Enhanced Awareness to Coastal Ecology: Protecting Endangered Species of the Bay of Bengal

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Abstract

This document outlines the importance of the coastal ecosystem, coastal resources, causes of species extinction, techniques to save the endangered species, governmental acts and policies, conservation trends and challenges in Bangladesh. Bangladesh has an extensive maritime boundary blessed with rich coastal and marine ecosystems. Coastal ecosystems have supported human communities for centuries by providing excellent services and influencing human well-being. As the human population of Bangladesh continues to grow, more fish, marine resources and other wildlife species have been put at risk by the loss and fragmentation of critical habitats, climate change, the introduction of non-native species and other environmental factors. Population increases the acceleration of the process of extinction of various marine resources. Out of 57 marine animals, 15 bony fish, 34 cartilaginous fish, five reptiles and three mammals (dolphin and porpoise) are found in the Bay of Bengal under different threatened categories prescribed by IUCN. The government of Bangladesh is aware of the species extinction and has adopted several laws and acts to conserve coastal and marine biodiversity. The success of conservation actions is highly dependent on various stakeholders such as governments, communities, the private sector, and academics. Differences in the interest of these stakeholders often lead to the failure of conservation programs. However, existing comprehensive actions, legislation and improved coordination among government, community, private sector, and academics will be improved significantly to overcome the upcoming conservation challenge.

Keywords: Coastal Ecosystem; Conservation; Endangered species; Extinction; Bay of Bengal

Abbreviations: DD: Data Deficient; NT: Near Threatened; VU: Vulnerable; EN: Endangered; CR: Critically Endangered; CITES: Convention on International Trade in Endangered Species; CMS: Convention on Migratory Species; MoUs: Memorandums of Understanding; IOSEA: Indian Ocean-South-East Asia; MPAs: Marine Protected Areas

Introduction

Concept of coastal ecology and ecosystem

Ecology is the scientific study of the interactions between living organisms, including humans, and their physical environment; it seeks to understand the vital relationships between plants and animals and the world around them [1]. According to the definition provided by Margalef [2], 'Ecology is the study of systems at the level in which individuals or whole organisms can be considered as elements of interaction, either among themselves or with a loosely organized environmental matrix. Systems at this level are called ecosystems, and ecology is the biology of ecosystems'. In general, ecology is the study of the relation of organisms or groups to each other and their environment [3]. Coastal ecology is a branch of ecology that deals with the diversity of life and the organization of various forms of habitats, from terrestrial (middle) to aquatic ecosystems. It provides information about the benefits of ecosystems and how we can use these diverse resources in ways that leave the environment healthy for future generations.

Coastal ecosystems services and human well-being

Coastal ecosystems have supported human communities for decades, and the performance of coastal services depends on the interrelation between human social and ecological systems [4]. Conservation planners and policymakers use the Millennium Ecosystem Assessment frame to conceptualize ecosystem services to assess the benefit. Ecosystem Services are the benefits that people obtain from the ecosystems. These include

a)   provisioning services such as fish, shellfish and seaweed for food, mangroves timber, algae, minerals, and health products

b)   regulating services such as coastal protection, prevention of erosion, water purification and carbon storage

c)   cultural services such as recreation, beauty, as well as spiritual, intellectual, and cultural benefits.

d)   support services such as habitat provision, nutrient cycling, primary productivity, soil formation etc. [5,6].

Changes in ecosystem services influence human well-being in a variety of ways. Normally, human well-being is supposed to have multiple constituents. These include

a)   basic materials for good life, such as secure and adequate livelihoods, sufficient nutritious food, shelter, clothing, and access to goods

b)   health, including feeling well and having a healthy physical environment, such as clean air and access to clean water

c)   good social relations, including social cohesion, mutual respect, and the ability to help others

d)   security, including secure access to natural and other resources, personal safety, and security from natural and human-made disasters

e)   freedom of choice and action, including the opportunity to be able to achieve what individual values being and doing (Figure 1) [5].
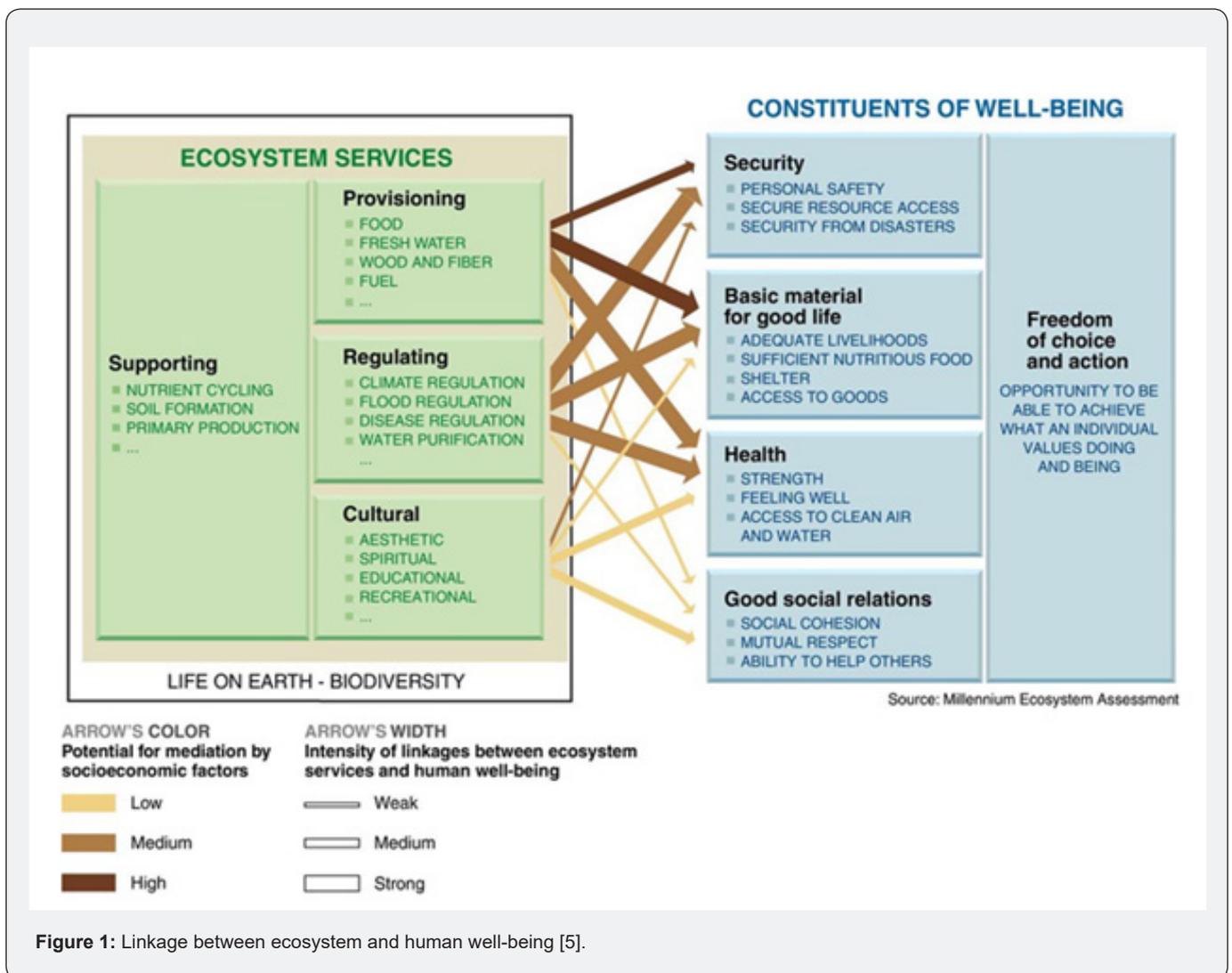

Figure 1: Linkage between ecosystem and human well-being [5].

Coastal Zone of the Bay of Bengal (BoB)

Coastal zone of Bangladesh is dominated by the Ganges Brahmaputra Meghna (GBM) river system and the Bay of Bengal.

Bangladesh has a vast coastal zone covering an area of 47,201 km², 32% of the country, being the landmass of 19 districts [7]. Over 35 million people of Bangladesh, representing 30% of the population, live in the coastal zone [7]. Depending on geographic

features, the coastal zone of Bangladesh has been divided into three parts

    a)   The eastern zone

    b)   The central zone

    c)   The Western zone

The coastline is approximately 714 km long, composed of the interface of various ecological and economic systems. This includes mangroves (the world's largest mangrove forest covering 6,017 km^2), tidal flat, estuaries, seagrass, about 70 islands, accreted land, beaches, a peninsula, and rural areas settlements, urban and industrial areas, and ports [8].

Living and non-living resources in Bangladesh coast

The Bay of Bengal is enriched with rich coastal and marine ecosystems, hosting a wide range of biodiversity, such as fishes, shrimps, molluscs, crabs, mammals, seaweeds, etc. (Table 1). Around 511 marine species, together with shrimps, exist within Bangladeshi waters [9]. The non-living resources in the Bay of Bengal include hydrocarbon deposits in the offshore areas such as gas fields – 26, heavy mineral – 17, and alternative power sources e.g., wind, wave and tidal force [10]. The potential of the coastal fisheries sector has not been rationally harvested. But the resources were overexploited, and as a result, fish stocks decreased [11].

Table 1: Coastal and marine fisheries resources of Bangladesh.

Category	[8]	[55]	[54]
Bony fish	475	475	442
Cartilaginous (soft-boned) fish	50	–	–
Shrimp	25	24	56
Crab	15	50	16
Lobster	5	–	3
Mollusk (Oyster)	301 (6)	301 (3)	336
Algae/Seaweed	56	20–22	168
Coral	13	–	66
Starfish/Echinoderms	3	–	4
Whales/Dolphin	11	-	-
Squids (Cuttlefish)	-	7(2)	-

Deterioration of coastal ecosystem – global perspective

Coastal ecosystems are some of the most globally used and endangered native systems. Human activities deteriorate this system at an increasing rate of 50% of salt marshes, 35% of mangroves, 30% of coral reefs, and 29% of seagrasses, leading to affecting at least three critical ecosystem services: the number of viable (non-collapsed) fisheries (33% decline); the provision of nursery habitats such as oyster reefs, seagrass beds, and wetlands (69% decline); and filtering and purification services provided by suspension feeders, submerged vegetation, and wetlands (63% decline) [12].

IUCN Red List Categories

In 1994, the International Union for Conservation of Nature (IUCN) illustrated the most well-known approaches to declining species. The approach contains explicit criteria and categories to categorize the conservation status of individual species based on their probability of extinction. This science-based species classification with assessment is published as the IUCN Red List of Threatened Species, more commonly introduced as the

IUCN Red List (Figure 2). Three of the categories are Critically Endangered (CR), Endangered (EN), and Vulnerable (VU) marked as "threatened." IUCN defines the CR species as those with an extremely high risk of extinction due to the rapid population declines of 80 to more than 90 percent over the previous 10 years (or three generations) [13]. EN species that retain a severe risk of extinction due to high population declines of 50 to more than 70 percent over the previous 10 years (or three generations). And the VU contains those species that possess a very high risk of extinction as a result of rapid population declines of 30 to more than 50 percent over the previous 10 years (or three generations), a current population size of fewer than 1,000 individuals, or other factors [13].

Endangered species in the BoB

According to IUCN RedList, a total of 57 marine animals of which 15 bony fish (mainly grouper, tuna and seahorse), 34 cartilaginous fish (sharks, rays, guitarfish and sawfish), 5 reptiles (turtle) and 3 mammals (dolphin and porpoise) are found in the Bay of Bengal under different threatened categories. Among the bony fishes, three are data deficient (DD), one is near threatened

(NT), eight are vulnerable (VU) and three are endangered (EN). Among the sharks and rays, nineteen are vulnerable (VU), nine are endangered (EN) and six are critically endangered (CR). Three vulnerable (VU), one endangered (EN) and one critically endangered (CR) turtle are found in the Bay of Bengal along with two vulnerable (VU) and one endangered (EN) mammal (Table 2) [14].

Table 2: List of Critically Endangered and Endangered species in the BoB [14].

English name	Scientific Name	IUCN Redlisting	Figure
Bony Fishes			
Humphead wrasse	*Cheilinus undulates*	EN	
Dusky grouper	*Epinephelus marginatus*	EN	
Southern meagre	*Argyrosomus japonicus*	EN	
Cartilaginous Species			
Ganges Shark	*Glyphis gangeticus*	CR	
Irrawaddy river shark	*Glyphis siamensis*	CR	
Pondicherry shark	*Carcharhinus hemiodon*	CR	
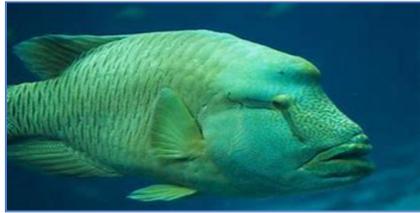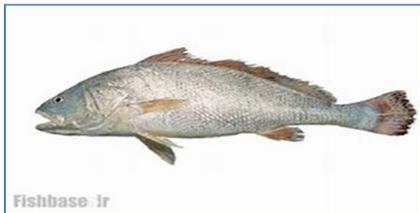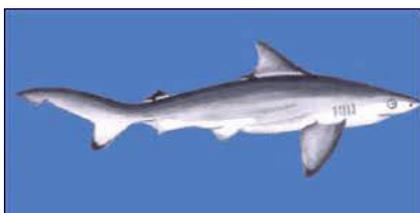
Small tooth sawfish	*Pristis pectinata*	CR	
Large tooth sawfish	*Pristis pristis*	CR	
Green sawfish	*Pristis zijsron*	CR	
Narrow sawfish	*Anoxypristis cuspidata*	EN	
Zebra Shark	*Stegostoma fasciatum*	EN	
Whale Shark	*Rhincodon typus*	EN	
Scalloped hammerhead	*Sphyrna lewini*	EN	
Great hammerhead	*Sphyrna mokarran*	EN	
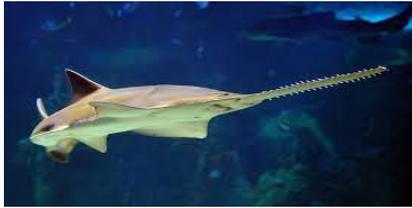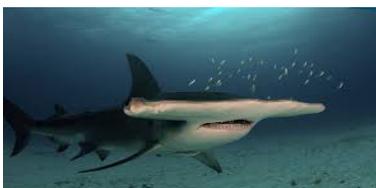
Winghead shark	*Eusphyra blochii*	EN	
Gaint Devil Ray	*Mobula mobular*	EN	
Longhead Eagle Ray	*Aetobatus flagellum*	EN	
Mottled Eagle Ray	*Aetomylaeus maculatus*	EN	
Reptiles			
Green turtle	*Chelonia mydas*	EN	
Hawksbill turtle	*Eretmochelys imbricata*	CR	
Mammal			
Irrawaddy dolphin	*Orcaella brevirostris*	EN	
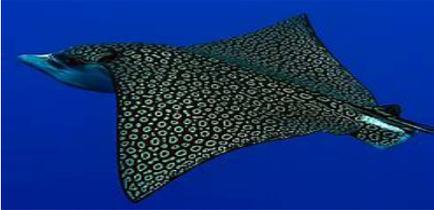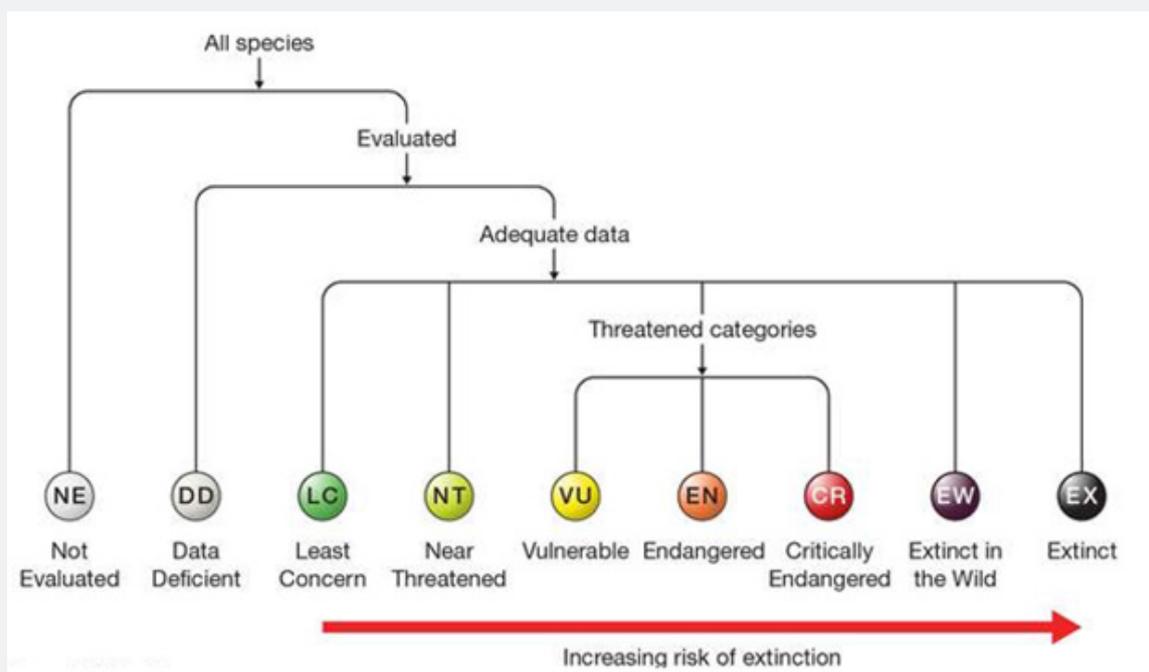
Figure 2: IUCN Redlist Categories (Source: IUCN Redlist).

Recently, another finding was reported on the conservation status of major marine megafauna in the Bay of Bengel by Begum et al. [15]. They considered 78 megafauna species belonging to different groups, 4 species of whales, 8 species of dolphins, 28 species of sharks, 31 species of skates and rays, and 7 species of marine turtles in the Bay of Bengal. The findings are summarized in the following Table 3.

Table 3: Major megafauna species in the Bay of Bengal and their IUCN conservation status (%) [15].

Mega Faunas	CR	EN	VU	NT	LC	DD	NE	LR
Whale			25		25	50		
Dolphin	12.5	12.5		12.5	62.5			
Shark	14.3	3.57	3.57	25		3.57	10.71	39.28
Skate/Ray		6.45	9.68	12.9	6.45	9.68	54.84	
Turtle	71.42		14.29			14.29		

*Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC), Data Deficient (DD), Not Evaluated (NE), Lower Risk (LR).

Causes of Endangerment

The extinction of an organism is influenced by two factors, namely internal and external factors [16].

Internal factors

High trophic level/size of the animals

Larger species typically have lower population densities and are more visible to predators, including humans [17]. The predator will receive a higher reward for the same amount of work. Because of this, these larger animals are more vulnerable than smaller ones, which could result in greater future losses than estimated [18].

Reproduction

The population size of an organism depends on its rate of reproduction. Low reproduction rates and the capacity for fewer offspring will make a species more susceptible to extinction. On the other hand, if the population size is small, there is a greater chance that organisms will perish [18].

Endemic species/ small geographical range size

Endemic organisms exist only in one geographic area. These species are easy prey to predators with limited range area and have a higher vulnerability of extinction [19].

Migratory species

Long-distance migrants are known to have severe population reductions because they are frequently exposed to a variety of challenges throughout their range. In the world, 21% of maritime migratory species are considered to be either critically endangered, endangered, or vulnerable [20].

External factors

Climate change and habiat loss

Climate change caused by global warming change the distribution and abundance of organisms. For example, high temperature reduces the physiological tolerance activity that is the cause of extinction related to climate change. Study predicted that approximately 15–37% of terrestrial species will be 'committed to extinction' due to climate-warming scenarios for 2050 [21]. Besides, habitat loss is important cause for organism extinction [22]. For example, it has been reported declining of reptile species in global scale due to several factors including habitat loss [23].

Exploitation, bycatch, invasive species and poaching

Over exploitation accelerates the loss of the entire population, causing the extermination [18]. Bycatch death caused by illgall fishing nets poses a serious threat to the preservation of endangered species [24]. It harms around 5% of total population size of ceatcean species per year. On the other hand, invasive species expand quickly, multiply, and damage the ecology. Invasive species pose a concern because they increase competition for resources like food and space, making organisms more vulnerable to critically endangered (Clavero and García-Berthou, 2005).

Human population density

Increased population immediately increases food needs, and those needs are heavily reliant on natural resources. Fish species may become extinct more likely as a result of the increased demand for natural resources brought on by population growth (population pressure) [25].

Other threats (pollution, and disease, wildlife trade)

Water contamination will have a huge negative impact on the population, eventually causing extinction [26]. Wildlife trade of live animals, meat, bones, or another part of the organisms have high economic value [27]. Trading in marine organisms has increased with people's interest in ornamental organisms and will increase the vulnerability to extinction.

Techniques to Save Endangered Species

Community awareness & media coverage

Increasing community awareness of the strategy's national, regional and global importance needs to be started early on to save endangered species. These include media coverage, campaigning, handbill for saving the endangered species etc.

Conserve habitats

Wild animals must have a place to find food and shelter to raise themselves. Consumption of trees, oil and gas, overfeeding and development are causing damage to the environment. The habitat of endangered species should be secured and these impacts should be reduced.

Make space for wildlife

Creating wilderness areas to host wildlife adds an extra element of nature to the landscape and helps support the environment by providing a safe place for animals to visit.

Recycle, reduce and reuse

Recycling and purchasing eco-friendly goods can greatly benefit our aquatic ecosystem's animal inhabitants. We should be aware of the effects of every product and refrain from buying anything that uses resources or items derived from threatened species.

Collaboration with organizations

Many different organizations, such as IUCN, WCS etc., are working to protect and conserve endangered species and their habitats. It is time to join any organization that suits your interests voluntarily, find a local chapter, and be the change we want to see in the world.

Development of relevant science

Researchers play a major role in determining environmental policy for the govt and other responsible bodies. In this regard, scientists have to conduct much more research on finding the gap in conserving the species by mentioning their threats and challenges by developing new science such as conservation science and biology [16].

Acts Rules and Policies

Bangladesh has adopted several laws and acts to protect the coastal, estuarine and marine biodiversity. The Constitution of Bangladesh inserted a new article 18A stated that guarantees to safeguard the natural habitats, biodiversity, wetlands, and wildlife in the fifteenth amendment in 2011 [28]. The existing acts include The Bangladesh Biodiversity Act 2017 (Act No. II) regulates biodiversity assessment and conservation through management committees [29]. Protection and Conservation of Fish Act (1950) and has provision for the establishment of sanctuaries, The Marine Fisheries Act 2020 also has a reassuring provision for establishing a marine reserve in the water body in Bangladesh. Some other acts such as The Wildlife (Conservation and Security) Act (2012), and Bangladesh Biodiversity Act (2017) also provide obligations for coastal and marine conservation, especially to protect endangered species [30].

Rules conserving marine fishes in Bangladesh

Several conservation strategies have already been developed in Bangladesh to save marine fishes in the BoB under different rules and acts. For example, five sanctuaries have been established to protect the single largest hilsha fishery from recruitment overfishing and growth overfishing [31]. Besides, the Department of Fisheries declared a 65-days ban period (20th May to 23rd July) on fishing for trawl fishing and shrimp harvest in the Bay of Bengal. To provide a safe breeding ground for these fish species, the marine reserve has been declared at four different areas covering 204 square nautical miles of the fishing ground of the south patches and the middle ground [32]. The department of Fisheries introduced a countrywide ban on catching, carrying, and selling juvenile hilsha (<25cm) from November to June every year. During the peak breeding season of hilsha in October, a ban of 22 days on the catching of brood hilsha exists [33]. However, these regulatory options mostly concern fisheries control [34]. Being a host to a major cetacean habitat, Bangladesh declared its first marine protected area (Swatch-of-No-Ground MPA covering an area of 1738 km^2), for the conservation of some species of dolphins, porpoises, whales and sharks. In 2019, the government declared another 3188 km^2 area around the Nijuhm Dwip Island as the second MPA of the country [30].

Turtle conservation strategy in Bangladesh

The Bay of Bengal has become a death trap for sea turtles because around 5,000 mother turtles have died in the last year because of these illegal nets [35] They are Mostly available in St. Martin's, Sonadia, Maheskhali island and Sundarbans. The existing Wildlife (preservation and safety) Act 2012 ban turtle collection in St Martins and Shahporir island. To restore turtle species, different conservation programmes on sea turtles (including establishing a beach hatchery) on St.Martin's Island in the Bay of Bengal [36]. During the last several months, over 30,000 olive ridley sea turtle hatchlings have been released into the wild from safe beach enclosures and natural nesting sites on the entire Cox's Bazaar coast, from St Martin's to Kutubdia islands [37]. Three turtles of Bangladesh have significant nesting grounds within the beaches (Table 4). Although Bangladesh is a signatory of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the turtles are still accidentally and randomly being killed. Convention on Migratory Species (CMS), there are 3 Memorandums of Understanding (MoUs) targeting marine species: Marine Turtles, Dugong, and Marine Sharks Indian Ocean-South-East Asia Marine Turtle Memorandum of Understanding (IOSEA) Marine Turtle Site Network is awaiting the nomination of sites [38].

Table 4: Recorded nesting and feeding habitats.

Species	Recorded Nesting and Feeding Habitats
Green turtle *(Chelonia mydas)*	St. Martin's Island
Hawksbill *(Eretmochelys imbricata)*	St. Martin's Island (rare)
Olive Ridley *(Lepidochelys olivacea)*	Sundarbans, St. Martin's Island, Sonadia and Maheskhali island of Cox Bazar

Dolphin conservation strategy in Bangladesh

To conserve dolphins, the Govt of Bangladesh has a dolphin conservation action plan for 2020-2030. This action plan includes two major threats to dolphins and their habitats (e.g., Reducing dolphin killing in rivers and coastal waters of Bangladesh and Ensuring the protection of existing dolphin habitats of Bangladesh). All actions identified under these threat categories evolved around four major themes

a) research on the population, ecology and habitats of dolphins

b) investigations on social dimensions of aquatic resource harvest and illegal killing of dolphins by local communities

c) engagement of local communities with the management of dolphins and their habitats

d) enforcement and advocacy for the protection of dolphins at local and regional levels [39]

The GoB has declared six sanctuaries to protect dolphins. Among them, three wildlife sanctuaries (WS) within the Bangladesh Sundarbans (Chandpai, 560 ha; Dudhmukhi, 170 ha; Dhangmari, 340 ha) were established in 2012 for the protection of freshwater dolphins [40] and the rest three WS established outside of the Bangladesh Sundarbans include the Silonda-Nagderma WS at Boral River (24.17 ha), Nagarbari-Mohonganj WS at Jamuna River (408.11 ha) and Nazirgonj WS at Padma River (146 ha) [39].

Sharks & Rays conservation in Bangladesh

Bangladesh signed the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 1981 and the Convention on the Conservation of Migratory Species of Wild Animals (CMS) in 2005 to protect shark and ray fishes. According to this, the government must monitor legal trade and combat the criminal traffic in wildlife, including sharks and rays, even though the country still exports 2000 tons of dried shark fins yearly. To protect shark and ray fish, the GoB updated the list of species and species groups under the "Wild Life Conservation Act 2012" in October 2021, which ensures that eight genera and 23 species of shark and ray fish are strictly protected, while one genus and 29 species are permitted to be sustainably exploited, consumed, and

traded [41]. The Ministry of the Environment, Forests, and Climate Change is working assiduously to implement our country's strong commitment to international accords for wildlife conservation [42].

Challenges on Conserving of Endangered Species

Data scarcity and difficulty in collecting data

In 2015, approximately 17% of the evaluated species were assessed as Data Deficient reported by the national committee of updating Redlist of Bangladesh because there aren't enough supporting materials, books, or field reports [43]. This deficiency of data is a major concern since the data are needed for species threat assessments [44]. Besides, there is a lack of coordination in data sharing and a lack of tracking and investigating equipment in the data collection for the conservation of endangered species. There is also a shortage of sustainable funding for the preservation of red-listed species in Bangladesh.

Conservation Vs livelihood

Conservation and livelihood are two potentially conflicting ideas that must be reconciled in practice to ensure conservation success [45]. Bangladesh's population is increasing daily with increasing economic activity evidenced by rising standards of living [46]. Rapid human activity has led to widespread conversion of natural habitats, the spread of exotic invasive species, pollution, climate change, and overharvesting of the resources. The combined effect of these impacts and economic expansion will further increase the risks to biodiversity [47]. So, resolving the conflicts between livelihood and conservation is a great challenge.

Rapid development of the private sector with various activities

Rapid expansion of the private sector with different activities has led to changes or habitat destruction at an alarming rate [48]. For example, huge illegal private infrastructure (buildings and hotels), unplanned tourism development, etc., cause coastal area reclamation in Cox's Bazar and Saint Martin Island [49]. Now, it is time to take action to increase global awareness and global policy and strategy to reduce pressure on the environment and the habitat of endangered species.

Law enforcement

The government of Bangladesh has provided various regulations related to the environment, but enforcement of these laws is very poor. Poachers and illegal wildlife traders are connected with political persons and frequently violate these laws. On the other hand, the DG of the Department of Environment has been given a wide range of power without any liability and scrutiny [50]. As a result, the court has no power to take action without prior written permission from DoE or the concerned authority. In addition, most people don't have full knowledge of these laws and so why they are violating them continuously. The interrelationship between the various concerned authorities is not so strong. As a result, it creates a haphazard situation.

Quality of Marine Protected Area (MPA)

Marine Protected Areas (MPAs) play a significant role in preserving marine organisms [51]. Effective MPAs can protect species diversity by restoring degraded habitats and bringing economic benefits [30]. Therefore, developing a lot of MPA with an area sufficient to function optimally is crucial. But it should be kept in mind that, MPA in large numbers become meaningless if the MPA lacks good quality. For example, Bangladesh declared two MPAs in the Bay of Bengal and the area around Nijuhm Dwip Island covering only 2.8% of its EEZ [30]. However, the Southeast coastal zone of Bangladesh needs to be declared a new MPA due to its wide range of species diversity from primary producers to top predators. Therefore, it needs skillful human resources, facilities and funding, and suitable regulations that are yet to be seen by The Department of Forest [52].

Genetic biodiversity of endangered species

Understanding endangered species' diversity and genetic structure are fundamental to engaging in effective environmental conservation and management actions [53]. The most important genetic challenge in managing threatened species is conservation biology's genetic issues [54]. Many species in Bangladesh are currently experiencing serious genetic destruction (inbreeding and loss of genetic diversity). Unfortunately, complete inventories and information about these species are typically inadequate [55,56]. Optimistically, the Bangladeshi government is well aware of this and has been preparing to deal with this situation for many years [43].

Recommendations

The government agencies, academia, and local and international conservation groups should work to save the endangered species in our water area. The following recommendations can be considered for the conservation of endangered species in the Bay of Bengal:

a)   Increasing public awareness

b)   Regular monitoring and assessing of the status of marine organisms and associated ecosystem linkages

c)   Information sharing to support decision-making

d)   Regulating fishing intensity, controlling gear selectivity, prohibition of destructive fishing

e)   Ensuring the qualities of MPAs

f)   Integrating sectoral policies, strategies, and legislation Coherent legal and institutional framework

g) Capacity and skill development of relevant stakeholders

h) Encourage volunteer engagement of university students

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