Chapter 8
Mangroves: A Reservoir of Biodiversity

Abstract Biodiversity of mangrove ecosystem includes a wide spectrum of flora and fauna with several direct and indirect societal benefits. There are different techniques to tag the benefits generated by mangrove-centric biodiversity with finance. The comprehensive valuation of mangrove biodiversity is still in an embryonic stage. On the one hand the value of provisioning services manifests itself through market prices; on the other, the importance of biodiversity as part of the ecosystem that produces and regulates cultural services cannot be captured in financial markets. The present chapter has highlighted the biodiversity of Indian Sundarban mangrove ecosystem with special emphasis on their ecosystem services.

Keywords Mangrove biodiversity · Flora · Fauna · Provisioning service · Cultural service

Biodiversity refers to all life on the planet Earth and ranges from the microbes in the human gut to blue whale of the ocean. So far 1.7 millions species have been indentified and recorded on the earth, but the total number is thought to be somewhat between 5 and 100 million. Biodiversity encompasses three important tiers or segments of biosphere, namely, habitat diversity, species diversity and genetic diversity. The major portion of the coastal zone of Bay of Bengal in the maritime state of West Bengal (India) is covered with luxuriant mangrove vegetation and the brackish-cum-saline aquatic phase of this environment nourishes the world's most famous mangrove chunk- the Sundarbans. In fact, mangroves forest, mangrove swamps and backwater of Sundarbans form a productive and protective margin of coastal West Bengal.

The Sundarbans Biosphere Reserve in the Indian part houses diverse types of habitats ranging from mud flats to sandy beaches and extremely saline to almost fresh water zones each exhibiting distinct seasonal oscillations of physio-chemical variables like salinity, pH and dilution factor. The various species thriving in this vibrating ecosystem exhibit high degree of adaptive modification as insurance against the fluctuation of environmental conditions.

The Indian Sundarban mangrove forest ecosystem in the lower Gangetic delta is dominated by the salt tolerant halophytic seed plants that range in size from tall

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Fig. 8.1 Specialized feature of mangrove tree is the presence of pneumatophores

trees to shrubs with some similarities in general architecture like presence of pneumatophores, crypto-viviparous seeds or propagules, xerophytic leaves etc. (Fig. 8.1) and physiology like presence of salt excretory glands or salt regulation system.

Substrate characteristic is an important determining factor that controls the community structure and growth of mangrove ecosystem. The mangrove soils are usually characterized by well sorted fine silts containing large quantities of organic matter, mainly fine fibrous root material. Redox potential and pH are typical of flooded anaerobic soils. A study done by Boto and Wellington (1984) on the soil characteristics and nutrient status in the northern Australian mangrove forests revealed that pH of the soils was consistently within the range 6.2–7.0 at all the sites, similar to results obtained in other flooded soils (Clarke and Hannon 1967; De Laune et al. 1976; Hesse 1961). During the period of high plant activity, as evidenced by rate of new leaf shoot appearance, the pH was consistently low (6.2–6.6) in the 20–40 cm depth zone. At other times, the pH was less variable with depth (around 6.8–7.0). This indicates that root exudates during high activity period may influence the soil pH (Motomura 1962). Among the major factors governing the pH of flooded soils, the concentrations of reduced iron and manganese hydroxides and carbonates, carbonic acid and humic acid are very important (Patrick and Mikkelsen 1971; Ruttner 1963).

Table 8.1 Organic matter and nutrient status of island soils

Parameter	Prentice range	Average	Lothian range	Average	Harinbari range	Average	Sagar range	Average
Organic matter:								
Organic carbon (%)	0.45–0.69	0.55	0.99–1.86	1.31	0.29–0.56	0.39	0.26–0.72	0.45
Humus carbon (%)	0.07–0.19	0.15	0.30–0.13	0.43	0.09–0.16	0.12	0.09–0.21	0.015
Humic acid carbon (%)	0.01–0.90	0.04	0.09–0.29	0.17	0.03–0.06	0.04	0.01–0.05	0.03
Fulvic acid carbon (%)	0.07–0.13	0.09	0.14–0.44	0..26	0.45–0.11	0.08	0.07–0.16	0.11
Carbon (%) HA-C/FA-C	0.14–0.90	0.47	0.42–1.71	0.73	0.40–0.86	0.59	0.11–0.56	0.33
Nitrogen								
Available N (me/100 g)	0.61–0.01	0.78	0.64–0.83	0.75	0.29–0.67	0.44	0.42–0.84	065
NH_4-N (me/100 g)	0.23–0.36	0.30	0.27–0.34	0.31	0.16–0.29	0.21	0.21–0.30	0.26
NO_3-N (me/100 g)	0.09–0.30	0.19	0.16–0.24	0.20	Trace-0.14	0.07	Trace-0.26	0.14
Total N (me/100 g)	3.57–5.00	4.05	4.29–5.71	4.88	3.57–5.00	4.05	2.85–5.71	4.05
Phosphorus								
Available P (ppm)	26–41	33.2	30–49	41.2	50–71	62.7	38–76	54.5
Ca-P (ppm)	180–249	211.4	145–173	159.5	251–316	291.9	323–371	354.9
Fe –P (ppm)	44–67	55.7	76–102	91.6	27–40	36.7	17–29	24.8
Total P (ppm)	459–541	501.0	499–601	554.2	550–609	585.3	611–646	631.2
Potassium								
Exchangeable k (me/100 g)	1.46–2.61	1.91	3.05–3.56	3.36	1.75–1.90	1.83	0.62–1.78	1.44
Water soluble K (me/100 g)	0.79–0.85	0.83	1.61–1.74	1.68	0.27–0.31	0.29	0.27–0.30	0.29
Fixed K (me/100 g)	12.28–13.78	12.95	15.32–16.05	15.8	15.61–18.45	17.28	7.85–18.92	14.60
Lattice K (me/100 g)	46.29–72.82	59.96	45.65–55.90	51.82	49.23–52.23	50.69	50.26–63.07	56.98
Total K	61.45–89.74	75.64	66.67–76.92	72.65	69.23–71.79	70.08	64.10–80.77	73.29
Sulphur								
SO_4 – S (ppm)	415–465	440.5	1090–1245	1167.2	297–365	333.9	232–301	276.2
Organic – S (ppm)	98–130	112.7	392–461	431.5	98–138	121.6	61–110	89.3
Total S (ppm)	659–727	659.9	1677–1797	1731.7	559–630	598.2	426–538	491.0
Zn (ppm)	1.7–14.0	9.2	2.5–10.8	6.7	1.66–4.5	2.8	2.5–4.8	3.3

(continued)

Table 8.1 (continued)

Parameter	Prentice range	Average	Lothian range	Average	Harinbari range	Average	Sagar range	Average
Cu (ppm)	41.0–6.2	5.4	5.9–8.2	7.0	1.6–3.8	2.8	3.9–5.8	5.1
Fe (ppm)	15.0–32.9	24.3	10.7–19.8	16.2	12.8–21.2	16.9	17.8–29.8	22.6
Mn (ppm)	31.4–45.0	42.7	21.0–100.2	56.9	9.9–26.4	17.5	36.0–51.2	41.7

Source: Gupta 1987

Nutrients availability may limit growth and production in many mangals. Among the nutrient list, the names of nitrogen, phosphorus and potassium are very important as their concentrations in soil often affect the growth of vegetation. The organic matter and nutrient status in some pockets of Indian Sundarbans are shown in Table 8.1.

The limiting nutrients may vary with individual mangrove habitats *e.g.,* potassium levels may be important in some regions, while phosphorus level may be a growth stimulator in some other places. *Rhizohphora apiculata*'seedlings do significantly better in plantation sites with enriched potassium (Kathiresan et al. 1994), while in mesocosm and field experiments with *Rhizophora mangle* seedlings, phosphorus enrichment produced nearly a seven fold increase in stem elongation rates and a three-fold increase in leaf area. Nitrogen addition did not show any significant response in terms of growth (Koch and Snedaker 1997).

The soil salinity is also an important parameter controlling the growth of mangrove vegetation. The salinity of the soil depends on the salinity of the tidal water, height of the tides, rainfall, elevation of the area, proximity to the creeks, proximity to fresh water inflow, depth of water table, texture of the soil, presence of vegetation and the number of consecutive days of a single tidal level (Chaudhuri and Choudhury 1994).

In Indian Sundarbans, salinity level of mangrove soils usually ranges from 5 psu to 25 psu with marked seasonal variations. High soil salinity often produces stunted growth of mangroves and reduces diversity. This is witnessed in few pockets of central Indian Sundarbans where the ambient soil is hypersaline owing to complete blockage of freshwater discharge because of the siltation of the Bidyadhari River. Few of the mangroves species (*Avicennia* spp.) present in this zone show highly stunted growth due to presence of saline soil.

The growth rate of mangroves, however, varies from species to species and also in different environmental conditions. It was observed that in the low saline stretch of Hooghly estuary, the growth of *Sonneratia apetala* is relatively more in comparison to the growth rate of the same species occurring at the high saline zone. A study done at an interval of ten years in 24 stations in Indian Sundarbans showed relatively more above ground biomass of *S. apetala* in low saline zone like Lothian Island, Sagar Island, Muriganga etc. compared to high saline zone like Thakuran, Herobhanga, Ajmalmari etc. (Fig. 8.2).

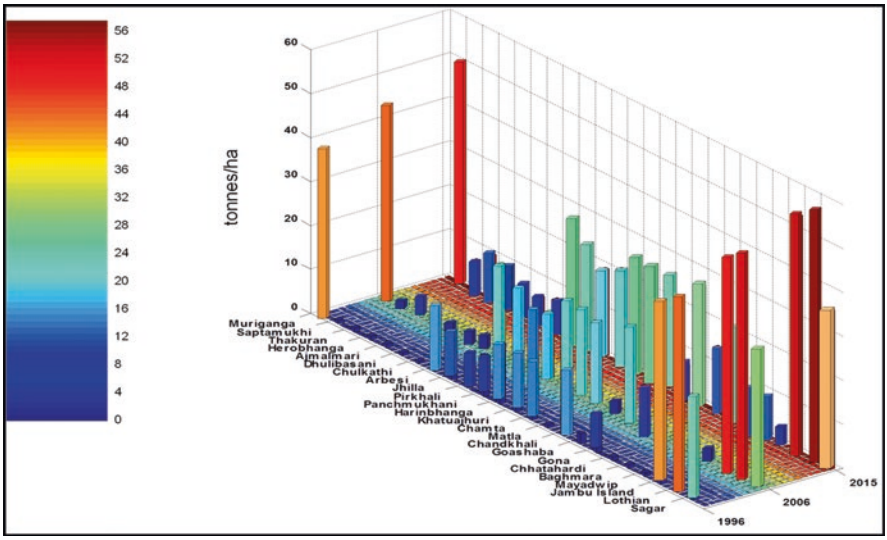


Fig. 8.2 Spatio-temporal variation of AGB in *Sonneratia apetala*

These very specialized mangrove vegetations play a vital role in maintaining the economic structure of the people inhabiting the islands of this deltaic lobe as they are the reservoir of various forestry products ranging from firewood, timber and construction materials for thatching houses to honey, wax, alcohol, tannins and fisheries. The huge quantum of detritus supplied by this ecosystem provides nutritional input to adjacent coastal water due to which the coastal habitat has become a unique nursery and breeding ground of a variety of fin fish and shell fish. Basically mangrove ecosystem is the reservoir of a wide range of flora and fauna with excellent adaptive potential to cope with the highly dynamic environmental conditions. A representive picture of the mangrove-centric biodiversity is presented in this chapter with focus on Indian Sundarbans.

Floral Biodiversity

A total of 69 floral species (included within 29 families and 50 genera) have been recognized in the Sundarbans area at the north-eastern coast of Indian sub-continent, out of which 34 species are true mangrove types (Mitra 2000). This ecosystem sustains almost all the mangrove species available in other part of the Indian subcontinent, Burma and other South East Asian countries. The list of the true mangroves in the Indian Sundarbans is shown in the Table 8.2.

A study conducted in 10 stations of Indian Sundarbans (Table 8.3 and Fig. 8.3) during three consecutive years (2016, 2017 and 2018) showed significant spatial variations in mangrove floral diversity, where I have used the Shannon Weiner

Table 8.2 True mangroves in the Indian Sundarbans

Scientific name of true mangroves	Common name	Family
1. Acanthus ilicifolius	Haraguja, sea Holly	Acanthaceae
2. Acanthus volubilis	Lata haraguja	Acanthaceae
3. Aegiceros corniculatum	Khalsi	Myrsinaceae
4. Aegialitis rotundifolia	Satari, Tora	Plumbaginaceae
5. Amoora cucullata	Amur	Meliaceae
6. Avicennia alba	Kala baen	Avicenniaceae
7. Avicennia marina	Peara baen	Avicenniaceae
8. Avicennia officinalis	Sada baen	Avicenniaceae
9. Brownlowia tersa	Lata, Bola Sundari	Tiliaceae
10. Bruguiera cylindrica	Sona champa, Thushia	Rhizophoraceae
11. Bruguiera gymnorrhiza	Kankra, Natinga	Rhizophoraceae
12. Bruguiera parviflora	Champa, Kankra Bokul	Rhizophoraceae
13. Bruguiera sexangula	Banduri, Kankra	Rhizophoraceae
14. Ceriops decandra	Goran	Rhizophoraceae
15. Ceriops tagal	Mat Goran	Rhizophoraceae
16. Cynometra ramiflora	Shingara	Leguminosae
17. Derris trifoliate	Kalilata	Leguminosae
18. Derris umbrellatum	Panilata	Leguminosae
19. Excoecaria agallocha	Genwa, Blinding tree	Euphorbiaceae
20. Excoecaria bicolor	Genwa	Euphorbiaceae
21. Heritiera fomes	Sundari	Sterculiaceae
22. Hibiscus tortuosus	Paras	Malvaceae
23. Kandelia candel	Goria	Rhizophoraceae
24.Lumnitzera racemosa	Kripa	Combretaceae
25. Nypa fruticans	Golpata, water coconut	Arecaceae (Palmae)
26. Phoneix paludosa	Hetal, sea date palm	Arecaceae (Palmae)
27. Rhizophora apiculata	Garjan	Rhizophoraceae
28. Rhizophora mucronata	Garjan	Rhizophoraceae
29. Sonneratia apetala	Keora	Sonneratiaceae
30. Sonneratia caseolaris	Keora	Sonneratiaceae
31. Tamarix dioica	Nona Jhau	Tamaricaceae
32. Tamarix gallica	Nona Jhau	Tamaricaceae
33. Xylocarpus granatum	Dhundul,Pohar	Meliaceae
34. Xylocarpus mekongensis	Pitamari	Meliaceae

Source: Chaudhuri and Chaudhuri 1994

Species diversity index as the proxy. Relative Abundance (RA or P_i = Abundance of a particular species/sum of the abundance of all species × 100) of the species is the basis of estimating Shannon Weiner species diversity index, which has been estimated as per the expression:

$$H = -\sum_{i=1}^{s} P_i \log P_i$$

Where, H = Shannon-Weiner Species Diversity Index; $P_i = n_i/N$ (n_i = Number of individuals of ith species and N = total number of individuals of all the species in the quadrat). Ten quadrats were considered for the present study and the average value of each species was considered for RA and H estimation.

The stations in the western region (stations 1–5) lie at the confluence of the River Hooghly (a continuation of Ganga-Bhagirathi system) and Bay of Bengal. In the central region, the sampling stations (stations 6–10) were selected adjacent to the tide fed Matla River. The two regions are significantly different with respect to salinity. The western region of the deltaic lobe receives the snowmelt water of Himalayan glaciers after being regulated through several dams on the way. The central region on the other hand, is fully deprived from such supply due to heavy siltation and clogging of the Bidyadhari channel in the late fifteenth century (Chaudhuri and Choudhury 1994; Mitra et al. 2009, 2011). The substrate of the Indian Sundarbans is mostly silt and clay, but in some places of the western region,

Table 8.3 Sampling stations with salient features

Station	Longitude & latitude	Site description
Harinbari (Stn. 1)	88°04′22.88″E 21°46′53.07″N	Situated in the western region of IndianSundarbans almost in the middle of the Sagar Island; receives the water of the Hugli River.
Chemaguri (Stn. 2)	88°08′49.01″E 21°39′42.88″N	Situated on the south-eastern side of Sagar Island and receives the water of the Mooriganga River.
Sagar South (Stn. 3)	88°04′0.51″E 21°37′49.90″N	Situated on the south-western part of the Sagar Island at the confluence of the River Hugli and the Bay of Bengal. Anthropogenically stressed zone due to presence of passenger jetties, fishing activities and pilgrimage.
Lothian island (Stn. 4)	88°19′8.47″E 21°39′08.04″N	Situated east of Bakkhali island; a Wildlife sanctuary; faces the River Saptamukhi.
Prentice island (Stn. 5)	88°17′3.62″E 21°42′43.31″N	Situated north of Lothian island; receives the water of the Saptamukhi River.
Canning (Stn. 6)	88°41′04.43″E 22°19′03.20″N	Situated in the central part of the Indian Sundarbans and faces the mighty River Matla, a tide-fed river. Due to presence of fish landing stations, passenger jetties and busy market, the area is anthropogenically stressed.
Sajnekhali (Stn. 7)	88°48′15.78″E 22°06′34.19″N	A Wildlife Sanctuary and a part of Sundarban Tiger Reserve; adjacent to River Bidhya and Gomor. Tourism pressure is extremely high in this station particularly during postmonsoon.
Chotomollakhali (Stn. 8)	88°54′26.71″E 22°10′40.00″N	Situated in the upper portion of Central Indian Sundarban adjacent to Jhila forest; receives the water of Rangabelia and Korankhali Rivers.
Satjelia (Stn. 9)	88°52′49.51″E 22°05′17.86″N	Situated adjacent to River Duttar in the upper region of Central Indian Sundarban facing western part of the Jhilla forest
Pakhiralaya (Stn. 10)	88°48′29.00″E 22°07′07.23″N	Situated adjacent to River Gomor; opposite to Sajnekhali Wild Life Sanctuary.

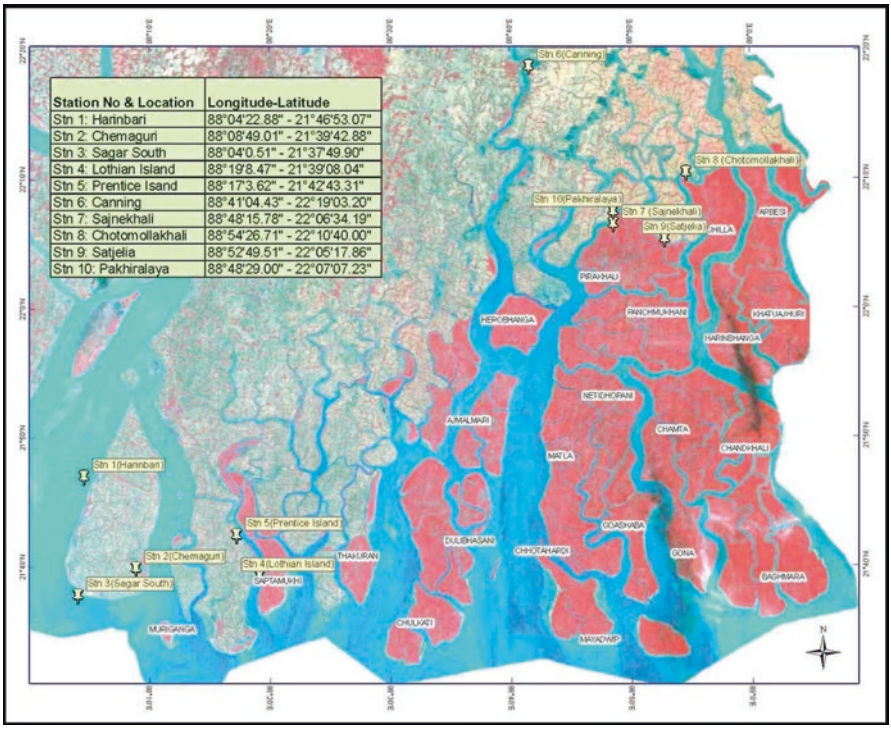


Fig. 8.3 Selected stations in Indian Sundarbans

there is a pure silt substrate. Both the regions exhibit productive mangrove vegetation, but high salinity in the central region likely reduces their growth. Freshwater loving mangrove species (*Heritiera fomes*, *Nypa fruticans* and *Sonneratia apetala*) are extremely rare in the central region.

The results of Shannon-Weiner Index are shown in Table 8.4 and Fig. 8.4.

The variation in the value of the Shannon Weiner Species Diversity Index reflects (i) the degree of stress (both natural and anthropogenic) (ii) conditions of the ambient environment (in terms of hydrological parameters and soil quality). Greater value of the index represents a more congenial environment which usually occurs due to the survival of more number of species or even distribution of the number of individuals amongst different species in the quadrate.

It is evident from the temporal data that Lothian Island has the highest mangrove biodiversity in all the 3 years and Canning exhibits the lowest values in similar years. This spatial variation of diversity Index is significant as revealed through ANOVA ($p < 0.01$). The significant spatial variation of diversity index (H) in the study area might be the result of anthropogenic and natural threats to which these stations are exposed to. Canning with lowest diversity index value is the gateway of central and eastern sectors of Indian Sundarbans and hence experiences large tourist pressure particularly during December to February. Apart from this, busy market places and

Table 8.4 Spatio- temporal variation of Shannon Weiner Species Diversity Index

Station no.	Name	2016	2017	2018
1.	Harinbari (Stn. 1)	2.3328	2.3313	2.3007
2.	Chemaguri (Stn. 2)	2.3017	2.2587	2.2469
3.	Sagar South (Stn. 3)	2.2459	2.2533	2.2409
4.	Lothian island (Stn. 4)	2.6344	2.6290	2.6086
5.	Prentice island (Stn. 5)	2.4509	2.4739	2.4766
6.	Canning (Stn. 6)	2.0661	2.0661	2.0524
7.	Sajnekhali (Stn. 7)	2.3901	2.3852	2.3852
8.	Chotomollakhali (Stn. 8)	2.0967	2.0922	2.0662
9.	Satjelia (Stn. 9)	2.1284	2.1405	2.1307
10.	Pakhiralaya (Stn. 10)	2.3454	2.3659	2.3068

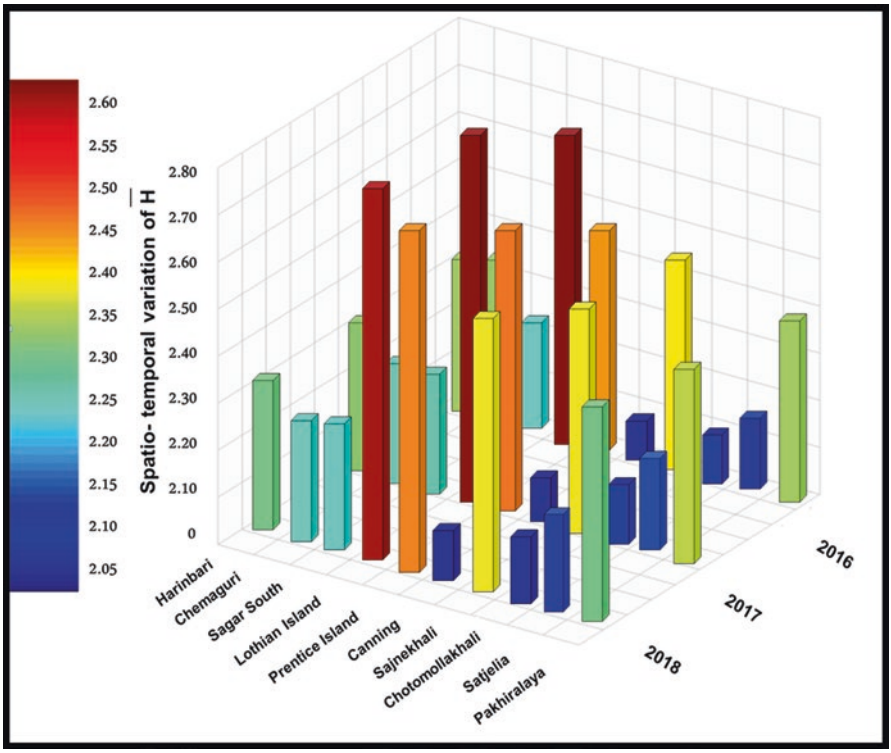


Fig. 8.4 Spatio-temporal variations of Shannon Weiner Species Diversity Index computed on the basis of relative abundance of true mangrove floral species

fish landing activities also pose adverse impact on the floral diversity of the sampling station. Sagar South, located in the western sector of Indian Sundarbans is within the navigational route of the ships. Moreover, fish landing and drying activities coupled with the negative impact of pilgrims experienced during the month of January is a

major threat to mangrove floral diversity in this sampling station. Harinbari and Chemaguri are also located in the western sector of Sundarbans and experience the negative impact of pollution of the Hooghly estuary. The station Lothian and Prentice Island although located in the western sector of Indian Sundarbans and exposed to Hooghly estuarine water exhibit maximum diversity index (H) values in all the 3 years. This may be attributed to their location within the Reserved Forest zone due to which the human interference is minimum in these stations. The dilution factor of the Hooghly estuarine water is also congenial for growth and survival of mangroves, which is also another important factor contributing to the maximum diversity of mangrove floral species in these sampling stations.

The true mangrove floral diversity values are relatively lower in the sampling stations of central Indian Sundarbans (Sajnekhali, Chotomollakhali and Pakhiralaya). This may be attributed to the synergistic effects of both hypersalinity and human intrusion in these sampling stations, except Sajnekhali which is a protected Reserve Forest under West Bengal Forest Department. The hypersaline water in the central Indian Sundarbans is the effect of Bidyadhari siltation since the late 15th century due to which the mangroves are less diverse and stunted in this zone.

The overall investigation thus pinpoints the hypersalinity and human intrusion as the major threats to mangrove floral diversity of Indian Sundarbans and advocates for an ecorestoration oriented management plan that encompasses (i) provision of alternative livelihood to reduce the exploitation of mangrove resources (ii) increase the dilution factor of the estuarine water through periodic dredging of the silted Bidyadhari River and (iii) freshening the central Indian Sundarbans through construction of rainwater harvesting ponds and plantation of mangrove associate species in mass scale (as ground cover) like *Sueada* sp., *Salicornia* sp., *etc*. that are potential absorber of salt from the ambient media.

In addition to true mangroves, mangrove associate floral species constitute an integral part of mangrove biodiversity. The mangrove associates in the Indian subcontinent include various marsh grasses, sea grasses, sand binders and macro algae. *Spartina* sp. is a common salt marsh grass (not documented in Indian Sundarbans) which plays an important role in the replacement of mangrove vegetation through competition. This particular marsh grass cannot survive in high salinities and fast sediment accretion. As a result, it grows poorly in areas where mangrove thrive (Kangas and Lugo 1990). This usually leads to its replacement by mangroves, as in Paranagua Bay, Brazil (Lana et al. 1991). In Indian Sundarbans, the salt marsh grass *Porteresia coarctata* is very common, which can tolerate a wide range of salinity (Fig. 8.5).

However, due to habitat destruction, erosion (Fig. 8.6), human interference and salinity fluctuation, the floristic species spectrum is presently under great stress.

A list of mangrove associate species commonly available in Indian Sundarbans is highlighted in Table 8.5.

Sea grasses are associated with mangrove habitats in many areas. In the Andaman Sea, there are three mangrove associated sea grasses *Thalassira hemprichii, Enhalus acoroides and Halophilus ovalis* (Provachiranom and Chansang 1994). The only sea grass found in intertidal mudflats of Indain Sunadrbans is *Halophilus baccarii*.

Fig. 8.5 *Porteresia coarctata* in the intertidal mudflats of Sundarbans

Fig. 8.6 Erosion of banks and intertidal mudflats in Sundarbans

Table 8.5 Herbs, grasses and sedges associated with true mangrove floral species of Indian Sundarbans

Species	Family	Species	Family
Aeluropus logopoides	Poaceae	*Myriostachya wightiana*	Poaceae
Aerva lanata	Amaranthaceae	*Panicum repens*	Poaceae
Ammania baccifera	Lythraceae	*Paspalum vaginatum*	Poaceae
Caesalpinia crista	Caesalpiniaceae	*Phragmites karka*	Poaceae
Canavalia cathartica	Caesalpiniaceae	*Porteresia coarctata*	Poaceae
Cyperus exaltatus	Cyperaceae	*Salicornia brachiata*	Chenopodiaceae
Fimbristylis halophila	Cyperaceae	*Sacobolus carinatus*	Asclepiadaceae
F. sub-bispicata	Cyperaceae	*Scirpus triquetra*	Cyperaceae
Heliotropium curassavicm	Boraginaceae	*Sesuvium portulacastrum*	Alizoaceae
Hoya parasitica	Asclepiadaceae	*Suaeda maritima*	Chenopodiaceae
Hydrophylax maritima	Rubiaceae	*S. nudiflora*	Chenopodiaceae
Ipomoea pes-caprae	Convolvulaceae	*Viscum orientale*	Loranthaceae
Lersia hemandra	Poaceae		

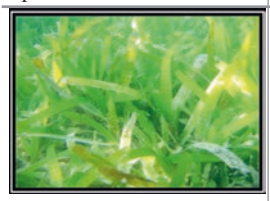
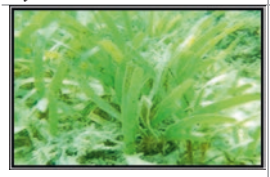
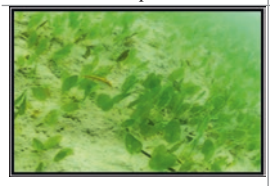
Mangrove and sea grasses serve more or less parallel functions in their habitats. Both trap sediments and also help to capture chemical elements including trace metals (Costa and Davy 1992; Lacerda 1998). A number of fish and shellfish often use sea grass/mangrove habitats as a nursery ground. Tussenbrock (1995) found that sea grass growth, biomass and primary production were all higher in vicinity of mangrove discharge than they occur in other habitats. Respiratory CO_2 derived from mangrove particulate organic matter (POM) could be a carbon source for sea grasses and hence, could promote rapid growth. A pilot study on assessment of stored carbons in the above ground biomass and below ground biomass of sea grass species in the Gulf of Mannar during December, 2017 was conducted by my team members Dr. Sufia Zaman and Dr. Rajrupa Ghosh who observed that these mangroves associate species are unique store house of carbon (Tables 8.6 and 8.7).

Three study sites namely Koswari (08°52.34′N, 78°13.04′E; Stn. 1), Kariyachalli (08°57.36′N, 78°14.42′E; Stn. 2) and Vilanguchalli (08°56.22′N, 78°15.59′E; Stn. 3) and three species (*Cymodocea serrulata, Thalassia hemprichii, Halophila ovalis*) were selected for estimation of stored carbon.

Mangrove ecosystem is highly dynamic with constant phenomena like erosion and accretion taking place due to waves, tides and currents. The erosion of soil and dune formation is largely controlled by *Ipomoea pes-capre*, which is a common **Sand-binder** in the Indian Sundarbans (Fig. 8.7). It is a creeper with extended root system and is noted for serving as indicator species in relation to Zn, Cu, Pb and Fe of the ambient aquatic phase.

Macroalgal diversity is rich in mangrove habitats where it contributes to primary production as well as providing habitat and food for a number of invertebrate and fish species. Among 800 species of Marine algae recorded from different parts of Indian coasts, about 60 species are commercially important sea weeds. A study conducted by CMFRI, CSMCRI and NIO estimated that total standing crop of seaweeds

Table 8.6 Species-wise Above Ground Biomass (AGB) and Above Ground Carbon (AGC) per unit area in Gulf of Mannar

Species	AGB (g dry wt. m^{-2})			AGC (g dry wt. m^{-2})		
	Stn 1	Stn 2	Stn 3	Stn 1	Stn 2	Stn 3
 *Cymodocea serrulata*	115.23 (49.6%)	109.60 (49.7%)	101.85 (49.9%)	57.15	54.47	50.82
 *Thalassia hemprichii*	56.98 (48.5%)	49.79 (48.9%)	38.64 (47.9%)	27.63	24.35	18.51
 *Halophila ovalis*	28.87 (41.23%)	25.19 (43.05%)	19.49 (45.16%)	11.90	10.84	8.80

in intertidal and shallow waters in 91,345 tonnes (wet weight) and 75,373 tonnes in deep water (Table 8.8), which consists 6000 tonnes of agar yielding seaweeds and the remaining quantity of edible and other seaweeds. At present there are about 30 agar and algin manufacturing units in India, but still the quantity of seaweed beds from Tamil Nadu coast is insufficient to meet the raw material requirements of Indian seaweed industries (Kaliperumal 1994).

Algal abundance and diversity are largely determined by the physico-chemical characteristics of mangal (Mazda et al. 1990) and these may be extremely variable. As with mangrove themselves, the most successful macroalgae have special adaptations that help them to tolerate extreme conditions.

Salinity, temperature, desiccation, tidal inundation, wave action, wetting frequency and light intensity are all environmental factors likely to produce patterns of horizontal and vertical distribution seen in many mangrove associate algae (Phillips et al. 1994; Farnsworth and Ellision 1996). In the Gazi Bay of Kenya, there is distinct macroalgal zonation. The upper intertidal is covered by *Boodleopsis pusilla* while the mid-intertidal zone is dominated by *Halophilus opuntia, Gracilaria salicornia and G. corticata.* The low water mark has primarily *Halimeda macroloba and Avrainvillea obscura* (Coppenjans et al. 1992). A distinct zonation has also been described for algae growing on the pneumatophores of *Avicennia marina*

Table 8.7 Species-wise Below Ground Biomass (BGB) and Below Ground Carbon (BGC) per unit area in Gulf of Mannar

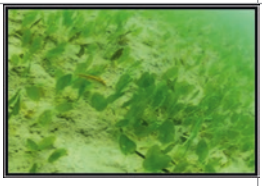
Species	BGB (g dry wt. m^{-2})			BGC (g dry wt. m^{-2})		
	Stn 1	Stn 2	Stn 3	Stn 1	Stn 2	Stn 3
 *Cymodocea serrulata*	144.04 (48.4%)	140.29 (48.6%)	132.41 (49.1%)	69.72	68.18	65.01
 *Thalassia hemprichii*	71.79 (47.9%)	63.23 (48.2%)	49.84 (48.5%)	34.39	30.48	24.17
 *Halophila ovalis*	36.31 (39.69%)	33.14 (38.43%)	24.75 (38.11%)	14.41	12.74	9.43

Fig. 8.7 *Ipomoea pes-caprae* in Indian Sundarbans

Table 8.8 Sea weeds resource of the Indian coast

Area	Annual yield in tonnes (fresh wt.)
Gujarat	
Gulf of Kutch	19,000–1,00,000
Hanummmandrandi to okha	650
Adttra Reaf	60
Sourashtra coast	282–608
Maharastra	
Entire coast	20,000
Goa	
Entire coast	2000
Karnataka	
Entire coast	Very less
Kerela	No reliable data
Tamil Nadu	
From cape comorin to colachel	5
From calimere to Kanyakumari	6000
Pamban	1000
Palk Bay	900
South East coast	20,535
Entire coast	28,550
Andhra Pradash	No reliable data
Orissa	No reliable data
West Bengal	No reliable data
Andaman and Nicober Island	No reliable data
Lakshadeep Island	3645–7589

(Steinke and Naidoo 1990). There are generally three zones, an upper *Rhizoclonium* zone, middle *Bostrychia* Zone and a lower *Caloglossa* zone. In Indian Sundarbans, common macroalgae are *Catenella* sp., *Caloglossa* sp., *Enteromorpha* spp., *and Ulva* sp. Among them *Enteromorpha* can tolerate wide range of salinity gradients (from 2 psu to 30 psu).

Microfloral Community

The microbial community of deltaic Sundarbans encompasses bacteria, cyanobacteria and phytoplankton of the ambient aquatic phase. It has been observed that the bacteria which are found in the "detritus" or the decomposed litters are also found in the different associated fauna of this complex (Table 8.9), especially from the evacuated gut tissues. So, it may well be presumed that the different types of bacteria that are found in the "detritus" of this deltaic complex could also be expressed within the different benthic fauna of this environment that rely on the substratum for their food sources. It is presumed that the microbes in Sundarbans mangrove

Table 8.9 List of a few specific lytic bacteria in Indian Sundarbans documented from different stations

Name of bacterium	Cellulolytic		Chitinolytic	Pectinolytic	Proteolytic	NH_3 formation	NO_3 formation from NH_3	NO_2 formation from NO_2
	C_1	C_2						
Bacillus alvei (Stn. 1)	–	–	++	++	+	++++	+	+
Bacillus cereus (Stn. 3)	–	x	–	x	x	x	x	x
Bravibacterium sp. (Stn. 5)	+	–	+	++	+++	++++	+++	++
Bravibacterium sp. (Stn. 18)	+	–	+	x	++	++++	x	x
Bravibacterium (Stn. 24)	–	–	–	–	+++	++	++	
Bravibacterium (Stn.2)	–	x	x	x	x	x	x	x
Marinopiscosum sp. (Stn. 4)	–	–	–	++	x	++	++	++
Bravibacterium sp. (Stn.7)	x	–	x	x	x	x	x	x
Bravibacterium sp. (Stn. 8)	+	+	++	–	x	++	++	++
Bravibacterium sp. (Stn. 9)	–	+	–	x	x	++	++	++
Bravibacterium sp. (Stn. 23)	++	x	x	x	x	x	x	x
Bravibacterium sp. (Stn. 20)	+	–	+++	–	x	++	++	++
Bravibacterium sp. (Stn. 6)	x	x	x	x	x	x	x	x
Bravibacterium sp. (Stn. 11)	x	x	x	x	x	x	x	x
Bravibacterium sp. (Stn. 13)	x	x	x	x	x	x	x	x
Bravibacterium sp. (Stn. 10)	x	x	x	x	x	x	x	x
Bravibacterium sp. (Stn. 19)	x	x	x	x	x	x	x	x
Butyribaterium sp. (Stn. 17)	+	x	–	–	x	++	++	++
Butyribaterium sp. (Stn. 21)	x	x	x	x	x	x	x	x
Clostridium werneri (Stn. 15)	+	x	–	–	x	++	++	++
Clostridium sp. (Stn. 16)	–	–	–	++	x	++	++	++
Clostridium sp. (Stn. 18)	x	x	x	x	x	x	x	x
Corynebacterium sp. (Stn. 2)	++	–	+	x	++	++	++	x
Kurthia bessonii (Stn. 21)	++	–	–	–	++	++	++	x
Kurthia bessonii (Stn. 22)	–	x	–	++	x	x	x	x

Name of bacterium	Cellulolytic		Chitinolytic	Pectinolytic	Proteolytic	NH_3 formation	NO_3 formation from NH_3	NO_2 formation from NO_2
	C_1	C_2						
Kurthia bessonii (Stn. 24)	−	x	+	−	x	x	x	x
Kurthia bessonii (Stn. 11)	++	x	x	x	x	x	x	x
Kurthia bessonii (Stn. 19)	−	−	x	−	x	x	x	x
Kurthia bessonii (Stn. 17)	−	x	++	x	x	x	x	x
Kurthia bessonii (Stn. 19)	++	−	++	++	x	x	x	x
Kurthia bessonii (Stn. 18)	−	−	−	++	x	++	++	++
Kurthia bessonii (Stn. 16)	x	x	x	x	x	x	x	x
Lactobacillus sp. (Stn. 10)	+	+	−	−	+++	++++	++	++
Lactobacillus delbrueckii (Stn. 7)	−	x	−	x	x	x	x	x
Lactobacillus sp. (Stn. 8)	x	x	x	x	x	x	x	x
Lactobacillus sp. (Stn. 5)	x	x	x	x	x	x	x	x
Lactobacillus sp. Stn. 14)	x	x	x	x	x	x	x	x
Lactobacillus sp. (Stn. 9)	x	x	x	x	x	x	x	x
Listeria sp. (Stn. 7)	−	−	+	x	+	++	x	x
Listeria monocytogenes (Stn. 6)	−	x	−	x	x	x	x	x
Micrococcus agilis (Stn. 10)	−	−	+++	x	++	++	++	x
Micrococcus sp.	−	−	x	++	++	++	−	x
Micrococcus candidus (Stn. 21)	−	x	−	x	++	++	−	x
Micrococcus sp. (Stn. 17)	−	x	+	x	x	x	x	x
Pseudomonus sp. (Stn. 18)	++	x	x	x	++	++	++	+
Pseudomonus sp. (Stn. 13).	x	x	x	x	x	x	x	x
Pseudomonus sp. (Stn. 11).	x	x	x	x	x	x	x	x
Pseudomonus sp. (Stn. 14)	x	x	x	x	x	x	x	
Pseudomonus sp. (Stn. 13).	x	x	x	x	x	x	x	

+ Positive, − Negative, *X* Not experimented yet

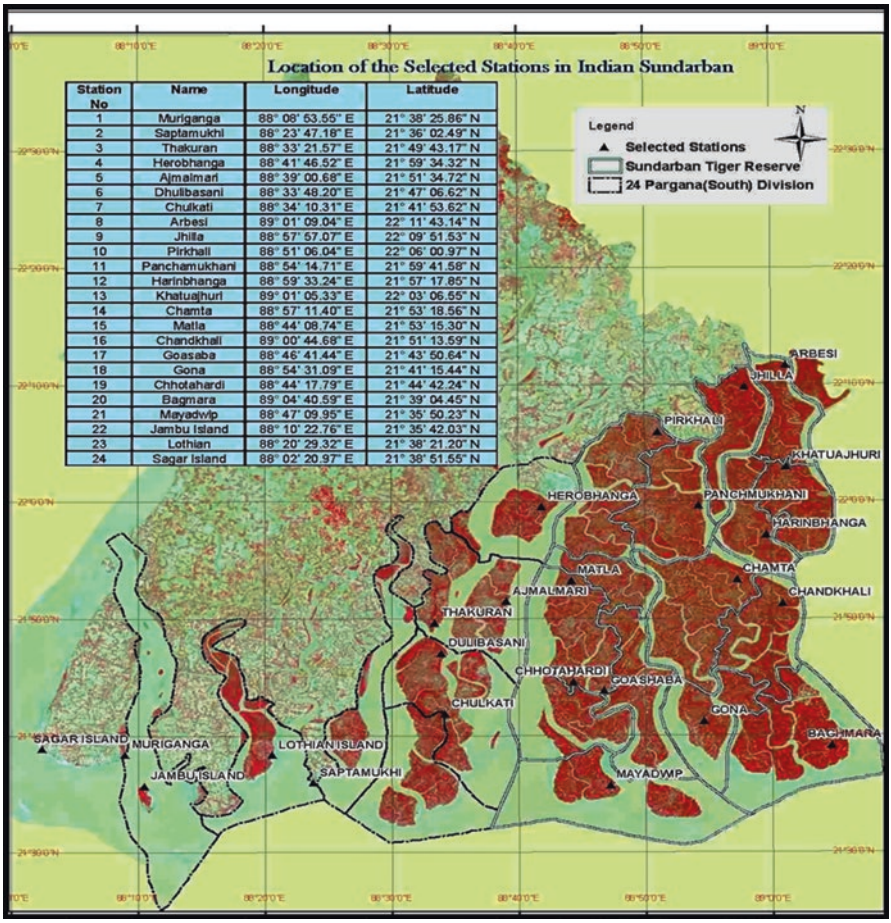


Fig. 8.8 24 different stations of Indian Sundarbans where microbial diversity was documented during 2018

ecosystem exhibit a wide range of their niche specificity irrespective of plants and animals. It is also contended that this heterologous association of different bacterial strain both in litters as well as in the detritivore benthic fauna may have some ecological implications in the ultimate food web system through microbial metabolic process. A survey conducted during 2018 by the present author in 24 different stations of Indian Sundarbans (Fig. 8.8) revealed a wide spectrum of lytic bacteria (Table 8.9).

The cyanobacteria are important microfloral representatives of mangrove ecosystem. Some common cyanobacteria strains isolated from the mangrove habitat of Indian Sundarbans are listed in Table 8.10.

Among the fungi, the genera *Aspergillus, Collectotrichum, Fusarium* and *Helminthosporium* are worth mentioning. It was found that the types of fungi playing major role in the degradation mainly belong to the genus *Aspergillus.* Four spe-

Table 8.10 Some common cyanobacterial strains of Indian Sundarbans

Cyanobacterial species with systematic position	Salient features
Anabaena variabilis Systematic position Class-Cyanophyceae Order Nostocales Family- Oscillatoriaceae	1. Thallus gelatinous and dark green in colour 2. Trichome without ant sheath, flexous 4–6 μbroad 3. Cells are barrel shaped and sometimes with gas vacuoles 4. Heterocyst spherical or oval 6 μ broad, up to 8 μ long
Anabaena torulosa Systematic position Class- Cyanophyceae Order- nostocales Family- Oscillatoriaceae	1. Thallus mucilaginous, thin and blue green in colour. 2. Trichome 4.2–5 μ broad 3. Heterocyst sub-spherical or ovoid with pores on both sides of it. 4. Cells sub spherical with rounded ends, upto twice as long as board.
Nostochopsis lobatus Systematic position Order-nostocales Family-Nostocaceae	1. Thallus more or less irregularly lobed, blue-green or olive green in colour Trichomes readily arranged seemingly straight with the inner parts class- cyanophyceae bent, tapering end or slightly pointed 2. Heterocytes mostly lateral or terminal on 2–3 or 4-celled lateral branch 3. Mucilage homogenous or colourless, and sheath present in the branching zone
Westilelopsis prolifica Systemic position Class- cyanophyceae Order- nostocales Family- Nostocaceae	1. Main filament torulose with short barrel shaped cells. 2. Cells 8–12 μ board as long as or slightly longer. 3. Branched filaments thinner and elongate, not constricted at the crass walls. 4. Heterocyst oblong or cylindrical
Oscillatoria limosa Systematic position Class-Cyanophyceae Order-Nostocales Family- Oscillatoriaceae	1. Thallus dark blue-green in colour 2. Trichomes more or less straight 3. Cells 13–16 μ board; 1/3–1/1 as long as board and 2–5 μ long 4. End cells flatly rounded with slightly thickened membrane
Oscillatoria subbrevis Systematic position Class-cyanophyceae Order- nostocales Family- Oscillatoriaceae	1. Trichomes single, 5–6 μ board nearly straight, not attenuated at the apex 2. Cells 1–2 μ long, not granulated at the cross walls 3. End cells are rounded 4. Calyptra is absent
Nostoc commune Systemic position Class- Cyanophyceae Order-Nostocales Family- Oscillatoriaceae	1. Thallus gelatinous, blue-green, filamentous, membranous or leathery and flexous 2. Trichomes 4.5–6.0 μ board. 3. Cells are short barrel shaped or nearly spherical, 5.0 μ long 4. Heterocyst nearly spherical, about 7.0 μ board.
Anabaena spiroides Systematic position Class-Cyanophyceae Order-Nostocales Family- Oscillatoriaceae	1. Trichome single, regularly spirally coiled, with thick and mucilaginous sheath. 2. Spirals 45–54 μ board and 40–50 μ distant 3. Cells spherical, 6.5–8.0 μ board with gas vacuoles. 4. Heterocyst spherical, 7.0 μ board and spores are spherical too.

cies of *Aspergillus* could be documented at this stage. Researchers have observed that after 30 days of degradation, the genus *Aspergillus* contributed about three forth of the total number of fungal population, the rest one fourth by the members belonging to the genus *Helminthrosporium.*

Phytoplankton diversity in the Indian Sundarbans is extremely rich and in some pockets like Lothian Island, the Shannon Weiner Index (H) has shown a high value. A total of 64 species has been documented from the brackish water system of Indian Sundarbans (Banerjee et al. 2000), among which some species are abundant almost in all the season of the year. Now the number of phytoplankton species has exceeded 150 (Mitra and Zaman 2016).

Faunal Biodiversity

The mangrove ecosystems of the north-east coast of Bay of Bengal in the Indian sub-continent also sustain a wide range of faunal diversity. Although, the faunal exploration of Sundarbans can be traced back to mid-eighteenth century (Stolicza 1869) and extensive studies have been carried out by the workers of the Zoological Survey of India (Annandale 1907; Kemp 1917; Hora 1934), but the works of Mandal and Nandi (1989) and Chaudhuri and Chaudhuri (1994) provide an excellent data base of macrofaunal diversity of the ecosystem, although the two data sets are somewhat mismatching (Table 8.11).

It is a fact that Sundarban ecosystem is still one of the most biologically productive and taxonomically diverse ecosystems of the Indian sub-continent, although about 6 vertebrates have disappeared from this ecosystem since the last 200 years and about 20 species are in the endangered species list (Table 8.12).

Mangrove swamps of Indian Sundarbans also invites two species of horseshoe crabs (Fig. 8.9) namely *Carcinoscorpius rotundicauda* and *Tachypleus gigas* during the premonsoon period of high salinity. These crabs have excellent biomedical values and have recently been established as potential source of bioactive substance, the Carcinoscorpius Amoebocyte Lysate (CAL) and Tachypleus Amoebocyte Lysate (TAL). These reagents are highly sensitive and useful for the rapid and accurate assay of Gram negative bacteria even if they are present in a very minute quantity up to the level of 10^{-10} gm. Hence, these reagents have wide application in the medical sphere as they have immense role in detecting endotoxins in several pharmaceutical products and other life saving drugs like interferon, insulin etc.

The list of macro-invertebrate species found in this deltaic ecosystem exhibits unique species diversity although the magnitude of diversity (as reflected through Shannon Weiner index or index of dominance) varies markedly with season (Mitra 2000). The invertebrate phyla act as magnificent "conveyer belts" in this ecosystem for the transferring energy to the higher vertebrates. The scat analysis of Indian Tiger (*Panthera tigris tigris*) revealed the presence of *Toxocara carti*, which proves the direct dependency of higher vertebrates on invertebrate species.

Apart from sustaining a wide spectrum of invertebrate species in the benthic substratum, this deltaic region also houses some marvellous beds of minor phyla. A relatively small phylum of marine worms, often overlooked by biologists, the Sipunculus, (number slightly more than 300 species in the globe with 16 recognised genera) is also a representative of Indian Sundardans. The benthic substratum

Table 8.11 Faunal diversity of Sundarban mangrove ecosystem

Serial number	Chaudhuri and Chaudhuri (1994) genera/species	Mandal and Nandi (1989) genera/species
I. Invertebrates		
1. Protista	13/21	1/1
2. Porifera	1/1	7/7
3.Cnidaria	16/17 (9)	1/1
4. Ctenophore	2/2	1/1
5. Platyhelminthes	8/8 (6)	1/1
6. Rotifera	–	4/5
7.Nematoda	50/55 (45)	2/2
8. Sipuncula	–	4/4
9. Mollusca	45/57 (5)	57/94
10. Echiura	1/3	2/2
11. Annelida	39/49 (2)	37/18
12.Crustacea	37/69(10)	92/169
13. Insecta	59/98(29)	126/187
14. Arachunida	8/8	28/35
15. Xiphosura	2/2	2/2
16. Bryozoa	1/1	3/3
17. Entopoda	1/1	–
18. Chaetognatha	–	1/2
19. Echinodermata	4/6(5)	12/14
20. Hemichordata	1/1	1/1
II. Vertebrates		
Chordates		
1. Pisces	96/250	100/141
2. Amphibia	4/7	4/8
3. Reptilia	49/57	40/57
4. Aves	120/300	122/161
5. Mammalia	33/40	32/40

Note: Figures within parenthesis indicate unidentified species or spp. *groups*

of deltaic Sunderbans supports one species of sipunculus namely *Phascolosoma arcuatum* (Gray), which is characterized by the presence of a spacious, unsegmented coelom, filled with fluid continuing free haemocytes.

The pelagic zone of the Bay of Bengal adjacent to Indian part of Sundarbans is characterized by unique assemblage of planktons and nektons. During the long course of planktonic survey in the offshore area, a total of 35 phytoplankton species distributed over 18 genera have been documented so far (Mitra 2000). The list of phytoplankton species has increased to 106 in recent times. The genus *Chaetoceros* contributes for the largest number of diatom population during the peak phase of the phytoplankton bloom. The genera like *Coscinodiscus*, *Biddulphia* and *Pleurosigma* are commonly found in the system round the year.

Table 8.12 Endangered species of Sundarban mangrove ecosystem

Scientific name of the endangered species	Common name
Mammals	
Felis viverrina	Fishing Cat
Panthera tigris tigris	Indian Tiger
Platanista gangatica	Gangetic dolphin
Orcaella brevirostris	Snub-nosed dolphin
Neophocaena phocaenoides	Little porpoise
Birds	
Ardea goliath	Giant heron
Leptoptilos javanicus	Lesser adjutant
Haliacetus leucogastar	White bellied sea eagle
Pandion haliaetus	Osprey
Reptiles	
Crocodylus porosus	Saltwater or Estuarine crocodile
Lepidochelys olivacea	Olive Ridley turtle
Batagur baska	Batagur terrapin
Kachuga tacta tecta	Indian tent turtle
Lissemys punctate	Indian flap shelledturtle
Aspideretus gangeticus	Indian soft shelled turtle
Aspideretus burun	Peacock marked soft shelled turtle
Varanus bengalensis	Common Indian monitor
Varanus flavescens	Yellow monitor
Varanus salvator	Water monitor
Oython molurus bivittatus	Indian monitor
Ophiophagus hannah	King cobra

Source: Chaudhuri and Chaudhuri 1994 and Indian Wild Life Protection (Act) 1972

Fig. 8.9 Horseshoe crab on the Sundarban mudflat

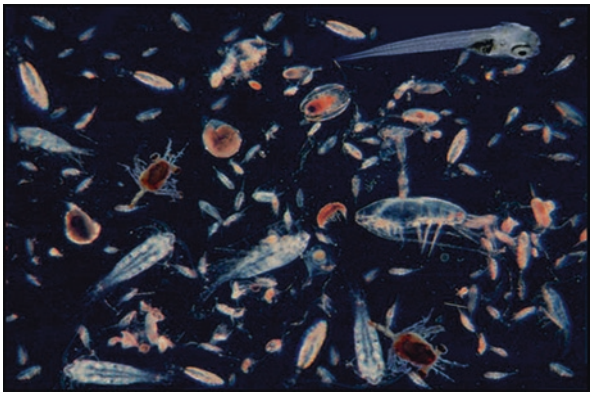


Fig. 8.10 Zooplankton community in Sundarban water

Fig. 8.11 Oyster colony on hard substratum

Zooplankton commonly found in the pelagic system comprises a heterogeneous assemblage of animals covering many taxonomic groups which include copepod, mysids, lucifer, gammarid amphipods, cladocera, ostracod, hydromedusae, ctenophore and chaetognath among haloplankters and larval stage of polychaete, molluscs, echinoderm, crustacean and fin fish among meroplankters (Fig. 8.10).

The benthic community of Sundarbans mangrove ecosystem encompasses several untapped marine living resources like edible oysters (*Saccostrea cucullata* and *Crassostrea cuttackensis*), clams, mussels etc. which can be brought under the umbrella of commercial culture to provide alternative source of income to the coastal population (Fig. 8.11). This approach can reduce the adverse pressure on mangrove forest and its natural resources to a great extent, which is a positive pathway to preserve the biodiversity in this dynamic deltaic ecosystem.

The aquatic sub-system of deltaic Sundarbans is the dwelling spot, nursery and breeding ground of a wide variety of finfish and shellfish. However, with respect to ecological tolerance, a large fraction of the fish species in the mangrove dominated estuarine complex is euryhaline in nature and move freely from the upper stretch of minimum salinity to lower stretch of maximum salinity.

Several workers have depicted the taxonomic diversity of fish species in the aquatic subsystem of mangrove dominated Indian Sundarbans deltaic complex. Pillay (1967) estimated the species number to be more than 120. Jhingran (1982) documented a total of 172 species and stated that the diversity is comparatively more in the high saline zone of Indian Sundarbans. His estimate reveals 73 species of fresh water origin and 99 species of marine/higher salinity origin. Mandal and Nandi (1989) documented 141 species under 100 genera, while Chaudhuri and Choudhury (1994) recorded 250 species under 96 genera in the aquatic sub-system of Indian Sundarbans. Khan (2003) recorded 107 species from Sundarban Biosphere Reserve region, but this figure does not include the species restricted in the low saline upper zone of the Hooghly-Matla estuarine complex. The fish fauna of the estuarine waters around Sundarbans has been classified into residents and transients (migrants). The species whose individuals of different sizes are present during all the months of the year in any zone of the estuary are referred to as resident species. The important resident species of fish are *Mugil parsia, Mugil tade, Polynemus paradiseus, Polydactylus indicus, Otolithoides biauritus, Lates calcarifer, Hilsa toli, Arius jella, Harpodon nehereus, Setipinna taty, Ilisha elongata, Setipinna phasa, Coilia ramcarati, Pama pama* and *Sillaginopsis panijus*. The transient or migratory fishes enter and stay in the Bay of Bengal associated estuaries for a short period. Depending on their migratory pattern and direction, the migrants may be divided into three categories (Jhingran 1982).

(1) Marine forms that migrate upstream and spawn in freshwater areas of the estuary like *Tenualosa ilisha, Polynemus paradiseus, Sillaginopsis panijus and Pama pama*. (2) Freshwater species, which spawn in saline area of the estuary like *Pangasius pangasius* (3) Marine species, that spawns in less saline water of the estuary like *Arius jella*, *Osteogeneious militaris* and *Polydactylus indicus*.

An updated checklist of fishes available in the mangrove creeks, estuaries and bays are listed here.

A Checklist of Sundarban Fish (Both Chondrichthyes and Osteichthyes) in Brackish Water and Fresh Water Ponds

Order: Carcharhiniformes (Ground Sharks)

Family: *Carcharhinidae* (Requiem sharks)
White cheek shark *Carcharhinus dussumieri*
Bull shark *Carcharhinus leucas*
Black tip shark *Carcharhinus limbatus*
Black tip reef shark *Carcharhinus melanopterus*
Tiger shark *Galeocerdo cuvier*
Ganges shark *Glyphis gangeticus*
Milk shark *Rhizoprionodon acutus*

Indian dog shark or Spadenose shark *Scoliodon laticaudus* Whale shark *Rhincodon typus*
Grey bamboo shark *Chiloscyllium griseum*
Slender bambooshark *Chiloscyllium indicum*
Family: *Sphyrnidae* (Hammerhead, bonnethead or scoophead sharks)
Winghead shark, *Eusphyra blochii*
Scalloped hammerhead *Sphyrna lewini*
Great hammerhead *Sphyrna mokarran*

Order: Pristiformes (Sawfishes)

Family: *Pristidae*
Knifetooth sawfish *Anoxypristis cuspidata*
Largetooth sawfish *Pristis microdon*
Smalltooth sawfish *Pristis pectinata*

Order: Rajiformes (Skates and Rays)

Family: *Dasyatidae* (Stingrays)
Small-eye stingray *Dasyatis microps*
Pale-edged stingray *Dasyatis zugei*
Bleeker's whipray *Himantura bleekeri*
Ganges stingray *Himantura fluviatilis*
Scaly whipray *Himantura imbricata*
Pointed-nose stingray *Himantura jenkinsii*
Blackedge whipray *Himantura marginatus*
Honeycomb stingray *Himantura uarnak*
Family: *Myliobatidae* (Eagle and manta rays)
Spotted eagle ray *Aetobatus narinari*
Banded eagle ray *Aetomylaeus nichofii*
Family: *Rhinobatidae* (Guitarfishes)
Annandale's guitarfish *Rhinobatos annandalei*
Smoothback guitarfish *Rhinobatos lionotus*
Giant guitarfish *Rhynchobatus djiddensis*

Order: Torpediniformes (Electric Rays)

Family: *Narcinidae* (Numbfishes)
Brown numbfish *Narcine brunnea*

Order: Osteoglossiformes (Bony Tongues)

Family: *Notopteridae* (Featherbacks or knifefishes)
Clown knifefish *Chitala chitala*
Bronze featherback *Notopterus notopterus*

Order: Elopiformes (Tarpons and Tenpounders)

Family: *Elopidae* (Tenpounders and ladyfishes)
Tenpounder *Elops machnata*
Family: *Megalopidae* (Tarpons)
Indo-Pacific tarpon *Megalops cyprinoides*

Order: Albuliformes (Bone Fishes) Family: *Albulidae* (Bonefishes) Roundjaw Bonefish *Albula glossodonta*

Order: Anguilliformes (Eels and Morays)

Family: *Anguillidae* (Freshwater eels)
Indian mottled eel *Anguilla bengalensis*
Indonesian shortfin eel *Anguilla bicolor*
Mottled eel *Anguilla nebulosa*
Family: *Moringuidae* (Worm and spaghetti eels)
Moringua macrocephalus
Purple spaghetti eel *Moringua raitaborua*
Family: *Muraenidae* (Moray eels)
Freshwater moray *Gymnothorax tile*
Family: *Ophichthidae* (Snake eels and worm eels)
Finny snake eel *Caecula pterygera*
Rice paddy eel *Pisodonophis boro*
Greenspot snake eel *Pisodonophis hijala*
Maimed snake eel *Muraenichthys schultzei*
Family: *Muraenesocidae* (Pike conger eels)
Yellow pike conger *Congresox talabon*
Indian pike conger *Congresox talabonoides*
Common pike conger *Muraenesox bagio*
Daggertooth pike conger *Muraenesox cinereus*

Order: Clupeiformes (Herrings)

Family: *Clupeidae* (Herrings, shads, sardines and menhadens)
Chacunda gizzard shad *Anodontostoma chacunda*
Thai gizzard shad *Anodontostoma thailandiae*
Ganges river sprat *Corica soborna*
White sardine *Escualosa thoracata*
Ganges river gizzard shad *Gonialosa manmina*
Indian river shad *Gudusia chapra*
Kelee shad *Hilsa kelee*
Bloch's gizzard shad *Nematalosa nasus*
Tardoore *Opisthopterus tardoore*
Raconda *Raconda russeliana*
Indian oil sardine *Sardinella longiceps*
Hilsa shad, River shad *Tenualosa ilisha*
Toli shad *Tenualosa toli*
Family: *Pristigasteridae*
Elongate ilisha *Ilisha elongata*
Coromandel ilisha *Ilisha filigera*
Kampen's ilisha *Ilisha kampeni*
Bigeye ilisha *Ilisha megaloptera*
Indian ilisha *Ilisha melastoma*
Indian pellona *Pellona ditchela*
Family: *Engraulidae* (Anchovies)
Goldspotted grenadier anchovy *Coilia dussumieri*
Ramcarat grenadier anchovy *Coilia ramcarati*
Reynald's grenadier anchovy *Coilia reynaldi*
Shorthead hairfin anchovy *Setipinna breviceps*
Dusky hairfin anchovy *Setipinna melanochir*
Gangetic hairfin anchovy *Setipinna phasa*
Scaly hairfin anchovy *Setipinna taty*
Indian anchovy *Stolephorus indicus*
Dussumier's thryssa *Thryssa dussumieri*
Hamilton's thryssa *Thryssa hamiltonii*
Malabar thryssa *Thryssa malabarica*
Moustached thryssa *Thryssa mystax*
Oblique jaw thryssa *Thryssa purava*
Bengal thryssa *Thryssa spinidens*
Slender thryssa *Thryssa stenosoma*
Orangemouth anchovy *Thryssa vitrirostris*
Family: *Chirocentridae* (Wolf herrings)
Dorab wolf herring *Chirocentrus dorab*
Whitefin wolf herring *Chirocentrus nudus*

Order: Gonorhynchiformes (Milk Fish)

Family: *Chanidae*
Milkfish White mullet *Chanos chanos*

Order: Cypriniformes (Carps)

Family: *Cyprinidae* (Minnows, carps, barbs)
Mola carplet *Amblypharyngodon mola*
Mrigal *Cirrhinus cirrhosus*
Sind danio *Devario devario*
Silver razorbelly minnow *Salmostoma acinaces (Chela argentea)*
Large razorbelly minnow *Salmostoma bacaila*
Finescale razorbelly minnow *Salmostoma phulo*
Bengala barb *Bengala elanga*
Zebra danio *Danio rerio*
Flying rasbora (barb) *Esomus danricus*
Slender rasbora *Rasbora daniconius*
Silver hatchet danio *Chela cachius*
Indian glass barb *Chela laubuca*
Catla *Catla catla*
Reba *Labeo ariza*
Bata *Labeo bata*
Kalbosu (Orange-fin labeo) *Labeo calbasu*
Rohu *Labeo rohita*
Swamp barb *Puntius chola*
Rosy barb *Puntius conchonius*
Golden barb *Puntius gelius*
Olive barb *Puntius sarana*
Pool barb *Puntius sophore*
Onespot barb *Puntius terio*
Ticto barb *Puntius ticto*

Order: Siluriformes (Cat Fish)

Family: *Bagridae* (Bagrid cat fishes)
Menoda cat fish *Hemibagrus menoda*
Day's mystus *Mystus bleekeri*
Gangetic mystus *Mystus cavasius*
Long whiskers cat fish *Mystus gulio*

Striped dwarf cat fish *Mystus vittatus*
Rita *Rita rita*
Long whiskered cat fish *Sperata aor*
Giant river cat fish *Sperata seenghala*
Family: *Siluridae* (Sheat fishes)
Butter cat fish *Ompok bimaculatus*
Pabdah cat fish *Ompok pabda*
Wallago *Wallago attu*
Family: *Schilbeidae* (Schilbeid cat fishes)
Gangetic ailia *Ailia coila*
Garua cat fish *Clupisoma garua*
Sharpnose cat fish *Eutropiichthys vacha*
Indian potasi *Pseudeutropius atherinoides*
Silond cat fish *Silonia silondia*
Family: *Pangasiidae* (Shark cat fishes)
Yellowtail cat fish, River pangus *Pangasius pangasius*
Family: *Sisoridae* (Sisorid cat fishes)
Dwarf goonch *Bagarius bagarius*
Goonch *Bagarius yarrelli*
Indian gagata *Gagata cenia*
Gagata gagata
Glyptothorax botius
Glyptothorax telchitta
Gogangra viridescens
Kosi nangra *Nangra nangra*
Sisor cat fish *Sisor rabdophorus*
Family: *Clariidae* (Airbreathing cat fishes)
Walking cat fish *Clarias batrachus*
Family: *Chacidae* (Squarehead cat fishes)
Squarehead cat fish *Chaca chaca*
Family: *Ariidae* (Sea cat fishes)
T hreadfin sea cat fish *Arius arius*
Engraved cat fish *Arius caelatus*
Blacktip sea cat fish *Arius dussumieri*
Gagora cat fish *Arius gagora*
Blackfin sea cat fish *Arius jella*
Spotted cat fish *Arius maculatus*
Smooth headed cat fish *Arius nenga*
Flat mouth cat fish *Arius platystomus*
Sagor cat fish *Arius sagor*
Sona sea cat fish *Arius sona*
Shovelnose sea cat fish *Arius subrostratus*
Beardless sea cat fish *Batrachocephalus mino*
River cat fish *Hemipimelodus jatius*
Soldier cat fish *Osteogeneiosus militaris*

Family: *Heteropneustidae* (Airsac cat fishes)
Stinging cat fish *Heteropneustes fossilis*
Family: *Plotosidae* (Eeltail cat fishes)
Gray eel cat fish *Plotosus canius*
Striped eel cat fish *Plotosus lineatus*

Order: Aulopiformes (Grinners)

Family: *Synodontidae* (Lizard fishes, Bombay duck)
Greater lizard fish *Saurida tumbil*
Brushtooth lizard fish *Saurida undosquamis*
Bombay duck *Harpadon nehereus*

Order: Batrachoidiformes (Toad Fishes)

Family: *Batrachoididae*
Grunting toad fish *Allenbatrachus grunniens*

Order: Gadiformes (Cods)

Family: *Bregmacerotidae* (Codlets)
Spotted codlet Bregmaceros mcclellandi

Order: Cyprinodontiformes (Rivulines, Killi Fishes and Live Bearers)

Family: *Aplocheilidae* (Killi fishes)
Blue panchax *Aplocheilus panchax*

Order: Beloniformes (Needle Fishes)

Family: *Belonidae*
Banded needle fish *Strongylura leiura*
Spottail needle fish *Strongylura strongylura*

Freshwater gar fish *Xenentodon cancila*
Family: *Hemiramphidae*
Gangetic half beak *Dermogenys brachynotopterus*
Wrestling half beak *Dermogenys pusilla*
Jumping half beak *Hemiramphus archipelagicus*
Congaturi half beak *Hyporhamphus limbatus*
Long billed half beak *Rhynchorhamphus georgii*
Ectuntio half beak *Zenarchopterus ectuntio*
Family: *Adrianichthyidae* (Ricefishes)
Rice fish *Oryzias carnaticus*

Order: Syngnathiformes (Pipefishes and Seahorses)

Family: *Syngnathidae*
Freshwater pipefish *Ichthyocampus carce*
Crocodile tooth pipefish *Microphis cuncalus*
Deocata pipefish *Microphis deocata*

Order: Synbranchiformes (Swamp and Spiny Eels)

Family: *Synbranchidae* (Swamp eels)
Cuchia, Gangetic mud eel *Monopterus cuchia*
Bengal eel *Ophisternon bengalense*
Family: *Mastacembelidae* (Spiny eels)
Lesser spiny eel *Macrognathus aculeatus*
One-stripe spinyeel *Macrognathus aral*
Barred spiny eel *Macrognathus pancalus*
Zig-zag eel, Tire-track spiny eel *Mastacembelus armatus*

Order: Scorpaeniformes (Scorpion Fishes & Flat Heads)

Family: *Platycephalidae* (Flatheads)
Bartail flathead *Platycephalus indicus*

Order: Perciformes (Perch-Like)

Family: *Latidae* (Perches)

Barramundi, Giant seaperch *Lates calcarifer*
Waigieu seaperch *Psammoperca waigiensis*
Family: *Ambassidae* (Glass fishes)
Bald glassy Ambassis *gymnocephalus*
Elongate glass-perchlet *Chanda nama*
Highfin glassy perchlet *Parambassis lala*
Indian glassy fish *Parambassis ranga*
Family: *Serranidae* (Sea basses: groupers and fairy basslets)
Orange spotted grouper *Epinephelus coioides*
Giant grouper *Epinephelus lanceolatus*
Family: *Terapontidae* (Grunters and tigerperches)
Fourlined terapon *Pelates quadrilineatus*
Jarbua terapon *Terapon jarbua*
Small-scaled terapon *Terapon puta*
Largescaled therapon *Terapon theraps*
Family: *Sillaginidae* {Sillagos (Smelt-whitings)} Flathead sillago *Sillaginopsis panijus*
Clubfoot sillago *Sillago chondropus*
Silver sillago, *Sillago sihama*
Soringa sillago *Sillago soringa*
Family: *Carangidae* (Jacks and pompanos)
Indian threadfish *Alectis indicus*
Razorbelly scad *Alepes kleinii*
Longnose trevally *Carangoides chrysophrys*
Malabar trevally *Carangoides malabaricus*
Bigeye trevally *Caranx sexfasciatus*
Japanese scad *Decapterus maruadsi*
Golden trevally *Gnathanodon speciosus*
Torpedo scad *Megalaspis cordyla*
Black pomfret, Brown pomfret *Parastromateus niger*
Barred queen fish *Scomberoides tala*
Bigeye scad *Selar crumenophthalmus*
Yellowstripe scad *Selaroides leptolepis*
Family: *Menidae* (Moonfishes, bat fishes)
Moonfish *Mene maculata*
Family: *Leiognathidae* (Pony fishes)
Goldstripe pony fish *Leiognathus daura*
Common pony fish *Leiognathus equulus*
Striped pony fish *Leiognathus fasciatus*
Splendid pony fish *Leiognathus splendens*
Pugnose pony fish *Secutor insidiator*
Deep pugnose pony fish *Secutor ruconius*
Family: *Lutjanidae* (Snappers)
Mangrove red snapper *Lutjanus argentimaculatus* Humpback red snapper *Lutjanus gibbus*

John's snapper *Lutjanus johnii*
Malabar blood snapper *Lutjanus malabaricus*
Russell's snapper *Lutjanus russellii*
Family: *Datnioididae*
Fourstripe perch *Datnioides polota*
Family: *Lobotidae* (Tripletails)
Atlantic tripletail *Lobotes surinamensis*
Family: *Gerreidae* (Mojarras)
Whipfin silver-biddy *Gerres filamentosus*
Saddleback silver-biddy *Gerres limbatus*
Slender silver-biddy *Gerres oblongus*
Common silver-biddy *Gerres oyena*
Strong spine silver-biddy *Gerres phaiya*
Small Bengal silver-biddy *Gerres setifer*
Family: *Haemulidae* (Grunts)
Bluecheek silver grunt *Pomadasys argyreus*
Silver bream *Pomadasys hasta*
Family: *Sparidae* (Porgies and sea breams)
Yellowfin seabream *Acanthopagrus latus*
King soldierbream *Argyrops spinifer*
Goldlined seabream *Rhabdosargus sarba*
Family: *Nemipteridae* (Threadfin breams and spinycheeks)
Japanese threadfin bream *Nemipterus japonicus*
Family: *Sciaenidae* (Croakers and drums)
Chaptis bahaba *Bahaba chaptis*
Reeve's croaker *Chrysochir aureus*
Bengal corvina *Daysciaena albida*
Goatee croaker *Dendrophysa russelii*
Belanger's croaker *Johnius belangerii*
Karut croaker *Johnius carutta*
Coitor croaker *Johnius coitor*
Cuja croaker *Macrospinosa cuja*
Soldier croaker *Nibea soldado*
Bronze croaker *Otolithoides biauritus*
Pama croaker *Otolithoides pama*
Hooghly croaker *Panna heterolepis*
Pennahia ovata
Blackspotted croaker *Protonibea diacanthus* Blotched tiger-tooth croaker *Pterotolithus maculatus*
Family: *Polynemidae* (Threadfins)
Fourfinger threadfin *Eleutheronema tetradactylum*
Indian threadfin *Leptomelanosoma indicum*
Striped threadfin *Polydactylus plebeius*
Sixfinger threadfin *Polydactylus sexfilis*
Paradise threadfin *Polynemus paradiseus*

Family: *Mullidae* (Goat fishes)
Sulphur goatfish *Upeneus sulphureus*
Family: *Toxotidae* (Archerfishes)
Largescale archerfish *Toxotes chatareus*
Family: *Drepaneidae* (Sicklefishes)
Concertina fish *Drepane longimana*
Spotted sicklefish *Drepane punctata*
Family: *Monodactylidae* (Moonyfishes or fingerfishes)
Silver moony *Monodactylus argenteus*
Family: *Nandidae* (Asian leaf fishes)
Gangetic leaf fish *Nandus nandus*
Family: *Badidae*
Badis *Badis badis*
Family: *Kurtidae* (Nurseryfishes)
Indian hump head *Kurtus indicus*
Family: *Mugilidae* (Mullets)
Largescale mullet *Liza macrolepis*
Gold-spot mullet *Liza parsia*
Greenback mullet *Liza subviridis*
Tade mullet *Liza tade*
Flathead mullet *Mugil cephalus*
Corsula *Rhinomugil corsula*
Cascasia mullet, Yellowtail mullet *Sicamugil cascasia*
Bluetail mullet *Valamugil buchanani*
Bluespot mullet *Valamugil seheli*
Speigler's mullet *Valamugil speigleri*
Family: *Cichlidae* (Cichlids)
Green chromide *Etroplus suratensis*
Family: *Uranoscopidae* (Stargazers)
Uranoscopus guttatus
Family: *Callionymidae* (Dragonets)
River dragonet *Callionymus fluviatilis*
Arrow dragonet *Callionymus sagitta*
Family: *Eleotridae* (Sleepers)
Duckbill sleeper *Butis butis*
Gangetic sleeper *Odonteleotris macrodon*
Dusky sleeper *Eleotris fusca*
Lutea sleeper *Eleotris lutea*
Family: *Gobiidae* (Gobies)
Tropical sand goby *Acentrogobius caninus,*
Acentrogobius cyanomos
Spotted green goby *Acentrogobius viridipunctatus*
Dragon goby *Apocryptes bato*
Scribbled goby *Awaous grammepomus*
Largesnout goby *Awaous melanocephalus*

Bathygobius ostreicola
Bumblebee goby *Brachygobius nunus*
Boddart's goggle-eyed goby *Boleophthalmus boddarti* Mudskipper *Boleophthalmus dussumieri*
Tank goby *Glossogobius giuris*
Glass goby *Gobiopterus chuno*
Rubicundus eelgoby *Odontamblyopus rubicundus*
Maned goby *Oxyurichthys microlepis*
Taileyed goby *Parachaeturichthys polynema*
Giant mudskipper *Periophthalmodon schlosseri*
Periophthalmodon septemradiatus
Atlantic mudskipper *Periophthalmus barbarus*
Pearse's mudskipper *Periophthalmus novemradiatus*
Elongate goby *Pseudapocryptes elongatus*
Many-finned eelgoby *Pseudotrypauchen multiradiatus*
Walking goby *Scartelaos histophorus*
Knight goby *Stigmatogobius sadanundio*
Eel worm goby *Taenioides anguillaris*
Burmese gobyeel *Taenioides buchanani*
Bearded worm goby *Taenioides cirratus*
Burrowing goby *Trypauchen vagina*
Family: *Scatophagidae* (Scats)
Spotted scat *Scatophagus argus*
Family: *Siganidae* (Rabbit fishes)
Streaked spinefoot *Siganus javus*
Family: *Sphyraenidae* (Barracudas)
Great barracuda *Sphyraena barracuda*
Family: *Trichiuridae* (Cutlass fishes and scabbard fishes)
Longtooth hairtail *Eupleurogrammus glossodon*
Smallhead hairtail *Eupleuroarammus muticus*
Coromandel hairtail *Lepturacanthus pantului*
Savalani hairtail *Lepturacanthus savala*
Gangetic hairtail *Trichiurus gangeticus*
Largehead hairtail *Trichiurus lepturus*
Family: *Scombridae* (Mackerels, tunas and bonitos)
Kawakawa *Euthynnus affinis*
Indian mackerel *Rastrelliger kanagurta*
Narrow-barred Spanish mackerel *Scomberomorus commerson* Indo-Pacific king mackerel *Scomberomorus guttatus*
Family: *Stromateidae* (Butterfishes)
Silver pomfret *Pampus argenteus*
Chinese silver pomfret *Pampus chinensis*
Pampus cinereus
Family: *Anabantidae* (Climbing gouramies)
Climbing perch *Anabas testudineus*

Family: *Osphronemidae* (Gouramies)
Banded gourami *Colisa fasciata*
Spiketail paradise fish *Pseudosphromenus cupanus* Dwarf gourami *Colisa lalia*
Frail gourami *Ctenops nobilis*
Honey gourami *Trichogaster chuna*
Family: *Channidae* (Snakeheads)
Barca snakehead
Channa barca
Channa gachua
Great snakehead *Channa marulius*
Walking snakehead *Channa orientalis*
Spotted snakehead *Channa punctata*
Snakehead murrel *Channa striata*

Order: Pleuronectiformes (Flatfishes)

Family: *Psettodidae* (Psettodids)
Indian spiny turbot *Psettodes erumei*
Family: *Paralichthyidae* (Largetooth flounders)
Largetooth flounder *Pseudorhombus arsius*
Deep flounder *Pseudorhombus elevatus*
Malayan flounder *Pseudorhombus malayanus*
Three spotted flounder *Pseudorhombus triocellatus*
Family: *Citharidae* (Chitarids)
Yellow-dabbled flounder *Brachypleura novaezeelandiae*
Family: *Soleidae* (Soles)
Oriental sole *Brachirus orientalis*
Pan sole *Brachirus pan*
Eyed sole *Heteromycteris oculus*
Kaup's sole *Synaptura albomaculata*
Highfin sole *Zebrias altipinnis*
Family: *Cynoglossidae* (Tongue fishes)
Largescale tongue-sole *Cynoglossus arel*
Bengal tongue-sole *Cynoglossus cynoglossus*
Long tongue-sole *Cynoglossus lingua*
Malabar tongue-sole *Cynoglossus macrostomus*
Speckled tongue-sole *Cynoglossus puncticeps*
Bengal tongue-sole *Cynoglossus semifasciatus*
Doublelined tongue-sole *Paraplagusia bilineata*

Order: Tetradontiformes (Puffers and Filefishes)

Family: *Triacanthidae* (Triplespines)
Short-nosed tripodfish *Triacanthus biaculeatus*
Family: *Tetraodontidae* (Puffers)
Immaculate puffer *Arothron immaculatus*
Milkspotted puffer *Chelonodon patoca*
Green rough-backed puffer *Lagocephalus lunaris*
Lattice blaasop *Takifugu oblongus*
Ocellated pufferfish *Tetraodon cutcutia*
Green pufferfish *Tetraodon fluviatilis*

Reports of amphibians are also available from the creeks and intertidal mudflats of mangrove dominated Indian Sundarbans.

A Checklist of Sundarban Amphibians

Order: Anura

Family: *Bufonidae*
Common Indian toad *Bufo melanostictus*
Family: *Microhylidae*
Ornate narrow-mouthed frog *Microhyla ornate*
Family: *Rhacophoridae*
Common tree frog *Polypedates maculatus*
Family: *Ranidae*
Skittering frog *Euphlyctis cyanophlyctis*
Indian pond frog *Euphlyctis hexadactylus*
Indian bull frog *Hoplobatrachus tigerinus*
Cricket frog *Limnonectes limnocharis*

The mangrove ecosystem of Indian Sundarbans houses a wide variety of reptiles as listed here.

A Checklist of Sundarban Reptiles

Order: Crocodilia

Family: *Crocodylidae*
Mugger crocodile *Crocodylus palustris*
Saltwater crocodile *Crocodylus porosus*

Order: Testudines or Chelonia or Testudinata

Family: *Dermochelyidae*
Leatherback sea turtle *Dermochelys coriacea*
Family: *Cheloniidae*
Loggerhead sea turtle *Caretta caretta*
Green sea turtle *Chelonia mydas*
Hawksbill sea turtle *Eretmochelys imbricata*
Olive ridley sea turtle *Lepidochelys olivacea*
Family: *Bataguridae*
Indian roofed turtle *Kachuga tecta*
Red crowned roofed turtle *Kachuga kachuga*
River terrapin *Batagur baska*
Spotted pond turtle *Geoclemys hamiltonii*
Family: *Trionychidae*
Narrow-headed soft turtle *Chitra indica*
Asian giant softshell turtle *Pelochelys cantorii*
Dark softshell turtle *Aspideretes nigricans* (B)
Indian flapshell turtle *Lissemys punctata*

Order: Squamata; Suborder: Lacertila

Family: *Gekkonidae*
Tokay gecko *Gekko gecko*
Brook's house gecko *Hemidactylus brookii*
Yellow-green house gecko *Hemidactylus flaviviridis*
Family: *Agamidae*
Indian garden lizard *Calotes versicolor*
Family: *Chamaeleonidae*
Indian chameleon *Chamaeleo zeylanicus*
Family: *Scincidae*
Keeled grass skink *Mabuya carinata*
Family: *Varanidae*
Bengal monitor *Varanus bengalensis*
Water monitor *Varanus salvator*
Yellow monitor *Varanus flavescens*

Order: Squamata; Suborder: Serpents

Family: *Acrochordidae*

Wart snake or file snake *Acrochordus granulatus*
Family: *Boidae*
Common sand boa *Gongylophis conicus*
Indian rock python *Python molurus*
Family: *Colubridae*
Common vine snake *Ahaetulla nasuta*
Striped keelback *Amphiesma stolatum*
Dog-faced watersnake *Cerberus rynchops.*
Ornate flying snake *Chrysopelea ornata*
Common bronzeback tree snake *Dendrelaphis tristis*
Common smooth water snake *Enhydris enhydris*
White-bellied mangrove snake *Fordonia leucobalia*
Glossy marsh snake *Gerarda prevostiana*
Common wolf snake *Lycodon aulicus*
Banded kukri snake *Oligodon arnensis*
Indian rat snake *Ptyas mucosa*
Checkered keelback *Xenochrophis piscator*
Family: *Elapidae*
Common Indian krait *Bungarus caeruleus*
Banded krait *Bungarus fasciatus*
Monocled cobra *Naja kaouthia*
King cobra *Ophiophagus hannah*
Family: *Hydrophiidae*
Hook-nosed sea snake *Enhydrina schistosa*
Blue sea snake *Hydrophis caerulescens*
Annulated sea snake *Hydrophis cyanocinctus*
Black-banded sea snake *Hydrophis nigrocinctus*
Estuarine sea snake *Hydrophis obscurus*
Ornate sea snake *Hydrophis ornatus*
Malabar sea snake *Lapemis curtus*
Banded laticauda *Laticauda laticaudata*
Family: *Viperidae*
Russell's viper *Daboia russelii*
Spot-tailed pit viper *Trimeresurus erythrurus*

The mangrove ecosystem of Sundarbans is noted for man-crocodile conflict. The researchers of Forest Department of the State of West Bengal (India) cited considerable number of crocodiles during 2009–2011 in the Reserve Forest area of Indian Sundarbans (Fig. 8.12). Occasionally the estuarine crocodiles of Sundarbans stray to village pond and are rescued. People believe that the straying is mainly to eat the fishes of the village ponds. A total of 69.23% crocodile straying in villages takes place in the month of September and October. This is the time when crocodiles are reported to start making nest to lay egg and are on search of safe nesting sites.

Saltwater crocodiles have a strong tendency to consider human beings in their territory as their lucrative prey. They have a long history of attacking human beings

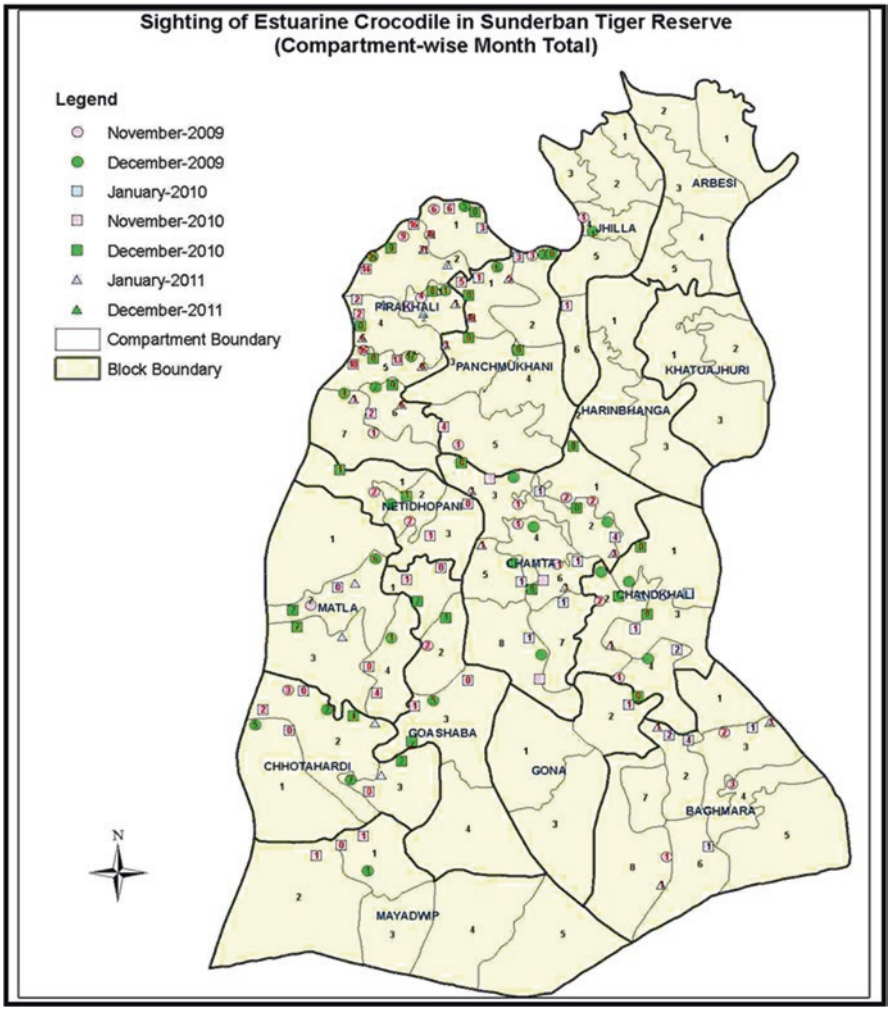


Fig. 8.12 Areas of citation for crocodiles in the Reserve Forest area of Indian Sundarbans

who stray into their territory. It has been reported by Marine Biologists that prawn seed collectors of Sundarbans estuaries, who are mostly women, are attacked by crocodiles during the time of dragging nets in the muddy estuarine water for tiger prawn seed collection. It is surprising that although saltwater crocodiles are relatively lethargic in nature, but as predators they display extreme reflex in terms of speed and attack. They are capable of explosive burst of speed when launching an attack from water. They can also swim at a speed of 24–30 km/hr if they target for their prey in their surroundings.

Fig. 8.13 Birds on the intertidal mudflats of mangrove habitat

Fig. 8.14 Birds on the mangrove pneumatophores

They feed mainly on fishes and are sometimes known to attack and kill sharks close to their own size. They are very aggressive and often attack and kill human beings within their range.

The species was indiscriminately killed for the purpose of making luxury goods from its skin in late sixties and early seventies. The level of poaching became so severe that the population subsequently declined, making the species endangered.

The mangrove ecosystem of Indian Sundarbans is also noted for avian diversity (Figs. 8.13 and 8.14).

The marshy area of mangrove dominated Sundarbans is the homeland of a variety of seabirds like herons, cormorants, egrets, kingfishers, storks and darters. About 250 species of birds have been documented in this deltaic lobe at the apex of Bay of Bengal, of which a sizable proportion is migratory. A number of species of eagles, including the White-bellied Sea Eagle, Crested Serpent Eagle, Palla's Fishing Eagle and owls such as the Barn owl, Scops owl, Spotted owl and Brown Fish Owl are also found in the mangrove trees. On the intertidal mudflats, different species of plovers and sandpipers are common. Marsh birds like herons, egrets, bitterns, storks and rails are resident birds and are found throughout the year. Migratory flocks of sandpipers, redshanks and whimlocks can be seen during winter. Table 8.13 lists few frequently sighted avifauna in Indian Sundarbans.

The aquatic phase of Indian Sundarbans also sustains a variety of mammals. The common species of dolphin found in the Gangetic stretch adjacent to coastal Bay of Bengal are Gangetic Dolphin (*Platanista gangetica*) and Irrawady Dolphin (*Orcaella brevirostris*). Gangetic Dolphin is restricted in fresh water zone whereas Irrawady Dolphin is widely visible in the brackish water in and around the deltaic Sundarbans.

Technically, porpoises comprise only a small group of blunt-nosed whales, but in some places the name "**porpoise**" is given to some of the dolphins. Porpoise, as a term, refers to smaller members of the group, which have spade-shaped teeth, a triangular dorsal fin and a smooth front end tapering to a point. Black finless porpoise (*Neomeris phocaenoides*) is often sighted in the brackish waters of Indian Sundarbans.

The intertidal mudflats of mangrove dominated Indian Sundarbans is the home land of a variety of mammals. The presence of the Royal Bengal Tiger (*Panthera tigris tigris*) has imparted a special status to this deltaic complex of the Indian sub – continent (Fig. 8.15).

The prey base of tiger comprises of monkeys (*Macaca mulatta*), deer etc. (Figs. 8.16 and 8.17).

The watch towers in the midst of the mangrove habitat have been constructed to observe the behaviour of wild animals in the mangrove forest (Fig. 8.18).

A checklist of mammals present in the mangrove habitats of Sundarbans is presented here.

A Checklist of Sundarban Mammals

Order: Primates

Family: ***Cercopithecidae***
Rhesus macaque *Macaca mulatta*

Table 8.13 Common avifauna of Indian Sundarbans

Vernacular name	Scientific name
Resident	
Little cormorant	*Phalacrocorax niger*
Great cormorant	*P. carbo*
Grey heron	*Ardea cinerea*
Purple heron	*A. purpurea*
Indian pond-heron	*Ardeola grayi*
Cattle egret	*Bulbucus ibis*
Open bill stork	*Anastomus oscitans*
Great egret	*Egretta alba*
Intermediate egret	*E. intermedia*
Little egret	*E. garzetta*
Black-crowned night heron	*Nycticorax nycticorax*
Greater adjutant	*Leptoptilos dubius*
Black-necked stork	*Xenorhynchus asiaticus*
Black-headed ibis	*Threskiornis melanocephala*
White-breasted water hen	*Amaurornis phoenicurus*
Bronze-winged jacana	*Metopidius indicus*
Pheasant -tailed jacana	*Hydrophasianus chirurgus*
Black-capped kingfisher	*Halcyon pileata*
Collared kingfisher	*H. chloris*
Brown-winged kingfisher	*Pelargopsis amauroptera*
Migratory species	
Spot-billed pelican	*Pelecanus philippenensis*
Northern pintail	*Anas acuta*
Common teal	*A. crecca*
Tufted duck	*Aythya fuligula*
Common pochard	*A. ferina*
Ruddy shelduck	*Tadorna ferruginea*
Whimbrel	*Numenius phaeopus*
Black-tailed godwit	*Limosa limosa*
Little stint	*Calidris minuta*
Great knot	*C. tenuirostris*
In shallow water	
Eastern golden plover	*Pluvialis dominica*
Kentish plover	*Charadrius alexandrinus*
Eurasian curlew	*Numenius arquata*
Wood sandpiper	*Tringa glareola*
Terek sandpiper	*Xenus cinereus*
Reclaimed area	
Indian darter	*Anhinga melanogaster*
Chestnut bittern	*Ixobrychus cinnanoneus*
Black bittern	*Butoridea stellaris*

(continued)

Table 8.13 (continued)

Vernacular name	Scientific name
Spoonbill	*Platalea teucorodia*
Red-wattled lapwing	*Vanellus indicus*
Grey-headed lapwing	*V. cinereus*
Herring gull	*Larus argentatus* (rare visitor)
Great crested tern	*Sterna bergii* (rare visitor)
Lesser crested tern	*S. bengalensis* (rare visitor)
Sooty tern	*S. fuscata* (rare visitor)
Red jungle fowl	*Gallus gallus (found in forest areas only)*
Swamp partridge	*Francolinus gularia*
Greater coucal	*Centropus sinensis*
Occasional visitors to the estuary	
Osprey	*Pandion haliaetus*
Black kite	*Milvus migrans*
Brahminy kite	*Haliastur indus*
White-bellied sea-eagle	*Haliaeetus leucogaster*
Crested serpent eagle	*Spilornis cheela*
Spotted dove	*Streptopelia chinensis*
Yellow-footed pigeon	*Treron phoenicoptera*
Large Indian parakeet	*Psittacula eupatria*
Rose-ringed parakeet	*P. krameri*
Barn owl	*Tyto alba*
Brown fish-owl	*Bubo zeylonensis*
Spotted owlet	*Athene brama*
Magpie robin	*Copsychus saularis*
Asian paradise flycatcher	*Terpsiphone paradise*
Black drongo	*Dicrurus adsimilis*
Treepie	*Crypsirina vagabonda*
Grey shrike	*Lanius excubitor*
Common swallow	*Hirundo rustica*
Indian roller	*Coracias bengalensis*

Order: Artiodactyla

Family: *Cervidae*
Indian muntjac *Muntiacus muntjak* (B)
Spotted deer *Axis axis*
Family: *Suidae*
Wild boar *Sus scrofa*

Fig. 8.15 Tiger in the midst of *Phoneix paludosa* (local name of the tree is Hetal)

Fig. 8.16 Monkey (*Macaca mulatta*) – a prey base of Sundarban tiger

Fig. 8.17 Deer (*Axis axis*) – a lucrative prey of Sundarban tiger

Fig. 8.18 Watch Tower in the heart of mangroves

Order: Carnivora

Family: *Canidae*
Jackal *Canis aureus*
Indian fox *Vulpes bengalensis*
Family: *Felidae*
Tiger *Panthera tigris*
Jungle cat *Felis chaus*
Leopard cat *Prionailurus bengalensis*
Fishing cat *Prionailurus viverrinus*
Family: *Mustelidae*
Smooth-coated otter *Lutrogale perspicillata*
Small-clawed otter *Amblonyx cinereus*
Family: *Viverridae*
Small Indian civet *Viverricula indica*
Large Indian civet *Viverra zibetha*
Common palm civet *Paradoxurus hermaphroditus*
Family: *Herpestidae*
Grey mongoose *Herpestes edwardsii*
Small Indian mongoose *Herpestes javanicus*

Order: Insectivora

Family: *Soricidae*
House shrew *Suncus murinus*

Order: Rodentia

Family: *Hystricidae*
Himalayan crestless porcupine *Hystrix brachyura* (B)
Family: *Sciuridae*
Five-striped palm squirrel *Funambulus pennantii*
Family: *Muridae*
Large bandicoot-rat *Bandicota indica*
Lesser Bandicoot-rat *Bandicota bengalensis*
House rat *Rattus rattus*
Long-tailed tree mouse *Vandeleuria oleracea*
Little Indian field mouse *Mus booduga*

Order: Chiroptera

Family: *Pteropodidae*
Indian flying fox *Pteropus giganteus*
Short-nosed fruit bat *Cynopterus sphinx*
Family: *Rhinopomatidae*
Lesser mouse-tailed bat *Rhinopoma hardwickii*
Family: *Emballonuridae*
Long-winged tomb bat *Taphozous longimanus*
Family: *Hipposideridae*
Tail-less leaf-nosed bat *Coelops frithii*
Family: *Megadermatidae*
Greater false vampire *Megaderma lyra*
Family: *Vespertilionidae*
Asiatic greater yellow house bat *Scotophilus heathii*
Lesser Asiatic yellow house bat *Scotophilus kuhlii*
Indian pipistrelle *Pipistrellus coromandra*
Indian pygmy bat *Pipistrellus tenuis*

Order: Cetacea

Family: *Platanistidae*
Ganges river dolphin *Platanista gangetica*
Family: *Phocoenidae*
Finless porpoise *Neophocaena phocaenoides*
Family: *Delphinidae*
Irrawaddy dolphin *Orcaella brevirostris*
Indo-Pacific bottlenose dolphin *Tursiops aduncus*
Common bottlenose dolphin *Tursiops truncatus*
Short-beaked common dolphin *Delphinus delphis*

In conclusion it can be advocated that biodiversity of mangrove ecosystem has a wide spectrum with several direct and indirect societal benefits. There are different techniques to tag the benefits generated by mangrove-centric biodiversity with money. Usually market prices can be applied when direct benefits of biodiversity are involved, *e.g*., when the consumer purchases the biodiversity-derived goods like fishes, honey, and wax from mangrove esosystem. When biodiversity loss is involved, preventative or mitigatory expenditure is applied. If a given ecosystem is under threat from human activites like shrimp culture in mangrove habitats or constructing fish landing units within the mangrove forests, the cost of implementing a conservation unit as proxy to protect the same ecosystem, may be used to estimate the benefit of that ecosystem's continued survival and representation. The idea is not strictly to estimate monetary value for biodiversity, but rather to provide alternatives

to avoid loss. It is not always possible to be precise in these cases, since the value relies on mitigation/compensation. It is about finding an alternative to reduce the impact on biodiversity caused by human activity resulting from the drive towards economic development.

Biodiversity also has social amenity value. For example, considering the riverine fisherman, or a honey collector collector in the forest, biodiversity can improve their standards of living, making these forest people proud, and helping them lead more fulfilled lives. Biodiversity reinforces economic and social security; economic and social values will in turn reinforce biodiversity conservation by means of cultural instruments. The comprehensive valuation of mangrove biodiversity is still in an embryonic stage. On the one hand the value of provisioning services manifests itself through market prices; on the other, the importance of biodiversity as part of the ecosystem that produces and regulates cultural services cannot be captured in financial markets. In the mangrove forests of Sundarbans, the cultural services like worshipping of Gods/Godesses as the protector of ecosystems has no market valuation in the present stage and needs lots of researches involving specialists in social science, economics and psychology to fill this gap zone. Also the energy flowing through food webs of the mangrove ecosystem has not yet been valued like electrical energy or thermal energy, although the end visible entities like species have their own market values. The overall ecosystem service of mangrove biodiversity is yet to go a long way to see the total financial coverage.

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