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Biomass and carbon density in Community Conserved Forest Areas - A Case study

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ABSTRACT

The present study was carried out in a Community Conserved Forest Area (Van Panchyat) dedicated to local deity in Rudraprayag district of Garhwal Himalaya to estimate biomass and carbon stock. The forest was dominated by *Quercus floribunda* and other associated tree species were *Aesculus indica*, *Alnus nepalensis*, *Persea duthiei* and *Lyonia ovalifolia*. Total carbon density ranged between 177.32 Mg ha^{-1} for *Aesculus indica* and 12.64 Mg ha^{-1} for *Buxus wallichiana*. The above ground biomass density ranged between 298.44 Mg ha^{-1} for *Aesculus indica* and 19.87 Mg ha^{-1} for *Buxus wallichiana*. The below ground biomass density values also ranged between 70.99±13.63 and 6.47±1.31 Mg ha^{-1}. The Community-based sacred and traditional conservation management of these landscapes strives to avoid deforestation and encroachment by combining local initiatives with programs of the Forestry Department. Hence such areas can be instrumental all across the country to mitigate GHG emissions at low cost and can be safe corridors for biodiversity conservation.

Key words:

Panchyat, Mitigate, Local, Diameter

INTRODUCTION

In recent years the inability of the state to control degradation of forest has been recognized in many countries. Governments are seeing the benefits of handing over forest areas to local communities under a variety of community forest management schemes in Burkina Faso, Cameroon, India, Mexico, Nepal, Papua New Guinea, Peru, Tanzania and many other countries, and it is estimated that around 14% of all forest in developing countries is under this kind of management today, three times more than it was 12 years ago (White and Martin 2002).

Biomass production in different forms plays important role in carbon sequestration in trees. Above-ground biomass, below-ground biomass, dead wood, litter, and soil organic matter are the major carbon pools in any ecosystem (FAO 2005; IPCC 2003; IPCC 2006). Forest ecosystem is one of the most important carbon sinks of the terrestrial ecosystem. It uptakes the carbon dioxide by the process of photosynthesis and stores the carbon in the plant tissues, forest litter and soils. As more photosynthesis occurs, more CO_2 is converted into biomass, reducing carbon in the atmosphere and sequestering it in plant tissue above and below ground (Gorte 2009; IPCC 2003) resulting in growth of different parts (Chavan and

Rasal 2010). Sequestration can be defined as the net removal of carbon dioxide from the atmosphere into long-lived carbon pools. Thus, forest ecosystem plays important role in the global carbon cycle by sequestering a substantial amount of carbon dioxide from the atmosphere (Vashum and Kumar 2012). Vegetation especially, forest ecosystems store carbon in the biomass through photosynthetic process, thereby sequestering carbon dioxide that would otherwise be present in the atmosphere. Undisturbed forest ecosystems are generally highly productive and accumulate more biomass and carbon per unit area compared to other land use systems like agriculture.

Carbon pools are composed of live and dead, above and below ground biomass, and wood products with long and short life and potential uses. Tree, shrub, soil and sea water play crucial role in absorbing atmospheric carbon dioxide. It is estimated that the carbon stored globally in the forest biomass amounts to 2, 40, 439 Mt with an average carbon density of 71.5 t ha^{-1}. The biomass carbon stock in India's forests was estimated at 7.94 Mt C during 1880 and nearly half of that after a period of 100 years (Flint and Richards 1994). The first available estimates for forest carbon stocks (biomass and soil) for the year 1986 are in the range of 8.58 to 9.57 Gt C (Ravindranath et al. 1997; Haripriya 2003; Chhabra and Dadhwal 2004). As per FAO estimates (FAO 2005), the total forest carbon stocks in India have increased over a period of 20 years (1986 - 2005) and amount to 10.01 Gt C. India is sequestrating more than 116 million tonnes of CO_2 per year, which is equal to 32 millions of carbon sequestration, contributes to reduce atmospheric carbon of the globe (Jasmin and Birundha 2011). In Garhwal Himalayan region of India Van Panchyat, CCAs coupled with sacred conservation practices of forest management has been very successful over the decades and hence effort was made to estimate the biomass, carbon density in the tree species in this particular landscape. This effort can go a long way ahead if application of carbon credit system can be applied to these CCAs. This can be helpful in both increasing income at local level, conservation of biodiversity and reduction of GHG emission at global level.

MATERIALS AND METHODS

Study Area

The study area falls in district Rudraprayag of Uttarakhand and is located at N30º 33' 58" to E78º 02' 6.6". The temple located in the forest falls at the latitude 30° 33' 49.1" N and longitude 79° 01' 59.7" E and elevation of 1805 m a.s.l. This forest is legally (Van Panchyat) community conserved area dedicated to deity by local community. The study area was dominated by *Quercus floribunda*. Other associated tree species were *Aesculus indica, Alnus nepalensis, Persea duthiei* and *Lyonia ovalifolia*. The common shrubs were *Daphne papyracea, Berberis aristata, Cyathula tomentosa* and *Hypercium uralum*. The common herb species were *Smilax aspera, Drypteris xyloides, Rumex hastatus* and *Senecio rufinervis.* Mostly households around this landscape are small farmers with less landholdings preferring agriculture and hence, majority of inhabitants in the region were dependent on forests for fuel wood, fodder, small timber etc.

Methodology

Quadrants of 10m × 10m were laid down in the entire study area. Quadrats were laid down randomly to represent entire forest area. The height and dbh (diameter at breast height) of all the trees falling within the sample plot were measured. After laying out the plot, measurements were done on individual tree basis and individual's having ≥ 30cm dbh (diameter at breast height i.e., 1.37m) as per Knight (1963) were taken for estimation of carbon storage. Density was calculated by the formula given by (Mishra 1963). The growing stock volume density (GSVD) 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 (Chaturvedi 1973; FSI 1996; Sharma and Jain 1977). 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 tree species with appropriate biomass expansion factor (BEF) (Brown et al. 1999). The BEFs for hardwood and pine were calculated using the following equations:

Hardwood: BEF = exp {1.91 − 0.34 × ln (GSVD)} (for GSVD ≥ 200m^3 ha^{-1}), BEF = 1.0 (for GSVD> 200m^3 ha^{-1}).

Pine: BEF = 1.68Mg m^3 (for GSVD < 10m^3 ha^{-1}), BEF = 0.95 (for GSVD = 10 − 100m^3 ha^{-1}); BEF = 0.81 (for GSVD > 100m^3 ha^{-1}).

Using the regression equation by Cairns et al. (1997) the below ground biomass density, BGBD (fine and coarse roots) was estimated for different tree species 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 C density (TCD) was computed by using the following formula: Carbon (CMgha^{-1}) = Biomass (Mg ha^{-1}) × (0.5).

RESULT AND DISCUSSION

The poor conservation outcomes that followed decades of intrusive resource management strategies and planned development have forced policy makers and scholars to reconsider the role of community in resource use and conservation. But despite its recent popularity, the concept of community rarely receives the attention or analysis it needs from those concerned with resource use and management. The communities in Himalayan region have long lasting tradition of conservation of forest resources, which has allowed them to accumulate more and more biomass over the decades. Total carbon density reported was 1096.51 Mg ha^{-1} and highest values were recorded for *Aesculus indica* and lowest values were obtained for *B. wallichiana*. The mean biomass density in Indian forests in 1993 was estimated at 135.6 Mg ha^{-1} and amongst the states it varied from 27.4 Mg ha^{-1} in Punjab to 251.8 Mg ha^{-1} in Jammu and Kashmir (Chhabra et al. 2002). In present study biomass density ranged between 26.34 Mg ha^{-1} for *B.wallichiana* and 369.43 Mg ha^{-1} for *A. indica*, the values for the present study were higher than the mean values for Indian forests; the reason for this may be due sacredness of the site were low amount of biomass is extracted. The total AGBD was 1676.52 Mg ha^{-1} and the values ranged between 298.44±58.59 for *Aesculus indica* and 19.87±4.65 Mg ha^{-1} for *Buxus wallichiana*, whereas BGBD varied between 70.99±13.63 and 6.47±1.31 Mg ha^{-1} for same species (Table 1). The values of AGBD (1676.52 Mg ha^{-1}) in the study are much higher than the earlier reported values from the Garhwal Himalaya, India and other parts of Asia (Pala et al. 2012; Brown and Lugo 1984; IPCC 1996; Haripriya 2003). The higher values in this study area may due to the credibility of the people towards the conservation of the area, as this area is regarded as sacred and usually extraction is prohibited. This faith of people towards conservation have increased the longevity of tree species and pled to the ability of forests to fix more carbon.

Total aboveground and belowground biomass in Indian forests has been estimated as 6865.1 and 1818.7 Mt respectively, contributing 79% and 21% respectively of the total biomass (Chhabra et al. 2002). Average TBD for this study was 96.76 Mg ha^{-1}, out of which average AGBD accounted for 78.75% (76.20 Mg ha^{-1}) of the TBD and average BGBD accounted for 21.24% (20.55 Mg ha^{-1}) of the TBD. In our study it has been found that there were highest values of TBD and TCD (total carbon density) this may be due to higher basal area for *Aesculus indica*. The stem biomass of bigger trees i.e. those having greater diameter, are the largest component of forest biomass (Ogawa et al. 1965). The prevention of deforestation and promotion of afforestation have often been cited as strategies to slow down global warming (Bala et al. 2007). Enhancing C sequestration by increasing forested land area (e.g. plantation forests) has been suggested as an effective measure to mitigate elevated atmospheric CO_2 concentrations and hence contributes to the prevention of global warming. But conservation of forests having large amount of C stocks is also a valuable way to reduce CO_2 emission as it may be more beneficial than afforestation in the short run. Canadell and Raupach (2008) pointed out that the overall potential of management activities to increase C density can be substantial and comparable to that of reforestation. Forests and thus could be responsive to management for enhanced C sequestration.

This conservation of forest may be better

Table 1: Tree species and their range of values across different parameters

Name of tree species	GSVD	AGBD	BGBD	TBD	TCD
Acer caesium	11.59±3.25	34.03±6.15	10.41±1.68	44.44±7.83	21.33±3.76
Aesculus indica	311.14±67.40	298.44±58.59	70.99±13.63	369.43±72.23	177.32±34.67
Albizia julibrissin	7.64±1.21	25.84±5.38	8.16±1.80	34.00±7.19	16.32±3.45
Alnus nepalensis	173.36±44.97	202.86±35.39	50.46±7.98	253.33±43.38	121.60±20.82
Betula alnoides	11.55±1.50	33.95±5.40	10.39±1.73	44.34±7.14	21.28±3.42
Buxus wallichiana	5.13±2.05	19.87±4.65	6.47±1.31	26.34±5.96	12.64±2.86
Carpinus viminea	21.68±8.04	51.44±12.60	15.00±3.26	66.44±15.86	31.89±7.61
Cupress torulosa	29.33±8.19	62.71±11.01	17.86±4.07	80.58±13.35	38.68±7.31
Fraxinus micrantha	15.45 ±3.39	38.71±5.33	11.53±1.38	50.24±6.71	24.11±3.22
Juglans regia	12.48±5.80	35.73±8.08	10.87±2.05	46.60±10.13	97.09±21.10
Lyonia ovalifolia	32.19±10.97	66.78±19.71	18.89±5.40	85.68±25.12	41.12±12.05
Neolitsea cuipala	7.79±1.02	26.18±4.93	8.25±1.68	34.44±6.61	16.53±3.17
Persea duthiei	14.55±2.42	39.55±8.06	11.89±2.53	51.44±10.60	24.69±5.
Prunus cerosoides	11.27±1.43	33.40±2.87	10.24±0.78	43.65±3.65	20.95±1.75
Pyrus pashia	26.78±12.63	59.14±13.50	16.97±3.22	76.11±16.73	36.53±8.03
Quercus floribunda	109.01±34.27	149.36±32.57	38.50±7.73	187.86±40.30	90.17±19.34
Quercus leucotrichophora	89.80±58.85	131.43±37.99	34.38±8.18	165.81±46.17	79.59±22.16
Quercus semecarpifolia	30.64±13.62	61.90±18.44	17.51±4.61	79.42±23.06	38.12±11.07
Daphniphyllum himalayense	5.28±0.69	20.27±3.65	6.58±1.27	26.85±4.93	12.89±2.36
Rhododendron arboreum	103.22±23.33	144.08±17.77	37.29±3.91	181.37±21.69	87.06±10.41
Swida macrophylla	23.38±2.70	53.97±8.79	15.65±2.75	69.62±11.55	33.42±5.54
Symplocus paniculata	47.90±1.74	86.80±2.59	23.82±0.66	110.63±3.25	53.10±1.56

than the afforestation in short run of the trees because as Thomas (1996) suggested that trees are expected to have higher growth rates, thus, fast-growing species may accumulate large amounts of carbon in the first stage of their lifespan, while the high specific gravity of slower-growing species allows them to accumulate more carbon in the long-term. The Community-based sacred conservation management of sacred groves strives to avoid deforestation and encroachment by combining local initiatives with programs of the Forestry Department (Pala et al. 2012). To be more accurate to summarize the role of the community based conservation systems in this system. Communities need to be approached as best of conserved sites should be selected for the estimation of biomass and carbon density. Because there are more than 12,000 Van Panchyats in Garhwal Himalaya only, as this can be cheap way to mitigate GHG emission with the involvement of local communities.

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