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Estimation of above-ground biomass and carbon stocking in tropical deciduous Forest of Lakhimpur Kheri Uttar Pradesh, India

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Abstract
The present study deals with the estimation of above- ground biomass and carbon stock of tree density, basal area, biomass and carbon stock with the help of non-destructive Volume equations method used in tropical deciduous forest in 0.1 ha permanent plots, established in sites Lakhimpur kheri forest is located at Uttar Pradesh. It was found that for inside the study area boundary, the dominant dense Sal forest decreased remarkably by 60% and agricultural land by 52%, mixed deciduous forest by 30% and teak plantation area by 25% recently a Above- ground biomass Variations in species composition, density, diameter distribution pattern, biomass and carbon stock at different forest sites were attributed to different forest sites. Above-ground biomass of each species was estimated taking tree volume and species specific gravity. Field measurements based methods used for survey, sampling in forest plot for density ranged from 100 trees ha-1 to total geographical area of Lakhimpur kheri 7,680 sq. km. The biomass ranged from 4.28 t·ha-1 to 42.7 t·ha-1 and carbon stock from 2.54 t·ha-1 to 30.6 t·ha-1 across the all different study sites. Tree species richness was highest at Gola gokaran nath and Dudhwa forest area. Forest surveying and data for estimating above-ground biomass density and the carbon stock stored in biomass of forest.

Keywords: Volume equation, basal area, above- ground biomass, tropical forest, destructive and non- destructive methods, specific gravity

Introduction
Carbon exists in the earth's atmosphere primarily as the gas-carbon dioxide. Dudhwa National Park (DNP), located in the foothills of Himalayas in Uttar Pradesh, has become an ideal home to the Great Indian one-horned rhino, Rhinoceros unicorn is These mega herbivores are not very specific in their food choices and chiefly feed on grasses, shrubs and herbs The tropical forests store large quantities of carbon in vegetation and soil, exchange carbon with the atmosphere through photosynthesis and respiration. They also prefer few species of plants, herb, shrubs and climbers. Some human activities (e.g. harvesting, clear cutting for conversion to non-forest purposes, poor harvesting procedures) or natural causes (e.g. wildfires) (Haripriya, 2003) [4]. Indian habitat specific and prefer alluvial plain grasslands, but are also found in adjacent swamps and forests Thus, estimating aboveground living biomass is the most important step in quantifying forest C-stocks and monitoring the changes. The study would not only provide the distribution pattern of carbon in different tree size classes but would also fill the AGB data gap for the tropical forests of Lakhimpur kheri. The forest of Kheri Forest Division mainly comprises Sal (*Shorea robusta*) and Teak (*Tectona grandis*) and other miscellaneous species for the management of Sal forest improvement exclusively felling were carried out. The other important objective was to develop spectral model to generate geospatial distribution of biomass and Carbon stock in the region. Assumed that the biomass estimates based on direct measurements of small areas of few tropical forest types could be extrapolated for other forest types. The objective of this study was to estimate forest aboveground biomass and C-stock as well as their increments using inventory data from PSPs collected from the Tropical forest in Lakhimpur kheri, Uttar Pradesh. The studies on carbon sequestration have been focusing on and expressing the sequestration in terms of biomass and carbon stock. Therefore, the present work aims to quantify carbon sequestration through estimation of aboveground carbon storage and AGB distribution pattern in different diameter classes in a natural and a plantation forest. The present study, conducted between January-December (2019), provides vital information to strengthen the available data of plants. The objective of this study was to estimate forest of Lakhimpur kheri above-ground biomass and Carbon-stock as well as their increments using field inventory data from collected from the tropical and sub- tropical forest area.

Materials and Methods
Study area
This study concludes that tropical and sub- tropical deciduous forests of the studied area in Lakhimpur- Kheri forest of Uttar Pradesh, India. The present study area is situated to the South of Sharda River and lies between 2800'' to 2803'' north latitude and 80060'' to 80035''east longitude.The major tree species of forest were Sal (Shorea robusta), Teak (*Tectona grandis*),
Butea monosperma, Shisam (*Dalbergia sissoo*), Cassia fistula, Khair (Acacia catechu),

Terminalia chhebula while the major tree species of were Sal (*Shorea robusta*). The cover is more than 50% by pole sized trees in both CFs. The study was conducted at Dudhwa tiger reserve, Gola gokaran nath, Bhira, Bankati, Mailani, Gaurifunta and Belrayan forest sites of Lakhimpur District Estimation of above ground tree biomass in the present study provides data for tropical deciduous forests covering a large part (30.%) of state for further use.

Introduction of site

Table 1: An extensive survey was conducted at Lakhimpur Kheri forest Districts in Uttar Pradesh. I have selected following Eights sites of forest area

S. N.	Study Area	Longitude	Latitude	Forest Type
1	Gola Gokaran Nath	80˚ 29' 11"E	28˚ 06' 23" N	Mixed Teak Forest
2	Bhira	80˚26'40" E	28˚ 18' 44" N	Mixed Deciduous Forest
3	Mailani	80˚ 21' 40"E	28˚ 15' 57" N	Tropical Deciduous Forest
4	Dudhwa	80 ˚35' 51" E	28˚ 30' 31" N	Tropical Teak Deciduous Forest
5	Bankati	80˚ 36' 00"E	28˚ 36' 00" N	Tropical mixed forest
6	Gori fanta	80˚ 31' 31"E	28˚ 39' 07" N	Mixed Teak Deciduous Forest
7	Paliya	80˚ 34'12"E	28˚ 31'12" N	Deciduous Forest
8	Belraya	80˚ 51' 55"E	28˚ 25' 24" N	Mixed Deciduous forest

Climate

The climate of the Lakhimpur kheri forest of three monsoon type. The area witnesses three distinct seasonal variations: winter (November to February), summer (April to June) and warm-rainy (July to September). The study area experiences alternation of long dry period with moderate rainfall, warm dry and warm moist climate are characteristics of this area and these climatic condition are responsible for phanero-therophytic phytoclimate. There are three type of climate seasons viz., winter (October to mid-March), summer (mid-March to mid-June) and rainy season (mid-June to September). The area of the forest is a vast alluvial plain, which shows succession of beds of sand, loam and clay. The Lakhimpur kheri receives about 150 cm of average annual rainfall. The mean minimum and maximum temperature varies from 9 °C to 22 °C in January and to 24 °C to 37 °C in May - June.

Table 2: Forest cover of Lakhimpur kheri district 2019 assessment

Class	Area
Total geographical area	7,680 sq. km.
Very dense forest	804.91 sq. km.
Moderate dense forest	158.21 sq. km.
Open forest	309.94 sq. km.
Percent of total	1,273.06 sq. km.
Percent of geographical are	16.58 sq. km.
Change wrt. 2017 assessment	-0.94 sq. km.
Scrub	4.49 sq. km.

Source: FSI Report 2019

Methodology

In the present study a new approach was adopted which used ground data as well as field measurement destructive and non-destructive based method data to get an accurate estimate of vegetation, carbon sequestration in the region sites were located with the help of Global Positioning System (GPS) and survey of forest sites reference topographic maps. For estimation of above-ground forest biomass and carbon stocking various methods are being employed which include destructive, non- destructive techniques. Non-destructive field measurement method is considered to good estimates of above- ground biomass (Devgiri *et al*., 2013) [21]. The best fit volume equation was used for estimation of Above-ground biomass and carbon stock in forest of Lakhimpur kheri. To estimate biomass increments, an equation relating above-ground biomass and annual above-ground biomass increment obtained from the field measurement based data. A similar relationship was also developed between forest Carbon stocking and its increment. For this, Carbon stocks were first estimated by multiplying the above-ground biomass by a factor of 0.5 (carbon fraction) (IPCC 2007) [19] and their values were used for analyzing the relationship between C-stock and its increment.

Sampling design

I have surveyed and sampling all the sites carried out in various Lakhimpur kheri forest area such as Dudhwa, Gola gokaran nath, Bhira, Mailani, Belrayan, Bankati, Gauri fanta sites of Lakhimpur kheri forest ranges. Samples Collected from all the rich forest pockets through several field trips covering all the sites in winter season during 2019. A non-destructive sampling approach was adopted to estimate the above-ground tree biomass and destructive sampling for herbs and shrubs in different vegetation types of litters.

The number of sample plots was finalized in consultation with s pecies accumulation curves and varies four (4) plots for each site. One super plot of 250 × 250 m size was laid down at each site (i.e. 8 sites).Four sample plots, each of 31.6 m × 31.6 m (0.1 ha) size 1m x 1m for herbs and grasses), quadrates for Shrubs 5m x 5m for shrubs size plots in all the four directions i.e. NE, NW, SW and SE, respectively were laid in each super plot. Thus, the total sample size consisted of 32 sample plots 8 super plots.

Required essential items and equipments in field survey and Laboratory work

GPS, Hypsometer, Field forms, Compass, Flag 4 (red colour), Ropes, Long Tap, Secateurs, Google earth print out, Pen, Marker, Camera + extra memory card and battery, Steel tape 3m, Knife, Electronic field Balance Weighing machine.

Observations

Study of forest above-ground biomass and carbon stocking are more accurate, as the volume equation estimate were made over large areas, which would be more representative than the estimates based on Lakhimpur kheri forest area. Trees having

more than 10 cm diameter at breast height (DBH; 1.37 m above-ground) measured using Steel tape 3m and height Hypsometer was considered as tree height. In each sample plot (0.1 ha quadrate), stratification in the forest was observed and data was classified into top, first and second order canopies in trees. Height and diameter at breast height (DBH) of all trees in four sample plots within each super plot were respectively. The Sal (*Shorea robusta*) rich forest lying under this circle primarily comprises of Sal as dominant species with Teak (*Tectona grandis*) plantation dominant trees biological floristic diversity. We also used the information on growing stock of cabon and area in Indian forests published by Forest Survey of India (FSI 2019). The identification of species recorded was done with the help of herbarium at Department of Botany, University of Allahabad, Prayagraj 211002, Uttar Pradesh, India.

Estimation of AGB

The estimation of AGB in forest different tree diameter classes in each forest was estimated using the above mentioned model, where the variable biomass was AGB. A non-destructive based methods in volume equation approach was used for assessing the above-ground biomass and carbon sequestration and sotck which requires the following parameters viz., tree measurements (tree height and DBH), application of standard volume equations and species specific gravity for each tree species estimated by using the site or region specific (phytogeographic/physiographic) volume, general biomass equations, procured from State Forest Department Forest Research Institute and Forest Survey of India (Dadhwal *et al*, 2009). A non-destructive Volume equation approach was adopted for assessing biomass/carbon stocking which requires the parameters like tree measurements (height and DBH) application of volume equations and species specific gravity for each tree, herb and shrub species. Tree volume was formula used for calculating biomass was as follows:

Biomass (t· ha-1) = Volume of tree × Species specific gravity

Biomass of herbs and shrubs was estimated using destructive methods. Two quadrates each of 5m x 5m size for shrubs and five quadrates each of 1m x 1m size for herbs were laid in each sample plots. All shrubs and herbs occurring in the sample plot were harvested, oven dried and dry weight was estimated above-ground biomass obtained from four (4) sample plots (each 0.1 ha) in different sites stratum was summed up to obtain total above ground biomass.

Estimation of carbon

Above- ground biomass has direct relationship with amount of carbon present in those trees, Herb, Shrubs and litter biomass. The carbon contained in the biomass is taken approximately as 50% of the above-ground biomass estimates. Carbon stocks were estimated from the total biomass by multiplying with IPCC 2007[19] default carbon fraction of 0.50 quoted by Mc Groddy. (2004), as follows.

Carbon (t) = Biomass (t) × Carbon %

Table 3: Above-ground biomass in trees, shrubs, and herbs layer in different sites of Lakhimpur kheri district.

Sites	Above Ground Biomass (t ha^{-1})			
	Tree	Shrub	Herb	Total
Gola Gokaran Nath	52.54	0.31	0.75	55.6
Bhira	58.56	0.42	0.85	59.83
Mailani	64.56	0.35	1.15	66.06
Dudhwa national park	150.55	0.52	1.96	153.03
Bankati	40.34	0.43	0.52	41.29
Gori fanta	48.66	0.62	0.72	50
Paliya	60.23	0.55	1.3	62.08
Belraya	65.32	0.20	0.8	66.32

Table 4: Above-ground carbon stock in trees, shrubs, and herbs layer in different sites of Lakhimpur kheri forest

Sites	Above Ground Carbon stock (t ha^{-1})			
	Tree	**Shrub**	**Herb**	**Total**
Gola Gokaran Nath	26.26	0.15	0.37	26.78
Bhira	29.28	0.21	0.42	29.91
Mailani	32.28	0.17	0.57	33.02
Dudhwa national park	75.27	0.26	0.98	76.51
Bankati	20.17	0.21	0.26	20.64
Gori fanta	24.33	0.31	0.36	25
Paliya	30.11	0.27	0.65	31.03
Belraya	32.66	0.1	0.4	33.16

Results

Observations of tree density, basal area, above- ground biomass and carbon of eight sites and covered by 32 plots sample using ANOVA test. The use of volume equation data from the inventories and subsequent conversion to biomass also has some limitations this section presents the above-ground biomass and carbon stock content of the 100 sample trees, herb and shrubs the fitted volume equations the estimates of carbon stock in forest dominant tree *Shorea robusts* & Teak plantation forest shrubs and herbs very rich dominant floristic diversity. Across different type vegetation, tree density and basal area cover varied are considerably. Total species were recorded from the tropical forest area and 100 trees species were recorded from the forest of Lakhimpur kheri. In tropical and sub- tropical type forest of Lakhimpur kheri. *Shorea robusta*, *Tectona grandis* (plantation) (were the dominant and co-dominant species in forest

respectively. There are four main sources of errors in this new estimate based on volumes wood densities, expansion factors, forest areas and stand volume. The relationships reported here for the different life forms could potentially be used in other forest ecosystems. The steepness of the cover–biomass slope for a life form should be determined by plant height, DBH because increasing plant height results in biomass per unit of surface.

Discussion

Similar studies have been reported in forest area that various factors such as vegetation types, net primary productivity of plants, biomass decomposition, size of trees, age of stands may affect the carbon stock in ecosystem (Shrestha and Singh, 2008). During the present study wide range of variations was observed in different studied parameters viz., tree density, basal area, above-ground biomass and carbon stock in different eight forest sites selected. Chaturvedi *et al.* (2011) Forest volume inventories are valuable source of data for estimating forest Above- ground biomass and carbon stocking also provide a basis forest Imation of Carbon source sinks and carbon sequestration. Although the biomass of medium size boles varied considerably among different forest area sites and such types of forests exhibited greater potential for sequestration of carbon as compared to the forests having large bowl size trees (Salunkhe *et al*., 2014). Tree density site wise eight sites also showed significant differences with more than 60% of the site selected of forest surveyed area in Lakhimpur kheri forest. Interestingly, basal area distribution showed an inverse relation with that of density. The drastic decrease in agricultural land can be due to significant increase in settlements. As the study shows that in India, most of the trees are in the lower diameter classes of potentially large diameter species, they are fair from reaching their maximum carbon stocks in forest area. During present study, regression analysis, revealed that, the linear increase in carbon stock was predicted with tree density, basal area, volume and above-ground biomass, the increase in carbon stock 0.1/h (t ha-1) regression analysis between different parameters were done viz., carbon stock vs. basal area, carbon sequestration vs. tree density and carbon it describes about linear regression, volume equation of carbon stock on tree density, basal area, tree volume and above- ground biomass estimated.

Conclusion

Above-ground biomass estimated with the help of volume equation and species specific gravity and diversity from the above- ground biomass and carbon stocking study it may be concluded that destructive and non- destructive based methods of biomass estimation through is very useful field measurements data in forest has been being useful for quick and reliable estimations of vegetation biomass and carbon sequestration over large areas in forest ecosystem. Carbon sequestration, stock was highest in 'stem' among different parts of vegetation in both CFs. In comparison to species-wise carbon pool and sequestration in the very dominant species of *Shorea robusta*. Above-ground biomass and carbon stocking in the present study has tried to estimates of volumetric data used that biomass and carbon stock present in the study areas field measurements methods data in order to understand the geospatial distribution in the Lakhimpur kheri forest. The present study analysis also revealed the presence of highest above-ground biomass carbon sequestration along the continuous forest of basal area, volume, biomass Frequency, density, abundance, relative frequency, relative density, relative abundance, relative dominance and important value index of trees, shrubs and herbs have been calculated the study sites of forest. Carbon stocking according to the concluded that photo, floristic diversity of herbs, shrubs and trees a very rich with sites i.e. some where it is very abundant frequency while some sites bears Few different species, evidently due to degradation of forest or over exploitation. The species *Shorea robusta* was very dominant and most valuable timber species on both study sites of Lakhimpour kheri forest.

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References

1. Terakunpisut J, Gajaseni N, Ruankawe N. Carbon sequestration potential in aboveground biomass of Thong pha phun national forest, Thailand. Appl. Ecol. Environ. Res. 2007; 5:93-102.
2. FSI. Volume Equations for Forests of India, Nepal and Bhutan. Forest Survey of India, Ministry of Environment and Forests, Govt. of India, Dehradun, India, 2006.
3. Bhat DM, Ravindranath NH. Above-Ground standing biomass and carbon stock dynamics under a varied degree of anthropogenic pressure in Tropical rain forest of Uttar Kannada District, Western Ghats, India. Taiwania. 2011; 56(2):85-96.
4. Haripriya GS. Estimates of biomass in Indian Forest, Biomass and Bioenergy. 2003; 19:245-258.
5. Brown S, Lugo AE. Biomass of tropical forests: a new estimate based on forest volumes. Science. 2000, 1984; 223:1290–3.
6. Clark DA, Brown S, Kicklighter DW, Chambers JQ, Thomlinson JR, Ni J, *et al*. Measuring net primary production in forests: concepts and field methods. Ecological Application. 2001; 11:356-370.
7. Brown S, Gillespie AJR, Lugo AE. Biomass estimation methods for tropical forests with application to forest inventory data. Forest Science. 1989; 35:881-902.
8. Brown S, Lugo AE. Biomass of tropical forests: a new estimate based on forest volumes. Science. 1984; 223:1290-1293.
9. FSI. Volume Equations for Forests of India, Nepal and Bhutan. Forest Survey of India, Ministry of Environment and Forests, Govt. of India, Dehradun, 2006.
10. Behera SK, Misra MK. Aboveground tree biomass in a recovering tropical sal (Shorea robusta Gaertn. F.) forest of Eastern Ghats, India. Biomass and Bioenergy. 2006; 30:509-521.
11. Sundarapandian SM, Amritha S, Gowsalya L, Kayathri P, Thamizharasi M. Estimation of biomass and carbon stock of woody plants in different land-uses. Forest Res. 2013; 3:115.

12. SandraL. Spatial distribution of biomass in forests of the eastern USA, 1999, 123.
13. Salunkhe Onkar, Khare PK, Sahu TR, Singh S, Prasad Yogesh, Rajagopal, *et al*. NOx Emissions from Biomass Burning of Shifting Cultivation Areas from Tropical Deciduous Forests of India, Estimates from Ground - Based Measurements "Atmospheric Environment. 2000; 34:3271-3280.
14. Pragasan LA. Carbon stock assessment in the vegetation of the Chitteri Reserve Forest of the Eastern Ghats in India based on non-destructive method using tree inventory data.J Earth Sci Climate Change, 2014, S11:001.
15. Kauimi T, Vashum S, Jaykumar. Methods to estimate above-ground biomass and carbon stock in natural forest. Journal of Ecosyst. Ecography. 2012; 2:116–122.
16. Pande PK. Biomass and productivity in some disturbed tropical dry deciduous teak forest of Satpura plateau, Madhya Pradesh. Trop. Ecol. 2005; 46:229–239.
17. Lal M, Singh R. Carbon sequestration potential of Indian forests. Environmental Monitoring and Assesment. 2000; 60:315-327.
18. Khangar H, Hirandhede DK. Studieson above ground biomass (agb) for assessingvegetation carbon pool in tropical forest ecosytem of central India. IJPSR. 2016; 7(11):4588-4591.
19. IPCC. Climate change 2007. The Physical basis. Summary for policymakers. IPCC Secretariat, c/o WMO, 7 bis, Avenue de la Paix, C.P.N. 2003, 1211 Geneva 2, Switzerland, 2007, 18.
20. FSI. Volume Equations for Forests of India, Nepal and Bhutan. Forest Survey of India, Ministry of Environment and Forests, Govt. of India, Dehradun, India, 2006.
21. Devagiri GM, Money S, Singh S, Dadhwal VK, Patil P, Khaple A, *et al.* Assessment of above ground biomass and carbon pool in different vegetation types of south western part of Karnataka, India using spectral modeling. Trop. Ecol. 2013; 54:149–16.
22. Chhabra A, Palria S, Dadhwal VK. Growing Stock-based forest biomass estimate for India. Biomass and Bioenergy. 2002; 22(3):187-194.
23. Brown S, Gillespie AJR, Lugo AE. Biomass estimation methods for tropical forests with applications to forest inventory data. Forest Sci. 1989; 35:881-902**.**
24. Alamgir M, Al-Amin M. Allometric models to estimate biomass organic carbon stock in forest vegetation. Journal Forestry Res. 2008; 19:101-106.
25. Baishya R, Barik SK, Upadhaya K. Distribution pattern of above ground biomass in natural and plantation forests of humid tropics in north east India. Tropical Ecology. 2009; 50:295-304.