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CARBON SEQUESTRATION RATES IN VAN PANCHAYAT FORESTS AND THEIR BENEFITS UNDER REDD

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ABSTRACT

This study assessed the potential of carbon stock and carbon sequestration rates in Van Panchayat forests at an altitude of 1500- 1800m. The Total forest biomass was 308.3 t ha^{-1}, of the total biomass tree layer contributed the most, followed by herbs and shrubs. The forest litter biomass varied between 5.4 t ha^{-1} (in rainy season) and 6.6 t ha^{-1} (in winter season). Maximum Carbon sequestration rate was 5.68 t ha^{-1} year^{-1} while, minimum carbon sequestration rate was 2.03 t ha^{-1} year^{-1}. In the present study the girth class of major species was in the younger size of 30-80cm. The Van Panchayats will have greater potential for future sequestration. If we want to maximize carbon sequestration rates, we need forest management practices that results in healthy forests of all ages. We should give careful consideration to encouraging the conversion of marginal agricultural and range lands to Van Panchayat forest land.

Keywords: Community managed forest**,** Van Panchayat, Carbon stock, Carbon sequestration.

INTRODUCTION

Estimation of biomass and productivity is a prerequisite to understand the ecosystem properties and functioning. Information on productivity of ecosystems, particularly in relation to species composition and environment is relevant to planning for ecologically sustainable development of the Central Himalaya (Singh and Singh, 1992). Knowing the spatial distribution of biomass is important for calculating the source and sink of the carbon and estimation of biomass flux (Houghton, 2005). The biomass in an oak forest ranged upto 400 t ha $^{-1}$ and *Pinus roxburghii* ranged upto 200 t ha $^{-1}$ (Singh and Singh, 1992). Similarly in oak mixed forest of central Himalaya has greater biomass, 556-782 t ha $^{-1}$ than several oak and other broadleaf forests of temperate latitude (102-450 t ha $^{-1}$; (Singh and Singh, 1992)). Forest growth is a matter of carbon sequestration and distribution. The carbon balances of the forests are important in the global carbon balance (Houghton, 2005). Carbon storage of the central Himalayan forests range from an average of about 175 t c ha^{-1} for chir pine forests to 400 t c ha^{-1} for oak and sal dominant forests (Singh, 2009). Estimation of land use changes, loss of top soil and soil organic carbon content by dominant land use categories have been documented from the available studies in the region.

REDD (Reducing Emissions from Deforestation and Degradation) has been receiving a considerable attention as a post-2012 Kyoto mechanism to compensate developing countries to reduce CO_2 emissions from deforestation and forest degradation (Ebeling and Yasue, 2008). The important role played by Van Panchayat forests in sequestering CO_2 from the atmosphere, and the livelihoods and environmental benefits that will be accruing to the local communities enable community forests to meet the objectives of sustainable development and emissions reduction (Rawat, 2012). Community forest management, as undertaken in the Himalayan region, is becoming an important strategy for increasing carbon pool levels in the region from a climatic perspective, as these forests are beginning to show signs of regeneration in previously deforested areas. Active forest management can certainly increase carbon sequestration, especially in community forests by improving growing conditions, controlling stand density, protection of fire, appointment of forest guard, rotational grazing, imposing fine on illegal felling and grazing etc. The faster a tree grows the more effective it is at removing carbon from the air. Therefore, conservation of forests, including those under the control of local communities in developing countries, is an important component of overall climate strategy.

MATERIALS AND METHOD

The selected sites are located in the Van Panchayat forests of Anriyakot and Bhatkholi in Almora district (29º 32.98′ to 29º 34.32′ N latitudes and 79° 41□□' to 79º 43.2' E longitudes). The monsoon strikes this area from June to the September and late October. The mean annual rainfall ranged from 274.5 mm to 463.2 mm (Rawat, 2012). The parent materials forming the soil in the present study area comprises of schist, micaceous quartizimeta morphism, plutonic bodies of granodiorites and granites (Rawat *et al.*, 2010). The vegetation type mainly comprises subtropical pine forest and Himalayan moist temperate oak forest. The dominated tree species in the studied Van Panchayats are *Quercus leucotrichophora* and *Pinus roxburghii* while, subordinate species are *Rhododendron arboreum* and *Myrica esculenta*.

Four aspects at both the Van Panchayats were identified, with in each aspect trees were analysed by placing randomly 10, 100 m^2 circular quadrats, saplings, seedlings and shrubs were studied in 10, 5×5 m^2, while herbs and litter were studied in 10, 50× 50 cm^2 quadrats placed randomly following Tewari and Karky (2007). Tree layer biomass was estimated on the basis of allometric equations previously developed by Rawat and Singh (1988) and Chaturvedi and Singh (1987). Carbon stock and sequestration rate were estimated as 50% of the dry weight of biomass and 50% of net primary productivity respectively (Hamburg, 2000; Brown, 2001).

RESULTS

Out of the total vegetation biomass (in the year 2008 was 120.07 t ha^{-1}) 93.26% was contributed by trees, saplings and seedlings species, while rest 6.74% by shrubs, herbs and litter. Of the total tree components the maximum contribution was of the bole (35.23%) and lowest contribution was that of the fine roots (0.57%). In the year 2009 the total vegetation biomass increased to 129.91 t ha^{-1}, of which 92.17% was contributed by trees, saplings and seedlings species, while remaining 7.83% by herbs and shrubs in Anriyakot Van Panchayat. In Bhatkholi Van Panchayat the total vegetation biomass in 2008 was 50.1 t ha^{-1}, of which 86.03 % was contributed by trees, saplings and seedlings species, while rest 14.97% by shrubs, herbs and litter. Of the total tree components the maximum contribution was of the bole (37.07%) and lowest contribution was that of the fine roots (0.48%). In the year 2009 the total vegetation biomass increased to 58.94 t ha^{-1}, of which 84.68% was contributed by trees, saplings and seedlings species, while remaining 15.32% by herbs, shrubs and litter. Of the average carbon sequestration rate in Anriyakot Van Panchayat forest (Table 2) the contribution of total above ground parts was 3.16 t ha^{-1} yr^{-1} while, the total below ground carbon sequestration rate was 0.72 however, the contribution of shrub, herb and litter was 1.05 t ha^{-1} yr^{-1}. In Bhatkholi Van Panchayat forest the contribution of total above ground parts was 2. 62 t ha^{-1} yr^{-1} while, the contribution of total below ground parts was 0.79 t ha^{-1} yr^{-1} however, the contribution of shrub, herb and litter was 1.02 t ha^{-1} yr^{-1}.

DISCUSSION

Loss of forests is a significant contributing factor in climate change however, the possibility of expanding carbon storage in forests has been identified as a potential measure to mitigate climate change by sequestering atmospheric carbon dioxide (DeFries *et al.*, 2000; Rawat., 2012). Van Panchayat forest of Uttarakhand covering 0.5 ha accumulated a large amount of carbon as CO_2 from the atmosphere and plays an important role for sequestering carbon in the regional, national and world scenarios. Studies carried out by different scientists for different countries in the earth showed that United States forests accumulated 12.1 Pg (Turner *et al.*, 1995), European forests accumulated 7.5 Pg (Kauppi *et al.*, 1992), Chinese forests sequester 4.63 Pg carbon (Fang *et al.*, 2001) and Japanese forests accumulated 1.39 Pg carbon (Alexandrov *et al.*, 1999). Indian forests sequester 572Gt of carbon dioxide (Garg and Singh, 2006). The previous study on various Van Panchayat forests reveals that the mean carbon sequestration rate for India was 3.7 t ha^{-1} yr^{-1} and that of Nepal was 1.88 t ha^{-1} yr^{-1}, are more or less similar to 2.79 t ha^{-1} yr^{-1} under normal management conditions, this is the condition when local people have extracted various forest products to meet their sustenance needs (Rawat, 2012). The present study illustrate that community forest management can be a viable strategy for reducing emissions from deforestation, as the Uttarakhand Van Panchayat forests sequestering carbon at the average rate of 3.5 t ha^{-1} yr^{-1}. However, these values varied from forest to forest. In least disturbed forests, such as sal, pine and oak forests generally carbon sequestration rates ranged between 4.0 to 5.6 t ha^{-1} yr^{-1}. The carbon sequestration values observed from the present study varied from 2.03 to 5.68 t ha^{-1} yr^{-1}. The carbon sequestration values observed from the present study are in agreement with the values reported earlier for different central Himalayan forests (KTGAL., 2003-2004; Phartiyal and Tewari, 2006; Jina *et al.*, 2008; Raikwal, 2009). In the present study the girth class of major species was in the younger size so calculated carbon sequestration are the higher side. The Van Panchayats will have greater potential for future sequestration if the forests are under appropriate management. Tree sizes in mixed deciduous forest at > 40–60 cm has trend of carbon sequestration potential more than other size classes, while size class at > 20–40 and > 40–60 cm in dry evergreen forest and tropical rain forest has more carbon sequestration potential than other size classes. This evidence indicates the potential for growth to reach the climax stage of succession in the near future. These smaller trees are not the higher carbon sequestration potential but they are relevant in terms of their future potential to grow up (Terakunpisut *et al*., 2007).

If we want to maximize carbon sequestration rates, we need forest management practices that results in healthy forests of all ages. We should give careful consideration to encouraging the conversion of marginal agricultural and range lands to Van Panchayat forest land.

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Table-1. Site structure and soil characteristics Van Panchayat (VP) forests

Stand characteristics	**Anriyakot VP**	**Bhatkholi VP**
Elevation (m)	1572 to1704	1646 to1715
Area of Van Panchayat Forests (ha)	36.12	50
Tree density (ind ha^{-1})	150 to 490	193 to 324.3
Soil bulk density (g cm^{-3})	1.09±0.07 to 1.42±0.01	0.97±0.06 to 1.36±0.004
Soil carbon%	1.00±0.29 to 2.73±0.51	1.41±0.54 to 2.97±0.46
Annual range of soil moisture (%)	7.53±1.06 to 29.72±1.15	6.52±1.09 to 14.50±1.15
Soil pH	5.0 to 6.3	4.6 to 6.4
Nitrogen	0.11 to 0.42	0.09 to 0.16
Phosphorus	0.0006 to 0.0018	0.0001 to 0.0007
Potassium	0.0035 to 0.0108	0.0026 to 0.0102

Table-2. Average tree, shrub, herb and litter biomass and carbon sequestration rate in Anriyakot Van Panchayat and Bhatkholi Van Panchayat forest

Aspect	Biomass Yr^1 (t ha^{-1}) **B1**	Biomass Yr^2 (t ha^{-1}) **B2**	Carbon sequestration rate (t ha^{-1} yr^{-1})
Anriyakot			
Bole	42.30±7.70	45.28±7.82	1.49
Branches	22.92±6.68	25.64±6.97	1.36
Twigs	11.61±4.12	12.09±3.88	0.24
Foliage	5.39±1.71	5.54±1.76	0.07
Total above ground	**82.22±5.05**	**88.55±5.11**	**3.16**
Stump root	24.22±7.02	25.15±7.42	0.47
Lateral roots	4.86±1.30	5.05±1.40	0.09
Fine roots	0.68±0.19	0.99±0.07	0.16
Total below ground	**29.76±2.84**	**31.19±2.96**	**0.72**
Total	**111.98±28.29**	**119.74±29.01**	**3.88**
Shrub	3.86±1.04	5.07±1.11	0.61
Herb	1.47±0.66	1.62±0.77	0.08
Litter	2.76±0.39	3.48±0.16	0.36

Total	**120.07**	**129.91**	**4.92**
Bhatkholi			
Bole	18.57±1.45	20.54±1.47	0.98
Branches	8.00±2.40	10.03±2.47	1.02
Twig	3.51±1.23	4.52±1.39	0.51
Foliage	1.82±0.41	2.04±0.52	0.11
Total above ground	**31.9±1.37**	**37.13±1.46**	**2.62**
Stump root	9.12±2.68	10.08±2.88	0.48
Lateral roots	1.84±0.38	2.30±0.42	0.23
Fine roots	0.24±0.05	0.40±0.08	0.08
Total below ground	**11.2±1.04**	**12.78±1.13**	**0.79**
Total	43.10±7.70	49.91±8.50	3.41
Shrub	2.57±0.64	3.37±0.91	0.40
Herb	1.39±0.16	2.06±0.45	0.34
Litter	3.04±0.30	3.60±0.14	0.28
Grand total	**50.1**	**58.94**	**4.42**

Fig-1. Carbon sequestration rates in Anriyakot and Bhatkholi Van Panchayat forests