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Shannon Weiner Index: A Proxy to Evaluate the Floral Health of Indian Sundarbans

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ABSTRACT: We assessed the Shannon Weiner species diversity index of true mangroves in Indian Sundarbans during 2000, 2006 and 2012 considering the natural-cum-anthropogenic threats along with conservation strategies operating in and around the ten selected sampling stations. Our analysis revealed pronounced spatio-temporal variations, which may be attributed primarily due to anthropogenic pressure that is more predominant in stations like Canning, Harinbari, Chemaguri and Sagar south. The adverse impact of hypersalinity on the diversity of true mangroves also surfaced out from this first order analysis.

KEYWORDS: True mangroves, Shannon Weiner species diversity index, spatio-temporal variation

I. 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 deflecting 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 [1-3] thus, helping to maintain the water quality. Evaluation of such ecosystem services of mangroves and their economic evaluation are yet unrevealed, although several literatures are available on the use of mangroves as nursery and breeding ground of fishes, sources of timber, honey, wax, firewood *etc.* [4-13]. 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.

II. MATERIALS AND METHODS

Site selection and sampling: The present study was conducted in the Indian Sundarbans mangrove ecosystem during December, 2000, 2006 and 2012. Several field trips were conducted to select the field stations viz. Harinbari, Chemaguri, Sagar South, Lothian Island, Prentice Island, Canning, Sajnekhali, Chotomollakhali, Satjelia and

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Pakhiralaya (Figure 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 major issues namely natural threats (like salinity fluctuation) and human induced factors (like industrialization, urbanization, tourism, aquacultural practice *etc*). These criteria have been selected primarily to observe the factors regulating the survival/degradation of mangroves in and around the selected sampling stations.

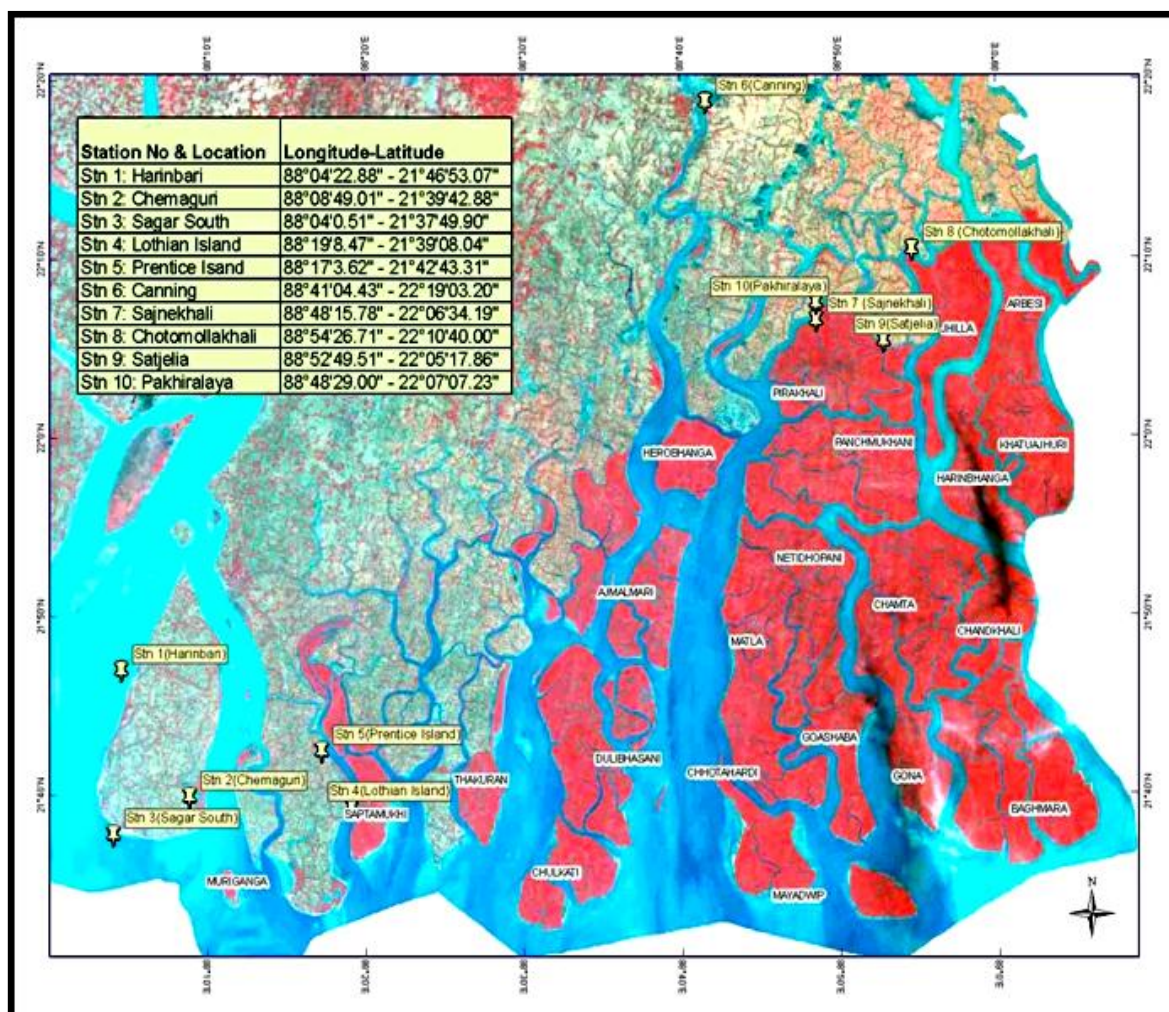


Figure 1: Location of sampling stations in Indian Sundarbans

Quadrates of 10m × 10m were laid randomly up to 500 m from LTL and data from each one were recorded from 15 such quadrates.

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

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

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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 quadrat). It is to be noted that Shannon Weiner index was calculated on the basis more than equal to 40% abundance of the species common to all the ten selected sampling stations.

III. RESULTS

A total of 25 mangrove species (Acanthus ilicifolius, Acrostichum aureum, Aegiceras corniculatum, Aegialitis rotundifolia, Avicennia alba, Avicennia marina, Avicennia officinalis, Bruguiera cylindrica, Bruguiera gymnorhiza, Bruguiera hexangula, Bruguiera parviflora, Ceriops decandra, Ceriops tagal, Excoecaria 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.

The total number of individuals of all the documented species per unit area, which represents the dense/sparse growth of the trees exhibits pronounced variation due to which the Shannon Weiner species diversity is affected. Highest numbers of individuals (N) are observed in the quadrat of Lothian island, a pristine forest patch almost with no human intervention, whereas lowest value is observed in Canning, the sampling station with maximum anthropogenic stress in the cobweb diagram(Figure 2).

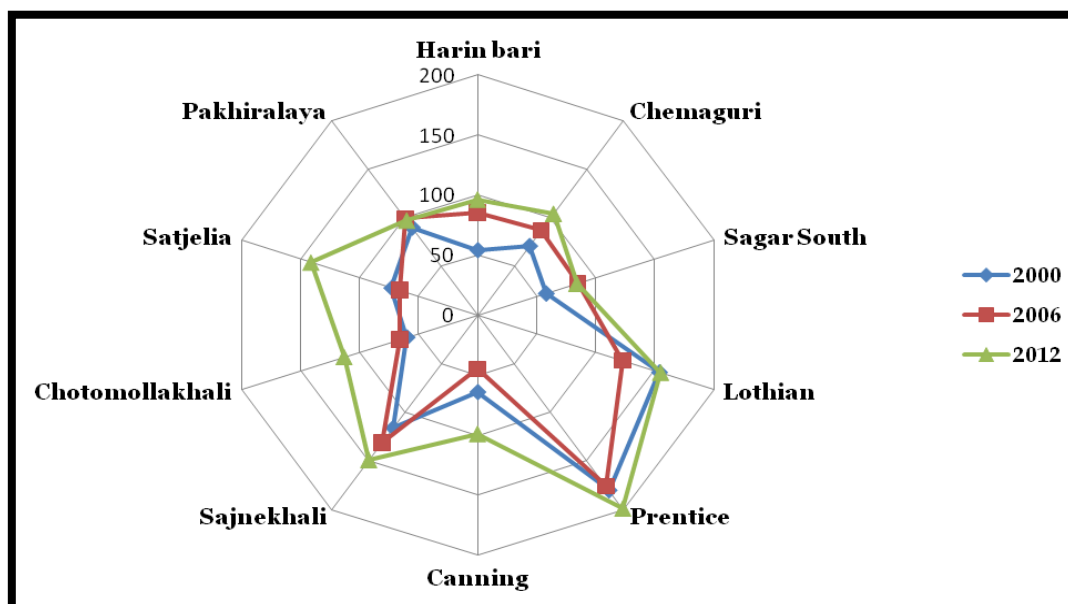


Figure 2: Spatio-temporal variation of total number of individuals of all species (N)

The results of Shannon-Weiner Index are shown in Figure 3. The spatial order of the index is Lothian island (3.052, 3.083 and 3.174 in 2000, 2006 and 2012 respectively) > Prentice island (3.043, 3.033 and 3.13 in 2000, 2006 and 2012 respectively) > Sajnekhali (3.035, 3.027 and 3.091 in 2000, 2006 and 2012 respectively) > Pakhiralaya (2.883, 3.008 and 3.074 in 2000, 2006 and 2012 respectively) > Satjelia (2.765, 2.928 and 3.07 in 2000, 2006 and 2012 respectively) > Chotomollakali (2.622, 2.828 and 2.948 in 2000, 2006 and 2012 respectively) > Harinbari (2.562, 2.701 and 2.88 in 2000, 2006 and 2012 respectively) > Chemaguri (2.563, 2.784 and 2.924 in 2000, 2006 and 2012 respectively) > Sagar South (2.44, 2.449 and 2.837 in 2000, 2006 and 2012 respectively) > Canning (2.145, 2.319 and 2.636 in 2000, 2006 and 2012 respectively).

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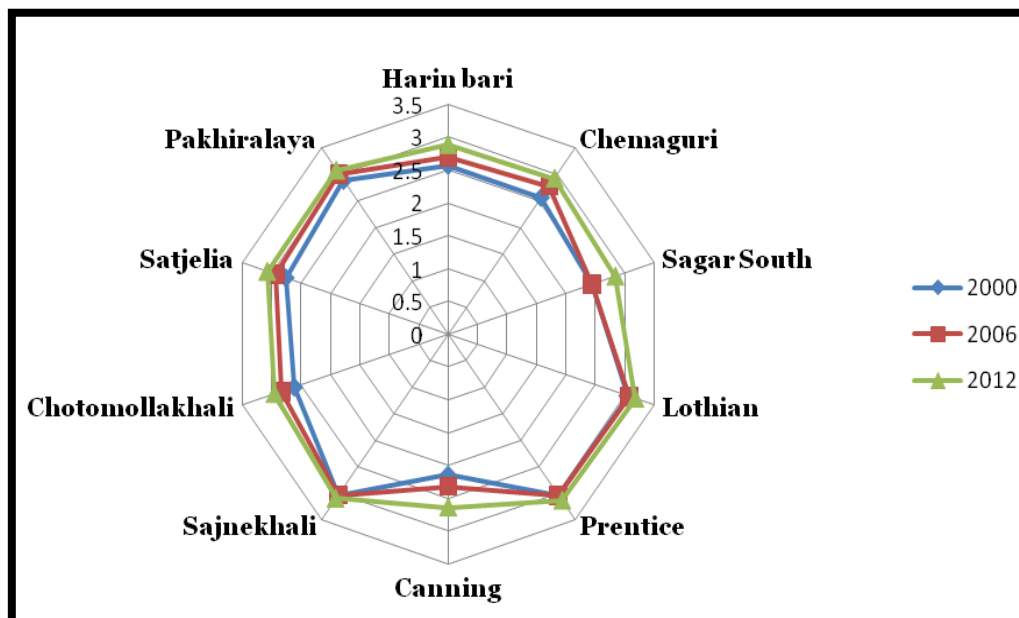


Figure 3: Spatio-temporal variation of Shannon Weiner Species diversity index (H)

The variation in the value of the index reflects (i) the degree of stress (both natural and anthropogenic) and (ii) conditions of the ambient environment. 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 quadrat.

IV. DISCUSSION

It is evident from the spatio-temporal data that Lothian Island has the highest mangrove biodiversity in all the three years under investigation and Canning exhibits the lowest values in similar years. This spatio-temporal variation of diversity Index is significant as revealed through ANOVA ($p < 0.01$), which might be the results of the magnitude 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 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 [14]. 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 three years. This may be attributed to their location within the Reserved Forest zone due to which the human interference is least in these stations (Mitra and Banerjee, 2005). More important is the declaration of Lothian Island as Wild Life Sanctuary (WLS), which has minimized human intervention in the island. The dilution factor of the Hooghly estuarine water is also congenial for growth and survival of mangroves, which is also an important factor contributing to the maximum diversity of mangrove floral species in these sampling stations [15-20].

The Shannon Weiner Species diversity index 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

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Bidyadhari siltation since the late 15th century due to which the mangroves are less diverse and stunted in this zone [15-20].

The overall investigation thus pinpoints the hypersalinity and human intrusion as the major causative factors 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 (preferably in central Indian Sundarbans) 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 *Suaeda* sp., *Salicornia* sp., etc. that are potential absorber of salt from the ambient media.

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