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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

Community forests of Nepal's midhills have high potentiality to sequester carbon. This paper tries to analyze 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) which were laid randomly. Diameter at Breast Height (DBH) and height of trees (DBH≥5cm) were measured using the DBH tape and clinometer. Leaf litter, herbs, grasses and seedlings were collected from 1*1m^2 plot and fresh weight was taken. For calculating carbon biomass is multiplied by default value 0.47. The AGTB carbon content of Chilaune, Katus and other species were 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. Carbon content at leaf litter, herbs, grasses and seedlings was found 2.73 t/ha. Below ground biomass carbon at whole forest was found 6.27 t/ha. Total biomass and carbon of the 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. This study record very low biomass carbon content than average of Nepal's forest but this variation in carbon stock is not necessarily due to dominant species present in the forest. Carbon estimation at forest of different elevation, aspect and location are recommended for further research.

Key words: Carbon, Aboveground carbon, Below ground, Sequestration

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Introduction

Climate change is evident in many respects (Karl and Trenberth, 2003; Trenberth, 2011). Recently published report of Intergovernmental Panel on Climate Change (IPCC) 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 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 out of which forests are the efficient carbon sinks (Canadell and Raupach, 2008).

Forests are crucial ecosystem for maintaining the global carbon balance as about 80% of all aboveground and 40% of all belowground 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 (Canadell and Raupach, 2008). Forests sequester large amounts of carbon annually (Bonan, 2008) and considered important natural "brakes" to climate change (Gibbs et al, 2007). 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 tons 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 13thConference of Parties to UNFCCC in 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 essential 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 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 such forests have huge potential to mitigate climate change through carbon sequestration (K C et al, 2013).

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). Schimawallichii (Chilaune) and Castanopsis species (Katus) are the dominant forest types especially in the midhills of Nepal. Schima wallichii and Castanopsis species constitute about 2.66% and 1.73% respectively of total stem volume of Nepal (DFRS, 2015). There is higher variation in past studies (Khanal, 2008; Neupane and Sharma, 2014; Pandit, 2014; Shrestha, 2009) 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 major 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 aboveground biomass is important from the perspectives of deforestation and degradation (Gibbs et al, 2007). In this regard this study was carried out with the aim of estimating carbon content in biomass of Schima-Castanopsis forest in community forests of midhills of Nepal.

Materials and Methods

Study Area

Study was carried out in Jaisikuna Community Forest of Pokhara-Lekhnath Metropolitian city-29 (previously Hemja VDC) of Kaski district, located on the western part of Nepal (Fig. 1). Kaski district covers an area of 2017 km^2. It lies between 83^0 40' to 84^0 12' latitude and 28^0 6'to 28^{0}36' longitude and is at 200 km distance far from Kathmandu the capital city of Nepal. The elevation of the district ranges from 450to 7969m above mean sea level so it comprises different climatic conditions in different parts of the district. Due to variation in landscape and altitude, there is greater variation in climate and resulting in diversity of natural vegetation. Range of rainfall varies from minimum 3038 mm to maximum 3353.3mm per annum. About 93649.85 ha (43.81 %) of the land is covered by forest out of which 17118.43 ha is handed over to 464 community forest user groups (DFO, 2017). Brief information of Jaisikuna community forest is presented in Table 1.

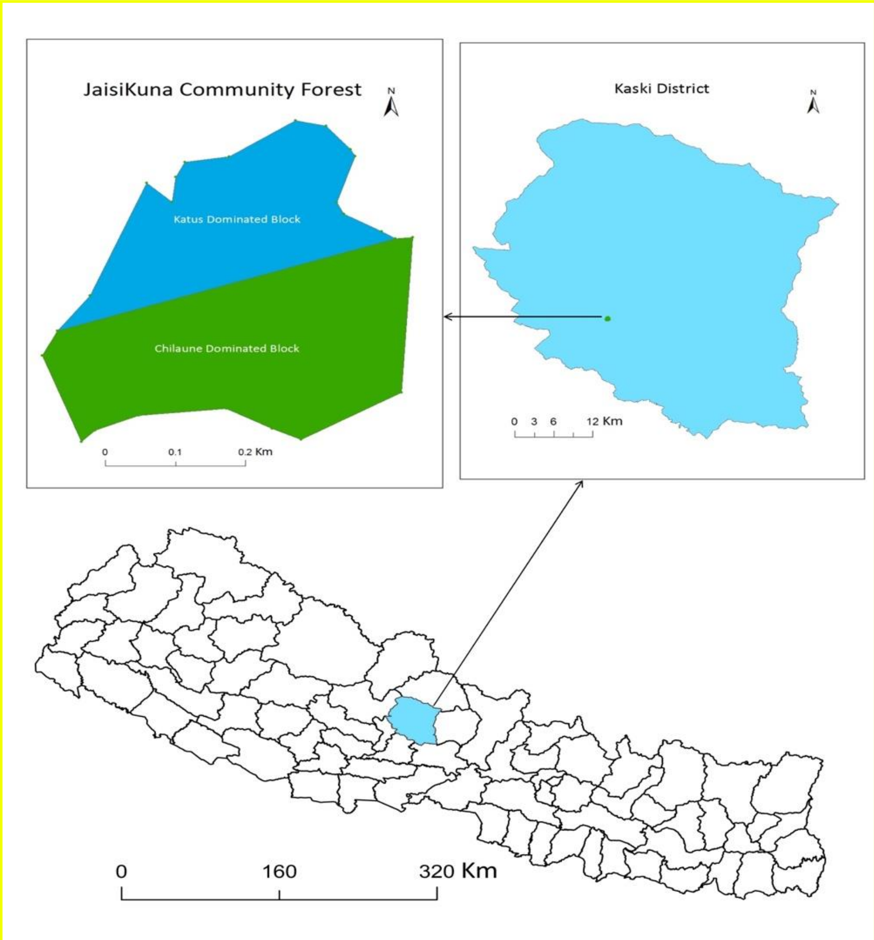

Figure 1: Studied Community Forest Table 1: Brief Information of Jaisikuna CF

Table 1: Brief information of Jaisikuna community forest

Total area	19.30 ha
Forest type	Schima-Castanopsis forest
Forest condition	Medium
Soil type	Silty loam and silty clay loam
Aspect	North east
Major forest species	Schimawallichii (Chilaune) and Castanopsisindica (Katus)
Other species	Myricaesculenta, MyrsiecapitellataHolarrhenapubescens, Engelhardiaspicata , Rhododendron arboretum

(Source: Jaisikuna CF OP)

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 has been employed for data collection. Sample plots are 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 $20\times25m^2$, $10x10m^2$,

$5\times5m^2$ 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 plots were 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 clinometers. 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 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 ANOVA and t-test. Analysis of variance (ANOVA) and t-test have been used to test the significance of different of mean biomass and mean biomass carbon content.

Aboveground 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)

Underground 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)

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 were 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 were found 93.16 t/ha, 84.74 t/ha and 88.95 t/ha respectively. Analysis of Variance (ANOVA) showed 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. Differences in the biomass value is resulted due to differences in site quality and number of dependent population. Kaski received the high precipitation than the Palpa which cause better site quality of Kaski than of Palpa. 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. Pandit (2014) conducted research in the community forest of the rural area having good condition of the forest in contrast to our study of the community forest of urban area and hence therefore he reported higher AGTB biomass.

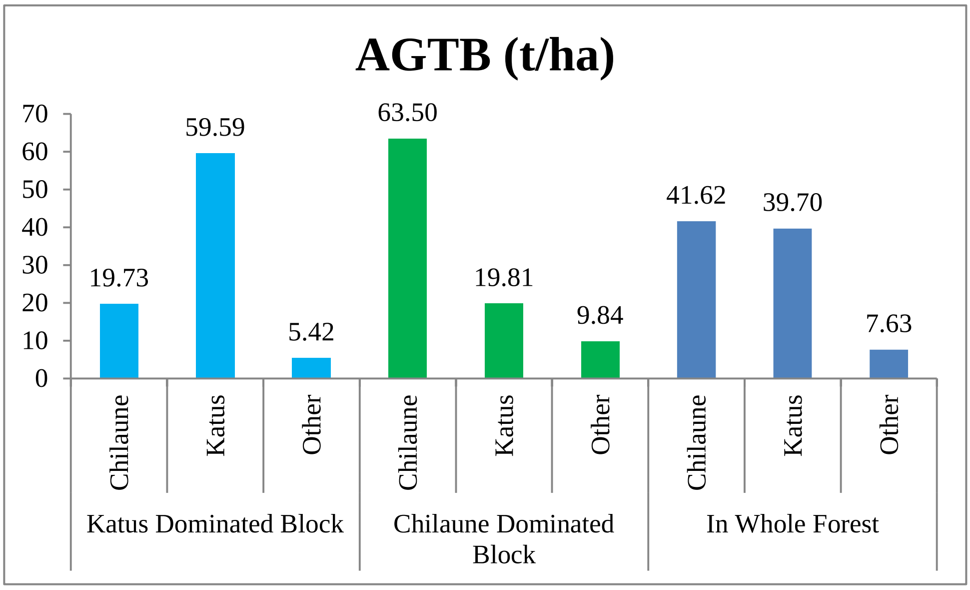

Figure 2: Above Ground Tree Biomass (AGTB) in different blocks

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.

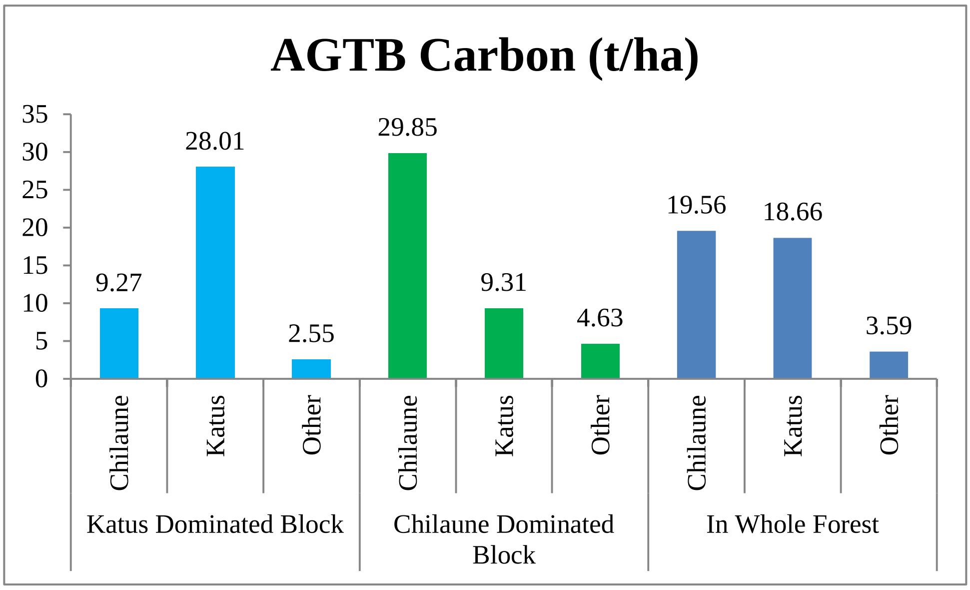

Figure 3: Above Ground Tree Biomass (AGTB) carbon in different blocks

The AGTB carbon of Chilaune dominated block, Katus dominated block 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. Differences in forest management practices, forest type, site quality and people's dependency cause difference in the AGTB biomass and carbon content.

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.

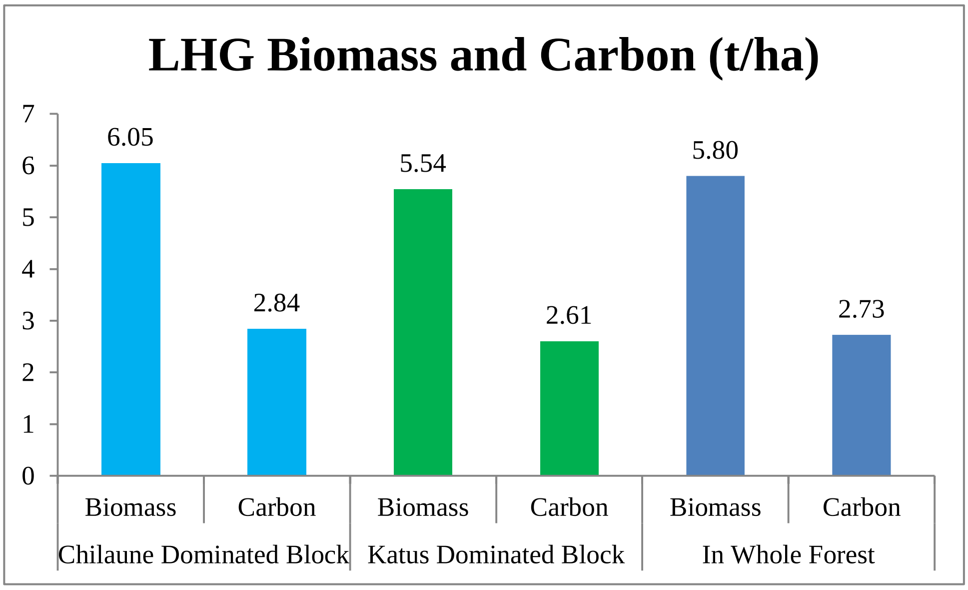

Figure 4: LHG biomass and carbon in different blocks

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. In contrast to our findings, LHG biomass and carbon was found 3.75 t/ha and 1.61 t/ha respectively at Schima-Castanopis forest of 1100-1200m elevation (Shrestha, 2009). Likewise, Pandit (2014) reported 1.725 t/ha LHG carbon in community forest of Kaski district. There is very variation in LHG biomass and carbon which is also affected by leaf litter collection practice in Nepal's forest.

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 in Katus dominated block (biomass=12.71 t/ha, carbon = 5.97

t/ha) (Figure 5). Below ground biomass and carbon of 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 at 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 at 1100-1200m and 1350-1500m respectively. Pandit (2014) reported 50.135 t/ha underground biomass carbon which is very much higher than our finding.

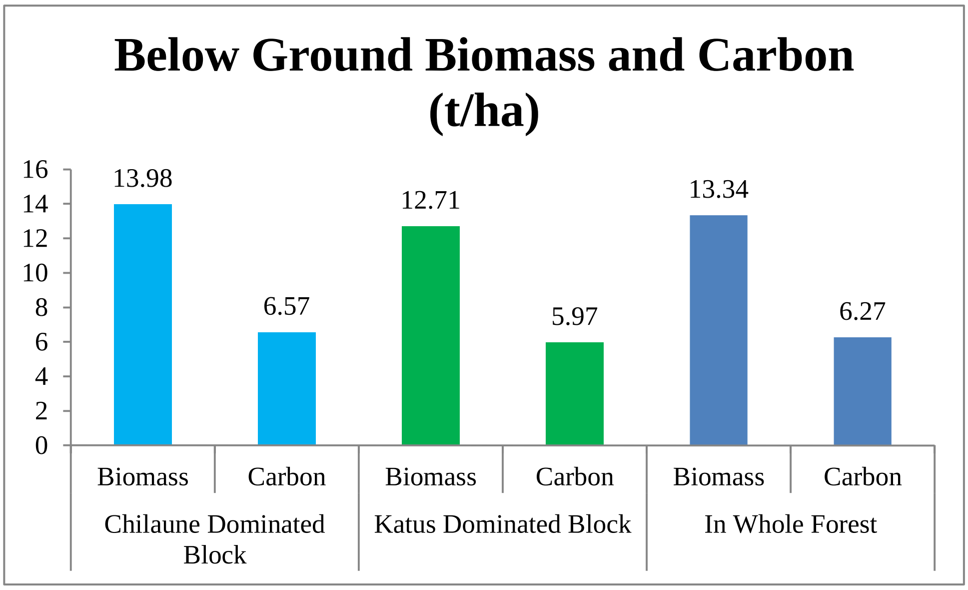

Figure 5: Below ground biomass and carbon in different blocks

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 5 and 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. National average carbon stock is 110.07 t/ha (DFRS, 2015) which is considerably higher than our findings. 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 the most of the studies conducted in 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.

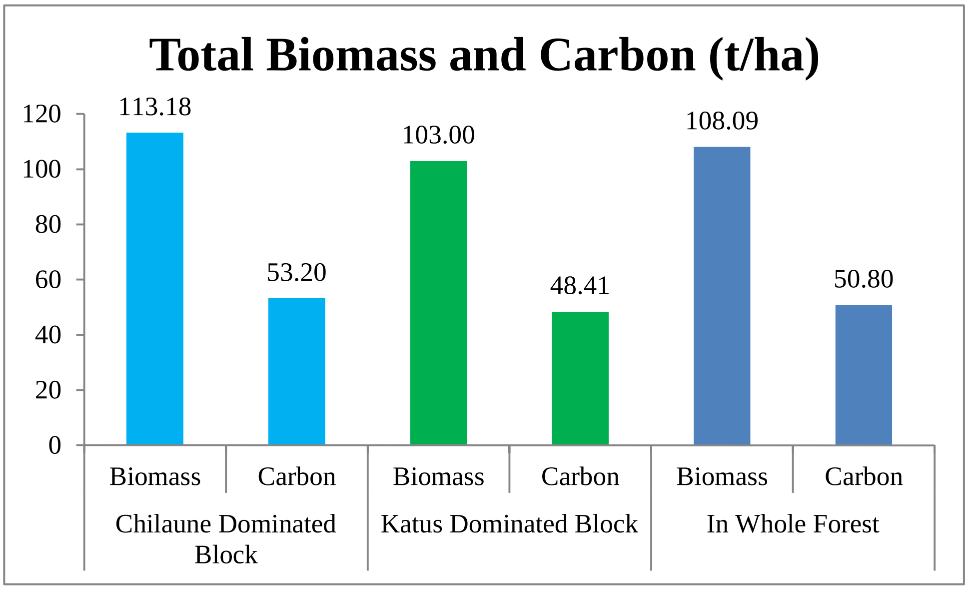

Figure 6: Total biomass and carbon in different blocks

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

Conclusion and Recommendation

Biomass and carbon content at Chilaune dominated block was slightly higher than that of the Katus dominated forest although the difference was not significant. Our finding on carbon stock is very much lower than the Nepal's average carbon stock. There is high variation in forest condition and resulting carbon sequestration in Nepal's forest. This study further adds that high level of variation can be occurred not only due to species but also site condition. Emphaisis should be given to increase carbon stock in the forest of semi-urban and urban area. 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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