International Journal of Geography, Geology and Environment

P-ISSN: 2706-7483
E-ISSN: 2706-7491
IJGGE 2021; 3(2): 35-46
Received: 09-04-2021
Accepted: 11-06-2021

Sanjeev Raj Dhakal
Ministry of Forest and Environment, Kathmandu, Nepal

Ram Asheshwar Mandal
School of Environment Science and Management, Kathmandu, Nepal

Ajay Bhakta Mathema
School of Environment Science and Management, Kathmandu, Nepal

Corresponding Author:
Ram Asheshwar Mandal
School of Environment Science and Management, Kathmandu, Nepal

Soil nutrients and carbon increment dynamics in broadleaf and chirpine forests of community forests Bhaktapur, Nepal

Sanjeev Raj Dhakal, Ram Asheshwar Mandal and Ajay Bhakta Mathema

Abstract

The study gaps have been seen on carbon stock status and Mean Annual Carbon Increment (MACI) in different staged plants. Therefore, this study aimed to assess status of carbon stocks in *Schima-Castanopsis* and Chirpine strata in community forest (CF), to compare the mean annual carbon increment in *Schima-Castanopsis* and Chirpine Forest among the community forests and to assess the status of major soil nutrients (N, P, K) & pH in both types of forest. Specifically, two (*Schima-Castanopsis* and Chirpine composition) of three community forests of Bhaktapur district were selected for this study. Stratified random sampling applying randomized block experimental design was used maintaining 5% sampling intensity. Altogether 45 sample plots were taken from *Schima-Castonopsis* and Chirpine strata, particularly, 28, 11 and 6 from Patle, Bhingali and Kandelipakha CFs respectively. The plots having 20*25, 10*10, 5*5, 2*5 and 1*1m^2 were established for tree, pole, sapling, seedling and litter, herbs and grass respectively. Parameter like diameter at breast height and height of the plant were measured and samples of seedling and Litter, Herbs and Shrubs were collected. Moreover, soil samples were collected from 0-10, 10-20 and 20-30 cm depth. Biomass carbon was estimated using Chave *et al.*, equation. Further, soil carbon, N, P, K and pH were calculated in the lab. The result showed that above ground biomass carbon (AGBC) was found to be highest with nearly 43 t/ha at Patle community forest which was followed with 39 t/ha by Bhingali community forest while it was the lowest 29 t/ha in Kadeliko Pakha community forest in Schima- Castonopsis forest strata. Likewise, in Chirpine strata, AGBC was the highest at Patle CF with about 28 t/ha, about 26 t/ha at Kadeliko Pakha CF and lowest amount of carbon was found at Bhingali CF with about 24 t/ha. The carbon stock in Schima-Castanopsis forest and Chirpine forest were found 71.52 t/ha and 58.36 t/ha respectively. The MACI was the higher in Schima-Castanopsis forest than in Chirpine forest. One way ANOVA showed that, the p value (df=2,17, p=0.176) was greater than 0.05, therefore the average MACI among the community forest were not significantly different at 5 % level of significance and so as Tukey's b test too. The N and K content were higher in Chirpine forest whereas P was found higher in Schima-Castanopsis forest. Soil pH value ranges from 4.44-6.14 and 5.10-5.98 in Schima-Castanopsis and Chirpine forests respectively indicating slightly acidic soil.

Keywords: Carbon stock, MACI, soil nutrients

1. Introduction

Fores carbon sequestration is the process of increasing the carbon content of a carbon pool other than the atmosphere (FAO, 2011) [15]. Carbon accumulatedin forest ecosystems involve numerous components including biomass carbon and soil carbon. The world's forests and forest soils currently store more than 1 trillion tons of carbon which is twice the amount floating free in the atmosphere (Oli and Shrestha, 2009) [27]. Forest can be both sources and sink so carbon, depending on the specific management regime and activities (IPCC, 2000) [37]. The trees store carbon by sequestrating atmospheric carbon in the growth of wood biomass through the process of photosynthesis and thereby increasing the soil organic carbon (SOC) (Shrestha and Singh, 2008) [31] which is major concern to climate change (Ranabhat *et al.* 2008, Lepetz *et al.*, 2009) [43, 24]. Carbon is contained not only in trees, but also in the soil, roots and organic debris Gregory, 1995, Batino, 2008, Bado *et al.*, 2010 [18, 3], for which tenure remains ambiguous (Pokharel & Byrne, 2009) [42]. Onan average, 50% of the biomass is estimated as the carbon content for all species of trees (MacDicken, 1997) [40]. It is believed that the goal of increasing the carbon sink and reducing carbon sources can be achieved efficiently by protecting and conserving the carbon pools in existing forests

(Brown *et al.*, 1996) [7]. Vegetation and soils are viable sinks of atmospheric carbon (C) and may significantly contribute to mitigation of global climate change (Bajracharya *et al.* 1998) [4].

There is a direct relationship between tree growth or Mean annual carbon increment with soil fertility. Plant absorbs nutrient from the soil in the form of minerals and other inorganic compounds. The quantity of available nutrient is determined by two main factors: the condition of the soils and the condition of the plants. Soil fertility is one of the key factors in determining agricultural output (Mathema *et al.*, 1999, Regmi & Zoebisch, 2004 Drechsel *et al.*, 2004) [28]. The primary nutrients for plant growth are nitrogen, phosphorus and potassium (Gruhn *et al.*, 2000, Cakmak, 2002 [19, 8], Tiwari *et al.*, 2009) [33]. Total nutrient content varies from soil to soil depending upon the nature of parent material and other soil forming processes (Ghani & W., 1997, Reddy *et al.*, 2012) [17, 44]. Soil pH is an important property which is used to measure acidity and alkalinity of soil solution. It can affect the availability of plant nutrients, toxins and activity of many essential micro- organisms. (KC *et al.*, 2013) [23]. Since there is a triangular relationship amongst Carbon stock, Mean Annual Carbon Increment (MACI) and soil fertility, it is an urgent need to establish a national baseline of forest carbon in our country. The study was conducted with the aim of quantifying the amount and distribution of carbon content in the plant biomass, Mean Annual Carbon Increment (MACI) of species composition and Soil nutrients within the soil profile in *Schima-Castanopsis* and Chirpine Forest in community forests.

2. Materials and methods

2.1 Description of the Study area

The study was carried out in the three community forests of Bhaktapur district Nepal. The details of the studied community forests are presented in table 1.

Table 1: Description of the study area

Community Forest	Strata	Area (Ha.)	Major Spp.
Patle	Broad leaf	17.63	*Schima wallichii, Castanopsis indica*
	Pine	10.32	*Pinus roxburghii/ Rhododendron Spps.*
Bhingali	Broad leaf	3.65	*Schima wallichii, Castanopsis indica*
	Pine	7.27	*Pinusroxburghii/Schima wallichii*
Kadelako Pakha	Broad leaf	0.75	*Schima wallichii, Castanopsis indica, Alnus nepalensis*
	Pine	0.33	*Pinus roxburghii*

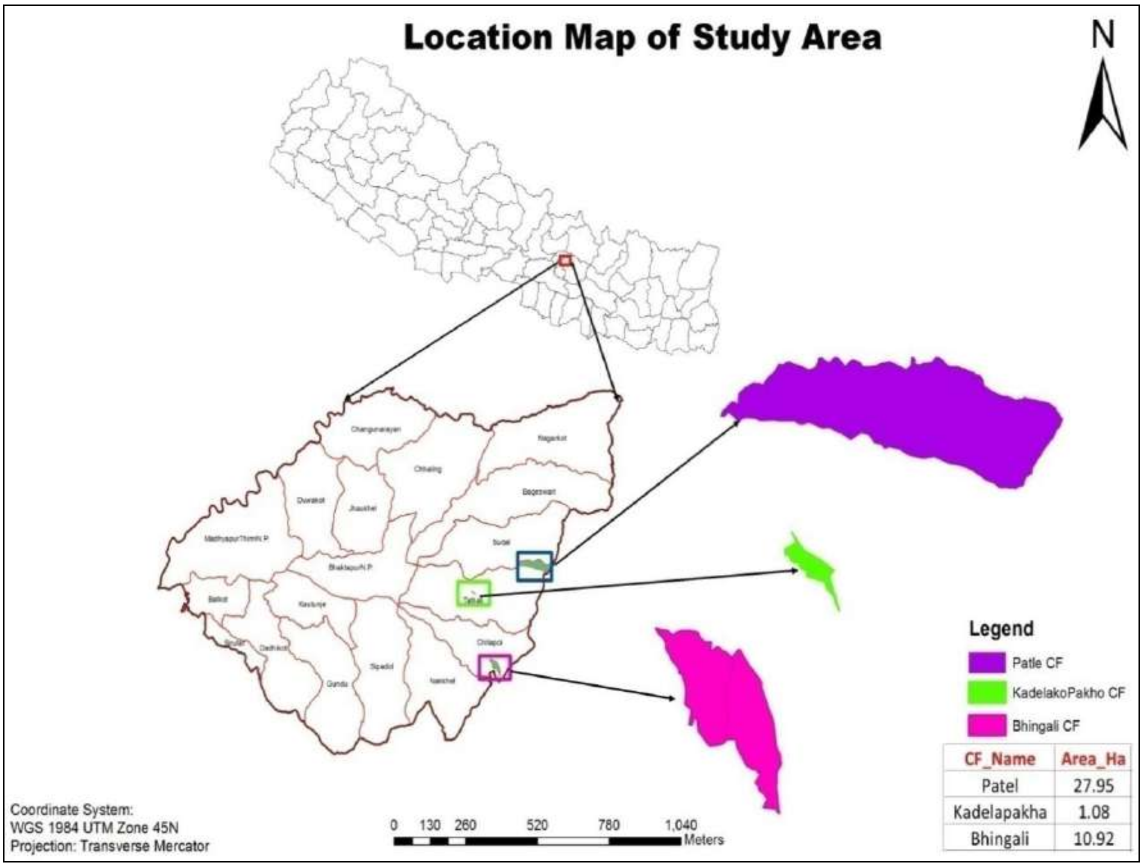

Fig 1: Map showing study area

2.2 Methodology

Firstly, the study area was selected. Next, the data specifically biophysical and soil samples were collected and they were analyzed. Based on the analyzed data the thesis draft was prepared and it was finally completed.

2.3 Methods of data collection

Primary and secondary data were collected for the study purpose. The secondary data and information were gathered from internet surfing, books, reports, journals, department of forest and district forest office etc. while the primary data were collected through field observation, direct measurement, and laboratory analysis, as per the method described below.

Stratification and sample collection: The total forest area was divided in two main strata (Broad leaf and Pine) according to forest composition. Sampling intensity of 5% was taken for the field inventory. Total 45 sample plots were established for the field data collection.28 sample plot for Patle, 11 for Bhingali and 6 for Kadeliko Pakha CF were selected as sample plots and they were laid down randomly to collect data from forest. The rectangular plot of size $20\times25m^2$, $10x10m^2$, 5×5 $m^2$and $2\times5m^2$ plots were laid down for the tree, pole, sapling and seedling respectively at the corner of each plot. Litter, herbs and grass were collected from the 1×1 m^2 laid down as nested plot (figure 2).

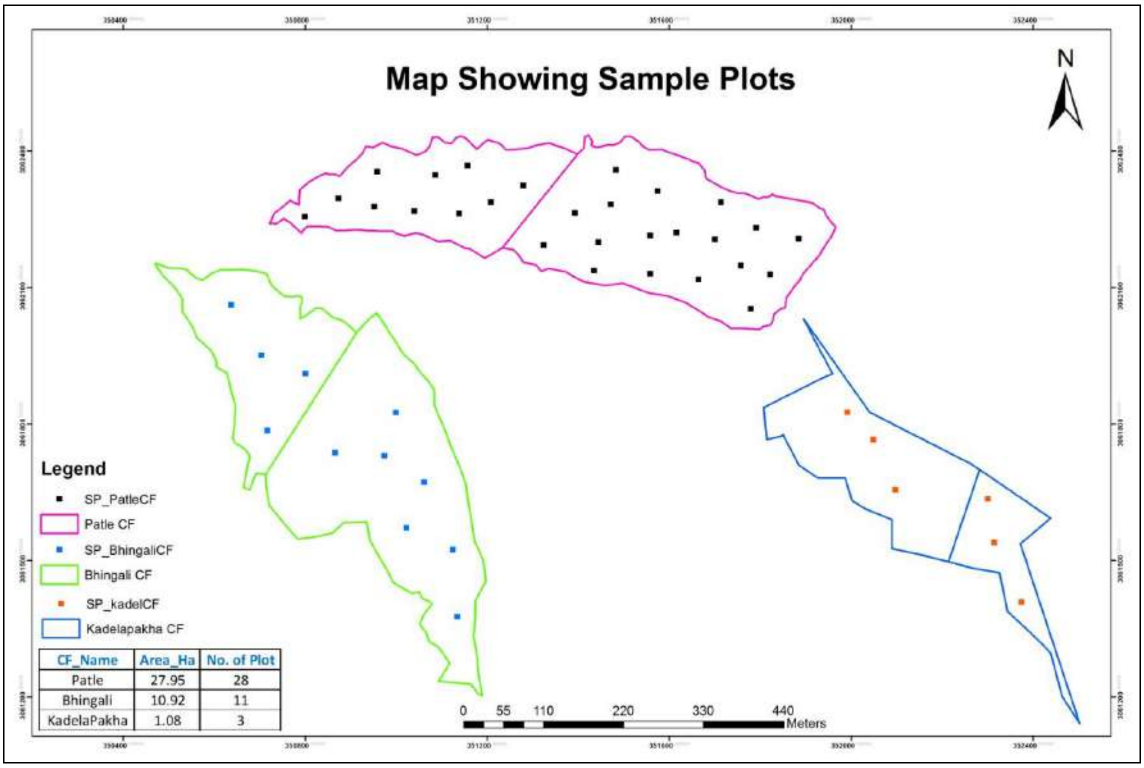

Fig 2: Map showing sample plots

2.4 Data generation

All the litter (dead leaves, twigs) was collect and the fresh sample weight of litter was taken in the field and sample of the live components (herbs and grass) within $1m^2$ was collected in a destructive manner. The fresh sample weight of herbs and grass was taken in the field. The samples of litter were placed in the marked sample bag for laboratory approach to determine the oven dry weight of the biomass.

Aboveground sapling biomass and seedling/ regeneration: The saplings of 1-5cm DBH at 1.3m above ground level was measured by using linear tape and sample fresh weight was taken in the field and then oven dry weight was in the laboratory.

3.4.3 Aboveground tree and pole

The DBH of individual tree (DBH≥5cm) was measured by diameter tape and the height of individual tree was measured by using clinometers. The tree height was estimated as;

H= tan (inclination) ×b+ a

Where H= height of tree
a = eye height of the observer (1.5m)
b = distance between the tree base and observer in meter.

3.4.4 Soil sampling

The soil samples at depth 0-10cm, 10-20cm and 20-30cm were collected at 2 different sample plots in each stratum by using soil corer and shovel and place in labeled sample bag and the fresh weight of sample were taken in the field with the help of weighted machine. After that the collected samples were bring to the laboratory to determine the carbon content. The collected soil Samples were oven dried at 105^0C in the laboratory until they reached a constant weight to estimate soil bulk density.

2.5 Data analysis

Aboveground tree/pole carbon stock (AGT/PB)

Since the rainfall data of Bhaktapurdistrict was lies within moist region so, the allometric equation developed by Chave *et al.* (2005) for moist forest stand was used to estimate above ground tree/pole biomass where the wood density was available for a tree after that the biomass stock density was converted to carbon stock density using the IPCC (2006) default carbon fraction of 0.47.

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

Where,
AGTB = above ground tree biomass (kg)
ρ = dry wood density (gm/cm^3)
D = tree diameter at breast height (cm)
H = tree height (m)

3.5.1.2 Aboveground sapling (AGS) and seedling (S) carbon stock

The dry weight of sample seedling were taken and converted in to biomass after that the biomass stock density was converted to carbon stock density using the IPCC (2006) default carbon fraction of 0.47.

Leaf litter, herb and grass (LHG) carbon stock

For litter, herbs and grass the amount of biomass per unit area was calculated by:

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

Where,
LHG = biomass of leaf litter, herbs and grass (t/ha)
W (field) = weight of the fresh field sample of leaf litter, herbs and grass destructively sample within an area of size A (gm)
A = size of the area in which leaf litter, herbs and grass were collected (ha)
W (dry subsample) = weight of the oven dry sub sample of leaf litter, herbs and grass taken to the laboratory to determine moisture content (gm)
W (wet subsample) = weight of the fresh sub sample of leaf litter, herbs and grass taken to the laboratory to determine moisture content (gm)
The carbon content in LHG, C (LHG) was calculated by multiplying LHG with IPCC (2006) default carbon fraction of 0.47.

Soil carbon

The Walkley and Black method was used to analyze the soil carbon.
SOC= Organic Carbon Content % x Soil Bulk Density (Kg/cc) x thickness of horizon. (Walkley & Black, 1958) [46]

Total Carbon= Total Biomass carbon + Soil carbon

Belowground biomass carbon stock (BC): The below ground biomass carbon was estimated as 15 % of above ground biomass carbon (MacDicken 1997) [40].

Total forest carbon stock

The total carbon stock was calculated by summing the carbon stock of the individual carbon pools.

Total Carbon stock = C (AGTB) + C (AGPB) + C (AGSB) + C (BB) + C(S) + C (LHG) + SOC

Whereas,
C (ABTB) = carbon in above ground tree biomass (t C/ha)
C (ABPB) = carbon in above ground pole biomass (t C/ha)
C (AGSB) = carbon in above ground sapling biomass (t C/ha)
C (BB) = carbon in below ground biomass (t C/ha)
C (LHG) = carbon in litter, herb and grass (t C/ha)
C(S) = carbon in seedling (t C/ha)
SOC = soil organic carbon (t C/ha)

Soil nutrients Calculation

The soil pH was analyzed in lab using the pH meter. Nitrogen was analyzed using Kjeldahl digestion and distillation method. The Bray's No. 1 (Bray and Kurtz, 1945) method was used to analyze the soil Phosphorus analysis in the lab. The Flame photometric method (Toth and Prince, 1949) was used to analyze the soil Potassium.

Statistical Analysis: Analysis of Variance (ANOVA) was used to test the significance of carbon status and MACI in different strata of community forests. Further Tukey b test was performed to test difference as post hoc test.

3: Result

3.1 Carbon stock in community forests according to different tree composition

3.1.1 Biomass Carbon Status in *Schima-Castanopsis* (SC) and Chirpine (P) strata

In *Schima-Castanopsis* strata,the tree carbon stock was found to be highest in Patle CF with 28.49 t/ha whereas lowest value with 13.59 t/ha of same strata were recorded in case of Kadeliko Pakha CF (Table 2).The SC strata of Bhingali CF remained almost at mid value with 21.24 t/ha compared to same strata of others. Total carbon stock was found to be highest 502.31 ton carbon in SC strata of Patle CF while on the other hand lowest value was found with 10.19 ton carbon in same strata of Kadeliko Pakha CF.
Concerning to *Pinus roxburghii* strata, Carbon stock in tree staged plants was found below 15 ton/ha ranging from 11.08 t/ha at Bhingali CF, 11.69 t/ha at Kadeliko Pakha CF and 14.76 t/ha at Patle CF. In addition, 152.30 ton carbon of same staged tree in that strata was found as highest value whereas 3.86 ton carbon in Kadeliko pakha CF was recorded as lowest value.
Similarly in the case of *Schima-Castanopsis* strata, the pole carbon stock was found to be 12.58 t/ha, 16.32 t/ha and 14.24 t/ha for Patle CF, Bhingali CF and Kadeliko Pakha CF respectively. Total carbon stock was found to be highest 221.79 ton carbon in SC strata of Patle CF while on the other hand lowest value was found with 10.68 ton carbon in same strata of Kadeliko Pakha CF.
Concerning to the *Pinus roxburghii* strata, Carbon stock in pole staged plants was found to be 12.56 t/ha, 10.54 t/ha and 13.55 t/ha for Patle CF, Bhingali CF and Kadeliko Pakha CF respectively. In addition, 129.57 ton carbon of same staged plant in Patle CF was found as highest value whereas 4.47 ton carbon in Kadeliko pakha CF was recorded as lowest value.
Furthermore, in *Schima-Castanopsis* strata the Sapling carbon stock was 0.66 t/ha, 0.65 t/ha and 0.55 t/ha for Patle CF, Bhingali CF and Kadeliko Pakha CF respectively. Total carbon stock was found to be highest 11.51 ton carbon in SC strata of Patle CF while on the other hand lowest value was found with 0.42 ton carbon in same strata of Kadeliko Pakha CF.
In case of*pinus roxburghii* strata, Carbon stock in Sapling staged plants was found to be 0.51, 1.52 and 0.40 t/ha for Patle CF, Bhingali CF and Kadeliko Pakha CF respectively. In addition, 11.08 ton carbon of same staged plant in those strata was found as highest value whereas 0.13 ton carbon in Kadeliko pakha CF was recorded as lowest value.
As depicted in table, in the case of *Schima-Castanopsis* strata, the seedling carbon stock was found to be 0.17 t/ha, 0.11 t/ha and 0.13 t/ha for Patle CF, Bhingali CF and Kadeliko Pakha CF respectively. Total carbon stock was found to be highest with 3.0 ton carbon in SC strata of Patle CF while on the other hand lowest value was found with 0.10 ton carbon in same strata of Kadeliko Pakha CF.

Concerning to the *Pinus roxburghii* strata, Carbon stock in seedling staged plants was found to be 0.12 t/ha, 0.13 t/ha and 0.10 t/ha for Patle CF, Bhingali CF and Kadeliko Pakha CF respectively. In addition, 1.24 ton carbon of same staged plant in Patle CF was found as highest value whereas0.03ton carbon in Kadeliko pakha CF was recorded as lowest value.

Besides, in *Schima-Castanopsis* strata, the LHG carbon stock was found to be 0.52 t/ha for Patle CF, 0.54 t/ha for Bhingali and 0.45 t/ha for Kadeliko Pakha CF. Total carbon stock was found to be highest 9.17 ton carbon in SC strata of Patle CF while on the other hand lowest value was found with 0.34 ton carbon in same strata of Kadeliko Pakha CF.

With regard to *Pinus roxburghii* strata, Carbon stock in LHG was found to be 0.49 t/ha in Patle CF, highest value 0.50 t/ha in Bhingali Cf and lowest value with 0.40 t/ha in Kadeliko Pakha CF. In addition, 5.06 ton carbon of LHG strata was found as highest value whereas 0.35 ton carbon in Kadeliko Pakha CF was recorded as lowest value.

Table 2: Above Ground Biomass Carbon Stock (ton/ha)

Strata	CF	Tree		Pole		Saplings		Seedling		LHG	
		t/ha	Total	t/ha	Total	t/ha	Total	t/ha	Total	t/ha	Total
Schima-Castonopsis	Patle	28.49	502.31	12.58	221.79	0.65	11.51	0.17	3.00	0.52	9.17
	Bhingali	21.24	77.51	16.32	59.57	0.66	2.42	0.11	0.40	0.54	1.97
	Kadelipakha	13.59	10.19	14.24	10.68	0.55	0.42	0.13	0.10	0.45	0.34
Chirpine	Patle	14.76	152.3	12.56	129.57	0.51	5.30	0.12	1.24	0.49	5.06
	Bhingali	11.08	80.54	10.54	76.61	1.52	11.08	0.13	0.95	0.50	3.64
	Kadelipakha	11.69	3.86	13.55	4.47	0.40	0.13	0.1	0.03	0.40	0.35

3.1.2 Total Carbon stock in different Community Forest

The total Carbon stock of three community forest was drawn by multiplying ton per hectare carbon by respective stratum area. Specifically, the carbon stock was found to be the highest in Patle Community Forest with 1260.23 which was followed by Bhingali CF with 424.07 t and lowest level of Carbon stock was found at Kadeliko Pakha CF with82.68 t. Variation in total Carbon stock in particular forest was majorly governed by area of the forest.

Table 3: Carbon Stock (t/ha) in different forest strata

Forest strata	Name of CF	Aboveground Biomass Carbon (t/ha)	Belowground biomass carbon (t/ha)	Soil carbon (t/ha)	Total carbon stock (t/ha)
Schima-Castonopsis	Patle	42.41	6.36	31.37	71.52
	Bhingali	38.87	5.83	32.41	
	Kadeliko pakha	28.96	4.35	24	
Chirpine	Patle	28.44	4.27	31.43	58.36
	Bhingali	23.77	3.57	29.77	
	Kadeliko pakha	26.15	3.91	23.78	

3.1.3 MACIs in SC and Chirpine Strata of Community Forests

Strata wise MACI of Tree, Pole, Sapling and Seedling of Patle, Bhingali and Kadelako Pakha CF have been presented as below. Further, to identify whether MACI of such staged plants were significant or not, One way ANOVA was applied for statistical test.

Table 4: MACIs in CFs (t/ha)

Strata	CF	Tree	Pole	Sapling	Seedling
Schima-Castonopsis	Patle	0.72	0.56	0.10	0.09
	Bhingali	0.60	0.72	0.09	0.06
	Kadeliko Pakha	0.48	0.66	0.10	0.07
Chirpiine	Patle	0.39	0.51	0.08	0.06
	Bhingali	0.25	0.46	0.22	0.07
	Kadeliko Pakha	0.40	0.63	0.06	0.05

In tree staged vegetation of *Schima-Castanopsis* strata, Highest value of Mean Annual Carbon Increment (MACI) with 0.72 t/ha was found at Patle CF whereas lowest value was recorded at Kadeliko Pakha CF with 0.48 t/ha. Value of Bhingali CF remained interestingly at mid level with 0.60 t/ha. On the other hand, in case of tree staged Chirpine strata, a reversal result was found while compared to SC strata, where highest value was recorded at Kadeliko Pakha CF and lowest value was at Bhingali CF.

As like as tree staged vegetation, MACIs of Pole varied in both *Schima- Castanopsis* and *Pinus roxburghii* strata. Such a variation was in a range of 0.46 t/ha to 0.72 t/ha. Highest level of MACI was found at SC composition of Bhingali CF whereas lowest value was found at Chirpine strata of same CF.

Concerning to the Sapling staged plants; there was a narrow discrepancyin both strata of three Community forests. The deference was ranging from 0.06 t/ha to 0.10 t/ha. Highest level of MACI could be seen at Chirpine strata of Bhingali CF with 0.22 t/ha whereas lowest level of MACI was found at Kadeliko Pakha CF with 0.06 t/ha of same strata. Here, more interestingly, Patle and Kadeliko Pakha CF with Schima-Castanopsis strata had the same value of MACIs with 0.10 t/ha.

As similar as Sapling staged plants, small deference of MACIsin Seedling staged plants was found in both strata of three Community Forests. Such a difference belonged between 0.05 t/ha to 0.09 t/ha. Highest level of MACIs was found at SC strata of Patle CF while lowest level was found at Chirpine strata of Kadeliko Pakha CF.

Comparing MACI in Tree of Schima Castonopsis strata:
One way ANOVA showed that, the p value (df=2, 22, p=0.614) is greater than 0.05, therefore the average MACI among the community forest were not significantly different at 5 % level of significance.

Table 5: ANOVA showing difference in MACI of

	Sum of Squares	**DF**	**Mean Square**	**F**	**Sig. (P value)**
Between Groups	0.182	2	.091	.499	0.614
Within Groups	4.011	22	.182		
Total	4.193	24			

The Tukey's b statistical test indicated that there were no significant differences in MACI of three Community Forests separately since all the test values are in same subset.

Comparing MACI in Pole of Schima Castonopsis strata: One way ANOVA showed that, the p value (df=2,22, p=0.803) is greater than 0.05, therefore the average MACI among the community forest were not significantly different at 5 % level of significance.

Table 6: ANOVA table to test difference in MACI of pole

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.122	2	.061	.222	0.803
Within Groups	6.057	22	.275		
Total	6.179	24			

The Turkey B statistical test indicated that there were no significant differences in MACI of three Community Forests separately since all the test values are in same subset.

Comparing MACI in Sapling of Schima Castonopsis strata: One way ANOVA showed that, the p value (df=2, 22, p=0.904) is greater than 0.05, therefore the average MACI among the community forest were not significantly different at 5 % level of significance.

Table 7: ANOVA table to test MACI of sapling

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.000	2	0.000	0.102	0.904
Within Groups	.049	22	0.002		
Total	.050	24			

The Tukey B statistical test indicated differences in MACI of three Community Forests separately since all the test values are in same subset.

Comparing MACI in Tree of Chirpine strata: One way Anova showed that, the p value (df=2,17, p=0.176) is greater than 0.05, therefore the average MACI among the community forest were not significantly different at 5 % level of significance.

Table 8: ANOVA table to test MACI of Pine

	Sum of Squares	**Df**	**Mean Square**	**F**	**Sig.**
Between Groups	.133	2	.067	1.924	.176
Within Groups	.588	17	.035		
Total	.721	19			

The Tukey B statistical test indicated differences in MACI of three Community Forests separately since all the test values are in same subset.

Comparing MACI in Pole of Pine strata: Chire Pine: Pole strata

One way anova showed that, the p value (df=2,17, p=0.966) is greater than 0.05, therefore the average MACI among the community forest were not significantly different at 5 % level of significance.

Table 9: ANOVA table to test MACI of Chirpine pole

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.013	2	.006	.035	.966
Within Groups	3.050	17	.179		
Total	3.062	19			

The Tukey b statistical test indicated differences in MACI of three Community Forests separately since all the test values are in same subset.

Comparing MACI in Sapling of Chirpine strata: One way anova showed that, the p value (df=2, 17, p=0.473) is greater than 0.05, therefore the average MACI among the community forest were not significantly different at 5 % level of significance. The Tukey B statistical test indicated differences in MACI of three Community Forests separately since all the test values are in same subset.

Table 10: ANOVA table for Chirpine sapling MACI

s

	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	.107	2	.054	.782	.473
Within Groups	1.163	17	.068		
Total	1.270	19			

3.1.4 Descriptive Analysis of MACI in Schima - Castonopsis and Chirpine strata

Above table was drawn by segregating the data into 6 main domains and each of them were again broken down into three categories according to Community forest. Data having comparatively higher value have been described as below. In *Schima-Castanopsis* strata, the descriptive statistics showed that, the values of mean, standard error, standard deviation, minimum and maximum of MACI and 5% level of significance value were 0.72, 0.11, 0.47, 0.12, 2.07respectively in Patle CF. 0.56. 0.13, 0.56, 0.02,1.98 respectively in Pole staged plants of same CF. 0.93, 0.28, 0.55, 0.04, 0.14 in Sapling staged plants of Bhingali CF.

In the context of Chirpine strata, depending on above said parameters were found to be quite reversal compared to SC strata in case of only Tree and Pole staged plants. Here, the descriptive statistics showed that, the mean, standard error, standard deviation, minimum and maximum of MACI and 5% level of significance value were 0.40, 0.25, 0.35, 0.15 and 0.65 respectively in tree staged vegetation of Kadeliko Pakha CF. Moreover, 0.22, 0.16, 0.44, 0.02 and 1.21 were recorded in Sapling staged plants of Bhingali Community Forest.

Table 11: Mean, Standard error, Standard deviation, Minimum & Maximum of MACI

Strata/Stage	CF	Mean	Standard error	Standard deviation	Min.	Maxm.
Schima-Castonopis (Tree strata)	Patle	0.72	0.11	0.47	0.12	2.07
	Bhingali	0.60	0.14	0.27	0.27	0.92
	Kadeliko Pakha	0.48	0.03	0.04	0.45	0.50
Schima-Castonopis (Pole)	Patle	0.56	0.13	0.56	0.02	1.98
	Bhingali	0.72	0.21	0.42	0.11	1.06
	Kadeliko Pakha	0.66	0.21	0.29	0.45	0.86
Schima-Castonopis (Sapling)	Patle	0.99	0.11	0.05	0.01	0.19
	Bhingali	0.93	0.28	0.55	0.04	0.14
	Kadeliko Pakha	0.10	0.02	0.03	0.08	0.12
Chirpine (Tree)	Patle	0.39	0.06	0.20	0.09	0.68
	Bhingali	0.25	0.04	0.10	0.15	0.42
	Kadeliko Pakha	0.40	0.25	0.35	0.15	0.65
Chirpine (Pole)	Patle	0.51	0.15	0.48	0.06	1.71
	Bhingali	0.46	0.08	0.21	0.31	0.90
	Kadeliko Pakha	0.64	0.52	0.73	0.12	1.15
Chirpine (Sapling)	Patle	0.08	0.02	0.05	0.02	0.21
	Bhingali	0.22	0.16	0.44	0.02	1.21
	Kadeliko Pakha	0.06	0.01	0.01	0.05	0.06

3.1.5 Soil Fertility in SC and Chirpine Strata of Community Forests

The soil pH varies in both strata of community forests. The pH varies between 4.44 to 5.98. It was about 4.44 values in *Schima Castonopsis* of Patle community forest. The highest pH was recorded about 5.98 in Chirpine strata of Bhingali community forest.

Table 12: Soil pH in CF

Strata	CF	pH
Schima-Castonopis	Patle	4.44-5.80
	Bhingali	5.00-6.14
	Kadelipakha	4.93-5.60
Chirpine	Patle	5.30-5.90
	Bhingali	5.10-5.98
	Kadelipakha	5.00-5.86

The value of soil Carbon ranged between 24.00 t/ha to 31.37 t/ha in *Schima-Castanopsis* strata of three community forests where highest value remained at Patle CF whereas lowest at Kadeliko Pakha CF. Bhingali CF remained at mid value with 32.41 t/ha. As like as in SC strata, same sequence followed at Chirpine composition. Highest level of Soil Carbon was found at Patle CF with 31.43 t/ha and lowest at Kadeliko Pakha CF with 23.78 t/ha (Figure 3).

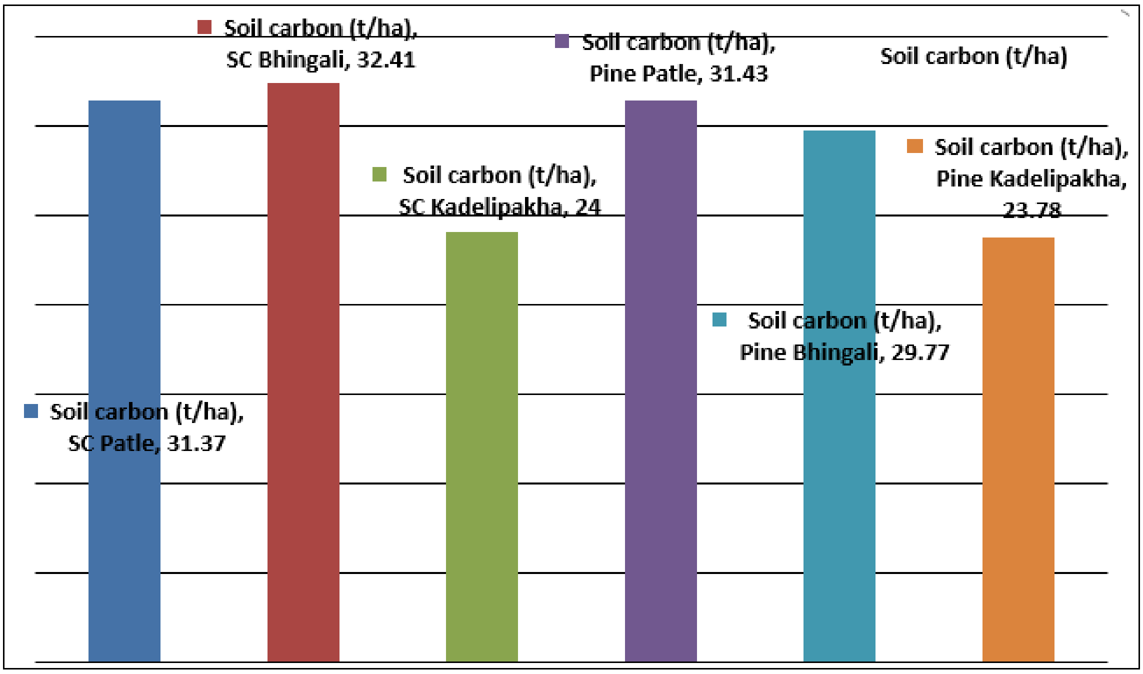

Fig 3: Soil carbon (t/ha)

In Schima-Castonopsis forest composition, the highest level of nitrogen was found at Patle Cf with 25.57 kg/ha whereas lowest level was found at Kadeliko Pakha CF. Same trend followed at forest with Chirpine composition, where highest value was at Patle CF with 31.43 t/ha and lowest value was at Kadeliko Pakha Cf with 23.78 t/ha (Figure 4).

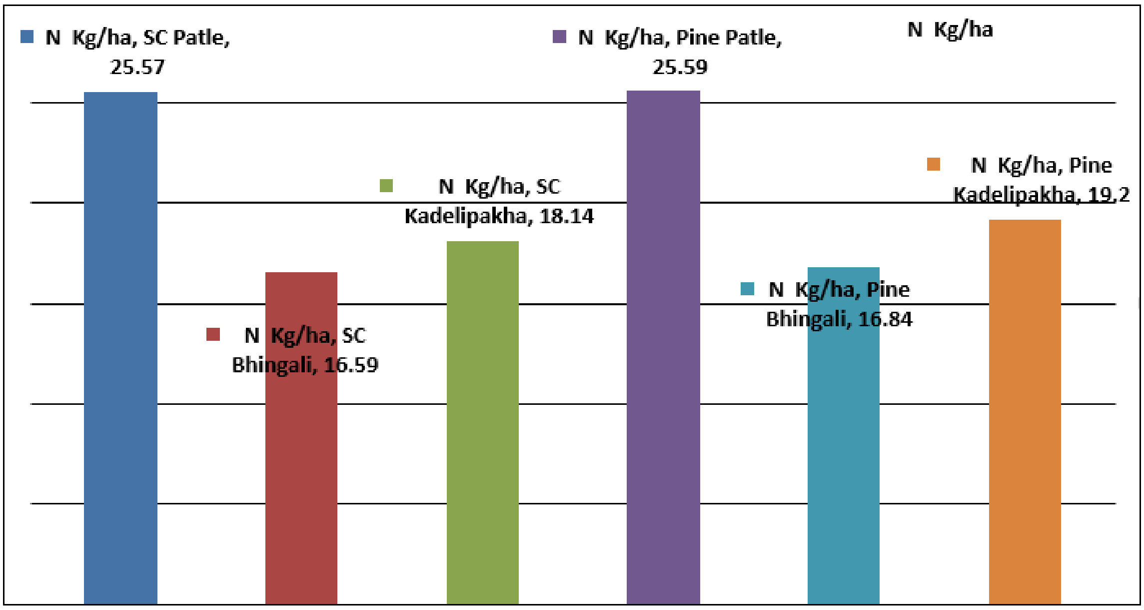

Fig 4: Nitrogen Kg/ha

Concerning to Phosphorus, level of Phosphorus varied from 73.54 t/ha at SC composition of Kadeliko Pakha CF to 211.09 t/ha at same composition of Patle CF (Figure 5).

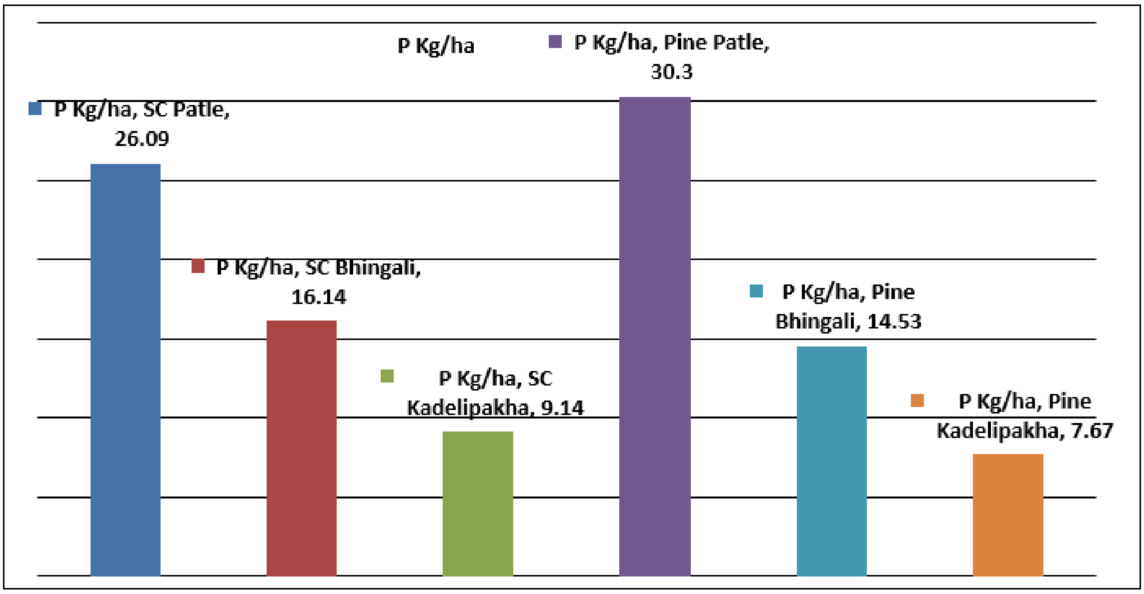

Fig 5: Phosphorus Kg/ha

In Schima-Castanopsis strata, highest level of Potash was recorded at Patle CF with 26.09 t/ha which was closely followed by Bhingali CF with 16.14 t/ha and lowest level was found at Kadeliko Pakha CF with 9.14 t/ha. In addition, in case of Chirpine strata, highest level was found at Patle CF with 30.30 t/ha which was closely followed by Bhingali CF and Kadeliko Pakha CF remained at last with value 7.67 t/ha (Figure 6).

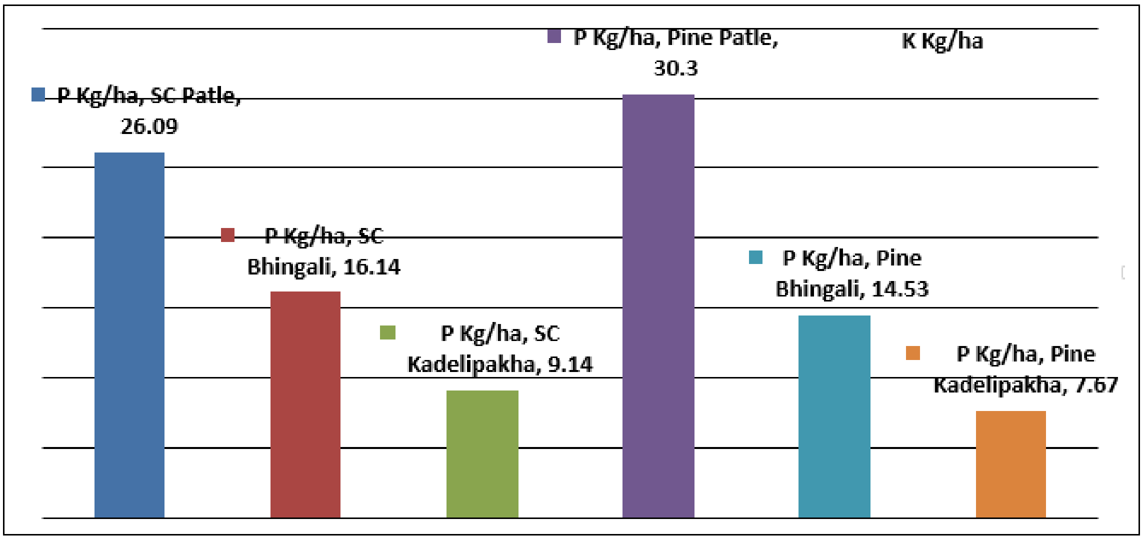

Fig 6: Potassium Kg/ha

4: Discussion

4.1 Carbon stocks and its incrementsin the community forests

Amongst various studies carried out on Carbon stock, some of them supports whereas some contradicts with my result in the following way:

In tree staged plants of Schima-Castanopsis strata of three community forests, the highest value 42.41 t/ha was found at Patle CF whereas 28.96 t/ha was found in case of Kadelipakha CF. Calculated value of this merely tallied with the study done in Same spp by Oli and Shrestha in 2009 [27] which entails that "Carbon stock in above ground biomass varies from 76 tons per hectare in Terai to 37 tons in Middle Mountain in Nepal's forest. In addition, my observed value for pole staged plants in *Pinus roxburghii* strata ranged between 13.55 to 10.54 t/ha which is almost equal to value with 17.27 t/ha in (20-30 dia. class) in study done by (Gupta, 2015) [20]. Similarly my value for LHG ranged between 0.49 t/ha to 0.4 t/ha also closely resembled with the value of same study done by (Gupta, 2015) [20]. In the same way as above, my result with 42.41 t/ha-28.96 t/ha nearly matched with the study made by (Aryal, 2010) [2] in case of Schima-Castanopsis tree composition with 31.4 t/ha, however, my result with 23.77 t/ha- 28.44 t/hain Chirpine strata contradict with his Chirpine forest with 113.29 t/ha.

Concerning to similarities of the result with above ground biomass carbon, my mean data with 35.69 t/ha closely resembles with the result brought by Baral *et al.* (2009) [5]. Their study was confined on above ground carbon stock assessment in different forest types of Nepal". Major findings of their study were the above-ground carbon stock of Hill Sal forest and Riverine forest were found to be higher i.e. 97.86 and 80.47 ton ha-1, respectively whereas the aboveground carbon of Schima-Castanopsis, Chirpine and *Alnus nepalensis* forests was lower i.e. 34.3, 38.7 and 34.6 ton ha-1 respectively.

In the same way, my result was supported by study made by Shrestha (2009) [32] on quantifying total carbon sequestration in two broad leaved forests (Shorea and Schima-Castanopsisforests) of Palpa district. The findings of his study was "Total biomass carbon in Shoreaand Schima-Castanopsis forest was found 101.66 and 44.43 t/ha respectively. Soil carbon sequestration in Schima-Castanopsisand *Shorea* forest was found 130.76 and 126.07 t/ha respectively. Total carbon sequestration in *Shorea* forest was found 1.29 times higher than *Schima-Castanopsis* forest". The study found that forest types play an important role on total carbon sequestration.

The present study was supported by Sheikh & Kumar (2010) [35]. They studied the tree composition and carbon stock in different aspect of sub-tropical region in Garhwal Himalayan and found that on northern aspect, *Pinus roxburghii* was dominant tree and they found higher carbon stock i.e. 62.49t/ha on northern aspect. Our value was less than this value; this may be due to small sized trees having smaller diameter, small height and lesser number of trees present in our study area.

My study result of above ground carbon with 35.69 t/ha seemed just below of such study done by Shrestha (2008) [31]. His result with Schima-Castanopsis was 47.08 t/ha. The reason behind the result matching with the study made by above said different authors might be the same forest condition; majority of sparse and small aged plants. In contrast, such value of my result contradicts with the following study:

The present study was contradicting wit the study conducted Jianmin and Zhiping (2007) [22] Miyun watershed surrounding the Miyun reservoir at the north east of Beiojing, china. The studies found the quantity of carbon sequestration in Chirpine forest with 145.8- 196.7t/ha.

The main reason of not matching my above ground biomass data; 35.69 t/ha with this result might be because of smaller aged trees, comparatively of lower height, distributed in more sparse condition and trees having lesser diameter.

lThe carbon stock in forest vegetation varies according to geographical location, plant species and age of the stand (Van Noordwijk *et al.*, 1997) [36].

Forest act as carbon reservoir as it stores large amount of carbon in trees, under storey vegetation, the forest floor and soil. In addition changes in forest, such as growth of trees can remove carbon dioxide from the atmosphere. Conversely, human activities degrade a forest, both the reservoir and sink potential are damaged, and the forest becomes a substantial source of carbon dioxide emission. Trees are long lived plants that develop a large biomass, thereby capturing large amounts of carbon over a growth cycle of many decades. Thus forest can capture and retain large amount of carbon over long periods. These stocks are dynamic, depending upon various factors and processes operating in the system, most significant being land use, land use changes, soil erosion and deforestation (IPCC, 2000) [37].

The Carbon stock of root was estimated by assuming the root shoot value of 15%. Therefore, carbon stock value of root depends up on the aboveground carbon stock value. The C (BB) was found lowest with 1.29 t/ha at Kadeliko Pakha Community Forest. My result coincides with study made by Neupane and Sharma (2012) [26]. "The root CS in Laxmi Mahila and Jalbire Mahila community forest was 2.50 t/ha and 2.71 t/ha respectively. This value was less than my observed value this may due to less carbon stock in above ground. The reason behind similarities of my result with this study was because of same condition of forest.

Concerning to Soil Organic Carbon (SOC), my result varied in the range of 23.78 t/ha-32.41 t/ha. Therefore result tallied with study made by Gupta, (2015) [20]; as his result showed 38.05 t/ha in south aspect.

In addition, my present study was supported by Mandal, R.A. (2013) [41]. He studied three parameters namely MACI, total carbon stock of forest and level of soil fertility in three public plantations of Mahottari district where his result in terms of SOC were 31.46 t/ha, 29.39 t/ha and 18.28 t/ha in different three level of soil depth. My result was just nearer to those values.

However, my data contradicts with study made by Gautam (2002) [16]; his study revealed the highest SOC in naturally grown forest as 53.25 ton/ha. Main cause of contradictory data might be because of low level of humus deposition and thereby less amount of organic matter content in forest soil.

The soil organic matter depends on the chemical quality of carbon compounds, Site climatic condition and soil properties like clay contain higher soil moisture, pH, nutrient status etc. Forest management practice affects these factors (Davidson and Janssen, 2006).

4.2 Mean Annual Carbon Increment (MACI)

In terms of MACI, the present study showed a glimpse as follows.

In case of Schima-Castanopsis strata, generally, MACI was highest at Patle Community forest with 0.72 t/ha for tree, 0.56 t/h for Pole, 0.10 t/ha for sapling and 0.09 t/ha for Seedling. Likewise, the MACI values were below those level in case of others in same strata.

While on the other hand, In case of Chirpine strata, each staged vegetation had the MACI value below 0.46 t/ha. The reason behind too low MACI inside the forest might be low level of fertility, medium growing spps and trees distributed sparsely. The present study contradicts with the study made by Mandal et.al (2013) [41], their result reflected MACI as highest in Shreepur plantation site with 10.19 t/ ha and lowest in Bisbitty public plantation site with 3.39 t/ha.

Another study made by Amatya *et al.* (2002) [1] showed as follows. The values of MAI of 4 years plantations of poor site was 5.8 m^3/ha and 6 years plantation of fair site was 19.4 m^3/ha, it means estimated values of MAIC which is equal to MAI (m^3) x wood density x 0.47(wood density of *Eucalyptus camaldulensis* is 0.96 kg/m^3), were 2.63 ton/ha and 8.75 ton/ha respectively. These values were quite higherin comparison to my findings. Moreover, Hawkin (1987) [21] stated that the Mean Annual Increment (MAI) of 5 years *Eucalyptus camaldulensis* was 25.4 m^3/ha, consequently estimated values of MACI was11.46 ton/ha, this value was very close to 6 years plantation of Shreepur site. Generally, the MACI values of this research were lower than the other; the reason behind it may be due to inferior soil quality of the present research sites. Growth performance of *Eucalyptus camaldulensis*is better on non-saline soil than on moderately saline soil (Dhakal, 2008). The growth rate of Schima-Castanopsis and Chirpine is lower than the Eucalyptus results lower value of MACI.The main reason of not matching with the present study might be because of growth nature of the species. Obviously, moderately growing and fast growing species put the different MACI, indeed.

4.3 Soil Fertility in Community forests

The present study was supported by study done by Pandey, P (2016) in three community forest of Dadeldhura district. Her result entailed that level of Phosphorus varied from 73.71 kg/ha 93.23kg/ha and level of Potassium varied from 2.54 kg/ha- 4.23 kg/ha. These data were nearly matched to site; Kadeliko Pakha CF.

Moreover, the present study was also supported to study done by Mandal *et al.* (2013) [41] in three sites of public plantation in Mahottari district. In Banauta public plantation, it was found to be highest quantity of N in 0-0.1m and followed by values at 0.1-0.3m and 0.3-0.6m with 42.00 kg/ha, 38.52 kg/ha and 14.96 kg/ha respectively.

The result compared to K.C. *et al.*, (2013) [23] showed a result that the total nitrogen in soil was medium and varies from 0.09% to 0.12%. Theconcentration of available phosphorus in soil was high and varies from 73.71 kg/ha-93.23kg/ha. The concentration of available potassium on soil was quiet low and varies from 2.54kg/ha-4.23 kg/ha. Those values were quite different to this study.

Furthermore, the results compared to the study done by Yadav *et al.* (2007) [47] in riverside on *Leucaena leucocephala* of 5 year plantation showed values of N, P and K 453.24, 25.46 and 340.62 kg/ha respectively, the present values were less. Moreover, the study done by Baral (2008) [5] showed that the values of N, P and K were 843, 61 and 310 kg/ha respectively in mixed *Schima- Castonopsis* forest of Gaukhureshwar Community Forest. Other study done by Paudel *et al.* (2003) in sandy loam soil of values of available P and K in the soil of the pure *Shorea robusta* forest were 76.64 and 267.73 kg/ha respectively. Comparing with the present research, these values were different.

5. Conclusion and Recommendation

The carbon stock, MACI, soil carbon, N, P, K and pH were varied in both strata of community forests. Carbon stock in Schima-Castanopsis forest (71.52 t/ha) was found higher than in Chirpine forest (58.36 t/ha). The MACI was the higher in Schima-Castanopsis forest than in Chirpine forest. The Soil carbon was higher in Schima-Castanopsis forest (87.78 t) than in Chirpine forest (84.98 t). Nitrogen content was higher in Chirpine forest (20.54 kg/ha) than in Schima-Castanopsis forest (20.1 kg/ha). Phosphorus content was higher in Schima-Castanopsis forest (152.16 kg/ha) than in Chirpine forest (144.74 kg/ha). Potassium content was higher in Chirpine forest (17.12 kg/ha) than in Schima-Castanopsis forest (17.5 kg/ha).

Strata wise carbon, MACI, N, P, K, and pH were studied in *Schima-Castonopis* and Pine, however, there are many important species in community which should be studied for monitoring and evaluation purposes. Study on Carbon accumulation in different forest types on the basis of species, aspects, climatic zones, altitude and different soil type to generate data on carbon stock should be well emphasized. The study on soil nutrient status of community forest is limited, so it is recommended to conduct more research on forest of different geographical region as well as in different composition of forest.

References

1. Amatya SM, Shresth KR. Nepal Forestry Handbook. Forestry Research Programme for Asia and the Pacific. Food and Agriculture Organization of the United Nations, Bangkok publication 2002, No.32/2002.
2. Aryal C. Status of carbon Stock at Toudol Chhap Community Forest, Sipadol, Bhaktapur. Central Department of Environmnetal Science, Tribhuwan University 2010.
3. Bado BV, Aw A, Ndiaye M. Long-Term Effect of Continuous Cropping of Irrigated Rice on Soil and Yield Trends in the Sahel of West Africa, Saint-Louis 2010.
4. Bajracharya RM, Lal R, Kimble JM. Soil organic carbon distribution in aggregates and primary particle fractions as influenced by erosion phases and landscape position. In Lal R., Kimble J., Follett. R &Stewart B.A. (eds.), Soil Processes and the Carbon Cycle. CRC Press, Boca Raton, Florida 1998, 353-367
5. Baral SK, Malla R, Ranabhat S. Above-ground carbon stock assessment in different forest types of Nepal. Banko Jankari 2009;19:10-14.
6. Brady NC. The Nature and Property of Soil (10 th edition ed.): Prentice Hall of India (P) Ltd. New Delhi India 1990.
7. Brown S, Sathaye J, Cannell M, Kauppi P. Mitigation of carbon emission to the atmosphere by forest management. Complete Forestry Review 1996;75:80-91.
8. Cakmak I. Plant Nutrition Research: Priorities to Meet Human Needs for Food in Sustainable Ways. Plant and Soil 2002, 247-22.
9. Campbell A, Miles L, Lysenko I, Hughes A, Gibbs H. Carbon storage in protected areas: Technical report. United Nations Enviroment Program-World Conservation Monitoring Centre 2008.
10. Chave J, Andalo C, Brown S, Cairns M, Chambers J, Eamus D, *et al.* Tree allometry and improved estimation of carbon stocks and balance in tropical forests. Oecologia 2005;145:87-99. 41.
11. Davidson EA, Janssens IA. Temperature sensitivity of soil carbon depositions and feedbacks to climate change. Nature 2006;440:165-173.
12. Dixon RK, Brown S, Houghton RA, Solomon AM, Trexler MC, Wisniewski J. Carbon Pool and flux of Global Forest Ecosystem. Science 1994;263:185-190.
13. Dhakal K. Carbon stock estimation of pashupati community forest in Sarlahi district. Dissertation, submitted to College of Applied Sciences, for the requirement of the partial fulfillment of Master's degree in Environmental Science, Tribhuvan University, Kathmandu, Nepal 2010.
14. Drechsel P, Giordano M, Gyiele L. Valuing nutrients in soil and water: Concepts and techniques with examples from IWMI studies in the developing world. Research Report 82. Colombo, Sri Lanka: International Water Management Institute 2004.
15. FAO. FAO Glossary terms. Food and Agriculture Organization of the United Nations. Rome, Italy 2011.
16. Gautam KR. Carbon sequestration in agro forestry and annual cropping system in inner Terai, Central Himalaya. M. Sc thesis, Management of Natural Resources and sustainable agriculture, Agriculture University of Norway, Norway 2002.
17. Ghani A, Brown M. Improvement of Soil Fertility in Nepal through Balanced Application of Fertiliser 1997.
18. Gregory PJ. Soil Fertility Management for Sustainable Hillside Farming Systems in Nepal, Project Draft Report. U.K.: ODA and Soil Science Department, The University of Reading 1995.
19. Gruhn P, Goletti F, Yudelman M. Integrated Nutrient Management, Soil Fertility, and Sustainable Agriculture: Current Issues and Future Challenges. 2033 K Street, N.W. Washington, D.C. 2006, U.S.A.: International Food Policy Research Institute 2000.
20. Gupta JP. Evaluating Effects of Geographical Aspects on Carnon Stocks in Pinus roxburghii Forests of Myagdi Districts, Nepal. A thesis report submitted in partial fulfillment of the requirements for the degree of Masters of Science in environmental management in Sch EMS, Pokhara University, Nepal 2015.
21. Hawkin T. Biomass and Volume Tables for Eucalyptus Camaldulensis, Dalbergia Sissoo and Cassia Siamea in the Central Bhabar- Tarai of Nepl. Oxford Forestry Institute Occasional 1987, 33-26
22. JianMin X, Zhi Ping W. Economic benefit analysis of carbon sequestration of five typical forest types in Beijing Miyun watershed. Chinese Forestry Science and Technology 2007;6(1):57-61.
23. KC A, Bhandari G, Wagle SP, Banjade Y. Status of Soil Fertility in Community Forest of Nepal. International Journal of Environment 2013;1(1):56-67.
24. Lepetz V, Massot M, Schmeller DS. Biodiversity monitoring: some proposals to adequately study species' responses to climate change. Biodiversity Conservation 2009;18:3185. doi:10.1007/s10531-009-9636-0.
25. Jina BS, Sah P, Bhatt MD, Rawat YS. Estimating Carbon Sequestration Rates and Total Carbon Stockpile in Degraded and Non-Degraded Sites of Oak and Chirpine Forest of Kumaun Central Himalaya. Ecoprint 2008;15:75-81.
26. Neupane Sharma R. An assessment of effect of vegetation size, type and altitude on above ground plant biomass and carbon. Journal of Agriculture and Crop research 2012.
27. Oli BN, Shrestha K. Carbon Status in Forests of Nepal. Journal of Forest and Livelihood 2009;8:1.
28. Regmi BD, Zoebisch MA. Soil Fertility Status of Bari and Khet Land in a Small Watershed of Middle Hill Region of Nepal 2004.
29. Sharma C, Gairola S, Baduni N, Ghildiyal S, Suyal S. Variation in carbon stocks on different slope aspects in seven major forest types of temperate region of Garhwal Himalaya, India. Journal of Bioscience 2011;36:701-708.
30. Shrestha S, Karki BS, Gurung A, Vettas OR. Assessment of carbon balance in Community forest in Dolakha. Small Scale Forestry 2012;12:5.
31. Shrestha K, Oli B. Carbon Status in forest of Nepal: An

Overview. Jounal of Forest and Livelihood 2008;8(1).
32. Shrestha BP. Carbon sequestration in Schima-Castanopsis Forest: A case study from Palpa district. The Greenery (A Journal of Environment and Biodiversity) 2009;7:34-40.
33. Tiwari KR, Sitaula BK, Bajracharya RM. Effects of Soil and Crop Management Practices on Yields, Income and Nutrients Losses from Upland Farming Systems in the Middle Mountains Region of Nepal. Springer Science Business Media 2009.
34. De Vries. The impact of nitrogen deposition on carbon sequestration by European forests and health lands". Journal of Forest Ecology and Management 2009.
35. Shekh MA, Kumar M. Carbon Sequestration Potential of Trees on Two Aspect in Sub-tropical forest. International journal of conservation sciences 2010;1(3):143-148.
36. Van Noordwijk M, Cerri C, Woomer PL, Nugroho K, Bernoux M. Soil carbon dynamics in the humid tropical forest zone. Geoderma 1997;79(1-4):187-225.
37. IPCC. Land use, land use change, and forestry: a special report of the IPCC. Cambridge, UK, Cambridge University Press 2000.
38. IPCC. Guidelines for National Greenhouse Gas Inventories. Prepared by the National Greenhouse Gas Inventories Programme ed H S Eggleston, L Buendia, K Miwa, T Ngara and K Tanabe (Japan: Institute For Global Environmental Strategies) 2006.
39. Lal JB. Forest Management Classical Approach and Current Imperatives. Natraj Publication, Deharadun, India 2007.
40. MacDicken KA. Guide to Monitoring Carbon Storage in Forestry and Agro forestry Projects Arlington(VA), Forest Carbon Monitoring Programme, Winrock International Institute for Agriculture Development 1997.
41. Mandal RA, Dutta IC, Jha PK, Haque SM. Potential Carbon Offset in Public Plantation: Offering opportunity for REDD$^+$ and Soil Fertility". International Journal of Ecology and Development 2013;25(2).
42. Pokherel B, Byrne S. Climate Change Mitigation and Adaptation Strategies in Nepal's Forest Sector: Can Rural Communities Benefit? NSCFP Discussion Paper No.7.Nepal–Swiss Community Forestry Project: Kathmandu 2009.
43. Ranabhat S, Awasthi KD, Malla R. Carbon Sequestration potential of Alnus nepalensis midhills of Nepal: A Case Study from Kaski District. Banko Jankari 2008;18(2).
44. Reddy ENV, Devakumar AS, Charan Kumar ME, Madhusudana MK. Assessmentof Nutrient Turnover and Soil Fertility of Natural Forests of Central Western Ghats. International Journal of Science and Nature 2012;3(1):5
45. Shrestha BM, Singh BR. Soiland Vegetation Carbon Poolsina Mountain Watershed of Nepal. Nutrient Cycling in Agro ecosystems 2008;81:179-191.
46. Walkley AJ, Black IA. An examination of Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Science 1934;37:29-38.
47. Yadav JN, Manjan SK. Use of Biological Resources for Reclamation of River Damaged Land. Sustainable Use of Biological Resources in Nepal (112-115.). Ecological Society (ECOS), Kathmandu, Nepal 2007.