American Journal of Earth and Environmental Sciences
2019; 2(1): 1-8
http://www.aascit.org/journal/ees

Impacts of Mangrove Plantations on Land Stabilization Along the Coastline in Bangladesh

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Citation

Mohammad Main Uddin, Md Abdullah Al Mahmud, Morgubatul Jannat. Impacts of Mangrove Plantations on Land Stabilization Along the Coastline in Bangladesh. *American Journal of Earth and Environmental Sciences.* Vol. 2, No. 1, 2019, pp. 1-8.

Received: January 23, 2018; **Accepted**: February 7, 2019; **Published**: April 9, 2019

Abstract: Rapid degradation of stabilized mangrove plantations in the southern and south-eastern part of Bangladesh has raised much concern to the scientists and environmentalists. In the past, land stabilization concept in connection to mangrove plantations is poorly understood. This study aimed at assessing the current status of mangrove plantations and understanding more about their impacts on land stabilization along the coastline of Bangladesh. The study was carried out at five Coastal Afforestation Divisions (here mentioned as CADs) of Bangladesh Forest Department (BFD) from September 2014 to August 2015. Primary data on stabilized mangrove plantations over the time period of 1966 - 2014 were collected from BFD field offices. Secondary data on natural accretion and erosion were collected from a large number of existing literatures. The results showed that more than 192,395 ha of mangrove plantations were stabilized over the period from 1966 through 2014 in five CADs with the highest distribution in Noakhali (40%) followed by that in Chittagong (26%), Bhola (20%) and Patuakhali (14%). The total area of stabilized mangroves maintained a significant ($P<0.01$) positive relationship with plantation age. Mean land stabilization rate in the mangrove plantation area was significantly higher than that in the non-mangrove areas. The outcome of this research provides useful information on the potential role of mangrove plantation in stabilizing naturally accreted coastal land along the coastline of Bangladesh and other similar areas. However, this study suggests for need of further research to investigate delta building activities in relation to actual accretion and erosion rates along the coast.

Keywords: Mangrove Plantations, Accretion, Coastal Zone Erosion, Stabilization

1. Introduction

Mangroves grow in the intertidal zones located in tropical and subtropical latitudes occupying approximately 138,000 km [7, 15]. Considering the depletion of natural mangroves, plantation mangroves have been established in many countries [2, 7, 31]. Bangladesh is pioneer in establishing mangrove plantations [30, 33, 35]. The country has a 710 km long coast line consisting of three landscapes - western, central, and eastern coasts that support of both natural and plantation mangroves [14, 20, 30, 33]. Excluding the natural mangroves, the extensive shoreline had no vegetation until the Bangladesh Forest Department (BFD) launched a plantation program in 1966 [13]. Repeated cyclones and tidal surges led BFD to establish mangrove plantations using mangrove species within five Coastal Afforestation Divisions (CADs) of BFD [30, 33, 34]. The primary objectives of mangrove plantations on newly accreted coastal lands were to minimize the loss of human life and property accelerating sediment deposition, land accretion and stabilization [28]. Up to 2001, 170,000 ha of newly accreted land were stabilized by mangrove plantations at five CADs [30]. Some places across the CADs could not be stabilized due to plantation failures caused by river erosion [30]. No study has yet been carried out after 2001 to evaluate the status of mangrove plantations and their impacts on land stabilization in Bangladesh [24, 33].

Bangladesh faces simultaneous and continuous erosion and accretion of land in the southern coast line [1, 30, 33]. IPCC reported that coastal erosion and accretion are influenced by tidal waves, storm surges, cyclonic winds, water currents and sea level rise (SLR). Studies show that the average rate of accretion in Bangladesh was about 46 km^2 per year, of which only 13.4 km^2 per year of newly accreted lands was usable to mangrove plantation purposes [23, 33]. Although land accretion rate was high in the coastal areas, the net gain in landmass was low due to the lack of land reclamation practices though mangrove plantations [13, 16, 34]. Newly accreted land remains unstable and surface erosion is a continuous process until the initiation of deep-rooted mangrove vegetation [16]. Mangrove plantations enhance sediment deposition because the aerial root system of mangroves is rapid and extensive [21, 23, 30]. This root system acts on reducing the energy of progressing waves and tidal current with decreased sediment carrying capacity of water, which in turn, increases the sediment deposition around the planted mangroves [30, 33]. Therefore, the rate of accretion was higher in mangrove plantations than non-mangrove barren lands which were not planted by BFD with mangroves [13, 30, 33, 34].

Bangladesh is one of the most vulnerable countries to climate change [6, 12, 17, 34]. Coastal communities in Bangladesh are always at risk because of natural cyclones and extreme events caused by climate change. However, extensive mangrove plantations in coastal areas can minimize the adverse impacts of climate change, such as soil erosion, flooding, loss of life and property [12, 25, 35]. Additionally, mangrove plantations act as a shelter belt which protects coastal life and property from climatic events, such as cyclones [30, 33, 35]. The principal effect of the shelter belt is the retardation of wind velocity during the coastal cyclonic events [5, 6, 30]. Thus, the mangroves reduce the devastation of cyclones decreasing the intensity of wind velocity and tidal surges [12]. During the period of 1960 to 2013, around 15 cyclonic events occurred in the coast of Bangladesh [34]. The loss of life and property due to these events was lower in mangrove areas than that in non-mangrove areas in the coast line [33, 34]. It has been predicted that about 96% of the Bangladesh Sundarbans could be lost because of a 28 cm SLR, if the land surface of the Sundarbans were not elevated by sedimentation [17]. However, both mitigation and adaptation might be the way of reducing the impacts of SLR [17, 29]. The exposed coast should be managed by planted mangroves for sediment accretion and land stabilization [12].

Though the previous studies focused on the rate of sediment deposition, land accretion and stabilization processes in mangrove areas was faster than those in the non-mangrove areas [12, 30, 34, 35], none of them focused on the significant impacts of mangrove plantations on land stabilization rate in comparison to natural land stabilization rate in non-mangrove areas. The connection of land stabilization through mangroves has not been sufficiently addressed in existing body of literature. However, frequent cyclonic events, unstable geo-morphological changes and predicted SLR along the coast of Bangladesh increased the importance of mangrove plantations in relation to their land stabilization and coastal protection capacities [1, 6]. Thus, this study was designed to evaluate the status of mangrove plantations in Bangladesh and their impacts on land stabilization.

2. Materials and Methods

2.1. Study Area

This study has been conducted in five CADs of the BFD. The CADs were Chittagong CAD (22^0 $22^{'}$ N to 91^0 $48^{'}$ E), Noakhali CAD (22^0 $42^{'}$ N to 91^0 $6^{'}$ E), Barisal CAD (22^0 $42^{'}$ N to 90^0 $22^{'}$ E), Patuakhali CAD (22^0 $21^{'}$ N to 90^0 $19^{'}$ 5 E) and Bhola CAD (22° 41′ N to 90° 38′ E) (Figure 1).

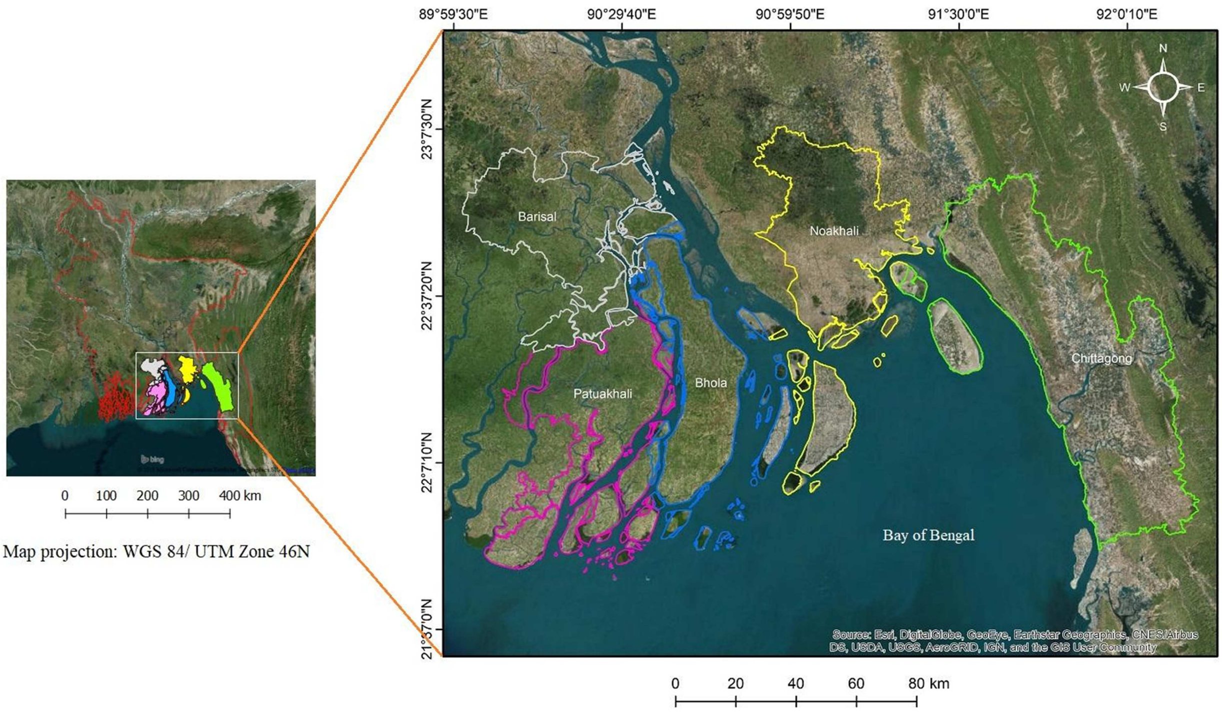

Figure 1. *Map of the study areas showing five Coastal Afforestation Divisions (CADs) of the Bangladesh Forest Department. This map was produced in ArcGIS environment.*

2.2. Data Collection

We were interested in the primary attributes of total planted area (ha), eroded area (ha), stabilized mangrove plantations (ha) from 1966 to 2014. We collected data on these attributes of the coastal mangrove plantation across the five CADs of the BFD. Secondary data on land area under natural accretion and erosion along the coast of Bangladesh was collected from existing scientific literatures like books, journals and proceedings.

2.3. Data Analysis

2.3.1. Comparing the Land Stabilization Rates

The rate of land stabilization (ha per year) in mangrove plantations and non-mangrove areas was calculated using the equations (1) through (4) developed by Uddin and Hossain [34].

$$E_m = C_m - D_m \tag{1}$$

$$F_m = \frac{E_m}{B_m} \tag{2}$$

$$E_n = C_n - D_n \tag{3}$$

$$F_n = \frac{E_n}{B_n} \tag{4}$$

Where, B is the age of the mangrove under study, C is the total area under mangrove, D is the total eroded area (ha), E is the total stabilized area (ha), and F is the land stabilization rate (ha per year), m and n are the planted mangrove and non-planted non-mangrove states of accreted land, respectively.

On determination of the stabilized areas and land stabilization rates, the state of accreted land was compared to identify whether each of these two attributes differed from a mangrove planted state of accreted land to a non-planted naturally stabilized state of the same. Our hypothesis was that the planted mangrove areas were better able to stabilize accreted land along the coastline of Bangladesh. We conducted an unpaired t-test to test the null hypothesis that $\underline{F_m} = \underline{F_n}$. The rejection of this null hypothesis would indicate that, land stabilization rates were different in the two states of accreted land. The sample sizes (n) for mangrove plantations and non-mangrove areas were 27 and 25, respectively.

2.3.2. Linking the Size of Stabilized Land and the Plantation Age

We hypothesized that, plantation age has a positive role to play in stabilizing the size of land. To test this hypothesis, we estimated the following ordinary least square regression model (equation 5).

$$E = \alpha + \beta(B) + e_i \tag{5}$$

Where, E is the area (ha) of stabilized mangrove plantations from five CADs of BFD was considered over the period of 1966 – 2014, B is the age (year) of plantations, α and β are the parameters to be estimated, e_i is the normally distributed error term with mean zero and constant variance. The sign of β will indicate the type of relationship exists between E and B, the magnitude of β will indicate the marginal change in E corresponding a unit change in B.

3. Results

3.1. Status of Mangrove Plantations in Bangladesh

Table 1 illustrates the stabilized area (ha) of mangrove plantations at five CADs of BFD from 1966 to 2014. Approximately 77,685 ha of mangrove plantations were recorded in Noakhali by 2014 followed by Chittagong (48,891 ha), Bhola (39,203 ha), Patuakhali (26,607 ha) and Barisal (9 ha) CADs.

Table 1. *Stabilized area (ha) of mangrove plantations at five Coastal Afforestation Divisions (CAD) of Bangladesh Forest Department over the period of 1966 - 2014.*

Year of plantations	Stabilized mangrove plantations (ha)					Total stabilization (ha)
	Chittagong	Noakhali	Barisal	Patuakhali	Bhola	
1966 – 1972	1,587	0	0	1,792	304	3,683
1973 – 1979	10,291	8,337	0	5,379	5,513	29,520
1980 – 1986	22,574	27,495	0	12,520	18,383	80,972
1987 – 1993	6,880	10,682	0	3,913	5,297	26,772
1994 – 2000	2,230	12,290	0	520	1,085	16,125
2001 – 2007	4,000	6,572	0	666	5,359	16,597
2008 – 2014	1,329	12,309	9	1,817	3,262	18,726
Total	48,891	77,685	9	26,607	39,203	192,395

Source: Bangladesh Forest Department, 2015

Approximately 192,395 ha of mangrove plantations have been stabilized over the period of 1966 - 2014 in five CADs of BFD. Figure 2 showed the highest area distribution (40%) of stabilized mangrove plantations in Noakhali CAD, whereas remaining 60% was distributed in other four CADs of BFD. Barisal CAD started plantation activities after 2008 and very few areas of mangrove plantations were stabilized by 2014.

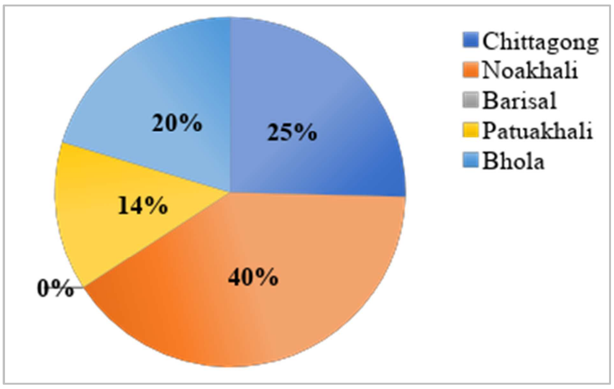

Figure 2. Area distribution of stabilized mangrove plantations at the five Coastal Afforestation Divisions of Bangladesh Forest Department.

3.2. Impacts of Mangrove Plantations on Land Stabilization

Mangrove plantations stabilized newly accreted land in all CADs of BFD except Barisal CAD (Figure 3). The stabilized area (ha) of plantations in Noakhali and Bhola CADs showed a highly significant (P<0.01) positive relationship with the age of the plantations over the period of 1966 – 2014 (Figure 3). In Chittagong and Patuakhali CADs, the land stabilization (ha) by mangrove plantations showed significant (P<0.05) positive relationship with the age of plantations over the same period (Figure 3). There was no significant relationship (P<0.05) in Barisal CAD between land stabilization (ha) and the planting of mangroves (Figure 3). The total stabilized area (ha) of mangrove plantations within five CADs showed a highly significant (correlation coefficient, R = 0.956, critical value of Pearson's correlation coefficient, R = 0.9343, df = 5, P<0.01) positive relationship with the age of plantation between 1966 and 2014 (Figure 4). The findings of the R-statistics support one of the two hypotheses showing a significant positive relationship between the stabilized area (ha) of mangrove plantation and the age of plantation over the period of 1966 – 2014.

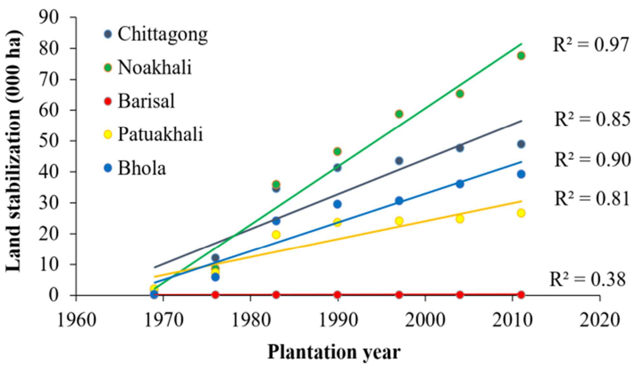

Figure 3. Stabilized area of mangrove plantations in all Coastal Afforestation Divisions of Bangladesh Forest Department showing the linear trend lines that represent the relationship between land stabilization and age of the plantations over the period of 1966 – 2014.

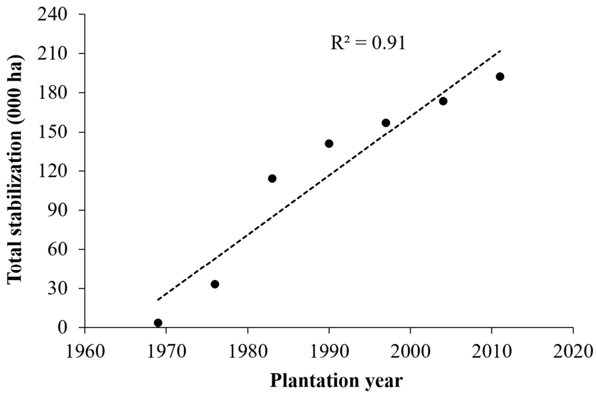

Figure 4. Total stabilized area of mangrove plantations in Bangladesh showing a linear regression line which represent the relationship between total land stabilization (ha) of all Coastal Afforestation Divisions and age of plantations over the period of 1966 – 2014.

3.3. Land Stabilization Rate in Mangrove and Non-mangrove Areas

In mangrove plantations, the estimated mean stabilization rate (Figure 5) of all CADs was approximately 1200 ha per year, whereas it was about 300 ha per year in non-mangrove areas (barren land) which were not planted by BFD. The stabilization rate (ha per year) between mangrove plantations and non-mangrove areas (newly accreted barren land) was highly significant (t-test, t= 3.56, df= 39, P<0.001) (Figure 5). This result confirms the other hypothesis that there is a highly significant difference (P<0.001) between stabilization rate (ha per year) in mangrove plantations and non-mangrove (newly accreted barren land) areas which were not planted by mangrove species.

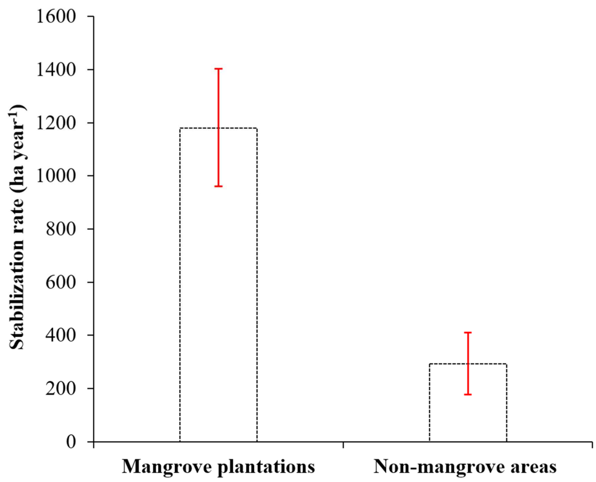

Figure 5. Land stabilization rate (ha per year) showing a highly significant difference (P<0.001) between mangrove plantations and non-mangrove areas. The error bar indicates the standard error of mean.

4. Discussion

4.1. Status of Mangrove Plantations in Bangladesh

The present study showed the reasons for which BFD took the initiatives of extensive mangrove plantations on newly accreted lands has been proved to be beneficial. Uddin [33] reported about 170,000 ha of stabilized mangrove plantations between 1966 and 2001 along the coast. In comparison to the previous study conducted by Uddin [33], the present study on mangrove plantations in Bangladesh showed an upward trend of stabilization (Figures 3 and 4). This study recorded approximately 22,395 ha of additional stabilized mangrove plantations over the last 13 years (2001-2014) representing additional stabilization rate of about 1,723 ha per year which was possible only due to the introduction of mangrove species on this newly accreted land. However, the findings of the present study increased the importance of conserving stabilized plantation mangroves in Bangladesh. The conservation of stabilized mangrove plantations is particularly important as there are concerns that 3% of the stabilized mangrove plantations are degraded due to the factors, such as shrimp farming, salt cultivation, industrialization and ship recycling [12]. Additionally, much of the accreted land remains exposed without vegetation although actual accretion and erosion rates along the coast remain under question [16]. This study suggests that introducing mangrove species on the exposed barren lands and their proper management through the BFD may increase the stabilized land area protecting the coastal communities from natural calamities, such as cyclonic events and SLR.

4.2. Impacts of Mangrove Plantations on Land Stabilization

No previous study has determined the significance of the relationship between stabilized mangroves (ha) and age of plantation. This study showed a significant relationship ($P<0.05$) between stabilized mangrove plantations and age of plantations over the period from 1966 to 2014. The land stabilization rate was significant in all CADs except Barisal (Figure 3). In Barisal CAD, only 9 ha stabilized mangrove plantations were recorded after 2008. The reason of the small Figure in Barisal CAD was the rapid sediment discharge, strong water current and very dynamic erosion and accretion rates [3, 29]. Total stabilization (ha) of all five CADs also showed a highly significant relationship in comparison to the age of plantation (Figure 4).

Uddin and Hossain [34] conducted a study on the role of mangrove plantations on land stabilization at Nolchira forest range of Hatiya Island under Noakhali CAD in Bangladesh. They reported that approximately 14,371 ha of newly accreted land were planted with *Sonneratia apetala* of which about 12,451 ha (87%) mangrove plantation was stabilized over the period of 1967 to 2007. Uddin and Hossain [34] also reported that almost 795 ha of stabilized forests were converted into agricultural land which was only possible due to land stabilization by mangrove plantations. Uddin et al. [35] conducted a further study in the Mirersharai coast within the Chittagong CAD and found that almost 5,477 ha newly accreted lands were planted by pioneer mangrove species (*S. apetala* and *A. officinalis*) of which approximately 4,852 ha of mangrove plantation was stabilized over a period of 1966 to 2014. In this study, they also reported that almost 625 ha of the planted land were damaged due to erosion caused by tidal waves and storm surges. Haque et al. [9] found that almost 2,694 ha mangrove plantation was stabilized in the coastal forest of Sitakunda and Mirsharai under Chittagong CAD between the years of 1993 - 1976. They also mentioned that newly accreted areas in this region were unstable as it was exposed to tidal inundation, tidal waves and storm surges. Tamin et al. [32] conducted a study on the impacts of mangroves in accreting coastal land at Sangai Haji Dorani, Selangor, Malaysia and reported that *Avicennia* species was helpful in depositing sand and silt in the soil from 5% to 18% within 18 months in comparison to the adjacent barren lands. They also mentioned that accreted shoreline was completely stabilized with 1.8 m tall *Avicennia* species over a period of 18 months (November 2008 to May 2010). From the study of Tamin et al. [32], it was evident that sediment deposition had increased by 13% within 18 months (1.5 year). Considering the study of Tamin et al. [32], sediment deposition could be increased by 100% over some 138 months by planting mangrove species on the new accreted land. Depositing 100% of the sediments on the surface of mangrove plantations increase the elevation of land along the coast. If the land can be elevated to about a one meter and stabilized, then coastal communities in vulnerable countries like Bangladesh can be protected from the risk of climatic events [30]. These findings and underlying concepts are similar to the findings of Hashim et al. [10] who reported that planting mangroves was an effective method for coastal rehabilitation in Malaysia. The mangrove species when planted on newly accreted land along the coast of Malaysia in 2010 showed beach morphological changes over 8 months resulted in rapid sediment accretion. Yang et al. [37] carried out a study on the North Island of New Zealand to investigate the response of mangroves (*Avicennia spp.*) to sediment deposition. They recorded that mangroves had induced rapid sediment deposition on the forest floor which increased the land area by 21% from 1940 to 2003. The findings of the Yang et al. [37] showed that the original area of mangroves had increased by 21% over 63 years, which is an increment of about one-fifth of the original mangroves added due to sediment deposition and land stabilization. This prediction can also help to find the number of years required for increasing the land area by stabilized mangroves in Bangladesh. However, the present study in five CADs of BFD only recorded the stabilized areas by mangrove plantations over a period of 48 years (1966 - 2014). Comparing with the findings of Tamin et al. [32] in Malaysia and Yang et al. [37] in New Zealand, the present study addresses the need for conducting further research to investigate the sediment deposition rate (%) in mangrove plantations and the area of land actually increased by mangroves along the coast of Bangladesh.

4.3. Land Stabilization Rate at Mangrove and Non-mangrove Areas

The present study compared the stabilization rate (ha per year) of areas with and without mangrove plantations. A hypothesis was assumed to determine whether mangrove plantations had a significant impact on land stabilization relative to natural stabilization in non-mangrove areas which were devoid of vegetation. The findings of the present study showed that the stabilization rate was significantly ($P<0.001$) higher in the areas with mangrove plantations in comparison to the non-mangrove areas (Figure 5). Although the general assumption is that mangroves stabilize land, some studies on the Sundarbans (natural mangroves) contradict this assumption. Rahman [27], for example, conducted time series analysis of coastal erosion of the Sundarbans and reported that it was very difficult to find conclusive evidence on accretion and erosion rates in mangrove or non-mangrove areas. Rahman [27] also recorded that the Sundarbans experienced a loss of about 630 ha per year which was greater than accretion rate (281 ha per year) over a period of 1973 - 2010. Similarly, Giri et al. [8] conducted a study on the entire Sundarbans region and reported that the accretion rate (145 ha per year) was lower than that of erosion rate (160 ha per year) over the period of 1970 - 1990. Both Rahman [27] and Giri et al. [8] mentioned that the findings of their study contradict the general assumption of mangroves on the development of land stabilization. Although the contradictory results on the accretion and erosion of the Sundarbans does not match with the stabilization rate of mangrove plantations in the central (Barisal, Patuakhali, Bhola) and eastern coast (Noakhali, Chittagong) of Bangladesh, some of the climate impacts reported and predicted by previous authors support the results of Rahman [27] and Giri et al. [8]. Sarwar [29] reported that approximately 5 – 7% of the entire Sundarbans has already lost due to 5 - 7 cm predicted SLR by 2005. Sarwar [29] also mentioned that the Sundarbans could be lost entirely with a one metre predicted SLR by 2100. He also concluded that 15% of the Sundarbans will be lost due to 10 cm SLR by 2020. IPCC [17] predicted that about 96% of Bangladesh Sundarbans could be declined with only a 28 cm SLR, if the land surface of this mangrove forest is not elevated by sedimentation. These findings have increased the importance of stabilizing mangrove plantations to protect the coastal communities from adverse impacts of climate change such as SLR and cyclonic events.

However, the findings of the present study on the stabilization rate of mangrove plantations in Bangladesh is in agreement with the findings of Perry and Berkeley [26], Uddin and Hossain [34] who mentioned that the rate of accretion was higher in mangrove plantations in comparison to non-mangrove areas along exposed areas of the Bay of Bengal. The new findings of this study concluded that the rate (ha per year) of stabilized land by mangrove plantations was highly variable in comparison to the rate at non-mangrove areas (barren lands). The findings of the present study were also supported by other studies in other parts of the World mangroves. Victor et al. [36] found that the mean rate (35 mg $cm^{-2}day^{-1}$) of sediment deposition was significantly higher in mangrove areas of Pohnpei Island, Micronesia in comparison to nearby barren areas. Similar trend was seen by Horstman et al. [11] in a study carried out in the Trang river estuary at the Thai Andaman coast. They suggested that sediment deposition was significantly lower in the areas where mangroves were absent. Allison and Lee [4] investigated the volume of sediment exchange along shore-fringing mangroves in French Guiana over a 30-year period. They reported that sediment accretion (8 – 26 million tons ha^{-1}) in the mangroves was higher than Amazon mud banks (6 – 23 million tons ha^{-1}) which were devoid of mangroves. However, from the study of Allison and Lee [4], it is evident that 30 years old stabilized mangroves accumulate about 17 million tons sediments per hectare. The findings of Allison and Lee [4] from French Guiana suggest an ability to predict the sediment deposition rate by the stabilized mangrove plantations. Comparing the result in French Guiana, it is predicted that the stabilized 192,395 ha of mangrove plantations in Bangladesh can accumulate a sediment load of approximately 3,270 billion tons, if plantations have been established for 30 years. Comparing with the findings in other parts of the World [4, 36], the evidence and findings of the present study showed that sediment deposition and land stabilization was higher in mangrove areas than non-mangrove barren lands. However, the present findings also demonstrated the need for further research to investigate more accurate sediment deposition rate of the stabilized mangrove plantations in Bangladesh.

5. Conclusions

The coast of Bangladesh along the Bay of Bengal, prior to 1966, had a limited protection with the exception of some natural mangroves, the Sundarbans. Repeated cyclones and tidal surges encouraged the BFD for planting pioneer mangrove species (*Sonneratia apetala* and *Avicennia officinalis*) within five CADs. What is clear geographically is that land accretion and erosion is a continuous process in these coastal areas and the delta building activities are quite unstable due to dynamic accretion and erosion processes. The reason of the mangrove plantation was to stabilize the newly accreted land along the coast protecting the coastal communities from the adverse impacts of cyclonic events caused by climate change. The majority of the mangrove plantations (about 192,395 ha) have been stabilized over the period of 1966 to 2014. Land stabilization and age of the plantations showed a significant positive relationship in all CADs except Barisal. Present study revealed that mangrove plantations stabilized a significant amount of naturally accreted coastal land. Additionally, land stabilization rate was significantly higher in the areas of mangrove plantations in comparison to naturally stabilized non-mangrove areas (barren lands) which were not planted by mangrove species.

6. Recommendations

Based on the findings of the present study, some suggestions are included here that could be helpful for conservation, management and restoration of mangrove plantations in Bangladesh. Data management by BFD is not up to date. The actual rate of land stabilization by mangrove plantation can only be determined if BFD takes initiative for a separate data management programme. An extensive plantation program on the newly accreted coastal land should be undertaken by BFD to accumulate more sediment on the forest floor. If rapid sediment deposition can be increased by mangrove species, then land stabilization and elevation can also be increased. Existing stabilized mangrove plantations in Bangladesh should be conserved and protected by BFD by strengthening and implementing existing Forest Act, 1927 because mangrove degradation due to shrimp farming, salt cultivation and industrialization is a regular scenario in Bangladesh. If BFD fails to stop mangrove degradation soon then the coastal communities will be more vulnerable to the impacts of climate change. In addition to the management of mangrove plantations by BFD, NGOs and local communities in the coastal areas could also be involved in plantation activities on the newly accreted land. Due to the lack of staff and funding, most of the accreted lands remain exposed without any plantations. The concept of community forestry can be applied for involving the local communities who will be responsible for managing and conserving the mangrove plantations. BFD can provide both financial and technical support (plantation technique, supply of seedlings, management technique, etc.) to the local communities. In this case, the coastal communities will get a scope to increase the awareness and necessities of stabilizing mangrove plantations in a changing climate. Further research should be conducted by government research organizations, non-government bodies and university professionals to investigate the complex delta building activities in the Ganges-Brahmaputra-Meghna (GBM) estuaries. The present data on delta building activities seems to be contradictory as the Figure on accretion and erosion vary from one author to others for the same location.

Acknowledgements

The authors would like to express their profound gratitude to the Director and other faculty members of the Natural Resources Institute (NRI), University of Greenwich at Medway, Kent, UK for their constructive criticism, suggestions, and encouragement throughout the period of this study as well as throughout the process of manuscript preparation. The authors are also thankful to the Commonwealth Scholarship Commission (CSC), UK and the University of Greenwich for providing financial support (BDSS: 2014/442) to conduct this study. The authors are thankful to Bangladesh Forest Department, Government of the People's Republic of Bangladesh for providing easy access to necessary data and information.

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