Orinigal Article

Forest Carbon Stock: A Case of Bosan Community Forest, Kathmandu, Nepal

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Abstract: Forests are the integral to the global carbon cycle, the main factor responsible for the current pace of climate change is attributed to anthropogenic emission of greenhouse gases (GHGs) mainly CO_2. Forest plays an important role in the global carbon cycle. Carbon stock and carbon sequestration are major approaches for the climate change adaptation and minimization. This study estimated the carbon stock of Bosan community forests in Dakshin Kali municipality and to compare carbon stock in North and South (N-S) aspect. The inventory for estimating above and below ground biomass of forest was carried out using random sampling technique. The biophysical data were analyzed using statistical analysis. Soil samples were collected from three different depths 0-10, 10-20 and 20-30 cm in order to determine the soil carbon. Total carbon stock was computed by adding carbon stocks of five different forest pools viz; tree, soil, litter, herb and grass, estimated using standard methods for each plot. The species composition of the community forest is broadly categorized as sub-tropical forest. Altogether ten species were recorded during study in both northern and southern side of forest. Along the community forest, *Schima walichii* were found to be higher in both northern and southern side followed by *Myrica esculenata* in the northern side whereas *Alnus nepalensis* in the southern side of community forest. This community forest has storage of 9034.87 (kg/ha) total biomass in both Southern and Northern aspects out of which southern total biomass is 4238.1 (kg/ha) and northern total biomass is 4796.81 (kg/ha). The total SOC for whole community forest i.e. 137.8 ha is calculated to be 6056.83 (t/ha). The mean soil organic carbon in Bosan Community Forest was found to be 84.630 (t/ha). The total carbon stock for the Bosan Community Forest is found to be 6057.64 (t/ha) with total carbon stock of entire community forest is estimated to be 834742.8 ton.

Keywords: biomass carbon, soil organic carbon, mixed broad leaf forest, Kathmandu

1. INTRODUCTION

Global climate has always been changing naturally, but the changes in the last 50 years are dramatic and scientists attribute the change to human induced factors linked directly to increased levels of carbon dioxide (CO2) and other greenhouse gases (GHGs). On an average, the global temperature rose by 0.74°C over the last hundred years, with more than half of this rise, 0.44°C, in the last 25 years. Eleven of the twelve years between, ranks among the twelve warmest years [1]. As per Intergovernmental Panel on Climate Change (IPCC) fourth assessment report, Climate change may be due to natural internal processes or external forcing such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes. Also, climate change is a phenomenon caused by emissions of greenhouse gases from fuel combustion, deforestation, urbanization and industrialization [2], resulting variations in solar energy, temperature and precipitation [3].It is considered to be one of the most serious concerns to sustainable development, with adverse impacts on environment, agriculture, economic activity, natural resources and physical infrastructures [4].Intergovernmental Panel on Climate Change (IPCC) report says that planet will warm 1.5 degrees Celsius (2.7 degrees Fahrenheit) above pre-industrial levels by as early as 2030. It was previously assumed that limiting warming to 2 degrees Celsius would be enough to avoid a worse-case scenario but new findings says that limiting warming to 1.5°C cannot be considered a 'safe' option and at 1.5°C of warming or above, we are likely to trigger climatic, environmental, and ecological tipping points and thresholds from which we won't be able to reverse or recover. So, to avoid temperatures exceeding 1.5°C, the rate of human-induced warming would need to be reduced, starting immediately, by 50% by the 2040s [5]. Community Forest is a national forest handed over to a group of local households known as Community Forest User Groups (CFUG) for its development, conservation, and utilization for collective benefit of the community [6]. It plays a significant role to reduce carbon in the atmosphere. It will be very beneficial to find out the role of community forests as carbon sink. Nowadays, community forests are recognized to have huge reserves of carbon stored in their biomass and in the soil carbon pool where carbon remains sequestered for long durations in the deeper layers [7]. Carbon cycle connects forests and climate change. Forests contain large quantities of carbon, as approximately 77% of the global vegetation carbon is in tree biomass and approximately 42% of the global 1 m top soil carbon is in the forest soil [8]. A study describes that forests plays a very important role in maintaining natural processes and one of the biggest reservoirs of carbon to maintain the carbon cycle and other natural processes working and help reduce climate change [9]. According to him it can also be one of the biggest sources of CO2 emissions. Author further verified that when trees are cut down or burned, carbon dioxide is sent into the air which means fewer trees available to store carbon and also if plantation is done it protect and reduce the impact of climate change by keeping carbon in the forests and creating new trees to absorb CO2 from the atmosphere. Impact of applied forest management and climate change scenarios on increment, felling's and growing stock have been described [10], showing higher increments than in 1990 until 2020–2030, when increments in all scenarios started to decline as a result of ageing of the forests and high growing stocks being reached. Analysis on the impacts of forest management and climate change on the European forest sector carbon budget between 1990 and 2050 [11] and found that under changing climatic conditions average carbon stock of the soil was slightly smaller than under current climatic conditions due to faster decomposition of litter and soil organic matter under warmer climate. Analysis also showed that Carbon stocks in tree biomass, soil and wood products increased in all applied management and climate scenarios, but slower after 2010–2020 than that before. This is due to ageing of forests and higher carbon densities per unit of forest land. Environmental protection Agency (EPA) reported that carbon stock in forest is an essential in order to stable forest ecosystems and once carbon dioxide is converted into organic matter by photosynthesis, carbon is stored in forests for a period of time in a variety of forms before it is ultimately returned to the atmosphere through respiration and decomposition or disturbance. The amount of carbon stored in forests indicated that whether forest ecosystems are stable, growing, or declining [12] Author further mentioned that forest degradation reduces the number of trees and the stock of carbon in a specific forest area. As per Global Forest Resources Assessment report (2015) degradation of forests and soils is primarily caused by human induced activities, such as, clearing of forest lands for cultivation (land use changes), livestock grazing, fuel wood and timber extraction activities, and unscientific cultivation practices. Also, report mentioned that the degradation of forest and soil contribute significantly to carbon emission to the atmosphere leading to the build–up of carbon dioxide in atmosphere and contributing to global warming. Also, according to Global Forest Resources report, the world's forests store an estimated 296 Gt of carbon in both above- and below-ground biomass, which contains almost half of the total carbon stored in forests. The highest densities of carbon are found in forests of South America and Western and Central Africa, storing about 120 tons of carbon per hectare in the living biomass alone. In the past 25 years the carbon stocks in forest biomass have decreased by almost 11.1 Gt, equivalent to a reduction of 442 million tons per year or about 1.6 Gt of carbon dioxide. This reduction is mainly driven by carbon stock changes as a result of converting forest lands to agriculture and settlements and degradation of forest land. The country who losses maximum carbon stock are Africa, South America, and South and Southeast Asia and maximum carbon stocks increased in Europe, East Asia and North America. Oceania, the Caribbean, and Western and Central Asia reported only a slight increase. In case of Nepal, Community forestry has been the major source of carbon stock. The evidences show that about 20% of total carbon has been stocked in community forestry of Nepal [13].

Different studies have even shown that there is a high potential for Nepal to benefit from the REDD+ mechanism by expanding the community forestry program and bringing the regime under the REDD+ mechanism, where the successful participation can bring ecological and economic benefits to the community as well as the country [14].Forest not only sequesters carbon in biomass but also give positive effects on livelihood of local people due to its cost effectiveness and associated environmental and social benefits [15]. Forest can be a major carbon sink which can effectively reduce the emitted carbon through sustainable management [16].Few studies that has been taken place in community forest of Nepal are still found to be lacking on the data relating to forest carbon stock. So, this study describe carbon stocks present in the aboveground and belowground biomass and the soil predicting the effects of climate change on the spatial distribution of the carbon stock. In addition, the importance of forest carbon is related to designing the Reducing Emission from Deforestation and Forest Degradation (REDD+) program. REDD programs are particularly attractive for their potential to provide cost-effective options to mitigate global greenhouse gases (GHG) emissions [17]. REDD+ has significance to control the Deforestation and Forest Degradation, but it needs sufficient record of data in forest carbon for designing the Monitoring, Reporting and Verification (MRV) system. Therefore, there is a need to assess and analyze the forest carbon stocks so that the result provides an accurate, precise, and affordable solution for additional forest inventory. Assessing the impact of climate change on carbon sinks and predicting carbon stocks in a changing environment will make recommendations for the sustainable development element like environment, society, and economy [18]. Specific research studies that focus on the exploration of role of community forestry on climate change in proposed area isn't available. Therefore, this study aims to explore forest carbon stock of Bosan Community Forest. The aboveground biomass and belowground biomass both need to be measured to enable better calculations of total forest carbon [19]. Estimation of the forest carbon stock will enable us to assess the amount of carbon loss from deforestation or the amount of carbon that a forest can store when such forests are regenerated [20]. In Nepal, most studies have been conducted in forests for their tangible economic benefits whereas very few studies have been done on intangible benefits like carbon sequestration. Information on carbon stocks at different forest ecosystem in Nepal is generally insufficient/lacking [21]. Regarding all this fact, this study can play important role to generate data on carbon stock and through this study the potential of community forest to sequester carbon will be known. The major objective of this study is to estimate the carbon stock of Bosan Community Forests in Dakshin Kali municipality. The specific objectives include; to estimate forest Carbon stock of the forest, to compare Carbon stock in North and South (N-S) aspect & to determine the Soil Organic Carbon of the Bosan Community Forest.

2. MATERIALS AND METHODS

Bosan Community Forest which is located at 27° 38' 20" N latitude, and 85° 15' 41" E longitude and about 15km southwest of Kathmandu City, Chalnakhel VDC. There is Lalitpur district in the east, Makwanpur district in the west, Kantipur, Chandragiri Municipality in the north and Makwanpur district on the south. It lies at an altitude of 1501 m to 2245 m from sea level and covers an area of 137.8 hectares. This Community Forest is highly diverse in cultural, biological and religious diversity and natural beauty as well. It represents the typical middle mountain ecological zone. The average slope of the forest is (10-45) degree with North east aspect. The forest is characterized by sub-tropical and temperate vegetation. Altitude varies from 1501 meter to 2245 meter. The study was carried out in two forest patches of the opposite aspect, the forest patches on the northern aspect are Kaji Danda, Khar Gairi, Bhatta Danda, Ratto mate Danda, Soli Thumko, Ramchechaur, Naubise, White house while that of the southern aspect is Chyan Gairi. Forests of both aspects were in the same VDC but different ward. The forest on northern aspect was comparatively denser than that of the southern aspect. The forest was managed by the forest Ranger.

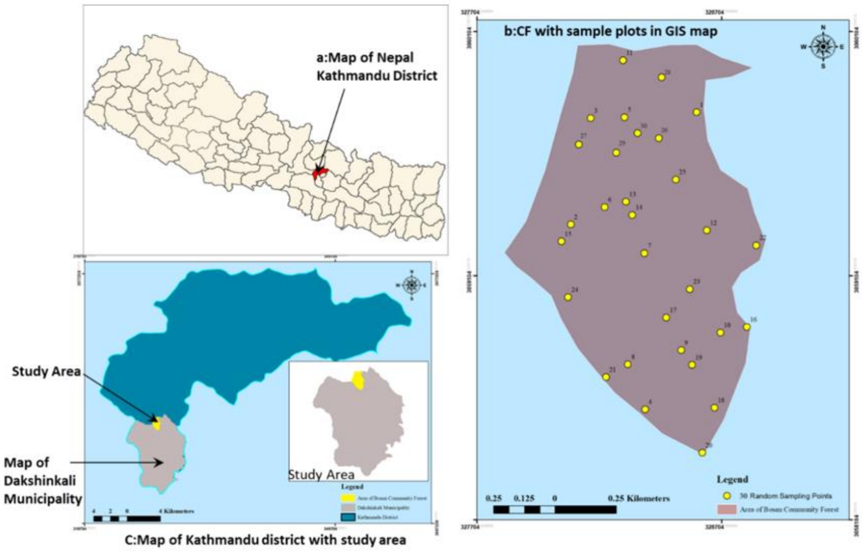

Figure 01: Location of study area

The name given to this Community Forest User Group is Bosan Community Forest which was handed over to government in 2051 B. S (1994). Total forest area is 137.8 hectare with 1252 no. of population and total household involved in this CFUG is 261.In this CFUG altogether there are 11 Committee members with 6 numbers of male and 5 numbers of female. The main castes and ethnic groups in the Community Forest include Tamang, Brahmin, Chhetri and Magar. Agricultural production, livestock rearing and forest resources are main sources of livelihood of the local people. Altitude varies from 1501-2245 meter. The Bosan Community Forest is very rich in plants diversity. *Alnus nepalensis* (Uttis), *Pinus Roxburghe* (Salla), *Castanopsis indica* (katas), *Schima walichii* (Chilaune) *Juglans regia* (Okar) and *Rhododendron arboretum* (Lali guarans).The forest area is divided into 9 blocks with different area namely (Kaji Danda-33.9 ha,Okhar Gairi-32.05ha, Bhatta Danda-40.9ha, Ratto mate Danda=25.79ha, Soli thumko-0.427ha, Chyan gairi-1.97ha,Ramchechaur-0.445ha,Naubise-1.332ha,White house-0.894ha.The average summer temperature of Kathmandu district varies from 28 to 30°C .The average winter temperature is 10.1°C .The city generally has a climate with warm days followed by cool nights and mornings. Two nearest meteorological stations, Khorana (lat: 27°64', long: 85°29', elevation: 1295 m/4249feet) and Godavari in Kathmandu district (lat: 27°35', long: 85°22', elevation: 1439m/4721feet) were selected as meteorological reference points for the description of the climate of the area.

The major timber species found in this forest are *Schima walichii* (Chilaune), *Castanopsis indica* (Katus), *Alnus nepalensis* (Utes), *Pinus Roxburghe* (Salla), *Juglans regia* (Okar), *Rhododendron arboretum* (Lali Guarans), and the major non timber species found in this forest are *Asparagus racemose* (Kurilo), *Swertia chirayita* (Charito), *Bergenia Ciliate (*Paka bed), *Zanthoxylum Arma tum* (Timur) and *Tinospora sinensis*(gurj) – (Bosan community forest, Nd).

Table 01: Vegetation Status of each forest block in Bosan Community Forest are as follows.

No. of Block	Name of Block	Forest Area	Timber Species
1	Kaji Danda	33.9 ha	Schima walichii, Castanopsis indica, Alnus nepalensis, Pinus Roxburghe
2	Okar Gairi	-32.05ha	Schima walichii, Alnus nepalensis, Castanopsis indica, Juglans regia
3	Bhatta Danda-	40.9ha	Schima walichii, Alnus nepalensis, Juglans regia
4	Ratto mate Danda	25.79ha	Alnus nepalensis, Castanopsis indica, Schima walichii, Juglans regia
5	Soli Thumko	0.427ha	Schima walichii, Alnus nepalensis
6	Chyan Gairi	1.97ha	Schima walichii, Alnus nepalensis, Pinus Roxburghe, Castanopsis indica
7	Ramchechaur	0.445ha	Schima walichii, Alnus nepalensis
8	Naubise	1.332ha	Alnus nepalensis, Castanopsis indica, Schima walichii,
9	White house	0.894ha	Alnus nepalensis, Schima walichii, Castanopsis indica

The primary data were collected from field observation such as height and DBH of the tree. Along with soil sample were collected from different depth. Besides, the data of geographical positioning system (GPS), altitude were recorded with the help of Garmin etrex GPS. Information from field interactions and discussions serve as primary data for the study. Secondary data were collected from literature review from related articles, books, dissertation papers and journals. These collected data were used in analysis of primary data. The plots were random sampled in the total study area of 1 Km^2. GPS was used to locate the plots. Using GIS tools, the sampling points were located in the map (ArcGIS 10.1) and altogether 30 points were selected randomly. The quadrate of size 20m×25m for trees, 1m×1m for litter were laid out and measurement of individual trees lying within the plots were taken following Community Forestry Inventory Guidelines 2061 BS. The soil samples were collected from four corners of the quadrate at two different depths i.e.0-10 cm, 10-20cm, and 10-30 cm. The study was carried out in two forest patches of opposite aspect and sample plots of equal area were laid out on the field. The number of plots on each aspect and its vegetation status are listed in Table 02.

Table 02: Sample design in different strata of forest.

Forest Aspect	Forest Area(ha)	Sample plot size(m2)	No. of plots	Vegetation Status
Northern Aspect	59.69 ha	20 x25	15	*Schima walichii, Castanopsis indica, Alnus nepalensis, Pinus Roxburghe, Fraxinus Floribunda, Engelhard a Spicata, Eugenia jambolana, Myrica esculenata, Rhododendron arboretum*
Southern Aspect	1.97ha	20 x25	15	*Schima walichii, Alnus nepalensis, Pinus Roxburghe, Castanopsis indica, Fraxinus Floribunda, Myrica esculenata*

The diameter at breast height (DBH) (at 1.3 m) and height of individual trees (having diameter more than 5 cm) was measured in plot of 20x25 m^2. Diameter tape and linear tape were used for this purpose. Each tree was recorded individually, together with its species' name. Tree present in boarder line was included if 50% of its body part lies inside the quadrate otherwise excluded. Trees overhanging into the plot were excluded, but trees with their trunks inside the sampling plot and branches outside were included. The regression model developed [22] was used to estimate the biomass of tree. The allometric model developed for moist forest (annual precipitation 1500-3500 mm) [23] was used for above ground biomass estimation;

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

Were,
AGTB = aboveground tree biomass (Kg)
ρ = wood specific gravity (gm cm^{-3}) from Community Forestry Inventory Guidelines 2061 BS.
D = tree diameter at breast height (DBH) (cm); and
H = tree height (m)

After taking the sum of all the individual biomass weights (in Kg) of sampling plots and dividing it by the area of sampling plots (500m2), the biomass stock density was obtained in Kg/m2.This value was then converted to (t/ha) by multiplying it by 10. Then biomass stock was converted into carbon stock after multiplication with the [24] default carbon fraction of 0.47. For Below-ground biomass calculation, [25] root-to-shoot ratio value of 1:5 as used. It means that below-ground biomass was calculated as 20% of above-ground biomass. The carbon content in below ground was calculated by multiplying BB with the IPCC,[26] default carbon fraction of 0.47. To determine the biomass of LHG, samples were taken from sampling plot of 1 m2. Fresh samples were weighed in the field with a 0.1 g precision; and a well-mixed sub-sample was then placed in a marked bag. The sub-sample was used to determine an oven-dry-to-wet mass ratio that was used to convert the total wet mass to oven dry mass. A sub-sample was taken to the laboratory and oven dried until constant weight to determine water content. For the forest floor (herbs, grass, and litter), the amount of biomass per unit area is given by:

$$LHG = W_{field} / A \times W_{subsample,\ dry} / W_{subsample,\ wet} \times 1/1000$$

Were,
LHG = biomass of leaf litter, herbs, and grass (t ha-1)
W_{field}= weight of the fresh field sample of leaf litter, herbs, and grass destructively sampled within an area of size A (g)
A= size of the area in which leaf litter, herbs, and grass were collected (ha);
$W_{subsample,\ dry}$= weight of the oven-dry sub-sample of leaf litter, herbs, and grass taken to the laboratory to determine moisture content (g); and
$W_{subsample,\ wet}$= weight of the fresh sub-sample of leaf litter, herbs, and grass taken to the laboratory to determine moisture content (g).

The carbon content in LHG, C (LHG), is calculated by multiplying LHG with the [27] default carbon fraction of 0.47. Soil samples from different depths (i.e.0-10 cm, 10-20cm, and 10-30 cm) were collected from the study site by removing all the vegetation and litter from the soil surface. The collected soil samples were carried to laboratory. The soil sample was sieved through 2mm sieve. Bulk density is needed for the calculation of soil organic carbon. Bulk density was estimated through core sampler method [28]. Soil sample collected were oven dried at 105oC until constant weight. Bulk density of soil was calculated; Bulk density = wt. of oven dried soil/volume of core sampler.
About 100gm soil sample collected from each plot and stratum were air dried in laboratory and sieved with 2 mm sieve. Finally the percentage of OC was determined with the help of titrimetric method [29]. % Soil Organic Carbon is calculated as:

$$\% C= 3.951/g\ [1 - T/S]\ \#$$

Were,
g=weight of sample in gram,
T=ml ferrous solution with sample titration,
S=ml ferrous solution with blank titration.
The carbon stock density of soil organic carbon will be calculated by equation [30]:
SOC = %C ×ρ ×d

Were,
SOC = Soil organic carbon stock per unit area (t ha-1)
%C = Carbon concentration
ρ = Soil bulk density (gm cm-3)
d = the total depth at which sample was taken (cm)
Estimation of total carbon content
Total above ground carbon Stock (t/ha) **=** [Total above ground tree biomass (t/ha) + Total under growth biomass (t/ha) 50%]
Total below ground carbon stock (t/ha) **=** [Total root biomass of tree (t/ha) * 50% + Total soil organic carbon stock (t/ha)]
Total carbon stock (t/ha) = [Total above ground carbon Stock (t/ha) + Total below ground carbon stock (t/ha)]
Total carbon stock:
$C_{Total} = C_{(AGTB)} + C_{(BB)} + C_{(LHG)} + SOC$
Were,
C_{Total} = Total carbon stock [ton C/ ha],
$C_{(AGTB)}$ = carbon in above-ground tree biomass [ton C/ ha],
$C_{(BB)}$ = carbon in below-ground biomass [ton C/ ha],
$C_{(LHG)}$ = carbon in litter, herb & grass [ton C/ ha], and
SOC = soil organic carbon [ton C/ ha]
The total carbon stock was calculated by multiplying the C_{Total} with area of forest (137.8 Hectares).

3. RESULT & DISCUSSION

The species composition of the community forest is broadly categorized as sub-tropical forest. Altogether ten species were recorded during study in both northern and southern side of forest. Along the community forest, *Schima walichii* were found to be higher in both northern and southern side followed by *Pinus Roxburghe* in the northern side whereas *Alnus Nepalese* in the southern side of community forest. Density is calculated by the number of individual trees per unit area and it indicates the numerical strength of a species in a community. The species composition of the studied area is illustrated in figure 02.

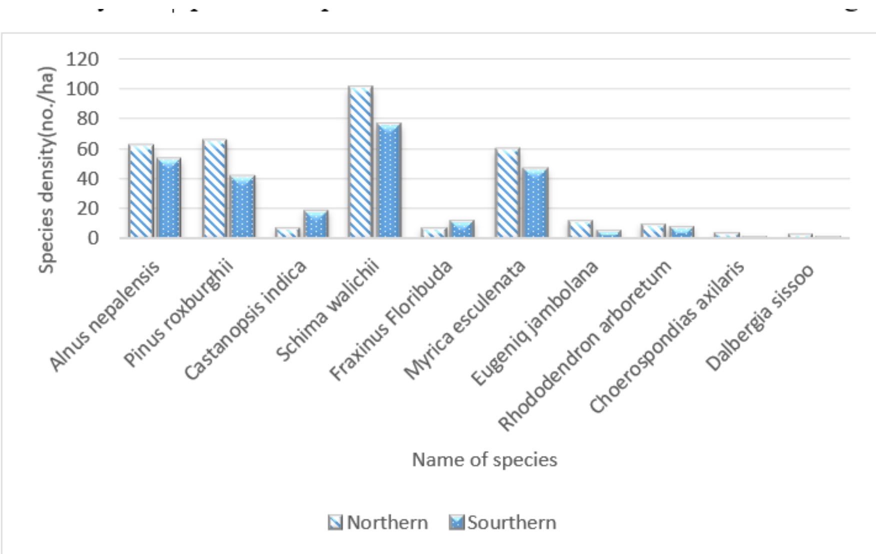

Figure 02: Species composition of Bosan community forest in two opposite aspects

Altogether 518 individuals of 10 species, 302 in northern side and 216 in southern side were recorded during the study in 30 sampling quadrates each of 500 m^2. The total no. of pole, small timber and large timber in both northern and southern side are 64, 388 and 66 respectively. The standing class of the tree is measured on the basis of categorization developed by Department of Forest, Forest Inventory Section (SSRC). On the basis of this classification, 70 trees/ha in northern and 14 trees/ha in southern side (DBH; 12 cm to 25 cm) of the sampled vegetation was observed, 280 trees/ha in northern and 237 trees/ha in southern side (DBH; 25 cm to 50 cm) of the sampled vegetation was observed and 52 trees/ha in northern and 36 trees/ha in southern (DBH; greater than 50 cm) were observed in Northern and Southern side of study area as shown in Figure 03.

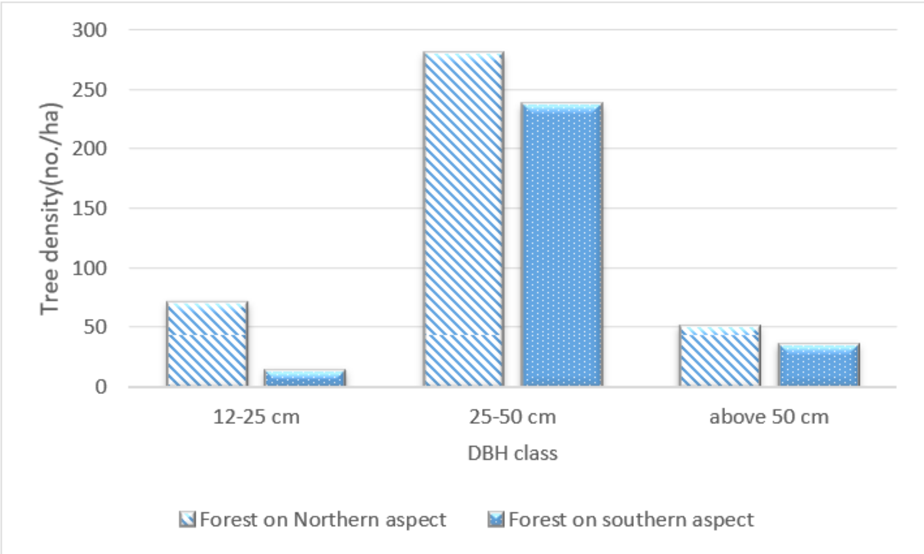

Figure 03: DBH class in the forests of opposite aspects

The total Carbon content of tree of all the sampling plots was found to be 231.87 t/ha out of which 132.12 t/ha was Northern Carbon content of tree and 99.75 t/ha was Southern Carbon content of tree.

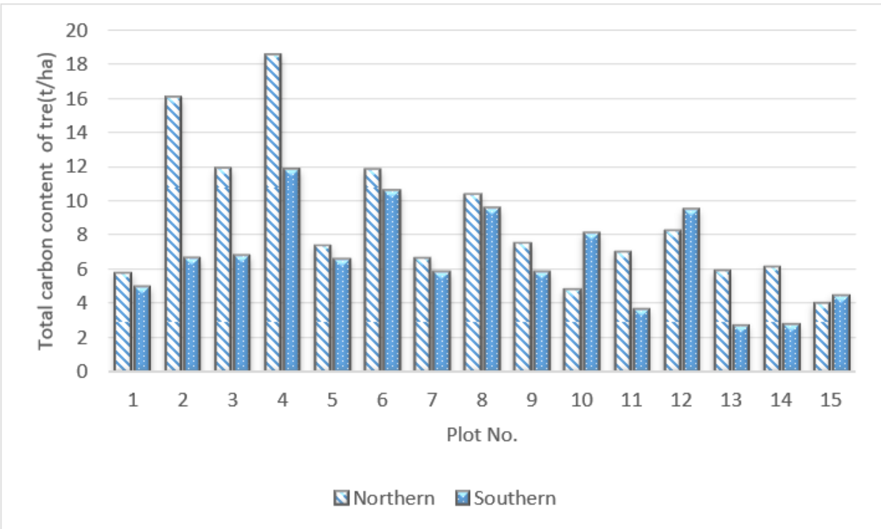

Figure 04: Plot wise Carbon content in the forest of opposite aspects

On species wise biomass carbon distribution, carbon content in *Schima Walachia was found* highest in both Northern and Southern aspects i.e.49.44(t/ha) and 30.32(t/ha) respectively followed by *Myrica esculenata* in which carbon content is 27.42 (t/ha) and 22.30(t/ha) in northern and southern aspects. The highest carbon content of these old growth trees may be due to favorable environmental and geophysical factors existing in the study area that supports large and mature trees that ultimately store more carbon even though the number is few. The lowest carbon content found in the species *Choerospondias axillaries* in both northern and southern aspects i.e.0.57(t/ha) and 0.33(t/ha) respectively. The species wise carbon distribution is given in below figure 05.

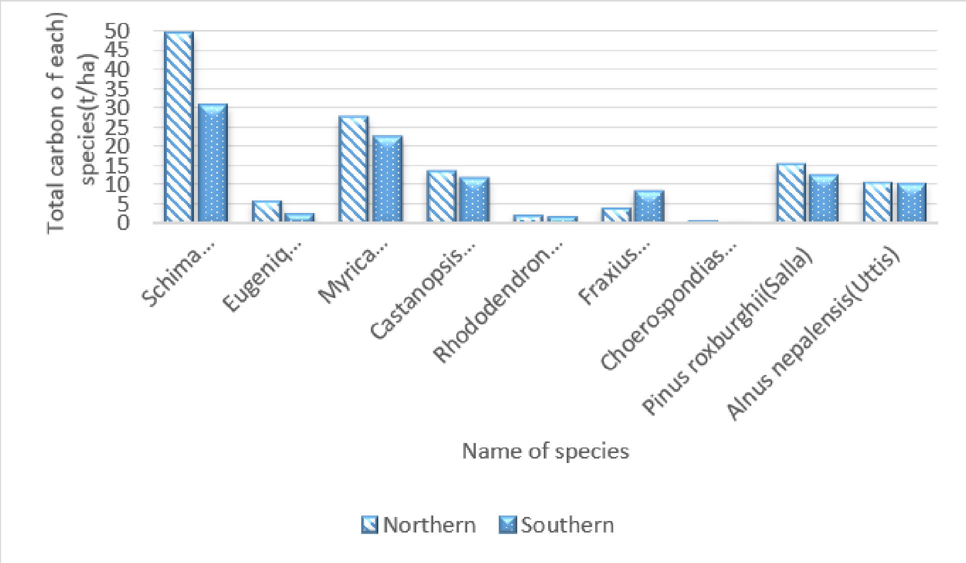

Figure 05: Species wise Carbon content analysis in the forests of opposite aspects

Carbon stock (t/ha) of both Northern and Southern aspects were compared and were found remarkable different of 1.26 in average of each 15 numbers of total plots in two aspects as shown in figure 06.

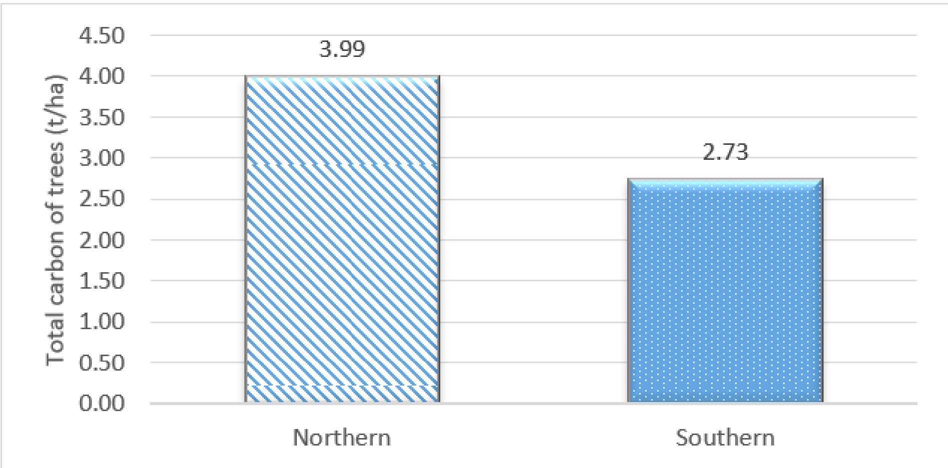

Figure 06: Comparison of carbon stock content in two opposite aspects

Soil Organic Carbon (t/ha) of both Northern and Southern aspects were compared and were found remarkable different of 22.56 in average of each 15 numbers of total plots in two aspects as shown in figure 06. The total SOC of studied area is found to be 5106.13 (t/ha). Average SOC of both Southern and Northern was taken and found more in Northern part i.e. 112.23 (t/ha). The present study data on the soil carbon are based on (0-30) cm depth. Higher value in Northern soil layer is due to accumulation of litter, debris and presence of dead and decomposed organic matter. Higher microbial activity, presence of soil air and water are the good condition for decomposition. Because of these factors, there is generally higher carbon content in soil layer.

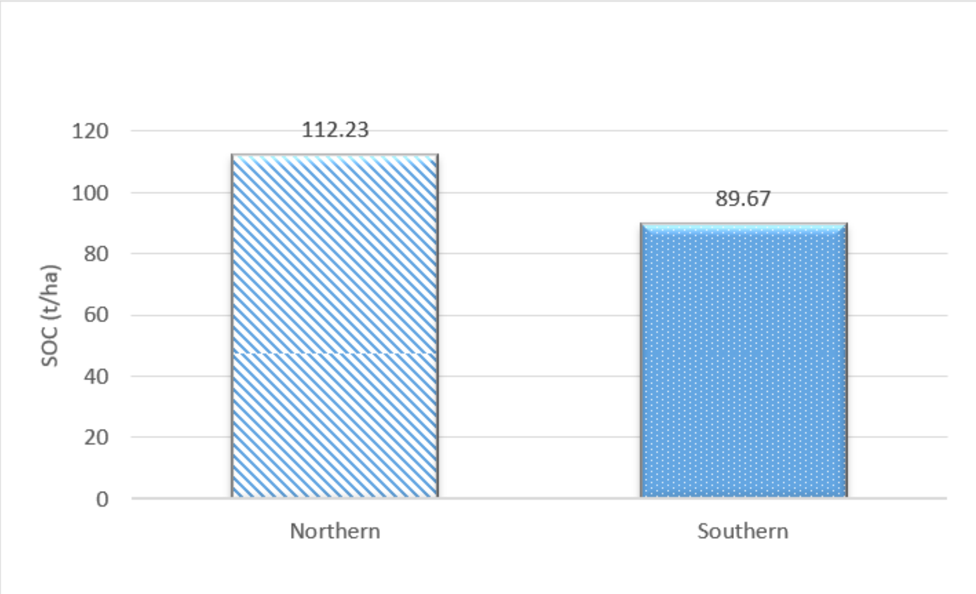

Figure 07: Comparison of Soil Organic Carbon content in two opposite aspects

Total carbon stock is calculated by adding biomass carbon and soil organic carbon. The total carbon stock for the Bosan Community Forest is found to be 5338.60 (t/ha). The total carbon stock of entire community forest is estimated to be 735658.71 ton. Total carbon stock (t/ha) of both Northern and Southern aspects were compared and were found remarkable different of 24.18 in average of each 15 numbers of total plots in two aspects as shown in figure 08. Average total Carbon stock of both Southern and Northern was taken and found more in Northern part i.e. 119.73(t/ha).

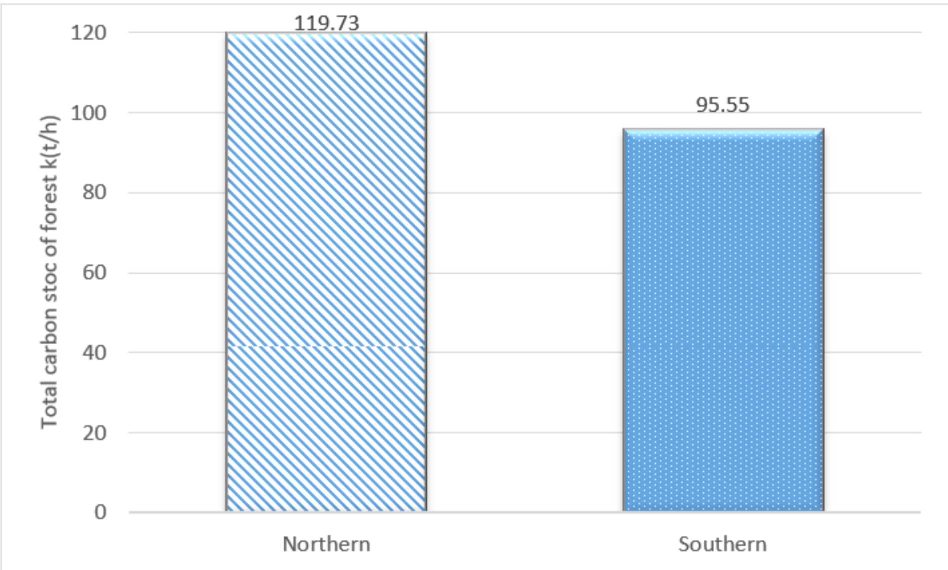

Figure 08: Comparison of total Carbon stock content in two opposite aspects

4. DISCUSSION

It is reported that SOC might be high when there is high growth of vegetation [31]. In contrast, average soil organic carbon of northern aspects (112.23 t/ha) is higher than southern aspects (89.67 t/ha). There might be different factors for such results. SOC is determined by the solar radiation, ground vegetation, biomass content and microbial activities and so on [32]. This might be the reason, the SOC in northern aspect was found to be more compared than southern aspect where the exposure of solar radiation is higher compare to other aspects. According to [33] higher microbial activity, presence of soil air and water are the good condition for decomposition that could be reason why average northern SOC is higher than southern SOC. Forest management activities especially the harvesting of biomass has the potential to significantly increase or decrease soil carbon [34]. It is said that, forest thinning changes soil temperature, soil water content, and root density and activity, and thus changes soil respiration, which in turn influence soil carbon cycling [35]. Harvesting may shift the soil carbon balance by altering the quantity and quantity of detrital C inputs, changing soil microbial community composition, and affecting the climatic conditions that drive plant and microbial processes [36,37]. According to the statistical analysis; there is no significance difference between northern and southern aspects SOC ($t = 2.05$, $df = 27$, $p > 0.05$). In Southern Forest there is grazing pressure disturbing the soil where as in the Northern Forest the land is not disturbed, which causes the high SOC content in North Forest than in South Forest. Minimizing soil disturbances generally lead to SOC accumulation, while high intensity and frequency of cultivation cause SOC decline [38]. As, from our analysis, SOC of Northern Forest was found to be higher than Southern Forest, similar to Dahal, 2007.The south aspects are warm and dry causing depletion in SOC, while north aspects are cooler, moister, with slower growth and decomposition rates; hence greater accumulation of organic carbon [39]. SOC was found to be higher in North Forest it might be because of, South Forest lies in the south facing slopes whereas the North Forest lies in cooler and moist place. According to FAO, 2005 report, SOC of South and South East Asia was 68.4 (t/ha). SOC of 55.25 (t/ha) in Shivpuri National Park [40]. Similarly, a study [41] reveals that highest SOC is in naturally grown forest and is 53.25 (t/ha). According to a study [42] 2004, the mean SOC pool to a depth of 1 m in the middle hills is estimated to be 89.1 (t/ha) for the forest. The present study has higher value of SOC than these studies. The organic carbon of mineral forest soil to 1 m depth varies between 20 to over 300 (t/ha) depending upon forest type and climatic condition [43]. The higher value of present study may be due to favorable microbial condition. Forest plays the significant role in the climate change as they emit as well sequestrate carbon dioxide. Trees absorbs atmospheric CO^2 for their growth and the carbon content in the soil as well revitalizing degraded forest lands and soil in the global terrestrial ecosystem can sequester 50-70% of the historic losses [44]. The potential of forest to sequester carbon depends on the forest type, age of forest and size of trees [45]. The carbon stock density would vary according to the geographical location, plant species, age of the stand, above ground input received from leaf litter, decomposition of fine roots below ground, management practices and other operating ecological factors [46]. In study site biomass carbon of vegetation varied between plots of forest because of variation in tree size, forest composition, as well as density of tree. From the study it was found that, the total biomass carbon content of tree was higher in northern aspects (132.12 t/ha) than southern aspects (99.75 t/ha) of Bosan community forest. According to the statistical analysis; there is no significance difference between northern and southern aspects total carbon stock of tree ($t = 2.04$, $df = 28$, $p > 0.05$). Around (75%) of the trees in the studied forests had the DBH of 25-50 cm. Trees in forest (including plantation) if well stocked, typically sequester carbon at a maximum rate between about age 10 and 20-30. As an indicator, at age 30 years, about 200-520 tons carbon dioxide (CO_2-e) are sequestered per ha in forests with productivity ranging from low to high [47]. So, the studied forest might have the potentiality to sequester more carbon. In the southern aspects, the tree density was lower than the northern aspects, having 288 trees/ha. So, these factors have led to the lower value of carbon stock in southern aspects. On species wise carbon distribution, carbon content in *Schima wallchii was found* highest in both northern and southern aspects i.e.49.44(t/ha) and 30.32(t/ha) respectively followed by *Myrica esculenata* in which carbon content is 27.42 (t/ha) and 22.30(t/ha) in northern and southern aspects. The highest carbon content may be due to wood specific gravity and DBH of mature tree. These old growth trees may be due to favorable environmental and geophysical factors existing in the study area that supports to store more carbon even though the number is few. The lowest carbon content found in the species *Choerospondias axillaries* in both northern and southern aspects i.e. 0.567(t/ha) and 0.33(t/ha) respectively. In southern aspects few areas are found to be barren, this might be the reason why northern aspects got the higher tree biomass stock than southern aspects. According to the statistical analysis; there is no significance difference between northern and southern aspects total carbon stock of tree species wise (t =2.11, df = 16, $p>0.05$). The total biomass of the Bosan CF was high than that of [48] this may also due to forest have high number of the small tree (DBH; 25 -50cm. Chhetri (1999) found 469 (t/ha) of biomass in an undisturbed protected forest in Kathmandu valley. The reason for the high biomass in studied area may be due to the presence of more trees up to 50 cm and also age and type of species and density affects the biomass. Similarly, the Bosan community forest has low use of forest products. It was found 115.29±13.12 (t/ha) during the study on the CF of Lalitpur, these is also low than that of Bosan Community Forest [49]. This may also due to use of less forest product by local people of Lalitpur. The average total carbon stock of studied area for the Bosan community forest is found to be 177.95 (t/ha), which was less than that estimated [50]. Average carbon stock (t/ha) of both northern and southern aspects is compared and found remarkable different of 24.18 in average of each 15 numbers of total plots in two aspects. Average total carbon stock of northern is found more i.e. 119.73(t/ha). According to the statistical analysis; there is no significance difference between northern and southern aspects total carbon stock (t =2.04, df = 20, $p>0.05$). The high carbon stock in this forest may be due to old age of the forest and also religious forest are less disturbed than any other forest in Nepal. This forest has been conserved by local people for thousands of years for the sake of religious belief. Due to this, carbon stock stored by this forest may be high. Moreover, forest management, topographic and edaphic factors [51] also influence the total carbon stock. Total carbon sequestered was higher in more southerly than northerly facing areas [52]. Also, the religious forest experience almost no disturbances as compare to other forest where the regeneration is very low as the forest canopy are not exposed. Wet or moist forest store more carbon than dry or semi dry forests and mature forests store greater quantities of forests than do young forests. Different management practices and age of the forest also affect the carbon stock in the forest. The amount of carbon stock in a forest change over time due to climatic conditions, succession of vegetation and disturbances [53]. Furthermore, tree biomass shows potential of changes with the forest management activities such as site preparation, soil drainage, selection of species and schedules such as planting and harvesting [54]. Hence, it is important to consider total forest carbon stocks in implementing these activities. This means that the forest needs to be regenerated following harvesting and need to be left to grow long enough to reach the previous level of carbon stocks. Species with the highest biomass has the highest rate of carbon stock [55]. This study also shows the biomass of *Schima Walachia* is higher than the other, so the carbon sequestration is also high in the forest dominated by the same species. Singh and Singh (1988) have reported highest carbon stock of 250 to 300 tons per hectare (t/ha) and carbon sequestration rate of 6.00 to 8.00 tons per hectare per year (t/ha)/year) to all Central Himalayan Forests. Similarly, [50] studied the seven Central Himalayan Forests and found the carbon stock of 166.80 (t/ha) to 440.10 (t/ha) with carbon sequestration rate of 6.83 ± 7.42 (t/ha)/yr. temperate forest of the world has carbon stock of 125.00 ± 4.19 (t/ha) .Net primary productivity differs according to vegetation types, age of the stand and the surrounding environment [52]. As compare to [53] this Bosan CF has high carbon stock, this may happen because this forest is present in the city area where dependency on forest products is less compared to rural areas. Reducing emissions from deforestation and forest degradation is potentially low-cost option for mitigating climate change. Application of REDD actions with Community Forest will further offer potential contributions to enhance the livelihood of rural communities. REDD implementation, monitoring and transaction cost was difficult to calculate due to the lack of REDD scheme implemented in Nepal. If REDD scheme is implemented, it will provide additional benefit to the local people in the future. It would help to enhance the economic standard and livelihood of the vulnerable and indigenous people and encourage them for sustainable management of forest resource.

5. CONCLUSION

All together ten species were present in both northern and southern side of Bosan community forest with *Schima Walachia* dominating the forest with 29.82 % of total trees. The reason that this species found to be higher in this community forest is there is favorable climate for this species and the regeneration is also high. Small timber having DBH; 25 cm to 50 cm were present more than 70% in the community forest. This is due to community strictly prohibited to cut the trees. Along the community forest, high carbon stock was found in *Schima walichii* in both northern and southern side followed by *Myrica esculenata.* The highest carbon content may be due to wood specific gravity and DBH of mature tree. These old growth trees may be due to favorable environmental and geophysical factors existing in the study area that supports to store more carbon even though the number is few. Biomass carbon content (t/ha) of both northern and northern aspects were compared and were found difference of 1.26 (t/ha) in average of each 15 numbers of plot. Bosan community forest has storage of 24666.99 kg total biomass in both southern and northern aspects out of which northern total biomass is 14055.39kg and southern total biomass is 10611.60 kg. Average SOC in this Community Forest up to 30 cm depth from the ground is found to be 170.20 (t/ha) in which average SOC of northern and Southern aspects are 112.23(t/ha) and 89.67(t/ha) respectively. The total SOC for studied community forest area is 5106.13 (t/ha). High SOC in northern aspects is due to climate, moisture, temperature and types of soil present with human settlements around there and also harvesting shift the soil Carbon balance by altering the quantity and quantity of detrital Carbon inputs, changing soil microbial community composition, and affecting the climatic conditions that drive plant and microbial processes. The total carbon stock for the Bosan Community Forest is found to be 5338.60 (t/ha). The total carbon stock of entire community forest is estimated to be 735658.71 ton. Total carbon stock is greater in *Schima walichii.* So, promotion and conservation of this species should be done and plantation in barren land of Bosan community forest should be done. The studied community forest has more than 70% of tree having DBH 25-50cm which indicate high potential of increasing biomass in the future. To increase the regeneration of forest, should be protected from rearing of domestic animals.

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