IUCN Conservation Outlook Assessment 2017 **(archived)**
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Sundarbans National Park

SITE INFORMATION

Country:
India
Inscribed in: 1987
Criteria:
(ix) (x)

Site description:
The Sundarbans covers 10,000 km2of land and water (more than half of it in India, the rest in Bangladesh) in the Ganges delta. It contains the world's largest area of mangrove forests. A number of rare or endangered species live in the park, including tigers, aquatic mammals, birds and reptiles. © UNESCO

SUMMARY

2017 Conservation Outlook

Good with some concerns

The values of the Sundarbans National Park remain in good condition overall, and the management of the site is largely effective. However, the site is threatened by multiple on-going threats from both within and external to the site. While it appears that the site’s biodiversity values (rare and threatened mammals, birds and reptiles) are largely stable, degradation of the floral diversity (globally endangered Sundri mangals) and on-going ecological processes has been, and continues to be, a major issue. Should the intensity of these threats increase in the future, the situation for the Sundarbans National Park’s rare and threatened species could alter dramatically. Sea level rise, hydrological alteration and coastal erosion have been severe, and the long-term impact of climate change on the integrity of the site’s values is a cause for concern. Conservation programmes for rare and threatened vertebrates, law enforcement for illegal activities, community participation in site management and alternative livelihoods, as well as reduction of human-wildlife conflicts have been largely effective. However, funding and capacity are currently inadequate and, if not addressed, may in the near future lead to increasing challenges to maintain the site's value’s in the face of the multiple threats, and particularly under increasing future population and climatic pressures. Studies into the resilience of the site and its values under the predicted changes to ecological processes as a result of climate change are necessary in order to develop and refine effective management action. Increasing transboundary cooperation with The Sundarbans, Bangladesh World Heritage site, including frequent coordination meetings between management authorities, is an essential positive step to develop effective regional strategies for climate change adaptation.

Current state and trend of VALUES

Low Concern
Trend: Deteriorating

The Sundarbans remains the largest continuous mangrove forest in the world, despite being almost half the size of the area that existed in the late 1800s. Degradation of the Sundarbans National Park's mangrove diversity (due to degradation and disappearance of globally endangered Sundri trees), biomass production, primary productivity and on-going ecological processes of tidal inundation, siltation and sediment dynamics, plant colonization and delatic and bank formation continues to be significant due to natural and anthropogenic alterations to the hydrology and ecology of the site. This degradation of the ecological values of the site is increasing and this trend is likely to continue with increasing population pressure and climatic changes. Available data on the site's rare and threatened mammals (i.e. the Royal Bengal tiger) and reptiles show that populations remain relatively stable, likely due to good legal protection and enforcement within the site and excellent breeding programmes for critically endangered reptilian species (Northern river terrapin, olive ridley turtle and estuarine crocodile). While monitoring of most mammal populations is currently insufficient to assess the status and trends of populations, this situation seems likely to be promising given the situation of the Bangladeshi populations of Ganges River dolphin and Irrawaddy dolphin. Thus, it appears that the effects of ecosystem degradation on the site's Outstanding Universal Value are currently not extreme, though ecosystem-level assessments of the impacts of threats is necessary to fully determine the resilience of the sites values. As the number and intensity of threats is likely to increase in the future, greater adequate and sustainable management action and capacity will be required.

Overall THREATS

High Threat

The current and potential threats to both the aquatic and terrestrial elements of the property are many. Largely effective management of the Sundarbans National Park means that current threats to the site are minimized. However, the Sundarbans National Park is part of the wider Sundarbans ecosystem, and activities both within the site's buffer zone and within the wider Sundarbans and the Bay of Bengal provide cause for concern in regards to the site's Outstanding

Universal Values. Future threats from sea level rise and increased frequency and intensity of extreme weather events (storms and tidal surges) under climate change are severe. The site's ecological and biodiversity values are all affected by these pressures and the Outstanding Universal Values of the site are therefore under serious threat in the future.

Overall PROTECTION and MANAGEMENT

Mostly Effective

The protection and management of the Sundarbans National Park's is currently good, and provides many examples of Best Practice. However, greater focus on monitoring of populations including aquatic animals, and research into biodiversity and ecosystem resilience in the face of current and future threats are issues not currently being adequately addressed. In addition external pressures on the site's buffer zone and from activities within the wider Sundarbans ecosystem, means greater focus on efforts to preserve its values from threats outside the site is needed. Funding and capacity is inadequate to tackle these wider threats, and boundaries and transboundary management with the Sundarbans, Bangladesh World Heritage Site should be increased in order to adequately address these issues, particularly in the face of climate change.

FULL ASSESSMENT

Description of values

Values

World Heritage values

- **The largest area of mangrove forest in the world**
  Criterion:(ix)

  The wider Sundarbans, which includes the Sundarbans National Park is the largest area of mangrove forest in the world and the only one that is inhabited by the tiger. The land area 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. Its role as a nursery for marine organisms and as a buffer against cyclones, represent just some of the natural process encompassed in the site (SoOUV, 2012).

- **Rare and threatened terrestrial and aquatic mammals**
  Criterion:(x)

  The Sundarbans provides the only remaining habitat in the lower Bengal Basin for many faunal species. 31 known species of mammal are recorded for the property (Gopal & Chauhan, 2006). The flagship mammal species of the area is the Royal Bengal tiger Panthera tigris ssp. tigris (EN) with the Sundarbans the only mangrove habitat in the world that contains tigers. The Indian Sundarbans population is currently estimated at 64-90 individuals (Jhala et al., 2011).
  The only ungulates present in the Sundarbans National Park are wild boar, Sus scrofa (LC), and spotted deer, Axis axis (LC), and the only primate is the

rhesus macaque, Macaca mulatta (LC), all of which provide the main prey for the Royal Bengal tiger (IUCN, 1987).
Three species of wild cat are present: the jungle cat, Felis chaus (LC), and leopard cat, Prionailurus bengalensis (LC), and the globally endangered fishing cat, Prionailurus viverrinus (EN) (Gopal & Chauhan, 2006; IUCN, 2013). Three species of otter are present, two of which are globally threatened – smooth-coated otter, Lutra perspicillata (VU), and the oriental small-clawed otter, Aonyx cinerea (VU), (Gopal & Chauhan, 2006). The area also contains highly threatened aquatic mammals: the rare Ganges river dolphin, Platanista gangetica (EN), Irrawaddy dolphin, Orcacella brevirostris (VU), Indo-pacific finless porpoise, Neophocaena phocaenoides (VU), and Indo-Pacific hump-backed dolphin, Sousa chinensis (NT) (IUCN, 1987; UNEP-WCMC & IUCN, 2013a; IUCN, 2013).

► Rare and threatened birds

Criterion:(x)

The Sundarbans National Park supports a varied and colourful birdlife, with more than 300 species recorded (IUCN, 1987; Chaudhuri & Choudhury, 1994; UNEP-WCMC & IUCN, 2013a). This includes 95 species of waterfowl, 38 species of raptors, nine species of kingfisher, and many gulls, terns, woodpeckers, barbets, shrikes, drongos, mynahs, minivets and babblers (Scott, 1989). Some of the bird species within the Sundarbans are rare and threatened. Species within the site considered to be of global conservation concern include the magnificent Palla’s fish eagle, Haliaeetus leucoryphus (VU), the white-rumped vulture, Gyps bengalensis (CR), the greater adjutant, Leptoptilos dubius (EN), the masked finfoot, Heliopais personatus (EN), White Bellied Sea Eagle, Haliaeetus leucogaster (EN), the greater spotted eagle, Aquila clanga (VU) and the brown-winged kingfisher, Pelargopsis amauroptera, the black-headed ibis, Threskiornis melanocephalus, the mangrove pitta, Pitta megarhyncha and the grey-headed fish eagle, Ichthyophaga ichthyaetus which are all considered to be near threatened (NT; IUCN, 2013).

► Rare and threatened reptiles

Criterion:(x)

The site has a diverse herpetofauna, with 59 documented species of reptile

and seven amphibians (Naskar et al., 2004; Gopal & Chauhan, 2006). It contains an exceptional number of threatened reptiles including the king cobra and significant populations of the endemic river terrapin, which was once believed to be extinct (SoOUV, 2012). Three species of monitor lizard are present (IUCN, 1997), all of which are considered near threatened (NT; IUCN, 2013). Though the estuarine crocodile, Crocodylus porosus (LC), still persists in the site (IUCN, 1987; Gopal & Chauhan, 2006; UNEP-WCMC & IUCN, 2013a; IUCN, 2013), the population is estimated to be only 100 individuals (UNEP-WCMC & IUCN, 2013a). The mugger, Crocodylus palustris (VU), and the critically endangered gharial, Gavialis gangeticus, the most primitive living crocodile, and one of the most highly endangered, are now locally extinct in the area (considered to be a result of overexploitation). There are 18 recorded snake species, including the globally threatened king cobra, Ophiophagus hannah (VU). Chelonids recorded within the site include four marine turtle species, all of which are globally threatened, olive ridley Lepidochelys olivacea (VU), green turtle Chelonia mydas (EN), loggerhead turtle Caretta caretta (EN) and hawksbill turtle Eretmochelys imbricata (CR) (Hussein & Acharya, 1994; IUCN 2013). Freshwater aquatic turtles include the Indian flap-shelled turtle, Lissemys punctate (LC), the threatened Indian peacock softshell turtle, Nilssonia hurum (VU), as well as the critically endangered freshwater Northern river terrapin, Batagur baska (CR), (IUCN, 1987; Gopal & Chauhan, 2006; UNEP-WCMC & IUCN, 2013a; IUCN, 2013).

► Rare and threatened flora

Criterion:(x)

The mangrove ecosystem of the Sundarbans is considered to be unique because of its immensely rich mangrove flora and mangrove-associated fauna. The mangrove diversity is some of the highest in the world (Sanyal et al., 2008). Some 78 species of mangroves have been recorded in the area making it the richest mangrove forest in the world. One of the most dominant mangrove species in the Sundarbans is the Sundri Heritiera fomes (IUCN, 1987; Gopal & Chauhan, 2006; UNEP-WCMC & IUCN, 2013a). This species is listed as globally endangered on the IUCN Red List due to its restricted distribution, and may qualify as critically endangered within India due to rapid population declines (IUCN, 2010).

Assessment information

Threats

Current Threats

High Threat

Due to ongoing effective management of the Sundarbans National Park, many of the identified threats affecting the forest both within and surrounding the site are being addressed with a number of the identified threats reducing in their intensity in recent years. However, current threats to the Sundarbans National Park from over exploitation, altered hydrology, pollution, poor fishing practices, poaching of high value species and extreme weather events remain significant. The combination and interaction of these multiple pressures represent some concern for the continued conservation of the site’s Outstanding Universal Values in both the marine and terrestrial environments.

► Shipping Lanes

High Threat
Outside site

Oil pollution is a serious threat, which is damaging to aquatic fauna and sea birds (V2, V3, V4; Blower, 1985; Hussain & Acharya, 1994). Oil spills also damage mangrove ecology (Rahman et al. 2010) and cause mortality of mangrove seedlings (Hussain & Acharya, 1994), ultimately reducing the extent and quality of mangroves and the habitat they provide for both terrestrial and aquatic species (V2, V3, V4). As a result of degradation of mangrove ecology, mangrove area and primary production, sedimentation, and deltaic and bank formation, are also influenced, compromising the on-going ecological processes of the site (V1). Numerous commercial and tourist vessels pass through the Sundarbans daily (Rahman et al., 2010), and oil leakages and spillages from these may infiltrate into the waters of the Sundarbans National Park through the interconnected nature of the

Sundarbans delta and the Bay of Bengal.

► Hunting (commercial/subsistence)

Data Deficient
Inside site, extent of threat not known
Outside site

Poaching of tigers for sale on illegal markets is possibly very severe in the Indian Sundarbans, with at least 17 seizures of tiger skins and body parts in areas around the Sundarbans between 2000-2010 (Verheij et al., 2010). The value of tiger products on illegal markets is high (Deodatus & Ahmed, 2002), providing a high incentive for illegal poaching of tigers throughout the Sundarbans despite the high levels of protection in the Sundarbans National Park. However, the true level of illegal hunting throughout the Sundarbans is unknown and unquantified (Deodatus & Ahmed, 2002).

► Household Sewage/ Urban Waste Water

Low Threat
Inside site, localised(<5%)
Outside site

Population increases near river basins and attempts to modernize living conditions in coastal areas has meant an increase in the production and amount of sewage and wastewater effluents released into the Sundarbans waters (Rahman et al., 2009). These inputs into the aquatic system can alter mangrove biogeochemistry (Rahman et al., 2009), reduce mangrove area, and impact on primary production. As a result sedimentation and deltaic and bank formation can also be influenced, potentially compromising the integrity of ecological processes of the site. Alterations to biogeochemistry can damage mangrove ecology (Islam, 2001), reducing the quality of habitat available for both terrestrial and aquatic species. As population pressure increases, the production of waste and modernization of lifestyles is likely to continue to increase, and impacts to the sites values are very likely to increase in intensity.

► Erosion and Siltation/ Deposition

Very High Threat

Inside site, scattered(5-15%)
Outside site

The eastward migration of the Ganges due to, the abandonment of some distributaries, and past diversion of water and withdrawals for irrigation, is resulting in a long-term ecological change in the Sundarbans. Up to 40% of the dry season flow of the Ganges was diverted in 1974 by the Farraka Barrage upstream in India. Diminished fresh water flushing of the Sundarbans has resulted in increased saline intrusion, particularly in the dry season. Reclamation has also led to salinisation and soil acidification. Siltation is another increasing problem resulting in a need for dredging to improve river flow: local fishermen expect that the Matla River will soon no longer be navigable up to Canning Town.

► Logging/ Wood Harvesting

Low Threat
Outside site

Many thousands of local people rely on the Sundarbans for livelihoods and subsistence. An estimated 300,000 people depend on the forest to extract timber, fish, honey and other forest produce (UNEP-WCMC & IUCN, 2013a). While extractive activities are strictly banned within the Sundarbans National Park, and are allowed only by permit in the buffer zone (IUCN, 1987; UNEP-WCMC & IUCN, 2013a), illegal felling remains a minor problem in the Indian Sundarbans (UNEP-WCMC & IUCN, 2013a), and thus poses a threat to the overall system and the site’s values. Extraction results in an overall reduction in productivity of the forest, compromising both the resource availability to sustain the high levels of biodiversity. The most valuable timber sources in the Sundarbans are from the Sundri trees, which are a globally threatened species (EN), and could be currently critically endangered within India (V5; IUCN, 2013). Extracting these trees not only reduces their global population and distribution, but reduces the floral diversity of the Sundarbans’ mangroves and results in shifts in the vegetation community composition (Rahman et al., 2010). Extraction of mangrove trees for these purposes also alters soil and sedimentation dynamics and can increase erosion, compromising the on-going ecological processes of the site. With the increasing gap between demand and supply and vast rural unemployment, as well as increased demand on local paper mills (through which illegal logging of the Sundarbans mangroves is occurring), the trend in cutting is

increasing. Due to the continuous and interconnected nature of the area, impacts from timber extraction on the biodiversity values of the Sundarbans National Park are likely significant.

► Other

High Threat
Inside site, scattered(5-15%)
Outside site

Top-dying is a disease that affects dominant Sundri trees (EN), and is causing die-back of these commercially-important and endangered trees in the WH site (UNEP-WCMC & IUCN, 2013a). Incidence of top-dying in Sundri appears to increase with increasing salinity (UNEP-WCMC & IUCN, 2013a), and it is subsequently replaced with the common Gewa Excoearia agallocha (Christensen, 1984). The disease reduces tree biomass, resulting in an overall reduction in productivity of the forest, compromising both the overall aesthetic beauty of the area and resource availability to sustain high levels of biodiversity. Due to declines in Sundri trees, forest structure in the Sundarbans has become simpler and mean forest height is decreasing, reducing habitat for arboreal mammals and birds (Iftekhar & Saenger, 2008). Stands of Sundri and Phoenix paludosa also provide ideal habitat for the Royal Bengal tiger (V3; IUCN-Bangladesh, 2004; Iftekhar & Saenger, 2008). Increasing saline conditions are likely to facilitate the increase in death of infected trees in the future (Rahman et al., 2010).

► Industrial/ Military Effluents

High Threat
Inside site, scattered(5-15%)
Outside site

Oil pollution is a serious threat, which is damaging to aquatic fauna and sea birds (Blower, 1985; Hussain & Acharya, 1994). Crude oil and its derivatives are the most dangerous pollutants entering the mangrove forest due to oil transportation (Iftekher 2004). Oil attached to mangrove leaves can reduce photosynthesis, respiration and water metabolism, reducing mangrove productivity (Islam, 2001). Other industry effluents (paper mill, match factory, and furniture making chemicals) can also degrade mangrove ecology (Peng, 2000). These inputs into the aquatic system serve to alter mangrove biogeochemistry (Rahman et al., 2009), reducing mangrove area (V2, V5),

and primary production. Sedimentation and deltaic and bank formation are also influenced, compromising the integrity of the on-going ecological processes of the site.

► Agricultural effluents

Low Threat
Outside site

Agro-chemicals, especially pesticides, have resulted in nutrient enrichment into Sundarbans waters, which can damage mangrove biogeochemistry (Rahman et al., 2009. Alterations to biogeochemistry can damage mangrove ecology (Rahman et al., 2010), reducing the quality of habitat available for both terrestrial and aquatic species.

► Solid Waste

Low Threat
Outside site

The Indian Sundarbans has been declared a “No Plastic Zone” and all waste generated within the site is removed for either recycling or incineration, and staff (trained “Eco-guides”) ensure strict regulation and management of garbage generated within the site and educate tourists on nature and natural resources. However, population increases near river basins and attempts to modernize living conditions in coastal areas has meant large-scale production of garbage and fisheries waste into the Sundarbans waters (Rahman et al., 2009). Moreover, fishing activities, particularly shrimp fry fishing, are resulting in the entanglement of threatened aquatic faunal species within discarded or active nets (Ganges river dolphin and Irrawaddy dolphin), which may contribute to their global population declines (Smith et al., 2009), and compromising the biodiversity value of the site.

► Earthquakes/ Tsunamis

High Threat
Inside site, widespread(15-50%)
Outside site

Cyclones and tidal waves normally cause some damage to the forest along the sea-face, and result in considerable occasional mortality among spotted deer. The effects of the 2004 tsunami were bad and those from the July and

September monsoon floods and cyclone Sidr in 2007 were disastrous. Cyclonic winds and a 6.5m storm surge along 100km 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 in the World Heritage site. Regeneration of the Sundarbans ecosystem, should normally take 10 to 15 years, if poaching and other intrusions do not jeopardize this (UNESCO PRESS, 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 will require much help to restore the infrastructure, field stations and equipment sufficiently to prevent uncontrolled exploitation before recovery.

► Crops

Low Threat
Outside site

Population pressure in the areas surrounding the Sundarbans is extremely high and historically such pressure has led to losses of mangrove forest area due to conversion of land to agriculture (Gopal & Chauhan, 2006). Population pressure and the resulting increase in agricultural land continues to threaten the integrity of the forest at the inland fringes in India. However, as the majority of the Indian Tiger Reserve provides a buffer zone in which extractive activities require permits (UNEP-WCMC & IUCN, 2013a), agricultural expansion is not a direct threat to the Sundarbans National Park itself. Despite the layer of protection provided by the Indian Tiger Reserve losses of habitat area to agricultural expansion elsewhere in the Indian Sundarbans may lead to impacts to the biodiversity values of the whole system (V2, V3, V5). With increasing population pressure at the inland fringes such impacts could become a problem in the future if not correctly managed (UNEP-WCMC & IUCN, 2013b).
Potential further indirect impacts from conversion of land to agriculture such as increases in agro-chemical loadings into the Sundarbans waters and increases in water extraction for agriculture, mean the indirect threats may be greater than from land-cover change alone.

► Marine/ Freshwater Aquaculture

High Threat
Outside site

Illegal shrimp/prawn farms continue to encroach into the Indian Tiger Reserve (UNESCO, 2002; UNEP-WCMC & IUCN, 2013a). This involves clearing areas of forest for their creation and in addition these developments are sources of solid and waste pollution, as well as sources of illegal trapping and hunting of forest vertebrates (Blower, 1985). While this threat is currently small within the boundaries of the Sundarbans National Park, due to the presence of an effective buffer area from the Tiger Reserve and adequate legal protection and monitoring (UNEP-WCMC & IUCN, 2013a), activities elsewhere in the area (i.e. in the buffer zone, where such activities have previously been identified as a problem; PR Questionnaire, 2003) may influence the ecological and biodiversity values of the site due to the contiguous and connected nature of the Sundarbans (Rahman et al., 2010; UNEP-WCMC & IUCN, 2013b).
As a consequence of land clearing, both habitat and food resources for higher level biodiversity are lost (V2, V3, V4, V5), and sedimentation dynamics are altered by the loss of mangrove areas and creation of embankments for fisheries and shrimp ponds, thus compromising the on-going ecological processes of the site (V1). These sites also release large amounts of natural and synthetic chemicals, which can have a direct impact on the biodiversity while also contributing to the loss of important ecological processes (Rahman et al., 2010), and subsequently to local biodiversity.

► Fishing / Harvesting Aquatic Resources

Low Threat
Inside site, localised(<5%)
Outside site

Temporary fishing camps are often established to facilitate illegal fishing, poaching and illegal aquaculture, activities that all encroach into the Reserve (UNEP-WCMC & IUCN, 2013a; 2013b). These temporary camps cause clearing of areas of forest for their creation and are sources of solid and waste pollution, and extensive illegal trapping and hunting of forest vertebrates (Blower, 1985). Clearing of mangrove areas may subsequently affect coastal and bank integrity, compromising on-going ecological processes. Loss of

habitat, pollution and poaching at fishing camps can also impact rare and threatened flora and fauna (V2, V3, V4, V5). While the threats from these activities are currently small within the Sundarbans National Park due to adequate legal protection and monitoring (UNEP-WCMC & IUCN, 2013a), their occurrence elsewhere in the area (i.e. in the buffer zone) may influence the values of the area due to the contiguous and connected nature of the Sundarbans (Rahman et al., 2010; UNEP-WCMC & IUCN, 2013b).

► Water Pollution

High Threat
Outside site

The Sundarbans ecosystem is vulnerable to many forms of water pollution including, spillage of oil and other pollutants, heavy metals, and nutrient enrichment from agro-chemicals as a result of industry, agriculture and aquaculture (Rahman et al. 2009). Alterations to biogeochemistry can damage mangrove ecology (Rahman et al. 2010) and also reduce the quality of habitat available for both terrestrial and aquatic species. As a result of degradation of mangroves, as well as the area they cover, and quality of the habitat, levels of sedimentation and deltaic and bank formation are also influenced. As population pressure continues to drive the expansion of industry, agriculture and aquaculture threats and impacts from water pollution are very likely to increase in intensity in the future.

► Poaching

Data Deficient
Inside site, extent of threat not known
Outside site

While poaching is strictly banned in the Indian Sundarbans and hunting of tigers was completely banned in India in 1970, illegal hunting activity (for terrestrial and aquatic species) still abounds (Blower, 1985; PR Questionnaire, 2003; Gopal & Chauhan, 2006; UNEP-WCMC & IUCN, 2013a). Hunting of mammal populations not only reduces the biodiversity values of the area directly (V2), but may also serve to reduce food resources for the Royal Bengal tiger throughout the forest, thus compromising the conservation value of the site. The Sundarbans area has endured significant levels of human-wildlife conflict since the 17th century – often involving hunting of tigers for their man-eating status. Historically, tigers stray into

villages and kill many people; as many as 65 deaths over a four month period occurred in 1988 (UNEP-WCMC & IUCN, 2013a). Preventative measures and tiger relocation have resulted in a decrease in tiger predation in recent years (UNEP-WCMC & IUCN, 2013a). Villagers now tend to drive straying tigers back into the forest rather than killing them (Milne, 1997). However, hunting of tigers in such conflicts in the Indian Sundarbans may be influencing tiger numbers. The Sundarbans are under severe population pressure (Gopal & Chauhan, 2006; Jhala et al., 2011), and increasing populations may lead to an increasing trend in this threat to the tiger population in the future.

► Other Biological Resource Use

Low Threat
Outside site

The Indian Sundarbans provides a livelihood for ~300,000 people, and many of these people enter the forest to collect honey (IUCN, 1987; UNEP-WCMC & IUCN, 2013a). Honey collection is allowed only by permit in the area from ten weeks from April 1st (UNEP-WCMC & IUCN, 2013a), and human-tiger conflict discourages unsustainable activity and high levels of illegal activity (Singh et al., 2010). However, in some cases these activities have been associated with producing forest fires when honey collectors attempt to expel bees from nests, which can create widespread destruction to mangrove trees and habitat (Rahman et al., 2010). Fires reduce the aesthetic beauty, destroying mangroves and thus available habitat for biodiversity. Sometimes fires can spread and destroy large areas of forest (Rahman et al., 2010). These activities have existed in the Sundarbans for thousands of years (Rahman et al., 2010). However, with increasing population pressure in surrounding settlements and decreasing human-tiger conflict (UNEP-WCMC & IUCN, 2013a), honey collection could increase in the future and may produce a relatively high threat to the aesthetic beauty and conservation integrity of the site.

► Dams/ Water Management or Use

Very High Threat
Outside site

Combined with the gradual eastward migration of the Ganges, increased diversion of freshwater sources to the Sundarbans forest has occurred in

recent years (i.e. up to 40% of the dry season flow of the Ganges was diverted upstream after the creation of the Farraka Barrage in 1974; UNEP-WCMC & IUCN, 2013a). Reduced freshwater flow serves to increase salt-water intrusion and irregular inundation, and also leads to increased soil acidification (UNEP-WCMC & IUCN, 2013a). The consequences of dam creation and freshwater extraction serve to significantly degrade the health of the Sundarbans ecosystem (Iftekhar & Islam, 2004; UNEP-WCMC & IUCN, 2013a), causing reduction in forest cover, mangrove species diversity, and thus availability and quality of habitat for the site's rare and threatened animals (Iftekhar & Islam, 2004; Akhtaruzzaman, 2000). Increasing siltation is occurring, affecting the on-going ecological processes of deltaic and bank formation, and reducing aquatic habitat (UNEP-WCMC & IUCN, 2013a). Reduced freshwater flow also decreases nutrient supplies to the Sundarbans, reducing available nutrients for plant diversity and the growth of the fish community (Rainbouth, 1991). Threatened aquatic species like the Ganges river dolphin and Irrawaddy dolphin have both been found to exhibit dependency for habitat characteristics associated with high freshwater flow, and as such are highly vulnerable to habitat loss from this threat (Smith et al., 2009). Increased salinity has also been associated with increased incidence of the top-dying disease of the endangered Sundri tree, and replacement of Sundri trees with the other common Gewa Exoecaria agallocha is occurring and believed to be a long-term threat (Christensen, 1984). Increased salinity is also associated with decreased numbers of some ungulate species (UNEP-WCMC & IUCN, 2013a). Increased freshwater extraction upstream may significantly increase this threat in the future, producing potentially serious problems. Coupled with the impacts of sea level rise under climate change, this threat may serve to significantly reduce the integrity of the site.

► Fishing / Harvesting Aquatic Resources

High Threat
Outside site

Shrimp and prawn fry harvesting to supply aquaculture farms is a serious problem throughout the Sundarbans (Rahman et al., 2010; UNEP-WCMC & IUCN, 2013a). Within the Indian Sundarbans, aquaculture farms are a serious problem, and are encroaching into the buffer zone of the Tiger Reserve (UNEP-WCMC & IUCN, 2013). Harvesting of shrimp and prawn fry is an

extremely destructive process in the area, as dragnets have not only depleted the tiger prawn population, but also juveniles of many other prawn and fish species, caused erosion of the banks and mudflats, and prevented mangrove seedling establishment (V1, V5; PR Questionnaire, 2003). These activities not only have severe implications for local, regional and potentially global fisheries (PR Questionnaire, 2003), but also have knock-on effects to the remainder of the Sundarbans' food chain, reducing resource availability for higher levels of biodiversity (V2, V3, V4). Moreover, another concern with these activities is the use of harmful equipment and gear. The use of gillnets in fisheries activities often results in the entanglement of threatened aquatic mammals (i.e. Ganges river dolphin and Irrawaddy dolphin; Smith et al., 2009), and turtles (UNEP-WCMC & IUCN, 2013a).

Potential Threats

Very High Threat

Potential threats to the site's values from climate change are extremely serious. If the IPCC's projections of sea level rise occur and nothing is done to combat projected increases, the forest's composition will be severely altered and large areas of the Sundarbans will certainly be lost. As the site is at the coastal margin of the forest, this threat will most certainly result in severe degradation of the site and its Outstanding Universal Values.

► Habitat Shifting/ Alteration

Very High Threat
Inside site, widespread(15-50%)
Outside site

Much of the Sundarbans forest is not of an elevation high above sea level (~ 7m max), and sea level rise thus threatens to submerge large portions of the area. From 1983-2003 annual sea level rise in the Bay of Bengal was 3.14 cm, which is well above the global average of 2.00 cm (UNEP-WCMC & IUCN, 2013a). The entire Sundarbans forest is also experiencing extensive coastal erosion and retreat, which is considered to be largely attributable to increased frequency of storm surges and other extreme natural events, rises in sea-level and increased salinity (Cornforth et al., 2013). In the Indian Sundarbans, between 1969 and 2009, 210.25 km2 has been lost, with 65.06 km2 being lost in the past decade (Danda at al., 2011). The net erosion rate

is ~1.9 km2 per year, with coastal retreat at ~3-4 km2 since 1792 (Rahman et al., 2010). This represents a potentially great loss of carbon storage (Rahman et al., 2010), and loss of habitat for biodiversity. Within the Indian Sundarbans, it is projected that a loss of area with sea level rise for 12 of the most vulnerable islands is 3-32% (WWF-India, 2014). With sea level rise, increased salinity will result in ecological succession to more salt-tolerant species, reducing mangrove biodiversity, particularly with salinity already threatened from reduced freshwater inputs into the Sundarbans. The result of increased sea level rise will be a reduction in overall mangrove area, alterations to on-going ecological processes, and reduced plant diversity, which overall will reduce habitat area and quality for biodiversity. Threatened aquatic species such as the Ganges river dolphin and Irrawaddy dolphin both have been found to exhibit dependency for habitat characteristics associated with high freshwater flow, and as such are highly vulnerable to habitat loss from this threat (Smith et al., 2009). Increased salinity has also been associated with increased incidence of the top-dying disease of the endangered Sundri tree, and thus its replacement with the other common Gewa Exoecaria agallocha. Such a loss of floral diversity and alterations to vegetation communities are thus likely to occur under sea level rise. There has already been an increase in the proportion of salt tolerant species Avicennia marina and A.alba during the last three decades from less than 1% to >8% in the Sundarbans National Park (Sanyal, 2012). Due to the low altitude of the area and the interaction with other existing threats (reduced freshwater inputs, resource extraction and pollution) the impact of sea level rise is likely to be very severe for the WH site. It has been estimated that a 25cm increase in sea level would destroy 40% of the Sundarbans, and a 45cm rise would destroy 75% by the end of the century (UNEP-WCMC & IUCN, 2013a). A 45cm rise in sea level has been projected to be likely by the end of the 21st century according to the IPCC (2013). This threat is likely unavoidable at a site level, but the creation of freshwater stores upstream to regulate dry season inundation, better protection of non-affected mangroves, and restoration activities could assist in adaptive management.

Protection and management

Assessing Protection and Management

► Relationships with local people

Highly Effective

Dependence of local people on Sundarbans' resources is considerable. Sustainable extractive activities are permitted by permit for honey and fish (West Bengal Forest Department, 2012). Those managing the site, the West Bengal Ministry of Environment and Forests and Project Tiger, work directly with local communities in participatory management through 10 Forest Protection and 14 Eco-Development Committees. Eco-Development projects provide communities with assistance in irrigation, water infrastructure, jetties, advice on fishing and aquaculture, medical clinics and training and employment as tourist guides (Mile, 1997; UNESCO, 2002; West Bengal Forest Department, 2012; UNEP-WCMC & IUCN, 2013a).
Participatory governance and alternative livelihood generation activities have been very successful in reducing antagonism between local communities and the management agencies and maintaining the Outstanding Universal Value of the site (West Bengal Forest Department, 2012). Management activities and methodological implementations (i.e. nylon fencing, encouragement of driving tigers back into forests over killings, relocation of problem tigers, introduction of electrified human models and introduction of face masks for the back of villagers heads) have served to reduce human-wildlife conflict in the buffer zone (West Bengal Forest Department, 2012).

► Legal framework

Mostly Effective

The site is protected under the Indian Forest Act, 1927 and its amendments, Forest Conservation Act 1980, Wildlife Protection Act, 1972 and Environment Protection Act 1986. These laws are being effectively implemented and zone laws and regulation of garbage pollution are all effectively enforced (UNEP-WCMC & IUCN, 2013a). Forest Guards follow an effective protection strategy in the field, and capacity for intelligence gathering to control poaching and illegal activities is regularly assessed and improved (West Bengal Forest Department, 2012). The site was listed as "Very Good" in the Independent

Management Effectiveness Evaluation in 2010-2011 (West Bengal Forest Department, 2012). However, despite excellent site management, pressures within the buffer zone remain high (PR Questionnaire, 2003). While poaching is strictly banned in the Indian Sundarbans and hunting of tigers was completely banned in India in 1970, illegal activity still occurs (Blower, 1985; PR Questionnaire, 2003; Gopal & Chauhan, 2006; UNEP-WCMC & IUCN, 2013a). Current and increasing external pressures may be impacting on the site's Outstanding Universal Values despite current management activities and effectiveness.

► Enforcement

Mostly Effective

The Forest Department holds primary responsibility for management of the property, along with the key responsibility for enforcement of the management and legal framework. The property itself is not permanently inhabited and extraction of resources is prohibited within its boundaries. It is difficult to confirm whether the regulations around resource extraction are fully respected but there are very few reports of illegal activities within the property itself. Poaching of tigers as well as their prey species has been identified as a concern, affecting tigers across all or most of the Sundarbans population. The resources and capacity to effectively address this threat and provide the necessary enforcement actions requires additional input from the management agency to ensure they continue at the current level of effectiveness.

► Integration into regional and national planning systems

Some Concern

The site is owned by the Government of India, and is managed by Project Tiger under the coordination of the state-level West Bengal Ministry of Environment and Forests (UNEP-WCMC & IUCN, 2013a). There appears to be limited integration of the site into national and regional planning systems beyond the importance given to it as a tiger site and there is greater need for coordination between this site and the Bangladeshi Sundarbans as well as other regional planning. In this regard, the reported intentions to reinforce transboundary cooperation between the States Parties of Bangladesh and

India for Sundarbans properties is positive.

► Management system

Some Concern

The original management plan for the site was requested to be updated by the World Heritage Committee at the time the site was inscribed. The management plan was updated for the period 2001-2010 (UNEP-WCMC & IUCN, 2013a). It is unclear if an updated management plan has been developed. The site is well managed by Project Tiger, the West Bengal Forest Department and through participatory management with local communities. However, illegal poaching, fisheries and aquaculture remain significant challenges to effective management of the site (UNEP-WCMC & IUCN, 2013a). The World Heritage Committee has requested cooperation with management authorities in the Bangladesh Sundarbans, and although outcome is yet to be seen, the State Party of Bangladesh reported in it 2017 state of conservation report for "The Sundarbans" World Heritage property, of the States Parties' intentions to reinforce transboundary cooperation for the two properties.

► Management effectiveness

Mostly Effective

The site is well managed, and the management plan and its regulations strictly followed. The site was listed as "Very Good" in an Independent Management Effectiveness Evaluation in 2010-2011 (West Bengal Forest Department, 2012). However, despite excellent site management, pressures within the buffer zone are high (PR Questionnaire, 2003). While poaching is strictly banned in the Indian Sundarbans and hunting of tigers was completely banned in India in 1970, illegal activity still occurs (Blower, 1985; PR Questionnaire, 2003; Gopal & Chauhan, 2006; UNEP-WCMC & IUCN, 2013a). Fisheries and aquaculture also remain significant challenges to site management (Singh et al., 2010; UNEP-WCMC & IUCN, 2013a). These current and increasing external pressures may be impacting on the site’s Outstanding Universal Value despite current management activities.

► Implementation of Committee decisions and recommendations

Mostly Effective

Previous World Heritage Committee decisions regarding the Sundarbans National Park have included (1) upon Inscription, the updating and development of an up-to-date management plan (UNESCO, 1987) and (2) a recommendation to work with tiger experts in order to further develop appropriate monitoring methodologies for the tigers in the area (UNESCO, 2001). A new management plan for 2001-2010 was developed and adopted following this (UNEP-WCMC& IUCN, 2013a). A recent survey by WWF-India of the tiger population in the Sundarbans was conducted using camera trapping methodologies (Jhala et al., 2011). It is unclear if a subsequent management plan has been developed.

► Boundaries

Some Concern

The WH property is managed as a designated wilderness zone in which no commercial operations or resource extraction is allowed. The remainder of the Tiger Reserve act as a buffer zone, comprising nine forest blocks in which sustainable extractive activities are allowed via permits, and fishing occurs in the tidal waters. The Sajnakhali Wildlife Sanctuary exists within the buffer zone and a further two Wildlife Sanctuaries (Halliday Island and Lothian Island) to the west of the Tiger Reserve, serve to further protect the Sundarbans National Park WH property (IUCN, 1987; UNEP-WCMC & IUCN, 2013a). The boundaries of the site were considered to be adequate upon site inscription (UNESCO, 1987; PR Questionnaire, 2003). However, there is significant human pressure within the buffer zone, and with increasing population pressure and poverty, it is possible that pressure on local biodiversity may begin to infringe upon the WH site and its values (PR Questionnaire, 2003). An important improvement to the preservation of the site’s Outstanding Universal Value would be the establishment of a transboundary site, managed jointly with the Bangladeshi Sundarbans World Heritage site as has been discussed previously (UNESCO, 2001; PR Questionnaire, 2003). Being part of a large interconnected system, management activities and their successful implementation affect both WH sites, and more systematic, integrated management would serve to increase the integrity of both sites.

► Sustainable finance

Mostly Effective

The main sources of funding are the federal Government of India and the state West Bengal Government (Ministry of Environment and Forests; PR Questionnaire, 2003; West Bengal Forest Department, 2012). The federal government provided US$ ~0.8 million and the state government provided US$ 2 million in 2010-2011. Other sources of funding come from civil society organizations for projects involving collaborative research and livelihoods projects (West Bengal Forest Department, 2012). However, funding is not considered adequate to build capacity (financial and human) for effective management of the site and protection of its Outstanding Universal Value (PR Questionnaire, 2003; UNEP-WCMC & IUCN, 2013a). Further funding is required in order to improve patrols, eco-development activities and eco-tourism (PR Questionnaire, 2003) and to include an ecosystem approach to management of the Reserve, integrating management of the existing Reserve areas and other activities that occur within and outside of the property (i.e. fisheries; UNEP-WCMC & IUCN, 2013a).
Ecosystem-based management systems across the two countries containing the Sundarbans, India and Bangladesh, for monitoring of existing and potential threats and conservation of the WH sites will be key to the continued preservation of the values of both WH properties (UNESCO, 2001; PR Questionnaire, 2003).

► Staff training and development

Mostly Effective

Based on a Training Need Assessment, the Tiger Project and West Bengal Forest Department identified 13 areas for necessary staff training and built a schedule programme for capacity building, both for various categories of staff and members of local Eco-development Committees. Training and capacity building programmes are available in Animal Capture & Restraint, Arms training, Mob control, First Aid, Hospitality training, Law and related matters, Computer Application, Waste Management, Radiocollaring and Monitoring, Surveillance and intelligence gathering, Tourism, interpretation and conservation, Livelihood options and Account keeping (West Bengal

Forest Department, 2012).

► Sustainable use

Mostly Effective

The Indian Sundarbans provides a livelihood for ~300,000 people. Local people are dependent on the area for charcoal, timber, nypa palm thatch, grass, reeds, shells, reptile skins, fish, crabs, and fishing for shrimps and fish (UNEP-WCMC & IUCN, 2013a). The WH property is managed as a designated wilderness zone in which no commercial operations or resource extraction is allowed. The remainder of the Tiger Reserve acts as a buffer zone, comprising nine forest blocks in which sustainable extractive activities are allowed via permits including fishing in the tidal waters (IUCN, 1987; UNEP-WCMC & IUCN, 2013a). Project Tiger and the West Bengal Forest Department have developed participatory governance measures within 10 Forest Protection and 14 Eco-Development Committees, that increases the support of local communities in maintenance of the site and its Outstanding Universal Value (West Bengal Forest Department, 2012; UNEP-WCMC & IUCN, 2013a). These cover 32 villages and >8,500 families (West Bengal Forest Department, 2012), and focus on community engagement and alternative livelihoods generation such as assistance in irrigation, water infrastructure, jetties, advice on fishing and aquaculture, medical clinics and training and employment as tourist guides (UNEP-WCMC & IUCN, 2013a). However, despite excellent site management, pressure within the buffer zone is very high (PR Questionnaire, 2003).

► Education and interpretation programs

Mostly Effective

Project Tiger and the West Bengal Forest Department have developed an important Outreach programme for school and college students, government departments and corporate offices, and police and military personnel. This programme disseminates conservation and awareness messages on the natural heritage of the Sundarbans and conservation of the site. School children are given tours to sensitize them about mangrove and tiger conservation (West Bengal Forest Department, 2012). A ‘Mangrove Interpretation Centre’ also exists within the buffer zone (PR Questionnaire,

2003).

► Tourism and visitation management

Mostly Effective

Tourists are not allowed within the National Park without a permit. However, tourism within the buffer zone averaged 34,390 visitors per annum between 1992-1997 (Project Tiger, 2001), and ~40,000 were reported in 2002 (UNESCO, 2002). Visitor disruption of the area's values is kept to a minimum through enforced rules that are outlined in the site's management plan (PR Questionnaire, 2003), including regulation of litter, and activities from boats and lodges is overseen by management (West Bengal Forest Department, 2012). Wildlife watching largely occurs from boats on the waterways. Watchtowers exist within the Sajnakhali Wildlife Santuary, and in Sudhanyakhali, Haldi and Netidhopani (UNEP-WCMC & IUCN, 2013a). The Sundarban Tiger Camp at Dayapur, Gosaba runs tours from Kolkata (UNEP-WCMC & IUCN, 2013a). There are relatively few lodges in the Tiger Reserve, but overnight facilities aboard sightseeing boats exist (UNEP-WCMC & IUCN, 2013a).
There is good access to the Tiger Reserve through organized trips from Kolkata, or by rail, and by boat and bus (UNEP-WCMC & IUCN, 2013a). There is a 'Mangrove Interpretation Centre' at the Sundar Cheetal Sajnekhali Tourist Lodge (PR Questionnaire, 2003; UNEP-WCMC & IUCN, 2013a). Project Tiger and the West Bengal Forest Department have put resources into facilitating the development of eco-projects for local communities in the form of guide training for employment on tourist boats (UNESCO, 2002). 25% of revenue generated through eco-tourism activities is shared with the Joint Forest Management Committees of the local communities, further aiding the funding available to the site and community participation in management (West Bengal Forest Department, 2012).

► Monitoring

Some Concern

Recent population estimates for the tiger population in the Indian Sundarbans were carried out using a double sampling method that uses a combination of remote camera trap based capture-recapture methods and line transect based distance sampling for estimating prey abundance. The

results of surveys in 2014 estimated a population size of 62-96 individuals (Jhala et al., 2015). Along with on going updated assessment of the tiger numbers, an assessment of the status of tiger prey species in the area is required at regular intervals. Consistent monitoring methodologies for the tiger population are required and their use is necessary for continued and appropriate assessment of the status of the population (UNESCO, 2001). Efforts should be made to coordinate monitoring methodologies between the two countries making up the Sundarbans, in order to assess the health of the metapopulation and the influence of differing management practices on the tiger population. There is little monitoring of other species including aquatic mammals. The Wildlife Conservation Society's Bangladesh Cetacean Diversity Project currently monitors populations of aquatic mammals in the Bangladeshi Sundarbans, and monitoring techniques used by projects such as these would be useful for adoption within the Indian Sundarbans (Smith et al., 2006). Remote sensing and GIS methodologies are being employed throughout the Sundarbans to monitor siltation and coastal erosion levels (PR Questionnaire, 2003; Rahman et al., 2011). Climate is monitored by Meteorological stations at Haldi, Jhingakhali and Sajnakhali (UNEP-WCMC & IUCN, 2013a). However, thorough and continued monitoring of hydrological changes from increased salinity due to reduced upstream freshwater flow and sea level rise is necessary (UNESCO, 1987).

► Research

Some Concern

There is a large body of research on the climate, ecology, hydrology and biodiversity of the Sundarbans: flora and fauna, human-wildlife relationships, harmful extractive activities (i.e. prawn aquaculture), fisheries, climate and hydrology (UNEP-WCMC & IUCN, 2013a). A biennial census of the tiger population is made by the zoological Survey of India and floral surveys have been conducted by the Botanical Survey of India (UNEP-WCMC & IUCN, 2013a). Research institutes working within the Sundarbans include the Indian Central Inland Fisheries Research Station, Sagar Marine Biological Insitute, Central Soil Saline Research Institute and several Meteorological stations at Hali, Jhingkhali and Sajnakhali (UNEP-WCMC & IUCN, 2013a). However, so far this information has not been compiled and made available to decision-makers. Little work has been conducted to assess the ecological resilience of the Sundarbans, in particular in the face of climate change, and to assess

appropriate indicators for monitoring of trends in resilience and change in the face of threats from climate change.

Overall assessment of protection and management

Mostly Effective

The protection and management of the Sundarbans National Park's is currently good, and provides many examples of Best Practice. However, greater focus on monitoring of populations including aquatic animals, and research into biodiversity and ecosystem resilience in the face of current and future threats are issues not currently being adequately addressed. In addition external pressures on the site's buffer zone and from activities within the wider Sundarbans ecosystem, means greater focus on efforts to preserve its values from threats outside the site is needed. Funding and capacity is inadequate to tackle these wider threats, and boundaries and transboundary management with the Sundarbans, Bangladesh World Heritage Site should be increased in order to adequately address these issues, particularly in the face of climate change.

► Assessment of the effectiveness of protection and management in addressing threats outside the site

Some Concern

Threats on the site and its values, from outside the site are numerous and intense. Pressure on the buffer zone from the growing population and more widely from increasing populations across the wider Sundarbans, including the portion in Bangladesh, as well as impacts from pollution, increasing intensity of aquaculture and fish and shrimp fry fishing, changes to inundation regimes and salinity, and predicted increasing sea level and frequency and intensity of storms and tidal surges under climate change, present increasing challenges for the fragile Sundarbans ecosystem. Current management of localized threats is relatively good and largely effective, with highlights including good community participation, staff training, education and tourism. However, the pressures on and within the buffer zone of the Tiger Reserve may in future have negative impacts on the Outstanding Universal Values of the site. Further focus on alternative livelihoods generation and increased funding and capacity for monitoring and informant measures to better control illegal extraction is needed. Due to the

interconnected nature of the Sundarbans ecosystem, activities occurring in both the Indian and Bangladeshi components of the site (freshwater extraction, biodiversity depletion, pollution and fisheries management) result in threats and impacts to the entire ecosystem. An important improvement to the management and preservation of the site's Outstanding Universal Values would be an establishment of a transboundary site, managed jointly with the Sundarbans, Bangladesh WH site, as has been discussed previously (UNESCO, 2001; PR Questionnaire, 2003). This will prove particularly important in the future under the impacts of sea level rise and increased frequency and intensity of extreme weather events under climate change.

► **Best practice examples**

Relationships with local people including excellent community engagement in participatory management, as well as training provided, and Eco-development Committees involving local people. Also excellent educational and resource/methodological inputs to reduce human-wildlife conflicts. Staff training and development such as identification of staff training needs through completing a Training Needs Assessment, training for staff at all levels of organization, development of training programmes within all areas of need identified – from legal training to computer application to tourism, interpretation and conservation. Education and interpretation programmes which include outreach to a wide range of stakeholders (students, government, corporate offices, police and military), education on both natural heritage and importance of the sites values, development of a Mangrove Interpretation Centre, training of local eco-tourist guides and staff in tourism, interpretation and conservation. Tourism and interpretation including rules to minimize damage and waste strictly implemented, recycling and waste removal programme, good facilities for visitor stay (terrestrial and on water), infrastructure for visitor activities (boats, watchtowers and Mangrove Interpretation Centre), good transportation links, links with existing tourism bodies, direction of revenue to participatory management and Eco-tourism Committees of local people so money generated goes back into site management.

State and trend of values

Assessing the current state and trend of values

World Heritage values

▶ The largest area of mangrove forest in the world

High Concern
Trend:Deteriorating

The Sundarbans remains the largest continuous mangrove forest in the world, with spectacular natural wilderness and scenery. However, the Sundarbans is now almost half the size of the area that existed in the late 1800s (Rahman & Asaduzzaman, 2010). The eastward migration of the Ganges River is causing a long-term ecological change in the entire Sundarbans forest. This process is intensified due to the increased diversion of freshwater sources to the Sundarbans forest that has occurred in recent years (i.e. up to 40% of the dry season flow of the Ganges was diverted upstream after the creation of the Farraka Barrage in 1974; UNEP-WCMC & IUCN, 2013a). Reduced freshwater flow serves to increase salt-water intrusion and irregular inundation, and also leads to increased soil acidification (UNEP-WCMC & IUCN, 2013a). The consequences of dam creation and freshwater extraction serve to significantly degrade the health of the Sundarbans ecosystem (Iftekhar & Islam, 2004; UNEP-WCMC & IUCN, 2013a), affecting plant biomass production and siltation, sedimentation and deltaic and bank formation. Increased saline intrusion is also impacting the recovery of the mangrove species from top-dying with Sundri trees being replaced by Gewa (UNEP-WCMC & IUCN, 2013a). This trend is predicted to be long-term (Christensen, 1984), and causes shifts in vegetation communities and habitat for the site's rare and threatened biodiversity (Iftekhar & Saenger, 2008). Siltation is also a problem within the site, and specific channels (i.e. the Matla River up to Canning Town) are becoming severely blocked and could soon be considered unnavigable (UNEP-WCMC & IUCN, 2013a). The wider Sundarbans forest is also experiencing extensive coastal erosion and retreat, which is considered to be largely attributable to increased frequency of storm surges and other extreme natural events, rises in sea-level and increased salinity (Cornforth et al., 2013). In the Indian Sundarbans, between 1969 and 2009, 210.25 km2 has been lost, with 65.06 km2 being lost in the past decade (Danda at al., 2011). This represents a

potentially great loss of carbon storage (Rahman et al., 2010), and loss of habitat for important biodiversity such as the Royal Bengal tiger. Sea level rise under climate change will exacerbate these alterations to on-going ecological processes within the Indian Sundarbans. With sea level rise, increased salinity will result in increasing ecological succession to more salt-tolerant species (loss of Sundri vegetation communities to those dominated by Gewa), reducing mangrove biodiversity.

► Rare and threatened terrestrial and aquatic mammals

Low Concern
Trend:Data Deficient

Eight globally threatened species have been locally extirpated over the last century: Javan rhinoceros Rhinoceros sondaicus (CR), Indian rhinoceros Rhinoceros univornis (VU), water buffalo Bubalus bubalis (EN), swamp deer Rucervus duvaucelii (VU), barking deer Muntiacus muntjak (EN), gaur Bos gaurus (VU), hog deer Axis porcinus (EN), and sambar Rusa unicolor (VU; IUCN, 1987; Gopal & Chauhan, 2006; UNEP-WCMC & IUCN, 2013a; IUCN, 2013).
The Sundarbans National Park supports a diverse assemblage of rare and threatened terrestrial and aquatic mammals (IUCN, 1987; UNEP-WCMC & IUCN, 2013a). Populations of the Ganges river dolphin, Irrawaddy dolphin and Royal Bengal tiger within the Sundarbans appear to be relatively high, with populations of the latter two species representing stronghold populations for these species globally (Smith et al., 2006; IUCN, 2013).
If the tiger population is to be considered as an indicator of the health of the Sundarbans, then it appears that the biodiversity in the Sundarbans National Park is in a relatively stable and good state (UNEP-WCMC & IUCN, 2013a).
The Sundarbans' populations of Ganges river dolphins and Irrawaddy dolphins appear to be stable at present, although the populations could begin to show decreases should important threats (saltwater intrusion and entanglement in fishing equipment) not be effectively addressed (Pers. comm., 2014). The on-going threats from illegal poaching, habitat loss and degradation (both aquatic and terrestrial), pollution, altered hydrology and entanglement in hazardous fishing equipment remain significant, and are likely to increase in intensity in the future. As such, there is some cause for concern for the current state of the site's values, and effective management to mitigate the impacts of current and future threats is essential to ensure

the continued integrity of the site's rare and threatened mammal populations.

▶ Rare and threatened birds

Low Concern
Trend:Data Deficient

The Sundarbans has a varied bird life with a high level of avian diversity for a mangrove ecosystem (Khan, 2005). The area provides habitat for several globally threatened species (IUCN, 2013). However, little empirical data on population trends exists for the rare and threatened birds of the Sundarbans. One bird species is known to have become locally extinct from the Sundarbans over the last century: Swamp francolin Francolinus gularis (VU; Ministry of Environment and Forests, 2010; IUCN, 2013). A study conducted in the Bangladeshi Sundarbans East Wildlife Sanctuary, suggests that the state of the avifauna in this particular Wildlife Sanctuary remains favourable (Khan, 2005) and given the inter-connected nature of the Sundarbans this is likely to be consistent across the area. However, threats to the Sundarbans' bird life (habitat loss and degradation from the overexploitation, top-dying of Sundri trees and clearing for conversion to aquaculture, and pollution) are significant and growing. Accordingly it is likely that declines in avian abundance have occurred in the area and will increase in the future with the increasing intensity of these threats, as well as climate change, if appropriate management action is not taken.

▶ Rare and threatened reptiles

Low Concern
Trend:Data Deficient

Reptile diversity in the Sundarbans remains relatively high, and the area provides habitat for several globally threatened species: king cobra (VU), olive ridley turtle (VU), green turtle (EN), loggerhead turtle (EN), hawksbill turtle (EN), Indian peacock softshell turtle (VU), and the Northern river terrapin (CR; IUCN, 1987; IUCN, 2013). Estuarine crocodiles are present, and while globally considered to be of Least Concern, they occur in low numbers in the Indian Sundarbans (100 individuals; UNEP-WCMC & IUCN, 2013a). The situation for many of these globally threatened/locally rare reptiles remains promising, due to good management and breeding programmes in the area carried out by the Department of Forests. Estuarine crocodiles are captive-bred at the Bhagabatpur Crocodile Breeding Centre for re-introduction into

the Sundarbans, and olive ridley turtles are also reared here and in captivity at Sajnakhali for release in the national park (UNEP-WCMC & IUCN, 2013a). A breeding program is also being run by the Turtle Survival Alliance and the West Bengal Forest Department in Sajnakhali for the Northern river terrapin and this has seen the successful hatching of several juveniles of this species (UNEP-WCMC & IUCN, 2013a). The species is considered functionally extinct in the Sundarbans, but this program offers a chance of recovery for this globally critically endangered species (TSA, 2009; UNEP-WCMC & IUCN, 2013a). Overall, the situation for the herpetofauna of the Indian Sundarbans looks promising, and management programs are assisting in increased survival of globally threatened species. However, the Sundarbans' biodiversity has been greatly depleted in the past, and on-going threats from illegal poaching, habitat loss and degradation (both aquatic and terrestrial), pollution, altered hydrology and entanglement in hazardous fishing equipment remain significant, and are likely to increase in intensify in the future.

► Rare and threatened flora

Low Concern
Trend:Deteriorating

Populations of Sundari trees (Heritiera fomes; EN) in the Sundarbans wider ecosystem are declining (IUCN, 2017) as a result of numerous impacts including "top-dying" and timber harvesting. The extent of pure H. fomes stands has decreased by 21% since 1926, and dominance of H. fomes in mixed stands is diminishing (Iftekhar & Saenger, 2008). Approximately 70% of H. fomes stems have been estimated to be moderately or severely affected by the "top-dying" disease (Islam & Wahab, 2005), which causes high mortality, threatening mangrove diversity, forest cover and ecosystem complexity. Due to declines in H. fomes, forest structure in the Sundarbans has become simpler and mean forest height is decreasing, reducing habitat for arboreal mammals and birds (Iftekhar & Saenger, 2008). In addition, as the dominant mangrove species in the back mangrove of the Sundarbans, loss of H. fomes trees poses a threat to the biodiversity, ecological and aesthetic values of the site (Rahman et al., 2010).

Summary of the Values

▶ Assessment of the current state and trend of World Heritage values

Low Concern

Trend: Deteriorating

The Sundarbans remains the largest continuous mangrove forest in the world, despite being almost half the size of the area that existed in the late 1800s. Degradation of the Sundarbans National Park’s mangrove diversity (due to degradation and disappearance of globally endangered Sundri trees), biomass production, primary productivity and on-going ecological processes of tidal inundation, siltation and sediment dynamics, plant colonization and delatic and bank formation continues to be significant due to natural and anthropogenic alterations to the hydrology and ecology of the site. This degradation of the ecological values of the site is increasing and this trend is likely to continue with increasing population pressure and climatic changes. Available data on the site's rare and threatened mammals (i.e. the Royal Bengal tiger) and reptiles show that populations remain relatively stable, likely due to good legal protection and enforcement within the site and excellent breeding programmes for critically endangered reptilian species (Northern river terrapin, olive ridley turtle and estuarine crocodile). While monitoring of most mammal populations is currently insufficient to assess the status and trends of populations, this situation seems likely to be promising given the situation of the Bangladeshi populations of Ganges River dolphin and Irrawaddy dolphin. Thus, it appears that the effects of ecosystem degradation on the site's Outstanding Universal Value are currently not extreme, though ecosystem-level assessments of the impacts of threats is necessary to fully determine the resilience of the sites values. As the number and intensity of threats is likely to increase in the future, greater adequate and sustainable management action and capacity will be required.

Additional information

Benefits

Understanding Benefits

► Carbon sequestration

Mangrove forests store enormous amounts of carbon, rivalling that of other tropical rainforests (Donato et al., 2011). As the world's largest remaining mangrove forest, the Sundarbans provides huge carbon storage, and its loss would incur enormous emissions of carbon currently stored in sediments and plant biomass. The area thus has major climate change mitigation value globally, as well as locally, due to the enormous potential impact of climate change to the area and to India as a whole (Rahman et al., 2010).

► Coastal protection

Mangrove forests provide protection for inland areas and human populations from storm damage e.g. cyclones, and from flooding e.g. tidal surges, tsunamis and storms. The Sundarbans, and particularly green belt mangrove restoration, are thus extremely important for protecting settlements, infrastructure and biodiversity from such events.

► Soil stabilisation

The on-going geological processes of the Sundarbans includes shifting deltaic and bank formation. The Sundarbans mangrove trees serve to trap sediment and organic matter inputs, stabilizing the sediments and reducing organic matter inputs into the Bay of Bengal.

► Fishing areas and conservation of fish stocks

The Sundarbans provide important spawning and nursery grounds for several fish species including some economically species (IUCN, 1987; UNEP-WCMC

& IUCN, 2013a). With increased aquaculture and fishing activities throughout the area, the protection of the WH site serves to sustain breeding and nursery areas for important fish species.

▶ **Sacred natural sites or landscapes**

The Sundarbans is the largest remaining mangrove forest in the world.

▶ **Pollination**

Sundarbans support large numbers of honey-bees, which produce great quantities of honey and wax, in turn providing livelihoods for local people outside the site (IUCN, 1987). These bees may also prove to be important for pollination of local crops, and to maintaining the Sundarbans forest diversity.

▶ **Outdoor recreation and tourism**

Tourists are not allowed within the Sundarbans National Park without a permit. However, visitation within the buffer zone is high, with ~40,000 visitors reported in 2002 (UNESCO, 2002). The majority of these visitors engage in wildlife watching activities from lodges and from the water. Project Tiger and the West Bengal Forest Department have put resources into facilitating the development of eco-projects for local communities in the form of training for employment on tourist boats as guides (UNESCO, 2002).

▶ **Importance for research, Contribution to education**

Project Tiger and West Bengal Forest Department have developed an important Outreach programme for school and college students, government departments, corporate offices, police and military personnel. This programme disseminates conservation and awareness messages on the natural heritage of the Sundarbans and conservation of the site at regular intervals. School children are given tours to sensitize them to mangrove and tiger conservation.

Summary of benefits

The benefits provided by this site are largely in the conservation of a magnificent wilderness area, with habitat for many charismatic species of

global conservation concern, as well as in mitigating against accelerating climate change through carbon storage, and protection of local infrastructure and populations from extreme events which may increase under climate change. There are also economic benefits in terms of job creation, fisheries stocking and tourism.

Projects

Compilation of active conservation projects

№	Organization/ individuals	Project duration	Brief description of Active Projects
1	Centre for Advanced Research in Natural Resources and Management (CARNIAM) (Bangladesh)		“Project Batagur”: breeding and reintroduction programme for the critically endangered Northern river terrapin. Also surveying for the presence and status of this species in the Sundarbans, and works on a with the Turtle Survival Alliance – India. Bangladesh-based projects: Marine Turtle Conservation Project – sea turtle nest site surveys, studying nesting habitats, threats, regular surveys along the coast line, training and advocacy for sea turtle conservation, awareness building. Currently conducting a survey of the Estuarine crocodile in the area to assess its conservation status in the Sundarbans. “Bangladesh Python Project”: a radiotelemetry project to gain insight into their biology, behavior, habitat preferences and movements.
2	Turtle Survival Alliance – India		Project with the West Bengal Forest Department breeding and rearing Northern river terrapins at Sajnakhali for eventual reintroduction.
3	WWF-India		Countrywide monitoring of tiger status (2009-2010) for population size within the Tiger Reserve and at South 24, Parganas Forest division. Currently involved in preparation of a Report on Sundarbans Biodiversity by a group of 19 experts. Aim is to provide a critical evaluation of information on biodiversity within the Indian Sundarbans (from microbes to flora and fauna). “Sundarbans Programme”: habitat conservation, adaptation to climate change, advocacy and policy, human-wildlife conflict, alternative livelihoods, capacity building, research and information dissemination.

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