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Carbon Stock Estimation in Standing Tree of Chir Pine and Banj Oak Pure Forest in Two Van Panchayats Forest of Garhwal Himalaya

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Abstract

A study was conducted to measure carbon stock in two Van Panchayat forest of Garhwal Himalaya. For comparative study, we selected the degraded and non-degraded site in Pine and Oak Forest and estimated total carbon stock (above and below ground). Van Panchayat are managing the forest in Uttarakhand from British Period. The aim of the research was to estimate the tree density, tree diversity,biomass and carbon stocks in degraded and non-degraded sites in both forests for forest management through Van Panchayat. From this research, we found that non-degraded site contains maximum (Density, total biomass and carbon stock) as compared to degraded sites. This paper recommends the importance of forest management committee in Uttarakhand and the world. Community based small scale carbon sequestration can contribute to the solution of global climate change through carbon trading.

Keywords: Van panchayat; Carbon stock; Carbon trading; Degraded and non-degraded sites

Introduction

Forest carbon sequestration is one of the key approaches to reducing atmospheric carbon concentrations. It is a safe, environmentally acceptable, and cost-effective way to capture and store substantial amounts of atmospheric carbon. The concurrent development of tradable carbon credits provides financial incentives for considering carbon storage in forest management decisions. Climate change is one of the most important global environmental issues, which is likely to impact natural ecosystems as well as socio-economic systems [1]. The global climate has warmed by 0.7°C during the last century and is projected to rise by 1.8-4.0°C during the current century [2]. Under Kyoto Protocol, forests are considered important for their unique role as carbon sinks because they are capable of capturing and storing carbon dioxide from the atmosphere [3]. According to FAO [3], each time there is a forest growth of 2 cubic meters of wood; roughly 1 ton of carbon of the air is captured. Forests act as carbon sink by increasing above ground biomass through increased forest cover and by increased level of soil organic carbon content. Biomass is defined as "mass of all organic matter per unit area at particular time (reported in g/m^2 or kg/ha). The above-ground biomass (AGB) is described by IPCC Guidelines for National Gas Inventories (2006) as "all biomass of living vegetation, both woody and herbaceous, above the soil including stems, branches, bark, foliage, bark and stumps". Forest biomass represents the largest terrestrial carbon sink and accounts for approximately 90% of all living terrestrial biomass. The amount of carbon sequestered (or lost) by a forest can be estimated from the biomass accumulation since approximately half of forest dry biomass weight constitutes carbon [3,4]. Forest biomass can be measured both in terms of fresh weight or in terms of dry weight. The present study is an attempt to estimate the total carbon stock in two VPs forest. Chir-Pine and Banj-Oak that occupied 16.36% and 12.29% of land area, respectively in Uttarakhand.

Materials and Methods

The selected sites of two forest are located in the Van Panchayats of Gwar and Aali situated in the Pauri districts of Uttarakhand. Geographical area of the Pauri district is 5440 sq.km and situated between 29°45' to 30°15' latitude and 78°24' to 79°23' E longitude.

The Van Panchayats of Aali and Gwar are situated between 30°08'10.52"-'30°07'05.4"N longitudes and -78°52'30.15" -78°45'29.02"E latitudes. The elevation of these Van Panchayats varies from 1750 m to 1825 m. Study area is located in a temperate environment but latitudinally it comes within the subtropical belt. The maximum temperature varied from 25°C to 30°C and minimum temperature varied from 1.3°C to 2.5°C (Figure 1) [5].

Categorization of degraded and non-degraded sites only one parameter (crown density) was used for present study

Crown density (crown cover) was measured by Spherical densitometer in both sites with the help of degraded and non-degraded categories, the site with less than 40% crown cover were considered as degraded and those having crown cover 60% as non-degraded [6].

Sampling design

For the present study two-forest types i.e., Chir pine and Banj oak dominated type Van Panchayat forest were selected for biomass, and Carbon stock estimation. Transect sampling technique was used for data collection. In each forest type, 500 m long and 100 m width transect were made. In Oak forest Gwar Van Panchayat, five Sample plot and Pine forest Aali Van Panchayat six sample plot were made in each transect 0.1 ha. (50×20 m) sample plot was made in each site. Within each sample plot ten quadrate (10×10 m) were made for as workable unit. In total 5 sample plot in Oak forest Gwar Van Panchayat and 6 Sample plot in Pine Forest Aali Van Panchayat were sampled.

Sample plot measurement

The height and DBH (diameter at breast height) of all the trees falling within the sample plot were measured. CBH was measured by using meter tape at 1.37 m above ground level and height was measured

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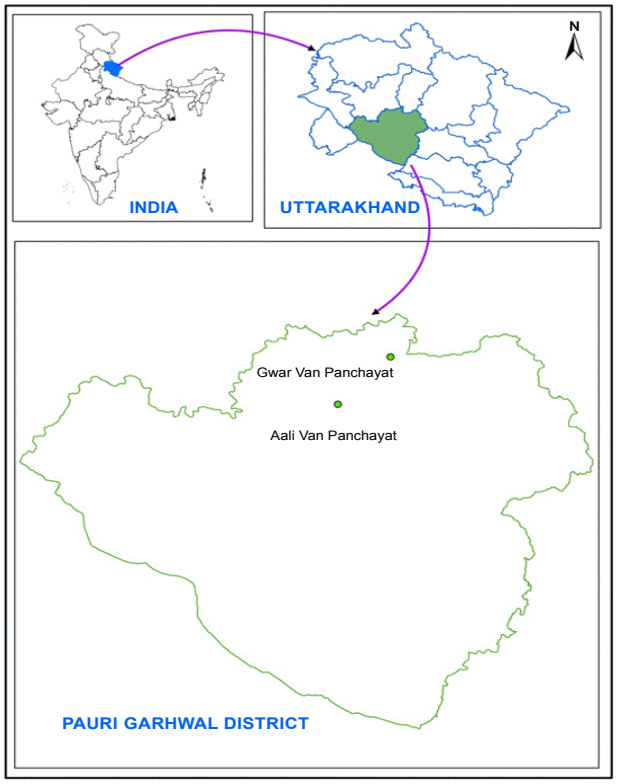

Figure 1: Map showing the geographical location of Pauri district of Uttarkhand.

by relay scope. Enumerated diameter classes were divided in to 5 classes at 10 cm of interval. Tree diversity was determined by using Shannon–Wiener diversity index [7] as ¯H=–pi ln (pi) where, ¯H is Shannon–Wiener diversity index, pi is the proportion of individuals belonging to species i and ln is natural log (i.e., base 2.718). The growing stock density was estimated using volume tables or volume equations based on the Forest Research Institute (FRI) and Forest Survey of India (FSI) publications for the respective species [8-11]. These volume equations were earlier developed by FRI and FSI using multiple regression methods in which basal area, girth or dbh along with height or form factor were taken into consideration. The estimated GSVD (m^3 ha^{-1}) was then converted into Above Ground Biomass Density (AGBD) of tree components (stem, branches, twigs and leaves), which was calculated by multiplying GSVD of the forest with appropriate Biomass Expansion Factor (BEF) [12]. The BEF (Mg m^{-3}) is defined as the ratio of above ground biomass density of all living trees at diameter at breast height (DBH) ≥ 2.54 cm to GSVD for all trees of DBH ≥ 12.7 cm. The BEFs for hardwood, and pine were calculated using the following equations:

Hardwood: BEF=exp {1.91–0.34×ln (GSVD)} (for GSVD ≤ 200 m^3 ha^{-1}).

BEF=1.0 (for GSVD>200 m^3 ha^{-1}).

Pine: BEF=1.68 Mg m^3 (for GSVD<10 m^3 ha^{-1}).

BEF=0.95 (for GSVD=10- 100 m^3 ha^{-1}).

BEF=0.81 (for GSVD>100 m^3 ha^{-1}).

Using the regression equation by Cairns et al. [4] the below ground biomass density, BGBD (fine and coarse roots) was estimated for each forest type as following:

BGBD=exp {–1.059 + 0.884×ln (AGBD) + 0.284} AGBD and BGBD were added to get the Total Biomass Density (TBD).

The Total Carbon Density (TCD) was computed by using the following formula:

Carbon (C Mg ha^{-1})=Biomass (Mg ha^{-1})×Carbon % where C=0.5 [13].

Result and Discussion

The present study is an attempt to estimate the total carbon stock in two major forest type, Chir Pine, Banj Oak which occupie 7.30 ha and 10 ha land area respectively in Uttarakhand under varying level of disturbance in two Van Panchayat forest in Khirsoo and Pauri block of Pauri district of Uttarakhand.

In the non-degraded site of the present investigation in carbon stock forest biomass ranged between 219.86 to 490.33 Mg ha^{-1} while in degraded site the carbon stock range between 193.36 to 294.38 Mg haa^{-1}. The present finding on Oak and Pine forest are in conformity with the finding of Rana et al. [14], Malhi et al. [15] states that in the Indian Himalayan forests, average carbon across all the forests studied (degraded and non-degraded). The density was 650.0 and 750.0 tree haa^{-1} in degraded and non-degraded sites of Oak forest. While in Pine forest, 346.66 and 406.66 tree haa^{-1}. The present study shows non-degraded sites contain maximum tree density. Ross suggested that more no. of young trees have maximum carbon stock. Our result showed that non-degraded sites contain maximum tree density as compared to degraded sites (Figure 2). The Crown density was 29.17 and 70.33% in degraded and non-degraded sites of Oak forest. While in Pine forest 32.38 and 84.98% Jina et al. [6] revealed that, degraded sites where lopped branches were 50% considered as degraded and less lopped branches trees as non-degraded. It indicates that Oak and Pine forest in the Present study have recorded the both degraded and non-degraded types forest. Therefore, non-degraded site found more crown density as compared to degraded sites in both type forest (Figure 2).

The average growing stock Volume density were 186.3 and 439.7 m^3ha^{-1} in degraded and non-degraded sites of Oak forest respectively. While in Pine forest 276.1 and 531.5 m^3ha^{-1} were observed in degraded and non-degraded sites respectively. The present GSVD value were compare with the GSVD value recorded of twenty forest types in

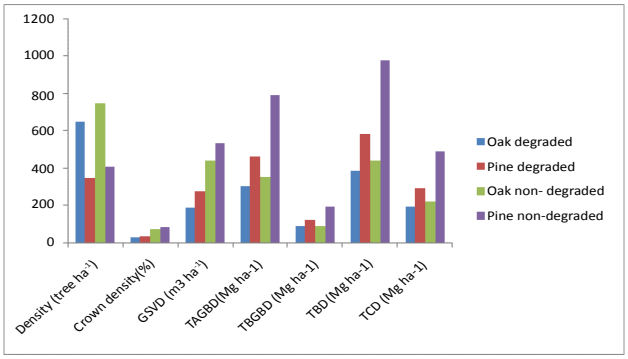

Figure 2: Comparison between degraded & non-degraded sites of Oak and Pine forest .

Garhwal Himalaya [9]. Growing stock depends on the growth phase of individual. Mature stage contains maximum growing stock in comparison of young stage. Therefore, Degraded and non-degraded sites contains more or less growing stock in Oak and Pine forest (Figure 2). The average values of AGBD in the present study were 304.8 and 350.89 Mg ha^{-1} in degraded and non-degraded sites of Oak forest respectively where as Pine forest 463.86 and 790.47 Mg ha^{-1} in degraded and non-degraded sites. These value are on the higher and earlier reported value from twenty forest type in Garhwal Himalaya [16,17]. Both forest types in this study were mature fully stocked old growth forest and have carbon stock higher end of the values recorded for the nearby forest of Kumanou central Himalaya which infer these forest have higher amount of carbon store to them (Figure 2). The Total below ground biomass density was 86.93 and 88.76 (Mg ha^{-1}) in degraded and non-degraded sites of Oak forest. While in Pine forest 118.92 and 190.41 (Mg ha^{-1}) (Figure 2). The sum of the earlier estimates of Indian forest biomass values compare with present study total biomass density values. Total biomass density values were recorded higher in non-degraded sites. These values are on higher total biomass reported values from twenty forest types in Garhwal Himalayas [11] (Figure 2). In oak and pine forest site of the present investigation the carbon stock in forest biomass were 219.86 and 490.33 Mg ha^{-1}. While in degraded and non-degraded forest site (Figure 2). The present finding on both the forest are in conformity with the finding of Bohra et al. [18] in Kumaon Central Himalaya, reported value range between 18.37 to 296.09 Mt ha^{-1} and according to Rana et al. [14], Malhi et al. [15] states that in the Indian Himalayan forest. Average carbon stock 148 ton $ha^{-1.}$ When average carbon stock 148-ton ha^{-1}. When average carbon in both the forest studies (degraded and non-degraded). Over, values are even higher in Banj Oak and Chir Pine forest. It was found that carbon stock in non-degraded site is greater than degraded forest.

The present study area falls under the protected area which reflects the high percent of carbon stock. A study conducted in Kumaon Himalayan forest [6] on degraded and non-degraded where higher amount of carbon was reported on non-degraded sites because the site was more protected than degraded. This finding was more or less similar to present investigation.

Conclusion

Present investigation showed that high carbon stock was found in Pine forest as compared to Oak forest. Negi et al. [19] observed that the three types have maximum c stored in the order of conifers>deciduous>evergreen >bamboos. It was concluded that most of the conifer-dominated forests have higher carrying capacity of c stock than broad leaf-dominated forest type [11]. In pine forest of Aali Van Panchayat due to absence of ground vegetation. There was no grazing and low dependency of villagers for their basic requirement (fuel, fodder, timber etc), however, in Oak forest of Gwar Van Panchayat, the dependency of the villagers were high due to proximity of forest. Villagers collect fuel, fodder and remove litters for beding materialist and therefore the forest was disturbed. Therefore, the human disturbance also influences the carbon stock of the forest. Ross concluded that land use changes and forestry practices alter the level and rates of carbon storage [20,21]. While leakage (shifting production) may be offset some of the increase is observed in forest carbon sequestration.

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