Wetlands: Biodiversity and Livelihood Values and Significance with Special Context to Bangladesh

17

A.K. Yousuf Haroon and Golam Kibria

Abstract

Wetlands provide various ecosystem goods and services to humans. Rice, the staple food of about 50% of global population and consumed at the rate of one-fifth of the total global calorie count, is grown in wetland systems. The total area of wetlands in Bangladesh is about 7–8 million ha, which constitutes about 50% of the land surface of the country. Wetlands of Bangladesh encompass *haors* (freshwater marshes of bowl or saucer-shaped shallow depression), *baors* (oxbow lakes – dead arms of a river), *beels* (saucer-shaped deeper part of the floodplain landscape), fishponds and *dighi* (large ponds), flooded rice lands and floodplains, natural lakes, man-made reservoirs (Kaptai Lake), and coastal (Sundarbans) and marine (St. Martin's Coral Island) areas. Wetlands are rich in flora and fauna (300 plant species, 400 vertebrate species, and 260 freshwater fish species are dependent on wetlands of Bangladesh). Some wetlands of Bangladesh are of national and international significance such as Tanguar *haor* (Ramsar and an Ecologically Critical Area), Hakaluki *haor* (Ecologically Critical Area), Sundarbans (Ramsar and UNESCO World Heritage Site and Ecologically Critical Area), and St. Martin's Coral Island (Ecologically Critical Area). About two-thirds of people in Bangladesh depend on wetlands for a variety of purposes including water (drinking, irrigation), food production (agriculture, aquaculture), fishing, livestock grazing, bird hunting, fire-/fuelwoods, medicinal plants, wild food, honey, waterway transportation, harvesting grasses and seaweeds, and tourism/recreational business. Some poorest of the poor in the vicinity depend

A.K. Yousuf Haroon (✉)
Food and Agriculture Organization (FAO) of the UN, Dhaka, Bangladesh
e-mail: dharoon@ymail.com; akyousuf.haroon@fao.org

G. Kibria
School of Applied Sciences, Royal Melbourne Institute of Technology (RMIT) University, Melbourne, Australia
e-mail: kibriagolam0@gmail.com

B.A.K. Prusty et al. (eds.), *Wetland Science*,
DOI 10.1007/978-81-322-3715-0_17

totally on the goods and services of the wetland for livelihood. Apart from biodiversity and livelihood support, wetlands have additional significances as a source and sink for greenhouse gases and in mitigation of disasters in Bangladesh. Livelihood diversification, awareness, and education of local communities on preservation and conservation of wetlands would be needed to reduce pressure on wetland resources.

Keywords
Bangladesh • Biodiversity • Ecosystem goods and services • Wetlands

17.1 Introduction

The Ramsar classification of wetland types include 42 types of wetlands, which belong to one of the three broad categories: inland wetlands (e.g., rivers, lakes, creeks), marine/coastal wetlands (e.g., shallow marine waters, estuaries, coral reefs), and human-made wetlands (aquaculture ponds and permanently or temporarily inundated agricultural lands such as rice paddies, salt pans, reservoirs, gravel pits, sewage farms, and canals). There is also a range of other wetland classifications used for different purposes, based on hydro-geomorphology and/or vegetation characteristics, such as:

- Marine (coastal wetlands, including coastal lagoons, rocky shores, and coral reefs)
- Estuarine (including deltas, tidal marshes, and mangrove swamps)
- Lacustrine (wetlands associated with lakes)
- Riverine (rivers and wetlands along rivers and streams)
- Palustrine (marshes, swamps, and bogs)

17.1.1 Importance and Role of Wetlands

Rice, the staple food of about 50% of global population and consumed at the rate of one-fifth of the total global calorie intake, is grown in wetlands. Wetlands, among the most productive and biodiversity-rich areas, filter pollutants and sequester carbon, whereas rivers transport water and nutrients from the catchment downstream. Lakes serve as sediment and carbon sinks (Fischlin et al. 2007). In addition, food (fish and aquatic plants), medicine, and building materials are available from wetlands because of the rich living aquatic resources. Living aquatic resources, as common property natural resources (Nishat 1993), from wetlands play an essential role in people's livelihood in rural areas in many parts of the world including Bangladesh. The most significant of these are fishes, prawns, crabs, molluscs, and clams that have all or part of their life cycle within a wetland system. Fresh and saltwater fishes are the main source of protein for about 3 billion people globally (at least 20% of

their animal protein intake) and an important source of essential vitamins and omega-3-polyunsaturated fatty acids (Kibria et al. 2010). In addition, fish generates a fishing industry that provides 80% of income and employment in developing countries. In countries like Bangladesh, Myanmar, Thailand, Cambodia, and Vietnam, where rice paddies are predominant, rice consumption reaches up to 70%. From wetlands such as mangroves, fuelwood, salt (produced by evaporating seawater), animal fodder, traditional medicines (e.g., from mangrove bark), fibers for textiles, and dyes and tannins are extensively sourced. Various studies also reveal that such wetlands have tremendous potentials for integrated concurrent rice-fish culture and fish nursery operations (Haroon et al. 1992; Haroon and Pittman 1997).

Production cycles in wetlands are closely linked with seasonal changes in temperature and precipitation and therefore are affected by seasonal climate variability or long-term climate changes. Climate change will have significant impacts on wetland ecology, biodiversity, and livelihoods of people connected with it. Wetlands in a natural state are crucial for humans mainly because of their capacity for storing large quantities of freshwater, mitigating the impact of floods and droughts for a whole area and for their enormous biological productivity that can be harvested in the forms of fish, wood, reed, etc. Some wetland types like peat swamps are inaccessible and unproductive. Wetlands, in general, provide the following ecosystem goods and services.

Goods: wetland nonfood products, freshwater, food for humans, genetic materials, biomass production, biodiversity, support for food chains, storage of floodwater, and production of logs, fuelwoods, peat, fodder, etc.

Cultural services: recreation and tourism, natural heritage values, scientific and educational, and spiritual and inspirational

Regulating services: groundwater recharge, shoreline stabilization and reduction of erosion, sediment trapping, nutrient retention/removal, habitat for wildlife, hazard reduction (flood control, storm protection), maintenance of hydrological regimes, water transport, pollution control and detoxification, microclimate stabilization (IWRB 1992), climate regulation, and carbon source and sinks

17.2 Wetlands of Bangladesh

Wetlands of Bangladesh encompass a wide variety of dynamic ecosystems, *viz*., mangrove forest (about 577,100 ha), natural lakes, man-made reservoir (Kaptai Lake), freshwater marshes, estuaries, and seasonal inundated floodplains and paddy fields. The freshwater marshes include 114,161 ha of saucer-shaped natural depressions locally called as *beels*/*haors*, about 5,488 ha of oxbow lakes locally called as *baors*, and 371,309 ha of fishponds and *dighi* (large ponds). The total area of wetlands, both inland freshwater and tidal saltwater wetlands, in Bangladesh, comes to about 50% of the land surface of the country (Table 17.1 and Fig. 17.1). Considering the major rivers (700 rivers), their tributaries and streams, the major wetlands in Bangladesh constitute the fluvial or floodplains, *viz*., Sundarbans mangroves

Table 17.1 Wetlands of Bangladesh based on their land types as well as hydrological and ecological functions

Wetlands	Types	Characteristics
Saltwater	Marine	Shallow waters at low tide, e.g., bay, coral reefs like St. Martin's Island
	Estuarine	Intertidal sand, mud or salt basins with specific vegetation, like newly accreted intertidal land, marshes, forests, and mangroves, e.g., the Sundarbans
	Lagoonal	Brackish to saline lagoons with narrow connection with the sea
Freshwater	Riverine	Rivers and streams with their tributaries including the *Chars*
	Lacustrine	Lakes, *beels*, or *jheels* of different sizes and shapes distributed all over the country, especially in the districts of Noakhali, Comilla, Brahmanbaria, Sylhet, Faridpur, Pabna, Rajshahi, Jessore, and Khulna
	Palustrine	Marshes and swamps with emergent vegetation or swamp forest of *Barringtonia acutangula* (Hijal), *Pongamia pinnata* (Koroch), *Crataeva nurvala* (Barun), *Trewia nudiflora* (Gotagamar), and *Salix tetrasperma* (Indian willow, Panijam). Associated with these at the edges of the water bodies are thick spiny bushes of wild rose, *Rosa clinophylla* (Jongli golap), and scrub - *Lippia javanica* (fever bush/lemon bush); *Ficus heterophylla* (Ludi sarbua in Chakma); and *Phyllanthus disticha* in the hoars of northeast region
Man-made		Aquaculture ponds (brackish and freshwater), irrigated lands and irrigation channels, saltpans or hydro-dam, e.g., the Kaptai Lake in Rangamati, brackish water shrimp farms (*ghers*) in the southwest coastal area (Satkhira)

(140,000 ha), Kaptai Lake (68,800 ha), Chalan *beel* (36,800 ha), Hakaluki *haor* (20,400 ha), Chakaria mangroves (20,000 ha), the Naaf river estuary (16,000 ha), Arial beel (14,400 ha), Hail *haor* (3,643 ha), Tanguar *haor* (2,802 ha), St. Martin's Coral Island and reef (800 ha), Kawadighi *haor* (414 ha), Dekhar *haor* (325 ha), Erail *beel* (320 ha), Dubriar *beel/haor* (150 ha), Meda *beel* (122 ha), Aila *beel* (106 ha), Ramsagar *dighi* (102 ha), Atadanga *haor* (102 ha), Kuri *beel* (73 ha), Bogakine Lake (60 ha), Baikka *beel*, Gopalganj-Khulna *beel*, *Beel* bhatia, Atrai basin, lower Punarbhaba floodplains, and Surma-Kushiara floodplains (Islam 2010). These wetlands form a unique mosaic of habitats, extremely rich in biodiversity. Wetlands are critically important in Bangladesh for water resources (rivers, *haors*), human settlements, biodiversity, agriculture/land resources, navigation and communication, and ecotourism. These wetlands have a wide range of ecological, sociocultural, economic, and commercial importance and values in Bangladesh.

17.2.1 Inland Freshwater Wetlands

Floodplains, *beels* (low-lying depressions in the floodplain), *haors*, and *baors* (oxbow lakes) represent the inland freshwater wetlands. Some important wetlands

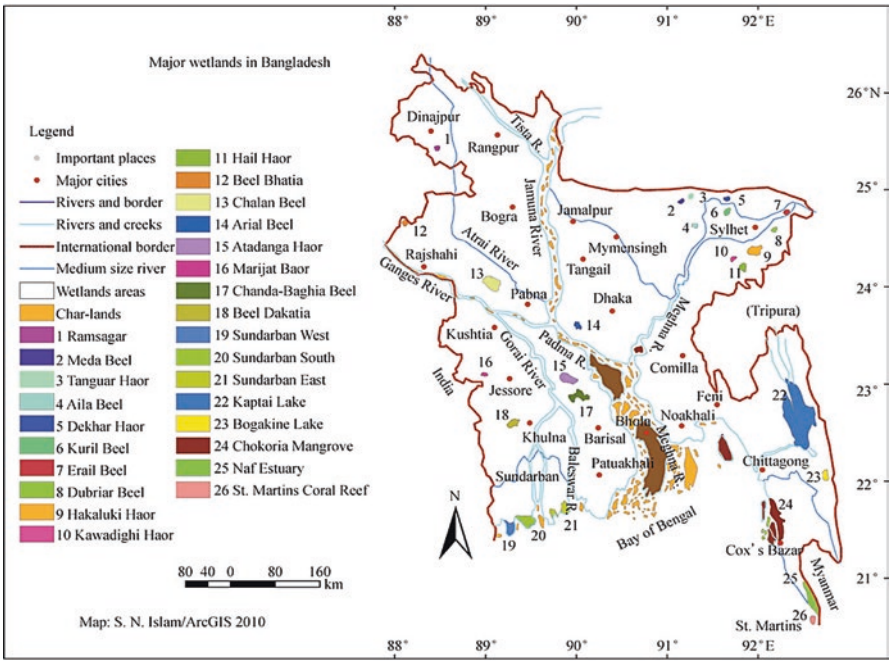

Fig. 17.1 The major wetlands in Bangladesh (Islam 2010); the Ecologically Critical Areas (ECAs)/Ramsar wetlands are *3*, Tanguar haor (Ramsar); *9*, Hakaluki haor (ECA); *19–21*, Sundarbans (west, south, and east (Ramsar and UNESCO World Heritage Site)); and *26*, St. Martin's Coral Island (ECA)

of the country are Chalan *beel*, lower Atrai basin, lower Punarbhaba floodplain, Gopalganj-Khulna *beels*, Arial *beel*, Akhaura terrace, Tanguar *haor*, and Hakaluki *haor* (Fig. 17.1) and Baikka *beel* of Surma-Kushiyara floodplain. Due to overexploitation of its natural resources and considering its critical conditions, the Government of Bangladesh declared Tanguar *haor* as an Ecologically Critical Area (ECA) in 1999. In 2000, the Tanguar *haor* was declared a Ramsar site of international importance. Hakaluki *haor*, with an area of 181.15 km^2, is one of the large marsh wetland systems of northeastern Bangladesh. It is spread over Barolekha, Kulaura, and Juri Upazila (subdistrict) of Moulvibazar district and Golapganj, Fenchuganj Upazila of Sylhet district. Ramsagar dighi (102 ha) is a man-made lake situated about 8 km south of the Dinajpur town. It was created by Raja Ram Nath in the mid-1750s. The lake is about 1,079 m wide from north to south and 192.6 m long from east to west. The Kaptai Lake (68,800 ha) is a man-made lake that was formed due to the Kaptai dam for hydroelectricity generation in the late 1960s in Rangamati, Chittagong.

Haors The *haors* are bowl-shaped natural depressions comprising of many individual *beels* formed during the monsoon, while the *beels* are low-lying depressions of the *haor* system retaining water even during the dry months of the year. The *haor*

Table 17.2 Major *haors* of Bangladesh

Basins/systems	Major *haors*
Eastern and lower Mymensingh basin	Baram *haor*, Banka *haor*, Habibpur *haor*, Maker *haor*, Makalkandi *haor*, Ghulduba *haor*
Foot of Meghalaya hills (Sylhet)	Tanguar *haor*, Shanir *haor*, Matian *haor*
East of the Tanguar haor system (Sylhet)	Dekhar *haor*, Pathar Chanli *haor*, Jhilkar *haor*, Jhinkar *haor*
Eastern rim of the basin	Jamaikata *haor*, Mahai *haor*, Nalua haor, Parua *haor*
Central Sylhet lowlands	Hakaluki *haor*, Chatal Bar *haor*, Haila *haor*, Kawadighi *haor*, Paglar *haor*
Southeastern hill ranges	Hail *haor*
South of the basin	Dingapota *haor*, Ganesher *haor*, Tolar *haor*, Anganer *haor*, Bara *haor*, Humaipur *haor*
Kishorganj district	Etna *haor*, Sania *haor*
Eastern Mymensingh	Khaliajuri *haor*
Southeast Mymensingh	Oail *haor*
Uncategorized	Dubriar *haor*, Chayer *haor*, Kangaler *haor*, Maijeil *haor*, Damrir *haor*, Panger *haor*, Kanamaiya *haor*, Ubdakhali *haor*, Balai *haor*, Bara *haor*, Gurmar *haor*

system is a complex of both lacustrine (lake) and palustrine (marsh) wetlands depending on the hydraulic behavior in different seasons. There are altogether 411 *haors* spread over 8,000 km^2 in the districts of Sunamganj, Sylhet, Moulvibazar, Habiganj, Netrokona, and Kishoreganj (Table 17.2 and Fig. 17.1). To protect the crops in the *haor* areas, the erstwhile landlords with the participation of the locals constructed dwarf dykes and appurtenant structures for early flood protection and irrigation. Since 1966, Bangladesh Water Development Board (BWDB), adopting " a better technology, has executed 46 Flood Control Drainage and Irrigation (FCDI) projects in the Sunamganj, Sylhet, Moulvibazar, Habiganj, Netrokona, and Kishoreganj districts. A total of about 0.29 million ha cultivable land has been made free from flash floods by implementing about 2,000 km submersible embankment and ancillary structures *[note: the main objectives of the FCDI are (a) to protect from crop losses, loss of life, and property damage due to floods and (b) to improve the physical environment to allow farmers to adopt improved agricultural practices and greater security for crop production].*

Oxbows Oxbow lakes are loops of meanders cut-off at times from rivers and gradually plugged with sediment. Locally, these are also known as *baor*, *jheel*, and commonly as *jalmohal*. Oxbows are quite common in Jessore, Faridpur, and Kushtia districts. Oxbows support a large variety of aquatic flora and fauna. During the monsoon season, oxbow lakes act as local water reservoirs and help to control the local flood level. In some areas, these lakes serve as valuable sources of irrigation during the dry season.

Fig. 17.2 A flooded haor wetland – during the lean season, most of the area of a haor may be dry (Photo courtesy: Md. Wahiduzzaman Sarker)

Floodplains Floodplain areas are the most hazard-prone areas of Bangladesh (Fig. 17.2). Elevation of the tidal floodplains from sea level is less than 1–3 m on the main rivers and estuarine floodplains. The floodplains of Bangladesh can be divided into four main regions: (i) the northwest region (in Dinajpur, Rangpur, Bogra, Rajshahi, and Pabna) between the Ganges and the Brahmaputra; (ii) the central region in Tangail, Dhaka, Comilla, and Noakhali, east of the Brahmaputra, Padma, and Lower Meghna; (iii) the main delta west of the Ganges-Padma and south to the coastal zone, in Kushtia, Jessore, Faridpur, Khulna, Barisal, and Patuakhali; and (iv) the northeast wetland regions of Sylhet, Sunamganj, Kishoreganj, Netrokona, and parts of Mymensingh.

Ponds, Dighis The man-made wetlands including ponds, *dighis* (about 147,000 ha), and lakes are distributed all over the country. These are predominantly used for bathing, washing, livestock, and fish culture and in some cases for drinking water.

17.2.1.1 Biodiversity of Inland Wetlands

The flora and fauna reported from the wetlands in Bangladesh are presented in Table 17.3a–f.

Vegetation Among the estimated 5,000 species of flowering plants and 1,500 of vertebrates of the country, up to 300 plant species and 400 vertebrate species are dependent on wetlands for all or part of their life. Flora of inland wetlands varies from place to place; but the major species are *Barringtonia acutangula, Pongamia pinnata, Rosa clinophylla, Eichhornia crassipes, Utricularia* spp., *Hydrilla verticillata, Myriophyllum spicatum, Ceratophyllum demersum, Elodea* sp., *Potamogeton* sp., *Ipomea aquatica*, *Colocasia esculenta, Monochoria vaginalis, Sagittaria sagittifolia, Cyperus papyrus, Typha* sp., *Scirpus* sp., *Salvinia* sp., *Pistia stratiotes, Lemna minor, Wolffia arrhiza, Azolla pinnata, Spirodela polyrhiza, Nymphaea nouchali* and

Table 17.3 Selected flora and fauna from the wetlands of Bangladesh

Common name – *scientific name*	Common name – *scientific name*
(A). Plants[a]	
After Islam (2010) and Islam and Kitazawa (2013)	
Amur (Pacific Maple) – *Aglaia cucullata* (NT)	**Keora** (Sonneratia mangrove) – *Sonneratia apetala* (LC); *S. caseolaris* (LC); *S. griffithii* (CR)
Arrow arum – *Peltandra virginica*	**Keya**/kewda (Thatch screw pine) – *Pandanus odoratissimus*
Baen/bain – *Avicennia officinalis* (LC)	**Khulshi** – *Aegiceras corniculatum* (LC)
Bhat, *Clerodendrum inerme*; bhat/ghetu, *C. viscosum*	**Koroch** (Indian beech) – *Millettia pinnata*/ *Pongamia pinnata* (LC)
Bhola – *Hibiscus tiliaceus*	**Kulekhana** – *Hygrophila auriculata* (LC)
Bijtarak – *Argyreia nervosa*	**Lotus** and water lilies, *Nymphaea* spp., *Nymphoides* spp.; **Indian lotus**/sacred lotus, *Nelumbo nucifera* (NE)
Boroi (Indian plum) – *Ziziphus mauritiana*; *Z. jujuba*	**Makhna**/makna (gorgon, prickly water lily) – *Euryale ferox* (LC)
Budding – *Clerodendrum viscosum*	**Maloncha** – *Alternanthera philoxeroides*
Casia – *Cassia tora*	**Narichha** – *Cynodon* spp.
Cattail – *Typha* spp.	**Neel nishinda** – *Vitex trifolia*
Chagal-kuri – *Ipomoea pes-caprae*; *Ipomoea* spp.	**Nal khagra/reed** – *Phragmites karka* (LC)
Dhoincha – *Sesbania* spp.	**Padma**, *Nelumbo nucifera* (VU)
Duckweed, *Lemna* spp.; common duckweed, *L. minor* (LC); rootless duckweed, *Wolffia arrhiza* (LC)	**Palms**, *Poresia coaractata*; grass, *Myriostachya wightiana*
Dumur – *Ficus hispida* (EN)	**Pan seuli** – *Phyllanthus reticulatus*
Durba ghash, *Cynodon dactylon*; Millet rampant, *Panicum repens* (LC)	**Pani fal** – *Trapa bispinosa*; *T. maxitnowizii*
Falashi paddy – *Oryza minuta*	**Passur** – *Xylocarpus granatum* (LC); *X. mekongensis*; *X. moluccensis* (LC)
Garzan – *Rhizophora apiculata* (LC)	**Ram karola** (duck lettuce) – *Ottelia alismoides* (LC)
	Shatamull, *Asparagus racemosus*
Gewa – *Excoecaria agallocha* (LC)	**Shrub** – *Lippia javanica*, *Ficus heterophylla*, and *Phyllanthus disticha*
Ghechu – *Aponogeton* spp.	**Sheora/shaora** – *Streblus asper*
Goal pata (Nypa/mangrove palm) – *Nypa fruticans* (LC)	**Sedges** – *Cyperus* spp., *Fimbristylis* spp.
Goda – *Vitex pubescens*	**Shapla** (national flower of Bangladesh) (blue lotus/ blue star water lily) – *Nymphaea nouchali*/*N. stellata* (LC)
Goicha (kodo millet), *Paspalum scrobiculatum* (LC); seashore paspalum, *P. vaginatum* (LC)	**Shetodron/thumbai** – *Leucas aspera*
Goran, *Ceriops decandra* (NT); Indian/ spurred mangrove, *Ceriops tagal* (LC)	**Spear grass** – *Imperata cylindrica*

(continued)

Table 17.3 (continued)

Common name – *scientific name*	Common name – *scientific name*
Gorjan (red mangrove/Asiatic mangrove) – *Rhizophora mucronata* (LC)	**Singara** (water chestnut/water caltrop) – *Trapa bispinosa*
Hantal palm (mangrove date palm) – *Phoenix paludosa* (NT)	**Sundari** – *Heritiera fomes* (EN)
Helencha (buffalo spinach/marsh herb) – *Enhydra fluctuans* (EN)	**Tamal/ebony** – *Diospyros cordifolia*
Hijol (Indian oak/*Barringtonia*) – *Barringtonia acutangula*	**Water fern/**mosquito fern – *Azolla pinnata* (LC)
Hogla (elephant grass/Indian reed mace) – *Typha elephantina* (LC)	**Water hyacinth** – *Eichhornia crassipes*
Jhau – *Casuarina equisetifolia*	**Wild rice** – *Oryza sativa* var. *fatua*; *O. coarctata* (*Porteresia coarctata*) and *O. minuta*
Jhora dhan – *Oryza rufipogon*	**Wild rose** – *Rosa clinophylla*
Kankra (oriental mangrove) – *Bruguiera gymnorrhiza* (LC); *B. conjugata*	
(B). Fish/prawn/shrimp[b,c]	
After Siddiqui et al. (2007a) and Islam et al. (2015)	
Aeir/bagha aeir (Gangetic goonch), *Bagarius bagarius* (EN); Aeir, *Aorichthys/Sperata aor* (LC); *A. seenghala* (LC)	**Kaikka** – *Xenentodon cancila* (LC)
Angrot – *Labeo angra* (LC)	**Kalabata** (Gangetic latia) – *Crossocheilus latius* (LC)
Anju (**zebra fish**) – *Danio rerio* (LC)	**Kajoli** (Gangetic ailia), *Ailia coilia*; Kajuli/baspata (Jamuna ailia), *A. punctata* (VU)
Ayre/aor (long whiskered catfish) – *Mystus/Sperata aor* (LC)	**Kalibaush** (black labeo) – *Labeo calbasu* (LC)
Bacha (Batchwa bacha) – *Eutropiichthys vacha* (LC)	**Kash khirra/**laubuca (Indian glass barb) – *Chela laubuca* (EN)
Baim/eel: Guchi baim (Indian striped spiny eel), *Macrognathus pancalus* (LC); tara baim (lesser spiny eel), *M. aculeatus* (NE/LC); baim (lesser spiny eel), *Mastacembelus armatus* (LC); Banehara (Indian mottled eel), *Anguilla bengalensis* (NT)	**Khalisha** Baro khalisa (striped gourami), *Colisa fasciata*; Lal khalisha (dwarf gourami), *C. lalia*; Choto khalisha, *C. chuna* (NT)
Bata: (mirror carp/boga labeo/bata labeo), *Labeo bata* (LC); Bata/Tatkani (Reba carp), *Cirrhinus reba* (LC); Bhangan, *Labeo boga* (LC)	**Khorsula** – *Rhinomugil corsula* (LC)
Batashi (Indian potasi) – *Pseudeutropius atherinoides/Neotropius atherinoides* (LC)	**Koi** (climbing perch) – *Anabas testudineus*
Behtki (barramundi, giant perch, Asian sea bass) – *Lates calcarifer* (NT)	**Kuchia** (Gangetic mud eel) – *Monopterus cuchia* (LC)

(continued)

Table 17.3 (continued)

Common name – *scientific name*	Common name – *scientific name*
Bele/baila (bar-eyed goby) – *Glossogobius giuris* (LC)	**Koksa/Khaksa/Joia/Baril** (Hamilton's barila), *Barilius bendelisis* (LC); Koksa (Vagra baril), *B. vagra* (EN)
Bheda/meni (mud perch) – *Nandus nandus* (LC)	**Kumirer khil** (Deocata pipefish) – *Microphis deocata* (NT)
Bhol/bol (Indian trout) – *Barilius bola* (EN)	**Lakha** – *Polynemus indicus*
Bistara/chitra (spotted scat) – *Scatophagus argus* (LC)	**Loytta** (Bombay duck) – *Harpadon nehereus*
Boal (freshwater shark) – *Wallago attu* (NT)	**Magur** (walking catfish), *Clarias batrachus* (LC); **Gang magur** (canine catfish eel), *Plotosus canius* (VU)
Bou/bou rani (Bengal loach) – *Botia dario* (EN)	Meni/bheda (mud perch) – *Nandus nandus* (LC)
Bujuri – *Mystus tengara* (NT)	
Catla (Gangetic major carp) – *Catla catla* (LC)	**Mahashoal/mahseer** (tor mahseer) – *Tor tor* (NT) – *T. putitora* (EN)
Cheka (squarehead catfish) – *Chaca chaca* (EN)	**Mola** (Carplet) – *Amblypharyngodon mola* (LC)
Chanda (Ranga Chanda) (Indian glass fish), *Parambassis ranga* (LC); Lamba/nama chanda (elongated glass perchlet) – *Chanda nama* (LC); Choto Chanda/Lal Chanda (highfin glassy perchlet) – *Parambassis lala* (NT)	**Mrigal** (Gangetic major carp) – *Cirrhinus cirrhosus*/*Cirrhinus mrigala* (VU)
Chang/cheng: Cheng/telo taki/raga (Asiatic snakehead), *Channa orientalis* (VU); Chang, *C. gachua* (LC)	**Pabda:** Kani pabda (Indian butter catfish), *Ompok bimaculatus* (NT); Madhu pabda (Butter catfish), *O. pabda* (NT); Pabda (Pabda catfish), *O. pabo* (NT)
Chapila (Indian river shad) – *Gudusia chapra* (LC)	**Mullet**/flathead mullet – *Mugil cephalus* (LC)
Chela/flkchela (finescale razorbelly minnow) – *Chela phulo/Salmophasia phulo* (LC)	**Nandi**l (Nandi labeo) – *Labeo nandina* (NT)
Chep chela/laubucha (Indian glass barb) – *Chela laubuca* (EN)	**Napit**/kio bandi (Badis) – *Badis badis* (LC)
Chiring/chewa bele (mudskipper) – *Apocryptes bato* (NE)	**Neftani** (Frail gourami) – *Ctenops nobilis* (EN)
Chital (clown knifefish) (humped featherback) – *Chitala chitala* (NT)	**Pangus** – *Pangasius pangasius* (LC)
Crab/mud crab – *Scylla serrata*/*Scylla olivacea* (NE)	**Potka** (ocellated puffer fish) – *Tetraodon cutcutia* (LC); *Tetraodon fluviatilis* (LC)
Cuchia (Gangetic mud eel) – *Monopterus cuchia* (EN)	**Golda chingri** (giant freshwater prawn) – *Macrobrachium rosenbergii* (LC)

(continued)

Table 17.3 (continued)

Common name – *scientific name*	Common name – *scientific name*
Darkina (flying barb), *Esomus danricus* (DD); darkina/leuzza darkina (Gangetic scissortail rasbora), *Rasbora rasbora* (EN)	Neftani – *Ctenops nobilis* (NT)
Datina – *Pomadasys hasta* (LC)	**Prawns**/minor freshwater prawns: Chotka icha (monsoon river prawn), *Macrobrachium malcolmsonii* (LC); Dimua icha, *M. villosimanus* (LC); Pata chingri, *M. rude*; Gura icha/chingri (Kuncho river prawn), *M. lamarrei* (LC); Gara icha, *Palemon styleferus*
Dhela (Cotio) – *Osteobrama cotio* (EN)	**Puti/punti:** Shar punti (Olive barb), *Puntius sarana* (CR/EN); Tit punti/two-spot barb (ticto barb), *P. ticto* (VU); Teri punti (one-spot barb), *P. terio* (LC); Bhadi punti/Jat punti (spot fin swamp barb), *P. sophore* (LC)
Ek thota (wrestling halfbeak) – *Dermogenys pussilus* (EN)	**Rani:** Bou/bou rani (Bengal loach), Botia dario (EN); Rani/putul/beti (Y-loach), *B. lohachata* (EN)
Ekthute (Congaturi halfbeak) – *Hyporhamphus limbatus* (LC)	**Rita** (Rita) – *Rita rita* (LC)
Foli/chital (bronze featherback) – *Notopterus notopterus* (VU)	**Rui/Rohu** (Gangetic major carp) – *Labeo rohita* (LC)
Gagla (Menoda catfish) – *Hemibagrus menoda* (LC)	**Rup Chanda** – *Stromateus/Pampus chinensis*
Gharua/ghaura (Gharua bacha) – *Clupisoma garua* (LC)	**Sephatia/along** (Bengal barb) – *Bengala elanga* (EN)
Ghora muikha/longu (Pangusia labeo) – *Labeo pangusia* (NT)	**Shilong** (Silond catfish) – *Silonia silondia (*LC)
Glass fish/chanda – *Ambassis ranga/Pseudambassis ranga* (LC), *A. nama*	**Shing/singhi** (stinging catfish) – *Heteropneustes fossilis* (LC)
Goni/gonya (Kuria labeo) – *Labeo gonius* (EN)	**Shoal** (snakehead murrel), *Channa striata* (LC); Pipla shol/tila shol (Barca snakehead), *C. barca* (EN)
Goza/gazar (giant snakehead) – *Channa marulius* (EN)	**Shrimps**: Bagda chingri (tiger shrimps), *Penaeus monodon* (NE); Chapda/sada chingri (Indian white prawn), *Penaeus/Fenneropenaeus indicus* (NE); Chapda/sada chingri (green tiger prawn), *P. semisulcatus* (NE); Harina chringri (speckled shrimp), *Metapenaeus monoceros* (NE), *Metapenaeus* spp., *Parapenaeopsis pargasias*
Gutum (Guntea loach) – *Lepidocephalichthys guntea* (LC)	**Sisor** (Sisor catfish) – *Sisor rhabdophorus* (EN)

(continued)

Table 17.3 (continued)

Common name – *scientific name*	Common name – *scientific name*
Hilsa/ilish – *Tenualosa ilisha* (LC)	**Tengra**: Golsha/kabashi tengra (Gangetic mystus), *Mystus cavasius* (VU); Bujuri/tengra, *M. tengara*; Tengra, *M. vittatus* (LC); Tengra nona, *M. gulio* (LC); Tengra (Assamese batasio), *Batasio tengana* (EN); Golsha (long whiskered catfish), *M. cavasius* (LC)
	Taki (spotted snakehead) – *Channa punctata*
(C). Amphibians	
Frog: Indian bullfrog – *Hoplobatrachus tigerinus/Rana tigrina* (LC)	
(D). Reptiles	
Cobra: spectacled cobra/Indian cobra, *Naja naja* (NT); king cobra, *Ophiophagus hannah* (VU)	**Python:** Indian python/black tailed python – *Python molurus* (NT)
Crocodile: mugger crocodile or marsh crocodile, *Crocodylus palustris* (VU); Saltwater/Indo-Pacific crocodile, *Crocodylus porosus* (LC)	**Terrapin:** river terrapin – *Batagur baska* (CR)
Gharial – *Gavialis gangeticus* (CR)	**Turtle:** leatherback turtle, *Dermochelys coriacea* (VU); loggerhead turtle, *Caretta caretta* (EN); peacock soft-shell turtle, *Trionyx hurum* (NT); black pond turtle, *Geoclemys hamiltonii* (VU); green turtle, *Chelonia mydas* (EN); Indian flap-shelled turtle, *Lissemys punctata* (LC); hawksbill turtle, *Eretmochelys imbricata* (CR); olive ridley turtle, *Lepidochelys olivacea* (VU); Sylhet roofed turtle, *Kachuga sylhetensis* (EN)
Lizard: yellow monitor – *Varanus flavescens* (LC)	
(E). Birds	
Adjutant: greater adjutant, *Leptoptilos dubius* (EN); lesser adjutant, *L. javanicus* (VU)	**Lapwing:** spur-winged lapwing, *Vanellus spinosus* (LC); yellow-wattled lapwing, *V. malabaricus* (LC); red-wattled lapwing, *V. indicus* (LC)
Bittern: black bittern, *Ixobrychus flavicollis* (LC); chestnut bittern/ cinnamon bittern, *I. cinnamomeus* (LC)	**Openbill:** openbill: Asian openbill, *Anastomus oscitans* (LC)
Cock: water cock – *Gallicrex cinerea* (LC)	**Osprey:** Osprey – *Pandion haliaetus* (LC)
Cormorant: little cormorant – *Phalacrocorax niger*/*Microcarbo niger* (LC)	**Oyster catcher**: Eurasian oyster catcher – *Haematopus ostralegus* (NT)
Crake: ruddy-breasted crake – *Porzana fusca* (LC)	**Pelican:** Dalmatian pelican, *Pelecanus crispus* (VU); Pelican, spot-billed pelican, *P. philippensis* (NT)

(continued)

Table 17.3 (continued)

Common name – *scientific name*	Common name – *scientific name*
Curlew: Eurasian curlew – *Numenius arquata* (NT)	**Pintail**: northern pintail – *Anas acuta* (LC)
Darter: darter/snakebird/oriental darter – *Anhinga melanogaster* (NT)	**Plover:** Kentish plover, *Charadrius alexandrinus*; common ringed plover, *C. hiaticula* (LC); American golden plover, *Pluvialis dominica* (LC); little ringed plover, *Charadrius dubius* (LC); Mongolian plover/lesser sand plover, *C. mongolus* (LC)
Dowitcher: Asian dowitcher, *Limnodromus semipalmatus* (NT)	**Pochard:** Baer's pochard – *Aythya baeri* (CD)
Duck: white-winged duck – *Cairina scutulata/Asarcornis scutulata* (EN)	**Pratincole:** small Indian pratincole/oriental pratincole – *Glareola maldivarum* (LC)
Eagle: Pallas's fishing eagle, *Haliaeetus leucoryphus* (VU); gray-headed fish eagle, *Ichthyophaga ichthyaetus* (NT); white-bellied sea eagle, *Haliaeetus leucogaster* (LC); imperial eagle, *Aquila heliacal*	**Quail:** Manipur bush quail – *Perdicula manipurensis* (EN)
Egret: large egret, *Egretta alba* (LC); Western reef-egret, *E. gularis* (LC)	**Rail:** western water rail – *Rallus aquaticus* (LC)
Finfoots: masked finfoot – *Heliopais personatus* (DD)	**Ruff:** ruff – *Philomachus pugnax/Calidris pugnax* (LC)
Francolin: swamp francolin – *Francolinus gularis* (VU)	**Sanderling**, *Calidris alba* (LC)
Goose: cotton teal/cotton pygmy goose, *Nettapus coromandelianus* (LC); greylag goose/bar-headed goose, *Anser indicus* (LC); greylag goose, *A. anser* (LC)	**Sandpiper:** marsh sandpiper, *Tringa stagnatilis* (LC); sandpiper, spoonbill sandpiper, *Eurynorhynchus pygmeus*/*Calidris pygmaea* (CR)
Grebe: little grebe – *Tachybaptus ruficollis* (LC)	**Shank:** Nordmann's greenshank/spotted greenshank, *Tringa guttifer* (EN); common redshank, *Tringa tetanus*; common greenshank, *Tringa nebularia* (LC)
Gull: black-headed gull, *Larus ridibundus* (LC); brown-headed gull, *Larus brunnicephalus* (LC); great black-headed gull/Pallas's gull, *Larus ichthyaetus* (LC)	**Skimmer:** Indian skimmer/Panikata – *Rynchops albicollis* (VU)
Hen: white-breasted water hen, *Amaurornis phoenicurus* (LC); moorhen/purple swamphen, *Porphyrio porphyrio* (LC)	**Snipe**: pintail snipe, *Gallinago stenura* (LC); common snipe, *G. gallinago* (LC); fantail snipe, *Gallinago gallinago*
Heron: gray heron, *Ardea cinerea* (LC); white-bellied heron, *Ardea insignis* (CR)	Stilt: black-winged stilt – *Himantopus himantopus* (LC)
Ibis: bar-headed goose/red-naped ibis, *Pseudibis papillosa* (LC); white ibis/black-headed ibis, *Threskiornis melanocephalus* (NT)	**Teal:** lesser whistling teal – *Dendrocygna javanica* (LC)

(continued)

Table 17.3 (continued)

Common name – *scientific name*	Common name – *scientific name*
Jacana: bronze-winged jacana – *Metopidius indicus* (LC)	**Tern**: gull-billed tern, *Gelochelidon nilotica* (LC); whiskered tern, *Chlidonias hybrida* (LC); little tern, *Sterna albifrons* (LC); Indian river tern, *Sterna aurantia* (NT); hirundo tern/common tern, *Sterna hirundo* (LC)
Kestrel: lesser kestrel – *Falco naumanni* (LC)	**Vulture:** cinereous vulture – *Aegypius monachus* (NT)
Kingfisher: brown-winged kingfisher, *Pelargopsis amauroptera* (NT); ruddy kingfisher, *Halcyon coromanda* (LC); stork-billed kingfishers, *Pelargopsis capensis* (LC); Blyth's kingfisher, *Alcedo hercules* (NT)	**Whimbrel** – *Numenius phaeopus* (LC)
Knot: eastern knot – *Calidris tenuirostris* (EN)	
(F). Mammals	
Bear: Asiatic black bear, *Ursus thibetanus* (VU); hog deer, *Axis porcinus* (EN); sloth bear, *Melursus ursinus* (VU)	**Langur**: capped langurs – *Trachypithecus pileatus* (VU)
Boar: wild boar – *Sus scrofa* (LC)	**Leopard:** clouded leopard, *Neofelis nebulosa* (VU); leopard, *Panthera pardus fusca* (NT)
Cat: Asiatic golden cat, *Catopuma temminckii* (NT); fishing cat, *Prionailurus viverrinus* (EN); marbled cat, *Pardofelis marmorata* (VU); jungle cat, *Felis chaus* (LC); leopard cat, *Prionailurus bengalensis* (LC)	**Rabbit:** hispid hare/Assam rabbit – *Caprolagus hispidus* (EN)
Civets: Bengal civets – *Viverra zibetha* (NT)	**Rhinoceros**: Javan rhinoceros, *Rhinoceros sondaicus* (CR); Indian rhinoceros/single-horned rhinoceros, *Rhinoceros unicornis* (VU)
Dog: Asiatic wild dog – *Cuon alpinus* (EN)	**Monkey:** rhesus macaques/monkey – *Macaca mulatta* (LC)
Deer: barasingha/swamp deer, *Rucervus duvaucelii* (VU); barking deer, *Muntiacus muntjak* (LC); spotted deer/chital, *Axis axis* (LC)	**Otter:** Asian small-clawed otter, *Aonyx cinerea* (VU); smooth-coated otter, *Lutrogale perspicillata* (VU)
Dolphin: Gangetic/South Asian river dolphin/Ganges susu/shushuk, *Platanista gangetica gangetica* (EN); Indo-Pacific bottlenose dolphin, *Tursiops aduncus* (DD); Indo-Pacific humpbacked dolphin, *Sousa chinensis* (NT); Shushuko/Irrawaddy dolphin, *Orcaella brevirostris* (VU)	**Porpoise:** finless porpoise – *Neophocaena phocaenoides* (VU)
Fox: Bengal/Indian fox – *Vulpes bengalensis* (LC)	**Tiger:** Royal Bengal tiger – *Panthera tigris tigris* (EN)
Gayal: gaur/gayal – *Bos frontalis*	**Wolf:** gray wolf – *Canis lupus* (LC)

(continued)

Table 17.3 (continued)

Source: [d,e]Reptiles, birds, and mammals following Nishat et al. (1993), Islam et al. (2015), IUCN Red List of Threatened Species, and various other sources
CR critically endangered, *EN* endangered, *VU* vulnerable, *NT* near threatened, *LC* least concern, *DD* data deficient, *NE* not evaluated
[a]http://www.iucnredlist.org/
[b]http://fisheriesbd.at.ua/news/threatened_to_extinct_fishes_of_bangladesh /2012-11-09-27
[c]http://www.iucnredlist.org/
[d]http://www.iucnredlist.org/
[e]http://fisheriesbd.at.ua/news/threatened_to_extinct_fishes_of_bangladesh/2012-11-09-27

N. stellata, Nymphoides sp., *Nelumbo nucifera, Euryale ferox, Phragmites karka, P. communis, Chara* sp., *Najas* sp., *Vetiveria zizanioides, Alternanthera philoxeroides, Enhydra fluctuans, Aponogeton* sp., *Hygrophila auriculata, Trapa bispinosa* and *T. maxitnowizii, Ottelia alismoides,* and *Asparagus racemosus*. However, many of these have now become scarce because of overexploitation (see Table 17.3a for common names and conservation status of plants).

Many submergent and floating hydrophytes are used as leafy vegetables. Rootstocks of *Aponogeton* sp., *Nymphaea* spp., *Nymphoides* sp., *T. bispinosa*, and *T. maxitnowizii* and seeds of *E. ferox* are relished by the rural people. Wild species of rice jhora dhan (*Oryza rufipogon*) of inland wetlands are used as a substitute for cultivated rice. In some wetlands of central (Faridpur, Gopalganj, Muksudpur, Kashiani and Kotalipara, Jessore), southern (Jhalokathi, Pirojpur, Sharupkathi, Najirpur, Banaripara, and Ujirpur), and northeastern areas (Kishoreganj, Netrokona, Brahmanbaria, Sunamganj) of Bangladesh, floating garden made on heaps of decomposed water hyacinth (*E. crassipes*), locally called *baira/daap* (Haq et al. 2002), a century-old practice to grow vegetables in flood-prone areas (see below), is evident.

Farming on floating beds (locally known as *baira*, *geto*, *bed*, or *daap)*, soil-less agriculture or hydroponics (Fig. 17.3), is an indigenous practice in the southwestern part of Bangladesh (Haq et al. 2002). This practice is now receiving renewed interest as a potential solution for farmers whose lands have been waterlogged and for landless people. This farming technique uses masses of rotting water hyacinths (*E. crassipes*) that choke the waterways, and it offers opportunities for the participation of men as well as women. Such agriculture/gardens can be an adaptation to adverse environmental conditions from waterlogging or prolonged flooding (Fig. 17.3). Here plants derive their nutrients not from soil but from water (UNEP 2012; Kibria et al. 2013). The approach employs beds of rotten vegetation, which acts as compost for crop growth. These beds are able to float on the surface of the water, creating areas of land suitable for agriculture within waterlogged regions. Mostly vegetables such as sweet gourd, pumpkin, brinjal, green chili, red and green amaranth, and beans are grown during the flood season. In winter when the water recedes, the farmers use the land to crop winter vegetables such as potato, tomato, radish, carrot, turnip, cabbage, cauliflower, and other crops such as onions and garlic depending on the local situation. Harvesting water hyacinth allows clearing the invasive weed, with the beneficial side effect of reducing breeding grounds for mosquitoes and improving conditions for open water fishing. This practice of floating agriculture

Fig. 17.3 Farming on floating beds, *baira/daap* (Photo courtesy: A. W. R. Hassan, FAO, Bangladesh)

also helps to supplement the income of local communities and contributes to poverty alleviation, greater food security by increasing the land output, and supporting capacity for poor and landless people. As both men and women can carry out floating agriculture, it also leads to improvements in gender equity. However, there is a possibility of transfer of pollutants such as trace/heavy metals accumulated in water hyacinth as compost to crops and vegetables grown on them (Kibria et al. 2016).

Fish The inland capture fishery is based on the vast freshwater fish resources with around 260 species of finfishes (most of them native) and 25 shellfishes. Economically important fishes include *Labeo rohita*, *L. gonius*, *L. calbasu*, *L. nandina, L. angra, Catla catla*, *Cirrhinus cirrhosus*, *C. reba, Tor tor, T. putitora, Wallago attu*, *Pangasius pangasius*, *Aorichthys/Sperata aor*, *A. seenghala*, *Bagarius bagarius, Rita rita*, *Clarias batrachus*, *Heteropneustes fossilis*, *Ompok bimaculatus*, *O. pabo*, *Mystus tengara, M. cavasius, M. vittatus*, *Lepidocephalichthys guntea*, *Anabas testudineus, Notopterus notopterus, N. chitala, Rhinomugil corsula, Botia dario, Pseudeutropius atherinoides*, *Puntius sarana, P. ticto, P. sophore, Puntius* sp., *Chela laubuca, Colisa fasciata, Ctenops nobilis, Nandus nandus, Ambassis ranga, A. nama, Macrognathus aculeatus, M. armatus, M. pancalus, Gudusia chapra, Glossogobius giuris, Channa gachua*, *C. punctatus*, *C. striatus*, *C. marulius*, *Xenentodon cancila, Amblypharyngodon mola*, *Osteobrama cotio*, *Danio rerio*, *D. devario, Esomus danricus*, and *Salmostoma laubuca* (Siddiqui et al. 2007a). These once common species are now threatened due to various anthropogenic interventions including pollution, climate change, and water diversion (see Table 17.3b for common names of fishes and their conservation status).

Prawns Among the freshwater prawns, *Macrobrachium rosenbergii, M. malcolmsonii, M. rude, M. lamarrei*, and *Palemon styleferus* are important and common.

17.2.1.2 Case Study: Hakaluki Haor

Hakaluki *ha*or (see Fig. 17.1 for Its Location) is a marsh wetland located in northeastern part of Bangladesh. It is the country's largest inland freshwater wetland. From the wetland, 558 species of animal species have been recorded that includes 417 species of birds. Of 417 avifaunal species, 26 are threatened, two are vulnerable, 10 are endangered, and 14 critically endangered.[1] Hakaluki haor is a very important wetland for its wide variety of waterfowl, particularly Anatidae (IUCN and CNRS 2006) (see Table 17.4). A variety of snakes, turtles, frogs, and tortoises are gradually getting extinct (Nishat et al. 1993), (e.g., Black Soft-shell Turtle, *Aspideretes nigricans*, is now extinct).

17.2.2 Tidal Saltwater Coastal Wetlands

These wetlands cover almost 25% of the land area of Bangladesh and include mangroves, saltmarsh, lagoons, deltaic islands, sand dunes and beaches, barrier islands, seagrass, and coral habitats. The major coastal wetlands are the Sundarbans mangrove forests, the Chakaria mangrove forest, Sonadia Island, Moheshkhali Island, and St. Martin's Island (Fig. 17.1). These coastal wetlands support a rich diversity of plants and animals (see Sect. 17.2.2.1). These habitats are dynamic and are susceptible to change due to coastal processes, lack resilience, and have a low threshold to irreversible damage. The physical and ecological characteristics of these habitats make them especially vulnerable to degradation. Coastal wetlands are also important for fishery, water resources, agriculture/land resources, and biodiversity.

17.2.2.1 Biodiversity of Coastal Wetlands

The coastal wetland vegetation in Bangladesh consists of 35 angiosperm species, 26 dicots, and 9 monocots. *Ipomoea pes-caprae, Ipomoea* spp., *Leucas aspera, Clerodendrum viscosum,* and *Argyreia nervosa* are common creepers that act as sand binders in the primary dunes. The grasses in these dunes include *Cynodon dactylon, Panicum repens*, *Cynodon* sp., *Paspalum scrobiculatum*, *P. vaginatum, Cyperus* sp., and *Fimbristylis* sp. The mature inland dunes consist of trees, shrubs, and herbs; common ones are *Phyllanthus reticulatus*, *Cassia tora, Clerodendrum inerme*, *Vitex trifolia, V. pubescens, Ziziphus mauritiana, Z. jujuba*, *Casuarina equisetifolia*, *Streblus asper, Pandanus odoratissimus, Calotropis gigantea, Porteresia coarctata, Myriostachya wightiana, Avicennia officinalis, A. marina, A. alba, Sonneratia apetala, Aegiceras corniculatum, Ceriops decandra,* and *Aegialitis rotundifolia.*

Vegetation The mangrove vegetation of Sonadia Island consists of 27 species. The common ones are *Avicennia officinalis, A. marina, A. alba, A. corniculatum,*

[1] http://en.banglapedia.org/index.php?title=Hakaluki_Haor

Table 17.4 List of amphibians, reptiles, birds, and mammals reported from Hakaluki haor

(A). Amphibians
Frog: Indian Bullfrog, *Rana tigrina/Hoplobatrachus tigerinus*
(B). Reptiles
Lizard: Calcutta Oval-grain Lizard, *Varanus flavescens*; Bengal Monitor Lizard/Common Indian Monitor, *Varanus bengalensis*
Turtle/tortoise: Black Spotted Turtle, *Geoclemys hamiltonii*; Assam Roofed Turtle, *Kachuga sylhetensis*; Indian Flap-shelled Turtle, *Lissemys punctata*; Assam Roofed Turtle, *Kachuga sylhetensis/Pangshura sylhetensis*; Black Soft-shell Turtle, *Aspideretes nigricans*; Indian Peacock Soft-shell Turtle, *Aspideretes hurum/Nilssonia hurum*; Three-keeled Land Tortoise, *Melanochelys tricarinata*
Snake: Indian Rat Snake, *Ptyas mucosa*; monocled cobra, *Naja kaouthia*; cobra, *Naja*; Burmese python, *Python molurus/Python bivittatus*
(C). Birds
Adjutant: Lesser Adjutant, *Leptoptilos javanicus*
Babbler: Marsh Babbler, *Pellorneum palustre*
Coot: Common Coot, *Fulica atra*
Cormorant: Little Cormorant, *Phalacrocorax niger/Microcarbo niger*; Great Cormorant, *Phalacrocorax carbo*
Crane: Sarus Crane, *Grus antigone*; Demoiselle Crane, *Anthropoides virgo*
Duck: White-winged Duck, *Cairina scutulata/Asarcornis scutulata*; Knob-billed Duck, *Sarkidiornis melanotos*; Lesser Whistling Duck, *Dendrocygna javanica*; Indian Spot-billed Duck, *A. poecilorhyncha*; Ferruginous Duck, *Aythya nyroca*; Tufted Duck, *A. fuligula*; Fulvous Whistling Duck, *Dendrocygna bicolor*
Eagle: Gray-headed Fish Eagle, *Ichthyophaga ichthyaetus*; Pallas's Fish-Eagle, *Haliaeetus leucorhyphus;* Eastern Imperial Eagle, *Aquila heliaca*
Egret: Cattle Egret, *Bubulcus ibis*; Little Egret, *Egretta garzetta*; Intermediate Egret, *E. intermedia, E. alba*
Falcon: Peregrine Falcon, *Falco peregrinus*
Francolin: Swamp Francolin, *Francolinus gularis*
Gadwall: Gadwal, *Anas strepera*
Garganey: Garganey, *A. querquedula/Spatula querquedula*
Goose: Cotton Pygmy Goose, *Nettapus coromandelianus*; Greylag Goose, *Anser anser*
Grebe: Little Grebe, *Tachybaptus ruficollis*; Great Crested Grebe, *Podiceps cristatus*
Greenshank: Spotted Greenshank, *Tringa guttifer*
Gull: Black-headed Gull, *Larus ridibundus*
Heron: White-bellied Heron, *Ardea insignis*
Jacana: Pheasant-tailed Jacana, *Hydrophasianus chirurgus*; Bronze-winged Jacana, *Metopidius indicus*
Kingfisher: Blyth's Kingfisher, *Alcedo hercules*
Kestrel: Lesser Kestrel, *Falco naumanni*
Pelican: Dalmatian Pelican, *Pelecanus crispus*; Spot-billed Pelican, *Pelecanus philippensis*
Pintail: Northern Pintail, *Anas acuta*
Pochard: Common Pochard, *Aythya ferina*
Quail: Manipur Bush Quail, *Perdicula manipurensis*

(continued)

Table 17.4 (continued)

Shoveler: Northern Shoveler, *A. clypeata/Spatula clypeata*
Skimmer: Indian Skimmer, *Rynchops albicollis*
Swamphen: Purple Swamphen, *Porphyrio porphyrio*
Teal: Common Teal, *A. crecca*
Tern: Black-bellied Tern, *Sterna acuticauda*; Common Gull-billed Tern, *Gelochelidon nilotica*; Whiskered Tern, *Chlidonias hybrida*
Vulture: Cinereous Vulture, *Aegypius monachus*
Watercock: Watercock, *Gallicrex cinerea*
(D). Mammals
Cat: Jungle Cat, *Felis chaus*; Fishing Cat, *Prionailurus viverrinus*
Dolphin: Ganges River Dolphin, *Platanista gangetica*
Fox: Bengal Fox, *Vulpes bengalensis*
Hare: Hispid Hare, *Caprolagus hispidus*
Jackal: Golden Jackal, *Canis aureus*
Mongoose: *Herpestes* sp.
Otter: Asian Small-clawed Otter, *Aonyx cinerea*; Smooth-coated Otter, *Lutra perspicillata*; Eurasian Otter, *Lutra lutra*
Squirrel: Hoary-bellied Squirrel/Irrawaddy Squirrel, *Callosciurus pygerythrus*

Source: Nishat et al. (1993)

C. decandra, A. rotundifolia, *and Sonneratia apetala.* Unlike mangroves of the Sundarbans, *Nypa fruticans* and *Heritiera fomes* are completely absent in Sonadia. *Sonneratia griffithii*, which was once common in the Chakaria Sundarbans (Chittagong), including Sonadia Island, is no longer available in other existing mangrove areas in Bangladesh. The population of *Porteresia* spp. at Sonadia Island is more salinity tolerant than any of its other land races along the central and western coast of Bangladesh. *P. coarctata* formerly classified as *Oryza coarctata*, a wild relative of rice, is native to the coastal saline areas of Bangladesh and eastern India. This species of brackish water is often used as a substitute for cultivated rice.

Seaweeds Common genera of seaweeds in Bangladesh include *Hypnea* (red seaweeds), *Ceramium* (red seaweeds), *Acanthophora* (red seaweeds), *Polysiphonia* (red seaweeds), *Sargassum* (brown seaweeds), *Dictyota* (brown seaweeds), *Ulva* (green seaweeds), *Sphacelaria* (brown seaweeds), *Padina* (brown seaweeds), *Chaetomorpha* (green seaweeds), *Enteromorpha* (green seaweeds), *Caulerpa* (green seaweeds), and *Halimeda* (calcareous green seaweeds). Species of seagrasses reported from the coastal wetlands of Bangladesh include ocean turfgrass, *Halophila beccarii*, *H. decipiens*, *H. pinifolia*, and *Halodule uninervis*, and beaked tasselweed, *Ruppia maritima* and *Spartina* sp. (Hoq et al. 2012). A total of 154 species of marine algae (including seaweeds) were reported from St. Martin's Island of Bangladesh (Thompson and Islam 2010).

Corals The rocky subtidal habitat supports diverse coral communities, of which 39 species have been identified as hard corals (reef-building *corals)* and 14 species as

soft. Living corals (coral bleaching, ocean acidification, and diseases may cause mortality of corals) include species of *Porites*, *Favites*, *Goniopora*, *Cyphastrea*, and *Goniastrea*. The soft corals include species of *Sinularia*, *Lobophytum*, *Anthelia*, *Dendronephthya*, *Palythoa*, *Nemanthus*, *Telemectius*, and *Discosoma*. Besides, four coral species of the genus *Acropora* (*A. pulchra*, *A. horrida*, *A. humilis*, and *A. variabilis*) were reported from neritic waters of the St. Martin's Island. In addition, *Stylocoeniella*, *Pocillopora*, *Stylophora*, *Porites*, *Pavona*, *Favia*, *Favites*, *Pseudosiderastrea*, *Goniastrea*, and *Montastrea* were recorded. Taxonomy of a good portion of corals occurring around the island is yet unknown. St. Martin's Coral Island is the only continental island in Bangladesh with coral communities.

Fishes The ichthyofauna of the coastal wetlands of Bangladesh includes 492 species (422 species are bony fish and 70 cartilaginous). About 89 fish species are coral associated. Major fish species are listed in Table 17.5.

Sharks, Skates, and Rays 70 species of sharks, skates, and rays (Haroon 2010) and at least seven species of edible oyster are reported from Bangladesh (Siddiqui et al. 2007b).

Shrimps Commercial shrimp and prawn species of coastal wetlands of Bangladesh are *Penaeus monodon* (jumbo tiger shrimp), *P. indicus* (Indian white shrimp), *P. semisulcatus*, *Metapenaeus monoceros* (speckled/ginger shrimp), *Parapenaeopsis sculptilis* (rainbow shrimp), and *Macrobrachium rosenbergii* (giant freshwater prawn).

Crabs Seven species of crabs have been reported from the coastal waters of Bangladesh (Siddiqui et al. 2007b).

Molluscs Gastropods, like *Conus striatus*, *C. textile*, and *C. geographus*, are abundant. Two economically important Gastropods, *Trochus niloticus* and *Turbo marmoratus*, are also reported.

Reptiles (Turtles, Snakes) Five species of marine turtle (*Chelonia mydas*, *Caretta caretta*, *Lepidochelys olivacea*, *Eretmochelys imbricata*, and *Dermochelys coriacea*) have been reported (Hussain and Acharya 1994). Other reptiles include *Varanus salvator* and the sea snakes *Laticauda laticauda*, *L. colubrina*, and *Enhydrina schistosa*. Altogether, coastal area supports 27 reptile species. Entire coastal beach of 710 km from the Sundarbans in the southwest up to Teknaf in the southeast and the St. Martin's Island is particularly important as nesting area for marine turtles.

Birds More than 200 species of birds have been recorded from coastal wetlands, of which 67 species are resident and 53 migratory. Major bird species are *Amaurornis phoenicurus*, *Anhinga melanogaster*, *Eurynorhynchus pygmeus*, *Ardea cinerea*, *Dendrocygna javanica*, *Egretta alba*, *E. gularis*, *Gallicrex cinerea*, *Gelochelidon nilotica*, *Ixobrychus flavicollis*, *Glareola maldivarum*, *Himantopus himantopus*,

Table 17.5 Major fish species reported from coastal wetlands of Bangladesh

Scientific name	Remarks
Tenualosa ilisha	Native; anadromous fish; found in the Bay of Bengal, estuaries, and tidal rivers; contributes about 12% of the total fish production, 10% of fish protein supply, and about 1% of gross domestic product (GDP) in Bangladesh; hilsa forms a single large inland fishery. Immature hilsa, known as "jatka," are fished extensively in rivers near Chandpur between February and May; large-sized fishes mainly contribute to the monsoon fisheries (May–October), and smaller individuals form the fishery during the winter months (November–January). There is now a ban on "hilsa" fishing in Bangladesh at the height of "hilsa" breeding season for 20 days (October–November). More than 450,000 people are directly involved in catching "hilsa" for livelihoods, and around 4–5 million people are indirectly involved in the "hilsa" trade. Overfishing, pollution, and lack of water in the rivers are believed to be reasons for the decline of "hilsa" fisheries in Bangladesh https://sites.google.com/site/pollutionwqbangladesh/news
Pangasius pangasius	Native, found in freshwater and brackish waters of Bangladesh including Choto Jamuna and the Ganges rivers
Lates calcarifer	Native; catadromous fish; found in the Bay of Bengal; very common in estuaries of Barisal, Patuakhali, and Khulna
Stromateus chinensis/Pampus chinensis	Native, found in brackish and marine waters of Bangladesh
Polynemus indicus/ Leptomelanosoma indicum	Native, found in the Sundarbans estuaries and Bay of Bengal
Herpadon nehereus	Native
Rastrelliger kanagurta	Native
Pomadasys hasta	Caught along in coastal brackish and saltwaters of Bangladesh
Johnius diacanthus	Marine, caught from the Bay of Bengal
Sardinella melanura	–
Sardinella gibbosa	Native, Bay of Bengal
Sardinella fimbriata	Native, Bay of Bengal, marine; brackish
Dussumieria acuta	–
Dussumieria elopsoides	–
Parastromateus niger	Native
Arius maculatus	Native
Arius thalassinus	–
Psettodes erumei	Native
Decapterus russelli	Native
Pellona ditchella	–
Scomberoides commersonnianus	Native

(continued)

Table 17.5 (continued)

Scientific name	Remarks
Scomberomorus commerson	Native
Congresox telabonoides	–
Eleutheronema tetradactylum	Native
Sillago sihama	–
Caranx melampygus	Native
Lobotes surinamensis	Native
Otolithoides pama	Native, found in the Bay of Bengal, very common in the river Meghna during monsoon
Panna microdon	–
Pampus argenteus	Native
Gerres filamentosus	Native

Sources: [a,b,c]Siddiqui et al. (2007b)
[a]http://www.iucnredlist.org/search
[b]http://mail.nbfgr.res.in/cgi-bin/fbis/barcodeinfo.pl?202
[c]http://fishbase.org/country/CountryChecklist.php?resultPage=3&what=list&trpp=50&c_code=050&csub_code=&cpresence=Reported&sortby=alpha2&ext_CL=on&ext_pic=on&vhabitat=fresh

Ixobrychus cinnamomeus, *Metopidius indicus*, *Nettapus coromandelianus*, *Phalacrocorax niger*, *Porphyrio porphyrio*, *Porzana fusca*, *Rallus aquaticus*, *Sterna albifrons*, *Sterna aurantia*, *Tachybaptus ruficollis*, *Vanellus malabaricus*, *V. indicus*, *V. spinosus*, *Anastomus oscitans*, *Gallinago stenura*, *G. gallinago*, *Calidris alba*, *Limnodromus semipalmatus*, *Halcyon coromanda*, *Chlidonias hybrida*, *Leptoptilos dubius*, *L. javanicus*, *L. dubius*, *Limnodromus semiplamatus*, and *Tringa guttifer*. St. Martin's Island is particularly an important wintering area for a wide variety of migratory shorebirds, gulls, and terns. This island supports two globally threatened birds *Vanellus cinereus* and *Sterna acuticauda* and two marine mammals *Sousa chinensis* and *Neophocaena phocaenoides*. Common avian migrants and winter visitors are *Anas acuta*, *Pluvialis dominica*, *Charadrius dubius*, *C. alexandrinus*, *C. hiaticula*, *C. mongolus*, *Numenius phaeopus*, *N. arquata*, *Tringa totanus*, *T. nebularia*, *T. stagnatilis*, *T. guttifer*, *Gallinago stenura*, *G. gallinago*, *Calidris alba*, *Chlidonias hybrida*, *Larus ridibundus*, *Philomachus pugnax*, *Sterna hirundo*, *Anastomus oscitans*, *Threskiornis melanocephalus*, *Pseudibis papillosa*, *Anser indicus*, *A. anser*, *Haematopus ostralegus*, *Calidris tenuirostris*, *Larus ichthyaetus*, *L. brunnicephalus*, *Rynchops albicollis*, *Eurynorhynchus pygmeus*, *Limnodromus semipalmatus*, and *Haliaeetus leucogaster*.

Mammals Important terrestrial mammal species include *Canis lupus*, *Cuon alpinus*, *Catopuma temminckii*, *Neofelis nebulosa*, *Pardofelis marmorata*, *Melursus ursinus*, *Ursus thibetanus*/*Selenarctos thibetanus*, *Prionailurus viverrinus*, *Amblonyx cinerea*, *Lutrogale perspicillata*, and *C. hispidus (*Khan 1986). Dolphins include *Platanista gangetica*, *Sousa chinensis*, and *Neophocaena phocaenoide.*

17.2.2.2 Case Study: Sundarbans Mangrove of Bangladesh

The Sundarbans, the largest continuous natural mangrove forest in the world, is located at the southern extremity of the Ganges river delta, i.e., bordering the northern margin of the Bay of Bengal spreading over the southern part of Bangladesh and West Bengal, India. The Sundarbans mangrove forest covers an area of about 10,000 km^2 of which 62% falls within the territory of Bangladesh, while the remaining (38%) area belongs to West Bengal, India. Of the total area, approximately 70% is lands. This forest has been managed for more than a century (Curtis 1933). At present the forest is divided almost in a north-south direction into polyhaline (>10 ppt), mesohaline (≥5–10 ppt), and oligohaline (<5 ppt) zones. This happened since 1982 due to Farakka Barrage in West Bengal, India. The Sundarbans occupies a flat deltaic swamp rarely exceeding 0.9–2.1 m above mean sea level, with a maximum of 10 m amsl. It is generally tidally flooded on a twice-daily basis with most of the area being under water during the high spring tides of the monsoon. Some parts of the mangroves are characterized by the presence of acid sulfate soils, especially in the Chakaria mangroves of Chittagong. The World Heritage Convention (WHC) declared Sundarbans as the natural and cultural site of outstanding universal value. Over 3.5 million people live within 20 km boundary of the Sundarbans mangrove forest (SMF) and are directly or indirectly dependent on its fisheries resources (Hoq 2008; Kibria 2014).

Mangrove ecosystem is a suitable feeding, breeding, and nursery ground for several marine, estuarine, and freshwater species. The intermingled root system of the mangrove acts as a coastal stabilizer and binders of sediment, thus aiding in preventing erosion in the mangrove areas (Hoq 2008; Hoq and Haroon 2012). The name "Sundarbans" is due to the dominance of the plant *Heritiera fomes*, locally called as Sundari gach. Other major plant species are *H. littoralis*, *H. minor*, *Excoecaria agallocha*, *Xylocarpus granatum*, *X. mekongensis*, *X. moluccensis*, *Bruguiera conjugata*, *B. gymnorrhiza*, *Sonneratia apetala*, *S. caseolaris*, *Avicennia officinalis*, *Ceriops decandra*, *C. tagal*, *Aegiceras corniculatum*, *A. corniculatum*, *Rhizophora mucronata*, *R. apiculata*, *Pandanus tectorius*, *Poresia coaractata*, *Myriostachya wightiana*, *Phoenix paludosa*, *Cynometra ramiflora*, *Hibiscus tiliaceus*, *Imperata cylindrica*, *Phragmites karka*, and *Nypa fruticans*. Since 1989, timber extraction has been banned in order to conserve the natural resources, although exemptions have been made for the harvest of some species for poles, sawlogs and hardboard (e.g., *H. fomes*), pulpwood (*E. agallocha*), thatching material (*N. fruticans*), and some non-timber species for fuelwood. While mangrove formation of the St. Martin's Island is quite different from other mangroves in the country in that, it is a pure *Lumnitzera racemosa* formation (large shrubs or small trees up to 8 m tall, locally known as *Kirpa*).

The Bangladesh Sundarbans supports diverse biological resources including at least 150 species of commercially important fishes, 270 species of birds, 42 species of mammals, 35 reptiles, and eight amphibian species. This represents a significant proportion of the species present in Bangladesh (i.e., about 30% of the reptiles, 36% of the birds, and 34% of the mammals) and includes a large number of species that are now extinct elsewhere in the country. Two amphibians, 14 reptiles, 25 aves, and

five mammals are at present endangered. The Sundarbans is an important wintering area for migrant water birds and is an area suitable for watching and studying them. Eighteen snake species including *Ophiophagus hannah*, *Naja* sp., *Python molurus*, green vine snake, checkered keelbacks and rat snakes, vipers, and sea snakes are reported. Monitor lizards found are *Varanus bengalensis*, *V. flavescens*, and *V. salvator*.

Waterways of the Sundarbans mangrove forest are now considered as the global "hot spot" of endangered Gangetic river dolphin, *Platanista gangetica gangetica*, and Irrawaddy dolphin, *Orcaella brevirostris* (Fahrni et al. 2008). Although there is no global population estimate for either species, both have disappeared from major portions of their range. However, both species occur in the Sundarbans in sufficient numbers that it may serve as a global safety net for preventing their extinction. Besides, world's second largest documented population, about 1,144 individuals of Indo-Pacific bottlenose dolphin, *Tursiops aduncus*, lives at the northern tip of the Swatch of No Ground in the Bay of Bengal, Bangladesh (Smith et al. 2008, 2010).

The varied and colorful birdlife includes about 315 species including 95 species of waterfowl and 38 species of raptors (Sarker 1985). Most readily seen are no less than nine species of kingfisher, including *Pelargopsis amauropterus*, *P. capensis*, *Haliaeetus leucogaster*, and *Ichthyophaga ichthyaetus*; raptors, the globally threatened *Leptoptilos javanicus*, *Heliopais personatus*, *Pandion haliaetus*, and *Ichthyophaga ichthyaetus*; herons; egrets; storks; sandpipers; whimbrel; curlew; and numerous other waders are seen along the muddy banks and on the chars or sandbanks. There are many species of gulls and terns, especially along the coast and the larger waterways. Apart from those species particularly associated with the sea and wetlands, there is also a considerable variety of forest birds such as woodpeckers, barbets, shrikes, drongos, mynahs, minivets, babblers, and many others (Salter 1984; Scott 1991).

The area is famous for the eponymous flagship species Royal Bengal tiger (*Panthera tigris tigris*) and leopard (*Panthera pardus fusca*), apart from the numerous faunal species. It is estimated that there are now about 500 Royal Bengal tigers and about 30,000 spotted deer in the area. In addition, there are several other threatened mammal species, such as the capped langur (*Semnopithecus pileatus*/*Trachypithecus pileatus*) (Vulnerable or VU), smooth-coated otter (*Lutrogale perspicillata*) (VU), Asian small-clawed otter (*Aonyx cinereus*) (VU), and large Indian civet (*Viverra zibetha*) (NT). The eco-region also harbors several smaller predators such as jungle cat (*Felis chaus*), fishing cat (*Prionailurus viverrinus*), leopard cat (*P. bengalensis*), Javan rhinoceros (*Rhinoceros sondaicus)*, Indian rhinoceros (*R. unicornis*), water buffalo (*Bubalus bubalis*), *C. duvauceli*, and gayal (*Bos frontalis*, *A. porcinus*). Other mammals include chital/spotted dear (*Cervus axis*/*Axis axis*), barking deer (*Muntiacus muntjak*), wild boar (*Sus scrofa*), saltwater crocodile (*Crocodylus porosus*), mugger (*C. palustris*), gharial (*Gavialis gangeticus*), common gray mongooses, foxes, jungle cats, flying foxes, and pangolins.

17.3 Significance of Wetlands

17.3.1 Significance of Wetlands as Biodiversity "Hot Spots"

About 400 species of vertebrates and 300 species of plants in Bangladesh are solely dependent upon the wetlands for their life or a part of it. About 260 species of freshwater fish live in the wetlands and are the main source of daily protein supplement (70%) in the country. The deepwater rice or floating rice had been the main source of food supplement in those areas before the introduction of high-yielding varieties (HYV) in the 1960s. It is widely believed that Bangladesh's aquatic diversity has not yet been adequately described. At any rate, the known levels of endemism in the Ganges-Meghna-Brahmaputra (GMB) basin are very high, 25% of the aquatic species found in this basin being endemic. Indigenous fish and prawn residents in wetlands of Bangladesh move into the floodplains to reproduce, and their offsprings use the wetlands for feeding and growth**.** Similarly, catadromous freshwater giant prawn (*M. rosenbergii*) and others needing an estuarine environment to reproduce migrate to the coasts from the rivers. Postlarvae of freshwater giant prawn again migrate upstream into the freshwater rivers and then laterally move into the floodplains to feed and grow. At the end of the flood season, fish and prawn on the floodplains move, with the receding waters, back into deeper permanent water bodies such as rivers, canals, and *beels* to survive through winter and dry season. They become the mother fishery stock to breed and multiply in the inundated floodplain in the following monsoon. In addition, several species of freshwater mussels and snails also occur in the floodplains. Several species of freshwater mussels bear pink pearls. Mussel/snail shells are also used to make lime for use with betel leaves and nuts. Snails are harvested to use their meat for feeding the freshwater giant prawn under cultivation. The country supports 650 species of birds[2] within an area of 144,000 km^2. This represents about 30% of the total number of bird species recorded from the entire Indian subcontinent and over 7% of the globally known bird species. The Assam plains in eastern Bangladesh are identified as Endemic Bird Area (EBA) by BirdLife International with the status of "urgent conservation priority."

17.3.2 Significance of Wetlands as Livelihoods of People

Poorer section of the society near any wetland depends totally on the goods and services of the wetland for livelihood. The rich biodiversity in wetlands of Bangladesh (as discussed in Sects. 17.2.1 and 17.2.2) contributes significantly to diversify livelihoods of people. It is estimated that about two-thirds of people living in rural Bangladesh (mostly poor) depend on wetlands for a variety of purposes such as water for drinking, irrigation, food production (agriculture, aquaculture), fishing (fish, prawn, crabs), livestock grazing/fodder, bird hunting, medicines, snail, honey, vinegar, glue, wax, firewood, timber, thatching materials, harvesting grasses

[2] https://www.cbd.int/doc/world/bd/bd-nr-04-p2-en.pdf

and seaweeds, and tourism/recreational business (Islam 2010; Kibria 2014). It has been estimated that over 60 million people are dependent on aquatic resources every day in Bangladesh, of which about a million are full-time and part-time fisher folk. The fishery and agriculture sectors employ 5% and 64.5% of the country's total workforce, respectively.[3] Over 500,000 fishers are involved in catching hilsa, and over 2,000,000 people are indirectly involved in the distribution and sale of the fish and other ancillary activities such as net and boat making, ice production, processing, and export.[4] About 600,000 people are employed directly in shrimp aquaculture in Bangladesh that supports approximately 3.5 million dependents.[5] The Sundarbans alone provides livelihood and employment to an estimated 112,000 people (http://iucn.org/about/union/commissions/ceesp/?21654). Out of 3700 people on St. Martin's Island, most are fishermen depending solely on fishing, shrimp fry collection, fish drying, exporting dry seaweeds, agriculture, and ecotourism business (Thompson and Islam 2010). About 200,000 people depend on resources of Hakaluki *haor* for agriculture (rice, oil seeds, pulses), fishing, duck rearing, cattle grazing, fish culture/aquaculture, snail collection, bird hunting, fuelwood collection (reeds), and sand extraction[6] (Islam 2010). Tanguar *haor* supports livelihood for more than 60,000 people (agriculture, commercial fishing, and trade in fuelwood, hunting/trapping waterfowl, the harvesting and sale of grasses and reeds, and coal collection). The principal activities of people living in Tanguar *haor* are agriculture (36.78%), fishing (21.56%), day labor (21.07%), business (7.55%), sand and coal collection (3.4%), and others (9.8%) (Alam et al. 2012). A significant number of people are employed in waterway transportation and ecotourism associated with wetlands across Bangladesh; but there is no statistics available on this.

17.3.3 Significance of Wetlands as Source and Sink of Greenhouse Gas

Wetlands used for rice farming (in waterlogged areas) emit significant quantities of methane (Yan et al. 2003). Dams/reservoirs emit GHG (greenhouse gas: methane, carbon dioxide) in several ways, from breakdown/decomposition of soil and plant carbon (by bacteria) and anaerobic conversion of organic carbon to methane and rotting/decay of vegetation at the bottom of dams/lakes (Bates et al. 2008). Though wetlands such as lakes/reservoirs are important sources of GHG emissions, they also provide an important role in climate change mitigation, for example, by exporting C and N, as fish biomass in fisheries and aquaculture. Afforestation, reforestation, and mangrove restoration remove CO_2 from the atmosphere and act as carbon sinks (carbon sequestration). Mangrove forests store more carbon than any other

[3] http://iucn.org/about/union/commissions /ceesp/?21654

[4] http://www.boblme.org/documentRepository /BOBLME-2012-Brochure-02.pdf

[5] https://www.academia.edu/7146833/Present_Status_and_Potentiality_of_Shrimp_in_Bangladesh

[6] https://en.wikipedia.org/wiki/Hakaluki_Haor; http://en.banglapedia.org/index.php?title= Hakaluki_Haor

tropical forests. In particular, mangrove-sediment stores about five times more carbon (Stecker and Wire 2012). Thus, restoration of mangrove forest would be an environment-friendly solution for mitigating climate change or global warming. Wetland systems have significant quantities of carbon stored in the vegetation and soil and hence have received increased attention for playing an important role to reduce GHG emissions (Box 17.1). As wetland soils are saturated with water creating an environment low in oxygen, the carbon that is sequestered is buried remaining relatively stable without decaying. When drained, such as through development, conversion to agriculture, or aquaculture, the carbon in the soil is exposed and oxidized, and that releases the stored carbon as CO_2 into the atmosphere.

17.3.4 Significance of Wetlands in Disaster Mitigation

Wetlands such as mangroves play an important role in the protection of the coast from natural and climate change-related disasters (cyclones, storm surges, tsunamis, rise in sea level). Wetlands could act as a barrier (live seawalls) against disasters and help minimize damage to property and life. In India, the Philippines, and Vietnam, people have been protected and suffering less damage to lives and property from disasters like tsunamis, cyclones, and other natural disasters in locations where mangroves were intact (shielded with dense forest). On the contrary, people suffered extensively in locations where either mangroves were lost, cleared, or absent or mangroves have been converted to shrimp farms (MSSRF 2005).

Box 17.1 Why Wetlands Are a Good Carbon Sink? (Lehmann et al. 2006)

- Only 6% of the world's land is wetlands and about 14.5% of the world's soil carbon is found in wetlands.
- Coastal wetlands (salt marshes, mangroves, and seagrass beds) can store large quantities of carbon. Some of the carbon that wetland plants capture gets added to soils either via internal transport in the plant or as plant parts, such as leaves and roots, which die and become incorporated into the soil.
- Since wetland soils are largely anaerobic (without oxygen), carbon that is incorporated into the soils decomposes very slowly and can persist for hundreds or even thousands of years. Decomposition of organic plant material is much slower when oxygen is not present, so the carbon present in this plant material remains intact, rather than being broken down by microbes and respired back to the atmosphere. As a result, wetlands are very good carbon sinks (i.e., wetlands store a lot of carbon).

Bangladesh frequently experienced extreme cyclones, *viz*., Bhola cyclone 1970, Bangladesh cyclone 1991, Cyclone Sidr 2007, and Cyclone Aila 2009.

17.4 Conclusion

Wetlands provide a wide range of economic, social, and ecological benefits. Wetlands of Bangladesh are "lifeblood" since two-thirds of people (mostly poor) depend on wetlands for water, agriculture, aquaculture, fishing, wild food, medicines, fuelwood, furniture wood, honey, thatching materials, bird hunting, sand extraction, river transportation, and ecotourism business. Apart from biodiversity and livelihood support, wetlands of Bangladesh provide other ecosystem services such as flood control (store excess water), climate change mitigation (forests and wetland sediments as carbon sinks), and disaster mitigation (mangrove acting as live walls to reduce impact of cyclones, tsunamis). However, wetlands of Bangladesh and its ecology and biodiversity are under increasing threats due to pollution (pesticides, metals), climate change (rise in sea level), population increase, conversion and drainage of wetlands for agriculture and development, deforestation, irrigation and flood control projects, water diversion, nature siltation, overexploitation of resources (fish, water birds, plants), overgrazing by livestock, and transboundary water regulation.

Conservation, restoration, afforestation, and management of wetlands would be vital since a healthy biodiversity-rich environment is more resilient to climate and environmental shocks and various other stresses. In addition, livelihood diversification, awareness, and education of local communities on preservation and conservation of wetlands are needed to reduce pressure on wetland resources. Community-based participatory wetland resource management (bottom-up approach) looks good for conserving wetland biodiversity and aquatic resources and is being followed in Bangladesh since long. But this would not be just enough without comprehensive policies, strategies, and management plans combining political, economic, social, and technological approaches to prevent further degradation of wetlands.

Acknowledgment The authors express their acknowledgment to S. N. Islam for permitting us to reproduce Fig. 17.1 from their earlier publication (Islam 2010) and to the anonymous reviewer(s) for their kind review of the earlier version of the manuscript.

References

Alam ABMS, Chowdhury MSM, Sobhan I (2012) Biodiversity of tanguar haor: a ramsar site of Bangladesh volume I: wildlife. IUCN Bangladesh, Dhaka, p xi+234

Bates BC, Kundzewicz ZW, Wu S, Palutikof JP (eds) (2008) Climate change and water. Technical paper of the intergovernmental panel on climate change. IPCC Secretariat, Geneva, p 210

Curtis SJ (1933) Working plan for the forests of the sundarbans division for the period from 1st April 1931 to 31st March 1951. Bengal Government Press, Calcutta

Fahrni M, Smith EBD, Mansur RM, Diyan MAA (2008) Two incidences of fishing gear entanglement of Ganges River dolphins *Platanista gangetica gangetica* in waterways of the Sundarbans mangrove forest, Bangladesh. Aquat Mamm 34(2):362–366

Fischlin A, Midgley GF, Price JT, Leemans R, Gopal BC, Turley C et al (2007) Ecosystems, their properties, goods, and services. In: Parry ML, Canziani OF, Palutikof JP, Van der Linden PJ, Hanson CE (eds) Climate change 2007: impacts, adaptation and vulnerability. Contribution of working group II to the fourth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge, pp 211–272

Haq AHMR, Asaduzzaman M, Ghosal TK (2002) Soil-less agriculture in Bangladesh. A Grameen Trust, Bangladesh publication under the component of research for poverty alleviation. Grameen Bank Bhaban, Mirpur, p 111

Haroon AKY (2010) Shark fishery in the Bay of Bengal, Bangladesh. In: Hoq ME, Haroon AKY and Hussain MG (eds) Shark fisheries in the Bay of Bengal, Bangladesh:Status and potentialities. p 11–32. Workshop Proceedings of the Support to Sustainable Management of the BOBLME Project, Bangladesh Fisheries Research Institute, 76 p

Haroon AKY, Pittman KA (1997) Rice-fish culture: feeding, growth and yield of two size classes of *Puntius gonionotus* Bleeker and *Oreochromis* spp. in Bangladesh. Aquaculture (The Netherlands) 154:261–281

Haroon AKY, Dewan S, Karim SMR (1992) Rice-fish production systems in Bangladesh. In: Dela Cruz CR, Lightfoot C, Costa-Pierce BA, Carangal VR (eds) Rice-fish research and development in Asia. ICLARM conference proceeding, Philippines, pp 165–171

Hoq ME (2008) Sundarbans mangrove: fish and fisheries ecology, resources, productivity and management perspectives. Graphic Media, Dhaka

Hoq ME, Haroon AKY (eds) (2012) National consultation meeting report on sundarbans fisheries of Bangladesh: current status and potentialities. SBOBLME Pub./Rep. 6. Support to sustainable management of the Bay of Bengal Large Marine Ecosystem (BOBLME) Project, Bangladesh Fisheries Research Institute (BFRI), Bangladesh, p 56. ISBN:978–984–33-5527-0. http://www.scientificamerican.com/article.cfm?id=restoring-mangroves-may-prove-cheap-way-to-cool-climate

Hoq ME, Haque MA, Haroon AKY (2012) Coastal and marine fisheries resources management-conservation. Training manual for awareness building of fishers and fish traders (In Bangla). Support to Bay of Bengal Large Marine Ecosystem (SBOBLME) Project. Bangladesh Fisheries Research Institute, Maskanda, p 76

Hussain KZ, Acharya G (eds) (1994) Mangroves of the Sundarbans. Vol. 2: Bangladesh. IUCN, Bangkok, Thailand

Islam SN (2010) Threatened wetlands and ecologically sensitive ecosystems management in Bangladesh. Front Earth Sci China 4(4):438–448

Islam MN, Kitazawa D (2013) Modeling of freshwater wetland management strategies for building the public awareness at local level in Bangladesh. Mitig Adapt Strateg Glob Chang 18:869–888

Islam MA, Islam MZ, Barman SK, Morshed F, Marine SS (2015) Study on present status of fish biodiversity in wetlands of sylhet district, Bangladesh. Agric For Fish 4(6):296–299

IUCN and CNRS (2006) Natural resource economic evaluation of Hakaluki haor. Coastal and wetland biodiversity management project: Hakaluki haor component (BGD/99/G31). International Union for Conservation of Nature and Center for Natural Resource Studies. Ministry of Environment and Forests, Government of Bangladesh, p 64

IWRB (1992) Action programme for the conservation of wetlands in South and West Asia. Northeast regional water resources development project (FAP 6), 1992. Draft thematic study. Regional Water Resources Development Status, Flood Plan Coordination Organization, Government of Bangladesh, Dhaka

Khan MAR (1986) Wildlife in Bangladesh mangrove ecosystem. J Bombay Nat Hist Soc 83:32–48

Kibria G (2014) Mangrove forests- its role in livelihoods, carbon sinks and disaster mitigation. https://www.researchgate.net/publication/261178318_Mangrove_Forests-Its_Role_in_Livelihoods_Carbon_Sinks_and_Disaster_Mitigation

Kibria G, Haroon AKY, Nugegoda D, Rose G (2010) Climate change and chemicals: environmental and biological aspects. New India Publishing Agency, New Delhi

Kibria G, Haroon AKY, Nugegoda D (2013) Climate change and agricultural food production: impacts, vulnerabilities and remedies. New India Publishing Agency, New Delhi, p 300

Kibria G, Haroon AKY, Nugegoda D (2016) Climate change and water security: impacts, future projections, adaptations and mitigations. New India Publishing Agency, New Delhi, 312 p. (with 58 Tables & 36 Figs.); ISBN:978-93-85516-26-9. https://www.researchgate.net/publication/303218799_Climate_Change_Water_Security_-_A_Book_Summary

Lehmann J, Gaunt J, Rondon M (2006) Bio-char sequestration in terrestrial ecosystems – a review. Mitig Adapt Strateg Glob Chang 11:403–427. doi:10.1007/s11027-005-9006-5

MSSRF (2005) MS Swaminathan Research Foundation. 2005 Tsunami & Pichavaram mangroves. http://www.mssrf.org/

Nishat A (1993) Freshwater wetlands in Bangladesh: status and issues. In: Nishat A et al. (eds) Freshwater wetlands in Bangladesh: issues and approaches for management. Published by IUCN-The World Conservation Union, Dhaka

Nishat A et al. (eds) (1993) Freshwater wetlands in Bangladesh: issues and approaches for management. Published by IUCN-The World Conservation Union, Dhaka

Salter RE (1984) Integrated development of the Sundarbans, Bangladesh: status and utilization of wildlife. FAO: TCP/BGD/2309(MF). Report No. W/ROO34. FAO, Rome, p 59

Sarker SU (1985) Density, productivity and biomass of raptorial birds of the Sundarbans, Bangladesh. Proceedings of SAARC seminar on biomass production, Dhaka, pp 84–92

Scott DA (1991) Asia and the Middle East in wetlands. Finlayson M, Moser M (eds). Oxford, pp 151–178. ISBN: 0-8160-2556-8

Siddiqui KU, Islam MA, Kabir SMH, Ahmad M, Ahmed ATA, Rahman AKA, Haque EU, Ahmed ZU, Begum ZNT, Hassan MA, Khondker M, Rahman MM (eds) (2007a) Encyclopedia of flora and fauna of Bangladesh, Freshwater fishes, vol 23. Asiatic Society of Bangladesh, Dhaka

Siddiqui KU, Islam MA, Kabir SMH, Ahmad M, Ahmed ATA, Rahman AKA, Haque EU, Ahmed ZU, Begum ZNT, Hassan MA, Khondker M, Rahman MM (eds) (2007b) Encyclopedia of flora and fauna of Bangladesh, Marine fishes, vol 24. Asiatic Society of Bangladesh, Dhaka

Smith BD, Ahmed B, Mansur RM, Strindberg S (2008) Species occurrence and distributional ecology of near shore cetaceans in the Bay of Bengal, Bangladesh, with abundance estimates for Irrawaddy dolphins, *Orcaella brevirostris* and finless porpoises, *Neophocaena phocaenoides*. J Cetacean Res Manag 10(1):45–58

Smith BD, Diyan MAA, Mansur RM, Fahrni-Mansur E, Ahmed B (2010) Identification and channel characteristics of cetacean 'hotspots' in waterways of the eastern Sundarbans mangrove forest, Bangladesh. Oryx 44(2):241–247

Stecker T, Wire C (2012) Restoring mangroves may prove cheap way to cool climate

Thompson PM, Islam MA (eds) (2010) Environmental profile of St. Martin's Island. United Nations Development Programme, Dhaka

UNEP (2012) Ecosystems based adaptation guidance. Moving from principles to practice (Lead authors: Ailbhe Travers, Carmen Elrick, Robert Kay and Ole Vestergaard). United Nations Environment Programme. http://www.unep.org/climatechange/adaptation/Portals/133/documents/Ecosystem-Based%20Adaptation/Decision%20Support%20Framework/EBA%20Guidance_WORKING%20DOCUMENT%2030032012.pdf

Yan X, Ohara T, Akimoto H (2003) Development of region-specific emission factors and estimation of methane emission from rice field in East, Southeast and South Asian countries. Glob Chang Biol 9:237–254