Coastal Mangrove Avifauna

An Ecological Study in the Greater Sundarbans with a Focus on Climate Change

By

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Dedicated to
Late parents Shaktipada and Anima
Late wife Krishna
Daughter Runa
Son Sumanta
Son-in-law Saptarshi
Daughter-in-law Sagarika
and
All eBirders of Greater Sundarbans

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Preface

Think globally, act locally - René Jules Dubos (1977)

Birds are among the most crucial species to the global ecosystem. Despite important ecological contributions, their diversity and abundance are declining at a shocking rate. One-in-eight bird species (755 Vulnerable, 423 Endangered and 231 Critically Endangered) is now threatened with extinction and must be protected at all costs (State of the World's Birds 2022, BirdLife International).

Globally, mangroves (often referred to as mangrove forests or thickets, mangals, swamps (fresh, brackish or saltwater), littoral, wetland, tidal, beach, coastal or oceanic rain forests) constitute the characteristic vegetation of the intertidal environment on sheltered tropical and subtropical coastline, globally covering roughly between 138, 000 km² and 200, 000 km² with a heavy presence in Asia, acting as a bridge connecting the land and sea. Between 35% and 50% of the world's mangrove forests were lost between 1980 and 2000 due to fish and shrimp culture, diversion of freshwater, land reclamation, agriculture, herbicides, salt ponds and coastal development.

Mangroves play an important role in capturing, transforming, and storing blue carbon (Choudhary et al., 2024). Blue carbon ecosystems play a critical role in regulating our climate. Global coverage of blue carbon ecosystems is estimated to be 139, 170 km² of mangroves (Siikamäki et al., 2012). One acre (0.405 hectare) of mangrove can sequester 1, 450 pounds of carbon, whereas one acre of salt marsh can sequester 1, 940 pounds of carbon. The existing blue carbon stock of the Indian Sundarbans was assessed at 26.5 Tg C (1 Tg= 1012 g) (Chanda & Akhand, 2023) as against 91.19 Tg C (36.24 Tg C and 54.95 Tg C in the above-ground and below-ground compartments respectively) in Bangladesh Sundarbans (Chanda et al., 2016). The intertidal mudflats of Indian Sundarbans are also potential sink of carbon (Sarker et al., 2021). This carbon stock might further be enhanced, provided deforestation remains arrested for the following years of this century.

In comparison to other tropical forests, mangrove stands are thought to have relatively low genetic diversity and population genetic structure gradually increasing with distance along the coastline. But these forests are most valuable, unique, special, productive and biologically complex as

well as vulnerable component of the coastal ecosystem with a relatively high degree of specialisation for the tidal wetland habitat and wild denizens including the array of birds. In addition to the resident terrestrial and aquatic birds, the vast tracts of coastal mangrove forests and swamps formed in the major river deltas of the world are important stop-over and wintering sites for migratory waterbirds belonging to the families Anatidae, Rallidae, Phalacrocoracidae, Scolopacidae, Laridae, etc. and, especially, the orders Ciconiiformes and Charadriiformes, using the Central Asian or East-Asia-Australasian flyway.

The Sundarbans, formed in the Bengal delta by the confluence of the rivers Ganges, Brahmaputra and Meghna on the north-eastern Bay of Bengal [phased accretion period of the westernmost coastal delta comprising whole of 24-Parganas Sundarbans: 5~2 ka BP (Bandyopadhyay, 2019)], is the single largest facultative and obligate halophytic coastal mangrove forests in the world, offering microhabitats and specialised niches to a huge avian diversity, which is little known in the absence of an extensive study in the transboundary ecosystem in India and Bangladesh. It is crucial to determine the species composition of the coastal mangrove bird community and understand the composition between migratory and resident birds and how they utilise the resources in the mangrove forest and hinterland. Bridging this knowledge gap through a longitudinal field research is, therefore, considered essential for efficient and effective biodiversity conservation in this World Heritage and Ramsar Wetland Site.

Sundarbans, which represents the best example of ecotone between the ocean and mainland, is divided into two parts, uninhabited (*baḍā*) reserve forests and inhabited (*ābād*) or hinterland, hereinafter referred to as the Greater Sundarbans. Whereas a hypothetical line, known as Dampier-Hodges line drawn in 1828, runs from west (Kakdwip, South 24-Parganas) to east (Basirhat, North 24-Parganas) in the Sundarban Biosphere Reserve (SBR) and is regarded as the northern limit of Indian Sundarbans, which contains both forests and densely populated non-forest areas demarcated by natural barriers (rivers), only the forested region in Bangladesh counterpart is regarded as Sundarbans and a sensitive Ecologically Critical Area (ECA) and Sundarban Impact Zone (SIZ) indicates the inhabited impact zone.

The Greater Sundarbans in the lower delta can be subdivided into four major vegetation units:

(1) The mangroves on the south and south-east: Dense forests (45%) decreased by 1.3%/year (1975-2020) and turned into moderate and sparse to barren, more in the Indian part than that of Bangladesh (Akbar Hossain et al., 2022).

(2) In the tidally active (saline-tidal) delta, human-dominated landscape on the south-west through north-east is scattered under the canopy shade of non-mangrove dominated vegetation;

(3) The human-dominated mature deltaic region on the north, often under the canopy shade of non-mangrove vegetation; and

(4) Canopy-patches in the transition zone exhibit a mixed mangroves and non-mangroves vegetation.

Factors influencing strata-preference by birds are resources, both food and space, as well as the bioecological characteristics of the birds themselves.

As per database prepared on the basis of a literature review followed by site-specific observations during the 21st century, 580 resident and migratory avifauna have been recorded from the contiguous coastal mangrove forests and reclaimed areas in India and Bangladesh (See Appendix). Additionally, a juvenile Tiger Shrike (*Lanius tigrinus* Drapiez, 1828), lacking the black mask over its eyes, actually a species known to breed in the temperate East Asia and a migrant to SE Asia (August-April), and in the instant case, an aberrant spring passage migrant to the coastal Sundarbans, has been clicked at Kargil beach on 14.5. 2024. Wondering how is it possible that the adults do not reach the spot as was experienced in Peninsular Malaysia and Singapore too! This is the first record not only in SBR, but also in India, and second record in the Indian Sub-continent followed by the first record in Bhutan in 2022. With this latest record, the total number of avian species in the Greater Sundarbans is 581. The highest number of bird species was, however, observed in the western (Indian) Sundarbans (518) than Bangladesh (434). Of course, both the sites have records of their own unique representation of species. The data highlight the importance of the coastal wetlands in the Greater Sundarbans as a strategic site, as well as the urgent

need for conservation of the avian communities in different landscape ecology as biodiversity and environmental indicators.

Ecologically, Sundarbans is a single ecosystem cleaved by the man-made borders. Indian Sundarbans has a shore length of about 130 km, of which a 30 km-long coastal non-forest (reclaimed) tract covers four sea-facing reclaimed islands (Sagar, Mousuni, Fraserganj-Bakkhali and G-Plot) and about 100 km tract is extended over eight uninhabited forest islands (e.g. Jambu, Lothian, Dhanchi, Kalas and Halliday in South 24-Parganas Division and Bulcherry, Dalhousie and Bhangaduni in Sundarban Tiger Reserve), all of which are vulnerable to climate change, particularly during the 21st century. The Bangladesh part covers about 230 km of shore length. It is also an ecologically fragile and climatically vulnerable region.

The mangrove system supports genetically diverse groups of both aquatic and terrestrial birds, specially adapted to exist under the level of salinity in monsoon (12.0 to 14.0 practical salinity unit or psu) and summer (29.0-30.0 psu), pH values between 5.3 and 8, tidal amplitudes between 3 and 5 m and up to 8 m in normal spring tide, monthly mean wind speed from 0.9 to 2.5 m/sec, air temperature from 11.96 to 37.0°C, mean annual rainfall variable from 1, 920 mm at Jhingekhali north of STR, to 2, 002 mm on the south-western coastal island of Sagar and about 1, 800 mm at Khulna to 2, 790 mm on the Bangladesh coast.

The muddy and anaerobic soil is rich in sodium, potassium, silicate and phosphorus. This review focuses on those excellent environmental indicators, yielding insights into the health of the wider environment of global importance and synthesises the wealth of information available on mangrove and shorebirds, particularly about the state of nature, the ecological stress upon them, vulnerability and conservation implications.

Evidently, Kolkata megacity was covered with mangrove vegetation and the saline marine condition extended up to north of Barrackpore, North 24-Parganas along with occurrence of tidal ingression at present Dum Dum (sic. the edge of the Saltlakes extended up to "the foot of a 9-m-high mound known as Dumduma) between 6, 000 and 10, 000 years BP (Mandal et al., 2010). In the beginning of the British rule (1770s), the forest was spread over 43, 252 km² under single administrative control and in the next two

hundred years, the forest cover reduced to 37, 813 km² (Sharma, 2013: 19), when longitudinally it covered about 400 km from Barisal and Jessore in Bangladesh to Sagar Island in West Bengal and the latitudinal extent was 170 km (Barua, 2013: 30), whereas currently the transboundary Sundarban mangroves, considered to be world's largest contiguous forested wetland system, is spread over nearly 12, 000 km² forest including about 5, 650 km² (47.08%) Protected Areas (PAs) and nearly 12, 000 km² reclaimed areas (part of prime mangroves and swamp forests about 250 years ago) in parts of seven districts, two in India and five in Bangladesh. At present, the Sundarbans is spread over about 260 km (east-west) and 80 km (north-south).

Historically, the dominant coastal habitat throughout the tropics has been mangrove forests, an ecosystem that commonly supports the largest regional populations of breeding waterbirds including the medium and shallow water generalists, stalking waders, pecking waders, mud picking waders and divers congregating for higher net available trophic energy and minimising competitive interactions by using varied feeding techniques. The coastal wetlands offer ready access to both nesting substrate and diverse foraging habitat in freshwater marshes, brackish estuaries, and saltwater mudflats that harbour a varied euryhaline prey-base. The specialist guild members show comparatively higher intra-guild niche overlap in comparison to much lower niche overlap of the generalist guild members. For example, whereas some birds require specific types of water habitats, such as the tidal flats that Spoon-billed Sandpiper (*Eurynorhynchus pygmaea*) uses during migration and winter, the mangrove forests and other coastal areas are favoured by many kingfishers like Black-capped Kingfisher (*Halcyon pileata*); but it can sometimes be found far inland.

Mangrove ecosystems are among the most threatened habitats in the world. Several physical and anthropogenic causes are responsible for mangrove degradation in the heterogeneous Sundarbans region. Climate denial has increased the risk of catastrophic global change by accelerating the vulnerability and extinction of the species that are dependent on the restricted mangrove and coastal habitats rapidly being lost or degraded through coastal development, overexploitation, pollution, salinity and other changes. Many projected climate changes including sea-level rise, higher temperatures (mean temperature increases by 1.4°C), evapo-transpiration losses, enhanced monsoon precipitation and run-off, potentially

reduced dry season precipitation, and increase in cyclone intensity have severe impacts on the habitats and habitants. Therefore, the mangrove and shore bird populations around the world provide us vital insights into the effects of climate change on species and ecosystems.

At the crossroads of science and ethics, the living species in a particular ecosystem are to be respected as a precious gift of nature for the survival of the human race. To avoid the consequences of global warming in the 21st century, scientists advocate a radical change in stakeholder's behaviour– "Changing minds, not the climate" was the slogan for the public awareness campaign of UNESCO's Strategy for Action on Climate Change (2018-2021). Changing minds means establishing a new order of priorities in politics, the economy, industry and the daily lives of the forest-dependent communities. It is in line with the 2015 Paris Agreement (COP21) and the United Nations' 2030 Agenda for Sustainable Development (SDGs). In November 2017, UNESCO adopted the Declaration of Ethical Principles in relation to Climate Change– a tool that is accessible to all actors in society, especially political leaders, to allow for the most appropriate decision-making. This declaration is based on six ethical principles:

(i) Prevention of harm: To comply with it, people should aim to "anticipate, avoid or minimise harm, wherever it might emerge, from climate change, as well as from climate mitigation and adaptation policies and actions."

(ii) Precautionary approach: It shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to anticipate, prevent or minimise the causes of climate change and mitigate its adverse effects.

(iii) Equity and Justice: It is the fair treatment and meaningful involvement of all people regardless of race, colour, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies.

(iv) Sustainable Development: It implies the fulfilment of several con-

ditions, i.e. preserving the overall balance, respect for the environment, and preventing the exhaustion of natural resources.

(v) Solidarity: Climate change has created a new global interdependence that requires a new form of solidarity as a global and intergenerational prosocial behaviour.

(vi) Scientific knowledge: Decisions should be based on, and guided by, the best available knowledge from the natural and social sciences and

(vii) Integrity in decision-making: States should take measures which help protect and maintain the independence of science and the integrity of the scientific process.

It is our moral responsibility to protect the vulnerable birds and their habitat. The ethics being explored in this study on the coastal mangrove birds with emphasis on the Sundarbans include:

1. Site-specific diversity of the birds, their habitat uses, food habits and breeding behaviour;

2. Status as threatened species;

3. Main threats to their survival (climate change and anthropological activities); and

4. Key conservation efforts and challenges, strategies and prospects.

In terms of ecology, this study explains how living species are suited to their particular habitat and how they respond to environmental changes, both natural and human-induced. Sea surface temperature (SST) in Sundarbans is increasing at 0.5°C per decade against a global figure of 0.06°C (Mahadevia Ghimire & Vikas, 2012). The rise of sea-level because of thermal expansion has been observed pushing the saline water upstream into estuaries and rivers, threatening the distribution and health of the freshwater-dependent lifeforms and forcing their range changes that may lead to extinction. The rise in sea-levels and temperature is thought to intensify the storms by 26% over the past 120 years (Karfa et al., 2020) as wind speeds

and precipitation levels are continually increasing causing havoc to the existing species for reduced habitat and decline in prey and other natural food items.

The composite vulnerability index (CVI) that incorporates mitigation capacity indicates wide inter-village variations in the degree of spatial vulnerability (Ghosh & Mistri, 2023). Whereas the southern and eastern Matla–Bidya inter-estuarine zones are extremely vulnerable (CVI > 0.544) due to their geographical location and high exposure to coastal hazards, the northern parts show low vulnerability (CVI < 0.387) due to less exposure and high resilience and other parts show moderate vulnerability. Warmer atmospheric temperatures result in higher rates of evaporation and increased levels of water vapour in the atmosphere, causing higher levels of precipitation and volatile weather patterns. The monsoon season in particular has been considerably erratic in recent years, resulting in unpredictable damage to the environment in the Sundarbans.

Changes in the timing of seasonal events are one of the most widely reported impacts of recent climate change. Remarkably, the timing of spring events has advanced by ± a month per year, which may disrupt the ability of birds to match their timing of breeding and migration to periods of peak resource availability.

The average elevation of the Sundarbans is <one metre above sea-level (masl), for which this region is highly susceptible to flooding during any swelling of ocean water. Though mangroves are somewhat resistant to submersion in water, they are dying when tidal inundation takes place too frequently or lasts too long. In addition, frequent and persistent flooding also causes coastal and riverbank erosion, which result in the decline of the total land area and increase of the aquatic area up to the highwater level. The recent disappearance of some of the delta's islands is of concern for the future of the extant islands. For example, during a period of 40 years (1975-2015) four vulnerable mangrove forest islands facing the Bay of Bengal shrunk considerably- Bulcherry (30.8 km² to 21.0 km²), Dalhousie (77.7 km² to 59.5 km²), Bhangaduni (43 km² to 23.3 km²) and Halliday (3.6 km² to 0.3 km²) (Mondal & Saha, 2018). Mayadwip was further reduced from 273.36 to 22.7 km² in 2021 (Justin & Ghosh, 2022).

Coastal dune system in the Sundarbans comprises a system of low ridges parallel to the coast, separated by large dry and wet sand flats. However, coastal dunes of the western islands are now being engulfed by the encroaching sea waves with the activities of cyclones. About 99 km^2 of land lost due to coastal erosion from 1990 to 2016. The rate of coastal erosion is high on the coast of Fraserganj, Bakkhali and Sagar. The Fraserganj coast is almost destroyed by the long-shore current attack from the west.

Furthermore, the mudflats in the Sundarbans are located at the estuary and on the deltaic islands where low velocity of river and tidal current occurs. The flats are exposed in low tides and submerged in high tides, thus being changed morphologically even in one tidal cycle. Therefore, the mudflat or the shoreline is the most significant zone of natural nutrient cycling in Sundarbans and is the ecotone of land and aquatic ecosystems as it is the zone of mixing of the brackish waters with the mudflat or the sandy beaches.

Due to the huge abundance of animals that live in the mud, it acts as an 'all you can eat food buffet' for birds. Many waders enjoy searching for food that lives inside the sediment while ducks and geese enjoy munching on the plants that live on top. Different birds are adapted to feed on different mud dwelling animals – birds with longer beaks can eat the animals who live deeper while shorter beaks are adapted for eating the animals which live near the surface. However, this buffet is only open when the tide is low. Otherwise, they can be found resting on high ground or manmade structures nearby when the tide is high, conserving energy and waiting for the mud to appear again.

Mudflat birds are the regular bio-indicator for the shoreline ecotone. The edge-effect sustains a lot of micro-fauna which are taken by some of the birds. Many of these shorebirds are migratory, often coming in the winter months, when bird density, diversity and species richness were observed higher than in other seasons. Since these mudflats are distributed along the forest edge and inhabited islands, loss of the intertidal mudflats is expected to have major impacts on habitat availability for migratory and resident waterbirds. Some anthropogenic activities cause negative impact on the mudflat habitat.

The abundance of different species of birds in this study area reveals that

they are already better able to adapt to changing environments, whereas the species that are rare, endangered and threatened already— from habitat fragmentation or invasive species or any other environmental change— are even more sensitive to climate change. Species that are relatively short-lived, but reproduce very easily, are able to adapt and respond quickly to such changes. The threatened species can recover very quickly if the governments, wildlife officials, stakeholders and non-government conservationists put the lost environment back on track for them.

This monograph includes a general account of the species diversity and distribution of birds in the mangroves and coastal areas in the Sundarbans and hinterland in a global perspective with special emphasis on their ecology and climate-change ethics. This has revealed multiple perspectives of the relationship between mangroves special heterogeneity and bird diversity, influences on birds from the growth and decline of mangroves, horizontal gradient of bird's diversity in mangroves, impact on mangroves from birds, role of birds in food web in mangroves, bird community in mangrove region and impact of the artificial facilities along the coast on the birds in mangrove area.

Acknowledgments

I am indebted to all those forest department officials, from whom I had initially gained a better understanding of the intricacies of biodiversity conservation and the tender balance of relationships within the natural world, as well as grateful to those field staff and other respondents, who provided valuable inputs while I was conducting the questionnaire and field surveys.

Chapter 1

Introduction: Mangrove Forests, Conservation Areas and Status

Global Perspectives

The interfaces between the global core realms are recognised as transitional realms, accommodating ecosystems, such as mangroves, that depend on unique conditions and fluxes between contrasting environments (Keith et al., 2020). Mangroves are trees and shrubs growing in intertidal zones or brackish water of tropical and subtropical coastal areas between 5°N and 5°S latitude spanning over 118 countries (Sharma, 2018).

Mangrove forests provide ecosystem services worth at least US $1.6 billion each year (Costanza et al., 1997). Mangroves stabilise coastlines, reduce erosion, foster biodiversity growth and protect coastal communities. Healthy mangrove ecosystems are, therefore, critical for global climate action. Mangroves and coastal wetlands annually sequester carbon at a rate ten times greater than mature tropical forests. They also store three to five times more carbon per equivalent area than tropical forests i.e. 350 million megagrams in both aboveground biomass and soil carbon and in building resilience to a rapidly warming world. That is why the Global Mangrove Alliance (GMA) has generated a revised goal for 2030- 'Halt loss, restore half, double protection' (Leal & Spalding, 2022).

Globally, there were 145,068 km² mangrove forests in 2020, among which Asia contained the largest coverage (39.2%); at the country level, Indonesia had the largest distribution of mangrove forests, followed by Brazil and Australia (Jia et al., 2023). But Leal & Spalding (2022) estimated 147,359 km² mangrove-coverage in 2020 as detailed below.

Sl. No.	Region	Area (km^2)	% of total
1	Southeast Asia: Brunei Darussalam, Cambodia, Indonesia, Malaysia, Myanmar, the Philippines, Singapore, Thailand, Timor Leste and Vietnam	48, 222	32.73
2	North and Central America and the Caribbean (Anguilla, Antigua and Barbuda, Aruba, Bahamas, Barbados, Belize, Bermuda, British Virgin Islands, Cayman Islands, Costa Rica, Cuba, Dominica, Dominican Republic, El Salvador, Grenada, Guadeloupe, Guatemala, Haiti, Honduras, Jamaica, Martinique, Mexico, Montserrat, Netherlands Antilles, Nicaragua, Panama, Puerto Rico, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Trinidad and Tobago, Turks and Caicos Islands, United States, US Virgin Islands)	22, 827	15.49
3	South America (Brazil, Colombia, Ecuador, French Guiana, Guyana, Peru, Suriname, Venezuela (Bolivarian Rep. of)	20,378	13.83
4	West and Central Africa (Angola, Benin, Cameroon, Congo, Côte d'Ivoire, the Democratic Republic of Congo, Equatorial Guinea, Gabon, Gambia, Ghana, Guinea, Guinea Bissau, the Ivory Coast, Liberia, Mauritania, Nigeria, São Tomé and Principe, Senegal, Sierra Leone and Togo)	21,715	14.74
5	Eastern Africa (Mozambique, Tanzania, Kenya, and southern Somalia) and Southern Africa (South Africa, Mozambique)	7,630	5.17
6	Australia and New Zealand	10,467	7.10
7	South Asia (Bangladesh, India, Pakistan, and Sri Lanka)	9,549	6.49
8	Pacific Islands (Fiji, Vanuatu, Papua New Guinea, Samoa, Solomon Islands, Tonga)	6,058	4.11
9	Middle East (United Arab Emirates, Iran)	285	0.19
10	East Asia (China, Japan and Taiwan)	228	0.15
Total		147,359	100.00

Table 1 *Global Mangrove-coverage*

Globally, out of 336,972 mangrove patches in 2020, Asia covers largest number (36.5%), followed by North America (20.8%), Oceania (18.7%), South America (12.4%), and Africa (11.6%) (Jia et al., 2023). Large patches are found in the estuary of the Amazon River, Sembilang National Park in Indonesia's South Sumatra Province and the Sundarbans along the northern Bay of Bengal. Mangrove forests in Australia are sparse, whereas natural reserves along these coasts are relatively large. In contrast, the coasts of southern and southeastern Asia hold large areas of mangrove forests;

however, the aerial extents of mangrove forests, that are notified protected areas, are much less.

Global Mangrove Extent: Change detection during 1996–2020

Overall, 152,604 km^2 (range 133,996–176,910) of mangroves, identified in 1996, decreased to 147,359 km^2 (127,925–168,895) in 2020 (−5,245 km^2 or 3.4%) (Bunting et al., 2022).

Global Biophysical Typology of Mangroves

Mangrove patches are classified as deltaic, estuarine, lagoonal or open coast (associated with bays, or no coastal embayment), based on their proximity to coastal features. The mangrove units are assigned to a sedimentary setting with all deltaic and estuarine units classed as terrigenous (i.e. dominated by minerogenic sedimentation from terrestrial sources), whereas lagoonal or open coast patches could be classed as terrigenous or carbonate (i.e. dominated by calcareous sedimentation). Based on 2016 extent (135,869 km^2) of global mangrove biophysical typology, 40.5% (54,972 km^2) of mangrove systems was deltaic, 27.5% (37,411 km^2) estuarine and 21.0% (28,493 km^2) open coast, with lagoonal mangroves the least abundant (14,993 km^2 or 11.0%) (Worthington et al., 2020).

Family	Genus	Species	Sub-species	Common name	Status
Acanthaceae	*Avicennia*	*alba*	-	Kalo Baen	LC
		balanophora	-	White mangrove	NE
		bicolor	-	Mangle Salado	VU
		germinans	-	Black mangrove	LC
		integra	-	Integral Mangrove	VU
		marina	*australasica*	Grey mangrove	LC
			eucalyptifolia		
			marina		
			rumphiana		
		officinalis	-	Indian mangrove	LC
		schaueriana	-	Schauer's Mangrove	LC

Family	Genus	Species	Sub-species	Common name	Status
Combretaceae	*Conocarpus*	*erectus*	-	Button mangrove	LC
	Laguncularia	*racemosa*		White mangrove	LC
	Lumnitzera	*littorea*	-	Red-Flowered Black Mangrove	LC
		racemosa	-	Black Mangrove	LC
Arecaceae	*Nypa*	*fruticans*	-	Nypa Palm	LC
Rhizophoraceae	*Bruguiera*	*cylindrica*	-	White Burma Mangrove	LC
		exaristata		Rib-fruited orange mangrove	LC
		gymnorhiza		Large-Leafed Orange Mangrove	LC
		parviflora		Small flower Bruguiera	LC
		sexangula		Upriver orange mangrove	LC
	Ceriops	*australis*		Smooth-fruited yellow mangrove	LC
		decandra		Jhamti Garan	NT
		tagal		Math Garan	LC
	Kandelia	*candel*		Narrow-Leaved Kandelia	LC
		obovata		Little Water Pen	LC
	Rhizophora	*apiculata*		Tall-Stilt Mangrove	LC
		harrisonii		Red Mangrove	-
		mangle		Red Mangrove	LC
		mucronata		Loop-root mangrove	LC
		racemosa		Gentleman Giant Mangrove	LC
		samoensis		Samoan Mangrove	NT
		stylosa		Spotted or Small-Silted Mangrove	LC
Lythraceae	*Sonneratia*	*alba*	-	Sweet-Scented Apple Mangrove	LC
		apetala	-	Sonneratia Mangrove	LC
		caseolaris	-	Crab apple mangrove	LC
		griffithii	-	-	CR
		ovata	-	Pedaba	NT
Acanthaceae	*Acanthus*	*ilicifolius*	-	Holy mangrove	LC
	Bravaisia	*integerrima*	-	Canacoite	LC
Bombacaceae	*Camptostemon*	*philippinensis*	-	Gapas-gapas	EN
		schultzii	-	Kapok Mangrove	LC
Cyperaceae	*Fimbristylis*	*ferruginea*	-	West Indian Fimbry	LC

Family	Genus	Species	Sub-species	Common name	Status
Euphorbeaceae	*Excoecaria*	*agallocha*	-	Milky Mangrove	LC
	Shirakiopsis	*indica*	-	Swamp Willow	LC
Lecythidaceae	*Barringtonia*	*acutangula*	-	Freshwater Mangrove	LC
		asiatica	-	Beach Barringtonia	LC
		racemosa	-	Powderpuff Mangrove	LC
Lythraceae	*Pemphis*	*acidula*	-	Small-leaved Mangrove	LC
Malvaceae	*Heritiera*	*fomes*	-	Sundri	EN
Meliaceae	*Xylocarpus*	*granatum*	-	Cannonball Mangrove	LC
		moluccensis	-	Cedar Mangrove	LC
Myrtaceae	*Osbornia*	*octodonta*	-	Myrtle mangrove	LC
Plumbaginaceae	*Aegialitis*	*annulata*	-	Club mangrove	-
		rotundifolia	-	Tora	NT
Primulaceae	*Aegiceras*	*corniculatum*	-	River Mangrove	LC
Pteridaceae	*Acrostichum*	*aureum*	-	Golden Leather Fern	LC
Rubiaceae	*Scyphiphora*	*hydrophylacea*	-	Yamstick Mangrove	-
Tetrameristaceae	*Pelliciera*	*rhizophorae*	-	Tea Mangrove	LC

Table 2 *True Mangrove Species with Status*

IUCN Red List of Mangrove Ecosystem

Around the globe, there are around 70 known species of true mangroves in 20 genera from 16 families (Hogarth, 2015), out of which 11 (c.16%) are threatened species. Losses of 11,700 km² mangroves are indicated since 1996, but also considerable gains are reported, mainly in the river-mouths and deltas, leading to an estimate of net loss since 1996 of 5,245 km². As per the GMA's Report (2022), rates of loss have greatly diminished (467 in 1990-2000, 363 in 2000-2010 and 212 in 2010-2020) with average losses over the last decade of just 66 km² or 0.04% of all mangroves per year.

Realm	Area (km^2)	Countries	Conservation Status	Protected Areas (km^2)	Important birds
Afrotropical					
Central African mangroves	27,570	Angola, Cameroon, Democratic Republic of the Congo, Equatorial Guinea, Gabon, Ghana, Nigeria	Critical/ endangered	7,261 (26%) e.g. Douala Edéa NP (Cameroon), Monte Alén NP (Equatorial Guinea), Akanda and Pongara NPs (Gabon), Mangroves NP (Democratic Republic of the Congo)	Striated heron (*Butorides striata*), Reed cormorant (*Microcarbo africanus*) and large flocks of migratory birds
East African mangroves 7.3000°S 39.3600°E	1,880	Kenya, Mozambique, Somalia, Tanzania	Critical/ endangered	843 (45%) e.g. Watamu Marine NP and Ras Tenewi Marine NP (Kenya); Mafia Island Marine Park, Jozani Chwaka Bay NP, Saadani NP (Tanzania); the Bazaruto Archipelago, Inhaca and Portuguese Island, Marromeu Game Reserve, and Pomene Reserve (Mozambique)	Migratory birds such as Curlew sandpiper (*Calidris ferruginea*), Little stint (*Calidris minuta*) and Caspian tern (*Hydroprogne caspia*), waterbirds such as Crab-plover (*Dromas ardeola*), Yellow-billed stork (*Mycteria ibis*), Malachite kingfisher (*Corythornis cristatus*), and seabirds such as Roseate tern (*Sterna dougallii*).
Guinean mangroves	22,165	Senegal, Gambia, Guinea-Bissau, Guinea, Sierra Leone, Liberia, Ivory Coast	Vulnerable	5,289 (24%) Saloum Delta NP and Basse Casamance NP (Senegal), Niumi NP (Gambia), and Tarafes de Cacheu NP (Guinea-Bissau).	Goliath heron (*Ardea goliath*), purple heron (*Ardea purpurea*), cattle egret (*Bubulcus ibis*), striated heron (*Butorides striata*), western reef heron (*Egretta gularis*), greater flamingo (*Phoenicopterus roseus*), lesser flamingo (*Phoeniconaias minor*), African spoonbill (*Platalea alba*), and African sacred ibis (*Threskiornis aethiopicus*) as well as migratory birds.

Realm	Area (km²)	Countries	Conservation Status	Protected Areas (km²)	Important birds
Madagascar mangroves 17°1′S, 44°12′E	5,200	Madagascar	Vulnerable	Mananara Nord NP	Madagascar heron (*Ardea humbloti*), Madagascar fish eagle (*Icthyophaga vociferoides*), African spoonbill (*Platalea alba*), great egret (*Ardea alba*), sakalava rail (*Zapornia olivieri*) and grey heron (*Ardea cinerea*).
Southern Africa mangroves	947	Mozambique, South Africa	Vulnerable	229 (24%) Beachwood Mangroves Nature Reserve near Durban and Simangaliso Wetland Park (formerly Greater St Lucia Wetland Park)	Endemic mangrove kingfisher (*Halcyon senegaloides*); breeding area for at least 48 species of birds, including lesser flamingo (*Phoeniconaias minor*), great white pelican (*Pelecanus onocrotalus*), pink-backed pelican (*Pelecanus rufescens*), grey-headed gull (*Chroicocephalus cirrocephalus*), Cape shoveler (*Spatula smithii*), yellow-billed duck (*Anas undulata*), pied avocet (*Recurvirostra avosetta*), saddle-billed stork (*Ephippiorhynchus senegalensis*), yellow-billed stork (*Mycteria ibis*), and Caspian tern (*Hydroprogne caspia*) as well as migratory birds.
Australasian					

Realm	Area (km^2)	Countries	Conservation Status	Protected Areas (km^2)	Important birds
New Guinea mangroves 5.1°S, 137.7°E	25,303	Indonesia, Papua New Guinea	Vulnerable	5,833 (23%) Bintuni Bay Nature Reserve, Lorentz NP and the Pulau Kimaam Wildlife Reserve (Indonesia) and the Kikori Integrated Conservation and Development Project (Papua New Guinea)	New Guinea flightless rail (*Megacrex inepta*), red-billed brush-turkey (*Talegalla cuvieri*), Wallace's fruit-dove (*Ptilinopus wallacii*), western crowned pigeon (*Goura cristata*), Salvadori's fig parrot (*Psittaculirostris salvadorii*), black lory (*Chalcopsitta atra*), brown lory (*Chalcopsitta duivenbodei*), Papuan swiftlet (*Aerodramus papuensis*), red-breasted paradise-kingfisher (*Tanysiptera nympha*), white-bellied pitohui (*Pseudorectes incertus*), and olive-crowned flowerpecker (*Dicaeum pectorale*).

Realm	Area (km^2)	Countries	Conservation Status	Protected Areas (km^2)	Important birds
Australian mangroves	11,500	Australia	Vulnerable	18%	Varied honeyeater (*Gavicalis versicolor*), mangrove honeyeater (*Gavicalis fasciogularis*), rufous-banded honeyeater (*Conopophila albogularis*), mangrove robin (*Peneothello pulverulenta*), lemon-bellied flycatcher (*Microeca flavigaster*), buff-sided robin (*Poecilodryas cerviniventris*), little shrike-thrush grey whistler (*Colluricincla harmonica*), white-breasted whistler (*Pachycephala lanioides*), northern fantail (*Rhipidura rufiventris*), mangrove grey fantail (*Rhipidura phasiana*), Arafura fantail (*Rhipidura dryas*), broad-billed flycatcher (*Myiagra ruficollis*), shining flycatcher (*Myiagra alecto*), spectacled monarch (*Symposiachrus trivirgatus*), white-eared monarch (*Carterornis leucotis*), yellow white-eye (*Zosterops luteus*), rose-crowned fruit-dove (*Ptilinopus regina*), little bronze-cuckoo (*Chrysococcyx minutillus*), Papuan frogmouth (*Podargus papuensis*), azure kingfisher (*Ceyx azureus*), little kingfisher (*Ceyx pusillus*), forest kingfisher (*Todiramphus macleayii*), Torresian kingfisher (*Todiramphus sordidus*), sacred kingfisher (*Todiramphus sanctus*) and fawn-breasted bowerbird (*Chlamydera cerviniventris*)
Indomalayan					

Realm	Area (km^2)	Countries	Conservation Status	Protected Areas (km^2)	Important birds
Godavari–Krishna mangroves	7,000	India	Vulnerable	14% Point Calimere Wildlife and Bird Sanctuary, Pulicat Lake Bird Sanctuary and Bhitarkanika NP	140 bird species, including lesser florican (*Eupodotis indica*), egrets, flamingoes (*Phoenicoptreus* spp.), spot-billed pelicans (*Pelecanus philippensis*), Eurasian spoonbills (*Platalea leucorodia*), and painted storks (*Mycteria leucocephala*).
Indochina mangroves 10°N, 106.25°E	26,936	Cambodia, Malaysia, Thailand, Vietnam	Vulnerable	Mui Ca Mau NP	Lesser adjutant (*Leptoptilos javanicus*), white-winged wood duck (*Cairina scutulata*) and spot-billed pelican (*Pelicanus philippensis*).
Indus River Delta–Arabian Sea mangroves 24.65°N, 67.30103°E	5,698	Pakistan	Critical/ endangered	Marho Kotri, Cut Munarki Chach Wildlife Sanctuaries and Mirpur Sakro Game Reserve	Greater flamingo (*Phoenicopterus roseus*), Dalmatian pelican (*Pelecanus crispus*), great white pelican (*Pelecanus onocrotalus*), grey heron (*Ardea cinerea*), purple heron (*Ardea purpurea*), night herons, Brahminy kite (*Haliastur indus*), Western marsh harrier (*Circus aeruginosus*), black-shouldered kite (*Elanus axillaris*), common kestrel (*Falco tinnunculus*), lesser kestrel (*Falco naumanni*), Eurasian sparrowhawk (*Accipiter nisus*), greater coucal (*Centropus sinensis*), grey-headed swamphen (*Porphyrio poliocephalus*), water rail (*Rallus aquaticus*) and migratory birds.

Realm	Area (km^2)	Countries	Conservation Status	Protected Areas (km^2)	Important birds
Myanmar coast mangroves 10°N, 106.25°E	<5,000	Myanmar, India, Malaysia, Thailand	Vulnerable	Mein-ma-hla Kyun Wildlife Sanctuary	Oriental darter (*Anhinga melanogaster*), little cormorant (*Phalacrocorax nigers*), Pacific reef heron (*Egretta sacra*), great-billed heron (*Ardea sumatrana*), ruddy shelduck (*Tadorna ferruginea*), bronze-winged jacana (*Metopidius indicus*), lesser sand plover (*Charadrius mongolus*), beach stone-curlew (*Esacus magnirostris*), black-winged stilt (*Himantopus himantopus*), Nordmann's greenshank (*Tringa guttifer*), lesser black-backed gull (*Larus fuscus*) and common moorhen (*Gallinula chloropus*).
Sunda Shelf mangroves	37,529	Brunei, Indonesia, Malaysia	Vulnerable	13.16% Borneo Bako NP (Malaysia), Tanjung Puting and Gunung Palung NPs (Indonesia), and Berbak and Sembilang NPs (Sumatra).	White-bellied Sea Eagle (*Haliaeetus leucogaster*), brahminy kite (*Haliastur indus*), and species of herons, cormorants, plovers, sandpipers, kingfishers, terns, sunbirds, munias, and tailor birds.
Sundarbans mangroves	See Indo-Bangladesh Sundarbans below				

Table 3 *List of Global Mangrove Ecoregions harbouring important birds with Status*

Indian Perspectives

The mangrove habitat in India [4,992 km^2 (2021) or 0.15% of the total geographical area] is broadly classified into three categories (Mandal & Naskar, 2008): Deltaic (Eastern Coast Mangroves, Bay of Bengal: 58%); Estuarine and Backwater (Western Coast Mangroves, Arabian Sea: 29%); and Insular (Andaman and Nicobar Islands between the Bay of Bengal to the west and

the Andaman Sea to the east: 13%). These forests are categorised into Very Dense Mangrove with canopy density >70% (29.54%), Moderately Dense Mangrove with canopy density 40-70% (29.67%) and Open Mangrove with canopy density 10-40% (40.79%), as shown in the table below.

Sl.no	State/Union Territory	Very dense	Moderately dense	Open	Total	Change since 2019
1	Andhra Pradesh	0.00	213.00	192.00	405.00	1.00
2	Goa	0.00	21.00	6.00	27.00	1.00
3	Gujarat	0.00	169.00	1,006.00	1,175.00	-2.00
4	Karnataka	0.00	2.00	11.00	13.00	3.00
5	Kerala	0.00	5.00	4.00	9.00	0.00
6	Maharashtra	0.00	90.00	234.00	324.00	4.00
7	Odisha	81.00	94.00	84.00	259.00	8.00
8	Tamil Nadu	1.00	27.00	17.00	45.00	0.00
9	West Bengal	994.00	692.00	428.00	2,114.00	2.00
10	Andaman and Nicobar Islands	399.00	168.00	49.00	616.00	0.00
11	Daman & Diu and Dadra & Nagar Haveli	0.00	0.00	3.00	3.00	0.00
12	Puducherry	0.00	0.00	2.00	2.00	0.00
Total		1,475.00	1,481.00	2,036.00	4,992.00	17.00

Table 4 *Distribution and Density of the Indian Mangrove Forests (area in km²) in 2021 with change detection since 2019*

Source: India State of Forest Report, 2021

India's mangrove forests account for only 3.3% of worldwide mangrove forests (ISFR Report, 2021). An increase of 2 km² mangrove cover in the South 24-Parganas district is primarily due to rehabilitation.

223 taxa of birds (30 Families under 9 Orders), e.g. ducks, shorebirds, gulls, terns and flamingos, were recorded from the coastal wetlands of India, out of which 91 species were residents, 90 trans-continental migrants, 37 resident migrants, four vagrant and one straggler including East Coast (166: eight orders and 27 families), followed by West Coast (163: eight orders and 26 families), and Andaman & Nicobar Islands (143: nine orders and 22 families)(Sivaperuman et al., 2015).

Bangladesh Perspectives

Extensive natural and manmade mangroves are present in Bangladesh under the following major forest associations, which provide habitat of 42% birds of the country (Hoque & Dutta, 2005):

Sl.No.	Forest type	Area (km^2)	% of total forest
1	Sundari (*Heritiera fomes*)	831	21.01
2	Sundari (*H. fomes*) – Gewa (*Excoecaria agallocha*)	165	29.45
3	Sundari (*H. fomes*) – Passur (*Xylocarpus mekongensis*)	22	0.57
4	Sundari (*H. fomes*) – Passur (*X. mekongensis*) – Kankra (*Bruguiera gymnorrhiza*)	65	1.64
5	Gewa (*E. agallocha*)	196	4.95
6	Gewa (*E. agallocha*) – Sundari (*H. fomes*)	585	14.78
7	Gewa (*E. agallocha*) – Goran (*Ceriops decandra*)	362	9.15
8	Goran (*C. decandra*) – Gewa (*E. agallocha*)	572	14.46
9	Goran (*C. decandra*)	93	2.35
10	Keora (*Sonneratia apetala*)	33	0.83
11	Other associations	32	0.81
Total vegetated area		3,956	100.00

Table 5 *Areas under major forest associations in the Bangladesh Sundarbans*

Natural mangroves are distributed in the southwestern and southeastern part of Bangladesh and mangrove plantations are mostly in the central part of the coast viz. in the Meghna estuary. The Sundarbans natural mangrove in the southwestern part of Bangladesh lies between 21°31′ and 22°30′ N and 89° and 90° E. Most of the southeast coast (except the beaches) of Bangladesh is lined with scattered and degraded fringe mangroves, of which the Chakaria Sundarbans, lying between 21°36′-21°45′ N and 91°58′-92°05′ E in Cox's Bazar extended over an area of about 182 km^2 but reduced sharply due to shrimp farming. In the Meghna estuary, there are about 110 km^2 of mangrove plantations scattered in the onshore and offshore islands.

Dividing into three major divisions as the eastern, central and western part, Bangladesh coastline extends over 710 km from the living coral island St. Martin's in the south-east to the pristine Sundarbans mangrove forest in the south-west. Chowdhury (2011b) recorded 59 species of shorebirds in Bangladesh, whereas according to Shamsuddoha & Islam (2016), 100