IUCN Conservation Outlook Assessment 2014 **(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

2014 Conservation Outlook

Significant concern

The values of the Sundarbans National Park are highly threatened by multiple on-going processes both within and external to the site, and are showing signs of deterioration. While it appears that the site's biodiversity values (rare and threatened mammals, birds and reptiles) are largely currently in a promising situation, degradation of the floral diversity (globally endangered Sundri mangals) and on-going ecological processes has been, and continues to be, significant. Moreover, should the intensity of these threats increase into 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 great 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 effective. However, funding and capacity are currently inadequate to maintain the sites value's sufficiently in the face of the multiple threats to the site, and particularly under increasing population and climatic pressures into the future. Studies into the resilience of the site and its values under changes to ecological processes and climate change are necessary in order to develop and refine effective management action. Moreover, transboundary cooperation with the Sundarbans, Bangladesh World Heritage site should be considered and may prove essential to develop effective regional strategies for climate change adaptation.

Current state and trend of VALUES

Low Concern
Trend: Deteriorating

The Sundarbans, while it remains the largest continuous mangrove forest in the world, is now almost half the size of the area that existed in the late 1800s due

to very high human pressure in settlements at its boundaries. 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 has been, and 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 the current situation appears promising, 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 marine mammals is currently insufficient to assess the status and trends of dolphin populations, this situation seems likely to also 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 its values into the future. Moreover, as threats continue to increase in intensity into 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. 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 remainder of the Sundarbans and the Bay of Bengal remain of concern to the site’s Outstanding Universal Values. Moreover, the future threat of sea level rise and increased frequency and intensity of extreme weather events (storms and tidal surges) under climate change is severe. The site’s ecological and biodiversity values are all affected by these pressures and the Outstanding Universal Value of the site is therefore

under serious threat into the future.

Overall PROTECTION and MANAGEMENT

Mostly Effective

Protection and management to preserve the Sundarbans National Park's Outstanding Universal Value within the site is currently very good, and provides many examples of Best Practice. However, greater focus on monitoring of aquatic animals, and research into biodiversity and ecosystem resilience in the face of current and future threats are issues not currently being adequately addressed. Moreover, due to external pressures from the site's buffer zone and from activities within the wider Sundarbans ecosystem, preservation of its values from threats outside the site is currently very high. Funding and capacity to preserve the site's Outstanding Universal Value is inadequate to tackle these wider threats, and boundaries and transboundary management with the Sundarbans, Bangladesh World Heritage Site should be deliberated 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 Sundarbans is the largest area of mangrove forest in the world and the only one that is inhabited by the tiger. The land area in the Sundarbans is constantly being changed, moulded and shaped by the action of the tides, with erosion processes more prominent along estuaries and deposition processes along the banks of inner estuarine waterways influenced by the accelerated discharge of silt from sea water. Its role as a wetland nursery for marine organisms and as a climatic buffer against cyclones is a unique natural process. (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 present in the property (Gopal & Chauhan, 2006). The flagship mammal species of the area is the Royal Bengal tiger Panthera tigris ssp. tigris (EN). The Sundarbans (including the Bangladeshi portion) is home to one of the largest populations of tigers in the world (estimated ~350-450 individuals; Gopal & Chauhan, 2006; IUCN, 2013), and the Indian Sundarbans population is currently estimated at 64-90 individuals (Jhala et al., 2011). The Sundarbans moreover is the only mangrove habitat in the world that contains tigers. 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 a total of >300 species recorded (IUCN, 1987; Chaudhuri & Choudhury, 1994; UNEP-WCMC & IUCN, 2013a). These include 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 Sundarbans 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) and 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 rare grey-headed fish eagle Ichthyophaga ichthyaetus are considered to be near threatened (NT; IUCN, 2013).

► Rare and threatened reptiles

Criterion:(x)

The site 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). The site has a diverse herpetofauna, with 59 documented species of reptile and seven amphibians (Naskar et al., 2004; Gopal & Chauhan, 2006). 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), though the estuarine crocodile Crocodylus porosus (LC) still persists (IUCN, 1987; Gopal & Chauhan, 2006; UNEP-WCMC & IUCN, 2013a; IUCN, 2013). The population of estuarine crocodiles in the Indian Sundarbans is low: 100 individuals (UNEP-WCMC & IUCN, 2013a). Three species of monitor lizard are present (IUCN, 1997), all of which are considered to be near threatened (NT; IUCN, 2013). There are 18 recorded snake species, including the globally threatened king cobra Ophiophagus hannah (VU). Chelonids include four marine turtle species, all of which are threatened with extinction globally (the 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 diversity in the Sundarbans is some of the highest in the world (Sanyal et al., 2008). The mangrove ecosystem of the Sundarbans is considered to be unique because of its immensely rich mangrove flora and mangrove-associated fauna. 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, 2013).

Assessment information

Threats

Current Threats

High Threat

Due to effective management of the Sundarbans National Park, many threats affecting the Sundarbans forest have been greatly reduced in their intensity. However, current threats to the Sundarbans National Park from over exploitation, altered hydrology, pollution, poor fishing practices and extreme weather events remain significant, and the combination and interaction of these multiple pressures represent some concern for the continued conservation of the site’s Outstanding Universal Value in both the marine and terrestrial environments.

► Crops

Low Threat
Outside site

Population pressure surrounding the Sundarbans is extremely high in both India and Bangladesh, and historically this has led to loss of mangrove forest area due to conversion of land to agriculture (Gopal & Chauhan, 2006). And population pressure continues to threaten the integrity of the forest at the inland fringes. 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. However, losses of habitat area to agricultural expansion elsewhere in the Indian and Bangladeshi Sundarbans may produce impacts to the biodiversity values of the whole system (V2, V3, V5). With increasing population pressure at the inland fringes in both India and Bangladesh, such impacts to Sundarbans’ biodiversity could become a serious problem into the future if not correctly managed (UNEP-WCMC & IUCN, 2013b). Moreover, potential further increases in agro-chemical loadings into the Sundarbans

waters mean this threat is greater than from land-cover change alone.

► Marine/ Freshwater Aquaculture

High Threat
Outside site

Illegal shrimp/prawn farms are currently encroaching into the Tiger Reserve (UNESCO, 2002; UNEP-WCMC & IUCN, 2013a), which can cause clearing of areas of forest for their creation and sources of solid and waste pollution, and extensive illegal trapping and hunting of forest vertebrates (Blower, 1985). While this threat is currently small within the Sundarbans National Park due to adequate legal protection and monitoring (UNEP-WCMC & IUCN, 2013a), activities elsewhere in the area (i.e. in the buffer zone (where such activities are currently a problem (PR Questionnaire, 2003) and in areas of the Bangladeshi Sundarbans) may influence the ecological and biodiversity values of the area due to the contiguous and connected nature of the Sundarbans as a whole (Rahman et al., 2010; UNEP-WCMC & IUCN, 2013b). As a consequence of land clearing, both habitat and food resources for higher level diversity 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). Moreover, these sites release large amounts of natural and synthetic chemicals on a daily basis, contributing to the loss of important ecological processes (Rahman et al., 2010), and subsequently to local biodiversity.

► 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). These spillages also damage mangrove ecology (Rahman et al. 2010) and cause instant mortality of mangrove seedlings (Hussain & Acharya, 1994), reducing the extent and quality of habitat available 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 integrity of the on-going ecological processes of the site (V1). Numerous commercial and tourist vessels pass

through the Bangladeshi 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.

► Fishing / Harvesting Aquatic Resources

Very Low Threat
Inside site

Illegal fishing, poaching and illegal aquaculture are encroaching into the Reserve (UNEP-WCMC & IUCN, 2013a), and such activities can result in the development of temporary fishing camps (UNEP-WCMC & IUCN, 2013b). Temporary fishing camps cause clearing of areas of forest for their creation and sources of solid and waste pollution, and extensive illegal trapping and hunting of forest vertebrates (Blower, 1985). Clearing of mangrove areas may serve to affect coastal and bank integrity, compromising the sites on-going ecological processes. Loss of habitat, pollution and poaching at fishing camps moreover compromises the integrity of the rare and threatened flora and fauna of the site (V2, V3,V4,V5). While these threats are currently small within the Sundarbans National Park due to adequate legal protection and monitoring (UNEP-WCMC & IUCN, 2013a), activities elsewhere in the area (i.e. in the buffer zone and in areas of the Bangladeshi Sundarbans) may influence the ecological and biodiversity values of the area due to the contiguous and connected nature of the Sundarbans as a whole (Rahman et al., 2010; UNEP-WCMC & IUCN, 2013b).

► Commercial hunting

Data Deficient
Inside site
Outside site

Poaching of tigers for sale on illegal international 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 the illegal markets is high (Deodatus & Ahmed, 2002), providing a high incentive for illegal poaching of tigers throughout the Sundarbans, including despite the high protection of the Sundarbans National Park. However, so far the true level of illegal hunting throughout the Sundarbans is unknown and unquantified (Deodatus

& Ahmed, 2002).

► Water Pollution

High Threat
Outside site

The Sundarbans ecosystem is vulnerable to spillage such as oil spillages, heavy metals, and nutrient enrichment from agro-chemicals as a result of industry, agriculture and aquaculture, through alterations to 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. As a result of degradation of mangrove ecology, mangrove area and primary production, sedimentation and deltaic and bank formation are also influenced, compromising the integrity of the on-going ecological processes of the site. As population pressure continues to drive the expansion of industry, agriculture and aquaculture, particularly in Bangladesh (Rahman et al. 2010), these impacts are very likely to increase in intensity into the future.

► Household Sewage/ Urban Waste Water

Low Threat
Inside site
Outside site

Population increases near river basins and attempts to modernize living conditions in coastal areas has meant that there has been large-scale production of sewage and wastewater effluents into the Sundarbans waters (Rahman et al., 2009). These inputs into the aquatic system serve to alter mangrove biogeochemistry (Rahman et al., 2009), reducing mangrove area, and primary production, sedimentation and deltaic and bank formation are also influenced, compromising the integrity of the on-going 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 into the future, 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.

► Subsistence hunting

High Threat
Inside site
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, and even by intruders from Bangladesh (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 Endangered flagship Royal Bengal tiger throughout the forest, thus compromising the conservation value of the site. Moreover, the Sundarbans area has endured significant levels of human-wildlife conflict in the form of hunting tigers for their man-eating status since the 17th century. Tigers frequently 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 moreover 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. Moreover, hunting the tiger within the Bangladeshi Sundarbans poses a severe threat to the metapopulation as a whole (Ahmad et al., 2009). The Sundarbans in India and in Bangladesh is under severe population pressure (Gopal & Chauhan, 2006; Jhala et al., 2011), and increasing populations in both countries may lead to an increasing trend in this threat to the Sundarbans' tiger population into the future.

► Logging/ Wood Harvesting

Low Threat
Outside site

The Sundarbans is under severe population pressure (Gopal & Chauhan, 2006; Jhala et al., 2011), and many thousands of local people rely on the forest 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 for honey collecting within 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. Moreover, timber extraction activities are extremely high within the Bangladeshi portion of the Sundarbans, for both subsistence, local livelihoods and commercial purposes (Rahman et al., 2010). Extraction results in an overall reduction in productivity of the forest, compromising both the resource availability to sustain the currently 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 the global population and distribution of Sundri trees, 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 will also alter soil and sedimentation dynamics and increase erosion, compromising the natural on-going ecological processes of tidal influences and deltaic and bank formation (V1). With the increasing wide 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 within the Bangladeshi portion (Rahman et al. 2010). 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. Management of the Indian portion is very good and the site is well protected; however, activities within Bangladesh and illegal activities within the Tiger Reserve present a significant threat to the site's values.

► Fishing / Harvesting Aquatic Resources

High Threat
Inside 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 unsustainably 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).

► 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, these activities are 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). In 2010, 250 ha of the Bangladeshi Sundarbans trees and habitat were lost to fire in a single event, and 12 incidents of fire occurred between 2007-2010 (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 is likely to increase into the future and may produce a relatively high threat to the aesthetic beauty and conservation integrity of the WH 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). These 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 extent, mangrove species diversity , and thus availability and quality of habitat for the site’s rare and threatened animals (Iftekhar & Islam, 2004; Akhtaruzzaman, 2000). Indeed, increasing siltation is moreover 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 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 moreover has 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 in both India and Bangladesh (according to increases in the development of industry and agriculture due to increased population pressure; Rahman et al., 2010) may significantly increase this threat into the future, producing potentially serious problems. Moreover, coupled with the potential impacts of sea level rise under climate change, this threat may serve to significantly reduce the integrity of the site. Creation of an upstream barrage may be the only option to store water for freshwater

inundation in dry season lows for the Sundarbans forest (Haq 2010).

► Erosion and Siltation/ Deposition

Very High Threat
Inside site
Outside site

A long-term ecological change is taking place in the Sundarbans, due to the eastward migration of the Ganges, the abandonment of some distributaries, and past diversion of water and withdrawals for irrigation. 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 necessitating dredging to improve river flow: local fishermen expect that the Matla River will soon no longer be navigable up to Canning Town.

► Other

High Threat
Inside site
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 thus its replacement with the other common Gewa Excoearia agallocha (Christensen, 1984). In the Bangladeshi portion of the Sundarbans, the extent of pure Sundri stands has decreased by 21% since 1926, and dominance of Sundri in mixed stands is diminishing (Iftekhar & Saenger, 2008). The disease moreover 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 the currently high levels of biodiversity. Moreover, 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 moreover 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 into the future (Rahman et al., 2010).

► Industrial/ Military Effluents

High Threat
Inside site
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 which enter 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. High concentrations of heavy metals (i.e. Zn, Cd, Cr, Pb and Cu) have been found within the Bangladeshi Sundarbans mangrove sediment (Rahman et al., 2009).

► Agricultural/ Forestry 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. High concentrations of organic pesticides have been reported in the Bangladeshi Sundarbans mangrove sediment (Rahman et al., 2009).

► Solid Waste

High Threat

Outside site

The Indian Sundarbans has been declared as a “No Plastic Zone”; 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, particularly in the Bangladeshi Sundarbans, has meant that there has been 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

Very High Threat
Inside site
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. 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. 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 World Heritage site. Regeneration of the Sundarbans ecosystem, should normally take 10 to 15 years, if poaching and other intrusions do not jeopardize this (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.

Potential Threats

Very High Threat

Potential threats to the site's values from climate change in the area are extremely serious. If the IPCC's projections of sea level rise occur and nothing is done to combat projected increases, large areas of the Sundarbans will certainly be lost and the forest's composition severely altered. As the WH site is at the coastal margin of the forest, this threat could result in the severe degradation of the site and its Outstanding Universal Value. The potential for increased pollutant loadings from the proposed Rampal power plant moreover provides a significant threat to the site's values into the future.

► Habitat Shifting/ Alteration

Very High Threat
Inside site

Much of the Sundarbans forest is not of elevation very 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 some areas of Bangladesh, coastal retreat has been found to be as much as 200 m per year (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 important biodiversity such as the Royal Bengal tiger. 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 higher level biodiversity such as the Bengal tiger. Threatened aquatic species 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). Moreover, increased salinity has 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, and 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 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.

► Industrial/ Military Effluents

Low Threat
Inside site
Outside site

If construction goes ahead, the proposed Rampal coal-fired power plant will be constructed along the banks of the Passur river, Bangladesh, 14km north of the Sundarbans. If not adequately managed, the operation of this plant will require shipping access through the forest for coal transport, and may emit industrial effluent to the Sundarbans water, and significantly increase the likelihood of oil spillages and airbourne pollutants, affecting wildlife populations , and mangrove ecology and productivity, subsequently producing severe impacts to the on-going ecological processes of the site.

Due to the interconnected nature of the Sundarbans ecosystem, the pollutive effects from this potential construction will also have negative impacts on the Sundarbans National Park.

Protection and management

Assessing Protection and Management

► Relationships with local people

Highly Effective

Dependence of local people on Sundarbans' resources is high. Sustainable extractive activities are permitted by permit for honey and fish extraction (West Bengal Forest Department, 2012). The site, managed by Project Tiger and the West Bengal Ministry of Environment and Forests, works directly with local communities in participatory management within 10 Forest Protection and 14 Eco-Development Committees. Eco-Development projects provide communities with assistance in irrigation, water infrastructure, jetties, advise 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 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 moreover served to reduce human-wildlife conflict in the buffer zone (West Bengal Forest Department, 2012).

► Legal framework and enforcement

Mostly Effective

The site is listed as a Strict Nature Reserve (IUCN category Ia; Protected Planet, 2014). 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 law enforcement of zone laws and regulation of garbage pollution are all strictly 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 (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, pressure within the buffer zone is very 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 abounds, and even by intruders from Bangladesh (Blower, 1985; PR Questionnaire, 2003; Gopal & Chauhan, 2006; UNEP-WCMC & IUCN, 2013a). These current and increasing external pressures may be impacting on the site’s Outstanding Universal Value despite current management activities.

► Integration into regional and national planning systems

Highly Effective

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).

► Management system

Mostly Effective

The original management plan for the site was requested by the World Heritage Committee to be updated upon inscription. The management plan was updated for the period 2001-2010 (UNEP-WCMC & IUCN, 2013a). The site is extremely well managed by Project Tiger, the West Bengal Forest Department and participatory management by local communities, and the management plan and its regulations strictly followed. However, illegal poaching, fisheries and aquaculture remain significant challenges to effective management of the site values (UNEP-WCMC & IUCN, 2013a), as well as increased cooperation with the Bangladeshi Sundarbans site.

► Management effectiveness

Mostly Effective

The site is extremely well managed, and the management plan and its

regulations strictly followed. 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, pressure within the buffer zone is very 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 abounds, and even by intruders from Bangladesh (Blower, 1985; PR Questionnaire, 2003; Gopal & Chauhan, 2006; UNEP-WCMC & IUCN, 2013a). Moreover fisheries and aquaculture 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

Highly 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 monitoring 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).

► Monitoring

Some Concern

The most recent population estimate for the tiger population in the Indian Sundarbans was carried out using a combination of camera trapping and satellite telemetry, and estimated a population size of 64-90 individuals (Jhala et al., 2011). Recently, monitoring of the population using scat DNA has begun, to validate estimates of population size (Pers. comm., 2012), which is believed to overestimate population size. Moreover, an assessment of the status of tiger prey species in the area is required (UNESCO, 2001). Rolling out of consistent monitoring methodologies for the tiger population over time is necessary for continued and appropriate assessment of the

status of the population (UNESCO, 2001). Moreover, 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, as monitoring methodologies employed in the Bangladeshi Sundarbans are currently not concordant with those being employed in India (Barlowe et al., 2008). However, there is little monitoring of aquatic populations in the Indian Sundarbans. 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). Negative impacts from intensive prawn aquaculture have been studied in the past (PR Questionnaire, 2003). 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).

► 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 is a buffer zone, comprising nine forest blocks in which sustainable extractive activities are allowed via permits and fishing occurs in the tidal waters, and the Sajnakhali Wildlife Sanctuary exists within the buffer zone. Moreover, 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 also (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 Sundarbans, Bangladesh WH 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 source of funding is from both the federal Government of India and 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, and other sources of funding have come from civil society organizations for projects involving collaborative research and livelihoods projects (West Bengal Forest Department, 2012). However, funding is not currently considered adequate to build capacity (financial and human) for effective management of the site and its Oustanding 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). Moreover, ecosystem-based management across the two countries containing the Sundarbans for monitoring of existing threats and conservation of the WH sites in both India and Bangladesh is key to the continued preservation of the values of both WH properties, as has previously been discussed (UNESCO, 2001; PR Questionnaire, 2003).

► Staff training and development

Highly Effective

Based on a Training Need Assessment, the Tiger Project and West Bengal Forest Department have identified 13 necessary staff training areas 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 also dependent on the area for charcoal, timber, nypa palm thatch, grass, reeds, shells, reptile skins, poaching of deer, 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 is a buffer zone, comprising nine forest blocks in which sustainable extractive activities are allowed via permits and fishing occurs in the tidal waters (IUCN, 1987; UNEP-WCMC & IUCN, 2013a). Project Tiger and West Bengal Forest Department have developed participatory governance measures within 10 Forest Protection and 14 Eco-Development Committees that increase 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 (assistance in irrigation, water infrastructure, jetties, advise 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

Highly Effective

Project Tiger and 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 at regular intervals. 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 interpretation

Highly Effective

Tourists are not allowed within the National Park without a permit. However, tourism within the buffer zone averages 34,390 visitors per annum within the buffer zone 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 within the site’s management plan (PR Questionnaire, 2003), and moreover strict regulation of litter and wasteful activities from boats and lodges is overseen by management (West Bengal Forest Department, 2012). Wildlife watching largely occurs from within the waterways. However, 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 conducted tours from Kolkata (UNEP-WCMC & IUCN, 2013a). There are relatively few lodges in the Tiger Reserve, but overnight facilities aboard sightseeing boats exists (UNEP-WCMC & IUCN, 2013a). There is good access to the Tiger Reserve by organized trips from Kolkata, rail, and by boat and bus (UNEP-WCMC & IUCN, 2013a). Boats can be hired to visit the site from the Tourist Bureau or Sundarbans Launch Association in Kolkata (UNEP-WCMC & IUCN, 2013a). A ‘Mangrove Interpretation Centre’at the Sundar Cheetal Sajnekhali Tourist Lodge also exists within the buffer zone (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 training for employment on tourist boats as guides (UNESCO, 2002). So far, 34 Eco-Guides have been trained and accompany visitors to provide interpretation of the forest and its natural resources (West Bengal Forest Department, 2012). Moreover, 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).

► Research

Some Concern

There exists a large body of research on the climate, ecology, hydrology and biodiversity of the Sundarbans: flora and fauna, on 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 are 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. Moreover, 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 global change. Such efforts should moreover be coordinated with the Bangladeshi portion, in order to assess the potential future resilience of the forest to current and projected threats and inform appropriate management.

Overall assessment of protection and management

Mostly Effective

Protection and management to preserve the Sundarbans National Park’s Outstanding Universal Value within the site is currently very good, and provides many examples of Best Practice. However, greater focus on monitoring of aquatic animals, and research into biodiversity and ecosystem resilience in the face of current and future threats are issues not currently being adequately addressed. Moreover, due to external pressures from the site’s buffer zone and from activities within the wider Sundarbans ecosystem, preservation of its values from threats outside the site is currently very high. Funding and capacity to preserve the site’s Outstanding Universal Value is inadequate to tackle these wider threats, and boundaries and transboundary management with the Sundarbans, Bangladesh World Heritage Site should be

deliberated 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

Major threats from outside the site are numerous and intense. High human pressure in the buffer zone and within the Bangladeshi portion of the Sundarbans, 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 are increasingly huge challenges for the fragile Sundarbans ecosystem. Current site management of localized threats is extremely good and effective, with highlights including good community participation, staff training, education and tourism. However, the high level of pressure within the buffer zone of the Tiger Reserve may in future have negative impacts on the Outstanding Universal Value of the site, suggesting further focus on alternative livelihoods generation and increased funding and capacity towards monitoring and informant measures to better control illegal extraction into the future. Due to the interconnected nature of the Sudnarbans ecosystem, activities occurring in the Bangladeshi portion (freshwater extraction, biodiversity depletion, pollution and fisheries management) also produce threats to the WH site. An important improvement to the preservation of the site’s Outstanding Universal Value 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 into 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 (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 (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 (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 (tourism in the area is growing and many people visit the site, rules to minimize damage and waste strictly implemented, recycling and waste removal programme, good facilities for visitor stay (terrestrial and waterbourne), 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 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). These 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 causing the replacement of Sundri trees by Gewa through top-dying (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 moreover a huge problem within the site, and specific channels (i.e. the Matla River up to Canning Town) are becoming severely blocked and considered to be soon unnavigable (UNEP-WCMC & IUCN, 2013a). Moreover, 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 some areas of Bangladesh, coastal retreat has been found to be as much as 200 m per year (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 important biodiversity such as the Royal Bengal tiger. Sea level rise under climate change will moreover exacerbate these alterations to on-going ecological processes 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 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:Stable

The Sundarbans National Park supports a diverse assemblage of rare and threatened terrestrial and aquatic mammals (IUCN, 1987; UNEP-WCMC &

IUCN, 2013a). Populations of Ganges river dolphin, Irrawaddy dolphin and Royal Bengal tiger within the Sundarbans are all currently relatively high, with populations of the latter two species representing stronghold populations for these species globally (Smith et al., 2006; IUCN, 2013). WWF-India consider the tiger population in the Indian Sundarbans to currently be stable to increasing (Jhala et al., 2011; UNEP-WCMC & IUCN, 2013a). 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 currently in a good state (UNEP-WCMC & IUCN, 2013a). Moreover, the Sundarbans' populations of Ganges river dolphins and Irrawaddy dolphins appear to be favorable 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). This suggests that the state of the site's rare and threatened terrestrial and aquatic mammals is currently good. However, due to the multiple threats present in the area, 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). Moreover, the threats from illegal poaching, habitat loss and degradation (both aquatic and terrestrial), pollution, altered hydrology and entanglement in hazardous fishing equipment are currently significant, and are likely to increase in intensity into 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

One bird species is known to be locally extirpated from the Sundarbans over the last century: Swamp francolin Francolinus gularis (VU; Ministry of Environment and Forests, 2010; IUCN, 2013). However, the Sundarbans has a varied bird life, and has a high level of avian diversity for a mangrove

ecosystem (Khan, 2005). The area moreover provides habitat for several globally threatened species (IUCN, 2013). Currently little empirical data on population trends exists for the rare and threatened birds of the Sundarbans. A recent study conducted in the Bangladeshi Sundarbans East Wildlife Sanctuary, suggests that the state of the Sundarbans' avifauna is currently favourable (Khan, 2005). 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 into the future with 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 Least Concern, 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 is currently 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-cum-Rearing Centre for re-introduction into the Sundarbans, and olive ridley turtles are reared here and in captivity at Sajnakhali for release into the national park (UNEP-WCMC & IUCN, 2013a). Moreover, a breeding program run by the Turtle Survival Alliance and the West Bengal Forest Department at the rearing site at Sajnakhali for the Northern river terrapin has seen the successful hatching of several juveniles of this species (UNEP-WCMC & IUCN, 2013a). The species is functionally extinct in the Sundarbans, and this program offers a good chance at 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

resulting in increased survival of globally threatened species. However, the Sundarbans' biodiversity has been greatly depleted in the past, and severe on-going threats from illegal poaching, habitat loss and degradation (both aquatic and terrestrial), pollution, altered hydrology and entanglement in hazardous fishing equipment are currently significant, and are likely to increase in intensity into the future.

► Rare and threatened flora

Low Concern
Trend:Deteriorating

Populations of Sundari trees (Heritiera fomes; EN) in the Sundarbans are rapidly declining (IUCN, 2013) due to overexploitation for timber use. The extent of pure H. fomes stands in Banglaesh has decreased by 21% since 1926, and dominance of H. fomes in mixed stands is diminishing (Iftekhar & Saenger, 2008). Moreover, approximately 70% of H. fomes stems have been estimated to be moderately or severely affected by the "top-dying" disease (Islam & Wahab, 2005), which is a disease that causes high mortality. Moreover, 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). Stands of H. fomes and Phoenix paludosa moreover provide ideal habitat for the Royal Bengal tiger (IUCN-Bangladesh, 2004; Iftekhar & Saenger, 2008). In addition, as the dominant mangrove species in the back mangrove of the Sundarbans, loss of H. fomes trees poses a significant threat to the other 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, while it remains the largest continuous mangrove forest in the world, is now almost half the size of the area that existed in the late 1800s due to very high human pressure in settlements at its boundaries. 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 has been, and 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 the current situation appears promising, 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 marine mammals is currently insufficient to assess the status and trends of dolphin populations, this situation seems likely to also 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 its values into the future. Moreover, as threats continue to increase in intensity into the future, greater adequate and sustainable management action and capacity will be required.

Additional information

Key conservation issues

▶ Climate change adaptation

National

Severe threats are posed to the site by climate change, and specifically sea level rise. Appropriate management activities for the avoidance (including national reduction of black carbon emissions), and adaptation and mitigation activities will be of the utmost importance into the future in order to minimize loss of habitat, and saltwater intrusion and altered hydrology. Such efforts should moreover be coordinated with the Bangladeshi portion, in order to assess the potential future resilience of the forest to climate change threats

and inform appropriate adaptive management. The Integrated Coastal Zone Management initiative may produce useful information and guidelines to inform such regional planning.

► Integration with the Bangladeshi WH Site

Regional

Due to the interconnected nature of the system as a whole, many of the major threats to the WH property in the Indian Sundarbans have their source in the Bangladeshi portion of the Sundarbans. In order to successfully manage the site in the face of these external pressures, integration of management activities with the Sundarbans, Bangladesh, as has been previously discussed, will prove an important and essential measure to minimize ecosystem-level threats to both sites' values. The Integrated Coastal Zone Management initiative may produce useful information and guidelines to inform such regional planning.

► Coastal erosion and mangrove degradation

National

The entire Sundarbans forest is 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 some areas of Bangladesh, coastal retreat has been found to be as much as 200 m per year (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 et 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 important biodiversity such as the Royal Bengal tiger.

► Alternative livelihoods

Local

The Government of India and the World Heritage Committee recognize that a large number of people currently rely upon the Sundarbans forest for livelihoods. However, the site management has implemented an effective "Zonation Plan" for the Tiger Reserve, in which extractive activities are not permitted within the core Sundarbans National Park area, and sustainable

harvest of fish, honey etc. is permitted within the buffer zone area (Government of India, 2012). Moreover, site management includes the involvement of participatory management from local communities (Government of India, 2012). However, illegal activity still persists within the buffer zone and National Park (UNEP-WCMC & IUCN, 2013). Moreover, with increasing population pressure and damaging impacts from existing activities and methodologies (i.e. shrimp fry fishing and the use of gillnets by fishermen), the need for the development of further appropriate strategies for alternative livelihoods within the Indian Sundarbans is likely to become necessary.

► Fisheries management

Local

Harvesting of shrimp and prawn fry is an extremely destructive process in the area, as dragnets have not only unsustainably 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 (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. 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). Efforts should be made to further reduce illegal activities and to put a stop to the use of harmful equipment.

► Monitoring methodologies

Local

The most recent population estimate for the tiger population in the Indian Sundarbans was carried out using a combination of camera trapping and satellite telemetry, and estimated a population size of 64-90 individuals (Jhala et al., 2011). Recently, monitoring of the population using scat DNA has begun, to validate estimates of population size (P. Sanyal pers. comm., 2012), which is believed to overestimate population size. Rolling out of consistent monitoring methodologies for the population over time is necessary for continued and appropriate assessment of the status of the population. Moreover, 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, as monitoring methodologies employed in the Bangladeshi Sundarbans are currently not concordant with those being employed in India (Barlowe et al., 2008).

Benefits

Understanding Benefits

► Is the protected area valued for its nature conservation?

Conservation of national and international geological and biodiversity values (including conservation of habitats for globally threatened, charismatic fauna: the Bengal tiger, Ganges river dolphin and Irrawaddy dolphin).

► 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 great protection for inland areas and human populations from storm damage from e.g. cyclones and from flooding from 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 are temporally 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.

▶ Does management of the site provide jobs (e.g. for managers or rangers)?

The Tiger Project and West Bengal Forest Department that manages the Sundarbans National Park employs many staff to as Forest Guards, to carry out necessary monitoring and management actions.

▶ Fishing areas and conservation of fish stocks

The Sundarbans provide important spawning and nursery ground for several, some economically important, fish 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 in the world.

▶ Pollination

Sundarbans support large numbers of honey-bees, which produce great quantities of honey and wax, which in turn provides 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) for 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 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 at regular intervals. School children are given tours to sensitize them about 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 Manageme nt (CARNIAM) (Banglades h)	“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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