Sequestration and Storage Capacity of Carbon in the Mangrove Vegetation of Sundarban Forest, Bangladesh

Anupa Datta, Towhida Rashid, Mithun Kumar Biswas

Abstract— In this study, the sequestration and storage capacity of carbon were quantified in canopy trees of Sundarbans - Sundari, Gewa, Baen, Keora, Golpata and Tiger fern- represent the largest part of the whole forest. Different parts of the trees such as branch, leaf, skin and wood were collected to measure carbon in the study area. They have also been selected according to their DBH≥ 10cm. The capacity of sequestration of C fluctuates in different components of a single species. C capture in Gewa, branches having diameter less than 5 cm, was 41.48% and for Sundari it was 41.3 %. Keora branches with diameter higher than 5cm showed 43.51% C retention capacity. The fresh leaves of Sundari (44.59%) have high C storing capacity after Golpata (46.71%). Tree skin and trunk of Sundari stored less carbon and C retention were 38% and 40% respectively. As for the C stored in different parts it was found that leaves showed high percentage in comparison to the other parts of the trees. Among the evaluated trees Sundari is the best sequester of C. So, maintaining the natural vegetation of mangroves or planting more C storage efficient trees like Sundari would be helpful to decrease the amount of CO_2 present in atmosphere. Increasing the use of sustainable forest management and promoting plantations will definitely come up with so many environmental benefits at low investment.

Index Terms— Carbon Sequestration, Global Warming, Mangrove Vegetation, Mangrove Plantation, Sundarban, Sundari.

1 Introduction

GLOBAL warming is suggested as the most vital problems of the new millennium. Carbon emission is supposed to be the main causal factor for global warming. Carbon needs to be pulled out from the atmosphere and put in a secured place. And here the simple but most important experts are trees. Forests play an important role in sequestration of carbon globally (*Ravindranath and Sukumar, 1998*). Ability of trees and forest as terrestrial carbon sink to absorb CO2 emission and mitigate climate change has attracted wide attention. According to the Department of Environmental conservation, New York State- The actual rate of carbon sequestration varies with species, climate and site, but generally, younger and faster growing forests have higher; annual sequestration rates. Tropical forests and temperate zones sequester and store more carbon than any other terrestrial ecosystem does. In addition, these ecosystems contribute to the 90% of the annual flow of C between the atmosphere and the ground (*Brown and Lugo, 1982*). This fact has generated a special concern about the great importance of these forests as C stock places since they store big amounts of greenhouse gases, especially CO2.

According to the Glossary of climate change acronyms, "Carbon sequestration is the process of removing Carbon from the atmosphere and depositing it in a reservoir". Mangroves growing near the coast play an important role in carbon sequestration by acting as sink for carbon. Mangroves and coastal wetlands annually sequester carbon at a rate two to four times greater than mature tropical forests and store three to five times more carbon per equivalent area than tropical forests (*Brown and Lugo, 1982*).

In Bangladesh, the Sundarbans mangrove eco-region is the world's largest mangrove ecosystem which covered 20,400 square kilometers. This forest contains a considerably high floral diversity. There are about 334 plant species available in Sundarban Reserved Forest (SRF) area. The dominant mangrove species is Sundari (Heritiera fomes) and it covers 73% of total landmass. The forest is named after Sundari "Heriteriafomes" trees. The second species is Gewa (Excoecaria agallocha) covers 16% of the total forest area. (*Rahman and Asaduzzaman 2010*). Other prominent species are found in Sundarban Reserve Forest includes the Keora, Goran, Singra, Garjan, Dhundal, Aamur, Passur and Kankra. Keora, and Baen.

2 Study area

The study was carried out in the Chandpai area of Compartment number 26 in Sundarban Reserve Forest, the world's largest mangrove forest, of which around two-third occurs in the south- east coastal region of Bangladesh. The area is located in the tropic of cancer and at the northern limits of the Bay of Bengal. The forest area is situated in latitude 21°27′30″ N to 22°30′00″ N and longitude 89°02′00″ E to 90°00′00 E in Khulna, Bagherhat, Shatkhira district (*Rob, 2009*). The study area is in between the North-eastern side of Sundarban where fresh water vegetation occurs. Fresh water vegetation is found around the North and east zone of the forest. River water in this zone is fresh or slightly saline in the rainy season.

In general, the northern eastern part of the Sundarban is better supplied with fresh water and floristically richer than the southern and western part. Trees like Sundari, Golpata palm becomes progressively less frequent towards south and west. Less saline water loving species like Sundari, Gewa have high density in Chandpai range. Forest of Sundarban has been

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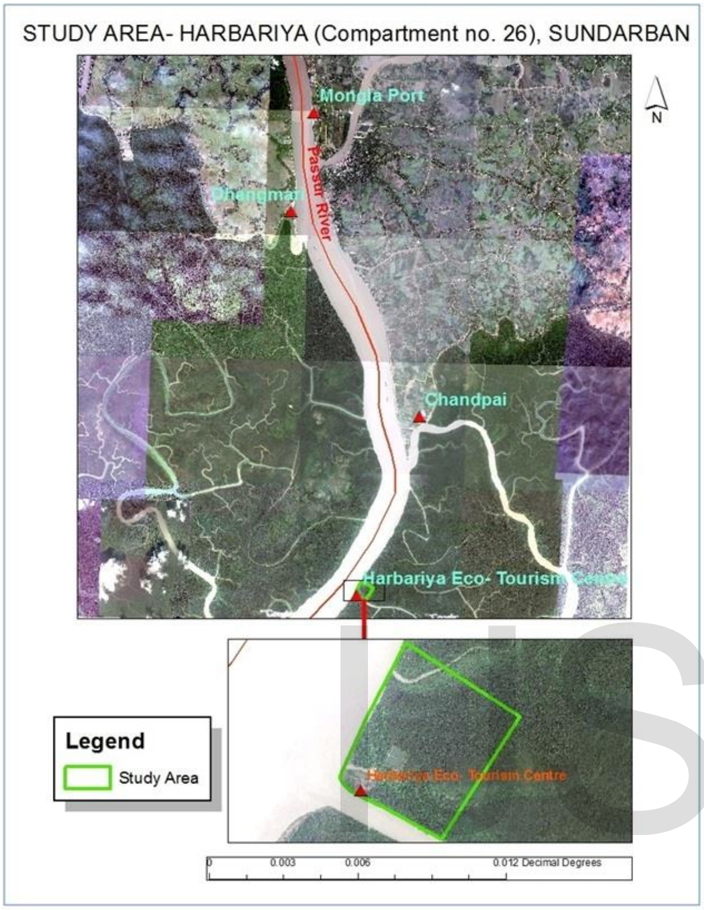
divided into three zones according to degree of salinity of water and vegetation composition, such as fresh water forest vegetation, moderately salt water forest vegetation, and salt water forest vegetation.



Like other parts of the country, in Sundarban the average temperature is above 26° C. The coolest temperature occurs during December to January and the warmest at the end of the dry season May to June. The temperature influences generally the growth, development, regeneration and growing stock of Sundarbans. It has been observed that Sundarban forest area experiences highest amount of rainfall in monsoon period as like the other parts of the country. Approximately 80 -85% rainfall occurs in this season. In the months of June- July approximately 300-500 mm rainfall occurs (*Integrated Resources Management Plans for the Sundarban, 2010-2020*).

3 Methods and Materials

The study has been carried out at Harbariya Ecotourism Center in Sundarban Reserve Forest. The methods used for collecting the samples were not destructive at all. It was easy to have access to the different parts of the seven selected trees from six different species using some simple manual techniques like simple rope technique and tree climbing equipment. Two tree climbers were associated with us to measure tree height, diameter and collect samples.

The leaf samples of all species have been oven dried at 70° temperatures in order to get a homogeneous drying to obtain biomass value. For each of the 7 study trees 20 leaves has been selected on random basis, then they were crushed and grinded using mortar and pestle. Fragments of the trunk and tree skin have been oven dried at 70° temperatures to get the biomass quantity foe chemical analysis. They were chopped and grinded using manual methods. All the samples have been passed through 2mm sieve and thus prepared for carbon testing.

4 Chemical Analysis

Principle:

Tyurin's method had been followed for the determination of total organic carbon. Tyurin's method (1931, 1936) is a modification of the volumetric determination of organic carbon by oxidation with potassium dichromate in strongly acid solution which leads to the formation of CO2 according to the equation:

$$3C+2K_2Cr_2O_7+8H_2SO_4 \rightarrow 3CO_2+2Cr_2(SO_4)_3+2K_2SO_4+8H_2O \quad (1)$$

$$6FeSO_4+ (NH_4)2SO_4+K_2Cr_2O_7+7H_2SO_4 \rightarrow Cr_2(SO_4)_3+3Fe_2(SO_4)_3+6(NH_4)2SO_4+K_2SO_4+7H_2O \quad (2)$$

The amount of oxygen consumed during the oxidation of organic carbon was calculated from the difference between the amount of dichromate taken and the amount remaining after oxidation. This was determined by titration with a solution of Mohr's salt ($FeSO_4$. $(NH_4)2SO_4.6H_2O$)

5 Result Analysis

5.1 Carbon sequestration in branch wood

The samples were taken from the branches of different species of mangroves such as Sundari, Gewa, Keora and Baen and their height varied from 3-4 meters. Different mangrove trees showed different percentage of carbon storage capacity despite having same height of the trees. The average branch diameter differs of the same trees.

Table 1: Comparison C (%) in different parts of individuals

Sample Name	Components C%				Mean %
	Leaves	Branches	Tree wood	Skin	
Sundari 1	44.79	41.3	38.57	40.22	41.22
Sundari 2	44.59	41.3	39.35	39.93	41.29
Gewa	36.82	41.48	39.17	38.77	39.06
Keora	37.99	43.51	39.35	41.88	40.68
Baen	41.3	41.77	40.05	39.73	40.71
Golpata	46.71				
Tiger Fern	39.35				

Field Survey, 2014

Table 1 showed that Sundari 1 (Diameter -6.36) and Sundari 2 (Diameter 3.5 cm) stored the same percentage of C (41.3%). Table 1 represents that Keora branch stored the highest amount of carbon (43.51 %). Baen (41.77%) stored more C in their branches than Gewa (41.48%) but they belonged to the same age group of approximately 20-25 years. Sundari tree branches

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contained 2.21 % less C than Keora. The C storage capacity of branches of Sundari had the lowest whereas Keora had the highest at the same height.

5.2 Percentage of Carbon sequestrated in Tree Skin

Tree skin is the covering layer of tree wood. Table 1 represents that Keora was the highest sequester of C, and it stored 41.88% C in their skin, followed by Sundari 1 (40.22%). Rather than this, Sundari 2 (39.93%) and Baen (39.73%) had same percentage of C. Gewa had the lowest amount (38.77%) of C storage in comparison to other species. The skin samples had been taken from breast height of the trees which varied from 1.3 to1.4 m. It appears that different tree trunks have varying capacity of C storage capacity.

5.3 Percentage of Carbon in tree wood

Samples of tree trunk were taken from breast height of trees that is 1.3-1.4m from ground. All the trees had diameter > 10 cm.

Gewa and Keora showed that the amount of C sequestration was 39.17 % and 39.35 % respectively, which were very close to Sundari 1 and 2. Baen tree stored 40.05% C at an age of 20-25 years (Table 1). Sundari trees had the similar with the other species and had ≤40 % at an age of 20 years.

5.4 Percentage of Carbon in leaves

For any tree, the most important part is its leaf because they are the kitchen of C production as they release and intake C for photosynthesis. Golpata stored the highest quantity of C in their leaves (46.71%). On the other hand, Gewa leaves had the lowest storage capacity of C (36.82%). Sundari trees had higher C storage capacity (average 42.97%) after Golapta. Baen and Tiger fern leaves also showed the similar amount of C such as 41.3 % and 39.35 % respectively (Table 1).

The study found that Golpata and Sundari, two distinctive species of Sundarban forest sequestering more C in comparison to others.

5.5 Percentage of Carbon in different parts of the individuals

Gewa is showing significantly less C storage capacity than the other mangrove species (39.06%). Sundari trees are having the highest C storage capacity (>41 %). Keora and Baen are in the middle position having capacity around 40 %. So, it is inferred that Sundaries are the major storehouse of carbon followed by Keora and Baen (Figure 2).

If a single tree is considered, Sundari had a significant amount of C in leaves, then in branches (41.3 %), whereas Keora stored higher amount of C in branches and less in leaves (37.99 %) and Golpata had stored the highest amount of C in its leaves in the study area (Table 1).

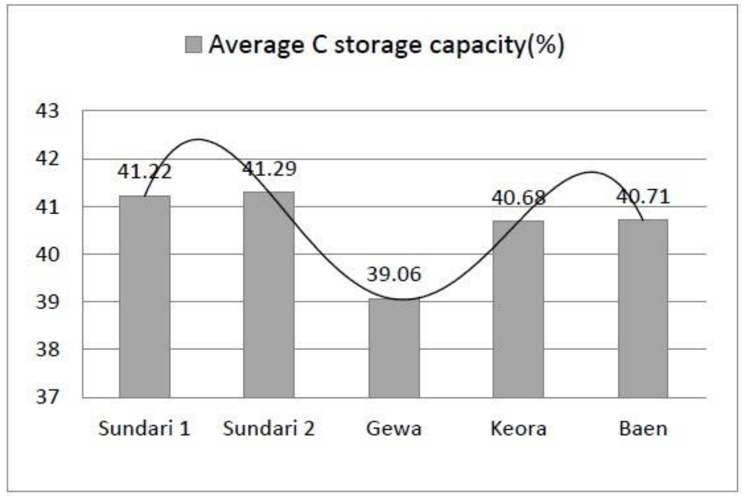

Figure 2: Percentage of C in different parts of the individuals

6 Discussion and Conclusion

In tropical dry forests the contribution of root to total biomass has been estimated from 18 to 46% (Kirby and Potvin, 2007). Concerning Sundarban mangrove forest Carbon percentage resembles within this range.

As in Bangladesh region, carbon study of SRF has not been yet practiced; comparison could be made with the other species tropical forests. It is inferred from the analysis that the results are approximately similar and so comparable. It was found that the percentage of C in the biomass of Sundari (Heritera fomes) trees, in all the cases, inferior to 50 % as stated by IPCC (Higuera and Martinez, 2006). It is inferior to values reported in other studies of Teak (Tectona grandis) plantations in panama, showing 46.4% carbon concentration in teak tissues.

It has been registered that the content of C of the wood of conifers between 50 and 53 % while in Sundarban it is in between 38 to 45 %. In wide leaves of conifers this value varies from 47 to 50% and in Sundarban it varies from 36 to 47 %. Golpata is found to be in high capacity to store C in their leaves which is 46.71 % and found in moderate density in the study area.

For tea-oil camellia, the biomass of coarse branches and foliage accounted for greater than 50% of the total tree biomass. Although the carbon concentration of all the plant tissues was approximately 50%, significant differences were observed among specific tissues of the different species. The average carbon concentration was estimated to be 55.66% for slash pine, 47.94% for Chinese fir, 50.34%, for tea-oil camellia, 57.72% for Masson pine, and 48.02% for blue Japanese oak trees (Zheng, 2005)

To calculate the percentage of storage capacity of C in a forest has become an important tool to expand vegetation coverage, as this is helpful to minimize global warming. It is also necessary to determine C storage capacity in biomass of all herbaceous forms of life rather only knowing wood biomass and storage (Higuera and Martinez, 2006). The full ecosystem of Sundarban and nutrient cycle of trees have to be well observed and analyzed to know and calculate in a precise way.

Table 2: Change in Species composition in 2009 and 1996

Species	2009	1996	2009	1996
	N/ha	N/ha	%	%
Sundari	205	105	69.00	73.58
Gewa	62	18	20.77	12.70
Others	30	20	10.23	13.72
Total	297	142	100	100

Source: IRMP, 2010-2020, vol. I

The species composition of SRF is dynamic. The number of species of Sundari, Gewa and other species (Keora, Baen and others) show that the percentage of Gewa tree has increased by 8.08% and the percentage of Sundari has reduced by 4.58% (Table 2). This is due to reforestation of Gewa and result of Sundari top dying. Another issue is natural disasters, crew's assessment on inventory plots show damages due to severe cyclones in 2007 and 2009 (*IRMP, 2010-2020, vol. I*)

Carbon is one of the main concerns of current world and trees are the main reservoir of it. The establishment of a natural system in a forest or plantation will ensure that CO2 is kept out of the atmosphere. If we can plant more Sundari trees and find out actual reasons of top dying, then this single species can secure more and long term storage of C. As trees die and return their C to the atmosphere they are replaced by new trees through natural regeneration or plantation. At this point, we need to know which one have highest sequestration capacity and can conduct several other studies with other species for comparing and contrasting.

Author Contribution

AD and TR conceived the presented idea and collected data & samples, AD performed the laberotory experiments and analyzed the data. AD and MKB discussed the results and wrote the manuscript.

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