INTERNATIONAL JOURNAL OF ENVIRONMENT
Volume-3, Issue-4, Sep-Nov 2014 ISSN 2091-2854
Received:10 November *Revised:21 November* *Accepted: 26 November*

ABOVEGROUND BIOMASS AND CARBON STOCKS OF AN UNDISTURBED REGENERATING SAL (*Shorea robusta* Gaertn. f.) FOREST OF GOALPARA DISTRICT, ASSAM, NORTHEAST INDIA

Debajit Rabha
Department of Ecology and Environmental Sciences, Assam University, Silchar
Corresponding author: d10rabha@gmail.com

Abstract

The present paper deals with the aboveground biomass and carbon stocks of an undisturbed Sal forest of Goalpara district, Assam, Northeast India. The average AGB and C were recorded 239.45 ± 12.8 Mg ha^{-1} and 119.73 ± 6.4 Mg ha^{-1}. Density distribution curve indicates the high carbon sequestration potential of the stand in near future which further helps in climate change mitigation. Currently, conservation measures are well imposed in combine effort of local community and government. Legal involvement of local community in conservation exercises along with the forest department might be very effective in management of Sal forests.

Keywords: Regeneration, Anthropogenic disturbances, *Banabasi Than*, Sal forest

Introduction

Global climate change triggered by increasing levels of carbon dioxide (CO_2) and other greenhouse gases and role of terrestrial vegetation in capturing atmospheric carbon dioxide (CO_2) and storing the carbon in plant biomass and soil draw considerable attention in the recent past especially after the Kyoto Protocol. For reduction of greenhouse gas emissions and to partly offset deforestation, the Kyoto protocol explicitly considered afforestation, reforestation and regeneration of forests for carbon sequestration accounting (IPCC, 2007). Assessments of aboveground biomass play significant role in studying of carbon stocks, effect of deforestation and carbon sequestration on the global carbon balance (Ketterings *et al.*, 2001). It also provides valuable information on structural and functional attributes of forest ecosystems across a wide range of environmental conditions (Brown *et al.*, 1999).

In Assam, Sal (*Shorea robusta* Gaertn. f.) is a semi-deciduous species having high timber value and generally found in the form of coppice forest confined specially to the Western part of state forming a mono-specific canopy (Sarma & Das, 2012). Champion & Seth (1968) categorized Assam's Sal forests as "Tropical Moist Deciduous Forest" further divided into "Khasi hill Sal forest" (3C/C1 1a (ii)) and "Kamrup Sal forest" (3C/C2 2d (iv)). Sal forests of Goalpara district including the present study area are part of the Kamrup Sal forests. Due to the various anthropogenic disturbances such as over-exploitation of timber, encroachment and alteration in land use and land cover the mother Sal forests of the district gradually replace by secondary regenerated Sal forest (Deka *et al.*, 2012) including the present study area. Ahmed and Medhi (2005) estimated that there was shrinkage of 1050.46 hectares reserve forests and proposed reserve forests areas of Goalpara district during the period 1981-2002 due to encroachment for human habitation, pasture and agricultural uses. Majority of Sal forest of the district has faced a huge destruction in the past which at present is regenerating once again into its natural habitat. The present study deals with the aboveground biomass and carbon stocks of an undisturbed regenerating Sal forest of Goalpara district, Assam, Northeast India.

Materials and Methods

Study area

The present study was performed in an undisturbed Secondary Sal forest (around 15 ha area) of Lankey reserve forest which is adjacent to a temple namely "*Banabasi Than*" (lat. 25° 58' 42.14" N and long. 90° 48' 23.00" E), Dudhnoi, Goalpara, Assam (Figure 1). The Goalpara district is located on the Western part of Assam, Northeast India and is bounded by West and East- Garo Hills districts of Meghalaya on the South, Kamrup District on the East, Dhubri District on the West and River Brahmaputra all along the North. The geographical location of the district is between 25° 53' N to 26° 30' N latitude and 90° 07' E to 91° 05' E longitude. The climate of the district is damp and warm humid and average annual rainfall of last five-year period (2008-2012) was 2173.02 mm yr^{-1} (Hydromet division, 2013).

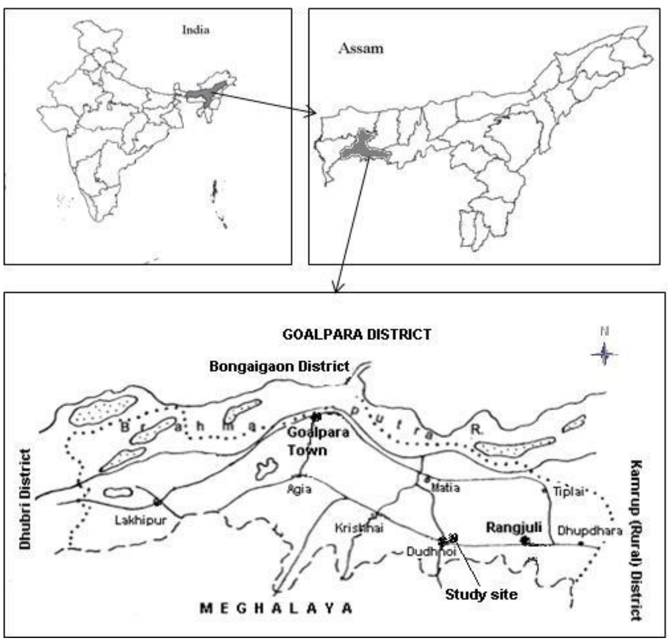

Figure 1. Location of study site, Goalpara district, Assam, Northeast India

Methods

The vegetation was analysed by delimiting five quadrats of size 31.62 m × 31.62 m (0.1 ha) randomly in the undisturbed Sal forest patch (around 15 ha area) which is contiguous to the temple "*Banabasi Than*". In each quadrat, girths of all the trees (≥ 10 cm dbh) were measured at 1.37 m height from the ground by using metal measuring tape.

Species-specific and region specific volume equations and wood density are available (Table 1), so, a non-destructive sampling method was adopted to estimate AGB and C stocks. The aboveground biomass of each individual tree was calculated by using species specific volume equation, wood density and default BEF (IPCC, 2003) as-

$$\text{Biomass} = \text{stem volume} \times \text{wood specific gravity} \times \text{BEF}$$

Table 1. Volume equations (FSI, 1996) and specific gravity (FRI, 1996) used in the present study

Sl no.	Species name	Volume equation	Specific gravity
1	*Shorea robusta* Gaertn.f.	$V=0.16019-2.81861D+16.19328D^2$	0.70
2	*Albizia procera* (Roxb.) Benth.	$V=0.13817-2.16947D+11.40870D^2+1.11636D^3$	0.56

Kishwan *et al.* (2009) reported average BEF value 1.575 for Indian forests which was used for present study. Estimation of C-stock in each tree was done by multiplying the tree biomass with 0.5 as in many other similar studies (Brown & Lugo, 1982; Montagnini & Porras, 1998)

Results and Discussion

Species richness was generally very poor in pure Sal forests and excluding *Shorea robusta* only one individual of *Albizia procera* was encountered. Low species richness in pure Sal forests was the agreement with the study carried out by Stainton (1972) in sal forests of Nepal. Average density and basal area was recorded 830 ± 33.6 tree ha^{-1} and 26.29 ± 1.0 m^2 ha^{-1} (Table 2). The density of pure conserve Sal forests mainly depends on its age and girth size because thinning exercise is done in recommended time interval. In the present study the average basal area was recorded 26.29 ± 10 m^2 ha^{-1} and similar basal area (7-29 m^2 ha^{-1}) was reported from Sal forest of Central India (Jha & Singh, 1990), 26.1 m^2 ha^{-1} form Sal Forest in Subtropical Submontane Zone of Garhwal Himalaya (Tiwari *et al.*, 2010), 26.3 m^2 ha^{-1} from Sal forest of Eastern Himalaya (Uma Shankar, 2001).

The mean AGB and C were recorded 239.45 ± 12.8 Mg ha^{-1} and 119.73 ± 6.4 Mg ha^{-1} in the present study (Table 2). The AGB score of the present study found lower than Sal plantation forest of Meghalaya with the value 406.4 Mg ha^{-1} (Baishya *et al.*, 2009) and higher than the value 154.94 Mg ha^{-1} recorded in open Sal forests of Satpura plateau, Madhya Pradesh (Pande & Patra, 2010). The witnessed AGB is also comparable with other forest types of Northeast India such as 32.47–261.80 Mg ha^{-1} in the tropical forests of Cachar district of Assam (Borah *et al.*, 2013), 179.14–246.38 Mg ha^{-1} in the sub-tropical broad leaved forests in Manipur (Thokchom & Yadava, 2013), 284.53 Mg ha^{-1} in Dipterocarpus forests of Barak Valley, Assam (Rabha *et al.*, 2014). From above comparison it reveals that a good amount of carbon was stored in present study area in respect to the Northeast Indian forests. Distribution of density and AGC in different dbh classes was shown in Figure 2. The lowermost two dbh class possesses 97 % density, pointing out the mass regeneration nature of Sal forests and 91.6 % AGC hints the potential of carbon sequestration of that stand in near future. Lack of more than 30-40 cm dbh trees indicates that the present study faced huge and mass destruction in past which at present regenerating and regain its natural habitat.

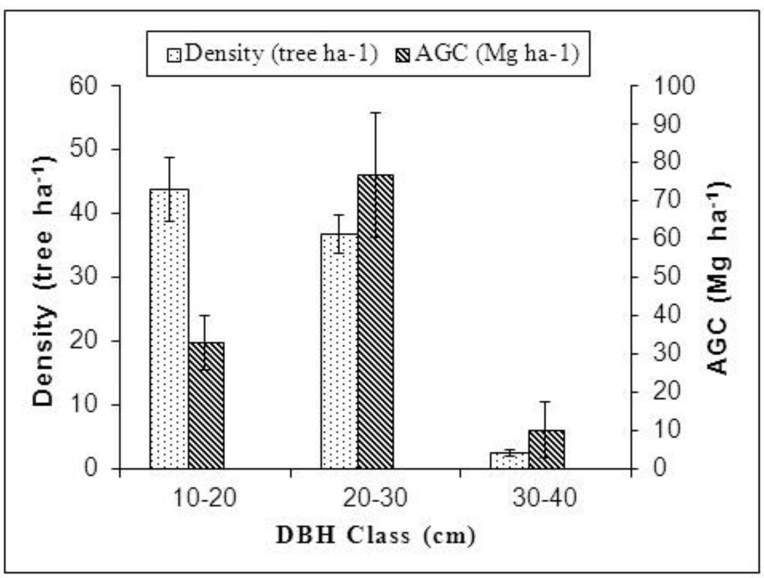

Figure 2. Distribution of Density and AGC of an undisturbed Sal forest in different DBH classes of Goalpara district, Assam, Northeast India

Table 2. Cumulative results of the sampled inventory of an undisturbed Sal forest in Goalpara district, Assam, Northeast India

Parameter	Score
Species number	2
Density (stem ha^{-1})	830±33.6
Basal area (m^2 ha^{-1})	26.29±1.0
AGB (Mg ha^{-1})	239.45±12.8
AGC (Mg ha^{-1})	119.73±6.4

The history of the present study sites is very old. The Sal forests of Goalpara district were exposed to different intensities of fire and anthropogenic disturbances in the past (Sarma & Das 2012; Deka *et al.* 2012; Rabha, 2014). Government always attempted to manage Sal forests for its high commercial timber value but found it difficult to conserve without the support of local communities. Though, natural Sal forests have high resilience capacity (Soni, 1961; Qureshi, *et al.*, 1968) but still phytosociological attributes of regenerating forests of the district are very poor. So, it is needed to improve our understanding of the causes of poor or no regeneration (Mishra *et al.*, 2013). Currently, timber felling and fuelwood collection are totally restricted in the present study and it is enforced by the local community the *Fofol Mouja committee* in support of the respective forest department. As the present study sites is contiguous to the temple-*Banabasi than* and the ritual believes also help to come forward the local community in conservation of that forest stand along with the government. In combine effort of local community and forest department currently present study site is well protected and not even single cut stem was evidenced during the field study.

Conclusion

Sal forests of the present study stand has faced a huge destruction in the past which at present is regenerating once again into its natural habitat and stored good amount of carbon in its biomass with high C sink potential. Currently, it is free from disturbance and it might be due to the involvement of local community in management practices. It can be concluded that legal involvement of local community in conservation exercises along with the forest department is very effective in management of Sal forests of Assam and elsewhere in India which further helps in climate change mitigation. Mapping of secondary regenerating forests is very important which can provide indicators of ecological response to disturbance, act as baselines for carbon stocks and carbon sequestration potential and so on, which needs further study.

Acknowledgement

Author is thankful to the forest department of Goalpara district for permission and support during the field study.

References

Ahmed, M. & Medhi, D., 2005. Encroachment causes shrinkages of forests in Goalpara district, Assam. Pp. 167-171. *In* A. Kumar (ed.) Environmental Biology. S.B. Nangia A.P.H. Publishing Corporation, New Delhi.

Baishya, R., Barik, S.K. & Upadhaya, K., 2009. Distribution pattern of aboveground biomass in natural and plantation forests of humid tropics in Northeast India. Tropical Ecology 50 (2), 295-304.

Borah, N., Nath, A.J. & Das, A.K., 2013. Aboveground biomass and carbon stocks of tree species in tropical forests of Cachar district, Assam, Northeast India. International Journal of Ecology and Environmental Sciences 39 (2), 97-106.

Brown, S. & Lugo, A.E., 1982. The storage and production of organic matter in tropical forests and their role in the global carbon cycle. Biotropica 14, 161-187.

Brown, S.L., Schroeder, P. & Kern, J.S., 1999. Spatial distribution of biomass in forests of the eastern USA. Forest Ecology and Management 123, 81-90.

Champion, H.G. & Seth, S.K., 1968. A Revised Survey of the Forest Types of India. Govt. of India publications, New Delhi.

Deka, J., Tripathi, O.P. & Khan, M.L., 2012. High dominance of *Shorea robusta* Gaertn. in Alluvial Plain Kamrup Sal Forest of Assam, N. E. Assam. International Journal of Ecosystem 2 (4), 67-73.

FRI, 1996. Indian Woods. Volume I-VI. Forest Research Institute, Ministry of Environment and Forests, Dehra Dun, India.

FSI, 1996. Volume Equations for Forests of India, Nepal and Bhutan. Forest Survey of India, Ministry of Environment and Forests, Government of India, Dehradun.

Hydromet division, 2013. Hydromet division, India meteorological department Available at:http://www.imd.gov.in/section/hydro/distrainfall/webrain/assam/goalpara.txt. (accessed: 19 Sep. 2014).

IPCC, 2003: Good Practice Guidance for Land Use, Land-Use Change and Forestry. Institute for Global Environmental Strategies (IGES), Hayama, Japan.

IPCC, 2007. Climate Change 2007: the Scientific Basis: IPCC fourth assessment report, Working group I.

Jha, C.S. & Singh, J.S., 1990. Composition and dynamics of dry tropical forest in relation to soil texture. Journal of Vegetation Science 1, 609–614.

Ketterings, Q.M., Coe, R., van Noordwijk, M., Ambagau, Y. & Palm, C.A., 2001. Reducing uncertainty in the use of allometric biomass equations for predicting above-ground tree biomass in mixed secondary forests. Forest Ecology and Management 146, 199-209.

Kishwan, J., Pandey, R. & Dhadwal, V.K., 2009. India's Forest and Tree Cover: Contribution as a carbon Sink. 130 ICFRE BL -23.

Mishra, A.K., Omesh Bajpai, O., Sahu, N., Kumar, A., Behera, S.K., Mishra, R.M., & Chaudhary, B.L., 2013. Study of plant regeneration potential in tropical moist deciduous forest in northern India. International Journal of Environment 2 (1), 153-163.

Montagnini, F. & Porras, C., 1998. Evaluating the role of plantations as carbon sink: an example of an integrative approach the humid tropics. Environment Management 22 (3), 459-470.

Pande, P.K. & Patra, A.K., 2010. Biomass and productivity in sal and miscellaneous forests of satpura plateau (Madhya Pradesh) India. Advances in Bioscience and Biotechnology 1, 30-38.

Qureshi, I.M., Shrivastava, P.B.L. & Bora, N.K.S., 1968. Sal (*Shorea robusta*) natural regeneration De-Novo effect of soil working and weeding on the growth and establishment. Indian Forester 94, 591-598.

Rabha, D., 2014. Species composition and structure of Sal (*Shorea robusta* Gaertn. f.) forests along distribution gradients of Western Assam, Northeast India. Tropical Plant Research 1 (3), 16-21.

Rabha, D., Borah, N. & Das, A.K., 2014. Assessment of Aboveground and Soil Organic Carbon Stocks in Dipterocarpus Forests of Barak Valley, Assam, Northeast India. International Journal of Ecology and Environmental Sciences 40 (1), 29-40.

Sarma, S.K. & Das, R.K., 2012. Community Structure of Sal (*Shorea robusta* Gaertn.f) Forests of Western Assam, India. The Botanica 59-61, 67-77.

Soni, R.C., 1961. Recent trends in Sal natural regeneration techniques with particular reference to B_3 Sal. Proc. × Silva. Conf., Dehra Dun.

Stainton, J.D.A., 1972. Forests of Nepal. John Murray, London.

Thokchom, A. & Yadava, P.S., 2013. Biomass and carbon stock assessment in the sub-tropical forests of Manipur, North East India. International Journal of Ecology and Environmental Sciences 39 (2), 107-113.

Tiwari, G.B.G., Pananjay, K., Tadele, K., Aramde, F. & Tiwari, S.C., 2010. Community Structure and Regeneration Potential of *Shorea robusta* Forest in Subtropical Submontane Zone of Garhwal Himalaya, India. Nature and Science 8, 70-74

Uma Shankar, 2001. A case of high tree diversity in a sal (*Shorea robusta*)-dominated lowland forest of Eastern Himalaya: Floristic composition, regeneration and conservation. Current Science 81, 776-786.