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Estimation of carbon stock and aboveground biomass mapping in Mayang Hill and Barduar Reserve Forests, Assam, India using Landsat data

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Abstract - **Barduar and Mayang Hill Reserve Forest are located in the outer hilly ranges of Khasi Hills are covered with tropical moist deciduous forest. Forest ecosystem contains more carbon per unit area than any other land type. The estimation of above-ground biomass is an essential aspect of carbon stock study. The Aboveground biomass (AGB) governs the potential carbon emission that could be released to the atmosphere due to deforestation and change of regional AGB is associated with changes in carbon and ecosystem. A field survey on this forest using 30 sample points of 30m x 30m dimension was carried out to with the aim to estimate the AGB of the woody trees of the two forests in 2015 and 2017 and to estimate the carbon stock present from 2015 to 2017. Landsat images were used to delineate the different canopy cover in the forest and extrapolation of AGB was done in different canopy cover using remote sensing techniques.**

Keywords: **Aboveground biomass, carbon stock, Landsat**

I. INTRODUCTION

Forest is one of the most important renewable natural resources and has significant role in the human life and maintaining environmental balance on the earth [1]. Forest biomass is an important measure of ecosystem productivity [2]. The quantity of biomass in a forest determines the potential amount of carbon that can be added to the atmosphere or sequestered on the land when forests are managed for meeting emission targets [3]. Forest biomass can be divided into Aboveground living biomass (AGB) and Belowground biomass living (BGB). AGB is easier to measure and can be used as the basis to estimate the other terrestrial carbon pools, therefore, research efforts on biomass estimation has been focused on AGB [5]. AGB estimation by traditional field study is time consuming and costly. Remote sensing offers an economic and efficient mode of AGB monitoring by facilitating forest stratification, which supports field inventory. A survey on forest studies that used remote sensing technique shows that remote sensing can provide information critically required for forest AGB assessment [5]. The present study has been carried out with the aim to estimate the AGB of woody trees of Mayang Hill & Barduar Reserve Forest (RF), Kamrup, Assam, India in 2015 and 2017 and to estimate the carbon stock present from 2015 to 2017.

II. MATERIALS AND METHOD

A. Study Area

The study was carried out in Mayang Hill (91o29/27.831//E, 25o50/34.412//N to 91o29/24.993//E, 25o51/48.923//N) and Barduar RF (91o26/19.40//E, 26o0/30.856//N to 91o25/32.258//E, 25o52/30.95//N) located in Kamrup district, Assam, India in the outer hilly ranges of Khasi Hills. Tropical climate prevails in the forests and distinct seasons can be recognized, May to mid October is the rainy season, when maximum monsoon rainfall occurs and average rainfall is about 1300 mm, the winter experiences only occasional showers. Both the RFs are drained by numerous streams. The Chandubi lake lies in between the two RFs. Champion & Seth (2005)[6] classified Kamrup district forest as tropical moist deciduous forest sub-categorized into Kamrup Sal forest and mixed moist deciduous forest. The most conspicuous naturally growing Shorea robusta Gaertn. is Kamrup Sal or moist Sal found near Chandubi lake in Kamrup district.

B. Data collection and processing

The study has be carried out using Landsat8 images of 30 m resolution obtained from USGS WRS2 Path 137 and Row 42 (https://earthexplorer.usgs.gov). For digital forest type mapping we have used temporal images of November and March and for forest canopy density mapping cloud free images of November month was used. The resolution merge of 30 m multispectral band with 15 m panchromatic band was performed and supervised classification on the 15 m multispectral image was carried out. As per Forest Survey of India standards the forest crown density was classified in four classes – scrub forest (SF) <10% crown density, open forest (OF) 10-40% crown cover, moderately dense forest (MF) 40-70% crown cover and dense forest (DF) >70 % crown cover. The raster layers of forest type map and forest crown density were vectorised, union of the two vector layers was performed to obtain the forest strata layer. As

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per standard methodology, allocation of sample points in the forest area was done by stratified random sampling method. Each category of forest strata was considered for allocating sample points. Stratified random sampling design followed to assign 30 sample plots of 0.1 hectare i.e. 31.62 m x 31.62 m for collecting field data. All tree species within the quadrate was measured at 1.37 m height from ground level for individuals with girth at breast height (gbh) > 30 cm or diameter at breast height (dbh) > 10 cm. The specimens were identified with the help of regional flora [7]. The AGB of the trees was estimated using allometric equation developed by Chave et al, 2005 [8] for moist forest stand

$$(AGB)_{est} = \rho \times \exp(-1.499 + 2.148 \ln(D) + 0.207(\ln(D))^2 - 0.0281(\ln(D))^3)$$

here $(AGB)^{est}$ is biomass per tree in kg, ρ is wood specific gravity in g/cm3 and D is diameter at breast height (DBH) in cm. Wood specific gravity is an important predictive variable in the equation was obtained for trees of North East region of India from Indian Woods Vol I - V, Forest Research Institute, India [9]. AGB was calculated for each tree then the sample plots were intersected with the forest strata layer using ArcGIS v10.2 software. Unit value for each strata was calculated forest strata wise and girth class wise i.e. G1 – 30 to 60 cm, G2 – 61 to 90 cm, G3 – 91 to 120 cm, G4 – 121 to 150 cm, G5 – 151 to 180 cm & G6 – 181 cm or above, using MS Excel 2007. The girth class unit values of respective forest strata were multiplied with respective strata area to obtain the AGB for each stratum. The carbon stock was calculated by assuming that the carbon content is 47.4% of the total biomass[10].

III. RESULTS AND DISCUSSION

The forest type map of the study area showed that there exists two forest type - 3C/C2d (iv) App. Kamrup Sal and 3C/C3 b East Himalayan Moist Mixed Deciduous Forest. We have observed no changes in forest crown density between 2015 and 2017. Therefore the forest crown density of 2015 was considered for 2017 also. The forest crown density area statistic has been shown in Table 1.

Table 1: Showing Forest Crown Density area

Land use	Crown Density				Others	Total
	SF	OF	MDF	DF		
Kamrup Sal Forest	1047.69	1541.56	1170.01	440.79		4200.05
Mixed Moist Forest	1049.4	1196.08	172.22	69.18		2486.88
Grassland					172.65	172.65
Plantation					0.00	0.00
Built up					554.76	554.76
Agriculture					1364.75	1364.75
Water bodies					502.65	502.65
Riverine Sand					10.3	10.30
Forest Blank					0.00	0.00
Total	2097.09	2737.64	1342.23	509.97	2605.11	9292.04

In the study we have considered trees of DBH ≥ 10 cm or GBH ≥ 30 cm as individuals because the forest stand is matured and trees of less than 30 cm GBH or 10 cm DBH were not found. Table. 2 and Table. 3 shows the estimated AGB of 2015 and 2017 and Carbon stock of 2015 and 2017 respectively.

Table 2: Showing estimated AGB of 2015 and 2017 in different Forest Strata girth class wise

	2015							2017							
AGB	G1	G2	G3	G4	G5	G6	Total	G1	G2	G3	G4	G5	G6	Total	Difference
SF KAS	1115.74	2101.63	4767.2	6564.08	10234.21	4095.43	36880.31	1597.22	4671.3	11584.8	46658.57	130622.8	251240	446674.7	409494.4
OF KAS	4466.09	8460.94	10688.67	15114.88	3416.06	10954.39	53101.03	4619.44	33595.44	46167.72	362022.4	63284.74	78655.23	264534.8	211433.8
MDF KAS	3908.84	6426.81	8429.19	12078.72	6818.88	17761.81	55424.25	3991.29	29195.8	42202.46	34397.05	67950.2	113682.1	291426.9	236002.7
DF KAS	1794.26	4333.51	5177.07	5193.94	6218.94	8735.44	31473.16	3346.6	14114.2	23638.27	24303.93	37595.06	0	102998.1	71524.9
SF MMD	1117.56	2107.09	3573.82	4365.64	10263.97	3194.57	32620.65	0	8041.02	9705.61	0	0	0	17746.63	-14874
OF MMD	1975.17	4837.23	6872.31	11203.88	3188.57	8499.4	36576.56	152.68	10062.06	16930.59	27790.59	27622.15	132920.2	214598.3	178021.8
MDF MMD	747.38	799.57	2022.72	2029.52	2429.79	2614.46	10643.24	1837.64	1639.48	4025.47	5040.72	4308.23	0	16871.54	6228.3
DF MMD	281.61	628.33	872.22	970.73	828.78	1374.13	4963.8	525.24	1452.1	4614.43	3136.07	6043.6	0	15771.44	10807.64

Table 3: Showing Carbon stock of 2015 and 2017 in different Forest Strata girth class wise

	2015							2017							
CARBON	G1	G2	G3	G4	G5	G6	Total	G1	G2	G3	G4	G5	G6	Total	Difference
SF KAS	524.4	988.72	2240.59	3085.12	8570.08	1924.85	17333.76	750.7	2195.51	5444.86	21929.53	70792.72	108682.8	209796.1	192462.4
OF KAS	2099.06	3976.65	5023.68	7104	1605.55	5148.57	24957.51	2171.14	15789.86	21698.83	17015.06	30688.53	36967.96	124331.4	99373.87
MDF KAS	1837.16	3020.6	3961.72	5677	3204.88	8348.05	26049.41	1875.91	13722.03	19835.16	16166.62	31940.36	53430.61	136970.7	110921.3
DF KAS	843.3	2036.75	2433.23	2441.16	2922.9	4115.06	14792.4	1572.9	6633.68	11109.99	11422.85	17669.68	0	48409.1	33616.7
SF MMD	525.26	990.33	1679.7	2050.92	8304.07	1501.45	15331.73	0	3779.28	4561.64	0	0	0	8340.92	-6990.81
OF MMD	928.33	2273.5	3229.99	5265.82	1498.63	3994.72	17190.99	71.76	4729.17	7543.78	13061.58	12982.41	62472.52	100861.2	83670.23
MDF MMD	351.27	375.8	950.68	953.78	1142	1228.8	5002.33	863.69	770.96	1891.97	2369.14	2024.87	0	7929.63	2927.3
DF MMD	132.36	295.32	409.95	460.01	389.53	645.84	2333.01	246.86	682.49	2168.79	1473.96	2840.49	0	7412.59	5079.58

KAS – Kamrup Sal Forest MMD – mixed moist deciduous forest

The total AGB in different forest strata in the year 2015 was 261683 ton and in 2017 is 1370322.43 ton. There is an increase of 1108639.43 ton of AGB in the study area. Similarly, the carbon stock has also increased by 521060.52 ton from 122991.14 ton in 2015 to 644051.66 ton in 2017. The values of AGB and Carbon are converted from kg to ton for better understanding. Though the AGB and carbon stock has increased in the two years period but there is considerable decrease of AGB from 32620.65 ton to 17746.63 ton in 2015 and 2017 respectively in SF category of mixed moist deciduous forest. Hence, the carbon stock has also decreased by 6990.81 ton from 2015 to 2017. Girth class wise if we analyze the AGB and Carbon stock values from 2015 to 2017 then there is a considerable decrease in higher girth classes i.e. 121 – 150 cm, 151 – 180 cm and 181 cm & above. The decrease in AGB and carbon stock in higher girth classes is indicative of felling or extraction of matured trees.

IV. CONCLUSION

Forest resources particularly wood, timber plays a vital role in the livelihood of the people living near the forests or the forest villages. AGB and Carbon stock of a forest are dependent on the landuse type and forest stand structure. The increasing AGB and Carbon stock shows the potential of future carbon sequestration due to the presence to maturing trees.

REFERENCES

[1] Waring, R.H., and Running, S.W., "Forest Ecosystems: Analysis at multiple Scales," Academic Press, San Diego, CA. 1998.

[2] Dixon, R., S. Brown, R. Houghton, A. Solomon, M. Trexler, and J. Wisniewski, "Carbon Pools and Flux of Global Forest Ecosystems." Science vol 263, no. 5144, pp. 185–190, 1994.

[3] Brown, S., Lugo, A., Silander, S., Liegel, L., "Research history and opportunities in the Luquillo Experimental Forest." General Technical Report. SO-44. USDA Forest Services, Washington DC, pp. 128, 1999.

[4] Goetz, S., and R. Dubayah, "Advances in Remote Sensing Technology and Implications for Measuring and Monitoring Forest Carbon Stocks and Change." Carbon Management vol 2 no 3 pp. 231–244, 2011.

[5] Timothy, D., Onisimo, M., Cletah, S., Adelabu. S., and Tsitsi, B., "Remote Sensing of aboveground biomass: A review." Tropical Ecology vol 57, no 2, pp. 125-132, 2016.

[6] Champion, H.G., and Seth, S.K., "A revised survey of the forest types of India." Natraj Publication, Dehradun, India. pp 404 (Reprint), 2005.

[7] Kanjilal, V.N., Kanjilal, p.C., Das, A., De, R.N., and Bor, N.L., "Flora of Assam." 5 Vols, Government Press, Shillong, 1934 – 1940.

[8] Chave. J., Andalo. C., Brown, S., Cairns, M.A., Chambers, J.Q., Eamus, D., Folster, H., Fromard, F., Higuchi. N., Kira, T., Lescure, J.-P., Nelson, B.W., Ogawa, N., Puig. H., Riera, B., Yamakura, T., "Tree allometry and improved estimation of carbon stocks and balance in tropical forests." Oecologia vol. 145, pp. 87 – 99, 2005.

[9] Agarwal, S.P., Chauhan, L., Raturi, R.D., Madhwal, R.C., "Indian Woods". Forest Resreach Institute (Indian Council of Forestry Research & Education, Dehradun – 248006, vol I – V, 2002.

[10] Martin, A.R., and Thomas, S.C., "A reassessment of carbon content in tropical trees." Plos one vol. 6 no. e23533, 2011.