

Estimation of Carbon Stock in Bimbia Bonadikombo Coastal Community Forest, South West Region, Cameroon: An Implication For Climate Change Mitigation

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Abstract

Forests are known to play an important role in regulating the global climate. Nowadays, especially in developing countries wide spread deforestation and forest degradation is continuing unknowingly and deliberately. This study was conducted to estimate carbon stock in undisturbed research section (Dikolo Peninsula) of Bimbia Bonadikombo Community Forest (BBCF). Three transects were created in the research plot and fifteen plots of 10m x10m were laid systematically along each transects, and five sub plots of 1m x1m quadrats were laid within 10m x10m i.e. at the four corners and middle. Trees data (DBH \geq 2.5cm and Height) were measured in the 10x10m plots. Soil, litter herbs and grass data were collected in the 1x1 m plots. The litters, herbs and grass (LHG) were weighed on the field and evenly mixed and dried at 65⁰C, to determine dry biomass and percentage of carbon. Soil samples were collected at 30cm depth (between 0-10, 10-20, 20-30 cm depths) and density cups was used to determine bulk density and percentage (%) of organic carbon concentration. Allometric equations was use to obtain trees biomass and carbon stock. The results revealed that the total carbon stock was 38.61 t·ha⁻¹. The Soil organic carbon (SOC) was 33.9 t·ha⁻¹ that is 87.8%, while the forest trees stored 2.91 t·ha⁻¹ that is 7.5% of the total carbon. LHGs biomass contributed only 1.82t·ha⁻¹ of carbon that is 4.7% of the total carbon stock. The result shows that BBCF is a reservoir of high carbon. To enhance sustainability of the forest potentiality, the carbon sequestration should be integrated with reduced emission from deforestation and degradation (REDD⁺) and clean development mechanism (CDM) carbon trading system of the Kyoto Protocol to get monetary benefit of CO₂ mitigation.

Key words: carbon sequestration, climate change, community forest, carbon stock

Introduction

Carbon stock assessment is one of the important step to start with sustainable land use planning in relation to low carbon emission. The change in carbon stock with the dynamics of land use changes may result into either carbon emission or sequestration (Jandl et al., 2006). Forests are known to play an important role in regulating the global climate by naturally taking carbon out of the atmosphere, thereby reducing the impact of carbon dioxide emissions (Perschel et al., 2007).

Even though the role of forests in climate change mitigation is widely recognized, the recent assessment shows carbon stocks in forest biomass decreased by an estimated 0.5 gigatone annually during the period 2005-2010 because of a reduction in the global forest area (FAO, 2010).

Loss of forest biomass through deforestation and forest degradation makes up 12 to 20% of annual greenhouse gas emission, which is more than all forms of transportation combined (Saatchi et al., 2011). Especially, in Africa, forest degradation is very high which accounts for nearly 70% of the continent's total emission (FAO, 2005). Hence, the endless rise of carbon emission is one of today's major concerns as it is the main causal factor for climate change.

The fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC) indicates that carbon emissions from deforestation account for an estimated 20% of global carbon emissions (IPCC, 2007). To successfully reduce greenhouse gas emissions from land cover change, effective strategies for protecting natural habitats are needed in the tropical world (Campbell et al., 2008) including the Central Africa Region which is particularly endowed with a great diversity of flora and fauna. The heart of this region, the Congo Basin, has the world's second largest continuous rainforest after the Amazon Basin.

Cameroon is part of the Congo Basin, with about 16.8 million hectares of rainforest covering 40% of the national territory (WRI, 2011) are home to a variety of biological resources; it is renowned for its high number of endemic plant and animal species (Fomété and Tchanou, 1998; Onana, 2011).

The establishment of protected areas has been presented as a way to manage and conserve biodiversity in the Congo Basin (Sonké, 2004). Linking biodiversity management to carbon stock maintenance an increase has recently been presented as an opportune way to manage the natural resources of the Congo Basin (Sonké, 2004).

Climate change is a global concern and the role of forest in climate change mitigation has been well documented in the global scale. In Cameroon, carbon stock assessments have been done within the alternatives to Slash and Burn Agriculture programme on many land use types in the forest fringe (Zapfack, 2005) and the cocoa agroforests (Sonke, 2004; EyohoEwane, 2012). Only a small number of carbon stock assessments have been conducted within the protected areas. One of the pilot research projects in the field is one conducted by Djuikouo et al. (2010) in the Dja Biosphere Reserve (East Cameroon). However, little or no work has been done concerning assessing carbon stock as an implication to climate change mitigation in Cameroon Community forest.

Therefore, this study was designed to estimate community forest reserve carbon in all carbon pools of trees, Litter, Herbs , Grasses (LHG) and soil of Bimbia Bonadikombo Community Forest which would have high important as an information basis that contribute to climate change mitigation and to conserve community forest in Cameroon

Materials and Methods

The Study Area

The Bimbia-Bonadikombo Community Forest is located on the coastline of the South West Region on the fringes of the coastal zone and the slopes of Mount Cameroon (Figure 1).

It is situated in the wet climate zone of Cameroon, characterized by two seasons with a long rainy season (from March to November) and dry season from December to February; it is always interspersed with rains. Annual precipitation is between 4000 and 5000mm. Humidity in the area is usually between 75-80%. Vegetation is evergreen with six different types, littoral vegetation, coastal bar forest, mangrove, freshwater swamp forest, stream and riverside vegetation, and low land rainforest (RCDC, 2002). The geology is of old volcanic rock and the soils are of old lateritic type. The area is marked by ridges and valleys running from south to north.

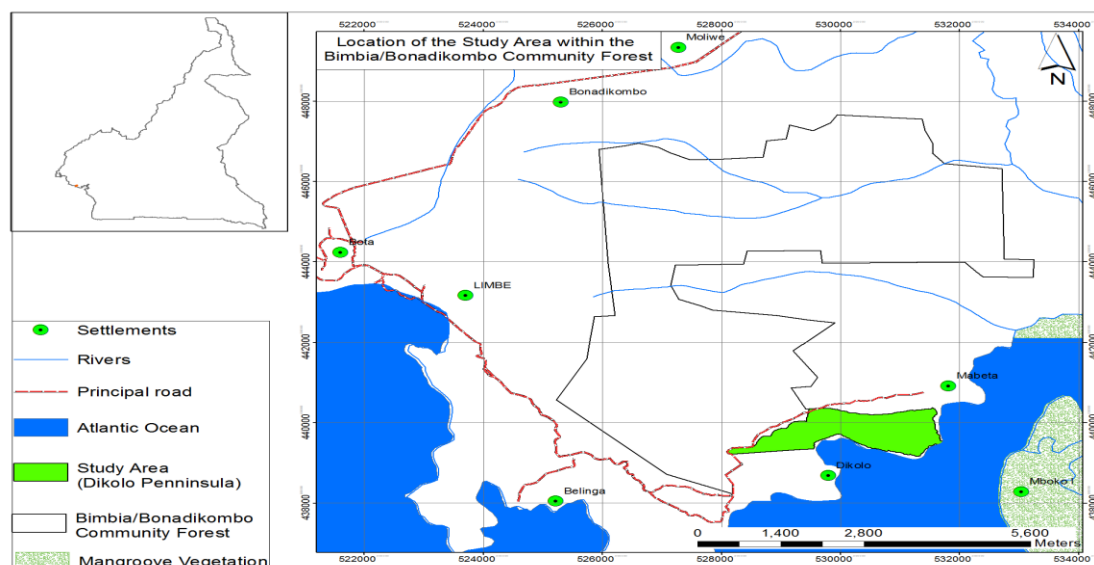


Figure 1: Location map of the study area.

Sampling Design and Measurements

This study was conducted from March 2016 to February 2017. A systematic sampling approach was used for location of sampling plots. Three transects were created and fifteen plots of 10m x10m (100m²) were systematically laid on adjacent side and equidistance (50m apart) to one another along transects. Each plot of 10m x10m was further divided into sub plots of 1x1m. In the plots of 10x10m, all the trees species with (DBH) diameter at breast height (1.3m) and height of all the trees who's DBH≥2.5cm were measured using diameter tape, clinometers respectively and appropriate estimated according to Bishma *et al.* (2011) guideline for measuring carbon stock in community managed forests.

The 1x1m plots were used for the collection LHGs samples. LHGs were collected at the four corners and at the middle of each plot and weighed on the field using a Demo scale with a precision of 0.1g to 100g. The LHGs were evenly mixed and brought to the laboratory to determine dry biomass and percentage of carbon. For soil organic carbon determination, soil samples were also collected within the 1x1m plots in which LHGs samples were collected up to 30cm in depth (between 0-10, 10-20, 20-30 cm depths) using a calibrated soil auger or density cups (IPCC,2007). A composite sample was obtained by mixing soil from three layers taken from five 1m x1m subplots and the bulk density and percentage (%) of organic carbon concentration was determined. About 105g of composite samples were collected from each main plot. Above ground biomass for trees was estimated using two methods.

1. Trees with DBH ≥5cm, existing generalized allometric equation for tropical trees developed by Chave *et al.* (2005) model II was used.

Chave *et al.* (2005) model II

$$Y = \text{Exp}(-2.187 + 0.916 \ln(D^2 \times H \times S))$$

Where:

Y= Above Ground Biomass (Kg),

H=Height of the tree (m),

D=Diameter (cm) at breast height (1.3m),

S= tree density (tm⁻³) for specific species (Morales, 1987; Reyes *et al.*, 1992; IPCC, 2003).

2. For trees having between ≥2.5 and < 5cm, an allometric model of biomass and volume tables with species description for community forest management developed by Tamarkar (2000) was used.

$$\ln(\text{AGSB}) = a + b \ln(D)$$

Where:

AGSB= above ground sapling biomass (kg),

A and b = species specific constants (Tamarkar, 2000; Sharma and Pukkala, 1990),

D = DBH.

Below ground biomass of trees species were calculated considering 15% of the above ground biomass (MacDicken, 1997). The biomass was then converted to carbon by multiplying 0.47 fraction of the IPCC (2006) value.

To estimate the carbon stock on LHGs, the sub samples from the field was used to determine an oven dry to wet mass ratio that was use to convert the total wet mass to oven dry mass according to Pearson *et al.* (2007). The scale used was a DEMO scale with a precision of 0.1g. The amount of biomass per unit area was calculated thus;

$$\text{LHGs} = W_{\text{field}}/A \times W_{\text{sub sample dry}}/W_{\text{sub sample wet}} \times 0.0001.$$

Where:

LHGs= Biomass of leaf litter, Herbs and Grasses (t/ha)

W_{field} = weight of fresh field sample of leaf litter, herbs and grasses destructively sampled with an area of size A (g), A = size of the area in which litter, herbs and grasses where collected (ha), W_{sub-sample dry} = weight of oven dry sub sample of litter herbs and grasses and W_{sub sample wet} = weight of the fresh sub sample of litter, herbs and grasses.

To determine of percent of carbon in LHGs the loss on ignition (LOI) method of Allen *et al.* (1986) was applied. The carbon stock density of LHGs was then calculated by multiplying biomass of LHGs per unit area with the percentage of carbon determine for each sample.

For SOC determination; Bulk density was estimated through core sampler method (Huq and Alam, 2005). In this method, the soil samples collected were oven dried at 105°C for 12 hours in an oven at the laboratory. Bulk density of soil was calculated by dividing oven-dried weight of soil by volume of the core sampler. Bulk Density = Weight of Oven-dried Soil / Volume of Core Sampler (USDA-NCRS, 2013).

To estimate the percentage of organic carbon (carbon concentration), samples were analyzed by the wet oxidation method (Huq and Alam, 2005).

In this method, soil samples from the field were air-dry for two days to remove moisture content. The soil samples were ground to fine powder so that they could pass through a 0.42mm sieve. 5g of each sample was weighed accurately and placed into a dry 250ml conical flask. Accurately, 10 ml of Potassium Dichromate ($K_2Cr_2O_7$) was added in each sample and swirled gently to disperse the soil in the solution followed by 20mL of concentrated sulphuric acid (H_2SO_4). Immediately, the flasks were swirled until the soil and the reagent are mixed over a gas burner and gauze until the temperature reaches 135 °C (approximately ½ minute).

The samples were set aside to cool slowly on an asbestos sheet in a fume cupboard (20–30 minutes). When cool, the samples were diluted to 200mL with deionizer water and proceed with the ferrous sulphate ($FeSO_4$) titration using potentiometer with an expanding scale pH/mV meter to read the percentage concentration of organic carbon.

The carbon stock density of soil organic carbon was calculated according to Pearson *al.* (2007) from the percentage concentration of carbon and bulk density of soil at predetermined depth of the samples were taken.

$$SOC = \%C \times \rho \times d$$

Where: SOC is soil organic carbon stock per unit area (Lha^{-1}), %C is carbon concentration (%), d is soil depth (cm) and ρ is bulk density (gcm^{-3}).

The carbon stock was calculated by summing the carbon stock of the individual carbon pools of that stratum using the formula below. It should be noted that any individual carbon pool of the given formula could be ignored if it did not contribute significantly to the total carbon stock.

Carbon stock of a stratum:

$$C(LU) = C(AGTB) + C(BGTB) + C(LHG) + SOC$$

Where,

C(LU) = carbon stock of the study area [tons/ha]

C(AGTB) = carbon in Above Ground Tree Biomass [tons/ha]

C(BGTB) = carbon in Below Ground Biomass [tons/ha]

C(LHG) = carbon in Leaf litter, Herb and Grass [tons/ha], and

SOC = Soil Organic Carbon [tons/ha].

The carbon stock was then converted to tons of CO_2 equivalent by multiplying it by 44/12 or 3.67 of molecular weight ratio of CO_2 to O_2 (Pearson *et al.*, 2007) in order to understand climate change mitigation potential of the study area.

Results

Carbon stored in trees species of BBCF

A total of twenty three major tree species recorded in the study area, *Strombosia pustulata* and *Chrysophyllum africana* stored enormous amount of carbon with 0.993 (32.06%) $t \cdot ha^{-1}$ and 0.516 (17.74%) $t \cdot ha^{-1}$ respectively; that amount accounts for approximately 50% of the total carbon stocked in trees in the study area of the BBCF. *Strombosia pustulata* had the highest total above ground biomass carbon and total below ground biomass carbon with 0.81 and 0.122 $t \cdot ha^{-1}$, respectively. The lowest carbon stock was recorded for *irvingia gabonensis* and *Hannoa klaineana* with 0.00081 (0.028%) $t \cdot ha^{-1}$ and 0.00059 (0.02%) t/ha respectively (Table 1).

Carbon stock share within DBH classes of tree species

Within the six categories of DBH classes (>0-10, >10-20, >20-30, >30-40, >40-50 and >50), the DBH class of > 0-10 cm had the highest density (486.7) of tree with seventy three trees/ha making approximately 59% of the total trees in the study area while trees with the DBH classes of greater than 40 – 50 and greater than 50 cm were the least dominant in the study area and consisting of four trees each making approximately 3% each respectively of the total trees species in the study area. The highest carbon stock reserves were found in the DBH class with the highest density of trees, which is the DBH class of >0 – 10 which account for about 32.5% of the total carbon stored in the study area. This was closely followed by the DBH class of >30-40 which also account for about 28.3%. The least carbon reservoir were found with the DBH class of >20- 30 (0.176 $t \cdot ha^{-1}$) which contribute only to about 7.1% of the total tree carbon stored in the community forest. (Table 2 and Figure 2).

Table 1: carbon stored in trees species in BBCF

FAMILY	LATIN NAME	TAGB	TBGB	TB	TAGC	TBGC	TC	%Proportion of TC
Olacaceae	<i>Strombosia pustulata</i> Oliv	1.73	0.26	1.99	0.81	0.122	0.933	32.06
Sapotaceae	<i>Chrysophyllum africana</i> Senu – Baker	1.082	0.156	1.098	0.51	0.073	0.5161	17.74
Flacourtiaceae	<i>Homalium letestui</i> Pellegr	0.5005	0.073	0.573	0.24	0.034	0.269	9.24
Irvingiaceae	<i>Klainedoxa gabonensis</i> Pierre ex Engl	0.42	0.06	0.48	0.193	0.028	0.23	7.9
Leguminosae	<i>Hylodendron gabunense</i> Taub	0.411	0.0617	0.473	0.193	0.029	0.22	7.56
Anacardiaceae	<i>Lannea welwitschii</i> (Hiern) Engl	0.24	0.036	0.276	0.113	0.017	0.13	4.47
Annoaceae	<i>Cleistopholis patens</i> (Benth) Engl &Diels	0.025	0.036	0.0296	0.118	0.0169	0.13	4.47
Olacaceae	<i>Strombosia grandifolia</i> Hook.f.Benth	0.235	0.0353	0.02703	0.11	0.0166	0.1266	4.35
Odnaceae	<i>Lophera alata</i> Bomks ex Gaertn.f.	0.194	0.029	0.223	0.09	0.014	0.105	3.61
melicaceae	<i>Entandrophragma africana</i> (Wehs) C.D.C	0.183	0.027	0.21	0.09	0.0127	0.098	3.368
Myristicaceae	<i>Pycnanthus angolense</i> (Wilwe) Warb	0.058	0.0087	0.0667	0.03	0.004	0.031	1.065
sterculiaceae	<i>cola</i> SPP	0.056	0.0086	0.065	0.026	0.004	0.03	1.031
Euphorbiaceae	<i>Uapaca guineensis</i> mull.Arg	0.041	0.0061	0.0471	0.019	0.0029	0.022	0.756
Violaceae	<i>Rinorea dentata</i> P. Beauv	0.039	0.0059	0.045	0.018	0.003	0.02	0.687
Ebenaceae	<i>Diospyros bipindensis</i> Gurke	0.032	0.0049	0.0369	0.015	0.0023	0.017	0.584
Myristicaceae	<i>Staudti stipitata</i> Waib	0.023	0.0034	0.026	0.01	0.0016	0.012	0.412
Burseraceae	<i>Santiria trimera</i> (Oliv) Aubrev	0.012	0.0017	0.014	0.0056	0.0008	0.0065	0.22
Myristicaceae	<i>Coclocayon preussii</i> warb	0.0087	0.0013	0.01	0.0041	0.00061	0.0047	0.162
Apocynaceae	<i>Rauvolfia vomitoria</i> Alzel	0.005	0.0008	0.0058	0.0024	0.0004	0.0027	0.093
Leguminosae	<i>Albezia adiantifolia</i> (Schum) W.F Wight)	0.0047	0.0071	0.00541	0.00221	0.000334	0.0025	0.086
Euphorbiaceae	<i>Drypetes paxii</i> Hutch	0.0029	0.00044	0.0033	0.0014	0.00021	0.0016	0.055
Irvingiaceae	<i>irvingia gabonensis</i> Aubry-Lecomte ex O'rocke	0.015	0.0023	0.0173	0.007	0.0011	0.00081	0.028
Simaroubaceae	<i>Hannoa klaineana</i> Pierre & Engl	0.0011	0.00017	0.0013	0.0005	0.00008	0.00059	0.02
TOTAL		5.378	0.807	6.185	2.528	0.379	2.91	

TAGB=total above-ground biomass, TBGB=total below-ground biomass, TB=total biomass, TAGC=total above-ground carbon, TBGC=total below-ground carbon, TC=total carbon

Table 2: Carbon stock share within DBH classes of tree species

DBH CLASSES	No OF TREES	TAGB	TBGB	TB	TC	DENSITY
>0- 10	73	1.8165	0.2725	2.08898	0.982	486.7
>10 – 20	21	0.3248	0.0487	0.374	0.176	140
>20 – 30	11	0.3974	0.0596	0.457	0.215	73.3
>30 – 40	11	1.5834	0.2375	1.8209	0.856	73.3
>40 – 50	4	0.92	0.138	1.058	0.497	26.7
>50	4	0.55	0.0825	0.6325	0.2973	26.7

TAGB=total above-ground biomass, TBGB=total below-ground biomass, TB=total biomass, TC=total carbon

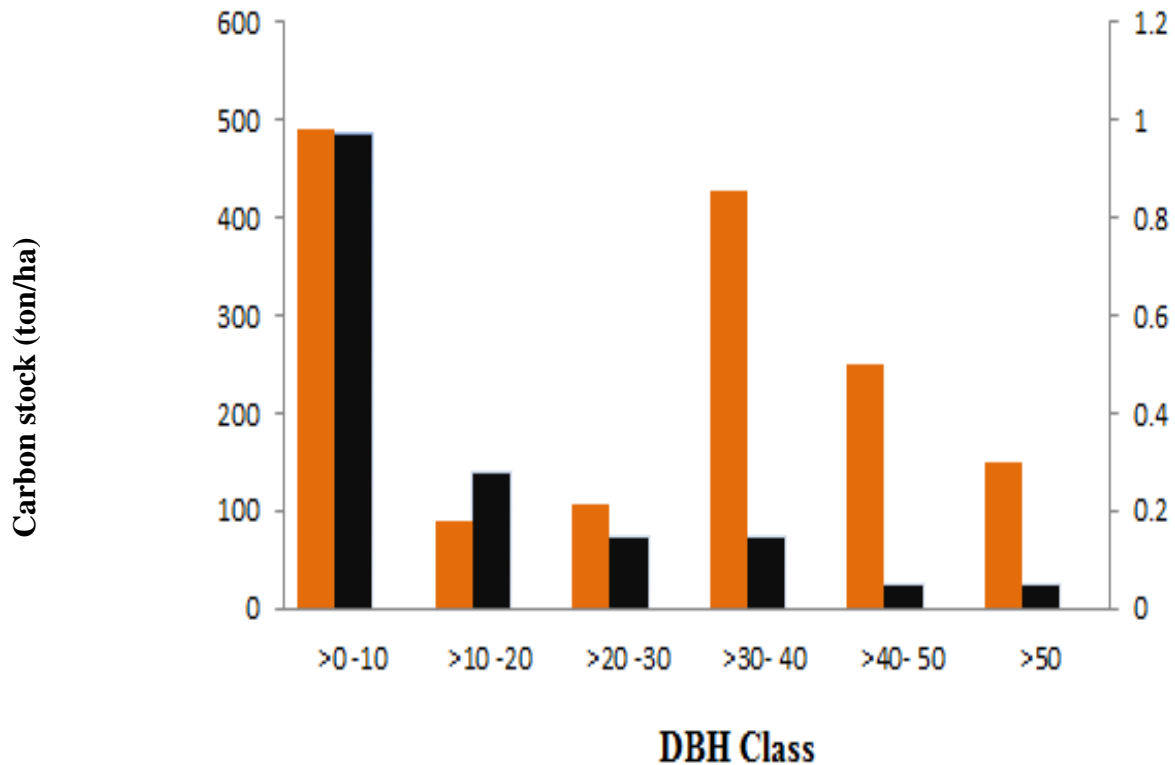


Figure 2: Carbon stock share within DBH classes of tree species

Carbon stock share within height classes of tree species

The height of trees in the study area were group into four categories as follows; > 0 – 10, >10 – 20, >20 – 30 and >30 – 40 respectively. The height class of >0- 10m had the highest density of fifty four (54) trees/ha making a(44.3%) followed by the height class of > 10-20m which had a tree density of forty eight (48)trees/ha making a 39.4% of the total trees in the study area respectively. The least density of trees was found within the uppermost canopy of trees with >30m of height class by accounting just one (1) tree/ha making just (0.8%) of tree/ha in the sample size. Irrespective of the trend in decreasing order of tree density based on height classes,

that is from >0-10 to the highest class (>30-40), there is an irregularity in the trend on the percentage and the amount of carbon stored in each height class. It was found that the height class of >20 – 30m have the highest carbon reserves of 1.856 t·ha⁻¹ making 52.0% carbon store in all the height class followed by the height class of >10-20m having a carbon reserves of 0.991 t·ha⁻¹ which contribute to approximately 27.8% of the total carbon in the trees species in the sample size respectively. The least carbon stock was stored in trees with the height class of >30-40m which contributes only to about 0.308t/ha making just 8.6% of the total carbon stored in the trees in the BBCF.(Table3, Figure 3)

Table 3: Carbon stock share within height classes of tree species

HEIGHT CLASS	No OF TREES	TAGB	TBGB	TB	TC	DENSITY
> 0 – 10	54	0.7624	0.1144	0.87676	0.412	360
>10 – 20	48	1.833	0.275	2.108	0.991	320
>20 – 30	19	3.4334	0.515	3.948	1.856	126.6
>30 – 40	1	0.57	0.0855	0.656	0.308	6.6

TAGB=total above-ground biomass, TBGB=total below-ground biomass, TB=total biomass, TC=total carbon

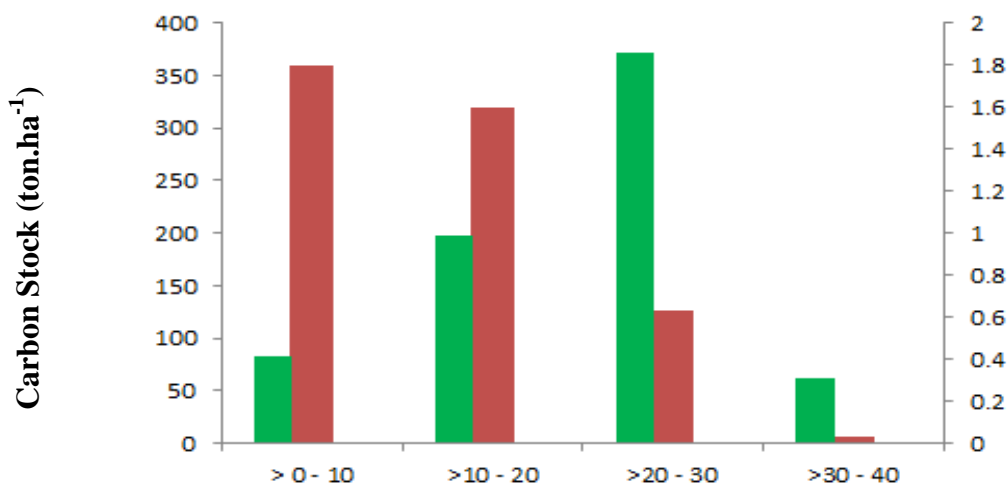


Figure 3: Carbon stock share within height classes of tree species

Carbon store in litters, herbs and grasses (LHG)

According to this studies, the total percentage of carbon stored in litters, herbs and grasses in the study area of BBCF was approximately 1.82% t·ha⁻¹.The highest store was seems to be herbs 0.0066t/ha making approximately (0.66%) t·ha⁻¹ and closely followed by grasses 0.0065 t·ha⁻¹ with a percentage of carbon reserves of 0.65% t·ha⁻¹. The least carbon stored was in litters 0.00508 t·ha⁻¹ which contribute to approximately 0.508% t·ha⁻¹ of the entire amount of carbon reserves in LHGs. (Table 4, figure 4)

Table 4: Carbon store in litters, herbs and grasses (LHG)

SAMPLES	FRESH WIEGHT(g)	DRY WIEGHT(g)	BIOMASS(t/ha)	CARBON STOCK(t/ha)
LITTERS	3000	558	0.0108	0.00508

HERBS	1190	290	0.014	0.0066
GRASSES	185	44	0.0138	0.0065

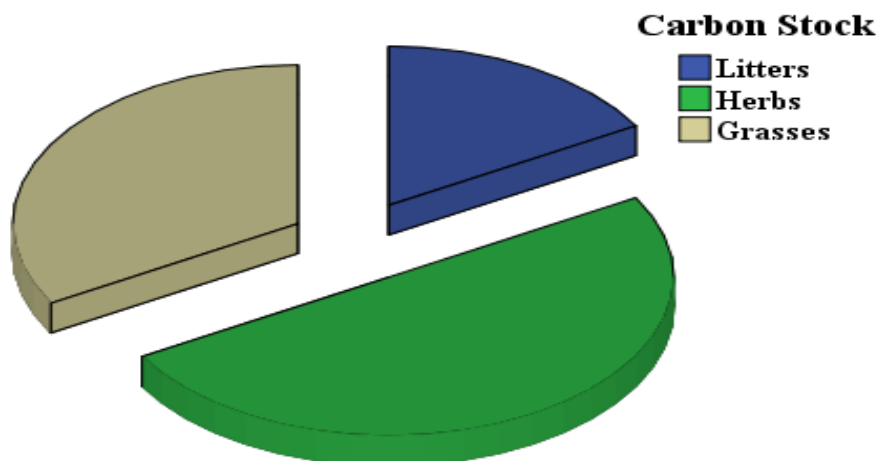


Figure 4: Carbon store in litters, herbs and grasses (LHG)

Carbon store in the organic soil:

The study estimated the average bulk density of soils in the study area of the BBCF to be 1.087g/cm and it ranges from 1.01g/cm, 1.12g/cm to 1.13g/cm according to the depth in the soil profile (0-10, 10-20 and 20-30) cm respectively. The percentages of carbon content of the soil in the study area ranges from 4.66%, 2.45% and 2.21% according to the different depth in the soil profile (0-10,10-20 and 20-30) cm respectively with a mean value of 3.12t/ha. Thus, the current average soil organic carbon investigated in the study area was found to be 33.9 t·ha⁻¹.

The SOC content was varied at the different depths but follows a common trend from top to bottom respectively. The uppermost depth (0-10) cm has the highest SOC contents of 47.066 t·ha⁻¹ and 20-30cm has the least carbon content of 24.97 t·ha⁻¹ of the amount of SOC stored in the soil. The average bulk density of the soil in the study area increases with depth increment. The mean values of bulk density from top, middle and deep soil profile were 1.01g/cm³,1.12g/cm³ and 1.13g/cm³ respectively. However, SOC decreases with depth increment as shown in (table 5)

Table 5: Carbon store in the organic soil

Depth (cm)	Bulk Densities (g/cm ³)	% Carbon concentration	Soil organic carbon
0-10	1.01	4.66	47.066
10-20	1.12	2.45	27.44
20-30	1.13	2.21	24.97

Figure 6: Soil organic carbon shared with % carbon concentration

Thus the study reviewed that the carbon stock of trees, LHGs and soil organic carbon were found to be 2.91 t·ha⁻¹, 1.82 t·ha⁻¹ and 33.9 t·ha⁻¹ respectively. Hence the total carbon stored in the sample space of the BBCF was 38.61 t·ha⁻¹ and carbon dioxide equivalence of 141.57 tons and in the research plot would be 965.25 t·ha⁻¹ and 3542.47tons of carbon dioxide equivalence (Table 6).

Table 6: Carbon stock and carbon dioxide equivalent on the different carbon pool

Samples	carbon stock (t/ha)	carbon dioxide equivalent (tons)
Soil	33.9	124.4
Trees	2.91	10.68
LHG	1.82	6.68
TOTAL	38.63	141.76

Accordingly, the maximum quantity of carbon stock was found in soil with reservoir of 87.8% of the total carbon. The forest trees carbon rank the second reservoir of carbon which has accumulated 7.5% of the total carbon in the study area. LHGs biomass contributes small amount of carbon; stored only 4.7% of the total carbon respectively (figure 7)

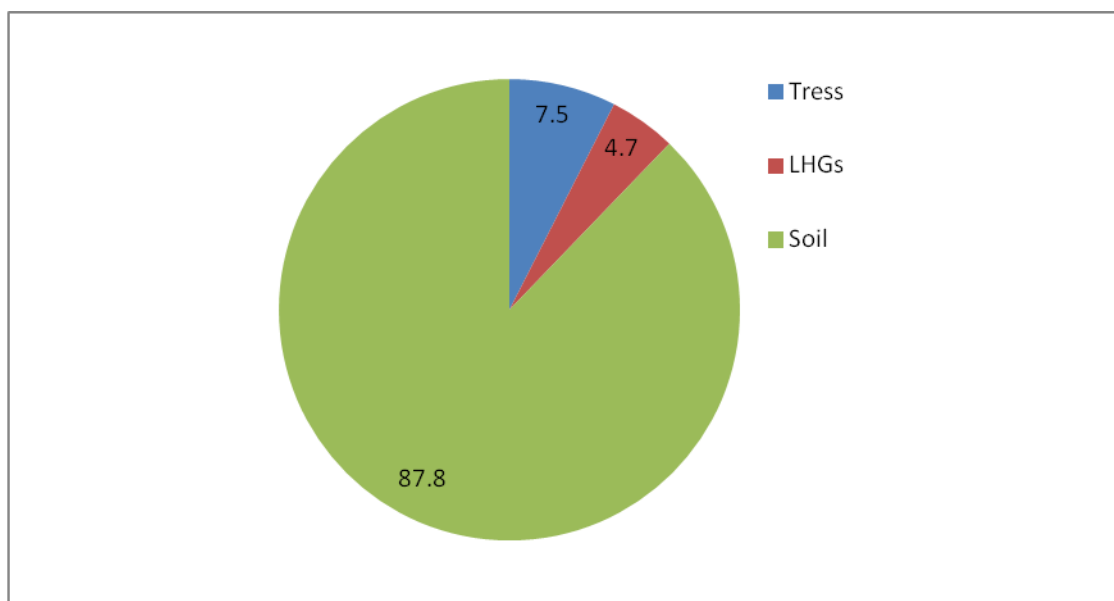


Figure 7: Percentage of carbon stock at each pool.

Discussion

Biomass mass and carbon stock estimation:

The present assessment of carbon stock estimates an implication for global carbon cycle, the average carbon stock of community forest of Mid Hill Region of Napel is 71.36t/ha (Anup *et al.*, 2013). Hence, the present study was lower than that in Napel as 38.63t/ha was found in the study area of BBCF. The above and below-ground trees carbon stock was lower than those obtain in Napel and almost comparable to those obtain in selected church forests (Tulu *et al.*, 2013).

The variation might come from variation of age of the trees, existing species, and management of the community forest. The use of an allometric model for biomass estimation might also help in explaining the difference in estimated value as explained that reliance on allometric equations could be one of limitation resulting in large variations in such estimates (Lasco *et al.*, 2000).

LHG biomass shared small amount of carbon in the BBCF. The assessment on mean LHGs carbon of tropical forest ranges between 2.6 t/ha to 3.8t/ha as reported by Brown (1997). The result was lower than this range. The reason for the small carbon stock of LHGs is due to the close canopies of *Strombosia pustulata* and *Chrysophyllum africana* up to the near ground making the growth of herbs and grasses unfavourable. The

dominance of even green tree species has also contributed to the existence of small litter falls. Litter runoff occurred due to the hilly nature of the study area and might also be the cause for small carbon account in this pool.

While analyzing diameter and height distribution in trees in the study area, number of trees per hectare decreased with the increase in DBH and height. The highest number of trees was found in the DBH and height class of (0-10) cm and (0-10) m respectively. This is closely related to the species composition as most of the canopy species are pioneers that rarely grow beyond 30 cm DBH and 20m in height.

It could be also due to the natural and human disturbances as can be seen in illegal timber and fuel wood harvesting by the nearby fishing ports around the community forest for the construction of ovens, houses and the smoking of finish. Except of these alterations, the condition indicates an immature forest.

In the present study we found higher soil carbon contrary to the dominant pattern reported in the literature (De Camargo et al., 1999; Sierra et al., 2007). Powers et al.(2011) showed that soil carbon stocks may increase or decrease after land use conversion depending on soil type and precipitation.

The increase in the soil carbon stock at BBCF may be due to an increase in soil carbon concentrations throughout the upper meter of soil associated with an increase in fine root biomass or landscape position. This suggests that fine root turnover might contribute to the increase in soil carbon stocks and /or BBCF location, that is more enriched sites lower down the slope where greater rate of erosion deposition occurred

Furthermore, the high SOC might be due to borrowing activities of the numerous crabs and rodents leading to the increase in production and decomposition.

The study revealed that, the study area in the research plot (Dikolo Peninsula) of the BBCF can sequester huge amount of carbon (38.61t/ha). Thus, it has a high potential to form a principal component in the mitigation of global warming and adaptation to climate change by naturally reducing the amount Carbon dioxide in the global atmosphere.

The largest amount of carbon stored in the study area was found in the forest soil with 33.9t/ha hence the forest soil have high potential in storing carbon when it is sustainably management.

The study also revealed that the forest trees in the study area have low amount of carbon stock in their above and below ground biomass and *Strombosia pustulata* and *Chrysophyllum Africana* have the height amount of carbon stock biomass in this pool respectively. More than 50% of the trees were found in less than 10cm DBH class. Hence, the study revealed that the research plot (Dikolo peninsula) in the BBCF is dominated by young trees after the implementation of community forest management through natural regeneration.

The carbon stock of LHGs was observed to be the least in the study area with just 1.82t/ha but contributed significantly to the carbon stored in the study area though small when compare to must tropical forest.

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