

COASTAL BIODIVERSITY – A REVIEW
REPORT PREPARED FOR COASTAL
EMBANKMENT IMPROVEMENT PROJECT,
PHASE-I (CEIP-I)

LONG TERM MONITORING, RESEARCH AND ANALYSIS OF
BANGLADESH COASTAL ZONE (SUSTAINABLE POLDERS
ADAPTED TO COASTAL DYNAMICS)

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9. COASTAL BIODIVERSITY

The coastal zone contains distinctive development opportunities that can be instrumental in reducing the vulnerability and poverty of coastal communities and can contribute significantly to the development of Bangladesh as a whole. Some of these are untapped, others have significant expansion potentials. The zone has a diversity of natural resources, including coastal fisheries and shrimp, forest, salt and minerals. In recent years, Bangladesh coastal areas received international attention due to its high potential for exploitation of both onshore and offshore natural gas. The coastal zone, including the estuaries and brackish ecosystems, contains several ecosystems that have important conservation values. Some parts of the world's largest uninterrupted stretch of mangrove ecosystem - the Sundarban – in Bangladesh has been declared World Heritage Site (WHS) in 1997, whereas coral-associated ecosystems are found around St. Martin's Island. These ecosystems are not only biodiversity hotspots, but they also provide the ecological foundation for an important common property resource - the fisheries and biological diversity of the Bay of Bengal (BOB).

Coastal ecosystems provide many vital ecological and economic services, including shoreline protection, productive commercial and sport fisheries, and nutrient cycling. Key near-shore ecosystems such as sea grass meadows, marshes, and mangroves are particularly valued for their extremely high productivity, which supports a great abundance and diversity of fish as well as shrimp, oysters, crabs, and other invertebrates. Because of the abundance of juvenile fish and shellfish they contain, near-shore ecosystems are widely considered as 'nurseries'. The nursery role of coastal estuaries and marine ecosystems is well accepted by all and it is often cited to support protection and conservation of these areas. Mangrove ecosystem is directly linked with the enhanced productivity of the nursery ground for marine fish and shellfish fauna (Hussain & Hoq 2010) and protection from the tidal surges and cyclones.

Mangroves are available in the form of natural forests Sundarban and planted (in Barisal, Noakhali, Chittagong and Cox's Bazaar Coastal Areas) forests together covering about 50% of the forest area of Bangladesh. The coastal mangrove forests constitute about 60% of the commercial productive forests including plantations, it covers 580 km². It extends along the coast in isolated groups with the exception of the Sundarban, which accounts for 74% of the reserve forest of the country. The Sundarban and mangrove forest in other parts of coastal area including offshore islands support a wide range of mammals, birds, amphibian, reptiles and crustacean.

The southern part of Bangladesh is bordered by about 710 km long coast line of the Bay of Bengal, which has the continental shelf of up to 50 m depth with an area of about 37,000 km². The Exclusive Economic Zone (EEZ) of Bangladesh (Fig. 9.1) lies from the base line to 200 nautical miles seaward (S&T. 1993).

An exclusive economic zone (EEZ) is a sea zone prescribed by the 1982 United Nations Convention on the Law of the Sea (UNCLOS) over which a state has special rights regarding the exploration and use of marine resources, including energy production from water and wind. It stretches from the baseline out to 200 nautical miles (nmi) from its coast.

EEZ km ²	Shelf km ²	EEZ+TIA km ² (Total Internal Area)
89,392	66,438	230,390

(Source: https://en.wikipedia.org/wiki/Exclusive_economic_zone)

The coastal zone of Bangladesh, covering an area of 47,201 km² and inhabited by 31 million people (adjusted in 2010), has a dynamic and complex environmental and social setting. For the purpose of the 'Long Term Monitoring, Research and Analysis of Bangladesh Coastal Zone (Sustainable Polders Adapted to Coastal Dynamics)' - a study under the Coastal Embankment Improvement Project-1 (CEIP-1) the entire coastal zone is divided into four zones- Ganges Tidal Plain West (GTPW), Ganges Tidal Plain East (GTPE), Meghna

Deltaic Plain (MDP) and Chittagong Coastal Plain (CCP). Salient ecological and habitat features are described for each of the coastal zones including the floral and faunal species inhabiting the zones. Protected areas declared by the government along the coast and continental shelf for the protection and conservation of the habitat, ecological services and species have also been mentioned.



Fig. 9.1. Demarcated area showing Exclusive Economic Zone including the coast of Bangladesh.
 (Source: <https://www.arcgis.com/home/webmap/viewer.html?layers=ba4891c6d1b544939e18143e06d69e88>)

9.1 Ganges Tidal Plain (West)

The Sundarban (Fig. 9.2) is the largest single continuous productive mangrove forest of the world, spreading over the southern part of Bangladesh and west Bengal State of India. The Sundarban is a unique ecosystem and has great interest in a number of ways. Global mangroves are calculated to be just over 1,80,000 km², a small area compared to other forests. Bangladesh is the 8th country in the world, which possesses a vast mangrove forest. This is the place where the mainland Bangladesh meets the Bay of Bengal, making the area a globally unique ecological niche. Out of the global total true mangrove species numbering 35, Sundarban has 12-13 sp. The Sundarban mangrove forests provide timber; pulp wood, fuel-wood, raw materials for industries. The major commercial timber/wood species of Sundarban are Sundri (*Heritiera fomes*), Gewa (*Excoecaria agallocha*), Keora (*Sonneratia apetala*), Goran (*Ceriops roxburghiana*). The most important non-wood forest product is Nipa palm - *Nypa fruiticans*. It is mentionable here that the World Heritage Convention (WHC) declared "Sundarban as natural and cultural site of outstanding universal value". Sundarban is the first RAMSAR site of Bangladesh declared under "The Convention on Wetlands" (also called the Ramsar Convention). Three wildlife sanctuaries – Sundarban West, Sundarban South and Sundarban East Wildlife Sanctuaries - declared by the government are located along the coast facing the Bay of Bengal. Moreover three dolphin sanctuaries (Fig. 9.3) have also been declared located along the Pussur, Shela and Bhola Rivers in the north Sundarban for the conservation and protection of the Gangetic and Irrawaddy dolphins.

A total of 334 species of (Spermatophytes and Pteridophytes) belonging to 245 genera were identified from the Sundarban forest and the adjoining areas. Of these no fewer than 123 occur in the present reserve forest of the Bangladesh Sundarban. The forest is rich in biotic diversity comprising 400 species of fishes, 53 species of reptiles, over 315 species of birds and 50 species of mammals. There are 283 species of finfish in Indian Sunderban and 222 species of finfish in Bangladesh Sunderban, 100 species of shellfish community, 15 species of shrimp, 8 species of prawn, 1 species of lobster, 5 species of crabs, 3 species of snails, 22 species of mussels and shells, 4 species of cuttlefish and squids (MOEF 2002).

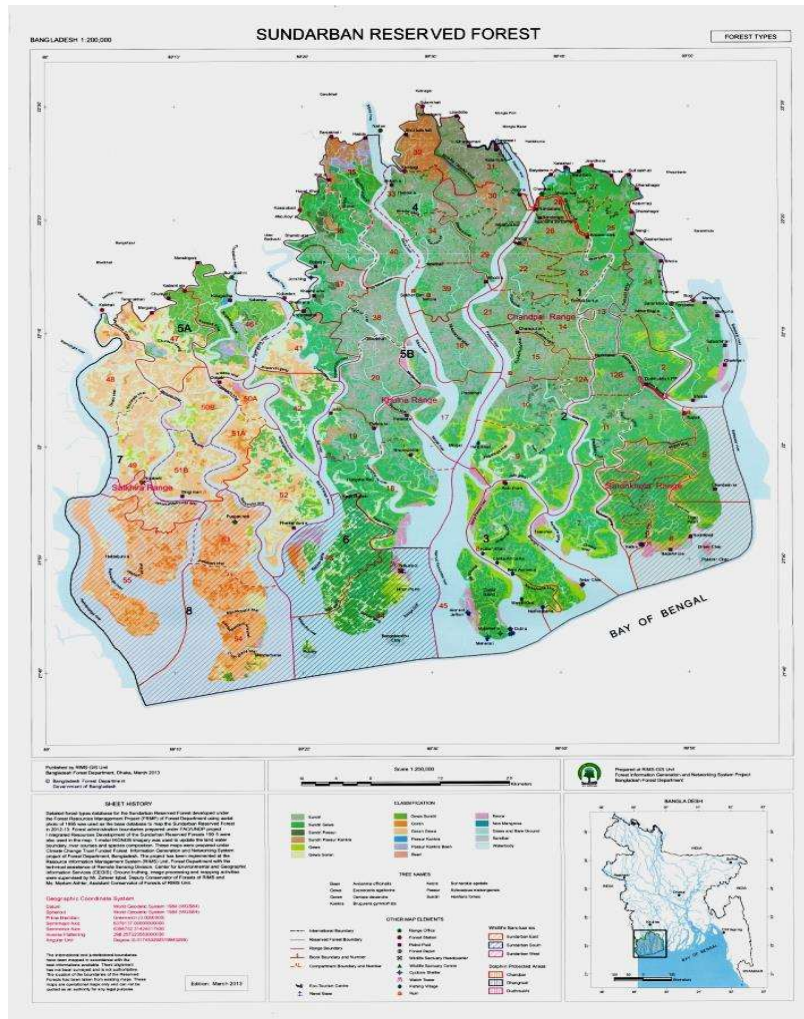


Fig. 9.2. Sundarban mangrove forest – the largest mangrove patch in the world. Shaded areas are the designated wildlife sanctuaries.

In addition to fin fish Bangladesh also has a rich diversity of shellfish, especially of Caridean shrimps, several of which are of commercial interest and export value. A total of 63 shrimp and prawn from inland and marine water of Bangladesh have been recorded. The brown shrimp, *M. monoceros*, contribute about 56% of the total shrimp catch, though *P. monodon* is the targeted species because of its export value. *Peneaus monodon*, *P. indicus*, *P. semisulcatus*, *Metapeneaus monoceros*, *M. brevocornis* are important penaeids. The shrimp and prawn culture sector of Bangladesh are very important in economic terms contributing significantly to foreign exchange earnings and employment generation in rural areas. About 600,000 coastal people are directly employed in this industry. In addition to the finfish and shrimps, more than 300 mollusk species are recorded

from Bangladesh. Two species of *Trochus* are recorded from the St. Martin's Island, which are depleted worldwide. Octopus and Cuttlefish (*Sepia*) occur in deep waters of the Bay and are exportable commodities.

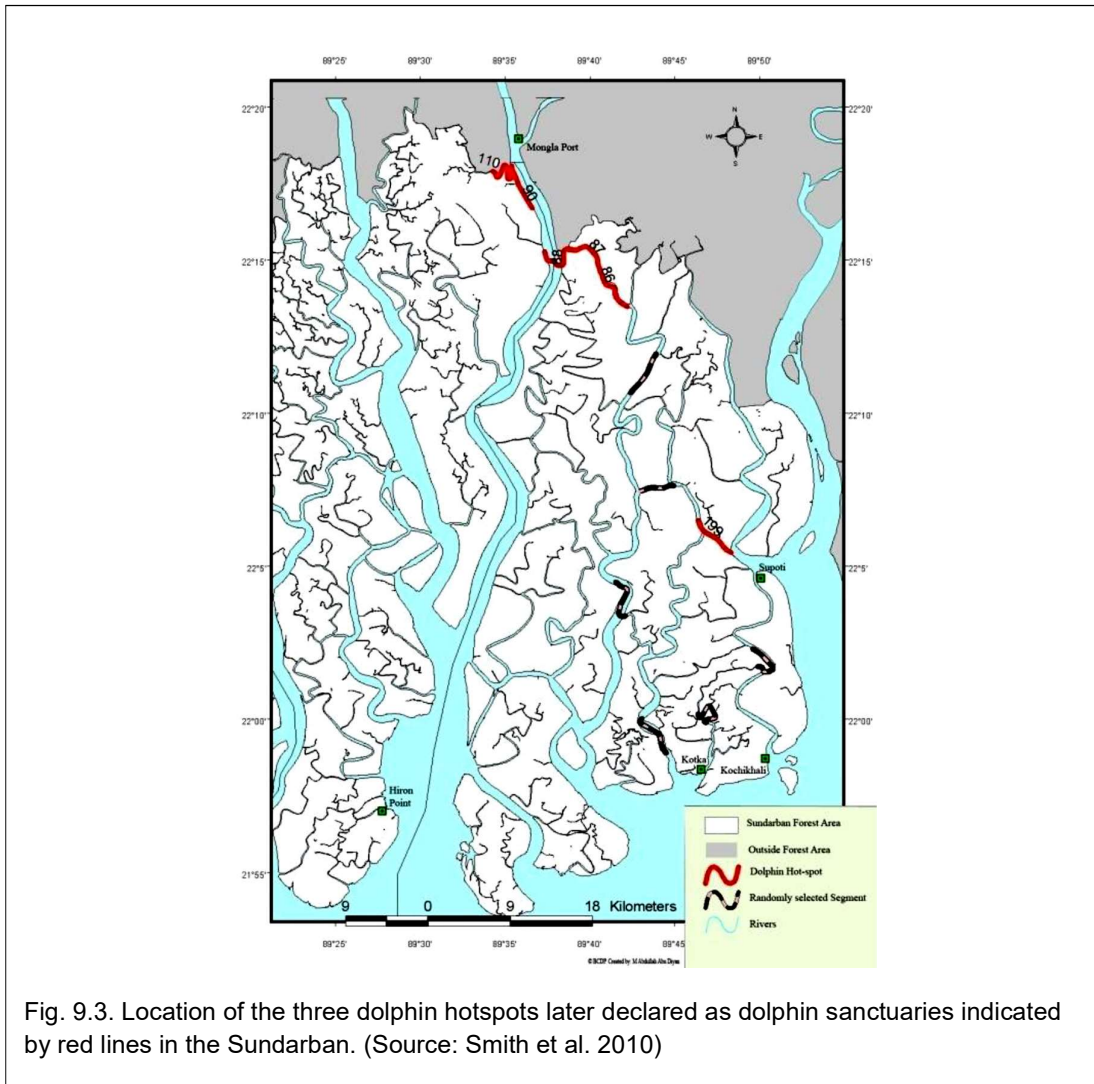
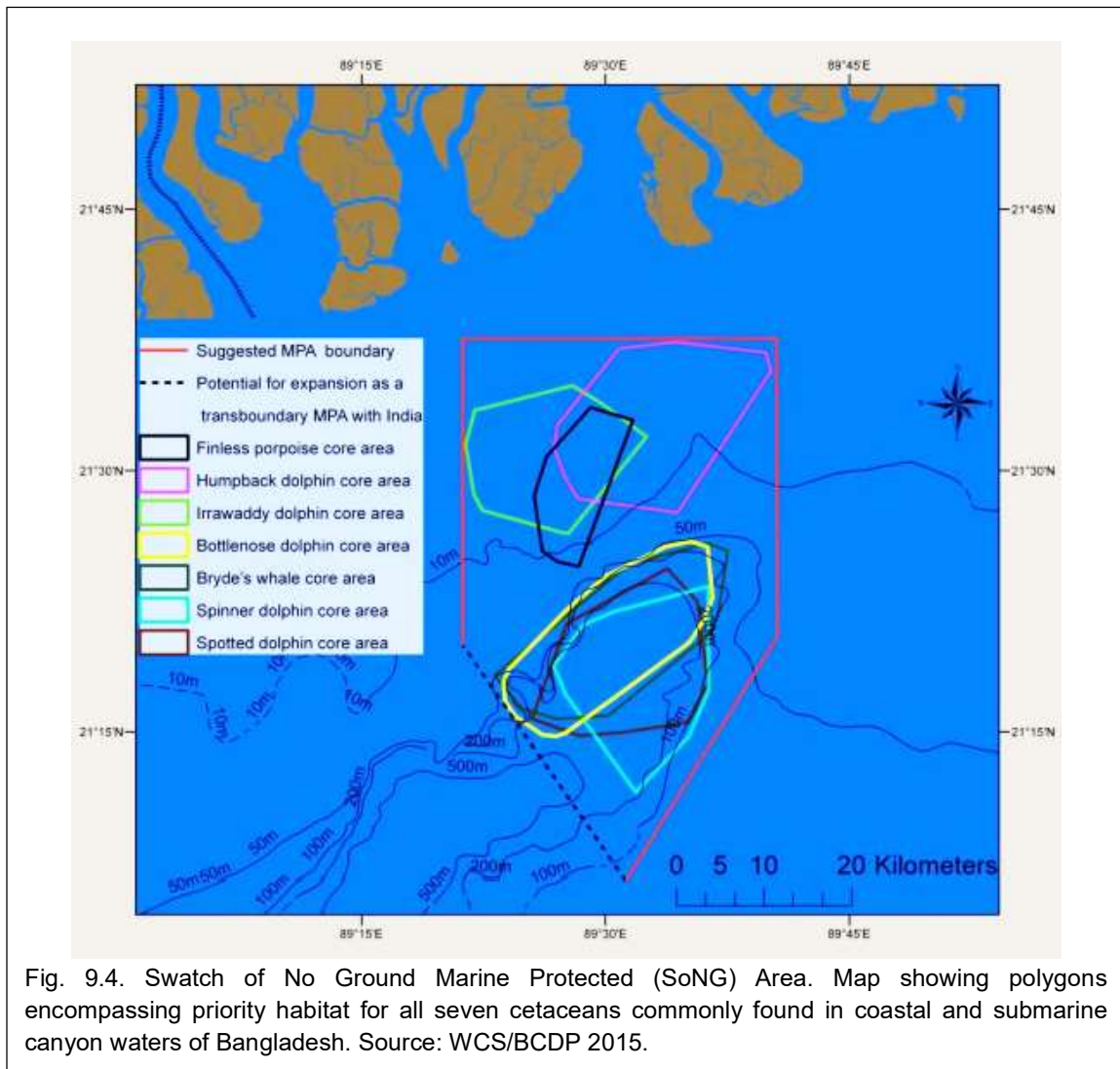


Fig. 9.3. Location of the three dolphin hotspots later declared as dolphin sanctuaries indicated by red lines in the Sundarban. (Source: Smith et al. 2010)

Bangladesh Wildlife (Protection & Security) Act (2012) described 30 shark and ray species including sea horse, 6 species of whales, 14 species of dolphins, 22 species of crabs and lobsters as protected marine species. The Swatch of No Ground (SoNG) has now been identified as a cetacean hotspot for globally endangered Irrawaddy dolphins, and several other cetaceans. The government has declared SoNG as the first Marine Protected Area (MPA) in the Bay of Bengal (Fig. 9.4). Among the estuarine/marine fish species several are found to be threatened, among them one is endangered Yellowtailed Pangas (*Pangasius pangasius*), and several are vulnerable (*Anguilla bengalensis*, *Plotosus canius*, *Carcharhinus limbatus* and *C. melanopterus*). Marine reptiles in Bangladesh such as sea snakes and marine turtles are found all along the coast. Among the marine turtle species, three are critically endangered (Hawksbill turtle - *Eretmochelys imbricata*, Green turtle - *Chelonia mydas*, Leatherback turtle- *Dermodochelys coriacea*), while two species are vulnerable (Loggerhead turtle - *Caretta caretta*, and Olive Ridley turtle - *Lepidochelys olivacea*). Ten species of marine mammals are found in the Bay of Bengal, Bangladesh waters. Of these four are vulnerable

(Irrawaddy Dolphin - *Orcaella brevirostris*, Bryde's Whale - *Balaenoptera edeni*, Sperm Whale - *Physeter macrocephalus* and Finless Porpoise - *Neophocaena phocaenoides*) (IUCN 2015).



9.2 Ganges Tidal Plain (East)

Recently on 24th June 2019 the Government of Bangladesh declared Nijhum Dweep Marine Protected Area (NDMPA) (Fig. 9.5) under Section 28 of the Marine Fisheries Ordinance 1983 (Ordinance No. XXXV of 1983). The 3,188 sq. km NDMPA area covers coastal and off-shore areas of Bhola, Noakhali and Patuakhali districts. It includes areas that are important for hilsa migration and spawning, foraging areas for the dolphins and staging areas for some of the critically endangered migratory bird species.

Fisheries provide millions of people with a source of livelihood. Yet across the world, these resources are fast diminishing because of pollution, habitat destruction, overfishing, natural disasters and climate change. Traditional approaches to halt this decline focus on regulating against destructive practices, but with little effect. The polders do have some impact on the local fish movement, migration, fish composition and breeding in a particular locality due to physical and biological factors of the aquatic environment. The Hilsa fish is anadromous (=fish born in freshwater who spend most of their lives in saltwater and return to

freshwater to spawn) in nature (an uncommon phenomenon in tropical waters), living in the sea for most of its life, but migrating up to 1,200 kilometers inland along major rivers in the Indian sub-continent for spawning. It is also one of the most important single-species fisheries in the Bay of Bengal, which Bangladesh shares with Myanmar and India. 250 million people are dependent on Hilsa for nutrition and more than half a million people for their livelihoods. Hilsa also has significant cultural value (Mohammed & Wahab 2013).

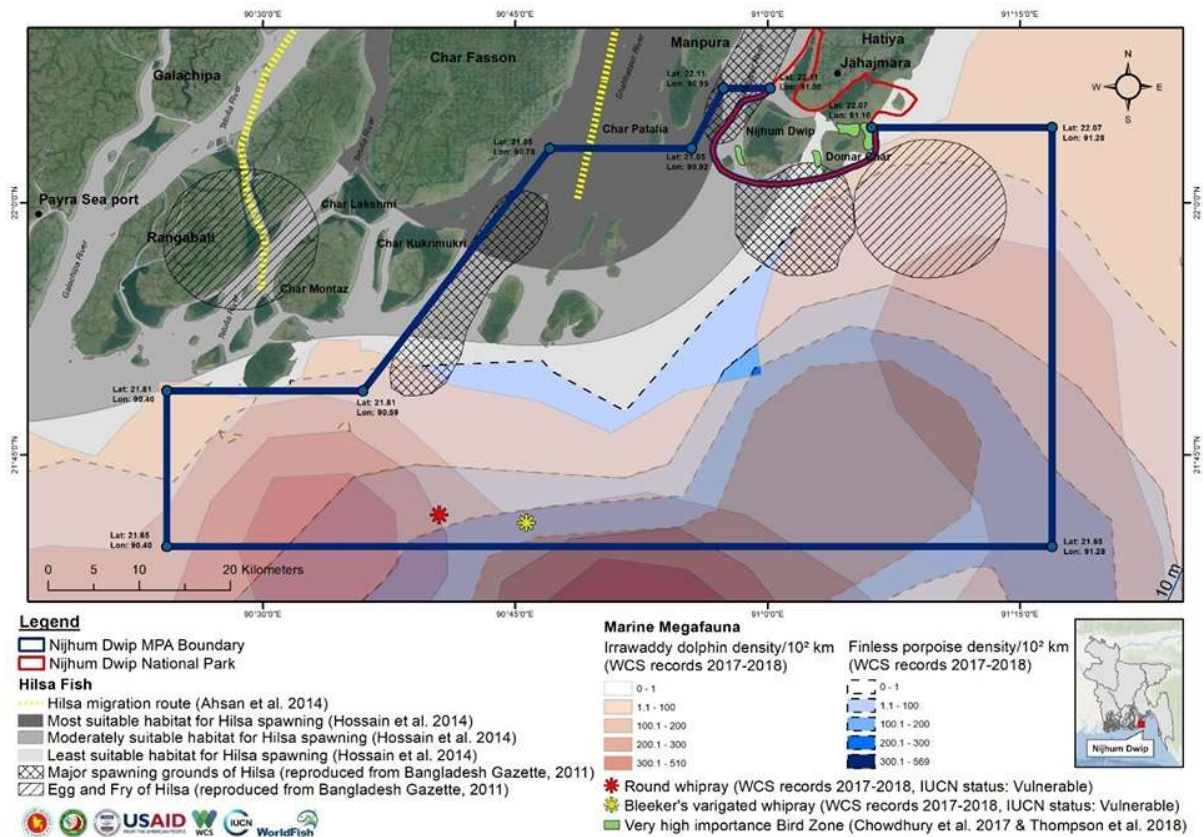


Fig. 9.5. Recently declared Nijhum Dweep Marine Protected Area.

Hilsa was once abundant in the 100 rivers of Bangladesh. Fishers used to catch plenty of fish, which were sold fresh to local and urban markets. It was cheap and affordable for the poor. From the 1970s, the Hilsa fishery began to gradually decline, with output reaching a low point of 0.19 million tons in 1991–1992. This situation was attributed to a combination of closure of migratory routes, river siltation, over-fishing, indiscriminate harvesting of brood stocks and juveniles (locally known as *jatka*), use of fishing nets with very small mesh sizes, the mechanization of fishing gear, increased numbers of fishers, pollution, and hydrological and climatic changes. Such a significant decline in Hilsa catches prompted the government of Bangladesh to declare some of the country's coastal rivers as Hilsa sanctuaries, restricting fishing during the breeding season. To compensate for loss of earnings due to fishing restrictions, the government started providing affected fisher communities (187,000 households) with 30 kilograms of rice per household per month and supporting alternative income-generating activities (AIGAs). While no study has been carried out to rigorously evaluate the ecological and social impact of the intervention, it is widely believed by both scientists from the Department of Fisheries, and the fishers themselves, that it has had significant positive ecological impacts (Mohammed & Wahab 2013).

Hilsa catch remained at similarly low levels from the base year of 1991–1992 to 2001–2002. Catch levels further declined during 2002–2003 (Fig. 9.6), which marked the implementation of economic incentive-based

mechanisms to halt further decline, and to focus on efforts to increase Hilsa production. Regulations on the catching of small Hilsa, a ban on fishing of *jatka* (juvenile Hilsa less than 23 cm in size) and restrictions on the catching of brood (mature and about to spawn) Hilsa during the breeding season were adopted in 2003–2004. The government mobilized its resources to build awareness, and introduced monitoring and enforcement involving the coast guards, navy, and fishery officers, including the seizure and destruction of monofilament nets. To compensate for the loss of earnings, the government started providing ‘affected’ fisher communities (187,000 households) with 30 kilograms of rice per household per month and providing training and cash to develop alternative income-generating activities (AIGAs) for fishermen and women.

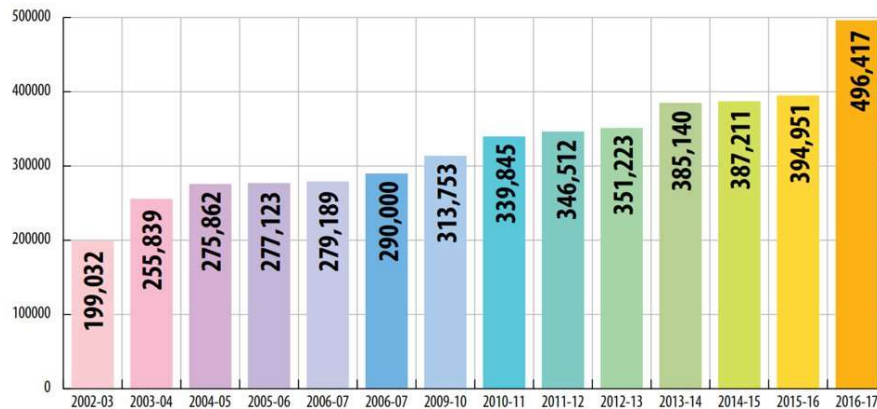


Fig. 9.6. Hilsa fish production increased following adoption of incentives and mitigation measures (Source: DOF 2018).

Tengragiri Wildlife Sanctuary declared as a protected area – Wildlife Sanctuary (WLS) by the government in 2010 (Fig. 9.7). The mangrove forest covers an area of 4,048.58 acres. The Tengragiri forest stretches from Taltali Upazila of Barguna District to the beach of Kuakata of Patuakhali District. Although it is officially named 'Tengragiri forest', locally it is known as 'Fatarban'. The forest is located about 71 km southwest from the Kolapara Upazila at the extreme southern part of the country. The sanctuary supports several national and globally significant species including the endangered Fishing Cat (*Prionailurus viverrinus*).

Sonarchar Wildlife Sanctuary (SWLS) (Fig. 9.7) – an off-shore island located within Patuakhali District was declared by the government as a protected area in 2012 covering an area of 2,026.48 acres. The sanctuary is covered with planted mangroves, extensive mudflats and submerged sand bars that expose during low tide and provides an excellent feeding and roosting habitat for migratory and resident waterbirds. The mangroves act as a nursery for a myriad of aquatic species especially invertebrates and fishes.

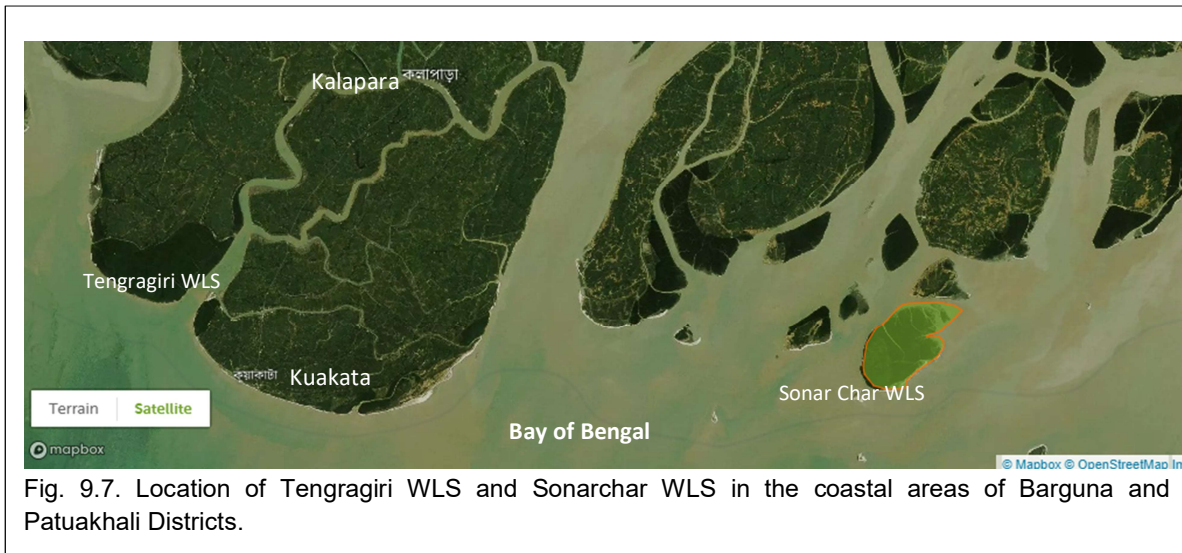


Fig. 9.7. Location of Tengragiri WLS and Sonar Char WLS in the coastal areas of Barguna and Patuakhali Districts.

9.3 Meghna Deltaic Plain

Moving east from the Sundarban and adjoining areas is the Meghna Estuary. Meghna Estuary is the easternmost sector of the Ganges Delta. The Estuary conveys the joint discharge of the Ganges/Padma, Jamuna/Brahmaputra, and Meghna Rivers and hence is very dynamic. The estuary is formed inside Bangladesh by the joining of the Surma and Kushiya rivers originating from the hilly regions of eastern India. Down to Chandpur, this area is hydrographically referred to as the Upper Meghna. After the Padma joins, it is referred to as the Lower Meghna which falls to the Bay of Bengal. Major tributaries in the Meghna river region included the Dhaleshwari River, Gumti River, and Feni River. The Meghna empties into the Bay of Bengal via four principal mouths, named Tetulia, Shahbazpur, Hatiya, and Bamni.

The government declared six Hilsa sanctuaries for its conservation (Fig. 9.8). The sanctuaries are: a 100 km strip of the Meghna River—from Shatnol to Char Alexandar; a 90 km strip of the Shahbazpur Channel at the Meghna estuary in Bhola district; a 100 km strip of the Tentulia River in Bhola district; a 40 km strip in Andharmanik River in Patuakhali district; a 20 km strip at the lower Padma (Padma Confluence) in Shariatpur district; and an 82 km strip of the Meghna River (from Hizla to Mehendiganj) in Barisal district. Three of these sanctuaries are located in the coastal areas. Moreover, the government has banned all kinds of fishing for 65 (sixty five) days from 20 May to 23 July in the coastal and marine areas for conservation of fishes as this period constitutes the breeding season for many fishes and other aquatic species (DOF Memo No. 33.00.0000.129.99.067.14(Part-2)-30 dated 04 February 2019). In addition there exists a ban from October 9 to 30 imposed to ensure safe spawning of the hilsa fish during its peak breeding period and from March to May to assist and protect the migrating juvenile from the rivers to the sea.

The entire area is tidal-influenced round the year. Tides are semidiurnal with two high and two low cycles during a lunar day. Tidal behavior varies along the coast in terms of magnitude but not of pattern. The tide ranges from 0.07 m during neap tide to 4.42 m during spring tide. The tidal range increases in the direction from South–West (around 4 m range at South Bhola) towards North–East (around 7 m range at Sandweep).

There is a pronounced seasonal variation of wind, river discharge, and sediment supply from the river system. The highest discharges occur in August–September and the lowest in February (MES 2000). This freshwater runoff is a dominant feature that influences the dynamics of the coastal and marine environment. From January to June the balance is restored to create estuarine conditions. These seasonal variations like increased salinity, changed flow, sediment, flow distribution affect the occurrence, abundance and

composition of aquatic and other water- and tide-dependent flora and faunal species. The tidal counter currents are biological hotspots within the river and estuarine areas. The attractive force of eddy currents traps primary nutrients and woody debris that retain nutrients and provides substrate and an array of cover and hydraulic gradients, which support fish and other invertebrate species.

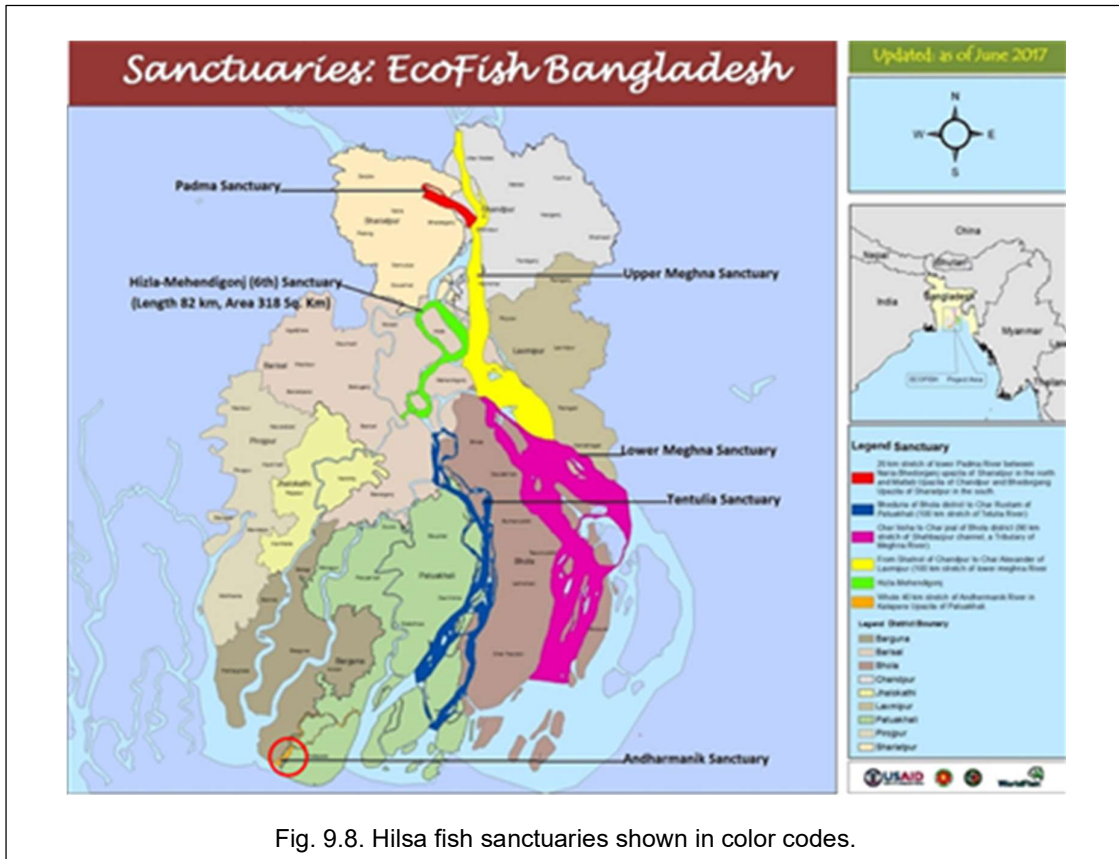


Fig. 9.8. Hilsa fish sanctuaries shown in color codes.

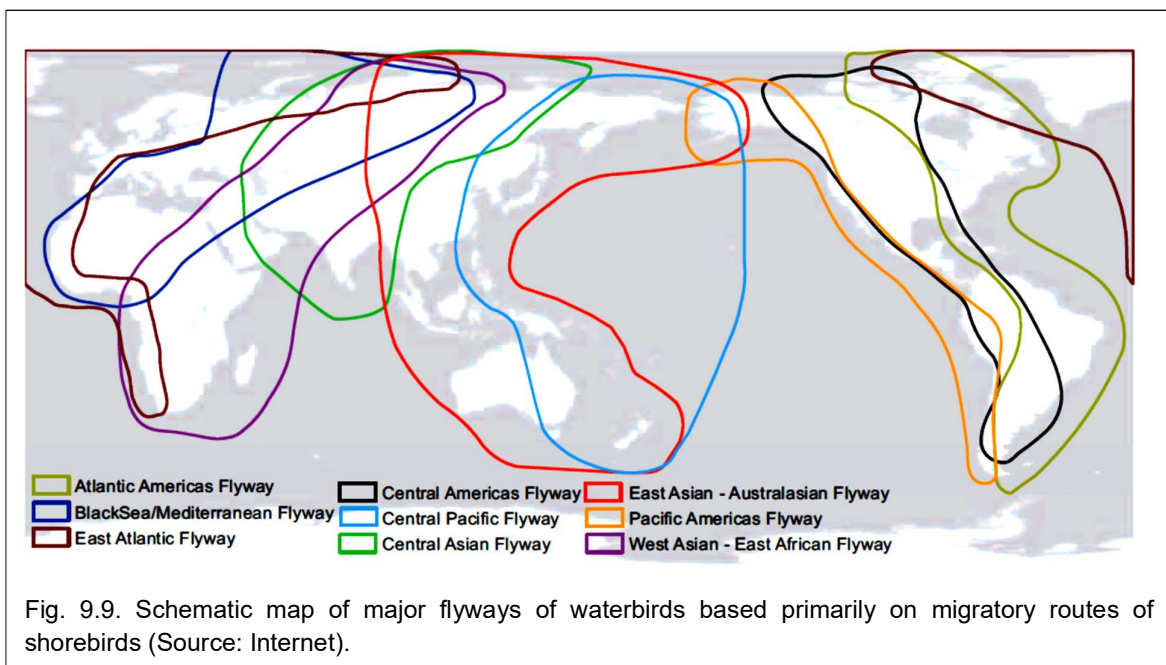
Coastal waters (together with inland waters) are also covered by the *Protection and Conservation of Fish Rules* (1985). This regulation refers to methods of fishing, fish species that cannot be caught during a particular season, mesh size of fishing nets, prohibition of landing and carrying fish of a certain size.

Hossain *et al.* (2012) reported 53 fin fish species from the Meghna estuary. Among them are *E. tetradactylum*, *G. giuris*, *H. nehereus*, *L. subviridis*, *O. rybicundus*, *P. paradesius*, *Arius bilineatus*, *Osteogeneiosus sp.*, *Setipinna taty*, *J. carutta*, *O. microlepis*, *A. caelatus* *A. thalassinus*, *B. mino* and *H. sona* each contributing more than 1% of the composition. Hossain *et al.* (2007) reported about 161 species collected by different types of net from Naaf river estuary located in the southeast bordering Myanmar, where Islam (1987) observed 97 species from the same area. Islam *et al.* (1992) reported about 185 species from the coastal waters of Bangladesh collected from the estuarine set bag net. Islam (2005), Ahammad (2004), Kamal (2000) and Nabi *et al.* (2011) identified 48, 76, 46 and 45 finfish species from Chittagong coast, Moheskhal Channel, Karnaphulli river estuary and Bakkhali estuary respectively. The fewer numbers of species recorded by Hossain *et al.* (2012) at the Meghna estuary may be due to long term changes in hydrological, meteorological parameters, fishing intensity, and disturbances to the ecosystem.

Downstream of the Meghna estuary is an assortment of countless islands, constantly disappearing and emerging, swallowing the homes of some and creating new niches for others. Some are permanent while some emerge with each low tide while others are washed away. These islands and associated mudflats are the prime staging areas for the migratory birds, particularly waders and other waterbirds during the winter.

Bangladesh holds an important strategic location in the migratory flyway (Fig. 9.9) where migratory birds from West Asian-East African Flyway, Central Asian Flyway, East Asian-Australasian Flyway regularly visit the coastal and inland river areas. Many of the migratory birds like Spoonbill Sandpiper, Nordmann's Greenshank, Asian Dowitcher, Great Knot are critically endangered. Some of the birds breed in the Siberian Tundra and winter along the coasts of Teknaf, Cox's Bazaar, Hatiya, Nijhumdweep, Sandweep Islands and Sundarban.

The coastal mudflats are the hidden treasures of biological diversity. Every year more than one hundred thousand birds visit these mudflats to feed on the invisible life that flourishes on mud, silt and clay found in intertidal areas. These areas generally support a range of invertebrates, which are extremely productive biologically. These include benthic organisms, molluscs, crustaceans and marine worms. Mudflats provide an important nursery and feeding ground for many fish species. Shallow water zones along our south central coast are critical habitats for Hilsa and Pangas. It's striking that the coastal mudflats still hold seven globally threatened and twelve other near-threatened resident and migratory birds. Irrawaddy Dolphins still come to the water surface to breathe and to offer a smile to the fishermen. Most of these areas are still wild and unchanged, such as Sonadia Island in Cox's Bazaar and the islands around Hatiya, Sandweep and Bhola. They are yet to be marred by development. However recent plans to embank Sonadia Island and construct coal-fired power plants and LNG terminals may deteriorate the natural landscape and obliterate ecological functions. The polders may protect the low-lying islands from tidal surges, human lives and property at the cost of upsetting many of the ecological functions and disturbing natural habitats.



Conservation in Bangladesh has mostly focused on the forests and their fascinating diversity, although how much we have managed to protect our forests is debatable. Attention to coastal or intertidal wetlands has been largely limited, or even totally omitted as areas of conservation interest by many of our decision-making bodies. Yet mudflats and tidal areas offer immense and irreplaceable value in biological diversity, number, uniqueness, beauty and their contributions to human livelihoods (Choudhury 2017).

The coastlines and estuarine coastal water-logged areas of Bay of Bengal harbor at least five species of sea grass; *Halodule univervis*, *Halophila decipiens*, *Halophila beccarii*, *Ruppia maritima*, *Halophila pinifolia*. Sea grass, *H. beccarii* occurs in the intertidal area and riverside co-existing with mangroves (*Avicennia alba* and *A. marina*), salt marsh grass, and scattered sparsely in the estuarine habitat with macro-algae *Ulva intestinalis*.

Seagrass *R. maritima* occurs in the aquaculture ponds and water logged areas while *H. pinifolia* occurs patchily in the sandy areas of Saint Martin's Island (Hena *et al.* 2015).

9.4 Chittagong Coastal Plain

Further east-southeast is the more stable coastline from Chittagong to Teknaf embracing the Naaf River estuary (bordering Myanmar) and the Saint Martin's Island in the southeast about 12 km into the Bay of Bengal. The coastal area comprises one of the prized fishing zones – the South Patches and the South of South Patches (Fig. 9.10).

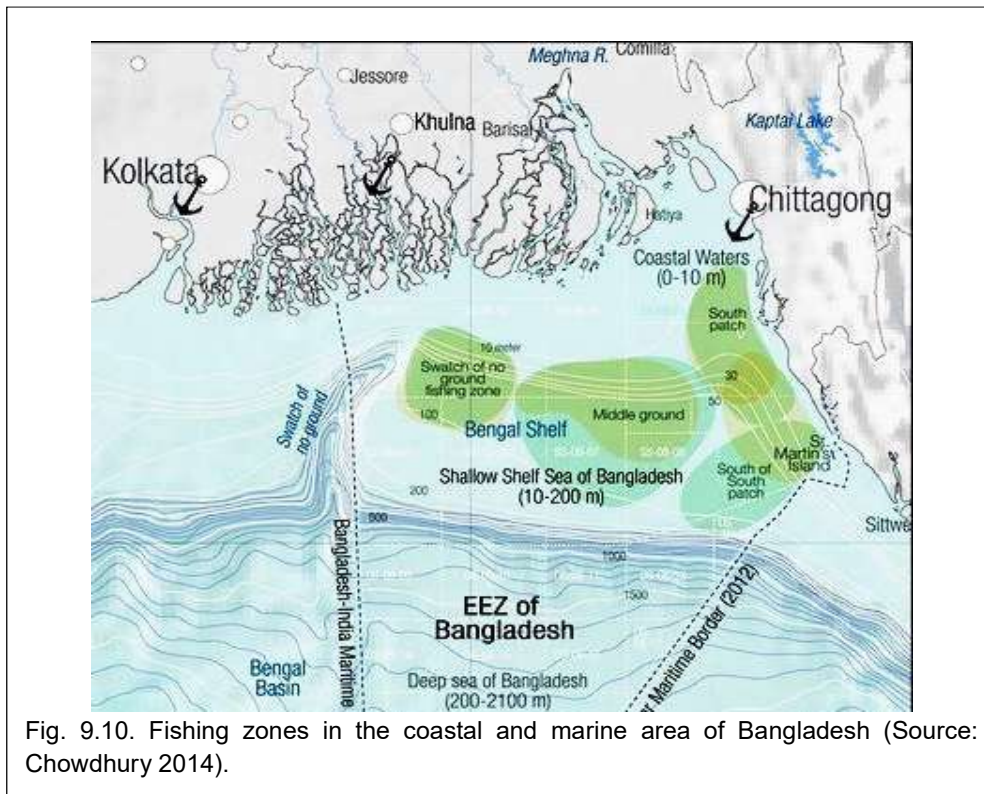


Fig. 9.10. Fishing zones in the coastal and marine area of Bangladesh (Source: Chowdhury 2014).

The main block of natural mangrove forest in Cox's Bazaar coast, the hundred-year-old Chakoria Sunderban, occupied the low-lying saline swamp at the mouth of the Matamuhuri River delta (Fig. 9.11). The swamp consisted of innumerable low-lying islands, which would mostly submerge at high tides. The water would remain brackish up to the inner boundaries even during the rainy season. Unlike the Sunderban mangrove forest along the southwestern coast of Bangladesh, the Chakoria Sundarban was protected from the open sea by Moheshkhali hills, an outlier of tertiary age. The presence of the forest along the coast is recognized to provide a buffer against storm and erosion damage as well as providing habitat for a variety of marine and terrestrial organisms (Hossain *et al.* 2001).

The vegetation before forest removal consisted of saltwater halophytes with abundance of *Dalbergia spinosa* and *Aegialities rotundifolia*. There were about 20 species of trees and none attained a height of more than 12 meters (Chowdhury 1969). Mangroves occurred in specific ecological zones on the islands, the coastal and riverine shorelines and in the upland locations. The area supported a very good habitat for different types of birds, mammals, reptiles, amphibians, and fish.

The mangroves have since disappeared totally and the factors responsible for the destruction of mangrove forest are removal of forest produces for fuel wood, high grazing pressures, fishing, human settlement, salt

production, and shrimp farming. In addition to this, the fishermen built dams in the mouth of the creeks, thereby disrupting tidal inundation and causing water stagnation. For this change in hydrology, the seedlings in stagnant water failed to survive which seriously affected forest regeneration (Siddiqi *et al.* 1994). Such interference, coupled with the government policy of covering the reserve mangrove forest to shrimp farms and human settlement, has led to the drastic depletion of the mangrove. Similarly the polders though provide refuge restricts and disrupts tidal inundation and exchange of nutrients that affect ecosystem and ecological services.

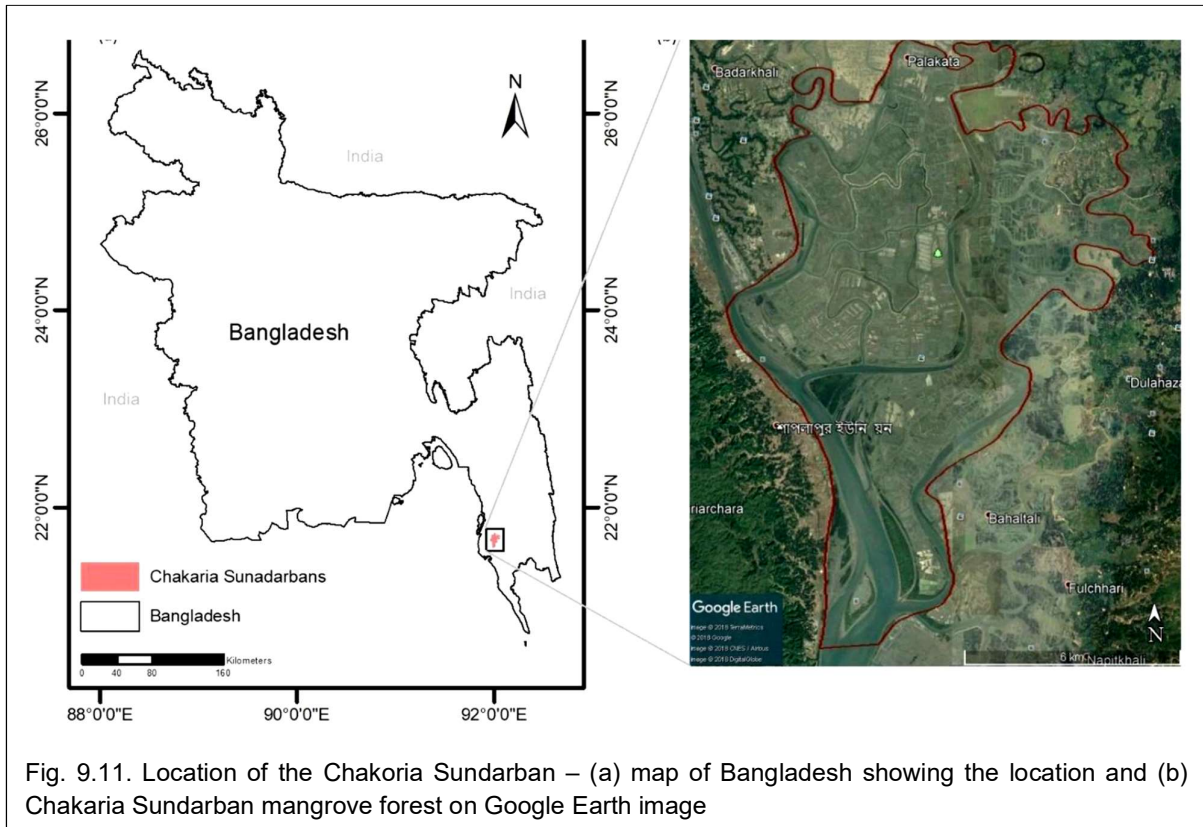


Fig. 9.11. Location of the Chakoria Sundarban – (a) map of Bangladesh showing the location and (b) Chakoria Sundarban mangrove forest on Google Earth image

Down south along the coast the Cox's Bazaar-Teknaf coastal area comprises a mosaic of unique habitats and supports an assemblage of diverse ranges of flora and fauna. Many of the fauna and flora species are nationally and globally important and threatened, and therefore have got immense conservation significance. Rapid expansion of economic activities, including conversion of mangroves to shrimp farming and salt production, establishment of a large number of shrimp hatcheries, expansion of huge unplanned tourism, unsustainable harvesting of marine and estuarine resources, resulted in the rapid degradation of its habitat quality and consequent loss of biodiversity, rendering the site to a critical state. These activities have caused and have been causing disruption in ecological integrity and its functioning leading to ecological imbalance. Realizing the biodiversity degradation in the area and its consequences, the Government of Bangladesh declared, along with few others, Cox's Bazaar-Teknaf beach area and Sonadia Island as Ecologically Critical Areas (ECA) under the provision of Article I of the Bangladesh Environment Conservation Act, 1995 (Fig. 9.12). The Department of Environment (DoE) is mandated for the management of the ECAs.

The Sonadia Island, located on the west of Cox's Bazaar and south-southwest of Moheshkhali Island and between the right bank of the Moheshkhali Channel Estuary and left bank of Kutubdia Channel Estuary. The island hosts remnants of the original mangrove forest crisscrossed by several tidal creeks and channels. It is one of the biodiversity hotspots and supports some internationally significant wildlife species, particularly

some critically endangered migratory birds and marine turtles. The surrounding Bay of Bengal (BOB) waters support several species of endangered cetaceans. Recently a unique Porifera - Siliceous Sand-Sponge (*Tetilla dactyloidea*) has been reported for the first time in Bangladesh from the tidal creeks of Sonadia Island (Rashid & Khan, In Press. 2019). The island has been leased to Bangladesh Economic Zones Authority (BEZA) in 2017 by the Ministry of Land (MOL) vide Memo No. 31.00.0000.041.41.222.16.264 dated 26/04/2017 on the recommendation of the Deputy Commissioner, Cox's Bazaar (Memo No. 05.20.2200.128.32.225.2015.1351 dated 17/11/2016). BEZA has taken the initiative for feasibility study and Master Plan to set up Eco-tourism Park in Sonadia Island. BEZA has planned to use only 30% of the space so that there is no adverse impact on the environment. However, the Ministry of Water Resources (Planning Section-1) asked BWDB to construct embankment disregarding the status of Sonadia Island as an ECA, which prohibits any activity that may cause any physical change to the landscape (Memo No. MOWR/Planning Section-1/42.00.0000.039.14.026.17-16 dated: 21/01/2018).

Teknaf Peninsula is one of the longest sandy beach ecosystems (80 kilometres) in the world. It represents a transitional ground for the fauna of the Indo-Himalayan and Indo-Malayan ecological sub-regions. Important habitats at the site include mangrove, mudflats, beaches and sand dunes, canals and lagoons and marine habitat. The site provides breeding areas for two globally threatened species of marine turtles and, lying along international bird migration flyways, serves as a significant bird area. Its inshore waters also host globally threatened marine mammals. Other important species include several crustacean species, fishes and molluscs.

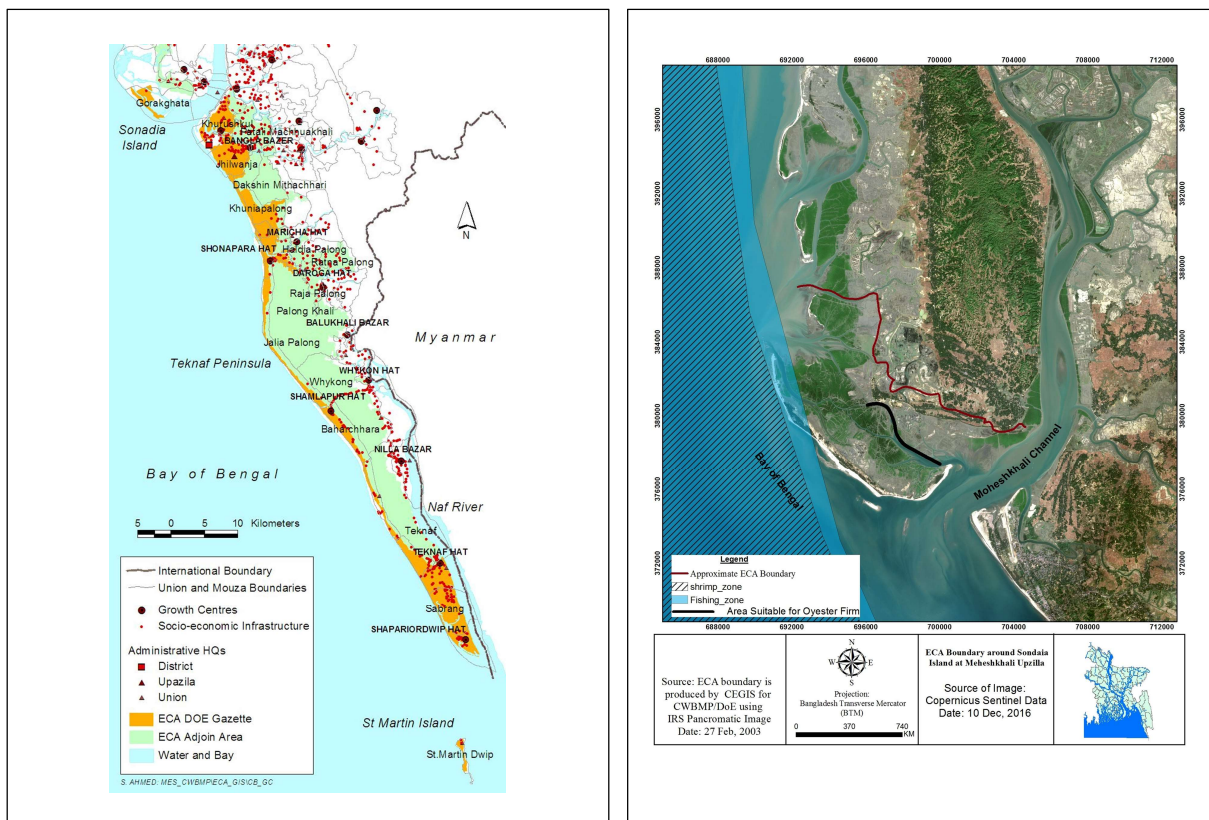


Fig. 9.12. (Left) The Cox's Bazaar – Teknaf coastline and (Right) Sonadia Island Ecological Critical Areas (Source: CWBMP/UNDP/Department of Environment).

The Cox's Bazaar-Teknaf ECA's northern, western and southern boundaries are delineated by waterways – the northern boundary by the Moheshkhali Channel from the Bay of Bengal up the channel as far as

Ghorokghata; the western boundary by the beach along the Bay of Bengal; and the southern boundary by the tip of the Peninsula bordered by both the Bay and the Naaf River Estuary. The site's eastern boundary follows mouza lines and incorporates the mouzas of Kurushkul and Jhilonja (Cox's Bazaar Upazilla), Jungle Khuniapalong, Jungle Dohapalong, Pechar Dweep and Jungle Goaliapalong (Ramu Upazilla), Jaliapalong and Inani (Ukhia Upazilla) and Shilkhali, Baradail, Lengurbil, Teknaf, Sabrang and Shahparir Dweep (Teknaf Upazilla). The boundaries of the Shilkhali, Baradail, Lengurbil and Teknaf mouzas are shared with the adjacent Teknaf Reserve Forest or Teknaf Game Reserve. While most mouzas share boundaries with adjacent mouzas, the Sabrang and Shahparir Dweep mouzas share boundaries with the Naaf River estuary.

The area acts as a corridor between terrestrial and marine biodiversity, with the site's habitats including sand dunes and beaches, mudflats, mangrove and estuaries facing the Bay of Bengal (BOB).

Sand dunes and beaches: The sandy beach extends the length of the site from Moheshkhali Channel in the north to the tip of the Teknaf Peninsula in the south, a distance of some 75 km. Sand dunes occur along the beach, with dune vegetation distinguishable between several zones (Rahman *et.al.* 2001). Vegetation is relatively sparse with few plants in the open pioneer zone immediately preceding the drift line. The vegetation is denser in the herbaceous zone with some mat forming herbs, and a mixture of herbaceous plants and shrubs including climbing species occurs in the middle mixed or bushy zone. Tree species interspersed with patches of low marshy areas dominate the inner inland zone, which merges into the hinterland of mudflats, sandy beaches and cultivated fields.

Mudflats: The 100-150 ha of grassy mudflat at Badar Mokam (Shahparir Dweep) is important spoon-billed sandpiper (*Calidris pygmaea*) habitat. Intertidal mudflats along the Naaf River are suitable wader feeding ground. Large extent of mudflats at Subrang and Shahparir Dweep have been converted and used for salt production.

Mangrove: Sparse patches of naturally occurring mangrove occur along the estuarine muddy banks of *khals* running down the hills, adjacent to the sand dunes along the coast line. Mangrove occurs in larger areas along the Naaf River estuary in Teknaf, but does not exceed 10-20m in width at any one place and has been mostly planted by the Forest Department (Coastal). Small patches of natural mangrove thickets occur sporadically along the Naaf River riverbank and along the Reju Khal.

Estuaries: The major estuaries of the site include the Moheshkhali Channel and Bak-khali River in the north and the Naaf River in the south east, which provide significant habitat for flora and fauna including mudflats and mangrove. The Naaf River estuary is the most unique and highly productive ecosystem within the site. Several major canals occur along the length of the coastline, and are connected to the inland canals during high tide. The Reju khal is the main one, entering the BOB between the Ramu and Ukhia Upazillas; others include the Baharchara, Rajarchara, Inani, Monkhali, Katabunia and Shilkhali canals. Hundreds of other small canals also occur along the coast line, originating from hill streams and carrying freshwater runoff to the BOB. The smaller ones remain dry throughout the winter, only becoming active with the monsoonal runoff. There are more than two hundred culverts and bridges along the Marine Drive to facilitate drainage of the hill streams.

Two hundred and forty eight (248) species of plants were recorded from 65 spots along the roads and homesteads close to the coastal areas. Of those, 47 were timber species, 35 were fruit species, 34 were ornamental and 31 were medicinal plants. Among these five were rare including *Clinogyne dichotoma* (Patipata), *Gymnema acuminata*, *Mangifera sylvatica* (Jangliam, Uria), *Rauvolfia serpentina* (Sharpagandha) and *Terminalia chebula* (Haritaki). A total of 128 species of sand dune vegetation have been recorded from the coast. Of the dune grasses, creeping plants, herbs, shrubs and tree species recorded, the largest number of taxa belonged to the Poaceae (Gramineae) and Fabaceae (Leguminosae) families. Estuarine vegetation adjacent to sand dunes included mangrove patches dominated by *Acanthus ilicifolius* and *Phragmites karka* (CWBMP 2005).

Algal formations are found on the boulders at Inani and between Teknaf and Shilkhali. Invasive alien species known to occur within the site include *Mimosa pudica*, *Ipomea carnea*, *Lantana camara*, *Mikania cordata* and *Eichornia crassipes* (water hyacinth).

A total of 90 mammals were recorded from the Cox's Bazaar – Teknaf Peninsula, of which 22 were fairly common, 18 were few, 40 were occasional and 10 were extinct (NCSIP-1 1997). At present important terrestrial mammal species include *Elephas maximus* (Asiatic Elephant). Seven species are globally endangered as per the IUCN Red List, 2015 and a further 14 vulnerable. At the national level, 24 species are critically endangered, 23 endangered and 19 vulnerable. The near- and off-shore waters support at least five species of globally threatened coastal marine cetaceans.

The area is important for a wide variety of waterfowl and shorebirds with more than 200 species of common residents, and a variety of common and rare migratory birds that visit the site for resting, roosting, feeding and wintering and to use the site as a staging ground during migration.

The NCSIP-1 (MoEF, 2001b) recorded 389 species of birds from the Cox's Bazaar and Chittagong Forest Divisions, of which 279 are resident and 100 migratory. Of those species recorded 235 species were non-passerine and 154 were passerine, with the three largest families being passerine. Among the non-passerine species, waterfowl represented 109 species. Five species are locally extinct. Three species recorded along the coast are listed as globally threatened - *Calidris pygmeus* (Spoon-billed Sandpiper), *Limnodromus semipalmatus* (Asian Dowitcher) and *Tringa guttifer* (Nordmann's Greenshank). The spoon-billed sandpiper is one of the rarest migratory birds in the world, with a population of just 200-250 pairs in the wild (Bird *et al.* 2010, Zöckler *et al.* 2008).

The NCSIP-1 (MoEF, 2001b) recorded 78 species of reptiles, including 24 species of turtles and tortoises, 14 lizards and 40 snake species, of which 15 species were poisonous. Some of the common species include Olive Ridley turtle, forest Calotes, common gecko and two lizards, checkered keel back snake, red-necked keel back water snake, dog-faced water snake, banded krait and king cobra. The BOB waters surrounding the site support three species of marine turtles including Olive Ridley (*Lepidochelys olivacea*), Hawksbill (*Eretmochelys imbricata*), and Green Turtle (*Chelonia mydas*), while the coastal beaches are important nesting sites for the Olive Ridley, Hawksbill and Green Turtles (Rashid and Islam, 2005).

Ten species of frogs and one species of toad were recorded at the site during the NSCIP-1 survey (MoEF, 2001b). The bull frog (*Hoplobatrachus tigerinus*), skipper frog (*Euphlyctis cyanophlyctis*) and climber frog (*Kaloula pulchra*) were all fairly common, while the others were few and occasional.

The critical biodiversity areas in Cox's Bazaar - Teknaf Wildlife Sanctuary, Himchhari National Park and Inani National Park – located along the coast face a grave risk of peril due to high level of human interventions due to the construction of the Marine Drive, tourist lodges/resorts and following the Rohingya influx. Already, more than 2,000 hectares of forest have been lost as a result of the expansion of campsites after the arrival of over 750,000 Rohingyas since August 2017. Before the latest influx, more than 300,000 Rohingyas were already living in the area. The financial cost of this destruction of forest in Ukhia and Teknaf upazilas stands at about Tk 1,865 crore, but the long-term consequences are more environmental than financial (Forest Department 2018). Clearing of forests and vegetation enhances soil erosion and promote landslide. It also amplified human-elephant conflict, with 13 human casualties so far in the area. The remaining elephant habitat is under severe pressure from uncontrolled firewood collection in the forest. It is affecting water resources, irrigation, and groundwater reserves including local biodiversity, marine resources, acoustic environment, and air quality.

A survey of the fisheries fauna of the Naaf River estuary from the mid-1980s to early 1990s recorded 67 species of fish (Islam, 1993b). The NSCIP-1 (MoEF, 2001b) recorded 123 fish species from the Cox's Bazaar

- Chittagong study area by observing fish catches from local rivers and estuary. The dominant species were represented by a few groups of small-sized fishes. Of the 123 species, at least 23 can be regarded as locally threatened. Species diversity reflects the different fish habitats occurring at the site. Common estuary species include the Estuarine catfish (*Mystus gulio*), Engraulids (*Coilia dussumieri*, *Thryssa hamiltoni*), Tade mullet (*Liza tade*), Speigler's mullet (*Valamugil speigleri*), Flathead mullet (*Mugil cephalus*), Croakers (Sciaenidae), Giant sea-perch (*Lates calcarifer*), Silver grunt (*Pomadasys argenteus*), Yellowfin seabream (*Acanthopagrus latus*), Terapon perch (*Terapon jarbua*), Four-finger threadfin (*Eleutheronema tetradactylum*), Whiting (*Sillago sihama*), Silverbiddy (*Gerres filamentosus*), Spotted butterflyfish (*Scatophagus argus*) and Eel catfish (*Plotosus canius*). Common coastal species include Clupeids and Engraulids including Bigeye shad (*Ilisha filigera*), *Sardinella fimbriata* and *Tenualosa ilisha*, Croakers (Scianidae), Ribbonfish (*Lepturacanthus savala*), False trevally (Lactarids), Ponyfish (Leiognathids), Halfbeaks (Hemiramphids), Indian Mackerel (*Rastrelliger kanagurta*), Four-fingered threadfin (*Eleutheronema tetradactylum*), Silver Pomfret (*Pampus argenteus*), Flathead sillago (*Sillaginopsis panijus*), Bombay duck (*Harpodon nehereus*), and Terapon perch (*Terapon jarbua*). The endangered whale shark (*Rhincondon typus*) also occurs in the coastal areas.

A survey of the invertebrate fauna of the Naaf River estuary from the mid-1980s to early 1990s recorded, among others, 20 species of shrimp and prawns, three species of crab and two species of lobster. In total seven species of crab and two species of lobster are recorded in the coastal waters. Of particular importance is the Indian Horseshoe Crab or King Crab (*Carcinoscorpinus rotundicauda*), which is considered a living fossil and is listed in the IUCN 2015 Red List of Threatened Species. Five species of oyster from natural beds in Cox's Bazaar and Teknaf were also recorded. Molluscan species belonging to 27 genera of bivalves, clams, mussels and oysters are known to occur along the coast (Anon., 1990). Surveys carried out under the CWBMP 2006, 66 species of mollusks were recorded. Some important bivalves are abundant, e.g. *Anadhara rhombia* and *Anadhara granusa*. Two economically important gastropods that are heavily depleted worldwide – *Trochus radiatus* and *Turbo sp.* are also present. A total of 51 species of butterflies were recorded in the Cox's Bazaar and Chittagong Forest Divisions under the NSCIP-1 survey including the coastal areas (MoEF, 2001b).

Shrimp hatcheries are also established at the site – Cox's Bazaar coast is one of three government shrimp centres and a shrimp hatchery zone has been established in Kalotali. Other hatchery zones exist just north of Inani and adjacent to the Teknaf Beach. All the hatcheries have been established either in, or directly adjacent to, sand dunes, adversely affecting nesting turtle habitat. Almost all have direct outlets to the sea to dispose of untreated hatchery water, which is polluted with chemicals and fertilisers.

The Teknaf Peninsula consists of a variety of fish habitats and therefore is subject to a range of fishing practices. The in-shore areas of the Bak-khali River estuary up to Choufaldondi canal are fished using beach seine, stake nets, push nets, cast nets, seasonal brush parks and monofilament gill nets. The Reju Canal estuary is fished using beach seine, cast nets, seasonal brush parks and hand lines. The mangrove-fringed lower Naaf River estuary from Shahparir Dweep to Nyttong Para is fished using the estuarine set bag net (ESBN), stake nets, cast nets, trammel nets and drifting gill net. The fine-mesh seine nets and stake nets used in the estuarine areas are the largest contributors to the destruction of juvenile fishes and other aquatic organisms, especially during the breeding season.

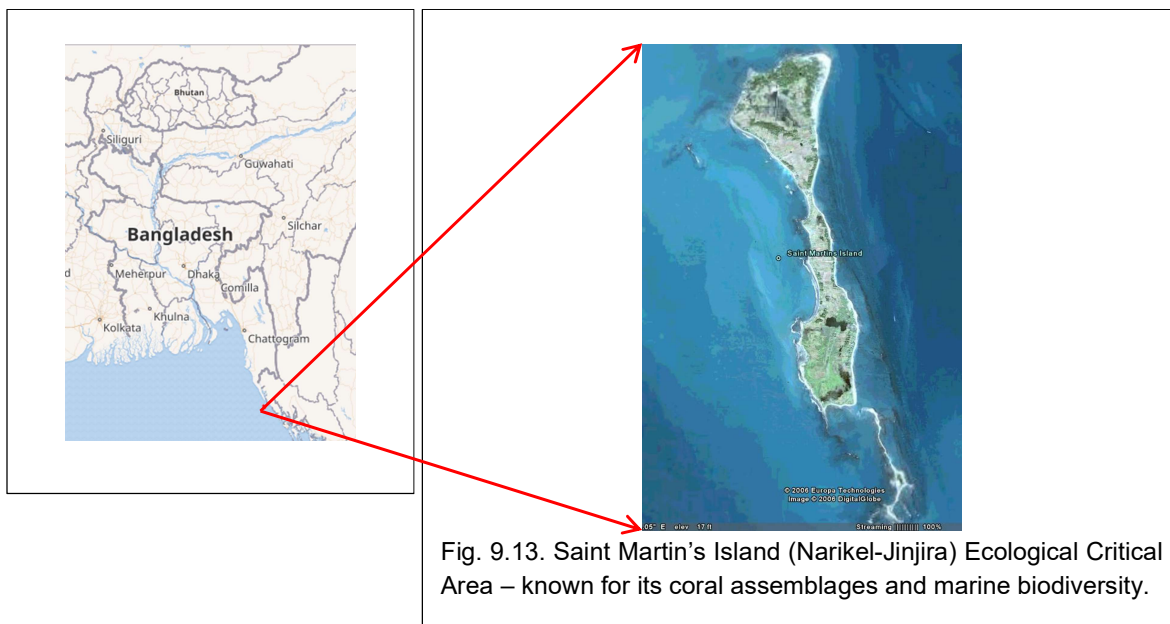
The sandy bottom coast between Cox's Bazaar and Inani is fished using the monofilament and bottom-set gill nets, cast nets and beach seine. The Inani-Baradail sandy/rocky bottom intertidal/coastal area is fished using the bottom-set and monofilament gill-nets, hook and line and wild plant extracts (poison). The Baradail-Shahparir Dweep sandy bottom coast is fished using the beach seine (mostly in winter – November to February), monofilament gill net and cast net. The collection of tiger shrimp fry with bag net and push net using very fine meshed mosquito netting causes massive destruction of fish and shrimp fry species and other aquatic species, especially during summer and the monsoon. Pelagic crabs (including gravid females), juvenile sharks, rays and other invertebrates are particularly at risk. An area of approximately 413 ha in Najiratek, Cox's Bazaar and Badar Mokam, Teknaf along the coast is used for processing dry fish.

Himchari National Park located south of Cox’s Bazaar, comprises 1,729.00 acres of evergreen/deciduous forest was declared in 1980 as a protected area for conservation, research, education and recreation. The habitat comprises lush tropical rain forest, grasslands and features a number of waterfalls, the biggest of which cascades down toward the sandy, sun-drenched beach and into the BOB. Himchari is home to a limited number of these majestic animals like the Asian Elephant (*Elephas maximus*), Barking Deer (*Muntiacus muntjak*). Other mammals include Rhesus Macaque, Leopard Cat, Fishing Cat, and Wild Boar. Additionally the Himchari National Park is home to more than 150 bird species, 56 species of reptiles and 13 amphibian species.

Inani National Park, located south of Cox’s Bazaar, halfway between Cox’s Bazaar and Teknaf along the coast. Comprises diverse habitat of low hillocks, wide beach interspersed inter-tidal areas with rocks and boulders making it an unique habitat providing substratum for algae, mollusks, echinoderms, and fishes.

Teknaf Wildlife Sanctuary is a protected area in the Cox's Bazaar District comprising a hill forest area of 11,615 ha (44.85 sq. mi.). In the east it is bordered by the Naaf River and in the west by the Bay of Bengal. It was established in 1983 as Teknaf Game Reserve under the Bangladesh Wildlife (Preservation) (Amendment) Act, 1974, later declared as Teknaf Wildlife Sanctuary in 2009. This is one of the few places in Bangladesh where Asian elephants can be seen in the wild. This vast sub-tropical forest has several other attractions like Nitong Hill, Kudum Cave, Kuthi Hill, etc. The popular Toinga Peak has an elevation of about 1000 feet. This sanctuary is rich in biodiversity. The coastal area comprises several habitat types - wide sandy beach, rocky inter-tidal zone, and mudflats which are important for the migratory and resident waterfowl, nesting site for the endangered marine turtles, host to several species of crabs, rocky shores act as vanguard against erosion of the coastline, etc. The coastal area is heavily exploited by the shrimp nurseries and fishermen. Recent Rohingya influx has virtually inflicted devastating impact on the forest biodiversity and coastal resources.

St. Martin’s Island located in the Bay of Bengal (BOB), at an aerial distance of 25 km from Teknaf Township and 12 km from southernmost mainland named Gola (Fig. 9.13). It is surrounded by boulders and corals. It is unique to harbor coral-associated ecosystem with more than a hundred coral species, several hundred coral fishes, mollusks, crabs and other coral-associated invertebrates.



The Island, which is 590 ha in area, has been declared an ECA in its entirety. It falls under the jurisdiction of St Martin's Island Union, Teknaf Upazilla. The site's northern section is known as Uttar Para, which is connected to the southern part of the Island by a narrow neck of land called Golachipa. The area directly south of Golachipa is termed Madhya Para, followed by Dakhin Para. The southernmost tip of the Island, Cheradia, is separated from Dakhin Para during high tide. The Island is accessible only by boat, from the town of Teknaf.

Lying in a north-south direction, the Island has a wider northern section and a narrower elongated southern section with a constriction between where the sand dunes of the western and eastern shores have almost joined. This narrow neck is gradually being eroded from both sides. Erosion from tides is also evident on the northern coast of Uttar Para where erosion of dunes up to 2 metres was reported in the late 1990s. The average altitude is 2.5 metres with a high point of six metres in Dakhin Para.

The site is particularly susceptible to cyclones. Cyclonic storms develop in the Bay, generally in April-May and October-November, occasionally coming to shore and causing severe damage to human settlements and vegetation. As a result of climate change, sea level rises of up to 43 cm are expected by 2050 and more frequent and extensive cyclones and tidal effects are expected (Alam, 2003). Historical tidal data for the 22 years to 2005 at the Cox's Bazaar coastal station has shown a sea level rise of 7.8 mm/annum, which is many times more than the mean rate of global sea level rises over the past 100 years (MoEF, 2005a). The effect of sea level rises may be reversed somewhat by uplifting; calculations from the presence of dead coral and microatolls in the intertidal zone suggest that the Island has uplifted 15 cm in the last 150 years and apparently continues to do so (Tomascik, 1997).

From Dakhin Para, an intertidal rocky reef extends about 1.8 km south, supporting three vegetated sand islands known locally as Cheradia. Cheradia is connected to the southern part of the Island during low tide by a narrow sand belt consisting of alluvial sands and littoral carbonates that has accumulated on top of the rocky intertidal reef. Almost the entire coastline of the Island is fringed by a rocky intertidal habitat consisting of small and large boulders, and varying between 100-500 m wide. Coral boulders are also present but are relatively rare. The presence of relatively well preserved dead coral colonies in the upper and middle intertidal zones suggests that the Island has been uplifted in relatively recent times. A coastal embankment has been constructed by piling loose boulders along a considerable length of the east and west coast.

The site's habitats/communities include sand dunes and beaches, a small mangrove patch, marine habitat including, among others, coral communities and a rocky intertidal zone, and lagoons/wetlands, rocky land and a small mudflat area.

Sand dunes and beaches: The main shoreline habitats are sandy beaches and dunes, with the main sediments being alluvial sands. Beaches and dunes on the southern part of the island have a higher carbonate content compared to the northern Uttar Para beaches. Most carbonates are molluscan shell fragments. The sandy beach in the north and north east stretches over 300-400 m into the sea. The western beach is sandy but the sub-tidal area consists of a bed of boulders. The island's sandy beaches are reputedly the best nesting sites in Bangladesh for globally threatened marine turtles (Rashid & Islam 1999).

Mangrove: The original mangrove formation at the site was considered quite different from any other mangrove in the country in that it was a pure *Lumnitzera racemosa* formation (GoB/GEF/UNDP, 1999). There is a very small remaining mangrove patch at the site nowadays consisting of *Sonneratia apetala*, *Acanthus ilicifolius*, *Avicennia marina* and *Hibiscus tiliceous*, among others.

Marine habitats: The shallow water marine habitats include rocky and sandy intertidal habitats, offshore lagoons, rocky sub-tidal habitats, coral aggregations, seagrass beds, soft coral habitats and offshore soft-bottom habitats. Due to the differences in exposure, benthic communities along the east and west coasts of

the island support different benthic communities. However the upper and middle intertidal habitats along both coasts generally support similar communities. A generalised zonation of east coast benthic communities along an inshore-to-offshore gradient starting from the lower intertidal is as follows: intertidal gastropod-algal community, coral-algal community, mixed seagrass-algal community, soft-coral community and soft-bottom (mud) community. The zonation on the west coast is as follows: gastropod-algal community, coral-algal community, algal community and soft-bottom community.

With the exception of the north eastern corner, the Island's entire intertidal zone is fringed with numerous boulders that extend from a few metres to a few hundred metres to the sub-tidal zone. These boulders of all shapes and sizes originate from the bedrock and provide a diverse microhabitat for numerous marine species sheltering from tidal influences. The upper portion of the rocky habitat is mostly dry during low tide and contains dead coral colonies. The lower intertidal area consists of diversified marine life, including coral, molluscs, echinoderms, reef fishes, barnacles, crabs, algae, etc. It also provides a huge number of rock pools of various sizes where small reef fish forage for the duration of the ebb tide. Depending on the tide, the intertidal zone rocky habitat covers 150-250 ha.

The rocky subtidal habitat from the seaward margin to about 1,000m offshore support a diverse coral community which can be classified as a veneering coral community. Of the 15 reef-building scleractinian coral families, 10 are present on the Island, represented by approximately 22 genera and 66 species. Of these, 39 have been identified as living corals and 14 as soft coral, growing up to a depth of 7 metres. Corals are found around most of the Island, but their abundance and cover is generally low. Small coral aggregations are also found in a number of small intertidal pools of the lower rocky intertidal zone. The coral community also supports associated fish and invertebrate fauna.

Sea grass meadows and algal flora associated with extensive coral reefs were discovered in 1997 by Tomascik and Paiker (MoEF, 2001a). The extensive algal and seagrass beds in the Island's coastal waters are highly productive and diverse and may be important spawning and/or nursery grounds for a number of economically important fish and shell fish species.

There are only a few examples worldwide where coral communities dominate rock reefs; St Martin's Island provides a unique set of environmental conditions (biotic and abiotic) not found elsewhere in Bangladesh and perhaps not in the world (Tomascik, 1997, in GoB/GEF/UNDP, 1999). The co-occurrence of corals, seagrasses and mangroves in the Island represents little known succession of corals in the tropical areas (Welch, 1962, and McCoy & Heck, 1976, in GoB/GEF/UNDP, 1999).

Lagoons/wetlands: Several lagoons/wetlands associated with mangrove and floodplain areas occur at the site, providing habitat for birds. There is a lagoon at Uttar Para, a freshwater wetland at Dakhin Para and sizeable floodplain areas scattered throughout the Island. A 40 ha internal lagoon lies at the south of the main island and within the three small islands comprising Cheradia.

Rocky land habitat: A small area of rocky land exists at Shil Buniya, south of Dakhin Para Morong (lake), and west of the Coast Guard base. The majority of the area is covered with giant boulders similar to that of the intertidal zone, with some lowland pools. The rocky land area covers about 100 ha and is the last remaining habitat for rare species such as the water monitor (*Varanus salvator*), Bengal cobra (*Naja kaouthia*), bush birds, water birds and garden lizards, and native herbs, shrubs and climbers. The rocky ground and shallow water pools provide an excellent terrestrial microhabitat, especially during winter.

Mudflat: There is a small mudflat area (Gaitta Buniya) located at the southern end of the western beach. It provides numerous food sources for shorebirds and a habitat for amphibious sea snakes and crabs.

One hundred and fifty one species of marine algae were identified from specimens collected under the NSCIP-1 in 1996, mainly from the Island's intertidal/littoral zone but some from the sublittoral zone and some as drifted forms.

The mangrove includes the following associated mangrove species: *Acanthus ilicifolius*, *Hibiscus tilliceous*, *Excoecaria agallocha*, *Avicennia marina* and *Clerodendrum inerme*. Salt-secreting mangrove, *Aegialitis rotundifolia*, an early coloniser, has disappeared from the Island. *Pandanus odoratissimus* and *Ipomea pescaprae*, in association with grasses *Panicum repens*, *Passpalum vaginatum* and sedges *Cyperus* spp. and *Fimbristylis* spp., constitute the vegetation of the sand dunes. *Streblus asper* and *Vitex trifoliata* are also found among the crevices formed by rocks, adjacent to a swamp supporting the young mangrove formation. A number of liverworts and mosses and one fern species (*Adiantum philippense*) have also been recorded at the Island.

Marine plant diversity is yet to be exhaustively explored in Bangladesh. Limited explorations have been done by far on the open sea waters. According to Volumes 3 and 4 of *Encyclopedia of Flora and Fauna of Bangladesh* (Ahmed 2008, 2009) there are 50 species of brown algae (Order: Laminariales, also known as kelp), 82 species of red algae (Class: Rhodophyceae), and 26 species of green algae (Class: Chlorophyceae). Almost all seaweed species are found on St. Martin's Island. In Bangladesh, five species have so far been reported from Bangladesh coast, namely *Halodule uninervis*, *Halophila beccarii*, *Halophila decipiens*, *Halophila pinifolia* and *Ruppia maritima* (Kamal and Short, 2009).

A total of 19 species of mammals were recorded from the Island during the NCSIP-1 survey, of which none of the land-based mammals are carnivorous. Among the cetaceans Finless Porpoise (*Neophocaena phocaenoides*), Common Dolphin (*Delphinus delphis*), Irrawaddy Dolphin (*Orcaella brevirostris*), spinner dolphins (*Stenella longirostris*), (*Stenella attenuata*) can be seen in the surrounding waters. Pest species include dogs, domestic cats and field rats (*Bandicota bengalensis*, *Mus musculus*, *Rattus norvegicus*, *Rattus rattus*).

The site lies on the East Australasian Flyway and Central Asian Flyway and provides a stepping stone for several globally threatened migratory waders. A total of 120 species of birds have been recorded from the Island (77 resident species and 43 migratory species) of which 18 species may be classified as locally threatened. Two species, the grey-headed lapwing (*Vanellus cinereus*) and Black-bellied Tern (*Sterna acuticauda*), are listed in the 2015 IUCN Red List of Threatened Species.

The Island supported a total of 27 reptile species, of which 11 are locally threatened. All five species of marine turtle known to occur in Bangladesh have been reported in the area including *Lepidochelys olivacea* (Olive Ridley Turtle), *Eretmochelys imbricate* (Hawksbill Turtle), *Chelonia mydas* (Green Turtle), *Dermochelys coriacea*, *Caretta caretta* (Loggerhead Turtle) and *Dermochelys coriaca* (Leatherback Turtle). Three species – the Olive Ridley, Hawksbill and Green turtles – are known to nest at the site (Rashid, 1986). Of these, the Olive Ridley and Green turtles are listed Endangered, and the Hawksbill as Critically Endangered. Other reptiles include, among others, monitors, five species of terrestrial snakes and six species of sea snakes, lizards and four species of freshwater turtle.

The Island supports four amphibian species, including a toad (*Duttaphrynus melanostictus*) and three frog species – Skipper Frog (*Euphlyctis cyanophylctis*), the Bull Frog (*Hoplobatrachus tigerinus*) and Tree Frog (*Polypedates maculatus*).

A total of 234 species of fish have been identified from the site, 89 of which are coral-associated fish species and only 16 of which are freshwater fish. Though coral reefs have not developed, the coral community supports fish fauna characteristic of coral reef environments. The most abundant coral or reef-associated herbivores are the Pomacentridae (damsel fish), Scaridae (parrot fish) and Acanthuridae (surgeon fish). Important coral or reef-associated predators are Serranidae (groupers), Lutjanidae (snappers) and Lethrinidae

(emperors). Five species of the common butterfly fish (Chaetodontidae) were recorded on the Island, as was one species of angel fish (Pomocanthidae). Croakers (Sciaenidae) are also present.

Of the 68 species of living corals identified from the Island, the *Porites*, *Favites*, *Goniopora*, *Cyphastrea* and *Goniastrea* genera are the most abundant. The soft corals include *Sinularia* sp., *Lobophyton* sp., *Anthelia*, *Dendronephthya*, *Palythoa*, *Nemanthus*, *Telemectius* and *Discsorna* sp. The taxonomy of a good portion of corals occurring around the island remains unknown. A total of 187 species of molluscs have been recorded at the Island. Of these, 44 species are gastropods and the rest are bivalves. Some important gastropods are abundant, e.g. *Conus striatus*, *Conus textile* and *Conus geographes*, and two economically important gastropods that are heavily depleted worldwide - *Trochus niloticus* and *Turbo marmoratus* - are also present at the Island. Four species of sea urchin, one species of sea star, a number of brittle stars and one species of sea cucumber have been recorded. A number of colourful nudibranchs have been recorded in the shallow subtidal rocky reefs. Seven species of crabs and six species of butterflies have been recorded from the Island.

9.5 Climate Change Impact on Coastal Biodiversity

Impacts on coastal systems are among the most costly and most certain consequences of climate change (Fig. 9.14). As temperature increases and rainfall patterns change, soil moisture and runoff to the coast are likely to be altered. As sea level rises, coastal shorelines will retreat, enhance erosion and land loss, and low-lying areas will be inundated more frequently, if not permanently, by the advancing sea. The salinity of estuaries, coastal wetlands, and tidal rivers will increase, thereby restructuring coastal ecosystems and displacing them further inland. Tropical cyclones will increase in intensity and frequency, as projected by many studies, shoreline retreat and wetland loss along the low-lying coastal margins will accelerate further (Burkett et al. 2008).

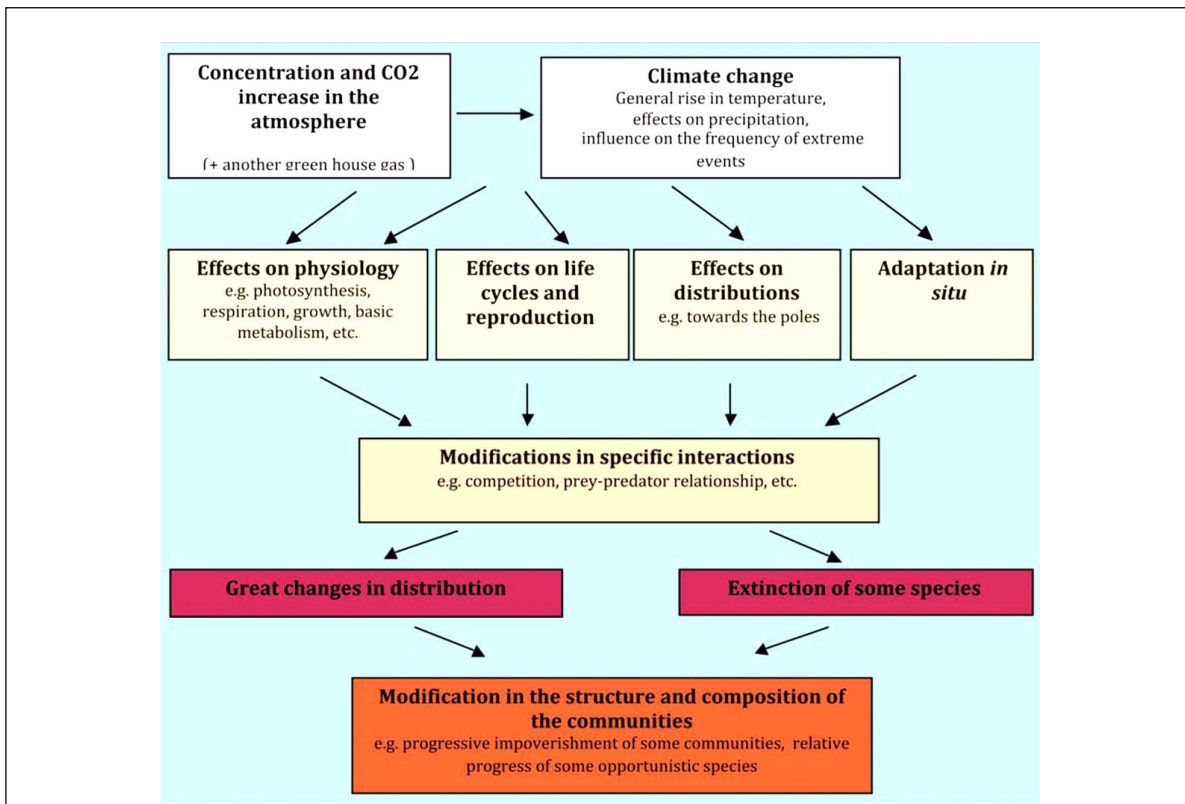


Fig. 9.14. Impact of climate change on biodiversity (according to Hughes (2000), TREE). Source: UNEP-MAP-RAC/SPA, 2010.

Climate change increases challenges by the abundance, distribution, recruitment, and migration of various aquatic species including invertebrates, fish, sea turtles, and cetacean species. Currently, attention to environmental sustainability and climate change impacts in the biodiversity sector is limited and has not been translated into practical adaptation and livelihood transformation solutions. Yet, climate change can adversely impact the productivity of marine and coastal biodiversity including fisheries, affecting future catch levels and rates of recovery for fisheries, due to shifts in the availability of food, habitat, and appropriate ocean conditions for fish stocks.

The broad categories of climate change impacts which will affect the coastal areas of Bangladesh are changes in temperature and rainfall patterns, sea-level rise, change in frequency and intensity of cyclones, storm surge, changes in river and soil salinity.

Moreover, salinity affects land and water in the coastal areas. With the consequence of climate change, it gradually extends towards inland water and soil. This scenario of gradual salinity intrusion into the coastal areas of Bangladesh is very threatening to the primary production system, coastal biodiversity and human health. The total amount of salinity affected land in Bangladesh was 83.3 million hectares in 1973, which increased up to 102 million hectares in 2000 and the amount has risen to 105.6 million hectares in 2009 and continues to increase (Soil Resources Development Institute, SRDI). In the last 35 years, salinity increased around 26 percent in the country, spreading into non-coastal areas as well.

Changes in river salinity and the availability of freshwater will affect the productivity of fisheries. It will adversely affect the wild habitats of freshwater fish and giant prawn. In addition, the salinity increase may induce a shift in the Sundarbans mangrove forest from Sundari (the single most dominant and important species, with the highest market value) to Gewa and Goran.

Due to the rise in soil salinity, Chittagong and Khulna districts are likely to witness the highest within-district additional migration, estimated between 15,000 and 30,000 migrants per year ("Coastal Climate Change, Soil Salinity, and Human Migration in Bangladesh", International Food Policy Research Institute (IFPRI) and the Ohio State University. 2018).

Societies throughout the whole world have always tried to adapt and to reduce their vulnerability to the consequences of weather and climate phenomena such as flooding, droughts or storms. Additional adaptation measures will however be necessary on a regional and local scale to reduce the nefarious effects of the anticipated evolution and variability of the climate in addition to the ample mitigation measures which will be set up in the next twenty or thirty years (IPCC report, 2007). Adaptation on its own will surely not be enough to offset all the anticipated effects of climate change, especially in the long term as there is a clear trend that most of the repercussions are being amplified. There are numerous adaptation possibilities, but it is vital for the action already engaged in to be intensified if vulnerability is to be attenuated in view of the climate change taking place. There are obstacles, limits and costs involved which are not always truly grasped.

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