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Vegetation Structure and Above Ground Biomass Carbon in Dry and Moist Deciduous Forests of Dharwad District in Karnataka, India

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Abstract
Vegetation structure, above-ground biomass (AGB) and carbon density was compared between two different vegetation types of Dharwad district in Karnataka. Results revealed significant differences between vegetation types for different parameters studied. Higher species richness (36 species) and diversity (H'=0.34) was recorded in dry deciduous forest followed by moist deciduous forest (27 species, H'=0.38). Similarly, tree density (119 stems ha^{-1}) was greater in dry deciduous forest compared to moist deciduous forest (59 stems ha^{-1}). Conversely, higher basal area of 20.58 m^2 ha^{-1} was recorded in moist deciduous forest compared to dry deciduous forest (10.28 m^2 ha^{-1}). The tree layer contributed most (32.62-74.78 Mg ha^{-1}) to the total AGB followed by shrub (10.08-19.61 Mg ha^{-1}) and herb layer (1.16 -1.48 Mg ha^{-1}) in both forest types. Carbon density ranged between 36.28-74.78 Mg C ha^{-1}across different forest types. The majority of AGB and carbon pool in our study was found within taller trees and trees with a larger diameter therefore, their removal substantially alters the C storage and dynamics in this region. Land-use systems with higher C sequestration potential are currently supported under $REDD^+$ projects that focus on forest conservation and management.

Keywords: *Dharwad district, greenhouse gases, biodiversity, above-ground biomass (AGB), carbon density*

Introduction

India's forests are one of the richest terrestrial ecosystems, which stores approximately half of the world living terrestrial carbon and a very significant proportion is fixed in the form of above ground biomass, thus they play an important role in global carbon cycle and regulating the biospheric climate. Besides, these forest ecosystems also support variety of life forms and maintain huge global biodiversity (Shi *et al*., 2002). However, since last few decades the increasing rates of deforestation, biomass burning and land use transformations coupled with rapid industrialization not only depleting the diversity but also releasing enormous quantities of CO_2 into the atmosphere, The net carbon release from tropical deforestation was estimated at 1.6 ± 0.4 Gt C annually, accounting to 21 % of the global carbon annually which is almost equivalent from 20 to 65 % of the emissions from fossil fuels (Houghton, 1991). Due to alarming rates of anthropogenic interferences, the CO_2 concentration in the atmosphere has increased by 15 to 25 % over the past 100 years (Haripriya, 2000).

Biodiversity loss and climate change due to habitat destruction and fragmentation are the current environmental challenges. Understanding the pattern of tree diversity and above-ground biomass (AGB) in natural forests is essential for conservation planning and climate change mitigation strategies. Biomass assessment is important for national development planning as well as for scientific studies of ecosystem productivity, carbon budgets etc. (Zheng *et al*., 2004; Pande *et al*., 2010). Biomass analysis is an important element in the carbon cycle especially, carbon sequestration. Recently biomass is being increasingly used to help quantify pools and fluxes of greenhouse gases (GHG) from terrestrial biosphere associated with land use and land cover changes (Cairns *et al*., 2003). The importance of terrestrial vegetation and soil as significant sinks of atmospheric CO_2 and its other derivatives is highlighted under Kyoto Protocol (Wani *et al*., 2010). Vegetation especially, forest ecosystems store carbon in the biomass through photosynthetic process, thereby sequestering carbon dioxide that would have been present in the atmosphere. Undisturbed forest ecosystems are generally highly productive and accumulate more biomass and carbon per unit area compared to other land use systems like agriculture. It is estimated that the carbon stored globally in the forest biomass amounts to 2.4 million Mt with an average carbon density of 71.5 t ha^{-1}. A recent estimate indicates that tropical forests account for 247 Gt vegetation carbon, of which 193 Gt is stored above ground (Saatchi *et al.,* 2011). Many researchers have estimated biomass and C stocks present in India's forests. Hingane (1991) estimated total phytomass carbon pool and carbon density of India’s forests at 2587 Tg C and 49.2 Mg C ha^{-1}, respectively based on ecological studies and mean phytomass density for each forest type. Ravindranath *et al*. (1997) estimated the standing biomass (both above and below ground) in India to be 8375 Mt for the year 1986, of which the carbon storage was reported to be 4178 Mt. The total carbon stored in forests of India including soil was estimated at 9578 Mt. Dadhwal *et al*. (1998) using FAO inventory for ecological zones estimated the carbon pool at 3117 Tg C and carbon density at 60.2 Mg C ha^{-1}. However, these estimates exhibit large temporal and spatial variation in biomass and C stocks. Hence, developing appropriate biomass estimation methods for accurate and consistent reporting of forest carbon inventories is important. This study was under taken in Dharwad district which lies in the northern part towards the edge of Western Ghats of Karnataka with a research hypothesis that vegetation structure, AGB and carbon stock are expected to vary among forest types with the highest diversity and AGB expected in moist deciduous forest, which are relatively less distributed of trees then expected to decrease with increasing land-use intensity and disturbances in moist deciduous forest. In accordance with the set hypothesis we aimed at three important objectives to (1) assess and compare the tree species diversity, structure and dominance among different forest types (2) examine how the basal area, AGB and carbon density differs between forest types and (3) know which diameter classes and species contribute more to AGB and carbon.

Material and Methods

This study was conducted in two forest types in Dharwad (Fig.1) which lies on the edge of northern Western Ghats region (N 15^0 10’ 0” and E 75^0 0’ 45”) covering an area of 4716 Km^2. The notified forest area is 45,197 ha which is 8.5% of the total geographical area. The study area, with an altitudinal range of 610 m to 750 m above MSL, receives average annual rainfall ranging from 998 mm to 594 mm with maximum rainfall during monsoon season (June to mid of October). April and May months experience highest mean maximum temperature (35^0 C), while January and February months are coldest with lowest mean minimum temperature of 15^0 C. Soils are black to red loamy and mixed soris are common in this district.

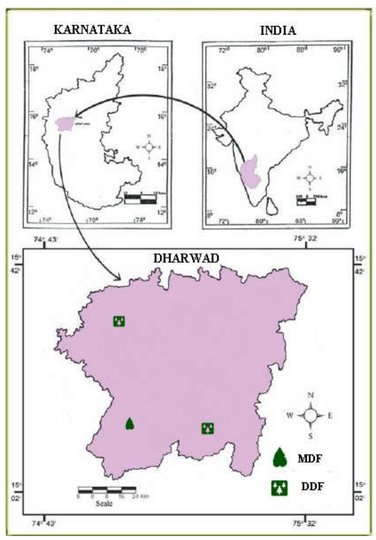

Fig.1. Location of the sample plots in Dharwad districts: MDF=moist deciduous forest and DDF=dry deciduous forest.

Two forest types’ namely moist deciduous forest (MDF) and dry deciduous forest (DDF) were selected for the present study and location of the selected sites within each forest type is depicted in Fig.2. Nested two stage sampling approach was adopted for collection of data on trees, herbs and shrubs and one super plot of 250 m x 250 m size was laid in each forest type and four sample plots, each of 31.6 m x 31.6 m (0.1 ha) size, were laid in each super plot. Thus, the total sample size consisted of 3 super plots and 12 sample plots across different forest types and this sampling scheme was implemented for representing spatial heterogeneity of super plots in each forest type.

In each of 0.1 ha plots, all the woody plants were counted and identified as far as possible *in-situ* at species level using field keys of Flora of Karnataka (Saldanha, 1996). Voucher specimens of species, which could not be identified in the field, were collected for identification at College of Forestry, Ponnampet with help of taxonomist. Height and Diameter at Breast Height (DBH) of all the trees with ≥10 cm DBH in four sample plots within each super plot were measured using Blume Leiss Hypsometer (which is based on the trigonometric method) and digital tree caliper (Haglof, Sweden), respectively.

Species richness (SR) was estimated by counting individuals of different species per unit area using species area accumulation curve as suggested by Chazdon *et al*. (1999). Species diversity (Shannon–Wiener diversity index-H’) and dominance (Simpson’s index-D) were calculated as per Magurran (1988). Tree population structure was characterized using DBH and total tree height classes. Importance Value Index (IVI) for each species was computed and expressed as the sum of relative density, relative dominance and relative frequency of the species within and among plots (Curtis, 1959). Based on the IVI values, we identified top ten species for estimation of density (stems ha^{-1}) and basal area (m^2 ha^{-1}) and their contribution to AGB (Mg ha^{-1}) and carbon density (Mg C ha^{-1}). The strata considered for the estimation of AGB were trees, shrubs and herbs. The data collected on tree parameters such as DBH (> 10 cm) and height were used for volume estimations using volume equations published by Forest Survey of India (FSI, 2006). We used local as well a regional volume equations depending on the availability for each species and mostly these regression equations follow general linear model (GLM) of the form of $V= a+bD+D^2$ or $V=a+bD^2H$. Tree biomass was estimated by multiplying volume with species specific wood specific gravity values. Wood specific gravity data were obtained from Forest Research Institute (FRI, 1996) (Appendix-I). AGB of stems with < 10 cm DBH was estimated by adopting the methodology developed by Devagiri *et al*. (2013) which is based on the large dataset of 1834 trees. Biomass of herbs and shrubs was estimated using destructive method. All shrubs and herbs occurring in the sample plot of 5 m x 5 m and 1 m x 1 m, respectively were harvested and oven dry weight was estimated. Biomass thus obtained from four sample plots (each 0.1 ha) in different stratum for each forest type was summed up to obtain total AGB and expressed in t-dry wt. ha^{-1}. Finally, based on the assumption that living biomass (tissues) is composed of 47% carbon, we calculated above-ground carbon stock as 0.47 x AGB and expressed as Mg C ha^{-1} for different forest types (Dadhwal *et al*. 2009).

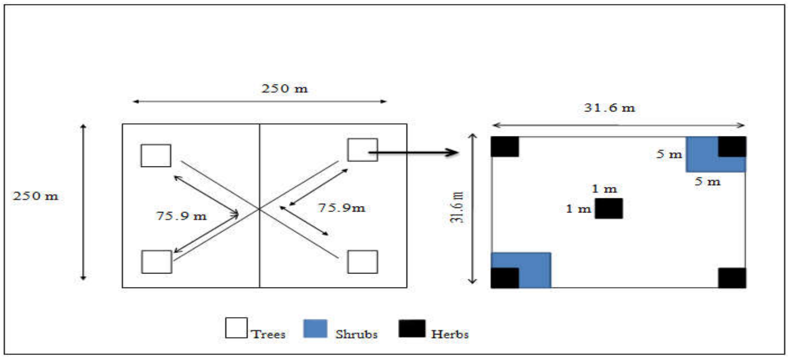

Fig. 2. Diagram showing the nested two stage sampling

Results and Discussion

Across different vegetation types, floristic diversity, tree density and basal cover varied considerably (Table 1). Maximum species richness (36 species) and diversity (H'=0.34) was recorded in dry deciduous forest followed by moist deciduous forest (27 species, H'=0.38). On the other hand, Simpson's index of dominance (D) was higher in moist deciduous forest (0.07) and lowest in dry deciduous forest (0.04). Tree height varied considerably across forest types with mean tree height ranged from 6.5 to 7.3 m (Table 1). None of the forest type showed reverse-J shaped curve for tree height (Fig. 3a). Higher numbers of individuals were found in 5-10 m height-class in dry deciduous and comparatively taller trees (> 10 m) were also noticed in dry deciduous forest. A comparison of size-class distribution of diameter at breast height (DBH) between forest types revealed significant variation. As expected a normal reverse-J shaped curve was observed only in dry deciduous forest while near normal distribution was noticed in moist deciduous forest type for stem diameter (Fig. 3b). These results indicate that moist deciduous forest was found to be short stature as compared to dry deciduous forests of this region. Further, we found lesser number of trees in lower diameter classes (< 10 cm DBH) and higher number of trees in intermediate class (10-20 cm DBH) in both forest types which is probably due to the fact that these forests face continuous pressure in the form of wood removal, primarily fuel wood and poles for domestic use, by the people leaving in the fringe areas. Similar effects of disturbance on stem density and forest stand structure have been reported in Western Ghats (Pascal and Pelissier, 1996; Pomeroy *et al*., 2003, Murthy *et al*. 2016). Similarly, higher density of 119 stems ha^{-1} was recorded in dry deciduous forest compared to moist deciduous forest (59 stems ha^{-1}) (Table 1). Conversely, higher basal area of 20.58 m^2 ha^{-1} was recorded in moist deciduous forest and lowest in dry deciduous forest (10.28 m^2 ha^{-1}). These values compare with tree density and basal area reported by Devagiri *et al*. (2013) for different forest types of South-Western part of Karnataka and Murthy *et al*. (2000) for forests of Uttar Kannada district of Karnataka. While on the higher side of the tree density range of 257-664 stems ha^{-1} and basal area range of 29-42 m^2 ha^{-1} was reported by Swamy *et al*, (2010) for tropical evergreen forests of Western Ghats region in Karnataka. Furthermore, though the density appears to be high in dry deciduous forests, the basal area was low (10.28 m^2 ha^{-1}) which indicates abundance of trees in lower diameter classes. This is consistent with many other dry deciduous forests which are characterized by the presence of lower diameter class individuals (Krishnamurthy *et al*. 2010).

Above-ground biomass (AGB) ranged between 43.86 to 95.87 Mg ha^{-1} across different vegetation types in the region (Table 1). As expected, the maximum biomass (95.87 Mg ha^{-1}) was recorded in moist deciduous forest and minimum in dry deciduous forest (43.86 Mg ha^{-1}). These estimates are towards the lower end of the range as compared to the Indian pattern of AGB estimates of 42-78 t ha^{-1} (Singh and Singh, 1991) and 420-649 t ha^{-1} (Rai and Proctor, 1986) and global pattern of AGB estimates of 30-273 t ha^{-1} and 213-1173 t ha^{-1} (Murphy and Lugo, 1986*b*) for tropical dry and wet forests, respectively. The tree layer contributed more to AGB (32.62-74.78 Mg ha^{-1}) followed by shrub layer (10.08-19.61 Mg ha^{-1}) to the total AGB among different vegetation types. The tree layer biomass values obtained in the present study are towards the lower side as compared to the values 397-527 t ha^{-1} reported by Swamy *et al*. (2010) for evergreen forest, 46.7 t ha^{-1} reported by Singh and Singh (1991) for dry deciduous forest. Carbon density in the present study ranged from 20.61 Mg C ha^{-1} in dry deciduous forest to 45.06 Mg C ha^{-1} in moist deciduous forest. These results could be compared with available biomass and carbon estimates of different forest types in India. Bhat *et al*. (2003) estimated the biomass accumulation in tropical rain forests of Uttar Kannada in the Western Ghats ranging from 92 to 268.49 t ha^{-1}. Chaturvedi *et al*. (2011) reported carbon density ranging from 15.6 to 151 t-C ha^{-1}in tropical dry forests of India. Srinath (2008) reported above ground biomass in the sacred groves of Kodagu district to the tune of 279.4 t ha^{-1}. According to Clark and Clark (2000), biomass accumulation in tropical forests was found to the extent of 161 to 186 t ha^{-1} while FAO (2007) estimated the average carbon density in India at 35 t ha^{-1}.

Size-class contribution to biomass was analyzed to know which diameter and height classes have contributed to total AGB. In both forest types higher biomass was contributed by 10-20 cm DBH.We found notable difference in species composition between forest types (Table 2). A total of 15.97% of all the trees present in dry deciduous forest belonged to species *Terminalia paniculata* while, rest of the species accounted more or less uniformly to the species composition. A substantial proportion of the total tree species was contributed by a one or two species such as *Tectona grandis* (14.29%) and *Dalbergia latifolia* (11.76) in dry deciduous forest. *Dalbergia latifolia* (11.86) and *Diospyros montana* (8.47) in moist deciduous forest. These results indicate that certain species in this area could only be found in particular forest type and not in others which calls for conservation priorities. Dawson et al. (2013) emphasized the consequences of rare species for the long-term conservation value of forest fragments. The authors argued that low density implies restrictions for regeneration, especially cross-pollination and an increased vulnerability to management interventions. Thus, the protection of existing forest fragments with specific attention to species present at low densities should have priority.

Table. 1. Tree diversity, structure and above ground biomass (AGB) and carbon density in different forest types of Dharwad district

Vegetation Parameters		Vegetation Type	
		MDF	DDF
Species richness		27.00	36.00
Shannon Weiner Index (H)		0.38	0.34
Simpson's Index (D')		0.07	0.04
Tree height (m)		7.32	6.52
Tree density (Stems ha^{-1})		59.00	119.00
Basal Area (m^{-2}ha^{-1})		20.58	10.28
AGB	Trees (Mg ha^{-1})	74.78	32.62
	Shrubs (Mg ha^{-1})	19.61	10.08
	Herbs (Mg ha^{-1})	1.48	1.16
	Total AGB (Mg ha^{-1})	95.87	43.86
	Above ground carbon density (Mg	45.06	20.61

MDF=moist deciduous forest and DDF=dry deciduous forest

Table 2. Tree species composition (%) of top ten species in different forest types

Species	MDF	DDF
Adina cordifolia	5.08	
Anogeissus latifolia	3.39	5.04
Butea monosperma		4.20
Dalbergia latifolia	11.86	11.76
Dillenia pentagyna		2.52
Diospyros melanoxylon		8.40
Diospyros montana	8.47	
Hardwickia binata	5.08	
Kydia calycina	5.08	
Lagerstroemia lanceolata	5.08	2.52
Lagerstroemia perviflora	5.08	3.36
Tectona grandis	8.47	14.29
Terminalia alata		5.88
Terminalia paniculata	3.39	15.97

DDF=dry deciduous forest and MDF=moist deciduous forest

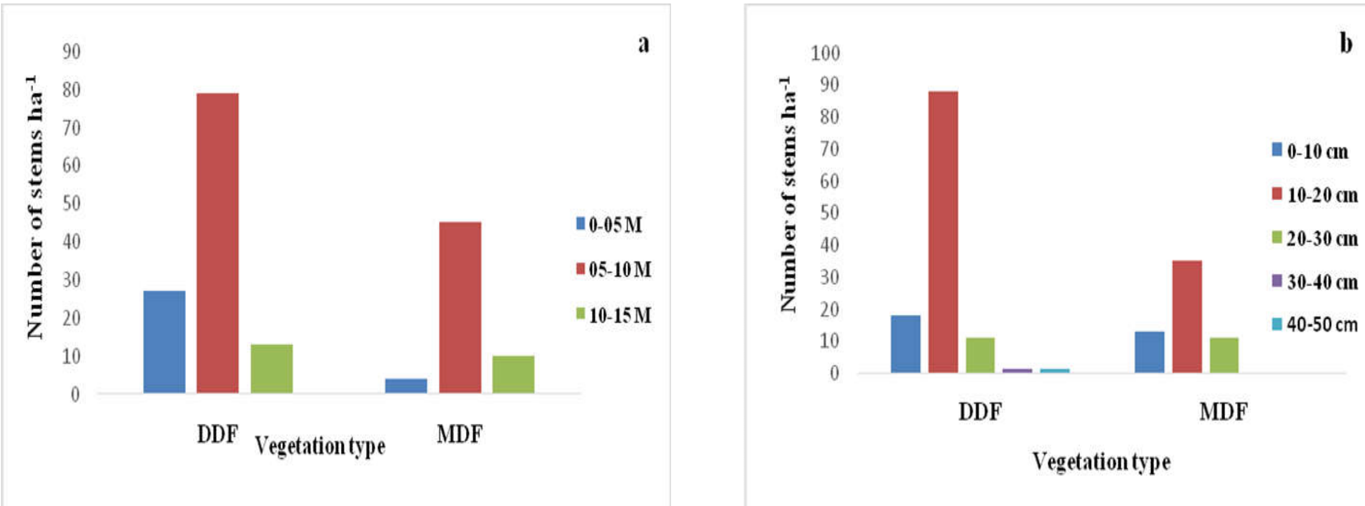

Fig 3. Size class distribution of trees with (a) height (b) diameter across different vegetation types; DDF=dry deciduous forest and MDF=moist deciduous forest

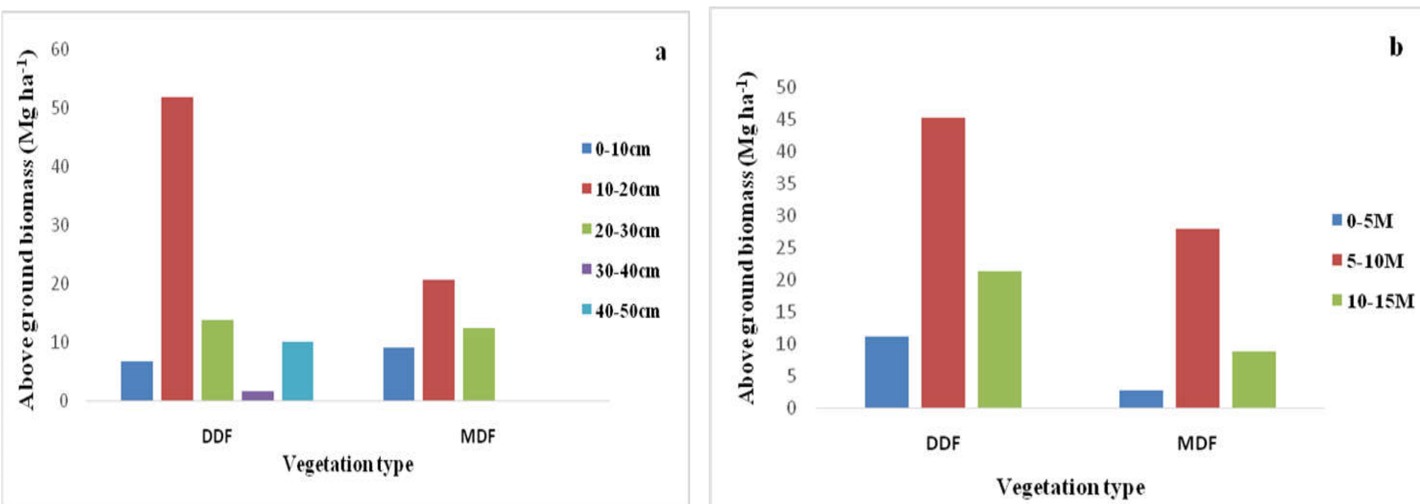

Fig 4. Contribution of (a) diameter and (b) height to biomass across different vegetation types; DDF=dry deciduous forest and MDF=moist deciduous forest

Tree species contribution to density, basal area and AGB was analyzed across different forest types and presented in Table. 3. In dry deciduous forest *Terminalia paniculata*, with 24 stems ha^{-1} accounted for 3.16 m^2 ha^{-1} basal area and contributed 9.45 Mg ha^{-1} to the total AGB and 4.44 Mg C ha^{-1} to the carbon stock. *Tectona grandis* was the next dominant tree species (21 stems ha^{-1} with 2.49 m^2 ha^{-1} basal area) which contributed 6.48 Mg ha^{-1} and 3.05 Mg C ha^{-1} of AGB and carbon stock in dry deciduous forest. Though the stem density of *Dalbergia latifolia* and *Diospyrous melanoxylon* was comparatively higher in dry deciduous forest however, these species contributed lesser AGB and carbon stock. In moist deciduous type, *Dalbergia latifolia, Diospyrous montana* and *Tectona grandis* contributed more to AGB and carbon density. Different degrees of disturbance result in forests with different AGB values and lower values are associated with more human or natural disturbance (Laumonier *et al*. 2010). In the present study disturbance intensities varied between forest types with moist deciduous forests with higher disturbance regime compared to dry deciduous forests. The estimated AGB and carbon values in the secondary forest, with a recovery time of almost thirty years after fire, were 2.5 times lower compared to the values in the primary forest. This is due to a lower density of stems ≥ 10 cm DBH, lower stand basal area and the occurrence of smaller trees in the secondary forest. Toma *et al*. (2005) compared their AGB value in the LDS (originally dipterocarp forest) with the AGB values in primary, dipterocarp forests in the region. The LDS contained 315 Mg ha^{-1}, while primary forests contained 481 to 542 Mg ha^{-1}, which means that the secondary forest contained approximately 1.5 times less AGB compared to the primary forests.

Table 3. Species contribution to density, basal area, above ground biomass and carbon in different forest type

Species	MDF				DDF			
	D	BA	AGB	CD	D	B BA	AGB	CD
Adina cordifolia	8	0.83	3.61	1.70				
Anogeissus latifolia	5	0.46	2.76	1.30	8	0.66	3.90	1.83
Butea monosperma					6	0.67	2.32	1.09
Dalbergia latifolia	18	0.94	2.74	1.29	18	1.87	5.43	2.55
Dillenia pentagyna					4	0.38	0.19	0.09
Diospyros melanoxylon					13	1.73	4.36	2.05
Diospyros montana	13	0.77	2.55	1.20				
Hardwickia binata	8	0.65	1.95	0.92				
Kydia calycina	8	0.18	0.04	0.02				
Lagestromia lanceolata	8	0.66	2.44	1.15	4	0.81	2.35	1.10
Lagerstroemia parviflora	8	0.66	2.22	1.04	5	0.68	1.93	0.91
Tectona grandis	13	0.97	3.10	1.46	21	2.49	6.48	3.05
Terminalia alata					9	0.54	5.27	2.48
Terminalia paniculata	5	0.38	1.06	0.50	24	3.16	9.45	4.44

MDF=moist deciduous forest; DDF=dry deciduous forest; D= density (stems ha^{-1}), BA= basal area (m^{-2} ha^{-1}), ABG=above ground biomass (Mg ha^{-1}) and CD= carbon density (Mg C ha^{-1}).

Conclusion

This study showed that vegetation structure, AGB and carbon density differed significantly between dry and moist deciduous forests. Species richness, diversity and stem density was higher in dry deciduous forests. Conversely the AGB and carbon density was higher in moist deciduous forest. We also found that major portion of the total AGB and carbon was accumulated within large sized trees and therefore, the removal of such trees from these forests will substantially reduces the C-stock. Under such circumstances these forests may become C-source rather than C-sinks. The further management prescriptions must be devised in a manner that larger diameter trees may have priority for conservation.

Ethics

All the authors read and approved the manuscript and no ethical issues involved.

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Appendix.1. List of volume equations and biomass equations used in present study

Sl. No	Botanical name	Equation
1	*Adina cardifolia*	V=0.296-2.829D+12.207D2
2	*Albizia lebbek*	V=0.27-2.953*D+12.336*D2
3	*Albizia procera*	V=0.009134+0.17315D2H
4	*Albizia species*	V=0.16948-1.85075*D+10.63682*D2

5	*Alstronia scholaris*	V=0.16948-1.85075*D+10.63682*D2
6	*Anogeissus latifolia*	V=-0.06868+1.56245D-2.91615D2+12.44122D3
7	*Aporosa lindliana*	V=0.16948-1.85075*D+10.63682*D2
8	*Azadirachta indica*	V=-0.03510+5.32981D2
9	*Bauhinia racemosa*	V=0.16948-1.85075*D+10.63682*D2
10	*Bridelia retusa*	SQRTV=0.1162+4.12711D-1.085085*SQRTD
11	*Butea monosperma*	V=-0.032-0.0619*D+7.208*D2
12	*Carya arborea*	V=0.014502+0.225928*D2H
13	*Cassia fistula*	V=0.16948-1.85075*D+10.63682*D2
14	*Ceiba pentandra*	V=0.16948-1.85075*D+10.63682*D2
15	*Chloroxylon swietenia*	V =-0.0532*D+3.2378*D2
16	*Dalbergia latifolia*	V=0.18945-2.46215D+10.54462D2
17	*Dillenia pentagyna*	V= 0.070-1.295D+9.429D2
18	*Diospyros melanoxylon*	SQRTV=-0.184139+2.892723*D
19	*Diospyros montana*	V=0.01456+0.32613D2H
20	*Emblica officinalis*	V=0.01244+0.34322D2H
21	*Eucalyptus Species*	V=0.02894-0.89284D+8.72416D2
22	*Garcinia indica*	V=0.16948-1.85075*D+10.63682*D2
23	*Grewia tilifolia*	V=-0.01611+4.9081*D2
24	*Hardwickia binata*	V= 0.063632+5.355486*D3
25	*Holigarna species*	V=0.16948-1.85075*D+10.63682*D2
26	*Holiptelia integrifolia*	V=0.16948-1.85075*D+10.63682*D2
27	*Kaigelia pinnata*	V=0.16948-1.85075*D+10.63682*D2
28	*Kydia calycina*	SQRTV=-0.2297+2.68423*D
29	*Lagestromia lanceolata*	V= -0.01611+4.90810D2
30	*Legestromia perviflora*	V=0.066188-1.334512 D+9.403257 D2
31	*Melia dubia*	V=0.16948-1.85075*D+10.63682*D2
32	*Pongamia pinnata*	V=0.16948-1.85075*D+10.63682*D2
33	*Premna tomentosa*	V=0.16948-1.85075*D+10.63682*D2
34	*Pterocarpus marsupium*	V=0.070-1.295*D+9.429*D2
35	*Randia dumetorum*	V=0.16948-1.85075*D+10.63682*D2
36	*Sapindus emerginatus*	V=0.16948-1.85075*D+10.63682*D2
37	*Semicarpus anacardium*	√V=1.67477+14.83747D-9.43386√D
38	*Shorea talura*	V=-0.17763+0.54602√D+3.62682D2
39	*Syzygium cumini*	V=-0.002043+0.361337D2H
40	*Tectona grandis*	V=-0.27773+3.10419*D-6.12739*D2+15.16993*D3
41	*Terminalia alata*	V=0.06517-0.21738*D+3.96894*D2+4.63954*D3
42	*Terminalia bellarica*	SQRTV=-0.15683+3.01055*D
43	*Terminalia chabula*	V=-0.5004-0.0344*D+6.35715*D2
44	*Terminalia paniculata*	V=0.13100-1.87132D+9.47861D2
45	*Wrightia tinctoria*	SQRTV=0.050294+3.115497*D-0.687813*SQRTD

V=volume (m^3), D= DBH (m), H= height (m), SQRT=square root, G=GBH (m)

Appendix. 2. List of specific gravity used in the present study

Sl. No.	Botanical name	Specific gravity
1	*Adina cardifolia*	0.58
2	*Albizia lebbek*	0.66
3	*Albizia procera*	0.579
4	*Albizia species*	0.76
5	*Alstronia scholaris*	0.44
6	*Anogeissus latifolia*	0.78
7	*Aporosa lindliana*	0.5
8	*Azadirachta indica*	0.69
9	*Bauhinia racemosa*	0.67
10	*Bridelia retusa*	0.5
11	*Butea monosperma*	0.56
12	*Carya arborea*	0.8
13	*Cassia fistula*	0.71
14	*Ceiba pentandra*	0.23
15	*Chloroxylon swietenia*	0.85
16	*Dalbergia latifolia*	0.75
17	*Dillenia pentagyna*	0.53
18	*Diospyros melanoxylon*	0.68
19	*Diospyros montana*	0.7
20	*Emblica officinalis*	0.8
21	*Eucalyptus Species*	0.51
22	*Garcinia indica*	0.75
23	*Grewia tilifolia*	0.68
24	*Hardwickia binata*	0.73
25	*Holigarna species*	0.5
26	*Holiptelia integrifolia*	0.5
27	*Kaigelia pinnata*	0.5
28	*Kydia calycina*	0.72
29	*Lagestromia lanceolata*	0.579
30	*Legestromia perviflora*	0.62
31	*Melia dubia*	0.4
32	*Pongamia pinnata*	0.64
33	*Premna tomentosa*	0.5
34	*Pterocarpus marsupium*	0.67
35	*Randia dumetorum*	0.78
36	*Sapindus emerginatus*	0.58
37	*Semicarpus anacardium*	0.64
38	*Shorea talura*	0.72
39	*Syzygium cumini*	0.7
40	*Tectona grandis*	0.604
41	*Terminalia alata*	0.85
42	*Terminalia bellarica*	0.63
43	*Terminalia chabula*	0.88
44	*Terminalia paniculata*	0.72
45	*Wrightia tinctoria*	0.8