Leptoptilos dubius* (EN) and *L. javanicus* (VU), band-tailed fish-eagle *Haliaeetus leucoryphus* (VU) and masked finfoot *Heliopais personata* (EN). There are many other water birds, including Asian open-bill stork *Anastomus oscitans*, black-necked stork *Ephippiorhynchus asiaticus*, white ibis *Threskiornis melanocephalus*, swamp francolin *Francolinus gularis* (VU), collared and black-capped kingfishers *Todiramphus chloris* and *Halcyon pileata*, brown-winged and stork-billed kingfishers *Pelargopsis amauroptera* and *P. capensis*. Waders include the Asian dowitcher *Limnodromus semipalmatus*, a rare winter migrant, sandpipers, whimbrel, curlew and numerous others are seen on the muddy banks and sandbanks exposed during the dry season. Marsh birds in the reclaimed areas include great, little and intermediate egrets *Casmerodius albus*, *Egretta garzetta* and *Mesophoyx intermedia*, purple heron *Ardea purpurea*, a rare vagrant from Africa, and green-backed heron *Butorides striata*. Raptors include osprey *Pandion haliaetus*, white-bellied sea-eagle *H. leucogaster* (131 breeding pairs), the rarer grey-headed fishing eagle *Ichthyophaga ichthyaetus*, short-toed snake-eagle *Circaetus gallicus,* peregrine falcon *Falco peregrinus*, oriential hobby *F. severus*, northern eagle owl *Bubo bubo* and brown fish owl *Ketupa zeylonensis* (Sarker & Sarker,1985,1986). There are many species of gulls and terns along the coast and larger waterways. There is also a considerable variety of forest birds such as woodpeckers, barbets, shrikes, drongos, mynahs, minivets and babblers (Salter, 1984). Further details of the avifauna are given in Scott (1989).

Some 53 reptile species (53% of the national total) and 8 amphibians are recorded (Hussain & Acharya, 1994). The eighteen recorded species of snake include king cobra *Ophiophagus hannah* (VU) and spectacled cobra *Naja naja*, Asiatic rock python *Python molurus,* three vipers and six sea-snakes (Salter, 1984). Estuarine crocodile *Crocodylus porosus* (100 individuals) still survives, its numbers greatly depleted by hunting and trapping for skins. There are also three species of monitor lizards, Bengal, yellow and water *Varanus bengalensis*, *V. flavescens* and *V. salvator*. River terrapin *Batagur baska* (CR), Indian flap-shelled turtle *Lissemys punctata* and Indian peacock soft-shelled turtle *Nilssonia hurum* (VU) are present. Four species of marine turtle have been seen, olive ridley *Lepidochelys olivacea* (VU) being the most abundant. Green turtle *Chelonia mydas* (EN) is rare due to excessive fishing. Hawksbill *Eretmochelys imbricata* (CR) are caught by fishermen and loggerhead *Caretta caretta* (EN) have been reported on the beaches (Hussain & Acharya, 1994).

Over 120 species of fish are said to be commonly caught by commercial fishermen (Seidensticker & Hai, 1983) and 400 species are said to exist in all, with 20 shrimp, 8 lobster and 7 crab species regularly fished (Pasha & Siddiqui, 2003). Brackish water and marine species are dominant, freshwater species being found only in the Baleswar River on the eastern edge (Mukherjee, 1975). A rare species of shark, the Ganges river shark *Glyphis gangeticus* (CR) swims the estuaries. Mud-skippers or gobys, the walking and even tree-climbing fish characteristic of mangrove swamps occur in large numbers. There are 48 species of crabs and a large variety of molluscs. The crustacea form by far the largest proportion of the animal biomass, with an estimated 40 million kilograms of fiddler crabs and 100 million kilograms of mud crabs (Hendrichs, 1975). The area supports a varied insect population including 300 species of spider (Pasha & Siddiqui, 2003) and large numbers of honey-bees, but other insect life has been little studied. Note that figures quoted above before 1987 may refer to the Indian side only and that references may not distinguish between that section and the whole area.

CONSERVATION VALUE

The Sundarbans are the world's largest halophytic mangrove forests and one of the most biologically productive of all natural ecosystems. In the 1860s they were the first mangrove forests to be scientifically managed. They contain a rich biota which includes the Bengal tiger and many threatened reptiles. They are also of great economic importance as a storm barrier, a shore stabiliser, a nutrient and sediment trap, a source of timber and natural resources, and before cyclone Sidr were the most important source of fish and shrimps on the east Indian coast, They are an excellent example of the ecological processes of monsoon rain flooding, delta formation, tidal influence and plant colonisation. They lie within a WWF Global 200 Eco-region, and are contained by both a Ramsar Wetland and a UNESCO Biosphere Reserve which contains the Tiger Reserve, National Park and three wildlife sanctuaries.

CULTURAL HERITAGE

In Bangladesh there is archaeological evidence of early human occupation on the deltaic islands which indicate the former presence of abundant freshwater, both from the Ganges and from non-saline ground water. Human occupation ceased in the 17th century, reportedly due to pirate attacks (Christensen, 1984). A ruined Hindu temple at Shekher Tek draws an annual festival (Ramsar, 2004). The Sundarbans feature in Bengali literature, for example, Bankim Chandra Chatterjee's novel *Kapal Kundla,* Amitav Ghosh's 2004 novel, *The Hungry Tide* and part of Salman Rushdi's *Midnight's Children*.

LOCAL HUMAN POPULATION

Approximately 2.5 million people lived in small villages surrounding the Sundarbans in 1981 which by 1991 had increased to 3 million (Ministry of Environment & Forests, pers. comm., 1995). At nomination, some 35,330 people worked in the forest, 4,580 of whom collected timber and firewood, 1,350 collected honey and beeswax and 4,500 harvested the natural resources and hunted mainly deer, and 24,900 were fisherman and shrimp farmers (Chakrabarti, 1986a). Today, the area provides a livelihood at some seasons of the year for an estimated 300,000 people. Some 4,500 people in Bangladesh are employed by contractors in the commercial logging of sundari and other timber, which is 45% of all that produced in state-owned forests. As well as construction timber they supply local newsprint paper, match and board mills (Hussain, 1997).

Local people are also dependent on the forests and waterways for charcoal, timber for boats and furniture, poles for house-posts and rafters, nypa palm thatch for roofing, grass for matting reeds for fencing, shells and reptile skins, with deer, fish, crabs and shrimps taken for food. The season for collecting honey and wax is limited to ten weeks from April 1st. Thousands of people, with permits from the Forest Department, enter the forest for nests. Honey production is discussed by Chakrabarti (1987c). Before Cyclone Sidr, which destroyed the fishing industry, more than 10,000 fishermen from as far away as Chittagong camped along the coast for 3-4 months in winter before returning home at the start of the monsoon season in April, and as many or more local people fished year-round (Hussain, 1997). In 1986 the average annual catch was 2,500 tonnes (Chakrabarty, 1986). Several activities encroach on tiger habitat, and throughout the Sundarbans some 300 people are killed by tigers or crocodiles each year. Transport is only by boat. Because of the annual flooding, only one crop can be taken each year. The people are therefore poor.

VISITORS AND VISITOR FACILITIES

Few tourists visit due to the difficulty and cost of arranging transport and to the lack of suitable accommodation and other facilities, - very few after cyclone Sidr in 2007. However, in 1996, about 500 foreign tourists plus 5,000 local tourists visited the area, most in the South Wildlife Sanctuary. and in recent years more than 100,000 local and about 1,500 foreign tourists per year visited the Sundarbans (BFD, 2008). There is no potential for mass tourism but limited eco-tourism from October to April or May is possible. Jungle trails, wildlife watching, fishing and beaches are available. The use of launches equipped with catering and sleeping facilities is more practicable than permanent land-based facilities and provide greater flexibility. There are large well-equipped rest houses with observation towers belonging to the Forest Department at Katka in the East and Hiron Point in the South Sanctuaries (Blower, 1985). However, investment in transport facilities may be lost owing to the increasing effects of climate change.

SCIENTIFIC RESEARCH AND FACILITIES

The Bangladesh Forest Research Institute was established in 1955, and mangrove research was initiated in 1985. In the first 15 years considerable information was generated and some 100 research papers were published on various aspects of mangroves. An outline of the ecology, botany and forestry

was given by Blasco in 1977.Faunal surveys include those of Gittins (1981) and Khan (1986) on rhesus macaque, Khan (1986) on spotted deer, Sarker and Sarker & Sarker on birds of prey (1985a & 1985b) and on other birds in 1986. Eight field stations provide data for a number of ongoing studies and researchers. An information and education centre was recently established at Khulna (Ramsar, 2004).

MANAGEMENT

The Sundarbans is the only large mangrove forest in the world managed for commercial timber production and has had a history of scientific management since 1879. In Bangladesh it is now managed by the Sundarban West Forest Division and Sundarban East Forest Division of the Forest Department, divided into four administrative ranges, Chandpai, Sarankhola, Khulna and Burigoalini, originally guarded by 16 forest stations. 55 compartments and 9 blocks are harvested in turn on a 20-year cycle, along with the three peripheral wildlife sanctuaries on the coast. Early management consisted of revenue collection by enforcing simple felling rules, subsequent enforcement of which reduced the amount of over-cutting of the four main timber species. A wildlife conservation plan prepared under the joint sponsorship of the World Wildlife Fund and the U.S. National Zoological Park emphasised management of the tiger and other wildlife as an integral part of sustainable forest and coastal management for both timber and the needs of the local population (Seidensticker & Hai, 1983). But the forest is now showing signs of degradation.

Well supported missions in the recent past have also thoroughly inventoried data on the forest as a basis for integrating the conservation of wildlife with profitable exploitation of timber, forest products and fisheries (Christensen, 1984; Salter, 1984; Blower, 1985). Under a plan drawn up in the late 1990s for managing the area as a single unit, buffer zones in peripheral areas were recommended in order to limit disturbance by restricting access. An Integrated Sundarbans Management Plan has been prepared under the Sundarbans Biodiversity Conservation Project funded by the Asian Development Bank (Ramsar, 2004). Three field stations have been established in Sundarbans West. There are no recognised local rights within the reserved forest. Entry and collection of forest produce are by permits issued by the Forest Department which may also issue hunting licences under the Bangladesh Wildlife (Preservation) (Amendment) Act, 1974. In practice none are issued and the whole Sundarbans is effectively closed to legal hunting. Under the provision of this Act, activities prohibited within the wildlife sanctuaries, include residence, cultivation of land, damage to vegetation, hunting, introduction of domestic animals and setting of fires. Any of these prohibitions may be relaxed for scientific purposes, aesthetic enjoyment or ‘improvement’ of scenery (Blower, 1985). The forest swamp is an essential buffer to inland areas from the ravages of cyclones and is now augmented by an efficient early-warning system and the building of concrete cyclone shelters.

MANAGEMENT CONSTRAINTS

The site is notable for a long history of scientific management and wise use of its wetland resources with protected areas established along the southern periphery. But a long-term ecological change is taking place in the Sundarbans, due to the eastward migration of the Ganges and the rise in sea levels. Forest cover, species diversity and ecosystem function have declined despite the several forest policies, laws and management plans enacted to protect them, the effectiveness of which is limited by poor implementation. Major anthropogenic disasters include over-exploitation of timber, of animals by poaching, of resources such as trawling for prawn seeds, irrigation and drainage canals, embankments for fisheries and shrimp ponds, and pollution from aquaculture, oil spills and dumped wastes.

The most pressing ongoing threat has been over-exploitation, both of timber resources and the fauna. Some agricultural encroachment has already occurred on the eastern and western boundaries and, with increasing population pressure in surrounding settled areas, could become serious unless checked. 18,200 hectares of the Chokoria Sundarbans was completely destroyed in recent years by shrimp farming (Akhtaruzzaman, 2000). Fishermen's camps are a major source of disturbance. Extensive illegal hunting and trapping is practised not only by fishermen and woodcutters but also reportedly by naval and military personnel from Hiron Point in the South Wildlife Sanctuary (Blower, 1985). A total of 118 offences was recorded and over 3,300m of deer nets were removed between 1981/82 and 1986/87 (Habib, 1989) but this poaching is now rare. The capture of adult marine turtles and river terrapin for food is a potentially serious problem (R.Salter, pers. comm., 1987). Smugglers moving to and from India with contraband goods also use the area.

Oil spills could cause immense damage to aquatic fauna and seabirds and probably to the forest itself (Blower, 1985). There have been several spillages from tankers passing nearby. In August 1994 a Panamanian cargo ship capsized near Dangmari Forest Station, oil from which spread about 15 km

downstream causing instant mortality of seedlings of *Heritiera* and *Excoecaria* and of grasses covered by oil. Mortality of fishes, shrimps and other aquatic animals from the Sundarbans was ascribed to the spill (Hussain & Acharya, 1994). The reduction in fresh water flow due to upstream water diversion, the construction of dykes combined with the pollution from the industries and the ports of Khulna and Mongla have greatly affected the plant and fish population of Sundarbans (Ramsar, 2004).

Cyclones and tidal waves normally cause some damage to the forest along the sea-face, and result in considerable occasional mortality among spotted deer. However, the effects of the 2004 tsunami were bad, but those of the July and September monsoon floods and cyclone Sidr in 2007 were totally disastrous, especially in the East Sanctuary. Cyclonic winds and a 6.5m storm surge along 100 km of coast took over 3,500 lives, affected up to four million people, damaged or destroyed some one million homes, livestock, rice fields and the region's entire fishing industry (Indian Water Portal Blog, 2007). A UNESCO Mission found that 40% of the site had been seriously damaged, most of it World Heritage site. Regeneration of the Sundarbans ecosystem, should normally take 10 to 15 years, if poaching and other intrusions do not jeopardize this. The field stations, boats, jetties and equipment of the Bangladeshi Forest Department in the area were washed out to sea by the storm, severely limiting the authority's capacity to manage the site and to prevent poaching of marine and terrestrial fauna and flora for commercial and subsistence purposes (UNESCOPRESS, 2007). The early warning system and concrete cyclone shelters limited the damage, but such storms emphasise the important protective function of the coastal forests, flood refuges and prompt evacuation. Recovery will take time and much help to restore the infrastructure, field stations and equipment sufficiently to prevent uncontrolled exploitation before order returns. Over US$100,000 was granted by the international community towards recovery though this could restore little of the destroyed infrastructure. Two years later many field stations remained unusable, particularly in the east, and radio-communications towers remained out of service. However, a 5-year rehabilitation project was being developed (UNESCO, 2009).

STAFF

In 1997 there were 3 field stations in Sundarbans West Wildlife Sanctuary each with 95 staff (2 officers and 7 forest guards). There were 2 stations in the South Wildlife Sanctuary and 3 in the East Wildlife Sanctuary but Cyclone Sidr damaged or destroyed much of this infrastructure in both areas.

BUDGET

The Government funds management of the forest but no specific information on the site is available. In 2008 UNESCO released US$78,500 to replace forest service infrastructure damaged by cyclone Sidr; and UNDP, FAO, UNDP and the World Bank are assessing the needs for short term monitoring and rehabilitation (B.F.D., 2008). According to a World Bank analysis, Bangladesh annually received US$1 billion in assistance 22-53% of which finances projects related to water supplies and climate change (Agrawala, S., *et al*., 2003). After cyclone Sidr in 2007 international sources granted US$75,000 emergency assistance and Switzerland granted US$32,590, which helped the acquisition of 12 patrol vessels and the restoration of 6 field station staff lodges, repair 11 boats and restore 2 field stations and a wildlife sanctuary shed (UNESCO, 2009).

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