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Vegetation Analysis of a Riverine Mudflat in Sundarbans

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Sundarbans have been witnessing increased erosion and decreased progradation over the years. Under such circumstance appearance of a riverine mudflat and the subsequent development of mangrove vegetation gave an opportunity to record the composition and diversity of species. A study was carried out in the year 2003, whereby using quadrate method, 9 mangrove species were identified. The 7 tree species among them had very high stem density but low stem basal area. The early colonizing trees – *Avicennia* and *Sonneratia* dominated. There was also abundance of *Porteresia* grass. The species diversity index was modest 2.329. Biomass estimation (by Allometric equation) was also made to assess the C-stock, which showed 37% allotment in the below ground biomass.

(***Key words:*** *Basal area, Biomass, Importance value, Stem density, Vegetation analysis)*

The mangrove forest area of the world was estimated to be a mere 0.7% of the total tropical forests (Giri *et al.,* 2011). In spite of that, mangroves were extremely important forest resource that provided variety of goods and services to mankind. They gave protection against storms, stabilized shoreline, maintained channel depth, recycled nutrients, acted as pollutant filter and were also the source of timber and non-timber forest products (NTFPs). However, the Food and Agriculture Organization in 2007 had estimated a sharp decline in worldwide mangroves**.** The reasons were such as encroachment, reclamation, over exploitation, unsustainable fishery practices, waste-water effluent and diversion of freshwater.

Among these many factors, habitat destruction due to land reclamation had been the major cause of mangrove depletion. This was especially true with respect to Sundarbans which had witnessed massive degradation for two centuries - so much so, that at present only 42% of that area exists now (Mandal *et al.,* 2010). The region was also characterized by continuous erosion of banks, land subsidence together with sediment accumulation.

However, at places there was formation of riverine mudflats which offered opportunities for gradual vegetal developments. Since mangrove regeneration was slow, studies on the same may be given priority. With that aim, a study was carried out in 2003 to record the species composition and diversity of mangroves in a newly formed landmass. Tree biomass were also estimated (by allometric equations) to deduce the carbon stock since mangroves produced organic carbon well in excess of the ecosystem requirements and thus contributed meaningfully towards carbon cycle.

MATERIALS AND METHODS

Study Area

The entire study was carried out on a riverine landmass (22°09′17″N – 22°08′40″ N Lat. and 88°51′32″ E – 88°50′32″ E Long.) – shaped as a reverse 'D' in Gomor tidal river. It was adjacent to the large inhabited island of Gosaba, Sundarbans (Fig. 1). At the time of study it covered an area of 48.65 ha. This mudflat came into existence nearly two decades ago (according to local EDC personnel) and was inundated during high tide.

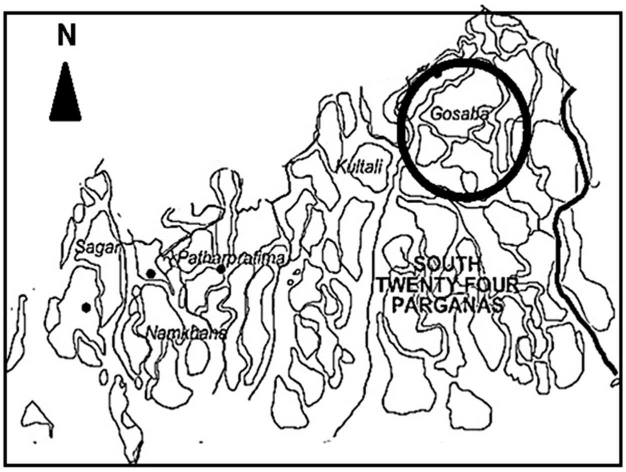

Fig. 1. *Outline map of a portion of Sundarbans showing the location of the study area (in circle).*

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Methodology

Samplings for vegetation analyses were carried out by laying a total of ten quadrats of 10 x 10 m dimensions during low tide. The quadrats were laid from the water edge towards the centre of the mudflat. They were laid along five lines drawn randomly from different directions, with two quadrats in each line. All the plant species in the sampling area were identified, listed and individuals counted. For correct identification, standard literatures were consulted (Naskar and Mandal, 1999). Circumference of the stem was measured at breast height (cbh, 1.3 m). Frequency, density, abundance of species was determined by following Curtis and McIntosh (1950) while the importance value index (IVI) by Curtis (1959). The ratio of abundance to frequency was used to interpret the distribution pattern of species (Whitford, 1949). Species evenness was evaluated following Pielou (1966). Species diversity and concentration of dominance were determined by following the procedures as outlined by Shannon and Weaver (1949) and Simpson (1949), respectively.

The tree species above ground biomass (AGB) and below ground biomass (BGB) were deduced by using the common allometric equations for mangrove by Komiyama *et al.,* (2005). They were given as -

$W_{top} = 0.251 þ D^{2.46}$.... Above ground tree weight (W_{top} in kg)

$W_R = 0.199 þ\, D^{2.22}$.... Below ground tree weight (W_R in kg),

where, D stood for stem diameter in cm and þ stood for wood density in t m^{-3}. The latter being site and species specific, the þ for each tree species were determined by taking five wood samples from different individuals of each species and then deduced by placing oven dried wood blocks over fresh volume. The average wood density of the tree species are :

Avicennia alba – 0.631 ± 0.101
Avicennia officinalis – 0.696 ± 0.080
Bruguiera cylindrica – 0.755 ± 0.047
Bruguiera gymnorhiza – 0.744 ± 0.089
Excoecaria agallocha – 0.753 ± 0.063
Rhizophora mucronata – 0.848 ± 0.032
Sonneratia apetala – 0.704 ± 0.065

The measure of the mudflat and the total vegetation cover were done by the application of RS & GIS. The Digital Globe image from Google Earth Imagery (Snapshot) was used for analyzing the study site area during 2003. The snapshot of the image was referenced with respect to control points from earlier multi-spectral image using TNTmips Pro software. Data were also availed from Landsat satellite image (28.5m x 28.5m spatial resolution for research purpose). This was in order to measure the changes in dimension of the mudflat over a period of time. Thus, Landsat IV imagery of 2000, were downloaded from GLCF (url: http://glcfapp.glcf.umd.edu/). Digital image processing were applied in terms of contrast enhancement and spatial filtering on the selected bands to increase the correlation for better judgment of training set, prior to supervised classification.

RESULTS AND DISCUSSION

A total of 9 mangrove species under 7 genera and 6 families were recorded from the study site (Table 1). There were 7 tree species (small statured 'True Mangroves') whose total stem density was extremely high - 8600 ha^{-1}. The total stem basal area was rather low 7.003 m^2 ha^{-1}, suggesting immature trees. However, *Avicennia* and *Sonneratia* together made up 7080 stems ha^{-1} and the basal area was 5.488 m^2 ha^{-1} (82% of stem density and 78% of basal area, respectively). Such high stem density but lower basal area was typical for the vegetation of formative island. The remaining trees - *Bruguiera, Excoecaria* and *Rhizophora* thus filled up merely 18% of stem density and 22% of basal area. Both *Avicennia alba* and *Avicennia officinalis* showed high importance among the trees (24.95% and21.16% of importance values, respectively). These two have wide range of salinity tolerance but preferred polyhaline open mudflats where their lighter propagules could easily be carried by the tidal waters. Collectively, these early colonizing trees (*Avicennia* and *Sonneratia*) together totaled 57.44% of the importance value. This diurnally inundated, mudflat was also dominated by the pioneering grass *Porteresia*, (16% of importance), especially in the open water edges. All the species in the study site were contagiously distributed. This was either because of the likeable micro-habitat within a clumped space or for a general tendency of the individuals to remain in the vicinity of parents. The species diversity index was a modest 2.329, the concentration of dominance a high 0.259 and evenness 2.441.It had been argued that succession played a minor role in mangrove zonation while Kathiresan and Bingham (2001) had suggested propagule size to be responsible for the same. However, in Sundarbans the salinity was the most important determinant for the distribution of species (Mitra *et al.,* 2011).

In this study, the total biomass was calculated to be 47.185 t ha^{-1} of which AGB contributed 63% and the BGB 37% (Table 2). The range for the proportion of AGB-BGB for these species were 67% - 33% (*Sonneratia*) and 60% - 40% (*Avicennia officinalis*), thereby showing consistently high BGB. The average ratio of the AGB to BGB in this study was 1.71 with a range of 2.01 (*Sonneratia*) to 1.53 (*Avicennia*

Table 1. *The density (D), basal area (B.A.) and importance value index (IVI) of the species in the study area*

	Species	Density (ha^{-1})	Basal area (m^2 ha^{-1} [Av. B.A. $tree^{-1}$ (cm^2)]	IVI
1.	*Avicennia alba* (Avicenniaceae)	3280	2.460 [7.5]	74.861
2.	*Avicennia officinalis* (Avicenniaceae)	3440	1.560 [4.53]	63.498
3.	*Bruguiera cylindrica* (Rhizophoraceae)	120	0.105 [8.67]	4.500
4.	*Bruguiera gymnorhiza* (Rhizophoraceae)	240	0.232 [9.65]	11.632
5.	*Excoecaria agallocha* (Euphorbiaceae)	440	0.557 [12.67]	17.33
6.	*Rhizophora mucronata* (Rhizophoraceae)	720	0.621 [8.63]	26.904
7.	*Sonneratia apetala* (Sonneratiaceae)	360	1.468 [40.77]	33.973
		Σ8600	Σ7.003	
8.	*Acanthus ilicifolius* (Acanthaceae)	1040		17.265
9.	*Porteresia coarctata* (Poaceae)	66/100m^2		50.037

Note :Sl. No. 1-7 are tree species, while Sl. 8 and 9 are shrub and grass and respectively.

Table 2. *The above ground (A), below ground (B) and total biomass (C) of the tree species in the study area. A_1, B_1 and C_1 represent above ground, below ground and total biomass per tree, respectively*

	t ha^{-1}(A)	kg $tree^{-1}$ (A_1)	t ha^{-1} (B)	kg $tree^{-1}$ (B_1)	t ha^{-1} (C)	kg $tree^{-1}$ (C_1)
Avicennia alba	8.584	2.62	5.277	1.61	13.861	4.23
Avicennia officinalis	5.465	1.59	3.574	1.04	9.039	2.63
Bruguiera cylindrica	0.444	3.7	0.270	2.25	0.714	5.95
Bruguiera gymnorrhiza	0.994	4.14	0.597	2.49	1.591	6.63
Excoecaria agallocha	2.657	6.04	1.519	3.45	4.176	6.63
Rhizophora mucronata	3.105	4.31	1.827	2.54	4.932	6.85
Sonneratia apetala	8.589	23.86	4.283	11.90	12.873	35.76
	Σ29.838		Σ17.348		Σ47.186	

officinalis). This was because mangroves tend to allocate more to root biomass for adaptation to soft, water-logged sediments (Komiyama *et al.,* 2008). *Avicennia alba* showed dominance in terms of biomass and collectively the two *Avicennia* species contributed 49% of the total biomass. But *Sonneratia* trees individually had the highest biomass (35.76 kg $tree^{-1}$), indicating comparatively older trees. Here, the three early colonizing pioneer species (*Avicennia* and *Sonneratia*) together contributed 76% (35.772 t ha^{-1}) of the total biomass while the balance 24% (11.412 t ha^{-1}) were contributed by rest of the four tree species.

Biomass estimation was essential for assessing the carbon stock in the tropical forest (Chave *et al.,* 2004). Though rather short in stature, the mangrove plants were hard, woody and thus had comparatively higher biomass. Conserving mangroves therefore could mitigate the problem of increasing atmospheric carbon dioxide. In order to calculate the vegetative carbon (t C ha^{-1}) it was assumed that 50% of total plant biomass (AGB+BGB) was carbon (MacDicken, 1997). In this study, the total carbon content was 23.593 t C ha^{-1}, of which the above ground and below ground carbon were 14.919 t C ha^{-1} and 8.674 t C ha^{-1}, respectively. Of particular significance was the high BGB which thus depicted large C-stock in the subterranean portion.

The Sundarbans have witnessed reduced fresh water flow, decreased progradation, increased salinity and erosion over the years. All these have adversely affected the mangrove vegetation in terms of change in species composition, lowering of bio diversity, high mortality and invasion of undesirable species. While erosion and accretion of sediment is occurring simultaneously, more areas were lost than gained (Nandy and Bandyopadhyay, 2011). Then again, by virtue of their locations, mangroves were predicted to be severely affected by the relative sea level rise (Gilman *et al.,* 2008). In such a scenario, formation of a riverine mudflat along with the development of a primary mangrove forest was much welcome. However, growth of a primary forest adjacent to human habitation could pose problem for the development of the vegetation. But it has been observed that unlike other Indian forests, grazing and fuelwood collection was rather low in Sundarbans.

This riverine mudflat, which was 38.05 ha in 2000, grew up to 48.65 ha in 2003 (28% increase of land area) (Fig. 2, 3). At the same time, mangrove vegetation grew more rapidly. There were only 2.40 ha vegetal cover in 2000 (6.3% cover) which then increased to 5.40 ha in 2003 (11.1% cover), thus an increment of 125%. This showed that mangroves actively aided in accretion of sediment that led to increase in land area (Ong and Gong, 2013). The maze of prop roots and pneumatophores slowed down tidal currents, thus allowing the sediment to settle and also trapped floating propagules. So when mangroves were declining globally, there were signs of improvement in Sundarbans.

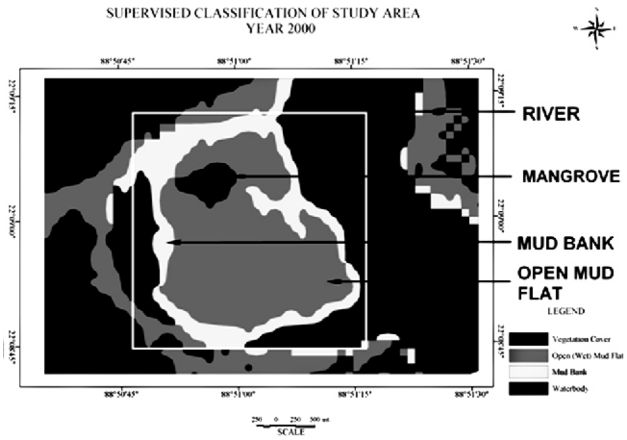

Fig. 2. Satellite image of the riverine mudflat (in box) in the year 2000 (after supervised classification)

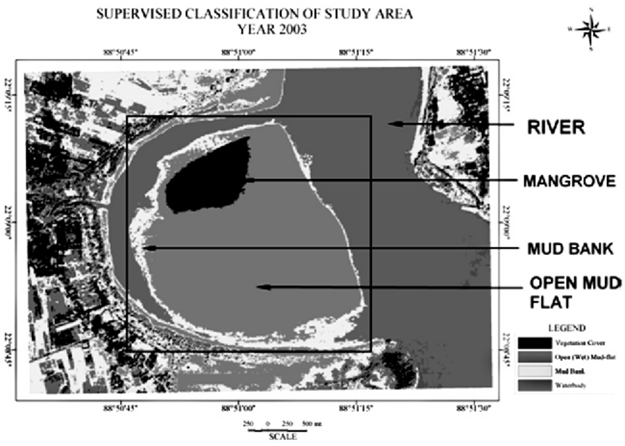

Fig. 3. Satellite image of the riverine mudflat (in box) in the year 2003 (after supervised classification)

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REFERENCES

Chave, J., Condit, R., Agnilar, S., Hernandez, A., Lao, S. and Perez, R. (2004). Error propagation and scaling for tropical forest biomass estimates. *Philosophical Transactions of the Royal Society B* **359**: 409-420.

Curtis, J.T. (1959). *The Vegetation of Wisconsin: An Ordination of Plant Communities.* University of Wisconsin Press, Madison. 657 p.

Curtis, J.T. and McIntosh, R.P. (1950). The inter-relations of certain analytic and synthetic phytosociological characters. *Ecology* **31**: 434-455.

Gilman, E., Ellison. J., Duke, N.C. and Fields, C. (2008). Threats to mangroves from climate change and adaptation options: a review. *Aquatic Botany* **89**(2): 237-250.

Giri, C., Ochieng, E., Tieszen, L.L., Zhu, Z., Singh, A., Loveland, T., Masek, J. and Duke, N. (2011). Status and distribution of mangrove forests of the world using earth observation satellite data. *Global Ecology and Biogeography* **20**: 154-159.

Kathiresan, K. and Bingham, B.L. (2001). Biology of mangroves and mangrove ecosystems. *Advances in Marine Biology* **40**: 81-251.

Komiyama, A., Poungparn, S. and Kato, S. (2005). Common allometric equations for estimating the tree weight of mangroves. *Journal of Tropical Ecology* **21**: 471-477

Komiyama, A., Ong, J.E. and Poungparn, S. (2008). Allometry, biomass, and productivity of mangrove forests: A review. *Aquatic Botany* **89**: 128-137

MacDicken, K.G. (1997). *Guide to Monitoring Forest Carbon Storage in Forestry and Agro Forestry Projects.* Forest carbon monitoring programme. Winrock International Institute for Agricultural Development. 87p.

Mandal, R.N., Das, C.S. and Naskar, K.R. (2010). Dwindling Indian Sundarban mangrove: The way out. *Science and Culture* **76**(7-8): 275-282.

Mitra, A., Sengupta, K. and Banerjee, K. (2011). Standing biomass and carbon storage of above ground structures in dominant mangrove trees in the Sundarbans. *Forest Ecology and Management* **261**: 1325-1335.

Nandy, S. and Bandyopadhyay, S. (2011). Trend of sea level change in the Hugli estuary, India. *Indian Journal of Geo-Marine Sciences* **40**(6): 802-812.

Naskar, K.R. and Mandal, R.N. (1999). *Ecology and Biodiversity of Indian Mangroves: Global Status* (Vol. I & II). Daya Publ. House, New Delhi. 754p.

Ong, J.E. and Gong, W.K. (2013). *Structure, Function and Management of Mangrove Ecosystems*. ISME Mangrove Educational Book Series No. 2, ISME, Okinawa and ITTO, Yokohama, Japan. 71p.

Pielou, E.C. (1966). Species diversity and pattern diversity in the study of ecological succession. *Journal of Theoretical Biology* **10**: 370-383.

Shannon, C.E. and Weaver, W. (1949). *The Mathematical Theory of Communication*. University of Illinois Press, Urbana. 144p.

Simpson, E.H. (1949). Measurement of diversity. *Nature* **163**: 688.

Whitford, P.B. (1949). Distribution of woodland plants in relation to succession and clonal growth. *Ecology* **30**: 199-208.