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Impact of patch size on tree biomass and carbon stock from a tropical dry forest of West Bengal, India

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ABSTRACT

The patterns of biomass and stock carbon distribution across different size of patches in a fragmented landscape have been poorly investigated. This paper deals with the estimation of biomass and carbon stock of trees in different girth classes by the nondestructive method in a dry tropical fragmented forest landscape of Jhargram district, West Bengal, India. I analyzed on the basis of DBH (Diameter at Breast Height) and density values of trees. These values were noticed highest in the girth class 67-101 (cbh in cm) for 1 ha, 50 ha, and 100 ha patches. But in case of 10 ha patch it showed top value in girth class 32-66 (cbh in cm). The amount of total biomass and stock carbon observed maximum (367.919 and 183.959 t/ha respectively) in 100 ha patch and minimum (45.846 and 22.923 t/ha respectively) in 1 ha patch. It may be due to the occurrence of greater density and age of the trees in 100 ha forest patch. This research indicates that the patch size of tropical forest is proportionally related to the amount of ground biomass and stock carbon. Hence, fragmentation creates major threats to the amount of stock carbon in the forest landscape.

Key words: *Forest patch, Biomass, Stock carbon, Tropical forest, Girth class.*

Introduction

Tropical forests are rich in biodiversity due to their favorable climatic state. It is home to a significant portion of the world's biodiversity (Sullivan *et al.*, 2017; Haddad *et al.*, 2015). Tropical forests accounted for 80% of the world's forest resource requirements (Ambasht, 1993). It is home to an important proportion of the world's biodiversity. It is also significantly related to the global carbon cycle by storing about 60% of the global total forest carbon as a living biomass (FRA, 2010). Extreme demographic pressures have accelerated industrial development and the conversion of forests into agricultural land has posed a threat to natural vegetation on the earth's surface. As a consequence, the extensive forest landscape becomes fragmented into small, isolated patches. These are leads to disrupt the carbon storage service provided by tropical forest.

India is an important developing nation. The rapid industrialization of recent decades has raised the level of atmospheric CO2 and reduced the carbon stock of forests. Typically, atmospheric CO2 is absorbed by plants through photosynthesis and stored as carbon biomass (Vashum and Jayakumar 2012). The estimation of stocks carbon biomass has become a key to understanding the global carbon cycle. However, the Forest Survey of India (2010) published comparative data on the stock carbon values of forest over a two-year period viz. 1994 and 2004. This was the part of the Second State Communication (SNC). The outcome has seen a steady decline in the value of carbon stocks, posing a major threat to the environment. Therefore, carbon sequestration study is very important in the current scenario. The range of the Lalgarh forest was chosen to estimate the distribution pattern of biomass and carbon stocks because of its fragmentation (Manna and Mishra, 2017) and lack of report so far. The current study was carried out to understand the impact of forest patch size on tree biomass and carbon stock of tropical forests.

Materials and Methods

Study sites

The study was carried out in the Lalgarh forest range during the year 2018-2019 (Figure 1). This range is the part of Midnapur forest division under western circle of West Bengal, India. The study area is spread out between 22° 31' 48" - 22° 40' 48" longitude and E-87° 4' 48"- 87° 7' 48" latitude. It is located on the slopes of the Chota Nagpur plateau with infertile laterite floor. The whole forest range is drought prone except the Kangshabati river bank. However, the range is experienced three main seasons in a year viz. rainy, winter and summer. Mean annual rainfall in the forest area was 1400 mm and highest in July and August. The maximum temperature observed during April and May (39 °C-46 °C). Further, the minimum temperature was noticed in the month of December which goes down to as low as 6 °C.

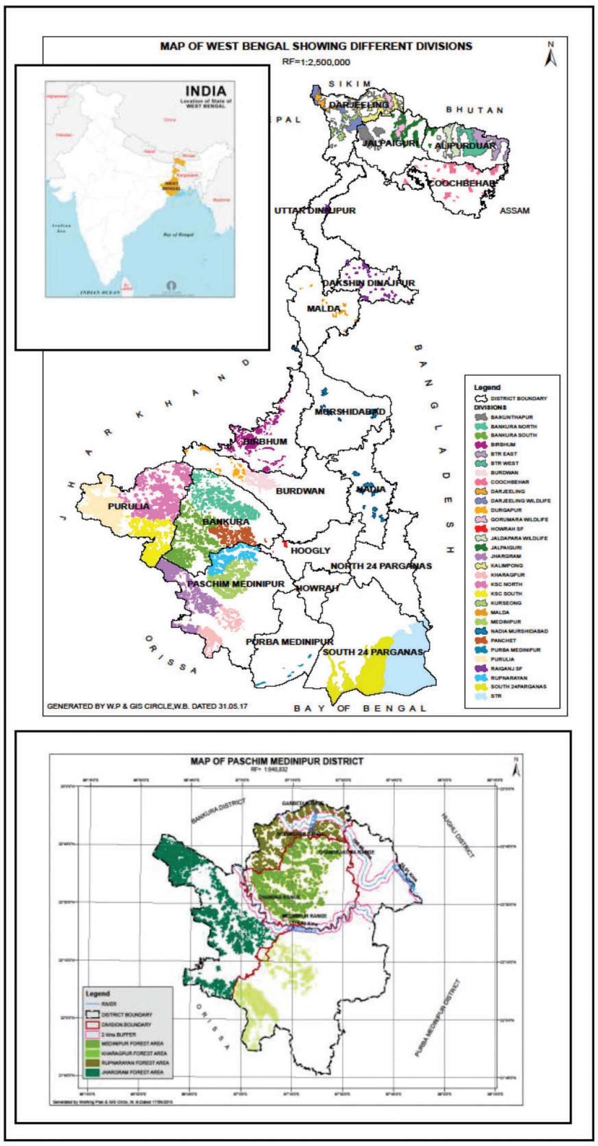

Fig. 1. Location of Lalgarh forest range.

Four forest patches of varying sizes (about 1ha, 10 ha, 50 ha and 100 ha) were selected from the fragmented Lalgarh range for study. These fragments were surrounded by agricultural land and highways. However, Sal (*Shorea robusta*) was the primary tree species at the survey site. The forest landscape was moderately disturbed through fuel-wood collection nearby villagers, construction of road and over grazing.

Sampling technique

Field data for tree species were recorded and measured by quadrate. The quadrate dimension was 20m X 20m. Ten quadrates were randomly placed for 1ha and 10 ha forest patches. However, twenty quadrates were plotted in 50 ha and 100 ha patches. The present sampling intensity is greater than the required standard minimum sampling intensity 0.01% (Sukumar *et al.,* 1992; Majumdar and Datta, 2016). The circumference at breast highest (cbh) of all the trees having minimum 10 cm cbh in each quadrate was measured. It was noted at 1.37m from the ground level for individual tree species. Density and diameter at breast height (DBH) were also calculated.

Biomass and carbon stock estimation

Depending upon the girth sizes, trees are grouped in to six categories (Singh *et al.,* 1986; Pradhan *et al.* 2016) as listed below- A 10-31 cm (Saplings) B 32-66 cm (Bole) C 67-101 cm (Post bole) D 102-136 cm (Mature trees) E 137- 171 cm (Mature trees) F >171 cm (Over mature trees)

The non-destructive method of Chamber *et al.* (2001) was used to estimate above ground biomass of trees for mixed forest. It is as ln (Y1) = -

0.37+0.33lnD+0.933[ln(D)]2-0.122[ln(D)]3. Here Y1 = Above Ground Biomass (AGB) of tree (kg/ha), D= Diameter at Breast Height (DBH). Further, shoot to root ratio from Carnis *et al.* (1997), was used to calculate Below Ground Biomass (BGB). Hence, Below Ground Biomass (BGB) = 0.26*AGB (t/ha). Therefore, Total Biomass (TB) = AGB + BGB. The stock carbon was estimated by multiplying biomass (AGB/BGB/TB) values with 0.5 as per method from references (Haripriya 2000; Ravindranath *et al.*, 1997).

Results

Changes of tree biomass along girth classes in different patches

Above ground, below ground and total tree biomass among different girth classes of four forest patches are recorded in Table 1. The observed values of density and basal area of the trees are used to calculate the ground biomass in the study site. Total biomass of 1 ha, 10 ha, 50 ha and 100 ha forest patches were 45.846 t/ha, 155.546 t/ha, 261.685 t/ha and 367.919 t/ha respectively. The highest amount of biomass was noticed from the 50 ha patch for the girth class 'A' and 'D'.

Further, 10 ha patch showed maximum biomass in girth class 'E'. The remaining girth classes showed highest biomass in 100 ha forest patch. However, lowest amount of biomass was recorded at the 1 ha patch in all three girth classes, except the girth class 'E' and 'F' where none of the tree species were noticed. Biomass value varies due to the variation of average DBH (diameter at breast highest) and density in different girth classes of four patches (Figure-2). Higher girth classes have larger DBH, but their density may be decreased. A clear relationship between DBH and density of trees in different patches are represented in Figure 3. These figures justified that DBH and density of tree species showed a negative relationship with each other in the study site. Further, larger patches have more trees in higher girth classes than smaller patches.

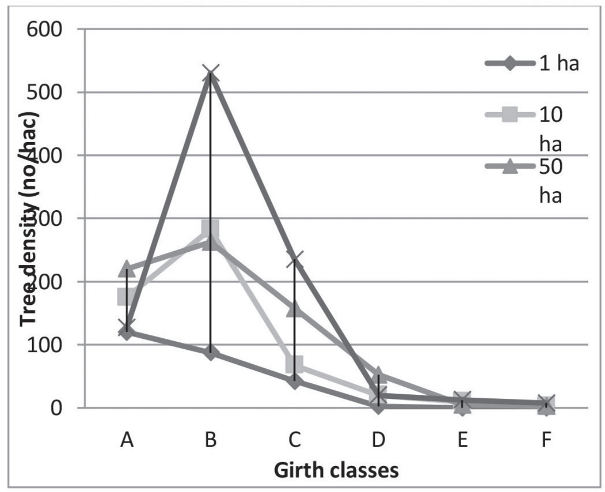

Fig. 2. Representing relationship between tree density and Girth class in different patches.

Variation of stock carbon values

The estimated stock carbon values for the four different sizes of patches analyzed ranged between 22.923 tC/ha at the 10 ha patch and 183.959 tC/ha at the 100 ha patch (Table 2). Further, the stock carbon

Table 1. Showing the Biomass in different girth classes of different patches.

Patches	Types of Biomass (t/ha)	Girth class (cbh in cm)						Total avrg. Bio. (t/ha)
		10-31	32-66	67-101	102-136	137-171	>171	
1 ha	AGB	2.289	8.979	20.645	4.473	0	0	45.846
	BGB	0.595	2.335	5.367	1.163	0	0	
	TB	2.884	11.314	26.012	5.636	0	0	
10 ha	AGB	4.513	33.883	29.500	28.650	26.903	0	155.546
	BGB	1.173	8.809	7.670	7.450	6.995	0	
	TB	5.686	42.692	37.170	36.100	33.898	0	
50 ha	AGB	5.343	40.720	87.271	55.756	10.455	8.142	261.685
	BGB	1.389	10.587	22.690	14.497	2.718	2.116	
	TB	6.732	51.307	109.961	70.253	13.174	10.258	
100 ha	AGB	3.933	89.487	114.347	34.734	23.046	26.452	367.919
	BGB	1.023	23.267	29.730	9.031	5.991	6.878	
	TB	4.956	112.754	144.077	43.765	29.037	33.330	

values in different girth classes of the forest patches were also varied. It was ranged 2.844 tC/ha to 6.732 tC/ha in girth class 'A', 11.314 tC/ha to 112.754 tC/ha in girth class 'B', 26.012 tC/ha to144.077 tC/ha in girth class 'C', 5.636 tC/ha to 70.253 tC/ha in girth class 'D', 13.174 tC/ha to 33.898 tC/ha in girth class 'E' and 10.258 tC/ha to 33.330 tC/ha in girth class 'F'. The amount of stock carbon may be increased with the increasing value of DBH. However, it may be restricted up to a specific DBH value for a specific size of forest patch (Figure 4). The reason behind this is that the density has decreased significantly after that specific DBH value of the study sites.

Figure-5 represents percentages of biomass/stock carbon values in different patches of the study site. It also indicates how the fragmentation process decreases biomass and stock carbon values of trees through conversion of large forest landscape into many smaller isolated patches.

Discussion

The total tree biomass were 45.846 t/ha, 155.546 t/ha, 261.685 t/ha and 367.919 t/ha at 1 ha, 10 ha, 50 ha and 100 ha forest patches respectively. The estimated above ground biomass were reported by

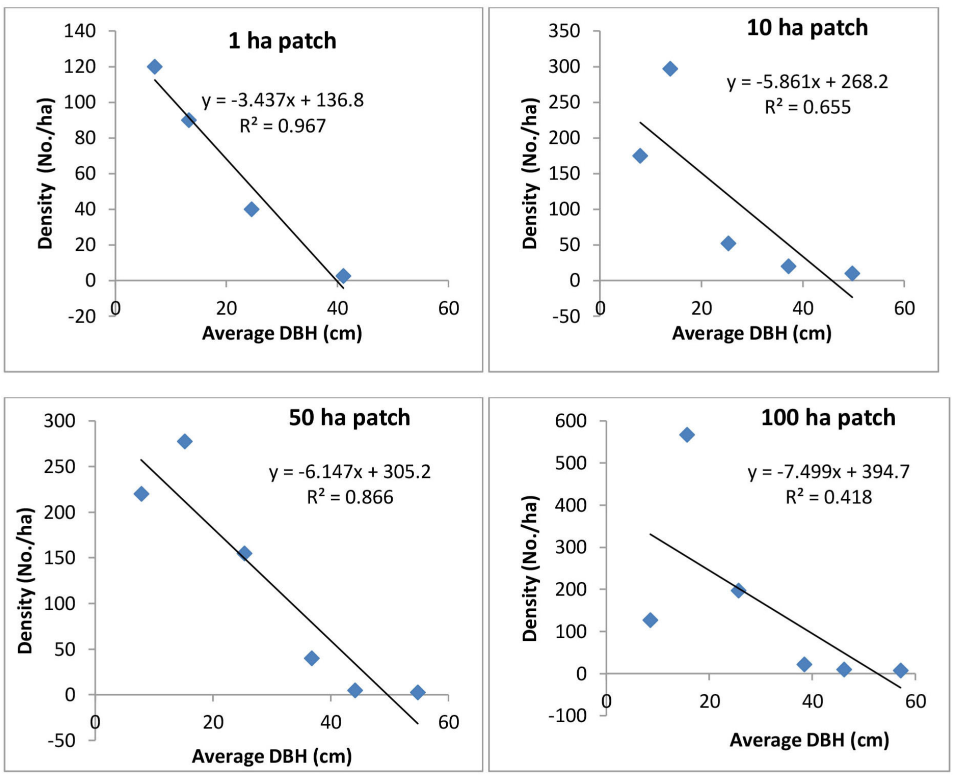

Fig. 3. Representing relationship of density with average DBH in different patches.

Table 2. Showing stock carbon at different girth classes of forest patches.

Girth class (cm)	Total average stock carbon (tC/ha) in different patches: 1 ha	10 ha	50 ha	100 ha
10-31	1.442	2.843	3.366	2.478
32-66	5.657	21.346	25.654	56.377
67-101	13.006	18.585	54.980	72.039
102-136	2.818	18.050	35.126	21.882
137-171	0	16.949	6.587	14.518
>171	0	0	5.129	16.665
Total	22.923	77.773	130.842	183.959

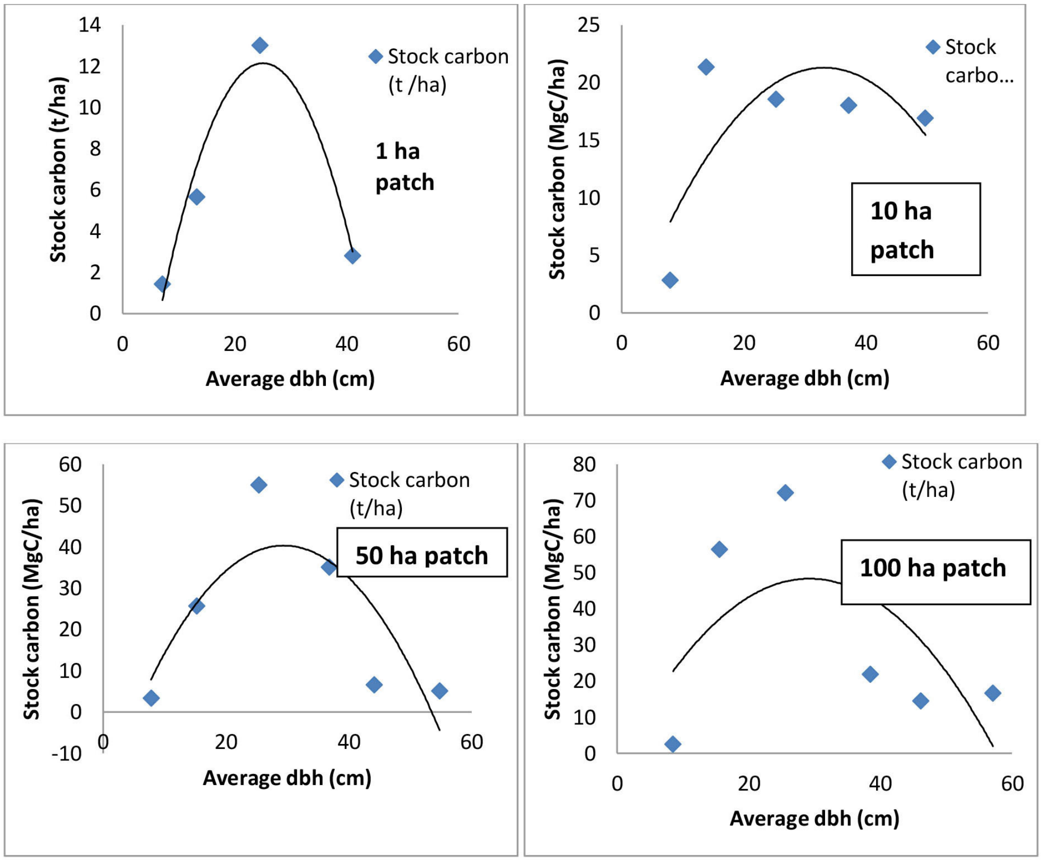

Fig. 4. Relationship of stock carbon with average DBH (cm) in different patches.

some worker (Singh and Singh, 1981; Singh, 1989; Negi, 1995) for tropical dry deciduous forest of northern India, ranged 38.6 t/ha - 239.8 t/ha and for disturbed tropical dry deciduous forest, biomass varied 28.1 t/ha - 85.3 t/ha (Pande, 2005). The present recorded value are little higher in 100 ha patch than the values given by earlier, which may be for girth class wise biomass estimation. Further, the biomass values are much lower in smaller patches than the earlier reported value, may be due to high rate of disturbance.

Similarly, the carbon stock values have also consistently declined with declining the patch sizes. It was varied from minimum 22.923 tC/ha (1 ha patch) to maximum 183.959 tC/ha (100 ha patch). Carbon stock values for tropical forests have also been reported in different parts of the world which are belonging to (Dantas *et al.*, 2021; Figueiredo *et al.* 2015) and just over (Behera *et al.*, 2017; Hoshizaki *et al.*, 2004) the recorded values of 10 ha, 50 ha and 100ha patch. But 1 hac patch represents very low amount carbon stock values compared to the previous report, due to its smallest size through most significant disturbances among rest of the patches.

Hence, total forest biomass and stock carbon were highest in 100 ha patch than the three other smaller patches. The percentages of biomass as well as stock carbon have increased with the increase of

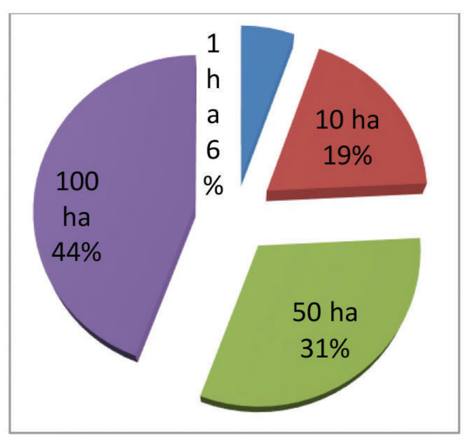

Fig. 5. Pie chart shows relationship between forest patch size and percentage of biomass as well as stock carbon.

patch size in the field and vice versa (Figure 5). That is the principal statement of current study. This variation at various patches can be attributed to some external and internal factors (Tarakunpisut *et al.,* 2007). The main factors are disturbance, density and age of the trees. The smaller patches are facing more disturbances by local villagers. As a result we were not getting any tree under the girth class E and F from 1 ha patch and also class F from 10 ha forest patch (Figure 2). Further, our result suggested that at 100 ha patch, tree density was less in some girth classes, but total biomass and stock carbon were very high than other smaller patches. This can be due to occurrence of old and big sized trees like *Shorea robusta, Diospyros melanoxylon, Terminalia bellirica, etc.,* at larger patches with higher density.

Conclusion

It can be concluded that the tree ground biomass and stock carbon are significantly related to the size of forest patches. Further, age, diversity, density and average DBH of trees towards different girth classes has great impact for the estimation of stock carbon. The largest size of forest patch (100 ha) showed highest stock carbon (tC/ha) than the other three (1 ha, 10 ha and 50 ha) lower sizes of patches those are comparatively more disturbed and had less number of mature trees. Generally, the matured and larger forest landscape is very rich with their species composition. However, mixed forest had highest ground biomass and carbon storage, compared to those in Sal or Teak dominated forest (Bijalwan *et al.,* 2010). The occurrence of higher trees density in higher girth classes of the 100 ha patch, compared to other lower size of patches was responsible for maximum carbon storage in the present study. However, the larger forest patch is characterized by better soil, greater geomorphology and microhabitat diversity which ultimately favors for better carbon storage. Further, Ground biomass of the tree is mainly the largest carbon pool and it is directly affected by forest fragmentation. The present study finds that forest patch size is very positively related with biomass and stock carbon value. The larger forest landscape not only stores a greater amount of stock carbon but also absorb huge amount of atmospheric carbon die oxide. They are also trying to protect the Earth from the effect of greenhouse gases. Therefore, such studies would be valuable in addressing forest dynamics and current environmental issues. Further, I recommended future studies to focus on the effect of fragmentation on climate change that are likely to impact carbon sequestration potential of global tropical forest. Finally, I must call attention to stop the tropical forest fragmentation by Government and public participation. Otherwise, we will be losing a huge stock carbon pool from the tropical forest landscape.

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Conflict of Interest

The author does not have any conflict of interest.

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