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Mangrove Health Card: A Case Study on Indian Sundarbans

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Abstract

Relative abundance and Shannon-Weiner species diversity index of true mangrove species were estimated in 10 sampling stations of Indian Sundarbans during 2013. The mangrove patches in the selected stations were categorized into a 4-point scale depending on the values of Shannon-Weiner species diversity index. The health of the mangrove forest as per our constructed 4-point scale was found to be regulated primarily by anthropogenic factors, although in station like Sagar South, the natural erosion may be the key player in determining the mangrove floral diversity.

Keywords: Indian Sundarbans, Relative abundance, Shannon-Weiner species diversity index, 4-Point scale, Anthropogenic pressure, Erosion.

1. Introduction

Mangrove forests are among the world's most productive ecosystems. The real ecosystem services of mangroves have come in the forefront only after the outbreak of Tsunami on 26th December 2004. Mangroves protect coastal lands by absorbing and diverting the energy of tidal currents and storm driven wind and wave action, creating natural break water that retards the process of erosion. The mangrove community also provides a buffer between a terrestrial and nearby marine environment; trapping and stabilizing sediments, nutrients and several types of conservative pollutants (Mitra, 2013; Chakraborty *et al*., 2014a; Chakraborty *et al*., 2014b), hence helping to maintain the water quality. Evaluation of such ecosystem services of mangroves and their economic evaluation are yet unrevealed, even though several studies are available on the use of mangroves as nursery and breeding ground of fishes, sources of timber, honey, wax, firewood, etc. (Naskar, 1993; Ewel *et al*., 1998; Hogarth, 2007; Naskar and Mandal, 2000; Saenger, 2002; Naskar, 2004; Nybakken and Bertness, 2005; Raman *et al*., 2007; Walters *et al*., 2008; Spalding *et al*., 2010). Considering the importance of mangroves as primary service providers to coastal populations and island dwellers, it is extremely important to assess the biodiversity and relate the same with the anthropogenic and natural threats existing in and around the habitats. The present study is an approach in this direction considering 500 m sampling width from the Low Tide Line (LTL) existing in different sampling sites of Indian Sundarbans. The significance of taking such a band width of 500 m is the niche preference of different mangrove species (Duke and Kleine, 2007) as shown in Figure 1.

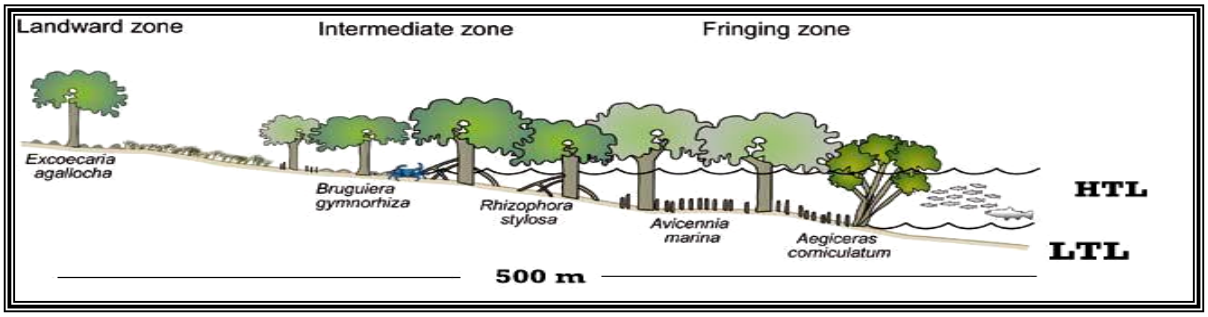

Figure 1. Distribution and preference of mangrove species in the intertidal mudflats of a model mangrove forest in the tropical estuary. (Source: modified after Duke and Kleine, 2007; www.dpi.nsw.gov.au/__data/assets/pdf_file/0020/.../mangroves.pdf)

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2. Materials and methods

2.1. Site selection and Sampling

The present study was conducted in the Indian Sundarbans mangrove ecosystem during 2013. Several field trips were made to select the field stations (Table 1) and study the distribution of mangrove vegetation, geographic nature of riverine system, salinity, environmental quality and anthropogenic pressure. While selecting the sampling sites, we focused on two broad issues namely natural threats (like erosion, sea level rise, salinity fluctuation, etc.) and human induced factors (like industrialization, urbanization, tourism, aquacultural practice, etc.). These criteria have been selected to observe the factors regulating the survival/degradation of mangroves in and around the selected sampling stations.

Table 1. Selected sampling stations with coordinates

Stations	Latitude	Longitude
Sagar South	21º38'54.37"N	88º03'06.17"E
Canning	22º19'03.20"N	88º41'04.43"E
Kakdwip	21º52'26.50"N	88º08'04.43"E
Chemaguri	21º39'58.15"N	88º10'07.03" E
Lothian island	21º39'01.58"N	88º22'13.99"E
Prentice island	21º42'40.97"N	88º17'10.04"E
Bonnie Camp	21º49'42.90"N	88º37'13.70"E
Sajnekhali	22º05'13.40"N	88º46'10.80"E

Quadrates of 10m × 10m were laid randomly up to 500 m from LTL and data from each one were recorded from 15 such quadrates. Plant materials collected during the sampling were identified from Naskar (1993) and confirmed from Botanical Survey of India, Kolkata (India).

2.2. Enumeration of mangrove health

Relative abundance of the species was estimated as per the expression: RA = Abundance of a particular species/sum of the abundance of all species × 100; where RA represents relative abundance.

Shannon Weiner index for diversity was calculated based on the abundance value of plant species in different categories as per the following expression:

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

Where, H = Shannon-Weiner species diversity index; $P_i = n_i/N$ (n_i = Number of individuals of i^{th} species and N= total number of individuals of all the species in the quadrate).

The values of Shannon Weiner index were calibrated on 4-point scale to assign a status to health of the mangrove diversity in each region. Four distinct groups were derived from the 4-point scale on the basis of the values of Shannon-Weiner Species Diversity Index. These groups are designated as follows:

< 1: Worst Health;

1-2: Moderate Health;

2-3: Good Health;

3-4: Excellent Health

3. Results

A total of 25 mangrove species (*Acanthus ilicifolius, Acrostichum aureum, Aegiceras corniculatum, Aegialites rotundifolia, Avicennia alba, Avicennia marina, Avicennia officinalis, Bruguiera cylindrical, Bruguiera gymnorhiza, Bruguiera hexangular, Bruguiera parviflora, Ceriops decandra, Ceriops tagal, Exocoecaria agallocha, Heritiera fomes, Kandelia candel, Lumnitzera racemosa, Nypa fruticans, Phoenix paludosa, Rhizophora apiculata, Rhizophora mucronata, Sonneratia apetala, Sonneratia caseolaris, Xylocarpus granatum, Xylocarpus mekongensis*) was recorded from the selected sites (Table 2).

The total number of individuals of all the documented species, which represents the dense growth of the trees, exhibits a pronounced variation due to which the Shannon Weiner species diversity is affected. Highest numbers of individuals are observed in the quadrate of Lothian island ($165/100m^2$), a pristine forest patch almost with no human intervention, whereas lowest value ($37/100m^2$) is observed in Kakdwip, the sampling station with maximum anthropogenic stress (Figure 2).

The results of Shannon-Weiner index are shown in Figure 3. The spatial order of the index is Prentice island (3.052) > Lothian island (3.006) > Sajnekhali (2.984) > Bonnie camp (2.737) > Chemaguri (2.563) > Sagar south (2.441) > Canning (2.192) > Kakdwip (1.719).

The variation in the value of the 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.

Table 2: Selected sampling species with their family

Species	Family
Acanthus ilicifolius	Acanthaceae
Acrostichum aureum	Pteridaceae
Aegiceras corniculatum	Myrsinaceae
Aegialites rotundifolia	Plumbaginaceae
Avicennia alba	Avicenniaceae
Avicennia marina	Avicenniaceae
Avicennia officnalis	Avicenniaceae
Bruguiera cylindrical	Rhizophoraceae
Bruguiera gymnorhiza	Rhizophoraceae
Bruguiera hexangular	Rhizophoraceae
Bruguiera parviflora	Rhizophoraceae
Ceriops decandra	Rhizophoraceae
Ceriops taga,	Rhizophoraceae
Exocoecaria agallocha	Euphorbiaceae
Heritiera fomes	Sterculiaceae
Kandelia candel	Rhizophoraceae
Lumnitzera racemosa	Combretaceae
Nypa fruticans	Palmae
Phoenix paludosa	Palmae
Rhizophora apiculata	Rhizophoraceae
Rhizophora mucronata	Rhizophoraceae
Sonneratia apetala	Sonneratiaceae
Sonneratia caseolaris	Sonneratiaceae
Xylocarpus granatum	Meliaceae
Xylocarpus mekongensis	Meliaceae

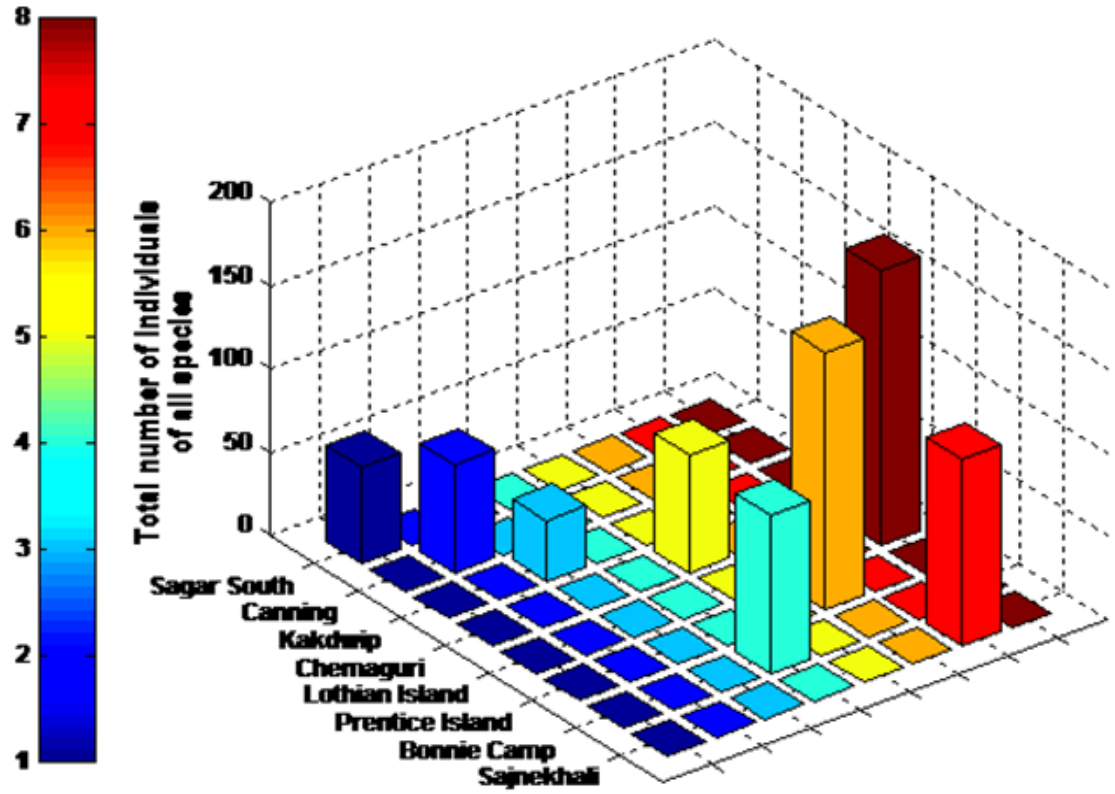

Figure 2. Spatial variation of total number of individuals of all species (N)

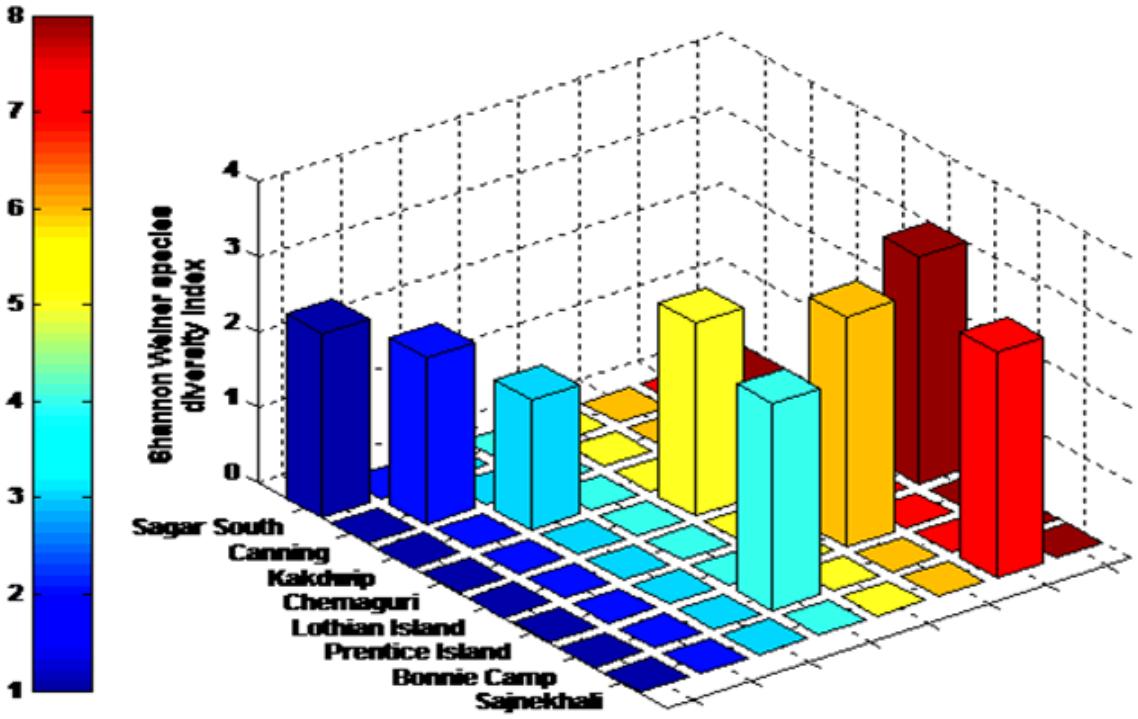

Figure 3. Spatial variation of Shannon Weiner species diversity index.

4. Discussion

Mangroves are salt tolerant plant communities that grow luxuriantly in the intertidal zone in the tropics and sub-tropics. A total of 52 species have been identified by Giesen *et al*. (2007) as true mangroves in south-east Asia. Mangroves that are dominant and typify the flora in most locations are considered as core species (Spalding *et al*., 2010; ITTO, 2012). Globally, a total of 38 core species have been identified in the Indo-West Pacific and Atlantic East Pacific regions. In Indian Sundarbans, a total of 34 true mangrove species have been documented (Chaudhuri and Choudhury, 1994; Mitra, 2000; Mitra *et al*., 2004; Mitra and Banerjee, 2005) of which, in the present study, only 25 species were documented during the sampling period (Table 2). On the basis of our calibration (as stated in the materials and method section) it is observed that Prentice island and Lothian island fall within the category of 'Excellent health'. The category of 'Good health' encompasses 5 stations in our study area namely Sajnekhali, Bonnie camp, Chemaguri, Sagar south and Canning, whereas Kakdwip with H value of 1.719 is under the category of 'Moderate health' as per our 4-point calibration scale. The variation in health may be attributed to degree and magnitude of threats to which these sampling stations are exposed. Prentice island and Lothian island showing 'Excellent health' fall within the protected area of the Reserve Forest due to which minimum human interference occur in these stations (Mitra and Banerjee, 2005). Moreover, the rich diversity of mangroves in these two stations may also be related to optimum salinity of the ambient aquatic phase due to inundation of the forest with the water of the Hooghly riverine system (Mitra *et al*., 2009; Mitra *et al*., 2011; Banerjee *et al*., 2012; Sengupta *et al*., 2013; Chakraborty *et al*., 2014a; Ray Choudhury *et al*., 2014) that receive the freshwater through Farakka discharge.

The stations exhibiting 'Good health' (like Bonnie camp and Sajnekhali) are hypersaline in nature due to complete blockage of the freshwater flow on account of Bidyadhari siltation since the late 15th century (Chaudhuri and Choudhury, 1994). These two stations also witness minimum human interference except seasonal tourism (preferably during the winter season prevailing from December to February). The other three stations (Canning, Chemaguri and Sagar South) within the category of 'Good health' experience threats like tourism, fish-landing, pilgrims and sporadic presence of shrimp farms. Inspite of these multifarious threats, appropriate dilution of the sampling sites with fresh water has provided the mangroves of these sites a congenial environment. It is to be noted, at this point, that mangroves are halophytes, but their luxuriant growth in brackish water (~ 5 psu to 15 psu) and stunted growth and extinction in high saline water have been observed by several researchers in the present geographical locale (Mitra *et al*., 2011; Banerjee *et al*., 2012; Sengupta *et al*., 2013). It is also observed, in the present study area, that species like *Heritiera fomes* is highly sensitive to salinity and prefers a low saline condition around 2-4 psu (Figure 4). The gradual vanishing of this species from the Indian Sundarbans is a confirmatory test of the preference of some mangrove species to hyposaline environment (Zaman *et al*., 2013; Mitra and Zaman, 2014).

Figure 4. *Heritiera fomes*: gradually vanishing from Indian Sundarbans

Kakdwip, located in the western Indian Sundarbans, exhibits 'Moderate health' due to high degree of anthropogenic pressure arising from passenger vessel jetties, fish-landing activities, shrimp farms, brick kilns, busy market related activities etc.

In addition to this, natural factors, like erosion due to wave action, also play a crucial role in modifying the health of the mangrove forest as seen in case of Sagar south. The gradual erosion of the island makes the substratum unstable and washes out the nutrient and organic matter from the intertidal mudflats on which the growth and survival of mangrove flora depend (Sengupta *et al*., 2013). The types of threats exerted on the mangroves inhabiting the selected stations are highlighted in Table 3.

Table 3. Nature of threats on the mangroves of selected sampling stations

Stations	Natural threat	Anthropogenic threat
Sagar South	Erosion, sea level rise	Fish landing, fish drying, tourism, pilgrim related pressure, navigational channel
Canning	Siltation and complete blockage of fresh water	Fish landing stations, boat/fishing vessels/trawlers mending and repairing units
Kakdwip	Erosion	Fishing harbour, market and fish selling points, heavy metal pollution from antifouling paints used for conditioning fishing vessels and trawlers
Chemaguri	Erosion	Fish landing units, shrimp farms
Lothian island	Erosion	Minimum because of its location within the Reserve Forest
Prentice island	Erosion	Minimum and adjacent to the Reserve Forest
Bonnie Camp	Erosion	Minimum and adjacent to the Reserve Forest, tourism pressure particularly during the postmonsoon season
Sajnekhali	Siltation and hypersalinity	Minimum because of its location within the Reserve Forest

5. Conclusion

The overall discussion, thus, leads to the conclusion that human interference is the major factor in the lower Gangetic delta that plays the key role in determining the health of the mangrove forest in terms of diversity. A more serious intervention of the Government and local NGOs is necessary to restore the degraded health of the mangrove forest in areas like Kakdwip, which otherwise may face complete degradation in near future.

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