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The Carbon Sinks and Mitigation Potential of Deodar (*Cedrus deodara*) Forest Ecosystem at Different Altitude in Kumrat Valley, Pakistan

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Abstract

Forest carbon monitoring and reporting are critical for informing global climate change assessment. The regional estimates of forest carbon attached greater attention, to assess the role of forest in carbon mitigation. Here using field inventory, we examined the carbon sink and mitigation potential of monospecific Deodar forest in the Kumrat valley, of Hindu Kush Himalaya, Region of Pakistan, at a different elevation. The elevation of monospecific Deodar forest ranges from 2300 to 2700 m (a.s.l). We divided the forest into three elevation classes (that is 2300 - 2400 m (EI) 2400 - 2500 m (EII) and 2500 - 2700 m (EIII) a.s.l respectively). In each elevation class, we laid out 09 sample plots (33*33 m^2) for measuring carbon values in living tree biomass (LT), soil (SC), litter, dead wood, cone (LDWC) and understory vegetation (USV). Our results showed that the carbon density at EI was 432.37 ± 277.96 $Mg{\cdot}C^{-1}$, while the carbon density at EII and EIII was 668.35 ± 323.94 and 1016.79 ± 542.99 $Mg{\cdot}C^{-1}$ respectively. Our finding revealed that the carbon mitigation potential of the forest increases with increasing elevation. Among the different elevation classes, EIII stored significantly higher carbon due to the dominance of mature, old age, larger trees, and the minimum anthropogenic disturbance, whereas EI stored statistically lower carbon because of maximum anthropogenic disturbance, which resulted in the removal of mature and over-mature trees. Furthermore, our correlation analysis between tree height and carbon stock and basal area and LT carbon, underlines that the basal area is the stronger predictor of LT carbon estimation than height. Overall our results highlight that deodar forest stored 716.94 ± 462.06 $Mg{\cdot}C{\cdot}ha^{-1}$. However, the rehabilitation, preservation and sustainable management of disturb forest located at a lower elevation could considerably improve carbon mitigation potential.

Keywords

Deodar Forest, Elevation, Carbon Sinks, Mitigation Potential

1. Introduction

The increased emission of greenhouse gases (GHGs) since the industrial revolution significantly influenced the global environment. The growing concern of environmental changes because of climate change, the problem of carbon balance, the major GHG, is important and the removal of carbon and their storage in different terrestrial ecosystems for cutting down the increased level of carbon dioxide are required (Ardo & Olsson, 2004). Forests are the major component of the carbon cycle and the global distribution of carbon in forests plays an important role in the carbon cycle (Zhang et al., 2013). Forests are extremely important in balancing of the carbon cycle by absorbing 2.9 ± 0.8 PgC each year (Le Quere et al., 2009; Calfapietra et al., 2015). Forests cover over 4 billion ha area of Earth Planet and the recent estimate of store carbon in world forest is 861 ± 66 PgC (Pan et al., 2011; Wani et al., 2014, 2015). However, other estimated carbon indicates that store carbon is in the range of 450 - 650 Pg in biomass and 1500 - 2400 Pg in soil and dead organic matter (Batjes, 1996; Prentice et al., 2001; IPCC, 2013).

Forestland has the ability to store and sink more carbon; forestland can hold 20 to 50 times more carbon (Houghton & Hackler, 1995). The woody and long living nature of the forest make them more attractive tools for the stabilization and reduction of GHGs (Sharma & Rai, 2007; Sharma et al., 2011). Forest carbon measurement and their management are critical for informing climate change (Kramer et al., 2015). The measurement of forest biomass carbon is required to understand the dynamics of carbon in forest and for making the decision to manage forest resources for climate change (Esser, 1984; Johnson & Kern, 2002; Malhi et al., 2004). In the recent climate, change scenario and their mitigation concern at national and international level, carbon management through forest attached greater value (FAO, 2010). To address the challenge of global climate change the IPCC and UNFCC are working at the regional and international level. The Kyoto Protocol (1997) of the UNFCC is working to coupe the issue of climate change (Wani et al., 2012). The KP recognized that different terrestrial ecosystems forests, grassland, and wetland can potentially store and sequester carbon from the atmosphere and can therefore slow down the increased concentration of carbon dioxide (Ardo & Olsson, 2004). The KP ranked the forestland as an important carbon sink, and included the sustainable management of forest in the second commitment period (2013-2020). The Durban Climate Change Conference also set rules for the emission reduction related to forestry and agroforestry activities (Calfapietra et al., 2015). The UNFCC and The KP give direction and guidelines for the measurement of carbon in the forest. To comply with the UNFCC and KP member countries periodically measure carbon in their forest ecosystems.

Pakistan is the member of the KP and UNFCC. The country has diverse ecology, forest types (Champion et al., 1963). The northern areas (NA) of Pakistan comprise of Hindu Kush, Karakorum, and Himalaya Ranges are the home of the forest. The estimates of forest carbon, a data gap in the northern part of Pakistan, are required in the present scenario of carbon management. The area is mostly dominated by the coniferous forest. Deodar (*Cedrus deodara*) the national tree of Pakistan is a long-living woody tree reaches up to the age of 500 to 700 years distributed at a range of 2000 m to 3000 m (Moinuddin et al., 2009; Khan et al., 2013). The tree is one of the most important dominant species of the region showing dynamics in stand structure and growing stock attributes, Moinuddin et al. (2010, 2011). Although the ecology regarding the species composition, stand structure and population dynamics has been worked out but, the carbon storage and mitigation services of the deodar community have been not studied yet. Taking the consideration in mind here, we conducted the present study to investigate the carbon mitigation potential of the tree. The research aimed to figure out the growing stocks attributes and biomass carbon of deodar forest at a different elevation. In this research, we developed regression models and guidelines for study the relation of stem density and diameter, stand basal area and stand volume. We also studied the relation of stand basal area and height with biomass carbon. We show that the stand basal area is a strong predictor of biomass carbon than stand height. It is expected that the present work would not only provide information regarding the current status and carbon dynamics but will also be helpful in the managing of forest for carbon and future carbon dynamics trend of deodar community in the region.

2. Materials and Methods

2.1. Study Area

The study area lies in Hindu Kush range, rich in forest resources. The area is dominated by the coniferous forest. The major coniferous species of the area are *Cedrus deodara* (Deodar), *Pinus wallichiana* (Kail), *Abies pindrow* (Fir), *Picea smithiana* (Spruce) and *Taxus bacata*. Among the broad-leaved, the common species include *Juglans regia*, *Quercus incana*, *Aesculus indica*, *Poplus caspica*, *Parrotia jacquemontians,* and *Alnus Nitida*. Deodar is found in the area as a single dominant species or form association with Kail, Fir, and spruce. The geographic location of the area is 35˚31′.46″N to 35˚32′.91″N and 71˚06′.18″4E to 72˚14′.98″E. The elevation of the area ranges from 2100 m to 6000 m. The deodar dominant community located at an elevation of 2300 to 2700 m. The average rainfall is in the range of 800 - 1200 mm. Temperature ranges from 0.10˚C to 25˚C. Diorites, norities, schist are the major types of rocks. The soil pH is 5.83 to 6.22. The mean soil bulk density is 1.03 $gm \cdot cm^{-1}$. The soil organic matter ranges from 3.12% to 4.77%.

2.2. Research Design and Field Measurement

We used stratified random sampling. The stratification was based on elevation. We divided the area of deodar community into three elevation classes (EI = 2300 - 2400 m, EII = 2400 - 2500 m, and EIII = 2500 - 2700 m). In each class, we take ten sample plots randomly in 2014-15. The size of each sample plot was 0.1 ha. Overall 30 sample plots were taken. The elevation and geographic location of each plot were measured by using GPS. In each plot stem, density (ha^{-1}) was measured. We used a caliper and Abneys level for tree height (m) and diameter (cm) measurement. Trees less than 6 cm diameter were not considered for enumeration. Local volume table also used for data computation. For understorey vegetation, litter, dead wood, and cones biomass measurement sample plots of 2 m^2 were laid in each plot of 0.1 ha. For soil carbon in each elevation class, we collected the soil samples at the depth of, 0 to 15 cm and 15 to 30 cm.

2.3. Biomass Carbon Estimation

We calculated the stem volume ($m^3 \cdot ha^{-1}$) from DBH and Tree height using (Philip, 1994). Stem biomass ($t \cdot ha^{-1}$) was measured from stem volume ($m^3 \cdot ha^{-1}$) and wood density ($kg^{-1} \cdot m^3$) and then converted into total tree biomass ($t \cdot ha^{-1}$) by using BEF (Haripriya, 2000; Fang et al., 2002; IPCC, 2003; Teobaldelli et al., 2009). The biomass of understory vegetation (UnSV) was measured by collecting the vegetation destructively from each subplot. The fresh weight (kg) was calculated and samples of one 1 Kg were brought to the laboratory and were dry for 48 hours at 72˚C and their dry weight was calculated for biomass measurement. The deadwood litter and cone were also collected in each subplot for and their dry weight was measured from biomass calculation. For assessing the carbon content in each biomass component, we converted the biomass into carbon using a carbon-measuring fraction (0.5) following Equation (1) (IPCC, 2003; Sharma et al., 2010; Ahmad & Nizami, 2015; Adnan et al., 2015; Ahmad et al., 2018; Manan et al., 2018)

$$\text{Carbon}\left(t \cdot ha^{-1}\right) = \text{Biomass}\left(t \cdot ha^{-1}\right) * \text{Carbon\%}\left(0.5\right) \quad (1)$$

For soil carbon (SC) measurement soil samples were collected using soil auger and core with a known volume of 104 cm^3 (height = 5.12 cm and diameter = 5.1 cm). The collected samples were analyzed by using Walkley and Black (1934) method. The percent organic matter was measured and form organic matter percentage we measured carbon content (%). For the measurement of soil carbon in $t \cdot ha^{-1}$ we calculated the soil bulk density ($gm \cdot cm^{-3}$) and using Equation (2), carbon in $t \cdot ha^{-1}$ was calculated (Pearson et al., 2008; Nizami, 2012; Ahmad et al., 2018).

$$\text{Soil carbon}\left(t \cdot ha^{-1}\right) = \text{SOC}\left(\%\right) * \text{Soil BD}\left(gm \cdot cm^{-3}\right) * \text{Soil depth}\left(cm\right) \quad (2)$$

2.4. Statistical Analysis

Std deviation (SD), and Std Error were worked out. Regression models were developed to study the relationship between tree diameter (cm) and stem density ha^{-1} using Sigma Plot V 12.5. Similarly, the relationship between stand basal area ($m^2 \cdot ha^{-1}$) and stem volume ($m^3 \cdot ha^{-1}$) and stand basal area ($m^2 \cdot ha^{-1}$) and total tree biomass ($t \cdot ha^{-1}$) was worked out (Sigma Plot V 12.5). The regression model for carbon stock ($t \cdot ha^{-1}$) estimation based on mean height (ha^{-1}) and mean basal area (ha^{-1}) were also developed using Sigma Plot V 12.5.

3. Results

3.1. Growing Stock Characteristics

Stem density varied from 203 ± 107 to 271 ± 48 $trees \cdot ha^{-1}$ with a mean value of 237 ± 48 $trees \cdot ha^{-1}$. Details of tree distribution in respective diameter classes are given in **Table 1**. It can be seen from the table that in EI and EII about 66% to 70% trees are found in lower and middle diameter classes while in EIII about 40% trees are found in same diameter classes and the rest of trees are distributed in the upper diameter classes. Overall in deodar community about 40% - 50% of trees occurred in the diameter classes from 66 to 178 cm. The present study outlines that the tree distribution pattern is uneven at a different elevation (**Table 1**). The uneven distribution of trees can be linked with different factors like forest management operations, grazing problem and local people excess to the forest and forest classification into different working circles. The forest of the study area is managed under the selection system; the forest department carries logging operation under the selection system. The forest located at lower elevation received more logging and wood removal (only snags and fallen trees are removed) operations as compared to a higher elevation. Similarly, the local people have certain rights in the forest like grazing and fuelwood and timber collection, so due to easy excess, the forests located at lower elevation are the first choices. Forest located on higher elevation was designated as a protection forest for the watershed, and therefore received minimum logging and wood removal operation that resulted in the occurrences of more mature and over-mature trees (**Table 1**). The ban on green felling since 1992 also resulted in a comparatively more number of the trees in upper diameter classes. In comparison the mean value of stem density in the present study falls within the ranges reported by (Moinuddin et al., 2011) from deodar community at different altitudes from Pakistan. However, the current value of stem density gives lower estimates from the reported value of tree density from the Himalaya region of Kashmir and western India by (Wani et al., 2015). The reason of more density may be the presences of small diameter trees and the absences of large diameter trees. The author reported trees of 10 - 110 cm diameter while in the present study we recorded trees up to diameter 178 cm.

The presence of larger diameter trees resulted in a higher value of the basal area (**Table 2**). The basal area in the ELIII (2500 - 2700 m) was the highest among all elevation classes. Similarly, the stem volume was also maximum at altitude 2500 - 7000 m. The basal area ($m^2 \cdot ha^{-1}$) and tree height (m) depend on tree diameter; forest having trees of larger diameter produces more value of basal

Table 1. Percent stem density distribution pattern in respective diameter classes (cm).

Diameter class (cm)	2300 - 2400 (m)	2400 - 2500 (m)	2500 - 2700 (m)
10 - 34	40.17	34.44	17.07
36 - 64	28.38	21.48	23.69
66 - 94	17.9	18.89	17.77
96 - 124	8.30	12.22	23.34
126 - 178	5.24	12.96	18.12
Total	100	100	100

Table 2. Growing stock and biomass in respective elevation.

S.No	2300-2400	2400-2500	2500-2700	Mean
Density·ha^{-1}	203 ± 101	238 ± 71	271 ± 48	237 ± 78
Basal Area m^2·ha^{-1}	79.95 ± 60.1	126.6 ± 58.4	198.8 ± 104.2	137.43 ± 35.93
Height (m)	27.09 ± 5.91	27.97 ± 4.59	33.16 ± 6.37	29.40 ± 5.62
Volume m^3·ha^{-1}	999.4 ± 852.6	1703.4 ± 888.8	2707.05 ± 1554.5	1835.65 ± 504.07
Stem Biomass t·ha^{-1}	472.5 ± 389.8	794.4 ± 414.7	1261.6 ± 724.2	857.85 ± 242.66
Total tree biomass t·ha^{-1}	692.2 ± 556.1	1177.9 ± 639.1	1904.2 ± 1093.8	1281.46 ± 360.58
UnSV biomass t·ha^{-1}	3.37 ± 1.2	2.11 ± 0.21	2.42 ± 0.70	2.63 ± 0.37
DWCL, biomass t·ha^{-1}	15.60 ± 10.8	14.50 ± 8.01	4.65 ± 2.32	11.58 ± 3.48

area and height (Nizami, 2012; Adnan et al., 2015). Furthermore, the volume (m^3·ha^{-1}) of a stand is the function of stand basal area (m^2·ha^{-1}), higher the value of basal area higher will be the volume (Philips, 1994; Sajjad et al., 2016). The relationship of stand basal area and stand volume has been presented in **Figure 1**. The value of R^2 (0.99) in **Table 3**, depicted a highly positive correlation of basal area with stand volume. The presences of smaller diameter trees in lower elevation resulted in a minimum value of height basal area and volume as compared to forest community located at middle and higher altitude. Overall our results of tree height and basal area are consistent with the results of (Champion et al., 1963; Sheikh, 1993; Moinuddin et al., 2011).

3.2. Biomass

Along the elevation, the highest value of USVB was recorded at EIII fallowed by EII. The UVB was maximum in the ELI due to presences of more woody shrubs. The DWCLB of ELI and ELII was recorded high as compare to ELIII due to more woody debris and cone on the forest floor. Growing stock volume based estimation of forest biomass is a reliable source and a major predictor of the above-ground biomass (Häme et al., 1992; Shavidenko et al., 2007; Somogyi et al., 2008). The biomass measurement in a forest determines the ability of forest for sink and source of carbon (Brown et al., 1999). The forest biomass measurement is also needed for predicting the change of carbon in different carbon pool,

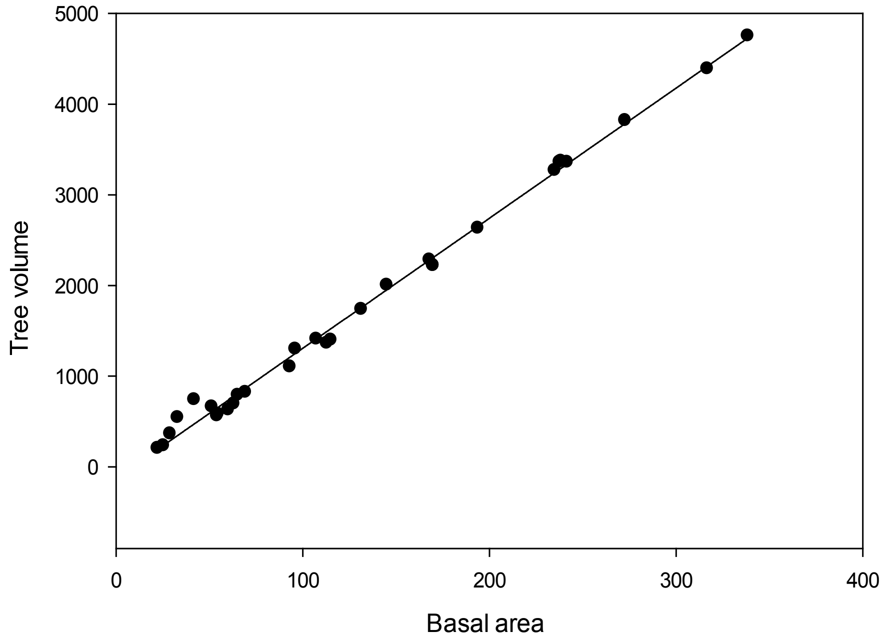

Figure 1. Relationship b/w tree Basal area ($m^2 \cdot ha^{-1}$) and Tree volume $m^3 \cdot ha^{-1}$ ($R^2 = 0.99$, $P \leq 0.0001$).

Table 3. Regressions equations for growing stock parameters, biomass and carbon stock.

Relation	Equation Type	y0	A	P	R^2
Basal area $m^2 \cdot ha^{-1}$ and volume $m^3 \cdot ha^{-1}$	P. Linear (f = y0 + a*x)	−126.8	14.34	<0.0001	0.99
Basal area $m^2 \cdot ha^{-1}$ and biomass $t \cdot ha^{-1}$	P. Linear ((f = y0 + a*x)	−101.4	10.09	<0.0001	0.99
Mean Height (m) and C. Stock $t \cdot ha^{-1}$	P. Linear (f = y0 + a*x)	−722.06	45.42	<0.0001	0.60
Basal area $m^2 \cdot ha^{-1}$ and C. Stock $t \cdot ha^{-1}$	P. Linear (f = y0 + a*x)	−50.86	5.046	<0.0001	0.99

(Esser, 1984). The biomass in a forest can be in measured two ways. To convert measured growing stock volume, to biomass by using basic wood density and BEF and to estimates biomass directly from growing stock volume and BECF without using wood density (IPCC, 2003; IPCC, 2006; Tolnnay, 2011). In the present study, we convert the growing stock volume to biomass using BEF. The USV biomass was higher at the elevation 2500-2700 which are similar to the study of (Sharma et al., 2011) who reported the highest biomass at the same altitude as India. The value of UnSV and DWCL biomass (**Table 2**) was more in ELI. At ELI more woody shrubs like *Indigofera wallichiana*, *Berberislycium*, *Berberisfrakraian*, and *Rosa webbiana* were found with other forbs and grasses like *Caltha alba*, *Rumuxdentatus*, *Artemisia vulgaris Bergenia ciliate Cthe ynodondacttylon*, *Agropyrondentatum*, *A. Canaliculatum* and *Poe* spp. The occurrences of more woody shrubs and dense UnSV resulted in more value of UnSV and DWCL biomass.

3.3. Biomass Carbon

The value of carbon density was assessed in USVB, UnSVB, and DWCL Biomass and in Soil. Details of total carbon are given in **Table 4**. It can be seen from the table that among different elevation, there is significant variation in carbon density. EIII significantly store more carbon comparable to EII and EI. The UpSV in ELIII hold more carbon than EI and EII. In the EIII, the occurrences of more number of trees in higher diameter classes as compare to EII and ELIII resulted in more value of basal area and carbon. The biomass carbon of the UnSV was higher in the ELI because of dense understory vegetation. The occurrence of more woody shrubs in the lower elevation also resulted in more UnSV biomass carbon. Similarly, in ELI, DWCL carbon and soil carbon was also higher as compare EII and EIII .On the forest floor at a lower elevation; there was more dead wood in the form of woody debris, small branches and twigs, which may be the reason of more dead wood, and litter carbon. Similarly, in the lower elevation, some area have been also affected by dieback that developed a slightly more wood debris and cone on the forest floor which resulted in more DWLC biomass carbon. The recorded SOC was also greater in the lower elevation as compared to higher elevation due to the presence of more organic matter in the top soil as a result of more woody debris on the forest floor. The forest located at higher elevation also has slightly more soil erosion because of more sloppy nature that also resulted to low soil carbon. In comparison, we reported higher biomass carbon from the reported value of the (Sharma et al., 2011). The biomass carbon ($t \cdot h^{-1}$) in a forest is the function of basal area ($m^2 \cdot ha^{-1}$) with an increase in the basal area of the tree the value of biomass carbon increases (Nizami, 2012; Adnan et al., 2014). In the current study, we developed the relationship between basal area and biomass carbon (**Figure 2**, **Table 3**). The value of R^2 (0.99) support the arguments of the functional relation of basal area and biomass carbon. In the present study, we also developed the relationship between the mean height (m) and total carbon ($t \cdot ha^{-1}$). **Figure 3** describes the functional relation between tree mean height and biomass carbon the value $R^2 = 0.60$ (**Table 3**) give a slight week functional relation of mean tree height (ha^{-1}) with biomass carbon as compare to the relation of the basal area with total tree biomass carbon. It can be concluded from our present results that the basal area of the stand is a strong predictor of biomass carbon than mean tree height.

Soil carbon is an integral part of the forest ecosystem and major carbon pool. The results of our study of soil carbon give lower value from the reported value of various authors (Gupta & Sharma, 2011) that reported soil carbon in the range of 120.35 ± 25 $t \cdot ha^{-1}$ to 145 $t \cdot ha^{-1}$ under deodar forest community from the Himalaya ranges of India. We attributed the lower estimates to various factors like grazing, fuelwood collection and soil erosion problems. The forest of the area is protected forest with different rights like grazing, timber, and fuelwood collection for domestic purposes. The trampling effect of the animal can cause soil compaction that would result in the low amount of carbon in soil. The

Table 4. Carbon density in each pool.

Carbon Pool	2300 - 2400 m	2400 - 2500 m	2500 - 2700 m	Mean	%
UpSV Carbon t·ha^{-1}	345.9 ± 277.90	589.03 ± 319.50	952.3 ± 547.04	640.6 ± 467.60	87.75
UnSV Carbon t·ha^{-1}	1.6 ± 0.60	1.05 ± 0.10	1.2 ± 0.30	2.63 ± 019	0.37
DWCL Carbon t·ha^{-1}	7.8 ± 5.40	7.25 ± 40	2.35 ± 1.10	11.58 ± 1.47	1.65
SO Carbon t·ha^{-1}	76.8 ± 5.50	71.01 ± 5.03	60.9 ± 8.30	69.57 ± 6.27	10.21
Total Carbon t·ha^{-1}	432.3 ± 289.50	668.3 ± 323.90	1016.7 ± 542.90	716.94 ± 462.00	100

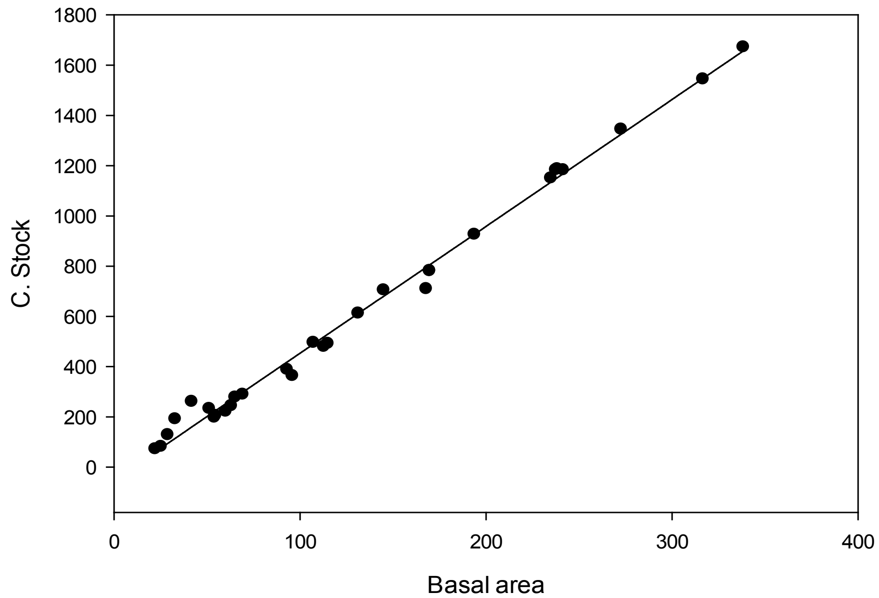

Figure 2. Relationship b/w tree basal area (m^2·ha^{-1}) and Carbon stock (t·ha^{-1}) ($R^2 = 0.99$, $P \leq 0.0001$).

soil in a forest has organic and inorganic carbon, the organic carbon that is the important component of soil stored in the soil organic matter. The organic matter in a soil is the function of residence time (Luo et al., 2001). The residence time is variable in the forest carbon pools (Gaudinski et al., 2000). Litter and fine roots have short residence time while the dead wood has long residence time (Calfapietra et al., 2015). The residence time of the dead wood varies in a forest depending on climate conditions and forest types (Barbati et al., 2007). The forest management operation greatly affected the amount of dead wood in a forest due to the removal of a snag and coarse woody debris (Calfapietra et al., 2015). Similar situation exist in the studded forest the removal of the dead and dry wood (snags) by the forest department and local community resulted in low amount of dead wood and woody debris on the forest floor that resulted in low SOM content and soil organic carbon. One of the reasons of lower soil carbon is the location and topography of the deodar community, the deodar community, particularly in the higher elevation, occurred on sloppy terrines that causing more soil erosion that decreases SOM in topsoil.

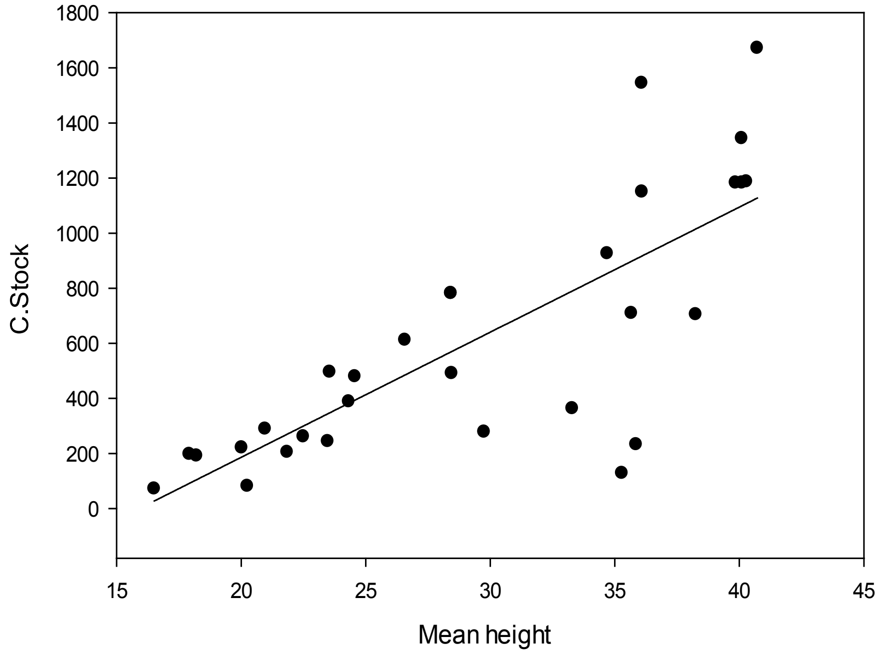

Figure 3. Relationship b/w tree mean height (m) and Carbon stock (t·ha^{-1}) (R^2 = 0.60, P ≤ 0.0001).

Mature forest with fully stocked and old age have a significant amount of carbon (Sharma et al., 2011). The natural old growth forest holds the potentially higher amount of carbon (Smithwick et al., 2002). The higher carbon stock of the mature and old forest are linked with higher tree layer biomass with long living nature and time-dependent carbon accumulation (Law et al., 2001; Pregitzer & Euskrichen, 2004; Fredeen et al., 2005; Zhang et al., 2012). The deodar community of the study area consisting of old age tree up to 600 years (Khan et al., 2013) with larger diameter reaches up to 178 cm. The presence of old age, mature and larger trees resulted in the higher amount of carbon (716.94 ± 462) as compare to other deodar forest located in the Himalaya ranges of India and Kashmir. However, the results of our study are consistent with the results of (Zhang et al., 2012) who reported 632 t·ha^{-1} carbon from the mature fir forest. Our results also support the arguments that mature old forest can stored from 200 to 500 to 1900 t·ha^{-1} carbon (Geoff Craggs, 2016).

The control of deforestation and the promotion of planted forest have been suggested for global warming reduction (Bala et al., 2007). The mitigation of elevated carbon dioxide can be effectively reduced through plantation (Watson, 2000). However, the conservation of the natural and old age forest with a large amount of carbon is the effective way to reduce the amount of carbon in the atmosphere and to mitigate the climate change. Mature forest continuously accumulates a significant amount of carbon (Zhang et al., 2013). The finding of the present study confirmed that the deodar forest community consisting of old age trees acts as a potential carbon sink having the highest carbon mitigation ability across the Himalaya range of the Subcontinent. The results indicated that the deodar community had the stronger capacity to sequester and hold carbon in the present climate change context. The conservation of the forest based on responsive carbon management approaches will be the effective means to sequester and store atmospheric carbon in the recent climate change context.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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