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Quantification of Above- and Below-Ground Carbon Stocks in Selected Community Forests of Nepal: A Case Study from Community Forest and Government Managed Forest of Sindhupalchok District, Nepal

Dinesh Humagain[1]*, and Yadav Humagain[2]

[1]*Ministry of Forest and Environment, Bagmati Province, Hetauda, Nepal*
[2]*Agriculture and Forestry University, Faculty of Agriculture, Chitwan, Nepal*

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Corresponding Author: **Dinesh Humagain** | E-Mail: **(dinesh.kavre@gmail.com)**

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ABSTRACT

The study entitled "Quantification of above and below ground carbon stocks in selected community forests of Nepal (A case from Community Forest and Government Managed Forest of Sindhupalchok, Nepal)" was aimed at to estimate the above ground and below ground carbon stock of Selang Manju Community Forest and LakpaDorje Government Managed Forest of Sindhupalchok district, Nepal. Out of the total 196.16 ha Community forest area 1.5 ha i.e. 0.76% area was selected for the forest inventory. All together there are 30 plots in the community forest and other 30 plots in the government-managed forest.Primary and Secondary data were collected and analyzed by using the t test. Tree carbon stock in Government managed forest was found to be higher with 77.86 ton/ha than CF with 74.39 ton/ha. Tree carbon stock of Government managed forest is very high because in the National Forest there were lots of old trees which have carbon storage but they do not have sequestrating capacity anymore. Sapling carbon stock was found to be lower in government managed forest with 0.92 ton/ha than in community forest with 0.97 ton/ha. LHG carbon was found to be higher 1.31 ton/ha in government-managed forest than CF with CF with 1.16 ton/ha. Dead wood carbon stock in Government managed forest was found to be higher with 12.01 ton/ha than CF with 11.48 ton/ha. The below ground carbon consists of Root Carbon. The root carbon of government managed forest was found to be higher with 16.58 ton/ha than community forest with 15.84 ton/ha. The soil organic carbon was found to be 170.54 ton/ha in community forest and 172.18 ton/ha in government managed forest. Total carbon stock of Government managed forest was found to be higher with 280.86 ton/ha than community forest with 274.28 ton/ha. The total carbon stock of the community forest is 274.28 ton/ha similarly the total carbon stock of the government managed forest 280.86 ton/ha. The total carbon in the community forest is 53802.76 ton similarly the total carbon in the government managed forest is 57576.30 ton. The total carbon in the community forest is less than the government managed forest. There is significance difference between mean above ground (Shoot, LHG, and dead wood) carbon stock of CF and GMF however there is significance difference between mean sapling carbon stock of CF GMF. There is significance difference between mean below ground (Root and Soil) carbon stock of CF and GMF at 5% level of significance.

Keywords: *Carbon pool, Carbon sink, Root Carbon, Soil Carbon.*

1. Introduction

Carbon is the term used for the C stored in terrestrial ecosystems, as living or dead plant biomass (aboveground and belowground) and in the soil. C=(0.50)*biomass. This means about 50% of plant biomass consists of Carbon [1-4]. To convert carbon in to CO_2, the tones of carbon are multiplied by the ratio of the molecular weight of carbon dioxide to the atomic weight of carbon (44/12).

Carbon sink is a carbon pool from which more carbon flows in than out. Forests can act as a sink through the process of tree growth and resultant biological carbon sequestration. Activities like afforestation, reforestation (AR), sustainable forest management (SFM), Conservation and Enhancement of forests acts as carbon sinks. Carbon source is a carbon pool from which more carbon flows out than flows in forests can often represent a net source of carbon due to the processes of decay, combustion, and respiration. Activities like deforestation, forest fire and forest degradation acts as sources of carbon [5-7].

Therefore, forests can switch between being a source and a sink of carbon over time depending on the type of activity they are experiencing. As both carbon sources and sinks, they have the potential to form an important component in efforts to combat global climate change. That is why forests play an important role in the global carbon balance.

Carbon pool is a system thathas the capacity to accumulate or release carbon. Examples of carbon pools are forest biomass, wood products, soils and atmosphere.Biomass is defined as mass of live or dead organic matter. It includes the total mass of living organisms in a given area or volume; recently dead plant material is often included as dead biomass. The quantity of biomass is expressed as a dry weight or as the energy, carbon, or nitrogen content. Therefore, a global assessment of biomass and its dynamics are essential input to climate change forecasting models and mitigation and adaptation strategies [8-10]. Carbon sequestration is the removal of carbon from the atmosphere and long-term storage in sinks, such as marine or terrestrial

ecosystems. Carbon stock is the mass of carbon contained in a carbon pool. Biomass density is Changes in time of vegetation biomass per unit area and can be used as an essential climate variable, because they are a direct measure of sequestration or release of carbon between terrestrial ecosystems and the atmosphere. Therefore, when using the term "biomass" we refer to the vegetation biomass density, that is mass per unit area of live or dead plant material.

A government-managed forest is a national forest to be managed by Nepal Government. Community Forest is a national forest handed over to a user group for its development, conservation and utilization for the collective interest. Community forestry management is considered as one of the popular models of decentralization in natural resource management. The program encompasses a set of policy and instrumental innovations that were especially designed to empower the local livelihoods through the proper management and utilization of forest products. Over the past three decades, the program has undergone a tremendous shift from state-centric and top-down to a community-based participatory approach to forest governance by restructuring and reformulating plans and policies related to forest governance in Nepal. Community forest management (CFM) essentially involves handing over of the national forest to local people over acertain period for the protection, management and utilization of the forest product. Local forest enterprises advise them on forest rehabilitation [12-14].

Participatory management is mostly practiced in forest management. Community forestry is found to be a successful practice in the management of forest in Nepal [12]. Nowadays forests are being managed scientifically.The stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfill, now and in the future, relevant ecological, economic and social functions, at local, national, and global levels, and that does not cause damage to other ecosystems.SFM implementation plan was proposed by DoF (Department of Forest) in 2069 with the objective of adoption of the principal of sustainable forest management while adopting the forest management techniques, and support to local and national economy. The aim of this study is to quantify the carbon stock of two differently managed forests (i.e.community-managed forest and government-managed forest).

2. Materials and Methods

2.1 Study area

Sindhupalchock is a geographically complex district which is located at 27° 36' N to 28° 13' N and 85° 27' E to 85º 85'E, and covers an area of 2542 km^2, equaling 1.73 % of land mass of the entire nation. The mid-hill generally has complicated physiography with a stepwise rise in altitudes from south to the north. This has led to the formation of deep river valleys below the elevation of 1000 m. The distribution of vegetation is remarkably displayed across south to the northern regions.The study area is situated at the Selang Manju Community Forest User Group, Selang 1, 8 and Syaule 3,4, Sindhupalchock and the DorjeLakpa national forest.TheSelangManjuCommunity forest consists of plantation as well as natural forest but in the DorjeLakpa Government managed forest all the forest is only Natural. Pinus patula, and Pinus wallichina are the main planted species and the *SchimaWalllichii* and *Alnus Nepalensis* are the main natural species of the community forest.

The Community Forest covers an area of 196.16hec in the mid mountain region. Out of the total 196.16 ha 0.05 % Community forest area 1 ha was selected for the forest inventory. Altogether there are 20 plots in the Community forest and other 20 plots in the government-managed forest.Both primary and secondary data were collected for the study purposeThe secondary data were collected from reviewing published and unpublished papers and reports of Governmental, Non-governmental and community-based organizations. For the collection of primary data, Group Discussion and Interviews, Field survey was applied. The data so collected from people perception was verified through field visits and triangulations [14-15].

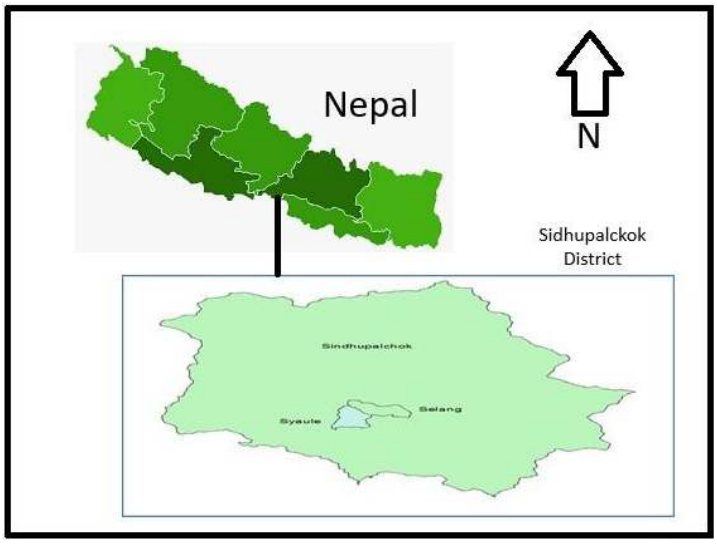

Figure 1: Map of study are

2.2 Reconnaissance survey

Reconnaissance survey was done in both CF and GMF for the sample size and sample plot fixation. Then, according to the species area curve and survey 20*25 Sq. m. sample size was fixed. Sample plots were fixed to be 20 in each forest type. Both sample size and no. are the representative of the study area.

A preliminary survey was done to identify the existing situation of the study area, location, ethnic composition of CFUGs and major species of CF. Rapport building with CFUG members, committee members and District Forest Office staff was made and informed about the research work.

2.3 Direct observation

Field observation was done with the help of forest guard. Thetotal area of the forest was divided into 5 blocks for the management of the forest. The study area was designed with respect to the systematic sampling techniques. Some photographs were taken from the forest as well as user group.

2.4 Forest sampling

The sampling wasdone by using the quadrate of 20*25 Sq. m. (CommunityForest inventory guideline, 2004.) The total number of tree species greater than 10 cm diameter at breast height belonging to quadrate was identified and noted. Plant greater than 10 cm DBH was regarded as tree and plant 4-10 cm DBH is regarded as Sapling Also the leaf litter from the ground was collected at 5 places in each 20*25Sq. m. quadrate with 1*1 Sq. m. quadrate. All the sample plots were taken on the equal distance of 100 m interval systematically[16]. All together 40 quadrats are taken in the forest sampling.

2.5 Secondary data collection
Secondary data regarding this study was collected through a literature survey. This included research reports and various published and unpublished documents available in the CFUGs, District Development Office, Forest Offices, internets, and other sources.

2.6 Data analysis.
The qualitative data was analyzed in descriptive texts while the quantitative data was analyzed by using Ms-excel and results was presented as pie chart, bar-diagram, mean, and tables.

2.6.1 Aboveground biomass estimation
The aboveground biomass included all parts such as stem, branches, foliage, and undergrowth biomass. Biomass estimation of big trees is difficult to measure directly *in situ*. According to the objectives of the study only tree stem biomass and leaf litter biomass was predicted by the combination of measurement and models. Diameter at Breast Height (DBH) was measured by using DBH tape and height with the Clinometers.

Tree biomass
For the estimation of above ground biomass of trees, DBH, wood specific density, and tree height were used. The algometric equation or model for estimating AGTB developed by ANSAB [7]was used, which is given below:
$AGTB = 0.0509 \times pD^2H$
Where,
AGTB = above ground tree biomass in kg
p = specific gravity (wood density) in kg/m^3
D = tree diameter at breast height in cm
H = tree height in m
Biomass stock was converted to carbon stock densities using the default carbon fraction of 0.47 [7].

Leaf litter biomass
To determine the biomass of leaf litter, samples was taken in the field within a small area of 1 m2. Fresh samples wasweighed in the field with a 0.1 g precision; and a well-mixed sub-sample wasthen placed in a marked bag. The sub-sample wasused to determine an oven-dry-to-wet mass ratio that will be 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 the amount of biomass per unit area is given by ANSAB [7]:

$$\text{Leaf litter Biomass} = \frac{\text{Wfield} \cdot \text{Weight sub sample, dry}}{A * \text{Weight Sub sample, wet.} * 10000}$$

Leaf litter biomass = biomass of leaf litter [t ha-1];
Wfield= weight of the fresh field sample of leaf litter, sampled within an area of size A [g];
A = size of the area in which leaf litter, herbs, and grass were collected [ha];
Weight subsample, dry= weight of the oven-dry sub-sample of leaf litter, herbs, and grass taken to the laboratory to determine moisture content [g]
Weight Sub sample, wet = weight of the fresh sub-sample of leaf litter taken to the laboratory to determine moisture content [g].
Then,
Samples of undergrowth leaf litter were oven dried at a constant temperature of 70°C until the weight of the samples became constant [17] and the final constant weight was used as dry matter content.
Dry biomass was converted to C content using an assumption that C content is approximately 47% of dry biomass.
Total above ground biomass organic carbon = (total above ground biomass of tree + total leaf litter biomass)* 47% [7].

2.6.2 Underground biomass estimation:
Root biomass
The measurements of root biomass were not a simple task. It wasrequired a lot of time as well as experience. Root biomass wasnot calculated in this study. [18-20] found 19.29% root biomass of total biomass. In a study by [21-23) for some temperate species, the root biomass was20 to 25% of the total aboveground biomass. Likewise [24-28] observed 9-22% of above ground biomass for different tropical species. The root biomass of trees varies according to species, age, microclimate and soil. On the basis of literature citing and forest type studied, the root biomass of tree has been assumed to be 18% of the above ground biomass.

2.6.3 Soil sampling
Reconnaissance survey was done in both CF and GMF for the sample size and sample plot fixation. Then, according to survey four pits were made in each corner of the quadrate (20mX25m) and one at the center of the quadrate. Altogether five soil samples were separately taken from the upper (0-10cm). All five samples are mixed thoroughly together to make a single soil sample. All together there are 20 samples in the CF and 20 samples in GMF which are the representative of the study area. The Soil Organic Carbon of below 10 cm was excluded from the study to maintain regularity because in 10 higher plots on Government managed forest and community managed forest soil samples were not possible to extract due to presence of intact rock mass.
Wet weights of soils are determined in the field with 0.1 g precision. Bulk densities of soil were calculated by using core ring of size 5cmX4.5cm. Soil was dried on shade for 4 days. The composite samples were separately sieved through 2 mm mesh screen. Then, 250 gm of each composite sample was bagged and labeled[7].
Subsequently, samples are transported to the laboratory and oven dried (70^0 C) until constant weight to determine water content. The carbon stock density of soil organic carbon is calculated as [7].

Soil organic carbon (SOC)
SOC (Kg/m^2) = organic carbon content (%) x soil density (kg/m^3) x thickness of horizon (m)
Further, it was expressed in ton/hectare

Estimation of net carbon value
The carbon was calculated using the stock method[7]. The carbon content wasassumed to be 47% of dry biomass. The formulae used for above and below ground carbon are:

- Total above ground biomass organic carbon = (total above ground biomass of the tree + total above ground biomass of the Sapling + total LHG biomass + total above ground Deaed wood biomass) x 47%
- Total below ground organic carbon = (total root biomass of tree) x 47% + total soil organic carbon.
- Total Organic Carbon: Total above ground organic carbon + Total below ground organic Carbon.

3. Result

3.1 Tree carbon stock

Tree carbon stock in Government Managed Forest was found to be higher with 79.12 ton/ha (From the analysis from the sample data, maximum tree carbon stock is 87.06 and minimum tree carbon stock is 68.26 ton/ha.) than CF with 72.69 ton/ha (From the analysis from the sample data, maximum tree carbon stock is 78.91 and minimum tree biomass is 60.88 ton/ha.)Tree carbon stock of Government managed forest is very high it's because in the National Forest there were lots of old trees which have carbon storage but they do not have sequestrating capacity anymore.The standard deviation of the tree carbon stock in Government managed forest is 9.51 and the Community managed forest is 9.44.

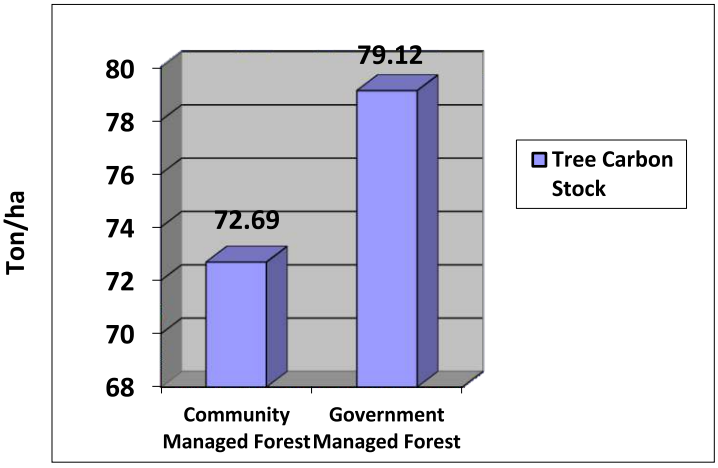

Figure 2: Tree carbon in different forests.

3.2 Sapling carbon stock

Sapling carbon stock was found to be lower in Government Managed Forest with 1.25 ton/ha. (From the analysis of the sample data, maximum sapling carbon stock is 1.37 ton/ha and minimum sapling carbon stock is 0.42 ton/ha.)than in Community Forest with 1.31 ton/ha. (From the analysis from the sample data, maximum sapling carbon stock is 1.6 ton/ha and minimum sapling carbon stock is 0.52 ton/ha.). The standard deviation of the Sapling carbon stock in Government managed forest is 0.59 and the Community managed forest is 0.85.

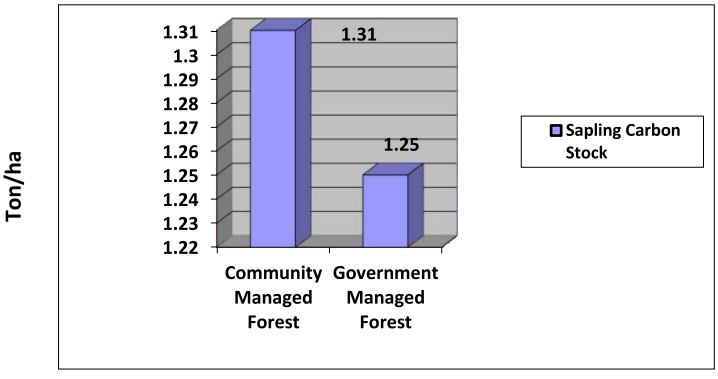

Figure 3: Sapling Carbon Stock

3.3 LHG carbon stock

LHG carbon was found to be higher 1.31 ton/ha in government managed forest (From the analysis of the sample data, maximum LHG carbon stock is 1.8 ton/ha and minimum LHG carbon stock is 1.03 ton/ha.)thanCF with 1.22ton/ha. (From the analysis from the sample data, maximum LHG carbon stock is 1.46 ton/ha and minimum LHG carbon stock is 0.89 ton/ha.).

The standard deviation of the LHG carbon stock in Government managed forest is 0.4 and the Community managed forest is 0.3.

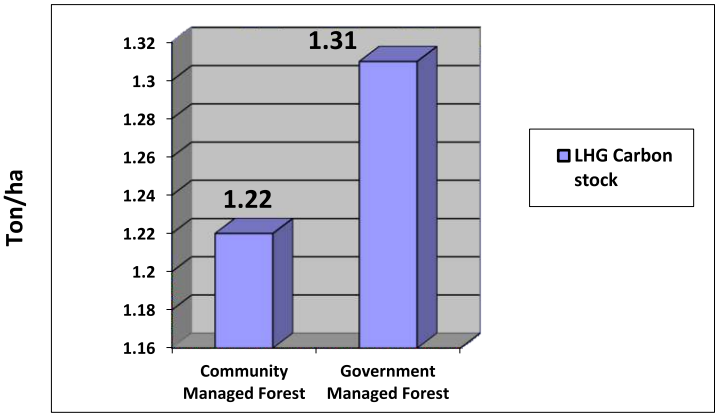

Figure 4: LHG Carbon Stock

Dead wood Carbon Stock

Dead wood carbon stock in Government Managed Forest was found to be higher with 12.25 ton/ha (From the analysis of the sample data, maximum Dead wood carbon stock is 13.53 ton/ha and minimum dead wood carbon stock is 10.46 ton/ha.) than CF with 11.28 ton/ha. (From the analysis of the sample data, maximum dead wood carbon stock is 12.28 ton/ha and minimum dead wood carbon stock is 9.34 ton/ha.) The standard deviation of the Dead wood carbon stock in Government managed forest is 1.56 and the Community managed forest is 1.54.

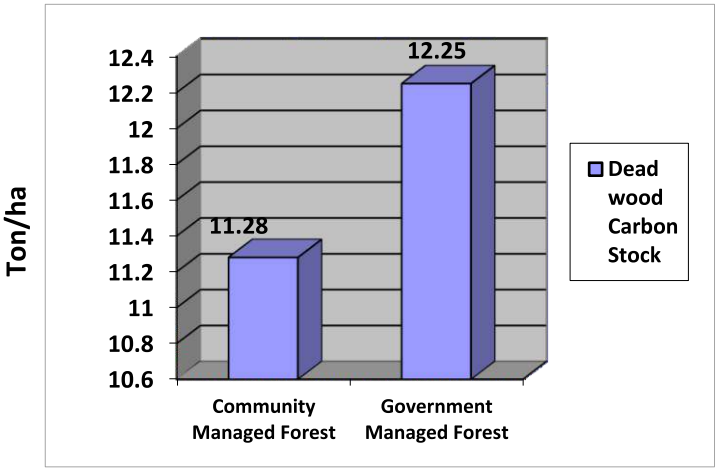

Figure 5: Dead wood Carbon Stock

3.4 Belowground carbon

The Below ground Carbon consist of Root Carbon. The root Carbon of Government managed forest was found to be higher with 14.70 ton/ha (From the analysis of the sample data, maximum total below ground Root Carbon is 16.23 ton/ha and minimum below ground Root Carbon is 12.54 ton/ha.) than community forest with 13.54. (From the analysis of the sample data, maximum total below ground Root Carbon is 14.74 ton/ha and minimum below ground Root Carbon is 11.21 ton/ha.)The standard deviation of the Root carbon stock in Government managed forest is 1.87 and the Community managed forest is 1.85.

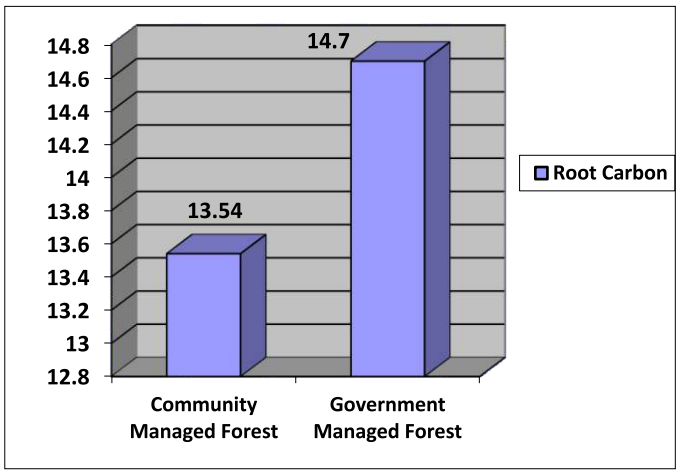

Figure 6: Root Carbon

3.5 Soil organic carbon

The soil organic Carbon was found to be 171.94ton/ha in Community Forest (From the analysis of the sample data, maximum soil organic carbon is 172.84 ton/ha and minimum is 170.22 ton/ha.)and173.94 ton/ha in government managed forest. (From the analysis of the sample data, maximum soil organic carbon is 174.98 ton/ha and minimum is171.21 ton/ha.)The standard deviation of the Soil carbon stock in Government managed forest is 2.07 and the Community managed forest is 1.08.

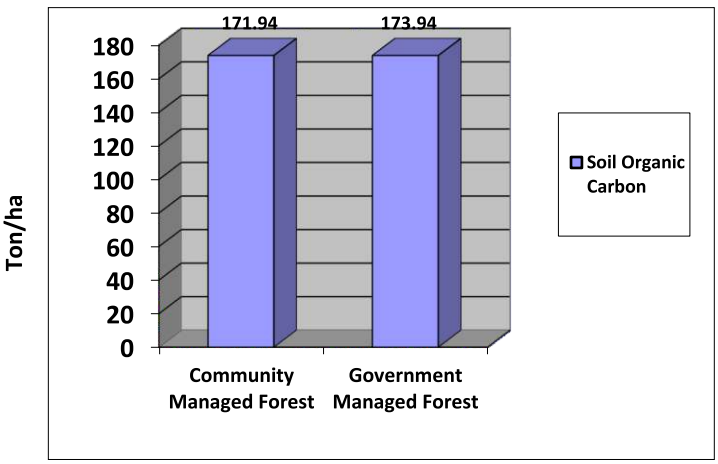

Figure 7: Soil Organic Carbon

3.6 Comparison total carbon stock

Total carbon stock of Government Managed forest was found to be higher with 282.57 ton/ha (From the analysis of the sample data, maximum total carbon stock is 293.92 ton/ha and minimum carbon stock is 266.66 ton/ha.) than Community forest with 271.95ton/ha (From the analysis of the sample data, maximum total carbon stock is 282.88 ton/ha and minimum carbon stock is 256.78 ton/ha.) including the soil carbon stock 10 cm below the ground level. The standard deviation of the Total carbon stock in Government managed forest is 19.54 and the Community managed forest is 13.22.

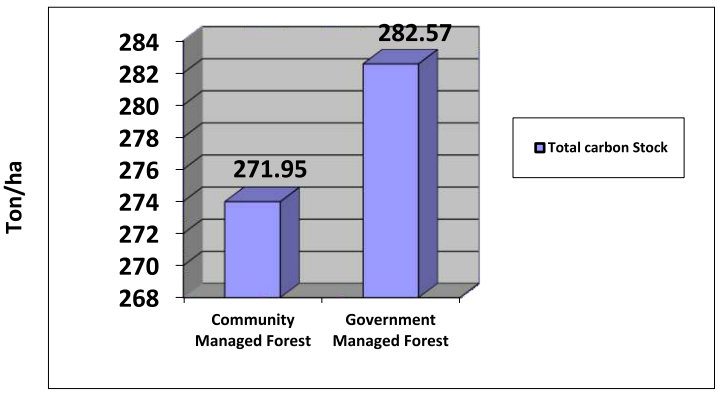

Figure 8: Total Carbon Stock

The table 1 shows the total carbon stock in the different forest types. The soil organiccarbon stock is 173.94 ton/ha which is highest then the other categories and the LHG Carbon stock is 1.31 ton/ha which is lowest among the categories in the government managed forest similarly in the community managed forestsoil organic carbon contains the 171.94 ton/ha which is highest then the other categories and the LHG carbon stock is 1.22 ton/ha which is lowest.

3.7 Carbon stock in two different forest management

Table 1: Total Carbon Stock in the different forest

Total Carbon Stock ton/ha in the different forest.				
Categories	Community Forest	Government Managed Forest	Carbon Pool in CF (%)	Carbon Pool in GMF (%)
Above ground Tree Carbon Stock	72.69	79.12	26.52	28.00
Sapling Carbon Stock	1.31	1.25	0.48	0.44
LHG	1.22	1.31	0.45	0.46
Root Carbon	13.54	14.7	4.94	5.20
Dead wood Carbon Stock	11.28	12.25	4.12	4.34
Soil organic Carbon	171.94	173.94	63.49	61.56
Total	271.95	282.57	100.00	100.00

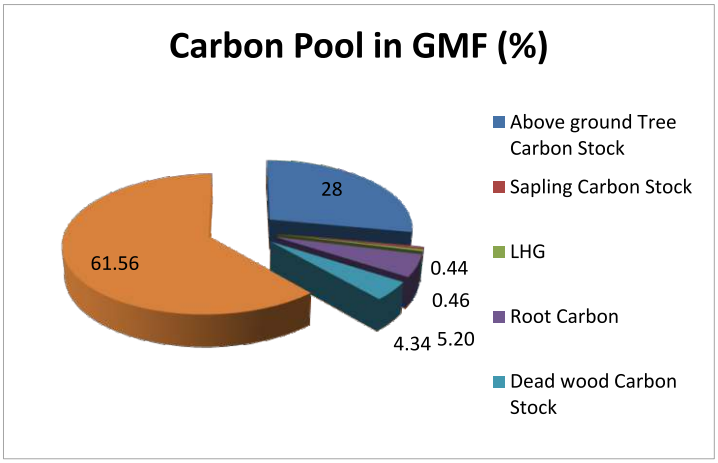

Figure 9: Carbon pool in GMF

The figure 9 shows the total carbonpool in GMF. The 61.56 % of the total carbon is stocked in the SOC and only 0.44 % carbon is stocked in the LHG.

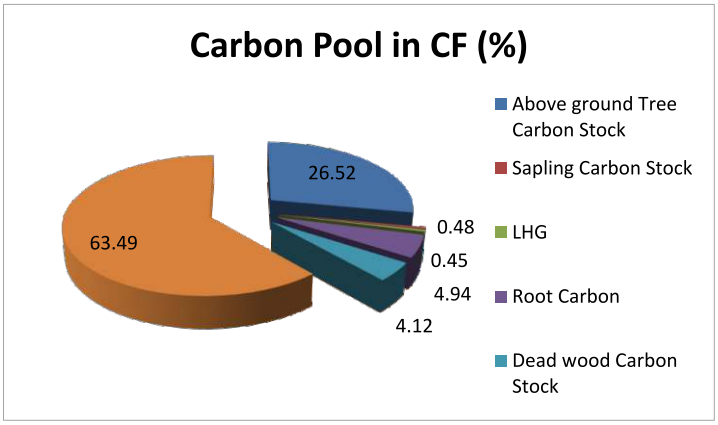

Figure 10: Carbon pool in CF

The figure 10 shows the total carbon pool in CF. The 63.49 % of the total carbon is stocked in the SOC and only 0.45 % carbon is stocked in the LHG. The total carbon stock of the community forest is 271.95 ton/ha similarly the total carbon stock of the government managed forest is 282.57 ton/ha. The total carbon in the community forest is 53345.71ton similarly the total carbon in the government forest is 57926.85 ton. The total carbon in the community forest is less than the government forest which is shown in the table 2.

Table 2: Total carbon stock in different forests

Forest	Area (ha)	Carbon ton/ha	Total carbon ton
CF	196.16	271.95	53345.71
	.		
GMF	205.00	282.57	57926.85

4. Discussion

Aboveground and belowground biomass and carbon of Trees are the plants that can develop a large biomass capturing a large amount of carbon over a growth cycle of many decades. So, forest can capture and retain a large volume of carbon for a long period of time. The carbon sink and storage in the forest are dependent with each other. Many trees in the studied forests had the DBH of less than 30 cm. The biomass of Government managed forest is comparablewithother similar forests. [31-33] had carried out the study in *Betulautilis* forest in KCAP and found out that the tree biomass was 166.81 t/ha. In this study, the tree biomass is 168.34ton/ha.

It seems that the tree biomass of the government managed forest is almost similar with the Betulautilis forest.Baral et al [12] estimated 168.5 t/ha and 146.2 t/ha carbon stock in Jarneldhara CF and LipindeviThulopakho CF of Palpa but in this study area soil organic carbon of the Selang Manju Community forest is 271.95 ton/ha carbon it is quite higher because of the higher amount of the soil carbon in the study area.

Soil, being the largest carbon reservoir of the terrestrial carbon cycle, about three times more carbon is contained in soil than in the world's vegetation and soils hold double the amount of carbon that is present in the atmosphere [34-36]. In my study area soil organic carbon is 173.94 ton per/ha in the government managed forest and 171.94 in communitymanaged forest. The total carbon content in the plant is only 100.64 ton/ha in the Community forest and only 108.63 ton per ha in the Government managed forest.So, the result shows that 63.48 % of the total carbon is stored in the soil but only 36.51% of the carbon is stored in the plant in CF. In case of Government managed forest 61.55% of the total carbon is stored in the soil but only 38.44% carbon is stored in the plant. Similarly, [38-39] studied in two different forests and concluded that the soil carbon value is significantly higher than the biomass carbon stock. The soil carbon composition was 55% in Shorea Robusta forest and it was 74% in SchimaCastanopsis Forest.

The average carbon stock in Community ForestandGovernment managed forest was 273.98 tonC/ha and 282.57 tonC/ha respectively. The values of carbon stock of this study are higher than the values obtained by ICIMOD, ANSAB and FECOFUN [10], inShorearobusta mixed sub- tropical hill deciduous forest in Ludikhola of Gorkhawas (165.91 tC/ha to 216.16tC/ha). It is because of the higher amount of organic matter in the forest floor, and most of the forest is virgin [38-341].Similarly, the C-stock densities estimated by different studies were different. [341-42] have calculated the Total Aboveground carbon stock of Pine Forest 38.70 tC/ha only.

Total above ground carbon stock of Government managed forest was found to be 92.53 ton/ha FAO [12] but in my study area total above ground carbon stock of Government managed forest was found to be 93.93 ton/ha. It is because in Government managed forest of my study area old trees were present in more numbers. Total above ground carbon stock of community forest was found to be 92.53 ton/ha FAO [12] whereas in my study area total above ground carbon stock of community forest was found to be 86.5 ton/ha which is lower because of the application of the community forest management by the Community forest user group. An actively managed community forest in Kailali district has total carbon stock 139.96 ton/ha [40-42] but community forest in my study area has 86.5 ton/ha which is relatively less that may be due to presence of smaller sized tree in the community forest where my study was conducted.

Total carbon stock of Government Managed Forest was found to be higher with 282.57 ton/ha thanCommunity Forest with 271.95 ton/ha including the soil carbon stock 10 cm below the ground level. The analysis of the data shows that community forest management should be encouraged to enhance the more carbon storage in the forest.

5. Conclusion

Tree carbon stock in Government Managed Forest was found to be higher with 79.12 ton/ha (From the analysis from the sample data, maximum tree carbon stock is 87.06 and minimum tree carbon stock is 68.26 ton/ha.) than CF with 72.69 ton/ha (From the analysis from the sample data, maximum tree carbon stock is 78.91 and minimum tree biomass is 60.88 ton/ha.).

Tree carbon stock of Government managed forest is very high it's because in National Forest there were lots of old trees which have carbon storage but they do not have sequestrating capacity anymore.The standard deviation of the tree carbon stock in Government managed forest is 9.51 and the Community managed forest is 9.44.Sapling carbon stock was found to be lower in Government Managed Forest with 1.25 ton/ha. (From the analysis of the sample data, maximum sapling carbon stock is 1.37 ton/ha and minimum sapling carbon stock is 0.42 ton/ha.) than in Community Forest with 1.31 ton/ha. (From the analysis from the sample data, maximum sapling carbon stock is 1.6 ton/ha and minimum sapling carbon stock is 0.52 ton/ha.)The standard deviation of the Sapling carbon stock in Government managed forest is 0.59 and the Community managed forest is 0.85.LHG carbon was found to be higher 1.31 ton/ha in government managed forest (From the analysis of the sample data, maximum LHG carbon stock is 1.8 ton/ha and minimum LHG carbon stock is 1.03 ton/ha.) than CF with 1.22 ton/ha. (From the analysis from the sample data, maximum LHG carbon stock is 1.46 ton/ha and minimum LHG carbon stock is 0.89 ton/ha.)The standard deviation of the LHG carbon stock in Government managed forest is 0.4 and the Community managed forest is 0.3.Dead wood carbon stock in Government Managed Forest was found to be higher with 12.25 ton/ha (From the analysis of the sample data, maximum Dead wood carbon stock is 13.53 ton/ha and minimum dead wood carbon stock is 10.46 ton/ha.) than CF with 11.28 ton/ha. (From the analysis of the sample data, maximum dead wood carbon stock is 12.28 ton/ha and minimum dead wood carbon stock is 9.34 ton/ha.) The standard deviation of the Dead wood carbon stock in Government managed forest is 1.56 and the Community managed forest is 1.54.The Below ground Carbon consist of Root Carbon. The root Carbon of Government managed forest was found to be highest with 14.70 ton/ha (From the analysis of the sample data, maximum total below ground Root Carbon is 16.23 ton/ha and minimum below ground Root Carbon is 12.54 ton/ha.) followed by community forest with 13.54. (From the analysis of the sample data, maximum total below ground Root Carbon is 14.74 ton/ha and minimum below ground Root Carbon is 11.21 ton/ha.). The standard deviation of the Rootcarbon stock in Government managed forest is 1.87 and the Community managed forest is 1.85.The soil organic Carbon was found to be 171.94 ton/ha in Community Forest (From the analysis of the sample data, maximum soil organic carbon is 172.84 ton/ha and minimum is 170.22 ton/ha.) and 173.94 ton/ha in government managed forest. (From the analysis of the sample data, maximum soil organic carbon is 174.98 ton/ha and minimum is 171.21 ton/ha.)The standard deviation of the Soil carbon stock in Government managed forest is 2.07 and the Community managed forest is 1.08.

Total carbon stock of Government Managed forest was found to be highest with 282.57 ton/ha (From the analysis of the sample data, maximum total carbon stock is 293.92 ton/ha and minimum carbon stock is 266.66 ton/ha.) followed by Community forest with 271.95 ton/ha (From the analysis of the sample data, maximum total carbon stock is 282.88 ton/ha and minimum carbon stock is 256.78 ton/ha.) including the soil carbon stock 10 cm below the ground level. The standard deviation of the Total carbon stock in Government managed forest is 19.54 and the Community managed forest is 13.22.

The table 2 shows the totalcarbon stock in the different forest types. The soil organiccarbon stock is 173.94 ton/ha which is highest then the other categories and the LHG Carbon stock is 1.31 ton/ha which is lowest among the categories in the government managed forest similarly in the community managed forest soil organic carbon contains the 171.94 ton/ha which is highest then the other categories and the LHG carbon stock is 1.22 ton/ha which is lowest. The figure 8shows the total carbonpool in GMF. The 61.56 % of the total carbon is stocked in the SOC and only 0.44 % carbon is stocked in the LHG. The figure 9 shows the total carbon pool in CF. The 63.49 % of the total carbon is stocked in the SOC and only 0.45 % carbon is stocked in the LHG.

The total carbon stock of the community forest is 271.95 ton/ha similarly the total carbon stock of the government managed forest is 282.57 ton/ha. The total carbon in the community forest is 53345.71ton similarly the total carbon in the government forest is 57926.85 ton. The total carbon in the community forest is less than the government forest which is shown in the table 2.

6. Recommendations

The following recommendation has been made based on the study.

- To generalize the above results,further research should be carried on Sindhupalchockdistrict as well as region by representing the different forest conditions and physiographic zone.
- Carbon inventory should be done regularly so as to enhance the existing forest condition.
- Community forest management should be encouraged to enhance the more carbon storage in the forest.
- The study of carbon stock and sequestration has been largely carried out in the community forests of Nepal but very few research works have been carried out the Government managed forest of Nepal. So, the study of carbon stock in the government managed forest should be encouraged because the government managed forest can reservoir significant amount of the Carbon.
- Recent climate policy such as REDD+ has been promoted to incentivize payment for carbon sequestration, so precise and accurate accounts of carbon in forests should be undertaken.
- The result of forest carbon of this study is just based on two forests in one region of Mid hills; similar estimation in other part of country is recommended.

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Author Contribution

D.H. and Y.H. designed the research plan, collected the required data, analyzed the data, prepared the manuscript and reviewed for final submission.

Declaration of Conflict of Interest

The authors declare that there is no conflict of interest with present publication.

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