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Species Diversity, Carbon Stock Density and Soil Physico-Chemical Properties of Chauras Campus (Garhwal University) Uttarakhand, India

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ABSTRACT

Trees are planted in educational institutions in order to maintain the greenery and to provide an aesthetic view. Along with this they also play a key role in accumulating carbon from the atmosphere. The functioning of trees largely depends on soil conditions too. In the present study we explored to document species diversity, carbon stock density and soil physico-chemical properties of Chauras campus (HNB Garhwal University). The tree biomass and carbon stock were calculated using non-destructive methods and soil properties were assessed in the departmental soil laboratory. A total of 831 individuals belonging to 38 species and 21 families were recorded. A total carbon stock density of 1,120.78 tCO_2e was also recorded. The present study analyses species diversity, carbon stock density, soil properties and the presence of vulnerable species in the Chauras campus in accordance with the IUCN Red List.

Keywords Species diversity, Carbon stock density, Chauras campus, Trees outside forest, Education institution.

INTRODUCTION

The environment depends on trees, which are essential to it. Trees make up the majority of the terrestrial biomass on earth by fixing carbon during photosynthesis and storing extra carbon as biomass, trees serve as a sink for CO_2. Trees act as carbon sinks in the atmosphere during regrowth after disturbance and can be managed to sequester or conserve significant amounts of carbon on the land (Brown 1997).

Scattered trees are the prominent feature of every urban and semi urban areas. Several governments offices, educational institutions, maintain greenery inside their premises which is called as Trees outside forest. "Studies on campus's tree diversity will serve as a baseline for the campus's diversity, and special consideration for the protection of tree species will be revisited" (Poonia *et al*. 2020). A taxonomic study of flora is necessary for assessing the species richness and documentation of existing green spaces is important to determine existing resources and to set target for future improvements. "The study of any region's

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biodiversity and environment requires knowledge of its vegetation and flora" (Rajendran *et al*. 2014).

Many evidence (De Deyn *et al*. 2004) has indicated that soil factors have greater impact on distribution and diversity of plant species, there is a certain relationship between vegetation and soil. An evaluation of soil properties under different tree covers is an important area of research to understand the impact of trees on soil. Physical properties and chemical characteristics of soil change considerably as a result of tree planting.

Few studies on assessment of tree species diversity and carbon stock density within an educational institution in India have reported the similar pattern with that of natural forest. For e.g., Tree diversity and carbon stock assessment of college campus at Sirsi, Karnataka (India) (Poonia *et al*. 2020), Tripura university campus (Deb *et al*. 2016) and Banaras Hindu University main campus, India (Singh 2011) and showed the similarity with the natural forest. In Northern part of India, very limited works on tree species diversity, carbon stock density including soil physico-chemical properties are reported from any institution. Thus, the present study was carried out to address the potential of trees in mitigating the global carbon issue by proper documentation of the tree species and soil properties and assessment of their contribution in total carbon stock of the Chauras campus.

MATERIALS AND METHODS

Description of study area

The study was conducted in Chauras campus of Hemvati Nandan Bahuguna Garhwal University (A Central University) Srinagar which is located in Chauras region (30° 22′ 77.94″ N, 78° 80′ 35.56″ E) under district Tehri Garhwal of Uttarakhand, India. The total area occupied by campus is 103.7 acres (42 ha) land area with permanent buildings, naturally growing patches of *Dalbergia sisso* and *Melia azedarach.* The map of Chauras campus is demonstrated in Fig. 1.

Data collection

Chauras campus is occupied with academic buildings, hostels and patchy to strip vegetation, therefore, floristic survey was conducted during December 2021 to July 2022 for complete enumeration of tree species and 39 soil samples (0-20, 20-40, 40-60 cm's depth) were collected randomly from 13 sites throughout the campus (Fig. 2). The trees with circumference >10 cm were considered in enumeration and the girth has taken at 1.37m by using measuring tape and girth is divided by 3.14 to convert into DBH. Wherever, forking was present below 1.37m, the forks were considered as separate individuals and recorded accordingly.

Estimation of tree biomass, carbon stock and soil properties

Tree biomass and carbon have been calculated by means of non-destructive method (using allometric/ regression equations). The above ground biomass (AGB) has been calculated using volume, wood density and biomass expansion factor (IPCC 2006) while the volume is calculated by using existing regression equations as provided in (FSI 1996). The wood density values for the species specific were collected form the web (ICRAF Database 2022) and Sheikh *et al.*

Fig. 1. View of Indian State of Uttarakhand (Left) and Chauras campus area (Right).

Table 1. Methods used to study different parameters/properties of trees and soil.

Sl. No.	Parameter	Formula/ method	Reference
		Tree parameters	
1	AGB (ton)	Volume (m^3) x wood density (g/cm^3) x BEF	IPCC (2006)
2	BGB (ton)	0.266 x above ground biomass (ton)	IPCC (2006)
3	Total biomass (ton)	Above ground biomass (AGB) + below ground biomass (BGB)	Sheikh *et al*. (2011)
4	Tree carbon storage (ton)	0.47 x total biomass (ton)	IPCC (2006)
		Soil properties	
5	Moisture content (%)	Fresh weight of soil (g) – dry weight of soil (g) ---------- x 100 Dry weight of soil (g)	Upreti (2019)
6	Soil texture and class	Weight of sieved soil proportion ---------- x 100 Total soil sample weight Class: Based on texture percentage values and assessed by using texture triangle method	Groenendyk *et al*. (2015)
7	Soil bulk density (g/cm^3)	Dry soil weight (g)/ Soil volume (cm^3) Soil volume (cm^3) = 3.14 x radius^2 x ring height (h)	Kishwan *et al*. (2012)
8	Water holding capacity (%)	W2-W3-W4 ----------× 100 W3-W1	Upreti (2019)
9	Soil pH	Determined using dynamic digital pH meter	Jackson (1958)
10	Soil organic carbon (%)	10 (B-T) 0.003 x 100 ---------- x ---------- B Weight of soil (g)	Walkley and Black (1934)
11	SOC stock (t ha^{-1})	Soil bulk density x soil depth x SOC (%)	Pearson (2007)
12	Soil nitrogen (kg/ha^{-1})	14 x Tv x 0.02N x 2.24 x 10^6 ---------- Soil sample weight (g) x 1000 Kg/ha x 0.4 = Kg/acre Total carbon stock density (tC ha^{-1})	Sáez-Plaza *et al*. (2013)
13	Total carbon stock density	$C_{AGB} + C_{BGB} + C_{SOC}$	IPCC (2006)
14	t C ha^{-1} to tCO_2e	44/12 or 3.67	Pearson (2007)

(2011). Biomass expansion factor is used as 1.575 (Kishwan *et al*. 2012) while BGB and carbon storage calculated by using method described in IPCC (2006). Soil samples were analyzed in a departmental soil laboratory, and total carbon density was calculated using carbon in tree biomass and carbon in soil, as described in IPCC (2006) (Table 1).

RESULTS AND DISCUSSION

Species composition

In this present study, we have documented 38 species with 831 individuals (19.78 individuals per hectare) associated with 21 families. Out of this, the dominant tree species is *Dalbergia sisso* with 136 individuals

Table 2. List of tree species, their number, biomass (t) and carbon stock (t) values of documented tree species from Chauras campus of HNB Garhwal University, Srinagar, Uttarakhand.

Sl. No.	Scientific name	Family	No. of trees	Avg biomass (Ton/tree)			Avg C stock t/tree	TB (ton)	Total C stock (ton)
				AGB	BGB	Total			
1	*Dalbergia sissoo*	Fabaceae	136	0.21	0.05	0.26	0.13	35.36	17.68
2	*Polyalthia longifolia*	Annonaceae	102	0.05	0.01	0.06	0.03	6.12	3.06
3	*Melia azedarach*	Meliaceae	68	0.74	0.19	0.93	0.43	44.4	20.89
4	*Albizia lebbeck*	Fabaceae	53	0.49	0.13	0.62	0.29	32.86	15.37
5	*Mangifera indica*	Anacardaceae	49	0.26	0.07	0.33	0.15	16.17	7.35
6	*Phyllanthus emblica*	Phllyanaceae	44	0.1	0.02	0.13	0.06	5.72	2.64
7	*Leucaena leucocephala*	Fabaceae	44	0.08	0.02	0.1	0.04	4.4	1.76
8	*Terminalia ballerica*	Combretaceae	42	0.06	0.02	0.08	0.04	3.36	1.68
9	*Grevillea robusta*	Proteaceae	38	0.15	0.04	0.19	0.09	7.22	3.42
10	*Jacaranda mimosifolia*	Bignoniaceae	33	0.16	0.04	0.21	0.09	6.93	2.97
11	*Holoptelea integrifolia*	Ulmaceae	28	0.12	0.03	0.15	0.07	4.2	1.96
12	*Roystonea regia*	Arecaceae	26	0.4	0.1	0.5	0.23	13	5.98
13	*Albizia procera*	Fabaceae	18	0.36	0.1	0.46	0.21	8.28	3.78
14	*Callistemon citrinus*	Myrtaceae	17	0.05	0.01	0.06	0.03	1.02	0.51
15	*Toona ciliata*	Meliaceae	14	0.67	0.18	0.85	0.39	11.9	5.46
16	*Aegle marmelos*	Rutaceae	13	0.14	0.03	0.18	0.08	2.34	1.04
17	*Syzygium cumini*	Myrtaceae	13	0.14	0.03	0.17	0.08	2.21	1.04
18	*Morus alba*	Moraceae	13	0.28	0.07	0.35	0.16	4.55	2.08
19	*Casia fistula*	Fabaceae	10	0.17	0.05	0.22	0.1	2.2	1
20	*Bombax ceiba*	Bombacaceae	9	2.38	0.63	3.02	1.43	27.18	12.87
21	*Gmelina arborea*	Lamiaceae	9	0.02	0.01	0.03	0.01	0.27	0.09
22	*Melia dubia*	Meliaceae	6	0.03	0.01	0.04	0.02	0.24	0.12
23	*Pinus roxburghii*	Pinaceae	5	0.26	0.07	0.32	0.15	1.6	0.75
24	*Acacia catechu*	Fabaceae	4	0.07	0.01	0.08	0.04	0.32	0.16
25	*Artocarpus heterophyllus*	Moraceae	4	0.13	0.03	0.16	0.07	0.64	0.28
26	*Caryota urens*	Arecaceae	4	0.42	0.11	0.53	0.24	2.12	0.96
27	*Ficus carica*	Moraceae	4	0.02	0.01	0.03	0.01	0.12	0.04
28	*Paulownia elongata*	Paulowinaceae	4	0.02	0	0.02	0.01	0.08	0.04
29	*Azadiracta indica*	Meliaceae	4	0.17	0.04	0.21	0.1	0.84	0.4
30	*Pisidium guajava*	Myrtaceae	4	0.03	0.01	0.04	0.02	0.16	0.08
31	*Tectona grandis*	Verbinaceae	3	0.63	0.17	0.8	0.37	2.4	1.11
32	*Ficus benjamina*	Moraceae	3	0.06	0.02	0.08	0.04	0.24	0.12
33	*Alstonia scholaris*	Apocynaceae	2	0.1	0.02	0.12	0.06	0.24	0.12
34	*Adina cordifolia*	Rubiaceae	1	0.04	0.01	0.05	0.02	0.05	0.02
35	*Delonix regia*	Fabaceae	1	0.13	0.03	0.16	0.07	0.16	0.07
36	*Jathropa caricus*	Euphorbiaceae	1	0.05	0.02	0.07	0.03	0.07	0.03

Table 2. Continued.

Sl. No.	Scientific name	Family	No of Trees	Avg biomass (Ton/Tree) AGB	BGB	Total	Avg C stock t/tree	TB (ton)	Total C stock (ton)
37	*Citrus medica*	Rutaceae	1	0.03	0	0.03	0.01	0.03	0.01
38	*Oroxylum indicum*	Bignoniaceae	1	0.04	0.01	0.05	0.02	0.05	0.02
	Total		**831**	**9.26**	**2.4**	**11.7**	**5.42**	**249.15±1.71**	**116.96**
				±0.06	**±0.01**	**±0.07**	**±0.03**		**±0.81**

followed by *Polyalthia longifolia* (102), *Melia azedarach* (67), *Albizia lebbeck* (53), *Mangifera indica* (49) (Table 2). These individuals further were classified into 4 DBH classes, viz., <15cm, 15-35cm, 35-55cm, >55cm. The maximum number of individuals were found in 15-35cm (n=435) followed by <15cm (n= 241), 35-55cm (n= 141) and >55cm DBH Classes (Fig. 3).

Biomass and carbon storage of standing trees

Total tree biomass is the sum of AGB and BGB (Sheikh *et al*. 2011). The average individual above ground biomass (AGB) and below ground biomass (BGB) of all tree species in the Chauras campus was estimated to be 9.26 t (0.22t ha^{-1}) and 2.53 t (0.06 t ha^{-1}) respectively. The total biomass and carbon stored in 831 trees of Chauras campus is 249.15t and 116.96t respectively (Table 2). This finding is comparatively higher than North Maharashtra University campus (76.028 t C) (Suryawanshi *et al*. 2014). Hence the carbon sequestration of Chauras campus (HNB Garhwal University) was 2.78 t ha^{-1}. This finding is comparatively, lower than COF Sirsi campus (34.83 t ha^{-1}) (Poonia *et al*. 2020) and Pondicherry University campus (8.7 Mg C ha^{-1}) (Sundarapandian *et al*. 2014). In present study *Dalbergia sissoo* stored high amount of biomass and subsequently carbon (35.36 t and 17.68 t respectively), this is because higher number of individuals of this species were present i.e., 136 trees. It was also found that *Bombax ceiba* has 12.87 t carbon sequestration potential even though they are less in number i.e., 9 trees of large boles. Further, *Adina cardifolia* (0.02t), *Citrus medica* (0.01t), have reported lowest carbon sequestration potential. The lower values of carbon could be because of lower number of individuals and smaller DBH classes. Species diversity and carbon stock density of Chauras campus was quite higher than similar works from different University campuses of India viz., Banaras Hindu University (312 species)> Adikavi Nannnanya University (236 species)> College of Forestry, Sirsi (93 Species and 34.83 t ha^{-1})> Tripura University (66 species and 11.82 t ha^{-1})> Guru Ghasidas Vishwavidyalaya (52 species)> Chauras campus (HNB Garhwal University) (38 species and 2.78 t ha^{-1}) (Present study)> Sivaji University (38 species) > Solapur University (30 species) > Vinoba Bhave University (25

Fig. 2. Soil sampling sites in Chauras campus.

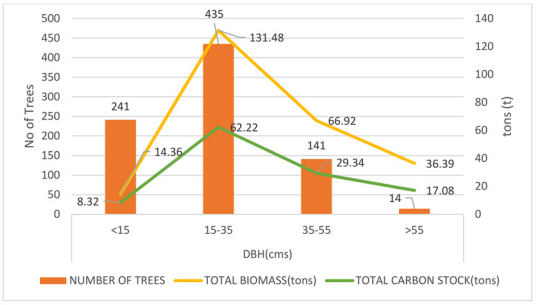

Fig. 3. Distribution of trees, biomass, and carbon stock across different DBH classes.

Table 3. Comparative analysis of tree species diversity and carbon stock in different University campuses.

Campus name	No. of tree species	Carbon stock/ sequestration rate	Reference
Banaras Hindu University	312		Singh (2011)
Adikavi Nannanya University	236		Rao (2016)
College of Forestry, Sirsi	93	34.83 t ha^{-1}	Poonia *et al*. (2020)
Tripura University	66	11.82 t ha^{-1}	Deb *et al*. (2016)
Guru Ghasidas Vishwavidyalaya	52		Patel (2012)
Chauras campus (HNB Garhwal University)	38	2.78 t ha^{-1}	Present study
Shivaji University	38		Dubal *et al*. (2013)
Solapur University	30		Gavali *et al*. (2016)
Vinoba Bave University	25		Ranjan *et al*. (2016)
Pune University	10	1694.54 t C yr	Haghparast *et al.* (2013)
North Maharashtra University	10	76.028 t C/tree	Suryawanshi *et al*. (2014)

species) > Pune University (10 species and 1694.54 t C yr) and North Maharashtra University (10 species and 76.028 t C) (Table 3) (Poonia *et al*. 2020).

Soil properties

In this present study we have analyzed different soil properties of Chauras campus in the department laboratory. Soil properties were analyzed statistically, and mean values were reported. The soil moisture content was estimated to be 3.30±0.28 wherever, Soil WHC and Bulk density recorded as 31.53±0.72% and 1.38±0.4g/cm^3 respectively. It has been reported that soil of Chauras campus is dominated by Sandy clay Loam soils. This finding is comparatively higher than construction area (WHC: - 10.42% and BD: - 0.97 g/cm^3) as reported by Upreti (2019).

Soil of Chauras campus was characterized as slightly acidic i.e., pH of 6.84±0.11 was recorded whereas, mean soil organic carbon and soil nitrogen of Chauras campus soil was estimated at 0.86±0.06% and 133.12±5.79 kg/acre respectively. Mean SOC stock estimated in all 13 sampling sites was estimated to be 302.62 t ha^{-1}. This finding is slightly lower than forest catchments of reservoirs areas i.e., 334.11 t ha^{-1} (Kumar and Sharma 2016).

Total carbon stock density

C_{AGB} and C_{BGB} was reported to be 2.21 t ha^{-1} 0.56 t ha^{-1} respectively. The soil organic carbon stock (C_{SOC}) recorded as 302.62 t ha^{-1} and while total carbon stock density was 305.39 t ha^{-1}. Hence, this study revealed that total amount of carbon stored in trees and soil of Chauras campus (HNB Garhwal University) was estimated as 1,120.78 tCO_2e.

CONCLUSION

The present study concludes that tree species diversity and soil properties of the campus is playing a vital role in carbon management along with the making the campus green, which can be useful for climate change mitigation and conservation point of view. It was noticed that False neem (*Melia azedarach*) tree act as the best carbon absorbing agent in the present study area. The campus is dominated by Fabaceae family species, which aid in nitrogen fixation, while the Chauras campus soil has a medium level of nitrogen availability.

It noticed that Chauras campus was home to some of the tree species, which were categorized as Threatened by International Union for Conservation of Nature (IUCN Red List Published in 2020) i.e., *Aegle marmelos* (NT- Near Threatened) and *Jacaranda mimosifolia* (VU- Vulnerable).

The following tree species- *Erythrina variegata* (Fabaceae), *Manilkara zapota* (Sapotaceae), *Prunus armeniaca* (Rosaceae), and *Sapindus mukorossi* (Sapindaceae) are present in Chauras campus but were not enumerated since their DBH is less than 10 cm.

The present study will act as a guide for the policy makers for making decision regarding any developmental projects by taking into consideration of the vegetation of this area.

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