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BIOMASS CARBON CONTENT IN *SCHIMA-CASTANOPSIS* FOREST OF MIDHILLS OF NEPAL: A CASE STUDY FROM JAISIKUNA COMMUNITY FOREST, KASKI

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ABSTRACT

Forests are considered as both the source and sinks of carbon. Different types of forests have different carbon stock. Nepal's midhills community forests have high potentiality to sequester carbon. This paper analyzes the biomass carbon stock in *Schima-Castanopsis* forest of Jaisikuna community forests of Kaski district, Nepal. Forest area was divided into two blocks and 18 sample plots (9 in each block) were laid randomly. Diameter at Breast Height (DBH) and height of trees (DBH≥5cm) were measured using the DBH tape and clinometer. Leaflitter, herbs, grasses and seedling were collected from 1*1m^2 plot and fresh weight was taken. Biomass of tree was calculated and below ground biomass is assumed 15% of above ground tree biomass. For calculating carbon stock, biomass is multiplied by default value 0.47. The above ground tree biomass (AGTB) carbon of chilaune, katus and other species was found 19.56 t/ha, 18.66 t/ha and 3.59 t/ha respectively. The AGTB of chilaune dominated, katus dominated and whole forest was found 43.78 t/ha, 39.83 t/ha and 41.81 t/ha respectively. LHG carbon was found 2.73 t/ha. Below ground biomass carbon at whole forest was found 6.27 t/ha respectively. Total biomass and carbon at forest was found 108.09 t/ha and 50.80 t/ha respectively. Difference in biomass and carbon content at chilaune dominated block and katus dominated block was found insignificant. Carbon estimation at forest of different elevation, aspect and location are recommended for further research.

Keywords : Biomass, carbon content, climate change, Kaski

INTRODUCTION

Climate change is evident (Karl and Trenberth, 2003; Trenberth, 2011) in many respects. Recently published report of Intergovernmental Panel on Climate Change (IPCC 2013) showed that global temperature has increased by 0.85 °C over the period from 1880 to 2012 (IPCC, 2013). Increasing concentration of Greenhouse Gases (GHGs) in the atmosphere is responsible for anthropogenic climate change. Carbon-dioxide (CO_2) is one of the major green house gases (GHGs) contributing to global warming. Concentration of CO_2 in atmosphere increased by 40% since pre-industrial time and reached 391 ppm in 2011 (IPCC, 2013).To deal with climate change we need to reduce emission and enhance sink of GHGs which the United Nations Framework Convention on Climate Change (UNFCCC) recognized. The main objective of the UNFCC is to stabilize the concentration of GHGs in the atmosphere at the level to allow ecosystem to adapt naturally (UNFCCC, 1992). Different sinks and sources of GHGs are identified to deal with the increasing GHG concentration in the atmosphere of which forests are the efficient carbon sinks.

Forests are crucial ecosystem for maintaining the global carbon balance as about 80% of all above ground and 40% of all below ground terrestrial organic carbon is stored in forests (IPCC, 2001). Forests play vital role in both carbon sequestration and storage and are considered as important component of global carbon cycle(Candell and Raupach, 2008). Forests sequester large amounts of carbon annually (Bonan, 2008) and considered important natural "brakes" to climate change (Gibbs et al, 2007). The trees sequester atmospheric carbon through photosynthesis and store it in the form of wood biomass (Brown and Pearce, 1994). World's forests and forest soils currently store more than 1 trillion tonnes of carbon, nearly double amount of carbon floating free in the atmosphere (Oli and Shrestha, 2009). After long discussion, the link between forests and climate change was acknowledged at the 13th Conference of Parties to UNFCCC at 2007 (Dhital, 2009).

Nepal is moving to participate in the internal carbon trading mechanism, Reducing Emission through Deforestation and Forest Degradation (REDD+). To participate in the REDD+ mechanism it is urgently needed to estimate the carbon content and sequestration rate of different forest types of Nepal. Community forestry is the major forest regime in midhills managing the forest resources. Community forestry has been recognized as a successful program for managing the forest resources (Paudel 2014;2015). Community forest user groups are involved in climate change adaptation (Acharya and Paudel, 2016) and its forest have huge potential to mitigate through carbon sequestration.

Carbon stock of community forest depends on climatic conditions, soil type, landscape, altitude, aspect, species, density of stands and forest age (Shrestha and Singh, 2008).Various spatial and temporal factors including forest type, size, age, stand structure, associated vegetation and ecological zonation are determinants of carbon storage in forest (Karki et al, 2016).*Schima wallichii* (Chilaune) and *Castanopsis species* (Katus) are the dominant tree species at midhills of Nepal. *Schima wallichii* and *Castanopsis species* constitute about 2.66% and 1.73% of total stem volume of Nepal (DFRS, 2015). There is higher variation in past studies (Khanal, 2008; Shrestha, 2009; Aryal, 2010; Neupane and Sharma, 2014; Pandit, 2014) regarding to carbon content in *Schima-Castanopsis* forest. The inconsistent findings indicate the higher level of variability and uncertainty in carbon sequestration in *Schima-Castanopsis* forest. Thus the previous studies about the carbon sequestration of *Schima-Castanopsis* forest of midhills are inadequate to characterize the carbon sequestration in these forests.More detail studies are needed to get better estimate of carbon sequestration in community managed forests (Bhattarai et al, 2012). The main carbon pools in forests are the living biomass of trees and understory vegetation and the dead mass of litter, woody debris and soil organic matter of which above ground biomass is important from the perspectives of deforestation and degradation (Gibbs et al, 2007). In this regard, this study aims to estimate the carbon content in biomass of *Schima-Castanopsis* forest in a midhill community forest.

MATERIALS AND METHODS

Study Area

This study was carried out in Jaisikuna Community Forest of Pokhara Lekhnath Metropolitian city-29 (previously Hemja VDC) of Kaski district.. The brief information of Jaisikuna community forest is presented in Table 1.

Table 1: Brief Information of Jaisikuna CF

Total area	19.00 ha
Forest type	*Schima-Castanopsis* forest

Forest condition	Medium
Total household	95
Total population of user group	863
Soil type	Silty loam and silty clay loam
Aspect	North east
Major forest species	*Schima wallichii (Chilaune)* and *Castanopsis indica (Katus)*
Other species	*Myrica esculenta, Myrsie capitellata Holarrhena pubescens, Engelhardia spicata , Rhododendron arboretum*

(Source: Jaisikuna Community Forest)

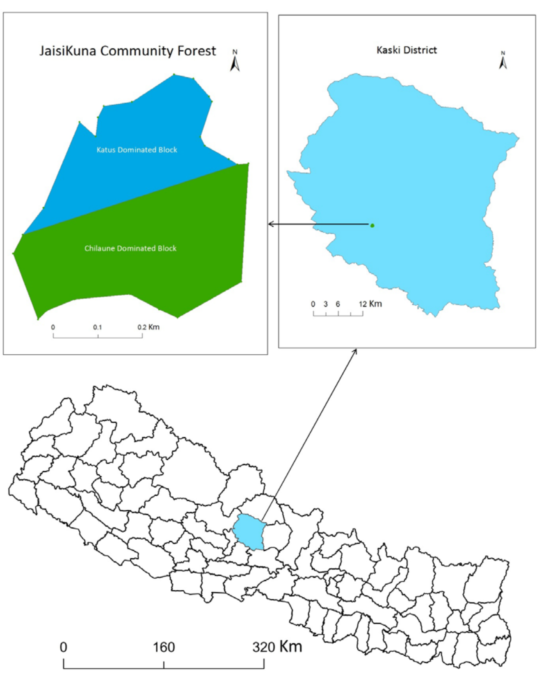

Figure 1: Studied Community Forest

Sampling

Total forest area is divided into two blocks*viz.* Chialune dominated and Katus dominated forest. Sampling procedures mentioned in Carbon measurement guideline (MFSC, 2011) formulated by the REDD implementation center was employed for data collection. Sample plots were taken at 10% sampling intensity on each block. Total 18 sample plots (9 in chilaune dominated block and 9 in katus dominated block) were established randomly for the field data collection. The rectangular plots of size 20×25m^2, 10×10m^2, 5×5m^2 were laid down for the tree, pole and sapling respectively at the corner of each plot. Litter, herbs and grass including seedling (LHG) were collected from the 1×1 m^2 laid down as nested plot.

Data Collection

The Diameter at Breast Height (DBH) of individual tree (DBH≥5cm) was measured by diameter tape and the height was measured by using a clinometer. All the LHG were collected and the fresh weight was taken in the field. The samples of LHG were placed in the marked sample bag and dried in the laboratory to determine the oven dry weight of the biomass.

Data analysis

Obtained data were fed into Ms-Excel and Statistical Package for Social Sciences (SPSS). Biomass and carbon content was estimated by using the following formulae.

Above ground tree carbon stock (AGTB)

Allometric equation developed by Chave et al. (2005) for moist forest stand was used to estimate above ground tree (tree, pole and sapling) biomass. Obtained value of biomass was multiplied by the IPCC (2006) default carbon fraction of 0.47 to estimate carbon content.

$$AGTB= 0.0509\rho \times D^2H$$

Where,

AGTB = above ground tree biomass (kg)

ρ = dry wood density (gm/cm^3)

D = tree diameter at breast height (cm)

H = tree height (m)

Under ground Biomass Carbon Stock

Underground biomass carbon stock was

calculated assuming 15% of the above ground tree biomass carbon stock.

Leaf litter, herb and grass (LHG) carbon stock

LHG includes litter, herbs, grass and seedling. The amount of biomass per unit area was calculated by:

LHG = W (field) /A × W (dry subsample) /W (wet sub sample)×10

Where,

LHG = biomass of leaf litter, herbs and grass (t/ha)

W (field) = weight of the fresh field sample of leaf litter, herbs, grass and sapling destructively sample within an area of size A (gm)

A = size of the area in which leaf litter, herbs, grass and sapling were collected (ha)

W (dry subsample) = weight of the oven dry sub sample of leaf litter, herbs, grass and seedling taken to the laboratory to determine moisture content (gm)

W (wet subsample) = weight of the fresh sub sample of leaf litter, herbs, grass and seedling taken to the laboratory to determine moisture content (gm)

The carbon content in LHG, C (LHG) was calculated by multiplying LHG biomass by 0.47 the default carbon fraction (IPCC, 2006).

Then total biomass carbon stock was estimated by adding up the value of all the biomass carbon pool. Total Biomass Carbon Stock (TBCS) = AGTB (carbon) + Below ground (carbon) + LHG (carbon)

Analysis of variance (ANOVA) and t-test have been used to test the significance of different of mean biomass and mean biomass carbon content.

RESULTS AND DISCUSSION

Above Ground Tree Biomass and Carbon

The AGTB of katus (59.59 t/ha) was found highest in katus dominated block followed by AGTB of chilaune (19.73 t/ha) (Figure 2). Likewise in chilaune dominated forest, AGTB of chilaune was highest (63.50 t/ha) followed by AGTB of katus (19.81 t/ha). In whole forest AGTB of chilaune, katus and other species was found 41.62 t/ha, 39.70 t/ha and 7.63 t/ha respectively. The AGTB of chilaune dominated block, katus dominated block and whole forest was found 93.16 t/ha, 84.74 t/ha and 88.95 t/ha respectively. Analysis of Variance (ANOVA) shows that the mean AGTB of species differs significantly in katus dominated block ($F=52.25$, $p=0.000$), chilaune dominated forest ($F=23.87$, $p=0.000$) and in whole forest ($F=12.65$, $p=0.000$). Khanal (2008) in *Schima-Castanopsis* forest at Palpa district found the aboveground tree biomass as 82.6±7.8t/ha.which was slightly lower than our findings. The AGTB was found 76.65 t/ha and 91.77 t/ha in *Schima-Castanopsis* forest at 1100-1200 and 1350-1500 elevation respectively (Shrestha, 2009). Neupane and Sharma (2014) reported 117.213 t/ha and 299.615 t/ha AGTB in Laxmi mahila and Jalbire mahila community forests in Gorkha district. Pandit (2014) reported the higher AGTB biomass (555.99 t/ha) in midhills community forests of Nepal.

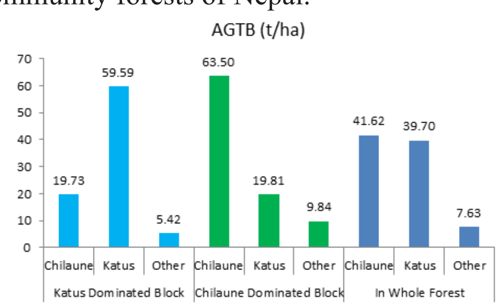

Figure 2: Above Ground Tree Biomass (AGTB) in different blocks

The AGTB carbon of katus (28.01 t/ha) was found highest in katus dominated block followed by AGTB carbon of chilaune (9.27 t/ha) (Figure

3). Likewise in chilaune dominated block AGTB carbon of chilaune was highest (28.85 t/ha) followed by AGTB carbon of katus (9.31 t/ha). In whole forest AGTB carbon of chilaune, katus and other species was found to be 19.56 t/ha, 18.66 t/ha and 3.59 t/ha respectively. The AGTB carbon of chilaune dominated, katus dominated and whole forest was found 43.78 t/ha, 39.83 t/ha and 41.81 t/ha respectively. Analysis of Variance (ANOVA) shows that the mean AGTB carbon of species differs significantly in katus dominated block ($F=52.25$, $p=0.000$), chilaune dominated forest ($F=23.87$, $p=0.000$) and in whole forest ($F=12.65$, $p=0.000$). Findings on AGTB carbon of the study is higher than the study carried out by Baral et al (2009). Baral et al (2009) reported AGTB and total above ground carbon stock as 76.24 t/ha and 34.30 t/ha respectively of *Schima-Castanopsis* forest. The AGTB carbon stock was found 32.91 t/ha and 39.46 t/ha in *Schima-Castanopsis* forest at 1100-1200 m and 1350-1500m elevation respectively. Pandit (2014) reported the higher AGTB carbon (250.66 t/ha) in a community forest of Kaski district. Neupane and Sharma (2014) reported 50.401 t/ha and 128.834 t/ha AGTB carbon in Laxmi mahila and Jalbire mahila community forests in Gorkha district.Aryal (2010) in his carbon assessment at the Sipadol Community forest in Bhaktapur found Carbon stock in *Schima-Castanopsis* forest 31.4 t/ha.

Leaf litter, Herbs, Grasses and Seedling Biomass and Carbon

The LHG biomass and carbon was found slightly higher in Chilaune dominated block (biomass=6.05 t/ha, carbon = 2.84 t/ha) than the katus dominated block (biomass=5.54 t/ha, carbon = 2.61 t/ha) (Figure 4). LHG biomass and carbon at whole forest was found 5.80 t/ha and 2.73 t/ha respectively. Neupane and Sharma (2014) reported the similar results in Laxmi mahila (biomass = 5.81 and carbon =2.501 t/ha) and Jalbiremahila (biomass = 6.295 t/ha and carbon = 2.707 t/ha) community forests in Gorkha district. There is very much variation in LHG biomass and carbon which is also affected by the leaf litter collection practice in Nepal's forest. In contrast to our findings, LHG biomass and carbon was found 3.75 t/ha and 1.61 t/ha respectively which at *Schima-Castanopis* forest of 1100-1200 m elevation (Shrestha, 2009). Likewise Pandit (2014) reported 1.725 t/ha LHG carbon in community forest of Kaski district.

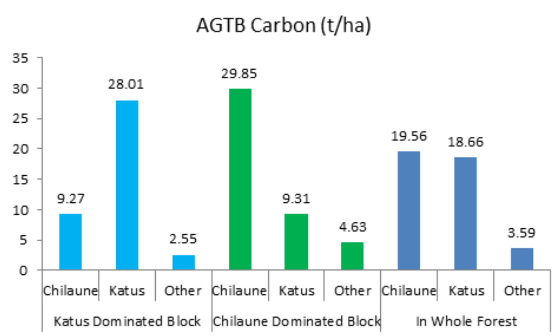

Figure 3: Above Ground Tree Biomass (AGTB) carbon in different blocks

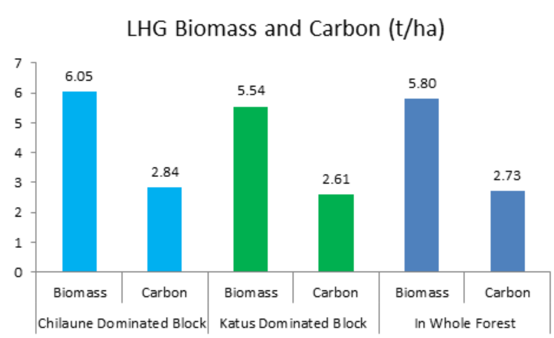

Figure 4: LHG biomass and carbon in different blocks

Below Ground Biomass and Carbon

The below ground biomass and carbon was found slightly higher in Chilaune dominated block (biomass=13.98 t/ha, carbon = 6.57 t/ha) than the Katus dominated block (biomass=12.71 t/ha, carbon = 5.97 t/ha) (Figure 5). Below ground biomass and carbon at whole forest was found 13.34 t/ha and 6.27 t/ha respectively. Root biomass was found 22.99 t/ha and 27.53 t/ha in *Schima-Castanopsis* forest of 1100-1200m and 1350-1500m elevation respectively (Shrestha, 2009). Shrestha (2009) also reported that carbon in root was 9.88 t/ha and 11.83 t/ha in 1100-1200m and 1350-1500m respectively. Pandit (2014) reported 50.135 t/ha underground biomass carbon which is very much higher than our finding.

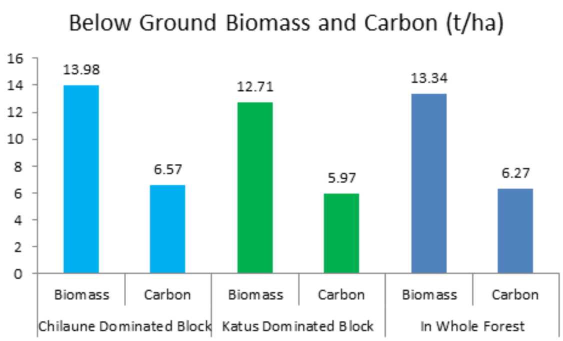

Figure 5: Below ground biomass and carbon in different blocks

Total Biomass and Carbon

The total biomass and carbon was found slightly higher in Chilaune dominated block (biomass=113.18 t/ha, carbon = 53.20 t/ha) than the katus dominated block (biomass=103.00 t/ha, carbon = 48.41 t/ha) (Figure 6). Total biomass and carbon at whole forest was found 108.09 t/ha and 50.80 t/ha respectively. Mean carbon content on chilaune dominated block was not found significantly different with the katus dominated forest (t-value=0.6597, p=0.5228) (Table 2).Our finding on total biomass carbon was similar with the findings of Shrestha (2009). He reported 52.32 t/ha and 47.9 t/ha total biomass carbon at *Schima-Castanopsis* forest of 1100-1200m and 1350-1500m elevation respectively. In contrast to our finding , Pandit (2014) estimated 302.004 t/ha total biomass carbon. Level of human disturbance and management intervention largely determines the carbon content. The variation in carbon content in different studies could be due to difference in disturbance and management intervention. Our finding is consistent with the findings of most of the studies conducted in the *Schima-Castanopsis* forest of midhills of Nepal. The variation in carbon content suggest us to conduct more studies about carbon content of forest having different biophysical condition and disturbance and management intervention.

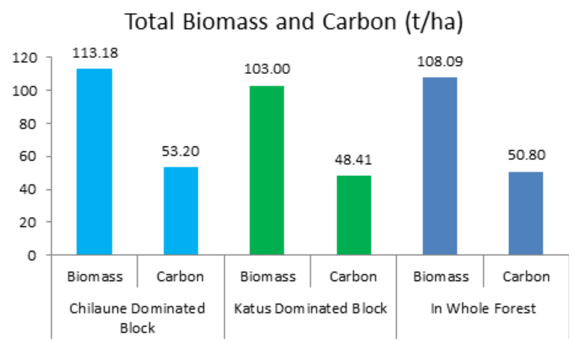

Figure 6: Total biomass and carbon in different blocks

Table 2 : Results of t-test to test equality of mean carbon content in Chilaune and Katus dominated block

Categories	t-value	sig.
AGTB carbon	0.6210	0.5468
LHG carbon	0.6896	0.5004
Underground carbon	0.6226	0.5458
Total carbon	0.6597	0.5228

CONCLUSIONS

AGTB of Chilaune, Katus and other species was found 41.62 t/ha, 39.70 t/ha and 7.63 t/ha respectively. Biomass and carbon content at Chilaune dominated block was slightly higher than that of the Katus dominated forest although the difference was not significant. Total biomass and carbon was found 108.09 t/ha and 50.80 t/ha respectively. The variation of the findings on the carbon content of the different studies suggests that there is high variation in forest condition and resulting carbon sequestration in Nepal's forest. Carbon estimation of *Schima-Castanopsis* forest in different elevation, aspect and region is recommended for further research to better understand the carbon sequestration dynamics of *Schima-Castanopsis* forest.

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