Assessment of Biomass Accumulation and Carbon Sequestration Potential of Chir Pine Forest in Altitudinal Zones of Naina Devi Hill, District Mandi, Himachal Pradesh, India

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ABSTRACT

The field work was conducted in six different sites of Chir pine forest model in the state of (HP). Climate change became one of the principal concerns around the world at the onset of the 21st century and increase in CO_2 concentration is being identified as the major reason. Carbon (C) sequestration through plantations is one of the important mitigation measures for rising levels of carbon dioxide and other greenhouse gases in the atmosphere. Results revealed that location, climate have marked effects on biomass content and carbon storage potential in different plantation.

Moreover species planting density age of plantation also plays a vital role in nutrient accumulation and carbon density. In the current study total carbon sequestration of Chir pine forest plantation ranged from 160.61 Mg C/ha and CO_2 accumulation was estimated to be between 588.92 mg/ha.

INTRODUCTION

The process of removing carbon dioxide (CO_2) from the atmosphere and storing it in natural reservoirs such as forests and soils is referred to as carbon sequestration (Pattanaik and Nayak 2023). Due to the fact that CO_2 has been rapidly increasing in the atmosphere since industrialization, it is regarded as a significant greenhouse gas and the main cause of global warming (> 70%). A system that can either store or discharge carbon is called a carbon reservoir. Any procedures or devices that eliminate greenhouse gases, aerosols or precursors of greenhouse gases from the atmosphere are considered carbon sinks. The measurement units for carbon stocks are mass and represent the total amount of carbon retained inside a pool at any given time (IPCC 2000). In recent years, it has become increasingly important to evaluate carbon pools systematically and to increase their accuracy. The importance of tree-based mechanisms

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to the global carbon cycle is widely acknowledged, and estimating the carbon sequestration potential of biomass remains a pivotal strategy for reducing elevated CO_2 levels in the atmosphere (Panwar *et al.* 2022). As a source of carbon sequestration, forests, cultivated lands and grasslands are useful. But somehow the quantity of carbon dioxide sequestered tends to vary depending on the type of crop and the amount of biomass produced (Balasimha and Kumar 2013). The mass of living or dead organic matter is referred to as biomass and is sometimes expressed as dry matter. When a specific tree is mentioned, it is expressed in kilograms per tree, and when an area's biomass is taken into account, it is expressed in kilograms per unit area (Kuyah *et al.* 2013). Carbon makes up about 50% of plant biomass. According to (Kuyah *et al.* 2012). Global climate change is being caused by anthropogenic activities such as excessive land use changes, deforestation, and the fossil fuel burning. These operations are to held responsible for continuous emission of atmospheric carbon dioxide (Nawaz *et al.* 2017).

MATERIALS AND METHODS

Study area

The present study was under taken in chir pine tree species (*Pinus roxburghii*). The research was carried out in Naina Devi hill of Mandi district of Himachal Pradesh during 2022-2023. The height of hill is approximate 1800 m. The estimation of carbon sequestration was conducted in the 6 altitudinal zones. The average temperature is 25°C. The annual rainfall is 1380 mm. From this place one can have a full view of all the surrounding mountain ranges. The distance from mandi to Naina Devi is 30 km.

Sample plot establishment

Data on biomass and carbon sequestration of chir pine forest was collected using nested plot design technique with main plot of 20 m × 20 m size (for the trees – dbh > 5 cm) and five sub- plots of 1 m × 1 m size (for litter, herbaceous vegetation - dbh < 5 cm) in four directions N, S, E, W and center inside the main plot. In each main plot, dbh and height of the trees was recorded. Height of tree species was measured by

Ravi altimeter, GBH was measured using measuring tape then value was converted into diameter at breast height (DBH) using the formula.

Allometric equations for biomass and carbon estimation

Ali *et al.* (2020) for chir pine tree

$$M = 0.0224 \, (D^2H)^{0.9767}$$

Where, M= Aboveground dry biomass of tree in kg, D= Diameter at breast height in cm, H= Total height of tree in m.

Aboveground tree biomass density

Tree biomass density of each species was calculated using the following formula.

$$\text{Aboveground tree biomass density (Mg ha}^{-1}） = \frac{\text{Aboveground tree biomass (Mg)}}{\text{Sample area in hectares}}$$

Aboveground tree carbon density

Generally, the carbon concentration of the different parts of a tree is assumed to be 50% of the biomass (Brown 1997).

Carbon sequestration/ carbon density in aboveground tree biomass (Mg C ha^{-1})

= Aboveground tree biomass density × Carbon concentration (%) (Where, Carbon Conc (%) = g C/ 100 g biomass for which default value of 50% was used to determine carbon stored in aboveground tree biomass).

Belowground tree biomass and carbon

Generally, ratio of the total biomass to below ground biomass is taken approximately 4:1 or, in other words, 25% of total tree biomass is below ground root as such, estimation of below ground coarse root biomass (including tap root) is easily achieved by utilizing aboveground biomass estimates and multiplying by 0.27 (IPCC 2003).

Belowground tree root biomass = Aboveground tree biomass × 0.27

Carbon sequestration/ Carbon density in belowground tree root (Mg C ha^{-1})

= Aboveground tree biomass density × carbon concentration (%)

Herbaceous vegetation and litter layer biomass and carbon

The samples collected were subjected to air and oven drying. Oven drying was set at 65–70ºC and was observed for at least 48 hrs or until the samples reach their stable weight. Oven-dry weights of sub-samples has been determined to compute for the total dry weights using the formula (Hairiah *et al.* 2001).

$$\text{Total dry weight (kg m}^{-2}) = \frac{\text{Total fresh weight (kg)} \times \text{Subsample dry weight (g)}}{\text{Subsample fresh weight (g)} \times \text{Sample area (m}^2)}$$

Further, each sample were provided (milled) using a grinding machine and a 0.5 gram sieved sample was weight for ashing. This was done by burning the sample in muffle furnace at 550ºC for 5 hrs until a white ash was obtained (Nath *et al.* 2015). Finally, the ash content and carbon fraction were calculated using the following equations

$$\text{Ash \%} = \frac{W_3 - W_1}{W_2 - W_1} \times 100$$

$$\text{CF \%} = 100 - \text{ash \%} \times 0.58$$

Statistical analysis

The interpretation of data was done by using the critical differences value calculated at 0.05 probability level. The level of significance was expressed at 0.005 probability. The F test was used to determine the significant difference.

Belowground soil carbon

Soil carbon was measured by collecting soil samples from the top 30 cm of soil. The most common method of estimating the amount of carbon sequestrated in soils is based on soil analysis, whereby the carbon content in a sample of soil is determined (mass per unit mass of soil, such as g C per 100 g soil) and

expressed in mega grams (Mg = 10^6 g) per hectare. The same five subplots (quadrats of 1m × 1m size) inside the main plot, used for herbaceous vegetation and litter, was used for soil sampling. Soil samples was taken from each of the quadrats at two depth intervals i.e. 0–15 cm & 15–30 cm depth. The soils was sieved through a 5-mm mesh screen and mixed to a uniform color and consistency then a subsample of 500 g was taken for carbon analysis using Walkley-Black method (Arthi and Kumar 2024).

Estimation were done using the following formula (Walkley 1947).

$$\text{\% Organic carbon in soil} = \frac{(B-S) \times N \times \text{meq wt of C} \times 100}{\text{Mass of soil in gram}}$$

Where B is the Blank titre i.e. ml of Fe $(NH_4)_2$ $(SO_4)_2$ used for titration of 10.5 ml of N $K_2Cr_2O_7$, S is the Sample titre i.e. ml of Fe $(NH_4)_2$ $(SO_4)_2$ used for titration of soil sample + 10.5 ml of 1.0 N $K_2Cr_2O_7$, meq wt of C =0.003, N is the normality of Fe $(NH_4)_2$ $(SO_4)_2$

$$N = \frac{10.5 \times 1.00}{\text{Blank titre}}$$

Then soil bulk density was calculated using the following formula given by (Muthuvel *et al.* 1992).

$$\text{Bulk density (g cm}^{-3}) = \frac{\text{Weight of dry soil (g)}}{\text{Total volume of soil (cm}^3)}$$

To calculate weight of soil organic carbon per hectare, the following formula given by (Chhabra *et al.* 2003).

Carbon sequestration/ carbon density of soil (Mg C ha^{-1}) = Bulk density of soil (g/cm^3) × Thickness (cm) × Soil organic carbon (SOC) %

RESULTS AND DISCUSSION

Biomass estimation of different sites of Naina Devi Hill, Distt Mandi (HP) (Refer to Table 1)

Aboveground tree biomass (kg/plot)

Aboveground biomass of Chir pine tree ranged between 4632.88-5771.96 kg/plot. Significance differences were observed between treatments (Sites) and significant highest aboveground tree biomass was

Table 1. Biomass estimation of different sites of Naina Devi Hill, Distt Mandi (HP).

Sites	Aboveground tree biomass (kg/plot)	Aboveground tree biomass density (Mg C ha^{-1})	Belowground tree biomass (kg/plot)	Belowground tree biomass density (Mg C ha^{-1})	Total tree biomass (kg/plot)	Total tree biomass density (Mg C ha^{-1})
Site 1 (0-300 m)	5771.96	144.30	1558.43	38.96	7330.39	183.26
Site 2 (300-600 m)	5611.08	140.28	1514.99	37.87	7126.07	178.15
Site 3 (600-900 m)	4632.88	115.82	1250.88	31.27	5883.76	147.09
Site 4 (900-1200 m)	4799.47	119.99	1295.86	32.40	6095.32	152.38
Site 5 (1200-1500 m)	4934.99	123.37	1332.45	33.31	6267.44	156.69
Site 6 (1500-1800 m)	4807.79	120.19	1298.10	32.45	6105.90	152.65
CD @5 %	489.902	12.25	132.27	3.31	622.18	15.55
SEm (±)	162.524	4.063	43.88	1.09	206.406	5.160
SEd	229.84	5.75	62.06	1.55	291.90	7.30
F-test	S	S	S	S	S	S

recorded in Site I (0-300 m altitude) while lowest in Site-III that is at 600-900 m altitude and statistically at par with Site II (5611.08 kg/plot). According to Milkuri (2014), the total above-ground biomass increased by 214.5 and 380.3% over 15 and 10 years, respectively, in a 20-year plantation.

Aboveground biomass density (Mg C ha^{-1})

The aboveground biomass density varied significantly among the sites, with the significant highest value recorded at Site I (0-300 m altitude) with 144.30 mg C/ha and statistically at par with Site II (140.28 mg C/ha) while the lowest value at Site III (600-900 m altitude) being 115.82 mg C ha^{-1}. The estimated aboveground tree biomass in horti-silvipasture agroforestry systems in the North-Western Himalayas, as reported by Saleem *et al.* (2023), was 43.11 t ha^{-1}, with total tree biomass reaching 55.73 t ha^{-1}, indicating strong potential for carbon sequestration. The aboveground carbon stocks in trees were 65 to 135 Mg C ha^{-1} (IPCC 2006).

Belowground tree biomass (kg/plot)

Belowground tree biomass of chir pine tree ranged between 1558.43–1250.88 kg/plot. Significance differences were observed between treatments (Sites) and significant highest belowground tree biomass was recorded in Site I (0-300 m altitude) and statistically at par with Site II (1514.99 kg/plot) while lowest in Site-III that is at 600-900 m altitude. Choudhary *et al.* (2016) for a 15-year-old plantation in Tripura reported similar figures. When compared to the current investigation, Brahma *et al.* (2016) reported a substantially lower estimate for belowground biomass.

Table 2. Carbon estimation of different sites of Naina Devi Hill, Distt Mandi (HP).

Sites	Aboveground tree carbon (kg/plot)	Aboveground tree carbon density (Mg C ha^{-1})	Belowground tree carbon (kg/plot)	Below ground tree carbon density (Mg C ha^{-1})	Total tree carbon (kg/plot)	Total tree carbon density (Mg C ha^{-1})
Site 1 (0-300 m)	2885.93	72.15	779.21	19.48	3665.20	91.63
Site 2 (300-600 m)	2805.54	70.14	757.50	18.93	3563.04	89.08
Site 3 (600-900 m)	2316.44	57.91	625.44	15.64	2941.73	73.55
Site 4 (900-1200 m)	2399.73	59.99	647.93	16.20	3047.66	76.19
Site 5 (1200-1500 m)	2467.50	61.69	666.22	16.66	3133.72	78.34
Site 6 (1500-1800 m)	2403.90	60.10	649.05	16.23	3052.95	76.32
CD @ 5%	244.95	6.12	66.14	1.65	311.08	7.78
SEm (±)	81.2622	2.031	21.94	0.54	103.201	2.58
SEd	114.92	2.87	31.03	0.78	145.95	3.65
F-test	S	S	S	S	S	S

Table 3. Carbon sequestration in herbaceous vegetation in different sites of Naina Devi Hill.

Sites	Total dry weight of herbs (kg m^{-2})	Carbon densty of herbs (Mg C ha^{-1})
Site 1 (0.300 m)	0.39	1.81
Site 2 (300-600 m)	0.39	1.91
Site 3 (600-900 m)	0.41	1.79
Site 4 (900-1200 m)	0.41	1.52
Site 5 (1200-1500 m)	0.38	1.67
Site 6 (1500-1800 m)	0.36	1.75
CD @ 5%	0.028	0.235
SEm (±)	0.00945	0.07785
SEd	0.01	0.11
F-test	S	S

Table 4. Carbon sequestration in litter layer in different sites of Naina Devi Hill.

Sites	Total dry weight of litter (kg m^{-2})	Carbon density of litter (Mg C ha^{-1})
Site 1 (0-300 m)	0.35	1.69
Site 2 (300-600 m)	0.37	1.50
Site 3 (600-900 m)	0.36	1.44
Site 4 (900-1200 m)	0.31	1.33
Site 5 (1200-1500 m)	0.36	1.51
Site 6 (1500-1800 m)	0.34	1.37
CD @ 5 %	0.037	0.225
SEm±	0.01218	0.0745
SEd	0.02	0.11
F-test	S	S

Belowground tree biomass density (Mg C/ha)

Significance differences were observed between sites and significant highest belowground tree biomass density was recorded in Site I (0-300 m altitude) that is 38.96 mg C ha^{-1} and statistically at par with Site II (37.87 mg C ha^{-1}) where as lowest in Site-III (600-900 m) altitude that is 31.27 mg C ha^{-1}. Kunhamu *et al.* (2017) for a 22-year-old plantation in Thiruvazham-kunnu, Kerala and Thakur *et al.* (2015) for Thrissur, Kerala, published comparable studies.

Total tree biomass (kg/plot)

Total tree biomass of chir pine tree ranged between 7330.39- 5883.76 kg/plot. Significance differences were observed between treatments (Sites) and significant highest total tree biomass was recorded in Site I (0-300 m altitude) and statistically at par with Site II (7126.07 kg/plot) whereas lowest in Site-III that is at 600-900 m altitude. Similar findings have also been reported by Zaro *et al.* (2019) in Brazil, and Choudhary *et al.* (2016) in Brazil.

Total tree biomass density (Mg C/ha)

Results revealed that Site-I with 183.26 (Mg C ha^{-1}) recorded the significant maximum total tree biomass density and statistically at par with Site -II (178.15 Mg C ha^{-1}) whereas while the minimum being recorded in Site-III 147.09 (Mg C ha^{-1}). A 25-year-old plantation in Karnal is predicted to have a total biomass of roughly 324.198 Mg ha^{-1} (Jangra *et al.* 2010).

Carbon estimation of different sites of Naina Devi Hills, Distt Mandi (HP) (Refer Table 2)

Aboveground tree carbon (kg C/plot)

Results revealed that Site I with 2885.93 (kg/plot) recorded the significant highest total aboveground tree carbon and statistically at par with Site II (2805.54 kg/plot) while the lowest being recorded in Site-III 2316.44 (kg/plot). Ghavale *et al.* (2020) Maharashtra and Mitra *et al.* (2018) West Bengal both reported results that were identical.

Aboveground tree carbon density (mg C ha^{-1})

Significance differences were observed between treatments (Sites) and significant highest above ground tree carbon density was recorded in Site I with 72.15 (Mg C ha^{-1}) and statistically at par with Site-II (70.14 Mg C ha^{-1}) whereas while lowest in Site-III with 57.91 (Mg C ha^{-1}). These results are comparable to those discovered in a previous study by Ranasinghe and Thimothias (2012) in Sri Lanka. Comparable results (30.18–44.93 mg C ha^{-1}) for coconut plantations in various West Bengal locations were published by Mitra *et al.* (2018).

Belowground tree carbon (kg C /plot)

The current study's findings show that the belowground tree carbon varied significantly among the sites, with the significant highest value recorded at Site I with 779.21 (kg/plot) and statistically at par with Site-II (757.50 kg/plot) whereas the lowest value

Table 5. Carbon sequestration in soil at different depth in different sites of Naina Devi Hill.

Sites	SOC% (0-15 cm)	Carbon density (Mg C ha^{-1}) (0-15 cm)	SOC% (15-30 cm)	Carbon density (Mg C ha^{-1}) (15-30 cm)
Site 1 (0-300 m)	2.16	33.54	1.89	31.80
Site 2 (300-600 m)	2.16	33.05	1.90	33.24
Site 3 (600-900 m)	2.18	33.66	1.93	32.58
Site 4 (900-1200 m)	2.19	34.07	1.91	32.11
Site 5 (1200-1500 m)	2.16	33.50	1.86	33.26
Site 6 (1500-1800 m)	2.20	34.07	1.95	33.68
CD @ 5 %	0.030	0.679	0.049	1.468
SEm (±)	0.010	0.225	0.0163	0.486
SEd	0.01	0.32	0.02	0.69
F-test	S	S	S	S

at Site-III with 625.44 (kg/plot). The below ground carbon levels found in the current study, when compared to plantations of comparable ages, were within the range described in the literature by Bhagya and Maheswarappa (2017) in Kasargod (Kerala).

Belowground tree carbon density (Mg C ha^{-1})

Significance differences were observed between treatments (Sites) and significant highest belowground tree carbon density was recorded in Site I with 19.48 (mg C ha^{-1}) and statistically at par with Site II (18.93 Mg C ha^{-1}) while lowest in Site-III with 15.64 (Mg C ha^{-1}).These findings are consistent with those of studies conducted in Tamil Nadu, Tamil Nadu and Maharashtra, as well as Kasargod, Kerala, by Bhagya and Maheswarappa (2017), Boomiraj *et al.* (2020), and Kasargod, Kerala, by Shinde *et al.* (2015), growing under various experimental settings.

Total tree carbon (kg C/plot)

Significance differences were observed between treatments (Sites) and significant highest total tree carbon was recorded in Site I 3665.20 (kg/plot) and statistically at par with Site II (3563.04 kg/plot) while lowest in Site-III 2941.73 (kg/plot). The results are consistent with reports from Kasargod by Prayogo *et al.* (2018) and Bhagya and Maheswarappa (2017).

Total tree carbon density (Mg C ha^{-1})

Results revealed that Site-I with 91.63 (Mg C ha^{-1}) recorded the significant maximum total tree carbon density) and statistically at par with Site II (89.08 Mg C ha^{-1}) while the minimum being recorded in

Site-III 73.55 (Mg C ha^{-1}). These results are well within the range of the results stated the study of Singh *et al.* (2018).

Carbon sequestration in herbaceous vegetation in different sites of Naina Devi Hill (Refer Table 3)

Total dry weight of herbaceous vegetation (kg m^{-2})

The significant highest total dry weight of herbaceous vegetation was recorded in Site III & IV 0.41 (kg m^{-2}) and statistically at par with Site I (0.39 kg m^{-2}) and Site II (0.39 kg m^{-2}) while the lowest total dry weight of herbaceous vegetation was recorded in Site VI 0.36 (kg m^{-2}). The same findings were also reported by (Gayathri and Raj 2022). The forests may have had more surface litter due to the shade trees' extra litter deposition.

Carbon density of herbaceous vegetation (Mg C ha^{-1})

The Table 3 represented that significant highest carbon density of herbaceous vegetation was recorded in Site II (1.91 Mg C ha^{-1}) and statistically at par with Site I (1.81 Mg C ha^{-1}), Site III (1.79 Mg C ha^{-1}), Site VI (1.75 Mg C ha^{-1}) while the lowest carbon density of herbaceous vegetation was recorded in Site IV 1.52 (Mg C ha^{-1}).

Carbon sequestration in litter layer in different sites of Naina Devi Hill (Refer Table 4)

Total dry weight of litter layer (kg m^{-2})

Results revealed that Site-II with 0.37(kg m^{-2}) re-

corded the significant highest total dry weight of litter layer and statistically at par with Site I (0.35 kg m^{-2}), Site III (0.36 kg m^{-2}), Site V (0.36 kg m^{-2}), Site VI (0.34 kg m^{-2}) while the lowest being recorded in Site-IV 0.31 (kg m^{-2}).

Carbon density of litter layer (Mg C ha⁻¹)

According to Table 4, Site I had the significant highest carbon density of Litter layer (1.69 Mg C ha⁻¹) and statistically at par with Site II (1.50 Mg C ha⁻¹) as well as Site V (1.51 Mg C ha⁻¹) while Site IV had the lowest carbon density of litter layer (1.33 Mg C ha⁻¹). Findings from Singh *et al.* (2018) had nearly the same results in terms of the litterfall biomass of an oil palm plantation.

Carbon sequestration of soil at different depth in different sites of Naina Devi Hill, Distt Mandi (Refer Table 5)

Soil organic carbon % at (0-15cm) depth

The soil sample was exposed to the Walkley Black method, and the results showed that Site VI had the significant highest SOC% values (2.20) and statistically at par with Site III (2.18%) as well as Site IV (2.19%), while Sites I, II ,V had the lowest SOC% values (2.16). The amount of biomass added to the system and the rate of degradation determine how much SOC accumulates.

Soil carbon density (Mg C ha⁻¹) for (0-15 cm) depth

According to Table 5 Sites IV, VI had the significant highest Soil carbon density 34.07 (Mg C ha⁻¹) and statistically at par with Site I (33.54 Mg C ha⁻¹), Site III (33.66 Mg C ha⁻¹), Site V (33.50 Mg C ha⁻¹), while Site II had the lowest soil carbon density 33.05 (Mg C ha⁻¹). The type of agroforestry management has a considerable impact on the soil carbon sequestration process in addition to the natural conditions (temperature, topography, substrate for creating soil (Kumara *et al.* 2023).

Soil organic carbon % at (15–30 cm) depth

Results revealed that Site-VI with 1.95 recorded the

Table 6. Total carbon sequestration and total CO_2 accumulation in different Sites of Naina Devi Hill.

Sites	Total carbon Sequestration (Mg C ha⁻¹)	Total CO_2 accumulation (Mg C ha⁻¹)
Site 1 (0-300 m)	160.61	588.92
Site 2 (300-600 m)	158.76	582.10
Site 3 (600-900 m)	142.98	524.26
Site 4 (900-1200 m)	145.49	533.48
Site 5 (1200-1500 m)	147.76	541.79
Site 6 (1500-1800 m)	146.26	536.27
CD @ 5 %	8.378	30.722
SEm ±	2.77	10.191
SEd	3.93	14.41
F-test	S	S

significant highest Soil organic carbon % and statistically at par with Site III (1.93 %), Site IV (1.91 %), while the lowest being recorded in Site-V 1.86. When soil is physically disturbed by ploughing, intact clumps of dirt called "aggregates" are broken up into smaller pieces, accelerating the decomposition of previously protected carbon and releazing soil carbon as the greenhouse gas carbon dioxide.

Soil carbon density (Mg C ha⁻¹) for (15 -30 cm) dept

According to Table 5 Sites VI had the significant highest soil carbon density 33.68 (Mg C ha⁻¹) and statistically at par with Site III (32.58 Mg C ha⁻¹), Site V (33.26 Mg C ha⁻¹), Site VI (33.68 Mg C ha⁻¹) while Site I had the lowest soil carbon density 31.80 (Mg C ha⁻¹).

Total carbon sequestration and total Co₂ accumulation in different sites of Naina Devi Hill, Distt Mandi (HP) (Refer to Table 6)

Total carbon sequestration (Mg C ha⁻¹)

Findings showed that the highest carbon sequestration can be seen when all components are combined, including soil carbon, herbaceous and litter layer carbon, and above and below ground tree carbon observed significant highest in Site I 160.61 (Mg C ha⁻¹) and statistically at par with Site II (158.76 Mg C ha⁻¹), whereas minimum total carbon sequestration observed Site III (143.98 Mg C ha⁻¹). A study by Arora and Chaudhary (2015) assessed the carbon

sequestration potential of populus deltoides plantations under a social forestry scheme in Kurukshetra, Haryana, reporting a vegetation carbon stock of 88.45 Mg C ha^{-1}.

Total CO_2 accumulation (Mg C ha^{-1})

Table 6 represents that there is significant difference among the sites and significantly highest total CO_2 accumulation was observed in Site I 588.92 (Mg C ha^{-1}) and statistically at par with Site II (582.10 Mg C ha^{-1}), whereas lowest in Site III 524.66 (Mg C ha^{-1}). The age structure, stand density and storage potential may be to responsible for the differences in total biomass and carbon between the plantations. The economic success of latex production ensures its long-term management and along with carbon sequestration, serves as a permanent sink for atmospheric CO_2.

CONCLUSION

The recent investigation found that highest total carbon sequestration/density and total CO_2 accumulation were highest in Site I (0-300 m) which are 160.61 mg C ha^{-1} and CO_2 accumulation was estimated to be between 588.92 Mg C ha^{-1}, respectively. The current study found that location (elevation), climate had a significant impact on biomass content and carbon storage capacity in various sites. Furthermore, species and plant density play an important influence in nutrient accumulation and carbon density.

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