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STUDIES ON ABOVE GROUND BIOMASS (AGB) FOR ASSESSING VEGETATION CARBON POOL IN TROPICAL FOREST ECOSYTEM OF CENTRAL INDIA

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ABSTRACT: For estimation of carbon stocks in tropical forest types belonging to southern part of Madhya Pradesh, 30 adopted representative sites comprising eight districts viz, Jabalpur, Seoni, Balaghat, Narsinghpur, Mandla, Dindori, Shahdol and Umaria were selected for study and studies were carried out during 2009 to 2011. The study covered three types of vegetation i.e. teak mixed forest, sal mixed forest and mixed forest. In the study modern tools like Remote Sensing (RS) and GIS were used for quick and reliable assessment of above ground biomass (AGI) and vegetation carbon pools in the region. Nested two stage sampling design was adopted to select sample plots in all forest and density classes. One super plot of 250 m x 250 m in size equivalent to MODIS pixel size was laid out in each super plot. The total sample size consisted o 30 super plots and 120 sample plots within super plots. The tree density and basal area in study sites was ranged between 105 (UMA-8) to 1508 (DIN-7) stems/ha and 22.2 L (JBP-7) to 325.65 (DIN-1) m2/ha. The AG was ranging between 6.39 (UMA-8) in mixed forest to 215.5 t/ha (DIN-1) in sal forest type vegetation. The carbon density range was distributed in the order of sal forest (36.10 to 102.39 t/ha) > teak forest (5.17 to 67.78 t/ha) > mixed forest (3.0 to 33.2 t/ha). The overall vegetation ground percentage in the study area ranged between 47.5% (JBP-3) to 97.30% (UMA-9).

INTRODUCTION: Forest-ecosystems are of particular importance because they contain 82% of the terrestrial plant biomass, which is inter-linked with atmospheric CO_2 levels through the carbon cycle. Variability in climatic conditions due to increase concentration of CO_2 from 315 ppm to 387.35 ppm in last 150 years [1] bring about drastic change in the environment interms of temperature rise, late onset of monsoon, uneven distribution of rainfall, decline in crop productivity and biodiversity etc.

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Forest ecosystems are playing major role in strong CO_2 concentration otherwise the amount of atmospheric CO_2 due to burning of fossil fuels could have been greater. It has been assumed that mature forest act as a carbon stock in which net exchange is close to nil [2, 3]. Major part of the carbon sink originated from the land ecosystem is located within forests in the northern latitude [4]. The amount of carbon stored in plant biomass globally exceeds that of atmospheric CO_2 and nearly 90% of the plant biomass carbon is stored in tree biomass [5].

This emphasizes the importance of forest ecosystem in the global carbon cycle [6]. Species diversity has functional consequences which influences the resislence and resistance of ecosystem to environmental change [7]. Madhya Pradesh has maximum area under forest cover among all the states in the country.

Therefore, it is necessary to estimate the amount of carbon stored in tropical forest ecosystem of central India to mitigate the ill effect of climate change. Keeping in view of the above facts, the present investigation entitled "Studies on above ground biomass (AGB) for assessing vegetation carbon pool in tropical forest ecosystem of central India was conducted during 2009-2011.

MATERIALS AND METHOD: The present study was carried out to estimate carbon stocks in tropical forest type of the southern parts of Madhya Pradesh at 30 adopted representative sites of different latitude and longitude during 2009-2011. These representative sites comprises eight districts of MP which are Jabalpur, Seoni, Balaghat, Narsinghpur, Mandla, Dindori, Shahdol and Umaria. The study covered with three types of vegetation namely teak mixed forest, Sal mixed forest and mixed forest distributed in the eight representative districts. The study area lies between 210 38' to 230 33' N latitude and 790 17' to 810 46' E longitude with an altitude of 316.15 to 1063.2 m from the mean sea level. Maximum and minimum temperatures of these study area varies from 35.5ºC – 42.5ºC and 7.5 – 8.0ºC respectively with annual rainfall of 1000-1600 mm.

In the present study, modern tools like Remote Sensing (RS) and GIS were used for quick and reliable assessment of above ground biomass (AGB) and vegetation carbon pools in the region.

NOAA, AVHRR, SPOT vegetation, MODIS and ASTER satellite data have high resolution and enormous potential in assessing terrestrial biomass and carbon pools. Remote sensing can be used with process-based models to quantify the net primary production (NPP) of forest [8, 9]. The advantage of this approach is that it can cover large area with uniformity, while the disadvantages are that it indirectly measures carbon and is not able to quantify the underground biomass. Therefore, estimation of carbon can be derived from the biomass after calculation of multiple values of the stem volume and basic density of the tree. The standard multiple factor of 0.5 was used for conversion of biomass to total carbon [10]. Nested two stage sampling design was adopted to select sample plots in all forest type and in all density classes (trees, herbs and shrubs). One super plot of 250m x 250m size equivalent to MODIS pixel size was laid out in each super plot. Thus, the total sample size consisted of 30 super plots and 120 sample plots within super plots.

RESULTS AND DISCUSSION:

Tree density and basal area: Tree density and basal area in forest study sites ranged between 105 to 1508 stems/ha and 22.21 to 325.65 m2/ha, respectively. Highest tree density (1508 stem/ha) was found in site ID DIN-7 of Dindori district where *Shorea robusta* was most dominant followed by 1163 stem/ha in UMA-5 of Umaria district in which *Tectona grandis* was dominant species. However, lowest tree density of 105 stem/ha was recorded in site ID UMA-8 of Umaria district where *Madhuca indica* was dominant species. Maximum tree basal area (325.65 m2/ha) was observed in site ID DIN-1 of Dindori district where dominant species was *Shorea robusta* and minimum at the site ID JBP-7 (22.21 m2/ha) of Jabalpur district in which *Butea monosperma* was dominant.

Above ground biomass (AGB): Total above ground biomass (AGB) ranged between 6.39 to 215.57 t/ha across different vegetation type in the study area. The maximum above ground biomass (215.57 t/ha) was recorded in the site ID DIN-1 of Dindori district where (*Shorea robusta*) Sal forest type vegetation was dominant. Out of this above ground biomass, bamboo layer contributed maximum (53.55 t/ha) followed by shrub layer (1.60 t/ha), tree layer (1.48 t/ha) and herb layer (0.75 t/ha). Minimum AGB (6.39 t/ha) was observed in site ID UMA-8 of Umaria district where (*Madhuca indica*) mixed forest was found. Out of this minimum AGB, shrub layer contributed maximum (2.98 t/ha) followed by herb layer (1.98 t/ha) and tree layer (1.45 t/ha).

However, contribution of bamboo layer was nil due to absence of this species in the site ID UMA-8.

In present study it was also observed that in 16 study sites were not having bamboo species, the contribution of AGB in 14 site ID was in the order of tree > shrub > herb except 2 remaining site where AGB contribution was in the order of shrub > tree > herb in site ID BAL-15 and shrub > herb > tree in site ID JBP-9. In 14 study site having bamboo species, maximum 7 site of ID contributed AGB layer in the order of bamboo > tree > shrub > herb, but 4 site ID contributed in order of tree > bamboo > shrub > herb. However, contribution of AGB in 2 site ID (BAL-11 and UMA-5) was in order of tree > shrub > bamboo > herb and remaining one site ID (JBP-2) contributed AGB in order of bamboo > shrub > tree > herb.

Carbon density: Carbon density of the study area ranged between 3.03 to 102 t/ha where different types of vegetation was found eg. Sal forest, teak forest, mixed forest etc. The maximum carbon density 102 t/ha was recorded in sal forest in site ID DIN-1 of Dindori district where dominant species was *Shorea robusta*. Out of this carbon density, tree layer contributed maximum (101.94 t/ha) followed by shrub layer (0.34 t/ha) and herb layer (0.10 t/ha). However, the contribution of carbon by bamboo layer was nil due to its absence in the study site. Minimum carbon density of 3.03 t/ha was observed in the site ID UMA-8 of Umaria district where (*Madhuca indica*) was dominant species and contribution of carbon was in order of herb (1.41 t/ha) > shrub (0.94 t/ha) > tree (0.68 t/ha). Bamboo species was also absent in this study area due to which its contribution in carbon layer was nil. Based on vegetation type, the carbon density range was distributed in the order of sal forest (36.10 to 102.39 t/ha) > teak forest (5.17 to 67.78 t/ha) > mixed forest (3.0 to 33.2 t/ha).

Overall vegetation ground percentage: Maximum vegetation ground percentage (97.50%) was recorded in the site id UMA-9 of Umaria district where *Tectonia grandis* was dominant species and its was minimum (47.50%) at site id JBP-3 of Jabalpur district where *Anogeissus latifolia* was dominant species. Thus, overall vegetation ground percentage in the study area ranged between 47.5 to 97.50 per cent.

TABLE 1: CARBON LAYER AND ABOVE GROUND BIOMASS (AGB) OF PLANT SPECIES AT DIFFERENT SITE ID IN TROPICAL FOREST ECOSYSTEM

Site	Selected site ID	Name of dominant tree species	Tree density (stem/ha)	Basal area (m^2/ha)	Above ground biomass (AGB) (t/ha)				Total AGB (t/ha)	Overall vegetation ground percentage	Carbon density (t/ha)				
					Tree layer	Bamboo layer	Shrub layer	Herb layer			Tree layer	Bamboo layer	Shrub layer	Herb layer	Total carbon layer
1	JBP-2	*Ougeinia oojeinesis*	328	25.21	1.48	53.55	1.60	0.75	57.38	76.25	0.70	25.43	0.76	0.35	27.25
2	JBP-3	*Anogeissus latifolia*	774	156.40	10.89	-	0.90	0.41	12.20	47.5	5.17	-	0.43	0.19	5.79
3	JBP-4	*Adina cordifolia*	658	176.11	35.27	17.96	13.72	3.92	70.85	93.75	16.75	8.53	6.52	1.86	33.65
4	JBP-5	*Xylia xylocarpas*	326	23.35	0.45	22.68	2.52	0.84	26.49	65.00	0.21	10.77	1.20	0.47	12.58
5	JBP-6	*Tectona grandis (10)*	369	109.08	26.53	18.28	2.97	0.85	48.63	63.75	12.60	8.68	1.41	0.40	23.10
6	JBP-7	*Butea monosperma (2)*	466	22.21	5.51	6.85	0.72	0.21	13.29	55.00	2.62	3.25	0.34	0.10	6.31
7	JBP-8	*Tectonia grandis*	376	95.31	8.58	3.45	0.85	1.45	14.33	90.00	4.07	1.64	0.40	0.69	6.80
8	JBP-9	*Butea monosperma*	216	81.78	1.01	-	5.50	1.97	8.48	88.75	0.48	-	2.61	0.93	4.03
9	BAL-9	*Lannea coromandelia*	440	111.10	6.92	58.36	3.72	0.93	69.93	77.50	3.29	27.72	1.77	0.44	33.21
10	BAL-10	*Lagerstroemia purviflora*	625	93.65	7.79	5.20	2.70	1.03	16.72	67.50	3.70	2.47	1.28	0.49	7.94
11	BAL-11	*Terminolia tomentosa*	552	235.40	28.87	2.36	4.20	1.47	36.90	92.50	13.71	1.12	1.99	0.70	17.53
12	BAL-12	*Tectona grandis*	241	127.05	52.87	87.02	2.06	0.75	142.70	96.25	25.11	41.33	0.98	0.35	67.78

13	BAL-14	*Cleistanthus collinus*	555	130.96	16.75	-	1.90	0.95	19.60	96.25	7.95	-	0.90	0.45	9.31
14	BAL-15	*Lannea coromandelica*	115	143.08	3.09	-	4.10	2.34	9.53	92.50	1.47	-	1.95	1.11	4.52
15	BAL-16	*Cleistanthus collinus*	335	109.06	10.94	-	1.75	1.00	13.69	85.00	5.19	-	0.83	0.47	6.50
16	SDL-16	*Shorea robuta (4)*	507	163.70	73.33	-	1.92	0.95	76.20	90.00	34.83	-	0.91	0.45	36.10
17	UMA-2	*Terminalia tomentosa*	501	108.57	8.62	15.75	5.56	1.26	31.19	72.50	4.09	7.48	2.64	0.60	14.81
18	UMA-5	*Tectona grandis*	1163	93.32	41.68	2.53	3.07	1.23	48.51	85.00	19.80	1.20	1.46	0.58	23.04
19	SEN-8	*Emblika officinalis*	499	120.35	15.51	-	1.68	0.56	17.75	72.50	7.37	-	0.80	0.26	8.43
20	MAN-12	*Tectona grandis*	770	180.56	47.89	-	0.82	0.39	49.10	57.50	22.75	-	0.39	0.18	23.32
21	DIN-1	*Shorea robusta*	749	325.65	214.62	-	0.73	0.22	215.57	67.50	101.94	-	0.34	0.10	102.39
22	SDL-1	*Shorea robusta*	174	187.50	86.23	-	0.32	0.20	86.75	65.00	40.96	-	0.15	0.09	40.73
23	MAN-13	*Tectona grandis*	628	116.82	33.68	-	2.65	1.06	37.39	70.00	16.00	-	1.26	0.50	17.76
24	MAN-15	*Tectona grandis*	161	44.46	3.82	-	4.72	2.34	10.88	77.50	1.81	-	2.24	1.11	5.17
25	SEN-2	*Terminalia tomentosa*	448	244.91	22.42	22.85	0.92	0.34	46.53	52.50	10.65	10.85	0.44	0.16	22.10
26	DIN-7	*Shorea robusta*	1508	94.28	154.78	-	0.48	0.15	155.41	73.75	73.52	-	0.23	0.07	73.82
27	UMA-8	*Madhuca indica*	105	27.03	1.43	-	2.98	1.98	6.39	88.75	0.68	-	1.41	0.94	3.03
28	NSP-6	*Tectona grandis*	678	163.63	6.53	20.32	3.60	0.90	31.35	67.50	3.10	9.65	1.71	0.43	14.89
29	UMA-9	*Tectona grandis*	659	71.68	22.22	-	3.20	0.94	26.36	97.50	10.55	-	1.52	0.44	12.52
30	NSP-11	*Tectona grandis*	428	121.88	32.17	-	8.25	3.02	43.44	91.25	15.28	-	3.92	1.43	20.63

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