IUCN Conservation Outlook Assessment 2014 **(archived)**
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Please note: this is an archived Conservation Outlook Assessment for The Sundarbans. To access the most up-to-date Conservation Outlook Assessment for this site, please visit https://www.worldheritageoutlook.iucn.org.

The Sundarbans

SITE INFORMATION

Country:
Bangladesh
Inscribed in: 1997
Criteria:
(ix) (x)

Site description:
The Sundarbans mangrove forest, one of the largest such forests in the world (140,000 ha), lies on the delta of the Ganges, Brahmaputra and Meghna rivers on the Bay of Bengal. It is adjacent to the border of India's Sundarbans World Heritage site inscribed in 1987. The site is intersected by a complex network of tidal waterways, mudflats and small islands of salt-tolerant mangrove forests, and presents an excellent example of ongoing ecological processes. The area is known for its wide range of fauna, including 260 bird species, the Bengal tiger and other threatened species such as the estuarine crocodile and the Indian python. © UNESCO

SUMMARY

2014 Conservation Outlook

Significant concern

The values of The Sundarbans are highly threatened by multiple on-going processes both within and external to the site, and the site's values are showing signs of deterioration. The ecosystem is showing a high level of degradation, with loss of important and globally endangered mangrove species due to felling, disease and altered freshwater inputs, changes to vegetation communities, and intense and on-going coastal erosion and retreat. Shrimp aquaculture and fry dishing are moreover severe and increasing threats, causing water pollution, habitat loss, loss of food resources for higher biodiversity, bank erosion and sedimentation and accidental mortality of rare and threatened vertebrates. As population pressure in the Sundarbans increases, these human extractive threats to the site's values will increase, and management funding and capacity is currently insufficient to adequately mitigate these pressures at their current intensity. Potential threats from proposed industry development in Bangladesh may also be high. Climate change poses an extremely high level of concern for the site and its values, through rapid sea level rise and increases in the frequency and intensity of storms and tidal surges, which may produce devastating impacts into the future. While internationally-funded programmes are underway to attempt to tackle these effects, scientific study into the resilience of the site in the face of these multiple changes to ecological processes and climatic changes to the site will be essential to inform effective management into the future. Transboundary management with the Sundarbans National Park, India should be further considered, as this may be essential into the future to develop effective regional management strategies for the Sundarbans ecosystem as a whole.

Current state and trend of VALUES

High Concern
Trend: Deteriorating

The Sundarbans Reserve Forest of which the World Heritage Site is part, while remaining 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 has been, and continues to be, significant due to natural and anthropogenic alterations to the hydrology and ecology of the site, including through impacts on, Bangladesh's mangrove diversity (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 deltaic and bank formation. 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. Populations of some of the site's rare and threatened mammals are large (some of the largest populations in the world for Bengal tiger and Irrawaddy dolphin). However, while the situation appears to be currently favourable for aquatic mammal populations, limited available evidence suggests that certain species of rare and threatened terrestrial mammals in the Bangladeshi Sundarbans may be decreasing (Bengal tigers and their prey), likely due to illegal poaching activities. Given the results of recent bird surveying, the situation for the rare and threatened birdlife within the site appears to currently be favourable. Recent success in breeding programmes for critically endangered and functionally extinct herpetofauna (Northern river terrapins) within the Sundarbans gives promise for the conservation of this species into the future if threats that lead to its demise can be properly addressed. However, little information exists on the status and trends of rare and threatened marine reptiles in the Bangladeshi Sundarbans. Moreover, the limited available evidence suggests that populations of crocodile and snake species may be declining. Thus, it appears that the effects of ecosystem degradation on the site's values are currently relatively high, and 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, the need for greater and more sustainable management actions and capacity will be required. While the status of the site's biodiversity appears to be currently largely favourable, however, an increase in the intensity of current

threats (i.e. under climate change or increased extractive pressures) or discontinuation of efficient management actions may greatly change the current state of affairs.

Overall THREATS

High Threat

The current and potential threats to both the marine and terrestrial elements of the property are many and severe. Threats of unsustainable and illegal extraction of wood and honey, aquaculture, shrimp fry fishing and harmful fishing practices are high and are currently not adequately managed due to insufficient funding and capacity. Moreover, processes occurring elsewhere in the Sundarbans and in the Bay of Bengal – altered hydrology due to freshwater extraction and the eastward migration of the Ganges, pollution and mangrove disease – pose a great threat to the site’s values. The threats from sea level rise and increased frequency and intensity of extreme weather events (storms and tidal surges) under climate change are severe, and pose significant cause for concern for the site into the future. As a coastal area that is moreover regularly affected by extreme weather events such as cyclone Sidr in 2007, the concern for the site’s values from these multiple threats becomes yet more severe, and the likely success of successful management greatly compromised. The potential for increased pollutant loadings from the proposed Rampal power plant, as well as the associated dredging of the Passur River, moreover provides a significant threat to the site’s values into the future.

Overall PROTECTION and MANAGEMENT

Some Concern

The current protection and management system shows major deficiencies and is currently unable to maintain the site’s values and integrity over the long-term. While the central government support for policy initiatives to protect the site’s values is good, capacity to implement policies effectively is currently limited. Funding is insufficient to provide the monitoring and protection necessary to ensure the safeguarding of the site’s Outstanding Universal Value, and redirection of increased funds from the Forest Department towards the Sundarbans, as well as greater input from the international community, is essential to improve capacity and training, and the ability to effectively monitor and research the state of the site’s values and the intensity of the impact of

current and potential threats. While projects funding to research into climate change adaptation is available for the area, funds required to successfully manage the site to mitigate these threats, and specifically sea level rise, into the future are furthermore likely to be extensive in the long-term. Moreover, many threats to the site’s Outstanding Universal Value have their source within the remainder of the Sundarbans ecosystem (within both Bangladesh and India) and Bay of Bengal. Funding and capacity to preserve the site’s Outstanding Universal Values is inadequate to tackle these wider threats, and transboundary management with the Sundarbans National Park World Heritage Site in India needs to 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

- **On-going ecological processes that lead to the creation and sustenance of mangrove ecosystems**
  Criterion:(x)

  The Sundarbans provides a significant example of on-going ecological processes as it represents the process of delta formation and the subsequent colonization of the newly formed deltaic islands and associated mangrove communities. These processes include monsoon rains, flooding, delta formation, tidal influence and plant colonization. As part of the world’s largest delta, formed from sediments deposited by three great rivers; the Ganges, Brahmaputra and Meghna, and covering the Bengal Basin, the land has been moulded by tidal action and other processes, resulting in a distinctive physiology (SOUV, 2013).

- **Exceptional level of biodiversity**
  Criterion:(x)

  One of the largest remaining areas of mangroves in the world, the Sundarbans supports an exceptional level of biodiversity in both the terrestrial and marine environments, including significant populations of globally endangered cat species, such as the Bengal tiger (SoOUV, 2013).

- **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. Of these, there have been documented 49 mammal species. The flagship mammal species of the area is the Bengal tiger Panthera tigris ssp. tigris (EN). The Sundarbans (including the Indian portion) is home to one of the largest populations of tigers in the world (estimated ~350-450 individuals, although these estimates are outdated and actual numbers may be lower), and the majority of the Bangladeshi tiger population is within the Sundarbans forest (IUCN, 1997). The area moreover is the only mangrove habitat in the world that contains tigers. Wild boar Sus scrofa (LC) and spotted deer Axis axis (LC) provide the main prey for the Bengal tiger (IUCN, 1997). 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; IUCN, 1997; 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; IUCN 1997). The area also contains highly threatened aquatic mammals: the rare Ganges river dolphin Platanista gangetica (EN) and Irrawaddy dolphin Orcaella brevirostris (VU; IUCN, 1997; IUCN, 2013). Bangladesh supports the largest known population of Irrawaddy dolphins in the world (~5,800 individuals; IUCN, 2013), with ~451 individuals within the Bangladeshi Sundarbans forest (Smith et al., 2006).The area contains only one primate: rhesus macaque Macaca mulatta (LC; IUCN, 1997; IUCN, 2013).

► Rare and threatened birds

Criterion:(x)

The Sundarbans supports a varied and colourful birdlife, with a total of 315 species recorded (SoOUV, 2013). 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 (IUCN, 1997). Some of the bird species within the Sundarbans are rare and threatened. Species within the Sundarbans of global conservation concern include the magnificent Pallas’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) and the greater spotted eagle Aquila clanga (VU). 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 Sundarbans has a relatively diverse herpetofauna, with 58 documented species of reptile and eight amphibians (SoOUV, 2013). 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, 1997). 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 a number of marine turtle species, all of which are threatened with extinction globally (the olive ridley Lepidochelys olivacea (VU), green turtle Chelonia mydas (EN), and loggerhead turtle Caretta caretta (EN) (Hussein & Acharya, 1994; IUCN 2013), and the critically endangered Northern river terrapin Batagur baska (CR; IUCN, 1997; 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). One of the most dominant mangrove species in the Sundarbans is the Sundri Heritiera fomes (Ministry of Environment and Forests, 2010; Rahman et al., 2010). This species is listed as globally endangered on the IUCN Red List due to its restricted distribution, and may qualify as critically endangered within Bangladesh and India due to rapid population declines (IUCN, 2013).

► Rare and threatened fishes

Criterion:(x)

The Sundarbans supports a rich fish diversity, many of which are commercially important in addition to their ecological values. Additionally, it is an important breeding and nursery site for benthic elasmobranches such

as sawfish. Two species are confirmed to be present: narrow sawfish Anoxyristis cuspidata (CR) and largetooth sawfish Pristis pristis (EN) (Hossain et al, in press), both of which were revealed to have suffered general population declines.

Assessment information

Threats

Current Threats

High Threat

Current threats to the Sundarbans from over exploitation, altered hydrology, pollution and poor fishing practices are very severe, and the combination and interaction of these multiple pressures represent a serious concern for the continued conservation of the site’s Outstanding Universal Value in both the marine and terrestrial environments. As a coastal area that is moreover regularly affected by extreme weather events such as cyclone Sidr in 2007, the concern for the site’s values from these multiple threats becomes yet more severe, and the likely success of management greatly compromised.

► Housing/ Urban Areas

Low Threat
Outside site

Along with the Forest Act, 1927, the Bangladesh Wildlife (Preservation) (Amendment) Act 1974, control activities such as entry, movement, fishing, hunting and extraction of forest produces within the WH site (SOUV, 2013). Under the provision of the Act, residence is moreover prohibited. However, fisherman’s camps are a major source of disturbance where they exist in the Sundarbans forest (UNEP-WCMC and IUCN, 2013), clearing areas of forest for their creation and creating sources of solid and waste pollution, and extensive illegal hunting and trapping of forest vertebrates is carried out by fishermen (also woodcutters and naval and military personnel) in the South Wildlife Sanctuary (Blower 1985). Loss of habitat, pollution and poaching at

fishing camps moreover compromises the integrity of the rare and threatened flora and fauna of the site. With the shrimp farming industry increasing rapidly over the past decades, and with the increasing population pressure in the country (Rahman et al. 2010), construction of fishing camps is likely to increase into the future, producing a potentially great threat to the site's values.

► Marine/ Freshwater Aquaculture

High Threat

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. The trend in shrimp farming expansion has been rapidly increasing in the Sundarbans over the last decades (Rahman et al., 2010), with increased production and clearance of large areas of mangroves to create shrimp ponds. Moreover, these sites are increasingly releasing large amounts of natural and synthetic chemicals on a daily basis, further 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 (Blower, 1985; Hussain & Acharya, 1994), which can occur from the rerouting of large shipping vessels into sensitive portions of the forest (Rahman et al. 2010). 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. 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 the Bangladeshi population continues to increase (Rahman et al. 2010), trade and import increases are likely to mean that shipping through the area will increase. With no management plans in place to combat this threat, the

impacts are likely to increase in intensity into the future.

► Commercial hunting

Data Deficient
Inside site
Outside site

Most illegal hunting appears to be concentrated on deer, but a (so far unknown and unquantified) risk remains for tiger poaching itself, due to high value of tiger products on the illegal markets (Deodatus & Ahmed, 2002). The government of Bangladesh acknowledges that poaching of tigers is one of the largest and most immediate threats to Bangladesh's tigers (BFD, 2013).

► Dams/ Water Management or Use

Very High Threat
Inside site
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, India in 1974; IUCN, 1997; Sanyal & Bal, 1986). Reduced freshwater flow serves to increase salt-water intrusion and irregular inundation serve to significantly degrade the health of the Sundarbans ecosystem (Iftekhar & Islam, 2004), causing reduction in forest cover extent and reduction in mangrove species diversity (Iftekhar & Islam, 2004; Akhtaruzzaman, 2000; Rahman et al., 2010). Habitat conditions for threatened biodiversity, i.e. the Bengal tiger, are also subsequently affected. Reduced freshwater flow also reduces nutrient supplies to the area, 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). Reduced freshwater flow also decreases sediment flow into the forest, altering deltaic and bank formation and compromising the on-going ecological processes of the site (Iftekhar & Islam, 2004). Increased freshwater extraction upstream (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 universal value of the site. Creation of an upstream barrage may be the only option to store water for freshwater inundation in dry season lows (Haq 2010).

► Commercial hunting

High Threat
Inside site
Outside site

Under the provision of the Wildlife Act, hunting within the site is prohibited. Within the remainder of the Sundarbans forest, legal permits for hunting are not given in practice and so the whole area in closed to legal hunting. However, illegal hunting of wildlife populations by fishermen and woodcutters is common, and produces one of the greatest threats to the Sundarbans ecosystem (Rahman et al., 2010; UNEP-WCMC and IUCN, 2013). Within the South Wildlife Sanctuary, illegal hunting has also been found to be practiced by military personnel (Blower, 1985) and is likely also practiced by the dacoits, groups of robbers and pirates present in the forest. Hunting of mammal populations not only reduces the biodiversity values of the area directly, but may also serve to reduce food resources for the Endangered flagship Bengal tiger throughout the forest, thus compromising the conservation value of the site. Moreover, hunting the Bengal tiger in human-wildlife conflict situations in the region, although not likely to occur within the property itself, poses a threat to tiger numbers within the WH site (Ahmad et al., 2009). As the Bangladeshi human population continues to increase (Rahman et al., 2010), exploitation of mammal populations continues to grow in intensity, leading to serious degradation, and there are few highly effective management activities taking place to reduce this threat, resulting in its likely increase in intensity into the future.

► Logging/ Wood Harvesting

High Threat
Outside site

Extraction of mangrove wood for subsistence and commercial purposes

throughout the forest is common and is a major source of threat to the overall system (Rahman et al., 2010; UNEP-WCMC and IUCN, 2013). Extraction results 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. 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; Ministry of Environment and Forests, 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 organic matter accretion and deltaic and bank formation. 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 (Rahman et al. 2010), and sustainable management to control these activities throughout the Bangladeshi Sundarbans is absent, meaning that this threat to the ecological, aesthetic and biodiversity integrity of the site is likely to continue to increase.

► 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. With no management action in place to combat this threat, and as population pressure continues to drive the expansion of industry, agriculture and aquaculture (Rahman et al. 2010), these impacts are very likely to increase in intensity into the future.

► Fishing / Harvesting Aquatic Resources

High Threat

Outside site

Shrimp fry (post-larvae shrimp) fishing to supply aquaculture farms in the Sundarbans is occurring at unsustainable levels (Rahman et al., 2010). Harvesting of shrimp and prawn fry is an extremely destructive process in the area, as dragnets not only severely deplete shrimp and prawn populations, but also juveniles of many other fish species, cause erosion of the banks and mudflats, and prevent mangrove seedling establishment. These activities not only have severe implications for local, regional and potentially global fisheries stocking, but also have knock-on effects to the remainder of the Sundarbans' food chain, reducing resource availability for higher levels of biodiversity. The trend in shrimp farming expansion has been rapidly increasing in the Sundarbans over the last decades (Rahman et al., 2010), and increased population pressure in the country (Rahman et al., 2010) mean that this trend is likely to continue to increase, furthering this threat to the biodiversity value of the site into the future. Fishing activities can also result in the entanglement of threatened aquatic vertebrate species (Ganges river dolphin, Platanista gangetica, and Irrawaddy dolphin, Orcaella brevirostis; Smith et al., 2009).

► Other Biological Resource Use

Low Threat
Outside site

Honey and wax collectors enter the Sundarbans to access nests with permission from permits from the Forest Department (Chakrabarti 1987). This increased entry from people into the forest results in damage to vegetation, contributing to reduced quality of habitat and compromising the biodiversity values of the site. Moreover, 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). Sometimes fires can spread and destroy large areas of forest (Rahman et al., 2010). In 2010, 250 ha of the forest 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 the population of the country overall (Rahman et al., 2010; UNEP-WCMC and IUCN, 2013), 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.

► Tourism/ visitors/ recreation

Very Low Threat
Inside site
Outside site

In some areas management of the impacts of tourist can be poor (i.e. oil spillages associated with tourist boats and waste production). However, tourism is currently low due to the lack of access, transport and accommodation facilities. Mass tourism and its impacts are thus unlikely to affect the values of the property significantly (SOUV, 2013).

► Invasive Non-Native/ Alien Species

Low Threat
Outside site

Invasive species have been found within the Sundarbans, and within the WH site (Biswas et al., 2007), and are more abundant and diverse at riverbanks. The three most harmful species have been found to be Derris trifoliate, Eichornia crassipes and Eupetorium odoratum, which cause concern for the health of Sundarbans biodiversity through e.g. threatening to out-compete native species for access to light, nutrients and moisture and causing physical damage to native species (Biswas et al., 2007). Invasive populations are abundant, rapidly spreading and locally dense. However, studies suggest that invasives are still in a controllable stage, if appropriate management activity is applied: effective monitoring of spread and targeted control actions for particularly destructive species (Biswas et al., 2007).

► Solid Waste

High Threat
Inside 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. As the Bangladeshi population continues to increase (Rahman et al., 2010), production of waste and modernization of lifestyles is likely to continue to increase. With no management action in place to combat this threat, and as population pressure continues to drive the expansion of industry, agriculture and aquaculture (Rahman et al. 2010), these impacts are very likely to increase in intensity into the future.

► 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 to 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). Oil spills and other industry effluents (paper mill, match factory, and furniture making chemicals) can also degrade mangrove ecology (Peng, 2000).
High concentrations of heavy metals (i.e. Zn, Cd, Cr, Pb and Cu) have been found within the mangrove sediment (Rahman et al., 2009). With no management action in place to combat this threat, and as population pressure continues to drive the expansion of industry, agriculture and aquaculture (Rahman et al. 2010), these impacts are very likely to increase in intensity into the future.

► Water Pollution

High Threat
Inside site
Outside site

Agro-chemicals, especially pesticides, have resulted in nutrient enrichment into Sundarbans waters, which can damage 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.

High concentrations of organic pesticides have been reported in the mangrove sediment (Rahman et al., 2009).

► Solid Waste

High Threat
Inside site

Population increases near river basins 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, Platanista gangetica, Irrawaddy dolphin, Orcaella brevirostis, and species of sawfish), which is contributing to their global population declines (Smith et al., 2009), and compromising the biodiversity value of the site.

► Air Pollution

Data Deficient
Inside site

Increased traffic (both terrestrial and shipping) in the area is resulting in the increase in airborne pollutants, which can degrade mangrove ecology (Rahman et al., 2010). With population pressure in the area driving the expansion of industry (Rahman et al., 2010), such impacts are likely to increase into the future. However, the extent to which airborne pollutants influence mangrove ecology and functioning in the area is unknown, and so an assessment of the intensity of this threat cannot be made based on available data.

► Earthquakes/ Tsunamis

Very High Threat
Inside site

Damage from extreme natural events (cyclones, tsunamis and tidal surges) may destroy Sundarbans vegetation faster than anthropogenic threats (Rahman et al., 2010), and can result in large mortality of some vertebrate populations (UNEP-WCMC and IUCN, 2013). Tsunamis, tidal surges and storms cause widespread destruction of forest area and habitat and can influence on-going ecological processes such as deltaic and bank formation.

The impact of cyclone Sidr in 2007 along 100km of coast, taking >3,500 lives, and destroying homes, livestock, agriculture and the region's entire fishing industry (UNEP-WCMC and IUCN, 2013). 40% of the site was seriously damaged, and most of this within the WH site (UNEP-WCMC and IUCN, 2013), and it is anticipated that this will take 10-15 years to recover, if the ancillary threats of poaching, woodcutting etc. do not affect regeneration time (UNEP-WCMC and IUCN, 2013). A great proportion of the mangrove biomass and primary production was also lost during this event (Cornforth et al., 2013). Much of the Forest Department's infrastructure that was within the path of the cyclone was completely destroyed, severely reducing the ability to manage the site to avoid uncontrolled exploitation of timber and fauna following the event (UNEP-WCMC and IUCN, 2013). A 5-year rehabilitation project ("Re-establishing essential management capacity in the Sundarbans World Heritage property following the passage of cyclone Sidr") is underway following the devastation. Due to the large spatial scale of cyclone, tsunami and tidal surge events, and the devastating impacts produced, coupled with the foreseen increases in these events under climate change (IPCC 2012), the current and future threats from these natural events, and interactions between these and other sources of threats, are severe.

► Erosion and Siltation/ Deposition

Very High Threat
Inside site
Outside site

Increased siltation of inland rivers has dramatically decreased freshwater inputs to the Sundarbans (Haq, 2010). Reduced freshwater flow serves to increase salt-water intrusion and irregular inundation serve to significantly degrade the health of the Sundarbans ecosystem (Iftekhar & Islam, 2004), causing reduction in forest cover extent and reduction in mangrove species diversity (Iftekhar & Islam, 2004; Akhtaruzzaman, 2000). Habitat conditions for threatened biodiversity, eg. the Bengal tiger, are also subsequently affected (WCMC, 2001). Reduced freshwater flow also reduces nutrient supplies to the area, reducing available nutrients for plant diversity and the growth of the fish community (Rainbouth, 1991). Reduced freshwater flow also decreases sediment flow into the forest, altering deltaic and bank formation and compromising the on-going ecological processes of the site (Iftekhar & Islam, 2004). Increased freshwater extraction upstream

(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 universal value of the site.

► Other

High Threat
Inside site

“Top dying” is a disease that affects dominant Sundri trees (Heritiera fomes; EN; V6), which is a major cause for the deterioration of the forest (Rahman et al., 2010). Incidence of top-dying in Sundri appears to increase with increasing salinity, and thus its replacement with the other common Gewa Excoearia agallocha (Rahman et al., 2010). In the Bangladeshi portion of the Sundarbans, the extent of pure Sundri stands has decreased by 21% since 1926 (including as a result of other factors such as sea level change, salinity change, and wood harvesting (IUCN Consultation, 2014)), and dominance of Sundri in mixed stands is diminishing (Iftekhar & Saenger, 2008). Moreover, approximately 70% of Bangladeshi Sundri stems have been estimated to be moderately or severely affected by the “top-dying” disease (Islam & Wahab, 2005). 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 Bengal tiger (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).

Potential Threats

Very High Threat

Potential threats to the site’s values from both climate change and industrial growth 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 destruction of the site and its Outstanding Universal Value. The potential for increased pollutant loadings from the proposed Rampal power plant, as well as the associated dredging of the Passur River, moreover provide a significant threat to the site's values into the future.

► Crops

High Threat
Inside site

Agricultural expansion exists at the Sundarbans fringes (both eastern and western), and with increasing population pressure in surrounding settled areas could become a serious problem into the future if not correctly managed (UNEP-WCMC and IUCN, 2013). Land conversion for agricultural expansion may cause an increasing rate of forest and habitat loss for local biodiversity. Moreover, potential further increases in agro-chemical loadings into the Sundarbans waters mean this threat is greater than from land-cover change alone.

► Other

Very High Threat
Inside site

Much of the Sundarbans forest is not of elevation very high above sea level, and sea level rise thus threatens to submerge large portions of the area. Two islands have already been submerged, and a dozen more are threatened with submergence (Rahman et al., 2010). Coastal retreat is indeed occurring relatively rapidly within the Sundarbans, with some areas losing as much as 200m of coast per year (Cornforth et al., 2013). With the Sundarbans WH making up a large part of the coastal parts of the forest, coastal retreat is indeed a serious threat. With sea level rise, increased salinity will result in ecological succession to more salt-tolerant species, reducing mangrove biodiversity, particularly with salinity already increasing from reduced freshwater inputs into the Bangladeshi 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, i.e. 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. 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 (UNESCO, 2007b). 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 better protection of non-affected mangroves, and restoration activities could assist in adaptive management.

► Industrial/ Military Effluents

High Threat
Inside site

If construction goes ahead, the proposed Rampal coal-fired power plant will be constructed along the banks of the Passur river, 14km north of the Sundarbans Reserve Forest. 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. The associated dredging necessary to keep the channels of the Passur River open for navigation is likely to alter the morphology of the river channels, which, in combination with erosion and sedimentation caused by the wakes of large vessels, would be likely to affect priority habitat for Ganges River dolphin and Irrawaddy Dolphin, as well as other aquatic species, such as the critically endangered Batagur turtle (Batagur baska) and vulnerable small clawed otter (Aonyx cinerea) (SOC report, 2014).

Protection and management

Assessing Protection and Management

► Relationships with local people

Some Concern

The government of Bangladesh and the Forest Department recognise the dependency of human populations on the Sundarbans for subsistence and livelihoods (UNESCO, 2011). The site has been controlled by the Forest Department, which has controlled human extractive activities within the forest since the early 20th century, with permits sold for extractive uses (SOUV, 2013). While extractive activities are banned within the WH site, however, it is currently not known the degree to which illegal extractive activities may be occurring within the site (UNESCO, 2011). As such, there is a need to better develop relationships with local people in order to reduce illegal activities both within and outside the WH site. Moreover, given the extremely high pressure in the remainder of the Bangladeshi Sundarbans and the threat from illegal activities, a much greater focus should be placed on generation of alternative livelihoods. Moreover, management should seek to develop greater links with local communities to enhance participation in outreach and education programmes, as well as participatory management.

► Legal framework and enforcement

Mostly Effective

The site appears to have adequate legal protection and exploitative activities are permitted only by permits granted by the government Forest Department (SOUV, 2013). The entire Sundarbans Reserve Forest is designated as a Ramsar Site (IUCN and UNEP-WCMC, 2014). The World Heritage Site consists of three large wildlife sanctuaries, with IUCN Protected Area status IV: Sundarban West Wildlife Sanctuary, Sundarban East Wildlife Sanctuary and Sundarban South Wildlife Sanctuary, managed for the protection of biodiversity (SOUV, 2013). Law enforcement is carried out by the Forest Department, which grants permits to local people for extractive activities. Individuals breaking the law are apprehended, prosecuted and either fined or jailed (SOUV, 2013). However, it is currently not known the degree to which illegal extractive activities may be occurring within the site (UNESCO, 2011),

and the recent BTAP states that monitoring capacity and resources are not currently sufficient for fully effective monitoring of illegal activity (Ahmad et al., 2009). Furthermore, despite a ban on mosquito net fishing for shrimp fry and the use of gillnets, illegal use of this equipment within the area is widespread. Increased monitoring capacity and resources are required if fully effective law enforcement is to take place to successfully manage the site, particularly following the reduction in capacity caused by cyclone Sidr (UNESCO, 2011).

► Integration into regional and national planning systems

Mostly Effective

This site is managed at a national level by the Forest Department (SOUV, 2013). Integrated Management Plan for Sundarban mangrove forest framed in 1998-99, valid up to 2010. A new Integrated Resource Management Plan is being developed. As the Sundarbans WH site is influenced by processes that occur outside of its boundaries (i.e. freshwater inputs and pollutants), regional development planning based on landscape and hydrological characteristics is important to manage resulting regionally-based threats to its continued integrity (Iftekhar & Islam 2004). The Integrated Coastal Zone Management initiative may produce useful information and guidelines to inform such regional planning.

► Management system

Some Concern

The site is managed centrally by the Forest Department (SOUV, 2013). Integrated Management Plan for Sundarban mangrove forest framed in 1998-99, valid up to 2010. A new Integrated Resource Management Plan is being developed. Bangladesh Tiger Action Plan 2009 exists (PR Questionnaire, 2014) as well as a Pilot National Program for Tiger conservation in Bangladesh (BFD, 2013). However, the management system is currently only partially being implemented (PR Questionnaire).

► Management effectiveness

Some Concern

No formal management effectiveness assessment has been conducted for the site. However, the current management system has been deemed

inadequate to maintain the property's Outstanding Universal Value as it is only being partially implemented, and few of the activities listed on the existing annual work/action plans are being implemented (PR Questionnaire).

▶ Implementation of Committee decisions and recommendations

Highly Effective

Committee decisions so far have included 32 COM 7B. 10 and 33 COM 7B. 12, in which the WH Committee has commended the state party for responding to with appropriate action (UNESCO, 2009; UNESCO, 2011).

▶ Boundaries

Some Concern

The boundaries of the World Heritage property are adequate to maintain the property's Outstanding Universal Value, and were deemed sufficient at the time of site inscription (PR Questionnaire). The boundaries are largely demarkated by rivers, making their presence well known, and no buffer zone is considered to be required for the site. However, an important improvement to the preservation of the site's Outstanding Universal Values would be to consider a transboundary site, managed jointly with the Sundarbans National Park World Heritage Site, India as has been discussed previously (UNESCO, 2008). 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

Some Concern

The majority of finance for management of the Sundarbans has been, at least until recently, from central government (98%; PR Questionnaire 2014), some of which is produced by revenue generated by sale of permits for extractive activities (~600,000 €; SOUV, 2013). Other previous funding has come e.g. from the WH International Assistance fund and UNESCO Sector for External Relations for post-Sidr recovery and restoration of management capacity (UNESCO, 2009), and from USAID for monitoring unsustainable exploitation (UNESCO, 2009). However, while existing funding sources are secure in the medium-term, the budget is currently extremely limited for many of the basic

activities that are necessary for the successful ecological monitoring, and monitoring and law enforcement for illegal activities (Ahmad et al., 2009; UNESCO, 2011; PR Questionnaire, 2014). This need for greater sustainable finance will likely increase into the future under increases in the intensity and severity of extreme storms, cyclones and tidal surges under climate change (IPCC, 2012). The current budget provided is thus inadequate for basic current and future management needs, and presents a serious constraint to the capacity to manage (PR Questionnaire).

► Staff training and development

Some Concern

Staff capacity is currently not sufficient to manage the site appropriately, and adequately trained and motivated staff are currently limited. There currently exists some staff training and development opportunity for Forest Department staff. However, the situation could be improved in most areas. There is very little availability of training opportunities for many very important areas: research and monitoring, promotion, and community outreach, interpretation and education (PR Questionnaire).

► Sustainable use

Some Concern

The Sundarbans is utilised relatively heavily for subsistence and livelihoods purposes (timber collection, honey collection, fishing and aquaculture, and some poaching). This is monitored and controlled by the Forest Department, who grant permits for access and collection of forest goods, and extractive activities are not permitted within the site itself (SOUV, 2013). However, threats from both legal and illegal resource extraction are extremely heavy throughout the forest, with potentially great impacts to the Outstanding Universal Values of the site itself. Moreover, it is currently not known the degree to which illegal extractive activities may be occurring within the site (UNESCO, 2011), and the recent BTAP states that monitoring capacity and resources are not currently sufficient for fully effective monitoring of illegal activity (Ahmad et al., 2009). Moreover, there is little baseline information currently to assess appropriate sustainable offtake rates (Ahmad et al., 2009). Increased monitoring capacity and resources are required if fully effective law enforcement is to take place to successfully manage the site,

particularly following the reduction in capacity caused by cyclone Sidr (UNESCO, 2011).

► Education and interpretation programs

Some Concern

The BTAP has identified education and awareness of the importance of the Bengal tiger as a key requirement (Ahmad et al., 2009). NGOs, including WildTeam and WCS, have been conducting education awareness activities in the Sundarbans over at least the past two years (IUCN Consultation, 2014).

► Tourism and interpretation

Some Concern

Tourism to the site is minimal, largely due to restricted access and poor facilities (SOUV, 2013). However, the trend in annual visitation is increasing (PR Questionnaire). The tourism industry does not work with the WH site managers, and while a fee is collected it does not contribute to the management of the site (PR Questionnaire). At present, tourism thus does not contribute to education and awareness of maintaining the values of the WH property, potentially highly compromising the Outstanding Universal Values of the site, particularly should the trend in visitor numbers continue to increase into the future.

► Monitoring

Some Concern

There is some monitoring carried out at the site, but it is directed towards apprehending illegal poaching and other activities, as opposed to towards management needs and improving understanding of the Outstanding Universal Values of the site (PR Questionnaire). Moreover, baseline information against which to assess trends in ecological and biodiversity values is largely lacking (Ahmad et al., 2009). In recent years, new projects have been proposed and launched to improve ecological monitoring following both the devastation of the area by cyclone Sidr in 2007 and to monitor the development of climate change impacts on the area (UNESCO, 2011). In addition, the BTAP and PNP has established plans to increase monitoring activities of threats to the tiger population and its habitat and food (Ahmad et al., 2009, BFD 2013), which, if appropriately implemented, may improve

understanding of the status and trends in the Outstanding Universal Values of the site.

► Research

Some Concern

There is some scientific research being conducted within the site, largely in the research and monitoring of tigers, Ganges river dolphins and Irrawaddy dolphins and their habitat (e.g. Burton et al., 2008; Smith et al., 2009). Further study has also been conducted on e.g. cyclone damage to mangrove health, invasive species, and threat assessment (Biswas et al., 2007; Rahman et al., 2009; 2010; Cornforth et al., 2013). However, large knowledge gaps still exist in many areas; specifically in the existence and generation of baseline information on animal populations, upon which management strategies can be made and the impact of specific threats to Sundarbans biodiversity assessed (Ahmad et al., 2009). Furthermore, research to improve understanding of the ecological processes, properties and functioning of the Sundarbans in relation to climatic, hydrological, biotic and edaphic influences on the health of the Sundarbans and the underlying on-going ecological processes that drive its persistence (Iftekhar & Islam, 2004). Such research is essential in order to further understanding of the impacts of specific threats to the system (also spatially), and to inform ecosystem management.

Overall assessment of protection and management

Some Concern

The current protection and management system shows major deficiencies and is currently unable to maintain the site’s values and integrity over the long-term. While the central government support for policy initiatives to protect the site’s values is good, capacity to implement policies effectively is currently limited. Funding is insufficient to provide the monitoring and protection necessary to ensure the safeguarding of the site’s Outstanding Universal Value, and redirection of increased funds from the Forest Department towards the Sundarbans, as well as greater input from the international community, is essential to improve capacity and training, and the ability to effectively monitor and research the state of the site’s values and the intensity of the impact of current and potential threats. While projects funding to research into climate change adaptation is available for the area, funds required to

successfully manage the site to mitigate these threats, and specifically sea level rise, into the future are furthermore likely to be extensive in the long-term. Moreover, many threats to the site's Outstanding Universal Value have their source within the remainder of the Sundarbans ecosystem (within both Bangladesh and India) and Bay of Bengal. Funding and capacity to preserve the site's Outstanding Universal Values is inadequate to tackle these wider threats, and transboundary management with the Sundarbans National Park World Heritage Site in India needs to 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. Large scale, unsustainable resource exploitation (particularly in terms of timber extraction and poaching), coupled with industrial, human and agricultural waste inputs, increasing intensity of shrimp aquaculture and fry fishing, changes to the inundation and salinity regimes of the area from reduced freshwater flows and sea level rise, and the predicted increase in the frequency and intensity of storms and tidal surges under climate change are increasingly presenting huge challenges for the fragile Sundarbans ecosystem. Management implementation and preventative action to reduce these threats, and particularly for climate change threats, has been severely lacking. However, the Forest Department's "Sundarbans Environmental and Livelihoods Security" (SEALS) project, which will be finished in 2014 (IUCN Consultation, 2014), provides ecological monitoring of the impacts of climate change. The Forest Department has also proposed a project to restore coastal greenbelt mangroves – "Rehabilitation of Sidr's Damage and Climate Change Resilient Afforestation" (UNESCO, 2009; UNESCO, 2011). The Forest Department and WH Committee further urged for improved work to understand, mitigate and adapt to the impacts of black carbon on the Sundarbans (UNESCO, 2011). However, many other threats to the Outstanding Universal Values occurring outside the site are largely unmanaged despite posing a potentially enormous impact to the values of the site itself.

State and trend of values

Assessing the current state and trend of values

World Heritage values

▶ **On-going ecological processes that lead to the creation and sustenance of mangrove ecosystems**

High Concern
Trend:Deteriorating

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; IUCN, 1997; UNEP-WCMC & IUCN, 2013). Reduced freshwater flow serves to increase salt-water intrusion and irregular inundation (IUCN, 1997; UNEP-WCMC & IUCN, 2013), and also leads to increased soil acidification. These consequences of dam creation and freshwater extraction serve to significantly degrade the health of the Sundarbans ecosystem (Iftekhar & Islam, 2004; Rahman et al., 2010; UNEP-WCMC & IUCN, 2013), affecting plant biomass production and siltation, sedimentation and deltatic and bank formation. Increased saline intrusion is causing the replacement of Sundri trees by Gewa through top-dying (IUCN, 1997; Rahman et al., 2010; UNEP-WCMC & IUCN, 2013). 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). 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). 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 Bengal tiger. Sea level rise under climate change will moreover exacerbate these alterations to on-going ecological processes within the 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.

► Exceptional level of biodiversity

High Concern
Trend:Deteriorating

The Sundarbans remains the largest continuous mangrove forest in the world (Rahman et al., 2010). However, the loss of habitat over time, which is occurring in all three of the wildlife sanctuaries, is significant (Cornforth et al., 2013). Overexploitation and top-dying of Sundri trees (and others) across the Sundarbans has resulted in a shift in existing vegetation communities (Ministry of Environment and Forests, 2010). The extent of pure Sundri stands has decreased by 21% since 1926, and dominance of Sundri in mixed stands is diminishing (Iftekhar & Saenger, 2008). Moreover, approximately 70% of Sundri stems have been estimated to be moderately or severely affected by the “top-dying” disease (Islam & Wahab, 2005). With these threats, and particularly that of coastal retreat under climate change, increasing into the future, the biodiversity of the Sundarbans is likely to be in great threat into the future should appropriate management activity not be taken.

► Rare and threatened terrestrial and aquatic mammals

Low Concern
Trend:Deteriorating

The Sundarbans supports a diverse assemblage of rare and threatened terrestrial and aquatic mammals (IUCN, 1997). However, due to the multiple threats present in the area, six globally threatened species have been locally extirpated over the last century: Javan rhinoceros (CR), water buffalo (EN), swamp deer (VU), gaur (VU), hog deer (EN) and sambar (VU; IUCN, 2013). Several mammal species within the Sundarbans are moreover currently threatened with extinction nationally: Bengal tiger (EN), oriental small-clawed otter (EN), smooth-coated otter (EN), Irrawaddy dolphin (CR), melon-headed dolphin Peponocephala electra (CR), finless porpoise Neophocaena

phocaenoides (EN), Ganges river dolphin, and barking deer Muntiacus muntjak (EN; Ministry of Environment and Forests, 2010; IUCN, 2013). Populations of Ganges river dolphin, Irrawaddy dolphin and Bengal tiger within the Sundarbans are all currently relatively high, with populations of the latter two species representing stronghold populations for these species globally (IUCN, 1997; Smith et al., 2006; IUCN, 2013). Currently little empirical data on population trends exists for the rare and threatened mammals of the Sundarbans, though a novel monitoring methodology is being implemented to survey trends in the relative abundance of tigers in the area into the future (Barlow et al., 2008). The status of populations of Ganges river dolphin and Irrawaddy dolphin in the Sundarbans appear to 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). However, foresters throughout the Bangladeshi Sundarbans have reported declines of tigers and deer are currently declining (Rahman & Asaduzzaman, 2010). Moreover, the threats from poaching, habitat loss and degradation (both aquatic and terrestrial), pollution, altered hydrology and entanglement in hazardous fishing equipment have been severe, and are likely to increase in intensity into the future. As such, declines in rare and threatened mammal populations over the last few years are likely, 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:Stable

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 and colourful bird life, and has a high level of avian diversity for a mangrove ecosystem (Khan, 2005). The area provides habitat for several globally threatened species (see Worksheet 1; IUCN, 2013). A recent study of the birdlife of the Sundarbans East Wildlife Sanctuary found that bird diversity remains high, with nine species recorded for the first time in the Bangladesh Sundarbans (Blue breasted quail Coturnix chinensis (LC), Spot-billed duck Anas poecilorhyncha (LC), Dollarbird Eurystomus orientalis (LC),

Indian pitta Pitta brachyura (LC), Black-naped oriole Oriolus chinensis (LC), Lesser racket-tailed drongo Dicrurus remifer (LC), Scaly thrush Zoothera dauma (LC), Yellow-eyed babbler Chrysomma sinense (LC), and ruby-cheeked sunbird Anthreptes singalensis (LC); Khan, 2005; IUCN, 2013). The study determined that the birds of the Sundarbans East Wildlife Sanctuary are not under severe pressure currently (Khan, 2005). Several bird species within the Sundarbans are, however, threatened with extinction nationally: Blyth's kingfisher Alcedo hercules (EN), Ruddy kingfisher Halcyon eoromanda (VU), Masked finfoot Heliopaid personata (EN), Greater adjutant Leptoptilos dubious (CR), lesser adjutant Leptoptilos javanicus (EN),Dollarbird (CR), Brown fish owl Ketupa zeylonensis (VU), White-bellied sea eagle (EN) and Malayan night heron Gorsachius melanolophus (CR; Khan, 2005; Ministry of Environment and Forests, 2010; IUCN, 2013). Currently little empirical data on population trends exists for the rare and threatened birds of the Sundarbans. However, despite the apparent favorable current situation for the avifauna of the Sundarbans (Khan, 2005), 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 severe 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:Deteriorating

Two species of globally threatened crocodilian were extirpated from the Sundarbans in the past due to over exploitation: mugger Crocodylus palustris (VU) and the critically endangered gharial Gavilalis gangeticus (CR). The estuarine crocodile Crocodylus porosus still remains, though its numbers have been largely depleted over the past century due to excessive exploitation for its skin (Rahman & Asaduzzaman, 2010). While it is thought that this trade has reduced in recent years, however, there seems to be no sign of population recovery (Rahman & Asaduzzaman, 2010). A population survey is currently being carried out for the species, though local foresters have reported declines in crocodiles in recent years (Rahman & Asaduzzaman, 2010). Many reptiles present within the Sundarbans are

currently threatened with extinction nationally: estuarine crocodile (CR), Northern river terrapin (CR), rock python Python molurus (EN), king cobra Ophiophagus hannah (EN) and spot-tailed pit viper Trimeresurus erythurus (EN; Ministry of Environment and Forests, 2010). Until recently, it was believed that the globally and nationally critically endangered (CR) Northern river terrapin Batagur baska was functionally extinct (no known nesting sites) in Bangladesh (Turtle Conservation Coalition, 2011). In 2013 juveniles were discovered in the Sundarbans (Lowe, 2013), suggesting the potential presence of a viable population. However, the high demand for use of this species within Bangladesh (Turtle Conservation Coalition, 2011) means that its persistence into the future may be unlikely. CARINAM are conducting a survey to determine the status of this species in the Sundarbans (Ministry of Environment and Forests, 2010). The Forest Department, partnered with CARINAM, the Turtle Survival alliance and IUCN-Bangladesh run a breeding programme for this functionally extinct species at Bhawal National Park near Dhaka for reintroduction, and the captive population are now increasing, enormously improving the situation for this species in the site (TSA, 2009). There has, however, been a general decline in densities and sightings of snake species in the area over the last 20 years (Rahman & Asaduzzaman, 2010). Currently little empirical data on population trends exists for the rare and threatened reptiles of the Sundarbans. However, considering the combined intensive threats of the large degree of habitat degradation and loss (both terrestrial and aquatic), poaching, entanglement in fishing gear, pollution and extreme weather events, it is likely that declines may be occurring (particularly for marine turtles).

► 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 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, threatening. 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 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).

► Rare and threatened fishes

Low Concern
Trend:Deteriorating

Sawfish – both narrow sawfish and largetooth sawfish – have suffered population declines and range reductions. A rapid assessment revealed the average annual sawfish encounter rate declines from 3.7 individuals (using 22 year lifetime recall data) to 1.5 (using 5 year recall data), and further to 0.7 (using 1-year recall data). The consensus for social research methods revealed by-catch as the main cause of the decline (Hossain et al, in press).

Summary of the Values

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

High Concern

Trend: Deteriorating

The Sundarbans Reserve Forest of which the World Heritage Site is part, while remaining 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 has been, and continues to be, significant due to natural and anthropogenic alterations to the hydrology and ecology of the site, including through impacts on, Bangladesh’s mangrove diversity (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 deltaic and bank formation. 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. Populations of some of the site’s rare and threatened

mammals are large (some of the largest populations in the world for Bengal tiger and Irrawaddy dolphin). However, while the situation appears to be currently favourable for aquatic mammal populations, limited available evidence suggests that certain species of rare and threatened terrestrial mammals in the Bangladeshi Sundarbans may be decreasing (Bengal tigers and their prey), likely due to illegal poaching activities. Given the results of recent bird surveying, the situation for the rare and threatened birdlife within the site appears to currently be favourable. Recent success in breeding programmes for critically endangered and functionally extinct herpetofauna (Northern river terrapins) within the Sundarbans gives promise for the conservation of this species into the future if threats that lead to its demise can be properly addressed. However, little information exists on the status and trends of rare and threatened marine reptiles in the Bangladeshi Sundarbans. Moreover, the limited available evidence suggests that populations of crocodile and snake species may be declining. Thus, it appears that the effects of ecosystem degradation on the site’s values are currently relatively high, and 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, the need for greater and more sustainable management actions and capacity will be required. While the status of the site’s biodiversity appears to be currently largely favourable, however, an increase in the intensity of current threats (i.e. under climate change or increased extractive pressures) or discontinuation of efficient management actions may greatly change the current state of affairs.

Additional information

Key conservation issues

► Capacity and funding

National

There are several internationally-funded projects in place or in development for the site; i.e. the CREL, Bagh and SEALS projects. However, government capacity and funding to successfully implement basic management

requirements to implement actions within the site's management plan is currently lacking and presents a serious constraint to the capacity to manage (PR Questionnaire, 2014). Forest department staffing levels and training are insufficient to address adequately even law enforcement within the site, and thus capacity (in the form of staff numbers and training) to carry out additional conservation monitoring requirements (i.e. of trends in the sites values and threats to them) is lacking. As a result, many of the actions within the management plan for the site are not currently being implemented, and no formal management effectiveness assessment has been conducted for the site. There is currently very little capacity within government, NGOs and universities to conduct conservation management activities. Moreover, as threats continue to intensify into the future, the need to generate and sustain adequate funds for effective management will increase. Lack of funding and capacity is the major reason for the current management system being inadequate to maintain the property's Outstanding Universal Value, and international assistance is further required to sustain long-term conservation management.

► Monitoring and research

National

There is considerable monitoring carried out at the site, but due to limited funding and capacity it is directed towards apprehending illegal poaching and other activities, as opposed to towards conservation management needs and improving understanding of the Outstanding Universal Values of the site (PR Questionnaire, 2014). Coupled with the limited conservation research capacity within the area, historical and current lack of appropriate monitoring activities mean that baseline information of the status and trends of values and their threats within and outside the site is severely lacking. Such information is however essential to inform appropriate management activities to protect the site's Outstanding Universal Value.

► 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.

► Regional planning to address pollutants and hydrology

Local

As the Sundarbans is influenced by processes that occur outside of its boundaries (i.e. freshwater inputs and pollutants), regional development planning based on landscape and hydrological characteristics is important to manage resulting regionally-based threats to its continued integrity (Iftekhar & Islam 2004). The Integrated Coastal Zone Management initiative may produce useful information and guidelines to inform such regional planning. Integration of management activities with the Sundarbans National Park World Heritage Site, India, as has been previously discussed, may prove an important strategy for minimizing ecosystem-level threats to the site’s values. The existing Memorandum of Understanding (2011) and tiger conservation protocol (2011) between India and Bangladesh will require implementation (IUCN Consultation, 2014).

► Alternative livelihoods

Local

The government of Bangladesh and the World Heritage Committee recognize that a large number of people currently rely upon the Sundarbans forest for livelihoods. With increasing population pressure, a lack of knowledge on sustainable offtake rates and on illegal extractive activities within the site, and damaging impacts from existing methodologies (i.e. fires caused by honey collectors, shrimp fry fishing and the use of gillnets by fishermen), there is currently insufficient research and existing policy emphasis on alternative livelihoods in the face of these potential threats.

► Integration with the Indian WH site – The Sundarbans National Park

Regional

Due to the interconnected nature of the system as a whole, many of the major threats to the WH property in the Bangladeshi Sundarbans also have their source in the Indian 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 National Park would 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.

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 a 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 Bangladesh 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 and tsunamis. As recently highlighted by the 2007, coastal communities and infrastructure, and biodiversity can be highly susceptible to such events (UNESCO, 2007a). 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 Forest Department that manages the Sundarbans employs ~1,200 staff to monitor and control the use of forest products, and to collect user fees.

▶ **Fishing areas and conservation of fish stocks**

The Sundarbans provide important spawning and nursery ground for several, some economically important, fish species (IUCN, 1997). 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, with many large areas that are highly remote and accessible only by boat (SOUV, 2013).

▶ **Pollination**

The Sundarbans supports 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, 1997). These bees may also prove to be important for pollination of local crops, and to maintaining the Sundarbans forest diversity.

▶ **Outdoor recreation and tourism**

Due to the broad inaccessibility of the Sundarbans and the WH site, as well as a lack of visitor facilities, tourism and recreation in the area is currently relatively low (SOUV, 2013). However, in recent years annual visitation has been increasing (PR Questionnaire, 2014), and into the future may begin to provide more jobs.

Summary of benefits

The Sundarbans benefits 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	WildTeam		Work with local communities and government to elicit education and awareness of tiger conservation issues, create Tiger Response Teams to reduce human-tiger conflict, training for local people (i.e. honey collectors) in safety, provide funds for tiger-related livestock losses, research into deer abundance and social research into threatening human behaviours. Monitoring work for the Bengal tiger to assess population size and trends – new methods of monitoring being developed.
2	Zoological Society of London Dr Gitanjali Bhattacharya		The Zoological Society of London has supported numerous conservation projects in the Bangladesh Sundarbans, focusing on both terrestrial and aquatic fauna. ZSL runs capacity building programmes via its EDGE programme, which supports local scientists who are working on conservation projects that address threats to the worlds most threatened and evolutionarily distinct species. ZSL also works with remote sensing to monitor the state of the Sundarbans mangrove forest and has worked closely with local partners and the BFD on tiger conservation. With Dhaka University, ZSL conducted a rapid assessment of sawfish status and exploitation in Bangladesh and is currently developing conservation measures based on the results.

№	Organization/ individuals	Project duration	Brief description of Active Projects
3	Wildlife Conservation Society - Bangladesh Cetacean Diversity Project		Systematic research and monitoring of cetacean populations and habitat. Work with government agencies and local communities to identify and address threats to cetaceans. Develop a conservation management plan with recommendations for an effectively managed Protected Area Network with local and government input and support. Provide training and technical support for scientists and resource managers to devise, advocate and implement rigorous research and effective conservation interventions. Foster support for cetacean conservation through community education programs, development of educational materials for dissemination through popular media, and workshops and meetings with government officials and NGO representatives.
4	Centre for Advanced Research in Natural Resources and Management (CARNIAM)		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. “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.

№	Organization/ individuals	Project duration	Brief description of Active Projects
5	IUCN Bangladesh		“Environmental Management and Biodiversity Conservation Plan for the Sundarbans’ Biodiversity”: develop a strategy and action plan for the management and biodiversity conservation for Sundarbans (fill information gaps that constrain informed decision-making in the Sundarbans, generate knowledge on biodiversity and explore conservation options that produce local benefits, identify policy reforms, investments and technical assistance needed to bolster the capacity of governmental agencies to address the environmental priorities linked with biodiversity conservation, and identify cost-effective investment options to enhance the welfare of the people living in the Sundarbans periphery areas and conserve biodiversity in the Sundarbans). “Implementation of Mangroves for the Future (MFF) outreach activities in Bangladesh”: prepare a national strategy and action plan to create opportunities for the sustainable management of coastal areas, participate in MFF regional training and knowledge-sharing events, develop capacity of professionals working for ICM in Bangladesh, publication and dissemination of outreach materials and knowledge products, and identify and develop coastal management opportunities in Bangladesh.

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