

Comparing Aboveground Carbon Sequestration Between Bamboo Forest and Dipterocarpus Forests of Manipur, North East India.

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ABSTRACT

The carbon stock and rate of aboveground carbon sequestration was assessed in bamboo forest and *Dipterocarpus* forests of Manipur, North-East India at 24° 18' 12.5" N latitude and 94° 15' 52.9" E longitudes with an altitude ranging from 478 m to 628 m above mean sea level. Allometric relationships were developed between the diameter at breast height (DBH) and biomass of harvested culms using a linear regression model for estimation of aboveground biomass in both the forests. The aboveground carbon stock was 78.11 and 7.80 Mg ha⁻¹ for bamboo and *Dipterocarpus* forest respectively, contributed by the culm/bole. The rate of carbon sequestration for bamboo forest and *Dipterocarpus* forests was 21.99 and 5.21 Mg C ha⁻¹ yr⁻¹. Our study shows that natural bamboo forest has higher potential for sequestering carbon from the atmosphere within a short period of time than that of *Dipterocarpus* forests existing in the same region.

Key Words: Aboveground Biomass; Allometric Equation; Carbon Sequestration ; Carbon Stock

INTRODUCTION

Forests play a significant role in capturing carbon dioxide from the atmosphere through photosynthesis, converting it to forest biomass and releasing into atmosphere through plant respiration and decomposition. Forests maintain high carbon stock by reducing deforestation and promoting the sustainable management of all types of forests. Sustainable forest management provides an effective framework for forest-based climate mitigation and adaptation.

Forests store more carbon dioxide than the entire atmosphere and the role of forests is more critical. But now more forests come under threat from deforestation and degradation, additional information on carbon stocks and pool especially in tropical forests worldwide is required to understand controls on carbon stocks and cycling to calibrate global cycle models and to support regulatory framework such as Clean Development Mechanism (CDM) and Reduced Emission from Deforestation and Forest Degradation (REDD). Carbon sequestration is an important part of an overall carbon

management strategy to help in the reduction and to mitigate global CO₂ emission. The United Nations Framework Convention on Climate Change (UNFCCC) and Kyoto Protocol have an international agreement on the incorporation of forestry activities to this major environmental challenge (Ramachandran et al. 2007, Yadava 2010). Recently IPCC (2006) has also emphasized on understanding the role of forests in carbon capture and storage under anthropogenic change. Therefore it is essential to emphasize the understanding of carbon cycle scenario, its impact and its efficiency on carbon sequestration options in natural ecosystems.

North eastern India is represented by varieties of forest types ranging from tropical rainforest through sub tropical and temperate forests (Champion and Seth 1968). Shifting cultivation and dependence of local people for their livelihood on the forest resources are the main biotic disturbances in the forest ecosystems. These forests play an important role in the sequestration of CO₂ from the atmosphere in India as they still occupy a large forest cover which is rich in biodiversity and falls in Indo-Burma hotspot of biodiversity.

LOCATION OF THE STUDY AREA, KHUDENGTHABI, CHANDEL DISTRICT, MANIPUR

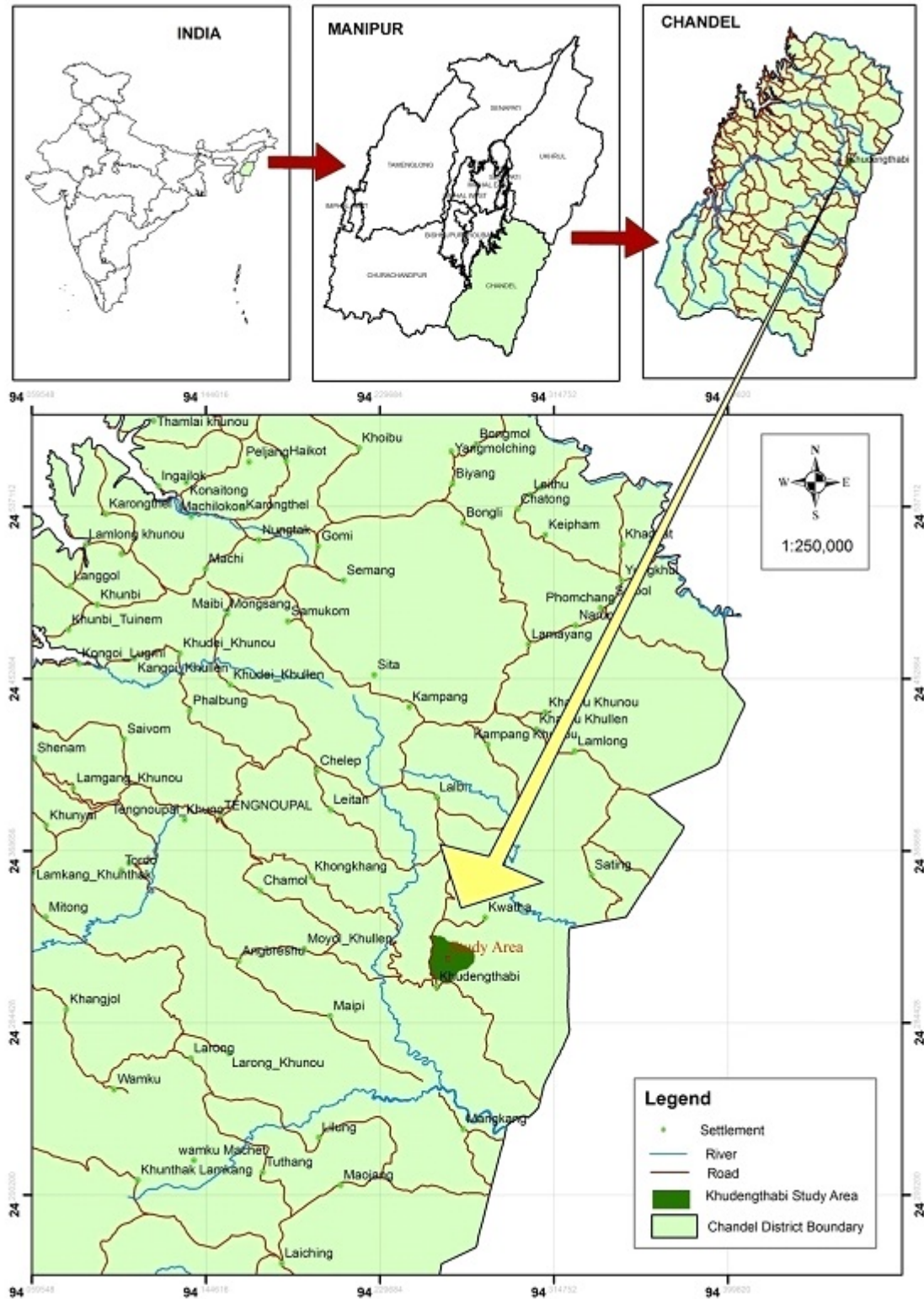


Figure 1. Location of the study site

Besides wood forests North East is recognised as one of the reserves of bamboo in India. Bamboo forest is an important part of forest ecosystem and an important carbon source and sink on the Earth. Bamboos occur in the tropical, subtropical and temperate regions of all the continents except Europe and western Asia, from lowland up to 4000m altitude. The climate of North-East Indian is suitable to Bamboo. It is one of the prominent ecosystems which plays an important role in the carbon cycle and carbon balance on the earth in fixing the CO₂ from the atmosphere through the process of photosynthesis and release it through respiration and decomposition process. The growth patterns of bamboos are different from woody plant species in having a unique characteristic of fast growth, high production and rapid maturation from shoot to culm (Scurlock et al. 2000). Bamboo forest ecosystem has a higher potential in fixing CO₂ from the atmosphere relative to other forest species (Zhou and Jiang 2004, Yen and Lee 2011).

After the Kyoto Protocol, several studies have been reported on the contribution of forests to the accumulation, storage and sequestration of carbon in the different parts of world (Metzker 2011, Hoover et al. 2012, Tang et al. 2012, Ngo et al. 2013, Thokchom and Yadava 2013). Recently bamboo forests have also received greater attention for their high productivity potential in sequestering CO₂ from the atmosphere in different parts of the world (Isagi et al. 1994, Li et al. 1998, Zhou and Jiang 2004, Xiao et al. 2007, Lou et al. 2010, Yen et al. 2010, Dükling et al. 2011, Song et al. 2011, Yen and Lee 2011, Zhou et al. 2011, Wang et al. 2013). In India limited information is available on the carbon stock and sequestration in the bamboo and *Dipterocarpus* forests (Tripathi and Singh 1996, Das and Chaturvedi 2006, Supriya and Yadava, 2006, Nath and Das 2012 and Debajit et al. 2014). Therefore the present study was undertaken to examine the role of bamboo and *Dipterocarpus* forests in the reduction of atmospheric CO₂ and to mitigate climate change. The data generated on C- source and sink in both the ecosystems would be useful for the national and global level carbon cycle as well as in computation of carbon credit and accounting. The main objective of the present study was to estimate the aboveground carbon stock and the rate of C-sequestration in the bamboo and *Dipterocarpus* forest ecosystem occurring in the same area of Manipur, North-east India.

MATERIALS AND METHODS

Study Area

The study was conducted on two forest types, bamboo forest and *Dipterocarpus* forest, in the same region. The study site is located at 24° 18' 12.5" N latitude and 94° 15' 52.9" E longitude, 105 km from Imphal city in Chandel district of Manipur, near Myanmar border at an altitude between 478 m and 628 m above mean sea level (Figure 1). It is a hilly terrain having low altitudinal range and forms the part of Indo-Burma Hot Spot of world's biodiversity (Myers et al. 2000). The detailed characterization of these two forest are summarized as follows: (i) the bamboo forest sites are dominated by *Schizostachyum pergracile* (Munro) R.B Majumdar synonymous of *Cephalostachyum pergracile*. It is a natural forest but under private management which has grown from a long time back and fairly protected. In general, culms are 1-5 years old and are distributed throughout the bamboo forest and the older culm are harvested every year and (ii) The *Dipterocarpus* forest is dominated by *Dipterocarpus tuberculatus* Roxb. (locally known as *Khangra*) and represents pre climax state and maintain by burning and sparse felling of trees by local inhabitants. The present bamboo is abundantly growing along the Indo-Myanmar border.

The climate of the area is monsoonic with warm moist summer and cool dry winter. The mean maximum temperature varies from 22.5 °C (December) to 34.2 °C (June) and the mean minimum temperature ranges from 5.0 °C (January) to 22.9 °C (August). The mean monthly rainfall ranges from 15.3 mm (December) to 200.7 mm (June). Annual rainfall was 1168 mm. The average relative humidity of air varied between 72.9% (March) to 86% (July). Soils of the study area are acidic and clay loam in texture and dark yellowish brown in colour at both the study sites.

Data Collection

For bamboo five experimental plots of 5m x 5m size were marked randomly in the study site in the bamboo forest area. Biomass was determined by harvesting randomly selected culms of different circumferences of different ages. Five circumference classes: 6-9 cm, 9-12 cm, 12-15 cm, 15-18 cm and 18-21 cm were recognised and culms from each circumference class were harvested to represent five age classes. After harvesting, culm samples were divided into leaf, branch and culm

component and their respective fresh weight were taken in the field. A sub-sample of each component was oven dried at 70 °C to a constant weight to calculate the dry matter of each component. Culm, branch and leaf biomass were determined from their respective dry weight to fresh weight ratio. Sum of all the aboveground biomass components yielded the aboveground standing crop of biomass. DBH (diameter at breast height) of all the individual culms were measured at the breast height of 1.37m above the ground and grouped into five age classes – Current year, 1 year, 2 year, 3 year and > 3 year. Age was identified in the field based on the morphological characters of culm (Embaye et al. 2005).

The biomass estimates for the *Dipterocarpus* were computed by randomly laid 20 quadrats of 10m x 10m along different girth classes (Newbould 1967). After harvesting, various parameters like diameter of the bole at the base, middle and top, total height of the tree and total numbers of the leaves were recorded. The fresh weight of all boles, branches, leaves and fruits were determined at the site. The sub-samples of different components were brought to the laboratory in the polythene bags. All the sub-samples were oven dried at 80°C to constant weight. Leaf samples of varying size (15 leaves) were also plucked from each tree of different constituent tree species for determining leaf area. The stand biomass was calculated by summing the biomass value across the girth class of all the species.

Biomass Estimation

Allometric equations were developed for leaf, branches and culm/bole of different age classes for bamboo and girth class for *Dipterocarpus*. By using the data collected from the harvested culm/bole regression linear model for leaf, branches and culm were developed between culm biomass and DBH was of the form:

$$Y=a+bx,$$

where Y is the component dry weight (g), x is the diameter at breast height (cm) and a and b are the regression co-efficient.

Litter and Litter Production

Litter floor mass was studied by randomly lying 10 trays of 50 cm x 50cm size and collected litter sample at monthly interval in both the sites and thereafter sorted into leaf, and branch and oven dry at 70 °C to estimate the oven dry weight.

Net Productivity

Aboveground net primary production was estimated by summing up the annual increment in the biomass and the corresponding litter fall deposited on the forest floor. The annual biomass increment in different component of tree species has been calculated by subtracting the biomass of 1st year from that of biomass of 2nd year. The net productivity data is used to estimate the rate of sequestration.

Estimation of Carbon Stock

Samples of culm/bole, branch, leaf and different components of litter were oven dried and powdered and analysed for determination of carbon percentage. Carbon concentrations of different components have been estimated through TOC analyser (Model: multi N/C 2100, Analytik jena, Germany).

The carbon storage in the different components was determined by multiplying the biomass of different aboveground components with respective concentration of carbon in both the forest sites. The total carbon storage was summation of carbon stored in different aboveground components in bamboo and tree forest.

C-Sequestration Estimation

The C-sequestration was estimated as per the equation:

$$Cs = C_n - C_{n-1} + L$$

where, C_n is the C-stock for nth year, C_{n-1} is the C-stock of the year preceding the nth year; L is the total litter production during the period.

RESULTS AND DISCUSSION

The culm density of the bamboo stand was recorded to be 8600 ± 1754 culm ha^{-1} and tree density was 1030 ± 107 trees ha^{-1} for *Dipterocarpus* forest. In bamboo forest highest density was recorded in 12-15 cm circumference class and then decreases with the increase in circumference (Figure 2) whereas in the *Dipterocarpus* forest maximum density was observed in 25-50 cm diameter class (Figure 3). Using a linear regression we found no relationship between culm density and mean circumference in bamboo but in *Dipterocarpus* forest there is a negative correlation between mean DBH and density i.e. tree density decreased with an increase in DBH.

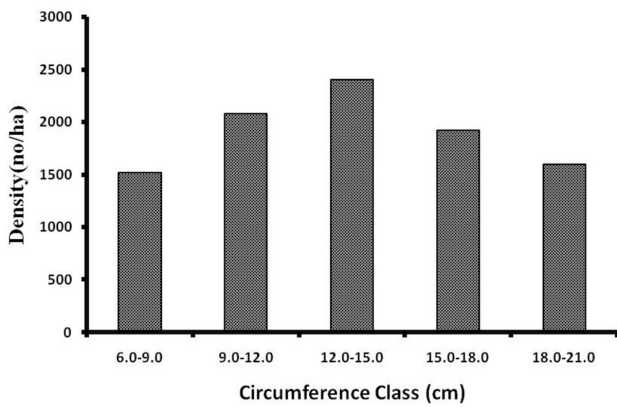


Figure 2. Culm density in different circumference classes of bamboo forest

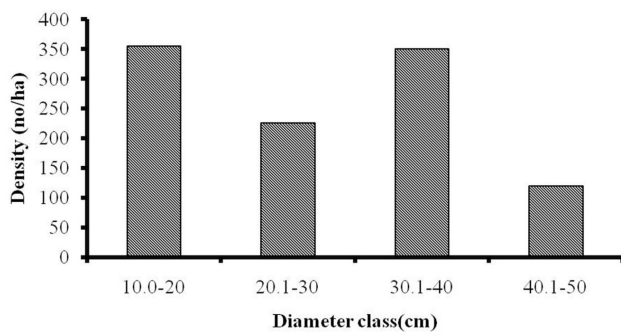


Figure 3. Density of tree in different diameter classes in *Dipterocarpus* forest

We used allometric equations to estimate the biomass of each age class in bamboo forest and *Dipterocarpus* forest (Tables 1 and 2). The relationships between the age and culm biomass shows that the culm biomass was accumulated mainly in the one year old and thereafter the biomass increased only slightly in subsequent years (Figure 4). The total aboveground biomass of bamboo forest was recorded to be 162.2 Mg ha⁻¹, out of it culm contributed 83.67%, branch 8.94% and leaf 7.39%. The total aboveground biomass of *Dipterocarpus* forest was recorded to be 15.70 Mg ha⁻¹ of which the bole contributed 90.27%, branch 4.91% and leaf 4.80%. The total aboveground biomass for both the ecosystems in different components was in the order of culm/ bole > leaf > branch (Table 3). ANOVA shows that aboveground biomass was significantly different between the bamboo and tree forest (p<0.05). In bamboo forest the biomass rapidly accumulated in the 1st year and then culm biomass increased slowly or not in

Table 1. Constants (a), slopes (b), coefficients of determination (r²) for allometric equations of the culm components in different culm age classes. Values in parentheses are ±SE.

Components	a	b	r ²	p-value
Culm				
Current	-2.84(0.35)	1.82(0.08)	0.97	<0.001
1-yr	-3.52(0.43)	1.95(0.09)	0.97	<0.001
2-yr	-3.58(0.49)	1.84(0.11)	0.95	<0.001
3-yr	-2.30(0.79)	1.25(0.17)	0.80	<0.001
>3yr	-2.60(0.42)	1.25(0.09)	0.93	<0.001
Branch				
Current	-	-	-	-
1-yr	0.31(0.02)	0.10(0.004)	0.97	<0.001
2-yr	0.14(0.04)	0.12(0.01)	0.91	<0.001
3-yr	-0.18(0.02)	0.16(0.005)	0.98	<0.001
>3yr	-0.21(0.01)	0.14(0.003)	0.99	<0.001
Leaf				
Current	-	-	-	-
1-yr	0.25(0.03)	0.09(0.01)	0.95	<0.001
2-yr	0.10(0.04)	0.10(0.009)	0.90	<0.001
3-yr	-0.25(0.02)	0.15(0.005)	0.98	<0.001
>3yr	0.23(0.02)	0.13(0.003)	0.99	<0.001
Total				
Current	-2.84(0.35)	1.82(0.08)	0.97	<0.001
1-yr	-2.95(0.43)	2.15(0.09)	0.97	<0.001
2-yr	-3.34(0.52)	2.05(0.11)	0.96	<0.001
3-yr	-2.74(0.77)	1.55(0.17)	0.87	<0.001
>3yr	-2.50(0.42)	1.52(0.09)	0.95	<0.001

Table 2. Allometric equation for different components of *Dipterocarpus* forest at p<0.001

Component	Parameter a	Parameter b	r ²
Stem	-1.752	0.170	0.893
Branch	-0.599	0.031	0.483
Foliage	0.190	0.023	0.463
Aboveground	-2.542	0.225	0.808

the subsequent year but there is increase in strength. Similar observation was also reported in Moso bamboo (Yen and Lee 2011) and village bamboo grove of Assam (Nath and Das 2008). The annual litter fall were

6.57 and 6.20 Mg ha⁻¹ yr⁻¹ in bamboo and *Dipterocarpus* forest respectively and the net production was 51.91 and 10.43 Mg ha⁻¹ yr⁻¹ respectively in both the forest. The biomass accumulation ratio of bamboo and *Dipterocarpus* forest was 2.89 and 1.59, respectively.

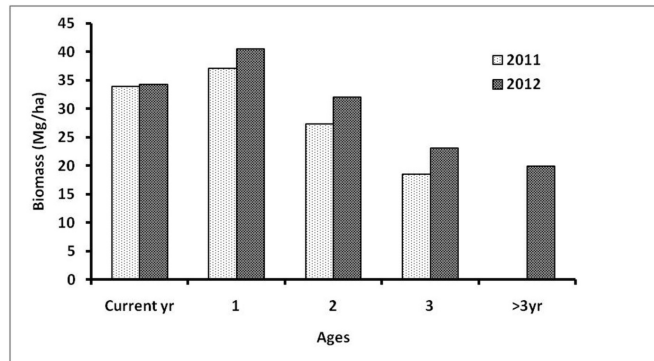


Figure 4. Aboveground biomass in different ages in 2011 and 2012 bamboo forest

Table 3. Aboveground biomass in leaf, branch and culm/bole of bamboo and *Dipterocarpus* forest

Component	Bamboo	<i>Dipterocarpus</i> Forest	ANOVA	
			F-value	P value
Leaf	11.99 ± 1.19	2.37±0.38	29.791	0.002
Branch	14.51±1.13	2.35±0.41	51.534	0.019
Culm/Bole	135.7±8.21	10.98± 1.81	21.774	0.156
Total	162.2± 4.97	15.70± 4.98		

Table 4. Carbon concentration (% dry matter) and carbon stock (Mg ha⁻¹) in different components of bamboo and *Dipterocarpus* forest

Components	Carbon Concentration		Carbon Stock	
	Bamboo	<i>Dipterocarpus</i>	Bamboo	<i>Dipterocarpus</i>
Leaf	44.47	49.67	5.33±0.79	1.177±0.19
Branch	47.36	49.12	6.87±0.53	1.154±0.19
Culm/Bole	48.38	49.80	65.91±3.97	5.469±0.90
Total			78.11±34.54	7.800±2.48

We observed that the aboveground biomass and total annual net production in five year old bamboo forest was higher than that of 10 year old *Dipterocarpus* forest. The lower value of aboveground biomass of *Dipterocarpus* forest is due to young secondary forest and at early succession stage and also subjected owing to biotic disturbance. Whereas bamboo forests was subjected to selective cutting of older culms every year to improve sprouting and to maintain the vigour of bamboo forest. However the productivity of the present bamboo forest is attributed to stand population structure producing more preponderant new culms with superior height and diameter. The biomass accumulation ratio has been also taken into consideration to assess the production condition in forest ecosystem and found that the bamboo forest has higher biomass accumulation ratio than that of the *Dipterocarpus* forest. Low value of biomass accumulation ratio in the *Dipterocarpus* forest is due to low biomass which may be resulted from the young forest and low tree density as compared to the bamboo forest.

The data of present study of aboveground biomass are compared with the different ecosystems of the world (Table 5).The data of present bamboo forest were compared with the other bamboo species of same age and was comparable with the data reported by Veblen et al.(1980) but lower than the value reported by Shanmughavel and Franchis(1996) whereas it is higher than the data reported by Isagi (1993); Nath et al. (2009) and Yen et al. (2010).Thus it shows that the biomass varies depending upon the species composition and climatic conditions.

From the data of aboveground biomass of different age woody forests we found that present value of ten years old *Dipterocarpus* forest were comparable with *Casuarina equisetifolia* forest of 4 years old by Lachica-Lustica (1997) and *Gmelina arborea* forest of 6 years old reported by Sakurai et al (1994) but lower than the older age forests. Thus it is essential to conserve and protect our forests from deforestation and degradation C-sink to mitigate climate change .

The total net annual productivity (TNP) of present bamboo forest was higher than that value reported by Tripathi and Singh (1996) for *Dendrocalamus strictus* plantation (15.8 Mg ha⁻¹ to 19.3 Mg ha⁻¹), Isagi (1994) for *Phyllostachys bambusoides* bamboo (15.7 Mg ha⁻¹). The present net primary productivity of *Dipterocarpus* forest was higher than that reported by Pande (2005) for tropical dry deciduous forest, Madhya Pradesh (4.8-6.4 Mg ha⁻¹) and cool temperate deciduous forest, Japan (5.6-8.6 Mg ha⁻¹) reported by Ryunosuke et al. (2004).

Table 5. Comparison of aboveground biomass (Mg/ha) and carbon stock (Mg/ha) of different bamboo and tree forest ecosystem of the world

Forest	Age (yr)	Aboveground Biomass	Aboveground Carbon Stock	Location	Source
A. Forests					
<i>Pinus auriculiformis</i>	9	108.20	48.7	Mindanao	Kawahara et al 1981
Dipterocarps	80	536.12	241.3	Makiling	Sakurai et al 1994
Dipterocarps	66	541.4	245.8	Makiling	Racelis 2000
<i>Gmelina arborea</i>	6	17.22	7.7	N. Ecija	Sakurai et al 1994
<i>Casuarina equisetifolia</i>	4	15.55	7.0	Iloilo	Lachica-Lustica 1997
<i>Tectona grandis</i>	6		7.97	West Bengal	Jana et al 2009
<i>Albizia lebbek</i>	6		6.26	West Bengal	Jana et al 2009
<i>Shorea robusta</i>	6		5.29	West Bengal	Jana et al 2009
<i>Artocarpus integrifolia</i>	6		7.28	West Bengal	Jana et al 2009
China fir	>30		99.5	Central Taiwan	Yen and Lee 2011
Dipterocarpus forest	10	15.7	7.8	Manipur	Present study
B. Bamboo					
Village bamboo grove	5	121.52	61.05	Assam,India	Nath et al. 2009
<i>Bambusa bambos</i> plantation	5	404		Tamil Nadu	Shanmughavel and Franchis 2002
<i>Phyllostachys bambusoides</i>	5-6	90.2-135.8		Japan	Isagi 1993
<i>Phyllostachys bambusoides</i> plantation	5-6		52.3	Japan	Isagi 1994
<i>Dendrocalamus strictus</i> plantation	5	34.9-47.4	16.3-22.1	Uttar Pradesh	Tripathi and Singh 1996
Moso bamboo forest	5		40.6	Central Taiwan	Yen and Lee 2011
<i>Gigantochloa scortechnii</i> plantation	3	36.36		Malaysia	Othman 1993
<i>Chusquea culeou</i>	>3	156-162		Central Chile	Veblen 1980
<i>Fargesia spathacea</i>	5	23.7		Sichuan,China	Taylor and Zisheng 1987
<i>Phyllostachys pubescens</i> bamboo	5	105.33	49.81	Central Taiwan	Yen et al 2010
<i>Scizostachyum pergracile</i> bamboo	5	78.11	162.2	Manipur	Present study

The biomass accumulation ratio was less than that reported by Singh and Yadava (1994) on secondary oak forest (7.7 to 8.9) in Manipur and *Phyllostachys bambusoides* (4.66) reported by Isagi (1994) in Japan.

We found that the aboveground C-stock was 78.11 ± 34.54 and 7.80 ± 2.48 Mg ha⁻¹ for bamboo and *Dipterocarpus* forest respectively, and contributed mainly by culm/bole with storage capacity of 65.91 ± 3.97 Mg ha⁻¹ and 5.469 ± 0.90 Mg ha⁻¹ in both the forests. Of the total aboveground biomass, over 84.38% and 70.12% was contributed by culm/bole in bamboo and *Dipterocarpus* forest respectively (Table 4).

Carbon stock in the aboveground biomass of bamboo forest in the present were compared with the data reported for similar age of other bamboo species (Table 5) we found that our bamboo species *Schizostachyum pergracile* stored more carbon in comparison to other bamboo species which may be due to fast growth rate and the increase of the culm density

depending upon the proper management practices. The present bamboo forest is open forest but still old culms are harvested every year by local people thus resulting higher carbon storage than plantation forest. The value of the present *Dipterocarpus* forest is lower since the forest is a secondary forest and even though dominated by fast growing species of *D. tuberculatus* which is subjected to logging and shifting cultivation. The carbon stock in present *Dipterocarpus* forest is comparable with the data reported from other tree species by Jana et al. (2009) on *Tectona grandis* species and *Artocarpus integrifolia* forest and by Sakurai et al. (1994) and Lachica-Lustica (1997) on *Gmelina arborea* and *Casuarina equisetifolia* forest. The present *D. tuberculatus* forest if well managed and protected then within six years it can stored aboveground carbon like the carbon stored by *Dipterocarpus tuberculatus* in protected forest of Cambodia (Khun et al. 2012).

The rate of carbon sequestration for bamboo forest and *Dipterocarpus* forests was recorded to be 21.99 ± 3.34 and 5.21 ± 2.52 Mg C ha⁻¹ yr⁻¹ respectively. In present bamboo forest the rate of carbon sequestration was highest in >3rd year and lowest in current year (Figure 5).

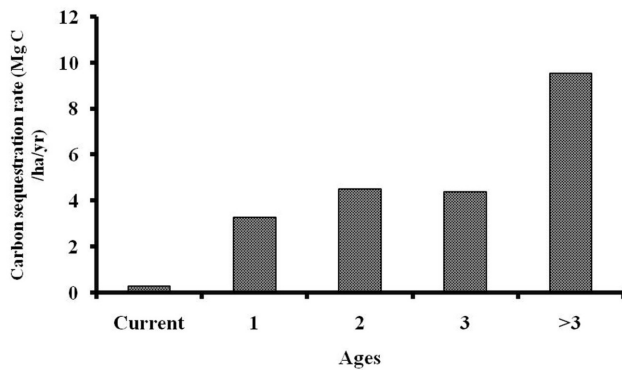


Figure 5. The rate of C- sequestration in different ages in bamboo forest

The rate of carbon sequestration was comparatively higher in bamboo forest than that of *Dipterocarpus* forest and the ratio of bamboo forest to *Dipterocarpus* forest was 4.22 which shows that the bamboo forest can sequestered four times than the *Dipterocarpus* forest. Greater C- sequester ability in the bamboo forest can be attributed to higher net productivity of *Schizostachyum pergracile* that resulted from high culm density and better management practices such as harvesting of old culms to maintain the vigour of bamboo forest. Our study has been carried out on the comparison of carbon storage between bamboo and *Dipterocarpus* forest based on the field study. Since bamboo and *Dipterocarpus* forest have different types of photosynthesis mechanism belong to C₄ and C₃ plant species respectively. In general C₄ plants accumulate more biomass due to higher rate of photosynthesis under certain environmental conditions (Bräutigam et al. 2008) which may response for increase in C-sequestration in bamboo forest.

Our data on rate of C-sequestration of bamboo forest (21.99 Mg ha⁻¹ yr⁻¹) was comparable with the data reported by Das and Chaturvedi (2006) for *Bambusa bambos* (20.5 Mg ha⁻¹ yr⁻¹) and in village bamboo grove (18.93 - 23.55 Mg ha⁻¹ yr⁻¹), Assam by Nath et al. (2008) but greater than that reported Yen and Lee (2011) for *Phyllostachys heterocycla* (8.13 Mg ha⁻¹ yr⁻¹) in

China. The rate of C-sequestration in *Dipterocarpus* forest (5.21 Mg ha⁻¹ yr⁻¹) was higher than the value reported by Lasco and Pulhin (2003) for natural forests (0.9 Mg C ha⁻¹ yr⁻¹) of Phillipines, and that reported by Jana et al. (2009) on *Artocarpus integrifolia* (3.33 Mg C ha⁻¹ yr⁻¹) and *Tectona grandis* (2.07 Mg C ha⁻¹ yr⁻¹) forest. However it was lower than the value reported by Lasco and Pulhin (2003) for fast growing tree plantations of *Eucalyptus* species and *Gmelina arborea* in Phillipines (17.5 Mg C ha⁻¹ yr⁻¹). Thus the rate of carbon sequestration is highly variable and depends on the species composition, age of the forest tree and climatic factors.

CONCLUSIONS

Dipterocarpus tuberculatus and *Schizostachyum pergracile* are fast growing species and naturally growing in the same region. The carbon stock and rate of carbon sequestration in bamboo forest is higher than that of *Dipterocarpus* forest. The ratio of rate of carbon sequestration of bamboo to *Dipterocarpus* forest was 4.22, i.e., the bamboo forest can sequester four times more carbon than the *Dipterocarpus* forest. By comparing the aboveground C sequestration of other young woody forests with our bamboo forest, we found that the bamboo forests can sequester more carbon within a short period of time than the other forests. Thus, *Schizostachyum pergracile* seems to be a superior species for carbon sequestration when compared with other woody forest and could be recommended for large scale plantation in degraded ecosystems in the North Eastern region of India to combat the global warming.

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