



A Monitoring Report on Forest Carbon Stocks Changes in REDD Project sites

REDD⁺ Pilot Project

Measurement I- Feb- March 2010
Measurement II- Feb-April 2011
Measurement III-Feb-May 2012



A

Monitoring Report on

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(Ludikhola, Kayarkhola and Charnawati)**

First measurement: February-March 2010

Second measurement: February-April 2011

Third measurement: February- May 2012

(ANSAB, ICIMOD and FECOFUN)

July 2012

Acknowledgements

This report has been prepared under the project ‘Design and setting up of a governance and payment system for Nepal’s Community Forest Management under Reducing Emissions from Deforestation and Forest Degradation’ jointly implemented by ANSAB, ICIMOD and FECOFUN and funded by NORAD. Here, we would like to take the opportunity to thank all the organizations and individuals for their valid contribution in completing the forest carbon monitoring report for the second year (2011).

Foremost we would like to thank ANSAB’s field technicians (Mr. Kabi Raj Praja, Mr. Shankarman Thami., and Mr. Shiva Prasad Subedi), District FECOFUNs (Dolakha, Gorkha and Chitwan), REDD watershed networks of all three watersheds, all 105 CFUGs, local communities, consultant forest technicians. Local Resource Persons (LRPs) and community forest users for their tireless effort in forest carbon monitoring and data collection in the field. Similarly, we appreciate hard work of ANSAB team (Mr. Nabin Raj Joshi, Mr. Yuba Raj Subedi, Mr. Megh Dhoj Adhikari, Mr. Sagar Godar Chhetri and Dr. Kalyan Gauli) for managing and conducting the forest carbon inventory, and its reporting. We are also thankful to Ms. Aakriti Poudel, Ms. Emma Karki and Mr. Deepak Charmakar for supporting the ANSAB team for data entry of hundreds of datasheets from field. Finally we would like to thank Mr. Eak Bahadur Rana, Mr. Hammad Gilani, Mr. Govinda Joshi, Dr. Bhaskar Singh Karky and Ms. Seema Karki from ICIMOD, **Dr. Bhishma Subedi (ANSAB)**, Mr. Kumar Bahadur Darjee and Ms Bandana Thapa (FECOFUN) for providing continuous feedbacks and suggestions for the improvement of this report. Last but not the least; we would also like to remember ICIMOD team, FECOFUN team, other ANSAB staffs and many others who provided their precious time, documents and ideas.

Abstract

International Centre for Integrated Mountain Development (ICIMOD), Asia Network for Sustainable Agriculture and Bioresources (ANSAB), and Federation of Community Forest Users' Nepal (FECOFUN) are jointly implementing the project “**Design and setting up of a governance and payment system for Nepal's Community Forest Management under Reducing Emissions from Deforestation and Forest Degradation (REDD)**” in 105 community forests of three watersheds of Nepal, namely; Kayarkhola of Chitwan district, Charnawati of Dolakha district and Ludhikhola of Gorkha district. The project has been in operation since July 2009 with financial support of Norwegian Agency for Development Cooperation (Norad). The watersheds cover an area of 27,000 ha where community forest area alone encompasses about 10,266 ha. The first forest carbon stock measurement was undertaken in 2010, the second measurement was executed in 2011, and the third monitoring was completed in May 2012. **The change in tree biomass was observed in five strata with the highest increment of 7.3 t dm ha⁻¹ in Ludikhola dense, followed by Ludikhola sparse 7.2 t dm ha⁻¹. In the case of saplings, the highest increment was observed in Charnawati sparse 3.92 t dm ha⁻¹ followed by Charnawati dense 0.19 t dm ha⁻¹, whereas a decrement in sapling biomass was observed in both the strata of the Kayarkhola and Ludhikhola watersheds. In terms of herb biomass, all strata show a positive increment with the exception of Kayarkhola sparse (-0.069 t ha⁻¹) and Charnawati dense (-0.11 t ha⁻¹). Biomass of dry leaf litter decreased in all strata except in Charnawati sparse: the maximum decrease was observed in Ludhikhola sparse (-1.16 t dm ha⁻¹) followed Kayarkhola dense and sparse strata (-0.71 and -0.56 t dm ha⁻¹) respectively. The mean forest carbon stock in dense and sparse strata was highest in Kayarkhola (300.71 and 258.41 t C ha⁻¹) respectively, and the mean carbon stock for Charnawati watershed varies from 224.76 and 171.63 t C ha⁻¹ in dense and sparse strata. Similarly the average forest carbon stock in Ludhikhola varies from 224.52 and 170.88 t C ha⁻¹ in dense and sparse strata respectively. At CFUG level, the maximum total annual carbon stock increment was observed in Charanawati CFUG of Dolakha (2056 t C) followed by Bhittheri CFUG of Charnawati (1464.48 t C), Nibuwater CFUG of Kayarkhola (868.5 t C) and Ludi Damgade CFUG of Ludikhola (801.64 t C) and a similar yet smaller increment has occurred in Paleko ban CFUG of Charnawati watershed (3.99 t) followed by Gahate Baghkhori CF (18.23 t C) and Bhirmuni Devithan CF (20.09 t C). This year's project (Feb- May 2012) witnessed an increment of 27,562 tons of carbon stock which is equivalent to 101152.5 tCO₂ in three watersheds. Results show that overall carbon stock has increased in all three project watersheds. The lowest annual rate of increment can be witnessed in Kayarkhola (1.87 t/ha) and the highest in Ludikhola (3.33 t ha⁻¹) while the carbon stock increment in Charnawati watershed lies in the middle with 2.88 t ha⁻¹. On average, annual per ha carbon stock increment in the three watersheds is found to be 2.69 (t C).**

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List of acronyms

AGSB	Above-ground sapling biomass
AGTB	Above-ground tree biomass
ANSAB	Asia Network for Sustainable Agriculture and Bioresources
BGB	Below-ground biomass
CF	Community forest
CFUG	Community forestry users' group
cm (or CM)	Centimeter
CO ₂	Carbondioxide
dbh (or DBH)	Diameter at breast height
DM	Dry matter
FECOFUN	Federation of community forest Users' Nepal
FSC	Forest Stewardship Council
GHG	Green house gas
GIS	Geographic information system
GPS	Global positioning system
ha (or Ha)	Hectare
HGB	Herb and grass biomass
ICIMOD	International Centre for Integrated Mountain Development
IPCC	Intergovernmental Panel on Climate Change
kg (of KG)	Kilogram
LHG	Leaf litter, herb and grass
LLB	Leaf litter biomass
LRP	Local resource person
m (or M)	Meter
Masl	Meter above sea level
NORAD	The Norwegian Agency for Development Cooperation
PISP	Permanent inventory sampling plot
PSP	Pilot sampling plot
REDD	Reducing Emissions from Deforestation and Forest Degradation
SOC	Soil organic carbon
t (or T)	Ton (mega gram, 1000 kg, or metric ton)
tC	ton carbon
UNFCCC	United Nations Framework Convention on Climate Change
VCS	Verified Carbon Standard

1. Introduction

1.1 Background

Asia Network for Sustainable Agriculture and Bioresources (ANSAB), International Centre for Integrated Mountain Development (ICIMOD), and Federation of Community Forest Users' Nepal (FECOFUN) are jointly implementing the project “**Design and setting up of a governance and payment system for Nepal's Community Forest Management under Reducing Emissions from Deforestation and Forest Degradation (REDD)**” in three watershed areas of Nepal, namely, Kayarkhola of Chitwan district, Charnawati of Dolakha district and Ludhikhola of Gorkha district with financial support from the Norwegian Agency for Development Cooperation (Norad). This pilot project aims to demonstrate the feasibility of REDD payment mechanism in Community Forests (CFs) by involving local communities including marginalized groups so that deforestation and forest degradation can be reduced by linking sustainable forest management practices with economic incentives. Furthermore, the project focuses on the concerns of indigenous peoples, marginalized people, women, Dalit and local communities dependent on forests by involving them in the designing and functioning of a national-level REDD governance and payment mechanism that supports community forestry at grassroots level. The specific objectives of the project include; strengthening the capacity of civil society actors in Nepal to ensure their active participation in the planning and preparation of national REDD-strategies; establishing a Forest Carbon Trust Fund that is sustainable and creditable in the long run; and contributing to the development of REDD strategies that can effectively and efficiently monitor forest carbon flux in community managed forests.

The first year of the project focused on development of biophysical and socio economic baseline information. ANSAB led the baseline information collection procedure for forest carbon stocks and developed a baseline report working closely with the Project Management Unit - PMU. The project developed forest measurement guidelines incorporating international accepted methodologies and standards as defined in Intergovernmental Panel on Climate Change (IPCC), Verified Carbon Standards (VCS) and other complementary guidelines including Pearson et al, Sandra Brown and MacDicken and other relevant and recent scientific literatures. The methodologies prescribed in forest carbon measurement guideline were truly applied while conducting forest inventory in the field. Local communities, local resource persons and Watershed REDD Network members were trained and involved during the carbon measurement process viewing to enhance their capacity in measuring forest carbon. With the field data taken in Feb- May 2012, this report summarizes the present stock and changes in forest carbon of five different pools namely above ground (tree and sapling), herb, litter, soil and below ground. The report further compares the forest carbon with first and second measurement undertaken in Feb-March 2010 and 2011. Based on the findings of the carbon measurement this report further tries to suggest appropriate activities needed to enhance forest carbon stocks and sustainable management of the Forests.

Likewise in previous years, the project employed the stock difference method in this year's inventory as well so as to assess forest carbon that makes reference to traditional forest resource assessments and calculates changes in average carbon stock per unit area as the difference between carbon stock at time 2 and time 1.

1.2 Objectives

Forest carbon measurement in community forests of three watersheds in Norad REDD+ project was basically undertaken to assess change in forest carbon in forests of different ecological set up. Most specifically the measurement was taken to train local communities in forest carbon monitoring and generate forest carbon data for them to make claim for rewarding their efforts in forest conservation and avoiding forest degradation. As mentioned above, during field data collection and analysis local resource persons, Watershed level REDD Network members and forest users were involved thereby enhancing their knowledge on forest carbon results by efforts of sustainable management of forests. The major objective of this report is to provide an overview of forest carbon stock available in all project sites within the watersheds. While specific objectives include:

- To assess the forest carbon at various levels and monitor the carbon stock changes
- To calculate forest carbon of individual community forest and generate forest carbon data for demonstrational payment in project

2. General overview of project sites

This section describes the locations of the pilot watersheds and their general vegetation/forest characteristics.

2.1 Physiography

The project areas are located in three different watersheds of Nepal covering different ecological zones ranging from tropical to temperate ecological regions. The total area of the three watersheds is 27,789 ha. Forest area represents nearly 65% of the total area of watersheds (Land cover analysis report 2010) and of this total forest area in the watersheds, about 60% (10,266.13 ha) is under community forest that is being managed by 105 CFUGs. Table 1 shows the summary of the project area.

Table 1: Physiography and demographic information of project watersheds

SN	Watershed (district)	Total Watershed area [ha]	No of CFUG within WS	Total CF Area [ha]	Households	Population
1	Kayarkhola (Chitwan)	8,002	16	2,381.96	4163	23223
2	Charnawati (Dolakha)	14,037	58	5,996.17	7870	42609
3	Ludikhola (Gorkha)	5,750	31	1,888.00	4110	23685
	Total	27,789	105	10,266.13	16143	89517

Source: Land cover analysis (2010) and socio-economic information from payment claim (2011)

The Kayarkhola Watershed is located in the Chitwan district of the Central Development Region of Nepal. The altitude of this watershed ranges from 245 m to 1944 m, covering an area of 8002 hectare. The 16 CFUGs of this watershed cover a total of 2381.96 hectare of community forest area. The watershed is inhabited by socially and ethnically diverse forest-dependent indigenous communities such as Chepang and Tamang; these being some of the most marginalized ethnic groups in the country.

Charnawati watershed is located in the Dolakha district of the Central Development Region of Nepal. It covers hill and mountain physiography. Altitude ranges from 835 m-3549 m. This watershed is spread over 14,037 hectares. There are 58 CFUGs within this watershed covering a total forest area of 5996.17 hectares. *Chhetri*, *Brahmin*, *newar*, *tamang*, *thami* and *dalits* represent the social diversity of this watershed.

The Ludikhola watershed lies in the Gorkha district of the Western Development Region of Nepal. It represents the hill physiographic region; altitude ranging from 318 m to 1714 m. This watershed covers an area of 5750 hectares. There are a total of 31 CFUGs within this watershed managing 1888.00 ha of forest area. This watershed is characterized by social diversity with presence of *Magar*, *gurun*, *tamang*, *dalit*, *Brahmin* and *chhetri*.

2.2 Vegetation/forest types

Due to differences in physio-climatic characteristics, watersheds under the present study constitute diverse ecology. Dominant forest types ranges from hill *Shorea robusta* forest through

Schima-Castanopsis to *Rhododendron*. Even though *Shorea robusta* mixed sub-tropical hill deciduous forest is the predominant forest type in Kayarkhola (Chitwan) and Ludikhola (Gorkha), representing the lower altitudinal ranges among the three watersheds, the associated species of this forest type vary between these two watersheds. *Lagerestreoemia* parviflora, *Mallatus phillipinensi* and *Terminelia tomentosa* are dominant associates in Kayarkhola (Chitwan) whereas *Schima wallichii* and *Castanopsis indica* are the most common associates in Ludikhola (Gorkha). On the other hand, even though *Shorea robusta* and *Schima - Castanopsis* forests are present in lower altitudes in Charnawati (Dolakha), the majority is formed by *Rhododendron* forests, extending high up to *Quercus* forest, representing the dominant higher altitudinal coverage by the watershed.

According to broader climatological categorization of forests, forests in Kayarkhola fall under tropical broadleaved, similarly forests in Charnawati belongs to sub tropical to lower temperate (*Quercus*) forests and in Ludikhola the forests are of sub-tropical broad leaved forest mostly with *Shorea robusta* and *Schima wallichii* (sal and chilaune).

2.3 Location, climate and land use

Table 2 presents information on location and climate and Table 3 presents information on land uses of all the project watersheds.

Table 2: Climatological information of watersheds

SN	Watershed	Geographical location		Altitude (m)*	Average temperature (°C)	Average rainfall (mm)
		Latitude (N)	Longitude (E)			
1	Kayarkhola (Chitwan)	27°40'07.79"- 27°46'37.15"	84°33'25.88"- 84°41'48.85"	245- 1944	29-32 (max), 16-19 (min)***	1436.32***
2	Charnawati (Dolakha)	27°35'16.12"- 27°44'47.92"	85°56'18.41"- 86°03'56.92"	835-3549	19.9 (max), 8.3 (min)****	2232.1**** *
3	Ludikhola (Gorkha)	27°55'02.85"- 27°59'43.88"	84°33'23.13"- 84°40'41.87"	318-1714	23.1**	1972- 2000**

Source: *Land cover analysis (2010), **District Profile, Gorkha, ***Department of hydrology and meteorology (1971-1986), ****Meteorological data from Jiri station

According to Table 2, Charanawati watershed appears to cover the higher altitudinal ranges among the watersheds with least average temperature and highest average rainfall.

Table 3: Land use profiles of the watersheds

Land cover type	Area (ha) of different land use system			Total area (ha) of three watersheds
	Kayarkhola (Chitwan)	Charnawati (Dolakha)	Ludikhola (Gorkha)	
Close to open broadleaved (dense) forest	4119 (51.48%)	4991 (35.56%)	3873 (67.34%)	27,789
Open Broadleaved (sparse) forest	1702 (21.27%)	2501 (17.82%)	996 (17.31%)	
Natural water bodies	31(0.39%)	1 (0.01%)	9 (0.17%)	
Bare Soil	30 (0.38%)	629 (4.48%)	241 (4.19%)	
Grassland and degraded forest	0.00	204 (1.45%)	0.00	
Clouds	81 (1.02%)	0.00	0.00	
Agriculture Land and built-up areas	2038 (25.47%)	5710 (40.68%)	632 (10.99%)	
Total area	8002 (100%)	14037 (100%)	5750 100%)	

Source: Land coveranalysis report (2010)

Table 3 indicates that forests dominate land use in all the watersheds. Within forest categories, the dense forest area is present in larger proportion in all watersheds compared to sparse forest area.

3 Methodology

3.1 Sampling design of and measurement techniques

This section describes the methodologies applied during the forest carbon monitoring and tools used for data analysis. Methodologies suggested in the forest carbon measurement guidelines developed by the project were followed during the forest carbon inventory.

3.1.1 Strategies for stratification

For the purpose of forest carbon monitoring, stratification that was established in the first year of the project was followed. Forests with more than 70% of canopy coverage were considered dense and less than 70% as sparse strata. Forest stratification was carried out using high resolution remote sensing imagery with the ERDAS imagine (geo-eye image), Defines Developer and ArcGIS software. Details of the stratification are given in figure 1.

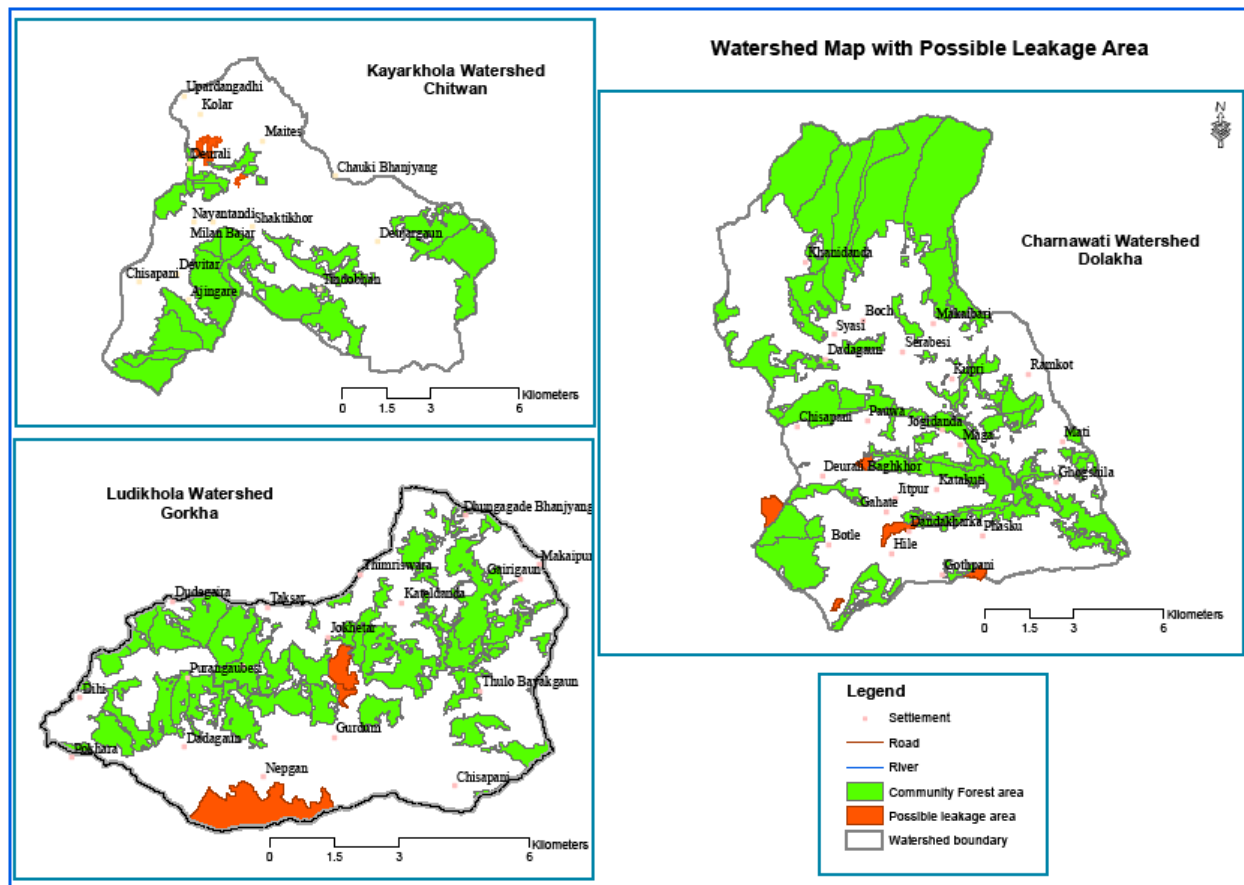


Figure 1: Map showing community forests, leakage belt and permanent plots

Table 4: Area of different forest strata in three watersheds

S N	Watershed/district	Total watershed area [ha]	Total forest area [ha] in watershed	Total CF area [ha]	Categories of forest within CF	
					Dense forest area [ha]	Sparse forest area [ha]
1	Kayarkhola (Chitwan)	8,002	5821	2,381.96	1,902.72	479.19
2	Charnawati (Dolakha)	14,037	7492	5,996.17	3,899.25	2,097.00
3	Ludikhola (Gorkha)	5,750	4869	1,888.00	1,634.64	252.9
Total		27,789	18182	10,266.13	7,436.61	2,829.09

Source: Land cover analysis report (2010)

3.1.2 Permanent plot distribution

The permanent plots that were established during baseline survey were measured for the purpose of monitoring. In year one i.e. in 2010, altogether 570 permanent plots were measured although 481 plots were sufficient for carrying out the forest carbon inventory in three watersheds. Additional plots were established and measured with a view to enhance the output and also to account for the outliers that might come during the measurement. Similarly during the second monitoring period in 2011 only 566 permanent plots were re-measured due to difficulty in accessing four plots, re-measurements were carried out in 180 plots of Kayarkhola, 201 plots in Charnawati and 185 plots in Ludikhola. Likewise in 2012, a total of **569** plots were re-measured. Out of these plots **108** plots were distributed in sparse forest strata and **461** in dense strata, detail is given in Table 5.

Table 5: Number of permanent plots for forest carbon inventory in three watersheds

Stratum	Total area under CF [ha]	No. of pilot sample plots (PSP)	Size of PSP [m ²]	Required no. of permanent inventory sampling plot (PISP)	Total plot laid on the ground during baseline year	Number of plot that were measured in 3 rd monitoring
Kayarkhola dense	1902.72	13	250	113	154	154
Kayarkhola sparse	479.19	17	250	17	26	26
Charnawati dense	3899.24	10	250	148	164	163
Charnawati sparse	2097.00	10	250	45	41	41
Ludikhola dense	1634.64	32	100	135	144	144
Ludikhola sparse	252.90	9	100	23	41	41
Total	10265.69	91	-	481	570	569

GPS coordinates that were recorded during the first measurement were loaded on the GPS set (GPS Map 60CSx, Garmin) as the centre of the nested plots. With the help of the GPS apparatus, the plot centre was navigated.

3.1.3 Size and shape of sample plots

The monitoring process followed the same procedure as adopted during first year measurements. As illustrated in Figure 2, several sub - plots were established within each plot for specific purposes: inside the plot of 8.92 m radius, a sub-plot of 5.64 m radius was established for saplings, a sub-plot with 1 m radius was established for counting regeneration. However, the sub-plot with 0.56 m radius was established 5m north from the center point. The position of this sub-plot was changed as leaf litter and herb was collected destructively in the previous year and hence collection within the same point may not give proper result. Slope correction in each permanent plot was done whenever required.

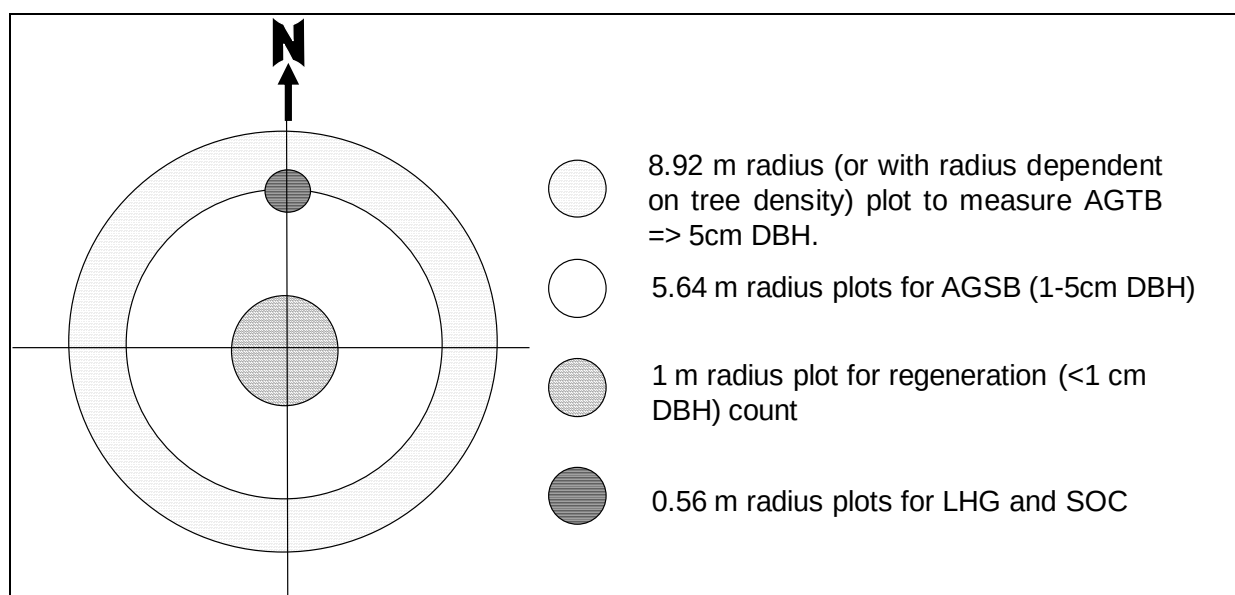


Figure 2: Sampling design for circular plot (default size)

3.1.4 Involvement of local communities in measurement process

As this project intends to increase the capacity of local communities in carrying out forest carbon measurement and monitoring, representatives from community forest user group, watershed REDD network and district level FECOFUN were actively involved in the whole process of forest carbon measurement. A total of 301 participants took part in the orientation training events. This kind of orientation event enhanced skills as well as improved confidence; both ensure consistency while collecting data (Table 6).

Table 6: Number of local users participated in forest carbon measurement training in 2012

District	Female participants				Male participants				Total participant
	BCN	D	IPs	Total	BCN	D	IPs	Total	
Kayarkhola	10	1	13	24	22	2	33	57	81
Charnawati	39	5	14	58	56	0	9	65	123
Ludikhola	10	5	16	31	20	4	42	66	97
Grand Total	59	11	43	113	98	6	84	188	301

Note: BC: Brahmin, Kshetri and Newar; D: Dalit; Ips: Indigenous peoples

Altogether 212 BCN, 61 Dalits, 185 IPs, 177 Women's and 281 Males from communities participated in the monitoring activity and gathered knowledge and skills on forest carbon measurement in all three districts. Members from REDD watershed Networks¹, Local resource person (LRPs) and CFUGs members (Table 7) took part in the process. Due to the involvement of locals during monitoring, navigation of the permanent plot was easy for the technicians.

¹Watershed REDD Network is a loose network representatives from CFUGs under the respective watershed. It works as a coordinating body among CFUGs at watershed level.

Table 7: Numbers of forest users involved in forest carbon measurement in the field in 2012

Watersheds	Participants involved in forest carbon measurement				
	BCN	D	IPs	Women	Men
Kayarkhola, Ludhikhola and Charnawati	212	61	185	177	281
Grand total	212	61	185	177	281

Source: Annual progress report (2012)

BCN = Brahmin kshetri Newar

D= Dalit

IPs= Indigenous peoples

3.1.5 Equipments and materials

All the required equipments and materials were collected before going to the field. All instruments and equipment were prepared, checked and calibrated beforehand the field inventory. The field inventory team ensured that every instrument was well functioning to avoid troubles and disturbances during field inventory. Due to the mobility of the monitoring team, complete checklist of instruments was prepared such that no any instruments and equipment gets left behind.

3.1.6 Human resource management

The monitoring team was formed following the practice adopted in the previous year. Because of increased confidence, the inventory cruise team was reduced to 5 members instead of the 8 member team made in the previous two years. Inventory teams were oriented well in advance to their field operation to ensure perfect and complete data collection. One forest technician having detailed knowledge of carbon measurement methodology was assigned as a crew leader and s/he was further supported by local resource persons, REDD Network Members and CFUG members. During the orientation, community members were trained on methodologies, tasks of each team member were clarified and a detailed plan was made.

3.2 Field measurement and analysis

As described in section 3.1.33, nested circular plots with horizontal diameters ranging from 0.56 m to 8.92 m were laid out for quantifying different carbon pools. Details of field measurement techniques and methods for estimating forest carbon stock of different pools are described in the succeeding sections.

3.2.1 Forest carbon pools

Descriptions of different carbon pools considered under this study are provided in this section. Carbon stock of four carbon pools including above ground (tress, sapling and herbs), below ground and leaf litter were monitored during the third monitoring period of 2012, while the soil organic matters which have been measured in Feb- March 2010 was monitored and used for this monitoring . The detailed process of the monitoring is described in the subsequent paragraphs.

3.2.1.1 Aboveground tree biomass (AGTB)

All the trees which were measured in 2010 and 2011 were re-measured in year 2012. The DBH (at 1.3m) and height of individual tree greater than or equal to 5 cm DBH were measured in each permanent circular plot with 250 m² area (with 8.92 m horizontal radius) using diameter tape, clinometers and linear tape or vertex-IV/transponder. Each tree which was tagged during first survey was recorded individually, together with its species name. Care was taken to ensure that the diameter tape is put around the stem exactly at the indicated point of measurement.

Table 8: Species ranking on the basis of frequency, wood specific gravity (ρ) [kg m³] values for the purpose of estimating AGTB [wood specific gravity source from MPFS (1988)]

Stratum	Rank 1 tree species	Rank 2 tree species	Rank 3 tree species	All other species
Chitwan (Kayarkhola) dense	sal (<i>Shorea robusta</i>), 0.88	botdhangero (<i>Lagerstroemia parviflora</i>), 0.85	sindure (Mean of terai/lower slope mixed hardwood forest), 0.72	Mean of terai/lower slope mixed hardwood forest, 0.72
Chitwan (Kayarkhola) sparse	sal (<i>Shorea robusta</i>), 0.88	parijat (Mean of terai/lower slope mixed hardwood forest), 0.72	saj (<i>Terminelia tomentosa</i>), 0.95	Mean of terai/lower slope mixed hardwood forest, 0.72
Dolakha (Charnawati) dense	guras (<i>Rhododendron arboretum</i>), 0.64	angeri (Mean of upper slope mixed hardwood forest), 0.594	khasru (<i>Quercus spp.</i> Mean of upper slope mixed hardwood forest), 0.594	Mean of upper slope mixed hardwood forest, 0.594
Dolakha (Charnawati) sparse	guras (<i>Rhododendron arboretum</i>), 0.64	khote sallo (<i>Pinus roburghii</i>), 0.65	chilaune (<i>Schima wallichii</i>), 0.69	Mean of upper slope mixed hardwood forest, 0.594
Gorkha (Ludikhola) dense	sal (<i>Shorea robusta</i>), 0.88	chilaune (<i>Schima wallichii</i>), 0.69	katus (<i>Catanopsos spp.</i>), 0.74	Mean of terai/lower slope mixed hardwood forest, 0.72
Gorkha (Ludikhola) sparse	sal (<i>Shorea robusta</i>), 0.88	chilaune (<i>Schima wallichii</i>), 0.69	bhalayo (Mean of terai/lower slope mixed hardwood forest), 0.72	Mean of terai/lower slope mixed hardwood forest, 0.72

Eq (i) suggested by Chave (2005, p. 93) and used during 2010 analysis was followed for monitoring as well.

$$AGTB = 0.0509 * \rho D^2 H \quad \dots\dots\dots \text{Eq. (i)}$$

Where;

- $AGTB$ = aboveground tree biomass [kg];
 ρ = wood specific gravity [kgm^{-3}];
 D = tree diameter at breast height (DBH) [cm]; and
 H = tree height [m].

Even though wood specific gravity (ρ) is a component in Eq (i), the specific value were only used for three most frequently encountered species in each stratum (if available), as the wood specific gravity of all the tree species encountered during the field measurements were not readily available. For the remaining tree species, a general value was used according to associated forest types (see **Error! Reference source not found.** 8 for detail).

After taking the sum of the entire individual tree biomass (in kg) of a sampled plot and dividing it by the area of a sampling plot (250 m^2), the biomass value was attained in kg m^{-2} . This value was then converted to tone per hectare (t ha^{-1}) by multiplying it by 40. Since the project area has both tropical and sub-tropical region, the biomass value was converted into carbon stock by multiplying with default carbon fraction of 0.47 as suggested by IPCC (2006).

3.2.1.2 Aboveground saplings biomass (AGSB)

Nested sub plots of 5.64 m radius were established for measuring saplings. Saplings with diameter $> 1 \text{ cm}$ to $< 5 \text{ cm}$ were measured at 1.3 m above ground level. National allometric biomass equations were applied to determine the above ground sapling biomass (AGSB) ($< 5 \text{ cm}$ DBH). These tables are developed by the Department of Forest Research and Survey (DFRS), and the Department of Forest, Tree Improvement and Silviculture Component (TISC), Nepal (Tamrakar 2000). In case of tree species other than given equations in the biomass table, equations were applied according to given associations of species (forest type). The biomass value was derived from the stem compartment only. The following regression model [Eq. (ii)] was used for an assortment of species to calculate biomass.

$$\log(AGSB) = a + b \log(D) \quad \dots\dots\dots \text{Eq. (ii)}$$

where;

- log** = natural log [dimensionless];
- AGSB** = aboveground sapling biomass [kg];
- a** = intercept of allometric relationship for saplings [dimensionless];
- b** = slope allometric relationship for saplings [dimensionless]; and
- D** = Over bark diameter at breast height (measured at 1.3m above ground) [cm].

Used variables (i.e. **a** and **b**) for all tree species is presented in Annex 1. Biomass stocks were then converted to carbon stocks using the IPCC (2006) default carbon fraction of 0.47.

3.2.1.3 Regeneration count

A nested plot of 1 m radius was laid out for evaluating status of regeneration (<1 cm dbh). All regenerations in the plot of this size were counted, identified and recorded.

3.2.1.4 Leaf litter, herbs, and grasses (LHG)

One circular sub plot of 1 m² (0.56 m radius) was established at 5m north of centre point as leaf litter, herbs and grasses of 1 m² plot at centre were destructively collected and carbon was measured as last year. All the litter (dead leaves, twigs, etc.) and all live components (herb and grass) within this sub plot were collected separately by a destructive harvest method.

Fresh samples were weighed in the field with 0.1 g precision. Previously developed conversion factors were used to calculate the biomass of LHG. Conversion factors were calculated from the results obtained from the lab report in 2010. Repeated lab test was not conducted in the subsequent years assuming that the ratio of wet to dry weight will remain same for both the years for the same season and the place. The only change in the plot will be in its green weight of LHGs. Conversion factor for dry leaf litter ranged from 0.702 to 0.954 (Detail is given in table 9).

Table 9: Conversion of factor used for dry leaf litter for various strata

Watershed	Strata	Average wt. of wet litter (t ha ⁻¹)	Average wt. of dry litter biomass (t dm ha ⁻¹)	Conversion factor
Kayarkhola	dense	6.25	5.39	0.86
	sparse	4.14	3.66	0.88
	leakage	2.15	2.05	0.95
Charnawati	dense	8.85	6.93	0.78
	sparse	7.38	5.83	0.79
	leakage	5.99	4.21	0.70
Ludikhola	dense	7.78	6.77	0.87
	sparse	6.07	5.23	0.86
	leakage	7.22	5.11	0.71

Similarly, conversion factors were also calculated for herbs. In this case, the conversion factor ranged from 0.27 to 0.69. Please see **Error! Reference source not found.10** for details.

Table 10: Conversion factor used for herbs for various strata

Watershed	Strata	Average green wt. of herbs (t ha ⁻¹)	Average wt. of herbs biomass (t dm ha ⁻¹)	Conversion factor
Kayarkhola	dense	1.73	0.73	0.42
	sparse	1.97	0.92	0.47
	leakage	0.85	0.23	0.27
Charnawati	dense	1.56	0.72	0.46
	sparse	1.28	0.67	0.53
	leakage	0.92	0.63	0.69
Ludikhola	dense	1.49	0.74	0.50
	sparse	0.45	0.28	0.63
	leakage	0.73	0.41	0.57

The carbon content in LHG, $C(LHG)$ is calculated by multiplying LHG with the IPCC (2006) default carbon fraction of 0.47.

3.2.1.5 Soil organic carbon (SOC)

With the presumption that soil organic carbon doesn't change significantly within time period of one or two years, soil samples were not taken for this year's measurement. Hence, the average value that was calculated in 2010 was used for this year's carbon stock monitoring. Details are given in table 11.

Table 11: Average soil organic carbon in various strata

Watershed and stratum	Mean [tC ha ⁻¹]
Chitwan (Kayarkhola) dense	109.60
Chitwan (Kayarkhola) sparse	141.85
Dolakha (Charnawati) dense	128.90
Dolakha (Charnawati) sparse	117.48
Gorkha (Ludikhola) dense	97.01
Gorkha (Ludikhola) sparse	95.70

3.2.1.6 Belowground biomass (BGB)

Below ground biomass was calculated by using the default root-to-shoot ratio 1:20 as used in 2010 and 2011. In this way, 20% of total above ground biomass was taken as below ground root biomass.

3.3 Forest carbon stock of a stratum:

Total forest carbon stock (tC) of a stratum was calculated by adding all carbon value of respective stratum.

$$C(LU) = C(AGTB) + C(AGSB) + C(HG) + C(BB) + C(L) + SOC \quad \dots\dots\dots \text{Eq. (vii)}$$

where;

- $C(LU)$ = carbon stock for a land use category [tC ha⁻¹];
- $C(AGTB)$ = carbon stock in aboveground tree biomass [tC ha⁻¹];
- $C(AGSB)$ = carbon in aboveground sapling biomass [tC ha⁻¹];
- $C(HG)$ = carbon in herbs and grass [tC ha⁻¹];
- $C(L)$ = carbon in leaf litter [tC ha⁻¹];
- $C(BB)$ = carbon in belowground biomass [tC ha⁻¹];
- SOC = soil organic carbon [tC ha⁻¹];

The total forest carbon stock is then converted to tons of CO₂ equivalent by multiplying by 44/12, or 3.67 (Pearson et al, 2007).

3.4 Leakage monitoring

To ensure that local communities have not deforested or caused degradation in surrounding lands, leakage plots were established during the first year of the project. These plots were monitored to check the carbon flux in surrounding area. 6, 3 and 5 permanent plots in Ludikhola, Kayarkhola and Charnawati were monitored respectively this year too. Measurements and analysis of carbon stock measurement were carried out in these plots using a similar method as in permanent sample plots.

Results and Discussions

Results and analysis of the measurements are presented in the subsequent sections. Analysis was done using R-statistical software (R Development Core Team 2009) and MS-excel 2007.

3.5 Aboveground tree biomass (AGTB)

Based on pre-analysis, plots with extreme biomass values were identified and within these plots individual tree with potential outlier variable values (i.e. DBH and height) were also identified and recorded. A total of 21,037 trees were measured in 2010 in three watersheds and 43 trees were identified as outliers, out of which measurements of 4 trees were corrected during re-measurement in 2011. Hence, there were still 39 trees measured in 2010 that remained outliers (Annex 2). During the second measurement period in 2011, altogether 20,939 trees were measured and 19 trees were identified as outliers. This demonstrate that in total 98 trees were decreased in the year 2011 and the total number of outlier trees measured in 2010 and 2011 became 58 (Annex 2). During the third monitoring period in 2012, altogether 22,042 trees were measured and about 88 trees were identified as possible outliers: the frequency of outliers tree was highest in Ludhikhola watershed (39 trees) followed by Kayarkhola watershed (35 trees) and Charnawati watershed (14 trees) respectively. The total number of outlier trees from the first monitoring to the third period reached 146 (Annex 2). Each stratum had few plots with outlier tree biomass values in all three monitoring periods. The frequency of outlier plots seems to be highest in Kayarkhola dense in year 2011 and 2012 followed by Charnawati sparse 2011 and 2012, Ludikhola dense 2010 and 2011, Ludikhola sparse 2011 and 2012 and Charnawati sparse 2010, 2011 and 2012 respectively. In order to re-include identified potential outlier trees in the analysis, measurements of these trees need to be reconfirmed from the re-measurements in the field.

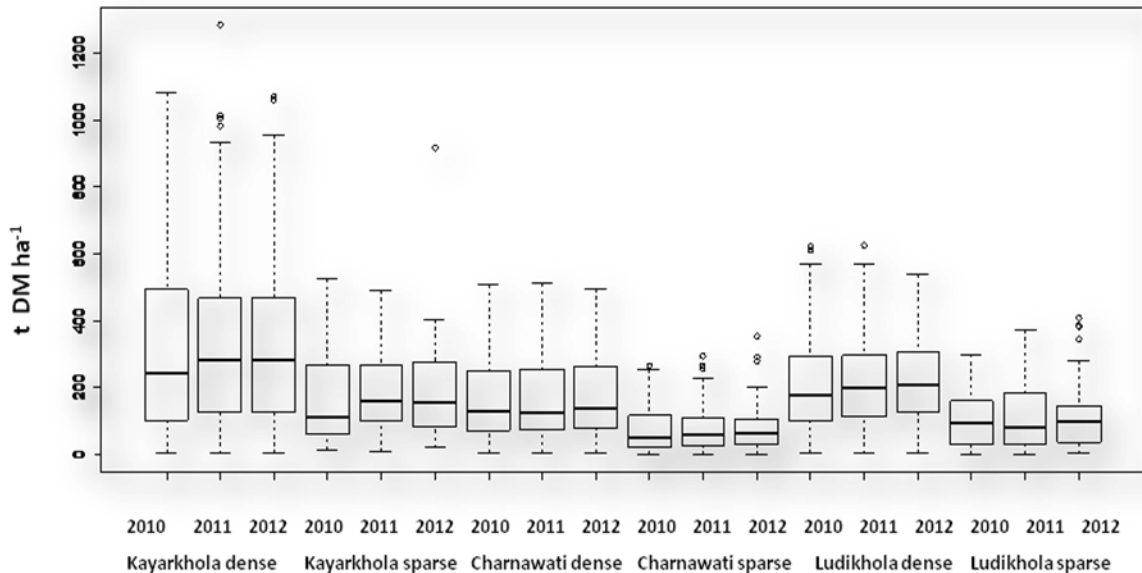


Figure 3: Box and whisker plot of AGTB in different strata showing five number summaries and outliers

Plots in Kayarkhola dense have the most widespread biomass values in all three monitoring periods 2010, 2011 and 2012 followed by Ludikhola dense 2010, 2011 and 2012 and Kayarkhola sparse 2010 (Figure 3). Sparse strata in Charnawati and Ludikhola show the least spread AGTB values in all three monitoring periods.

Referring to **Error! Reference source not found.**, the highest tree biomass increment (7.3 t dm ha^{-1}) is seen in dense strata of Ludikhola watershed followed by Ludikhola sparse strata (7.2 t dm ha^{-1}). The reason behind this highest increment is the fact that it possesses a very young forest with better growth conditions. There is no negative decrement in tree biomass in both dense and sparse strata in all three watersheds in the third monitoring period in 2012 indicating signs of sustainable forest conservation and carbon enhancement.

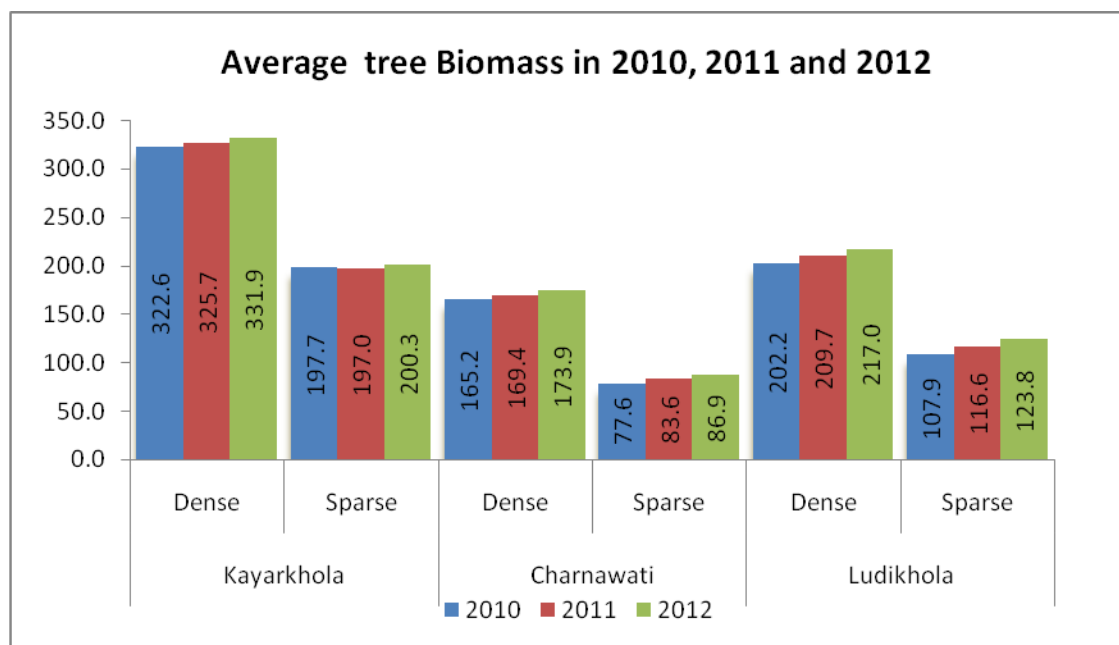


Figure 4: Average tree biomass in 2010, 2011 and 2012

As indicated by Figure 5, tree biomass, tree density and basal area has increased in five strata. However, in Charnawati dense tree density has decreased by ($14.6 \text{ t tree ha}^{-1}$). The highest ($86.5 \text{ trees ha}^{-1}$) increment in tree density was recorded at Kayarkhola dense. Thinning and other tending operations carried out by local CFUG may be the reasons for negative correlation between the value of tree density, and biomass and basal area.

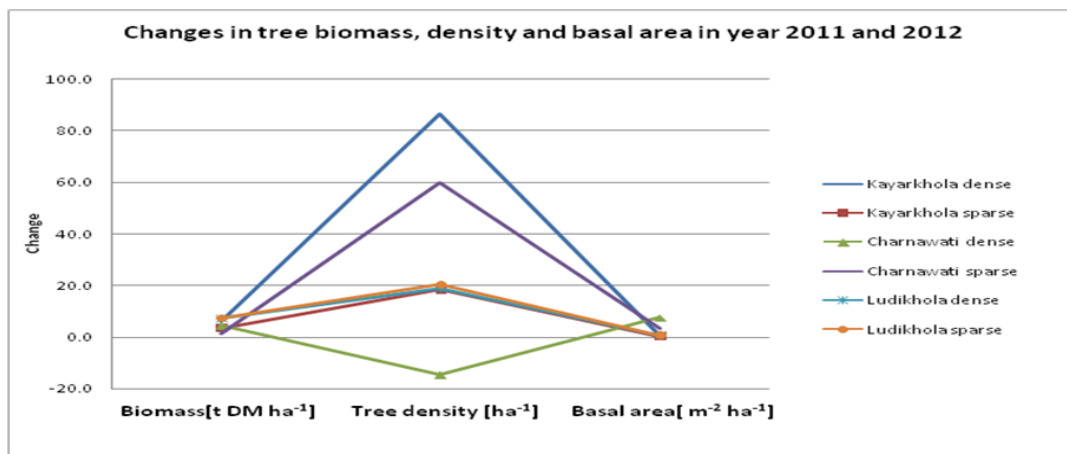


Figure 5: Change in tree biomass, tree density and basal area

Detail table for tree biomass, tree density and tree basal area is given in Annex 3.

3.6 Aboveground sapling biomass (AGSB)

Figure 6 suggests that Charnawati dense and sparse measured in year 2011 and 2012 has the highest spread of plots in terms of AGBS followed by Ludikhola dense and sparse in year 2011 and 2012. Both sparse and dense strata in Kayarkhola recorded the least spread AGBS values. Many outlier plots have been observed in Charnawati Dense and sparse in year 2011 and 2012.

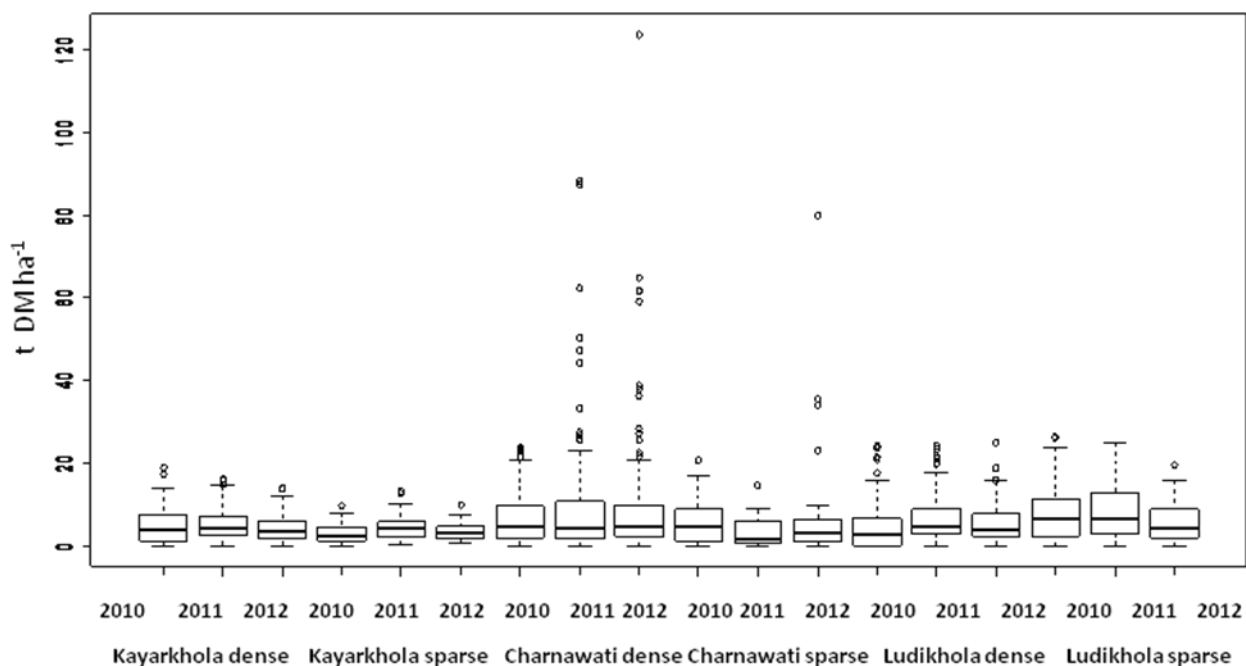


Figure 6: Box and whisker plot of AGSB in different strata showing five number summaries and outliers

As seen table 12, increment in sapling biomass has only occurred in the dense and sparse strata of Charnawati, while in the two remaining watersheds a decrease in sapling biomass seems to have occurred. Similar trends have been observed for the basal area and sapling density. Detail is given in Annex 4.

Table 12: Difference in AGSB biomass, density and basal area in two measurements

Strata	Difference in year 2011 and 2012					
	Biomass [t DM ha ⁻¹]		Basal area [m ² ha ⁻¹]		Density [ha ⁻¹]	
	2011	2012	2011	2012	2011	2012
Kayarkhola dense	0.48	-0.96	0.07	-0.16	103.25	-41.55
Kayarkhola sparse	1.63	-1.21	0.26	-0.46	338.46	-11.46
Charnawati dense	1.86	0.20	-0.26	0.11	310.75	82.08
Charnawati sparse	-1.86	3.93	-0.59	0.06	-201.50	457.63
Ludikhola dense	1.93	-1.13	0.50	-0.36	1773.61	-738.86
Ludikhola sparse	-0.38	-2.13	-0.08	-0.50	924.39	-1443.34

3.7 Herb and grass biomass (HGB)

Referring to Figure 7, all measurements in the year 2010, 2011 and 2012 seem to have more outlier plots containing herb and grass biomass, except in Ludikhola sparse plots in the year 2010. Charnawati dense in 2011 and Charnawati sparse in 2012 followed by Ludikhola dense and Ludikhola sparse in 2012 seem to have the higher spread of HGB, whereas the rest of the strata in 2010 show little spread in terms of HGB values.

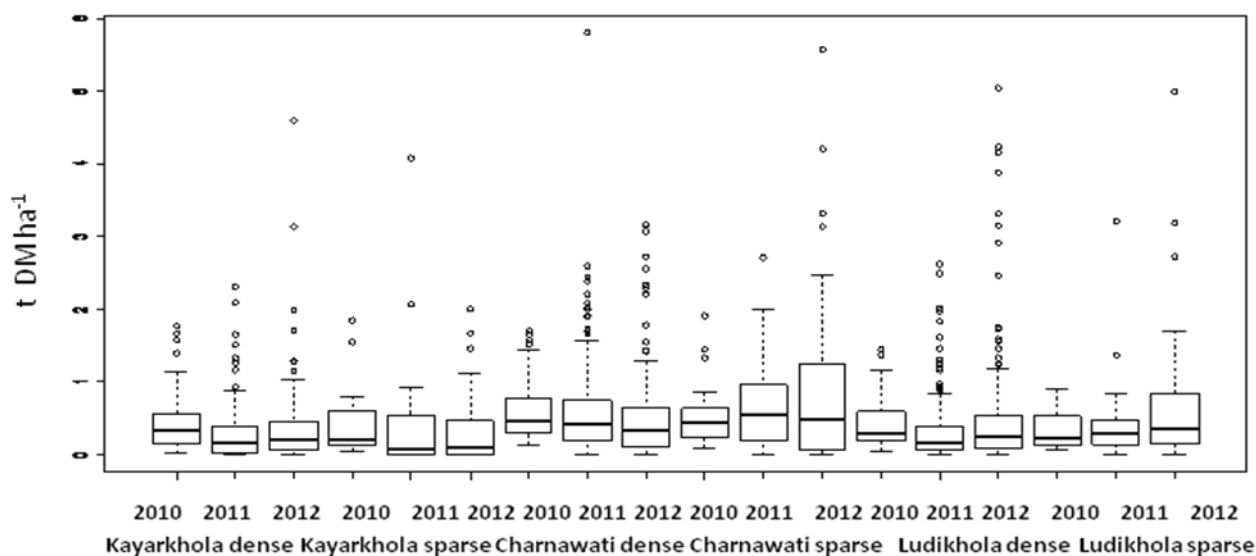


Figure 7: Box and whisker plot of HGB in different strata showing five number summaries and outliers

Graph showing herb biomass in three measurement period reveals that herb biomass has increased in Charnawati sparse and Ludikhola dense and sparse strata in 2012 (Figure 8) but decreased in the case of Kayarkhola dense and sparse as well as in Charnawati dense in 2012.

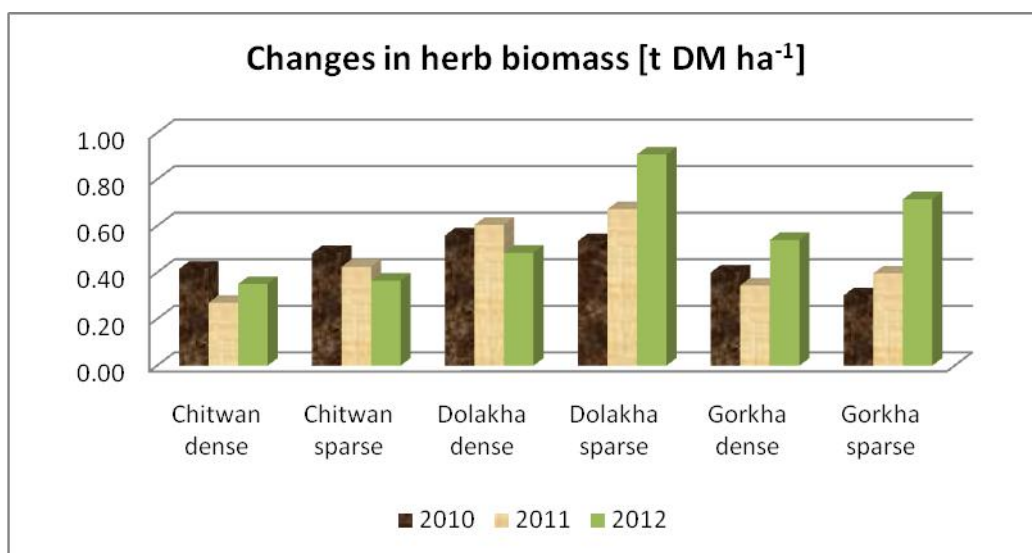


Figure 8: Herb biomass in 2010, 2011 and 2012

For cost efficiency as well as for simplification of monitoring process, conversion factors for converting herb and litter biomass into dry biomass have been developed. Otherwise, fluxes in herb carbon can be ignored considering it to be insignificant. Detail table is presented in Annex 5.

3.8 Leaf litter biomass (LLB)

Likewise in the herb and grasses biomass pool, outlier plots have increased in case of LLB in the year 2011 and 2012. The LLB has decreased in all the strata in 2012 as compared to the first and second monitoring period except in Charnawati sparse in 2012 (figure 9).

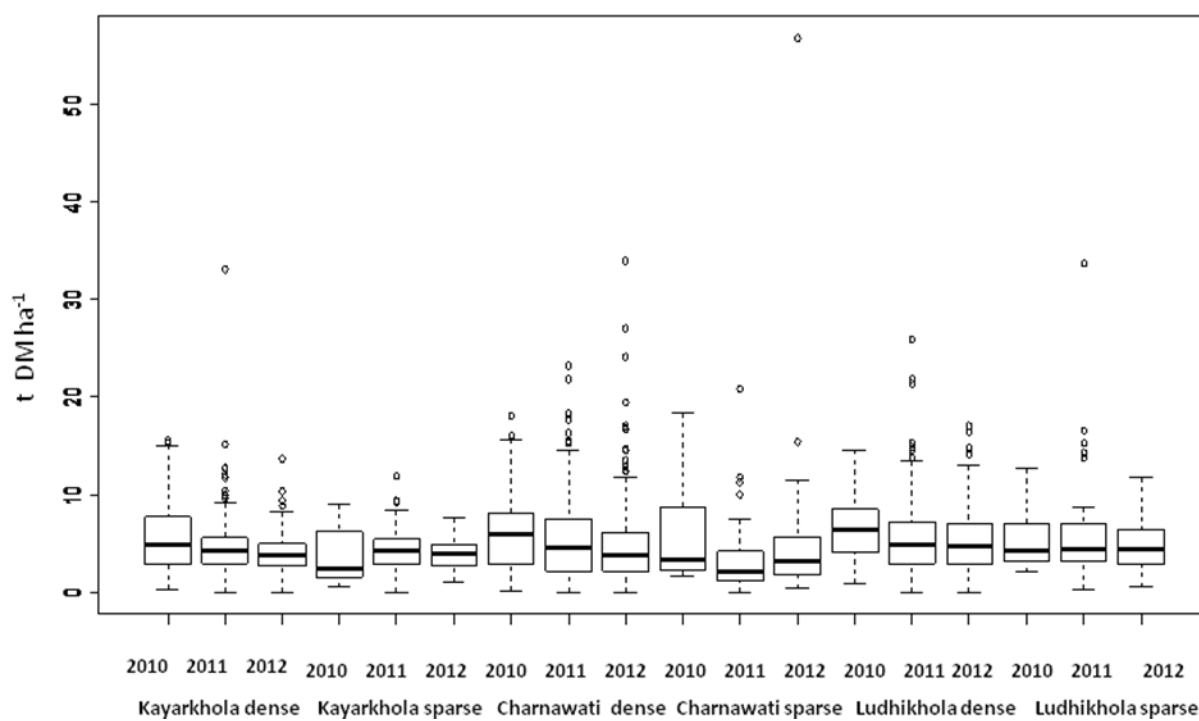


Figure 9: Box and whisker plot of LLB in different strata showing five number summaries and outliers

Referring to Figure 10, biomass of dry leaf litter has decreased in all strata except in Charnawati sparse in 2012. Maximum decrease was seen in Ludikhola sparse (-1.16 t DM ha⁻¹) followed Kayarkhola dense and sparse strata (-0.71 and -0.56 t DM ha⁻¹) respectively. A detailed analysis table is presented in

Annex 6.

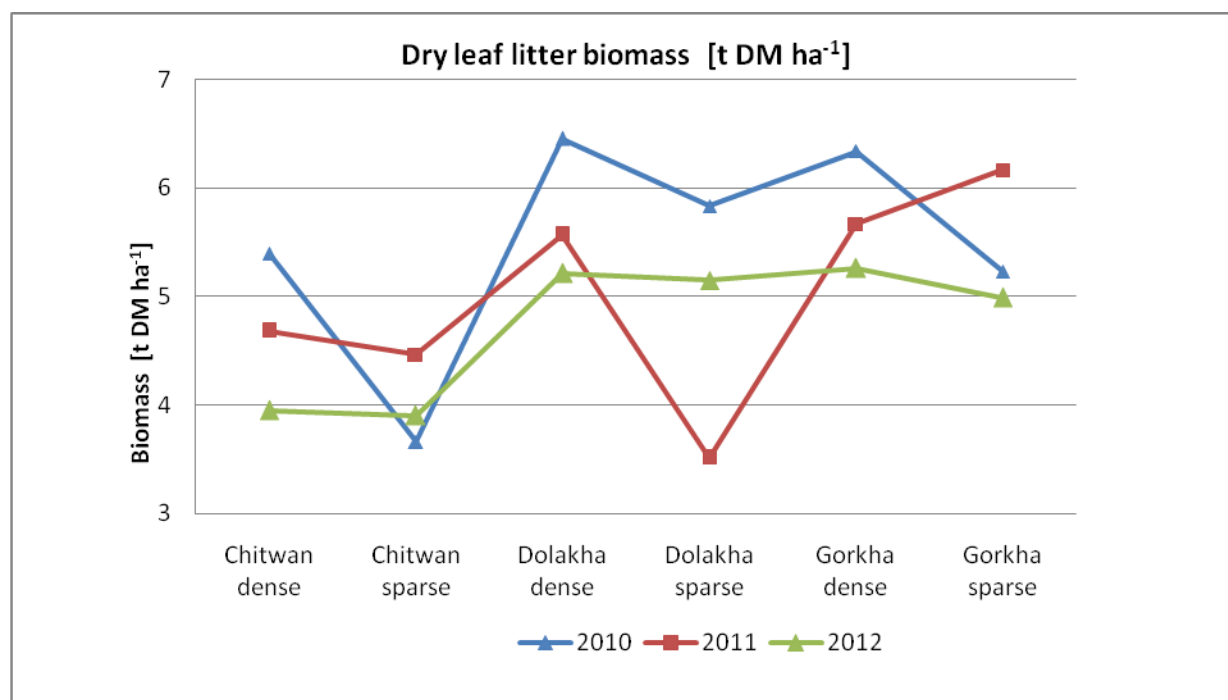


Figure 10: Showing dry leaf litter biomass in 2010, 2011 and 2012

3.9 Belowground biomass (BGB)

As the mean BGB is considered to be 20% of AGTB, the trend of BGB is similar to the one in AGTB, i.e. highest in Kayarkhola dense (66.37 t DM ha⁻¹) followed by Ludikhola dense (43.39 t DM ha⁻¹) and lowest in Charnawati sparse (16.96 t DM ha⁻¹). Summary of BGB is given in Table 13.

Table 13: Changes in below ground biomass (t DM ha⁻¹) in three measurements

Watersheds	Strata	2010	2011	2012	Differences in 2011	Differences in 2012
Kayarkhola	Dense	64.53	65.15	66.37	0.62	1.22
	Sparse	39.55	39.40	40.06	-0.15	0.66
Charnawati	Dense	33.05	33.87	34.76	0.82	0.89
	Sparse	15.53	16.71	16.96	1.18	0.25
Ludikhola	Dense	40.44	41.95	43.39	1.50	1.46
	Sparse	21.57	23.32	24.76	1.75	1.44

3.10 Per ha carbon (t C ha⁻¹) in different pools in two forest strata of three watersheds during 2010, 2011 and 2012

Table 14 reveals that forest carbon changes in different carbon pools of two forest strata in three watersheds. In the case of above ground tree pool and below ground pool, carbon changes are positive in

all strata except in Kayarkhola sparse in 2011. Similarly, sapling carbon shows positive changes in Charnawati watershed while in Kayarkhola and Ludikhola sapling carbon was decreased in 2012. In the case of litter, negative changes have been observed in five strata viz. Kayarkhola dense, Kayarkhola sparse, Charnawati dense, Ludikhola dense and, Ludikhola sparse in 2012. However, litter carbon increased in Charnawati sparse in 2012. In the case of herb carbon, decrement was observed in Kayarkhola sparse and Charnawati dense in 2012 and an increment has been observed in the remaining strata in 2012 (table 14).

Table 14: Per ha t C in different pools in three watersheds in three measurements

Watershed/Strata	Year	below ground	soil carbon	litter	herb	sapling	Tree	Per ha carbon stock in two measurements
Kayarkhola dense	2010	30.33	109.60	2.54	0.20	2.13	151.64	296.44
	2011	30.62	109.60	2.20	0.13	2.36	153.10	298.01
	2012	31.19	109.60	1.85	0.17	1.90	155.98	300.71
Kayarkhola sparse	2010	18.59	141.85	1.72	0.23	1.38	92.93	256.70
	2011	18.52	141.85	2.10	0.20	2.15	92.58	257.39
	2012	18.82	141.85	1.83	0.16	1.56	94.15	258.41
Charnawati dense	2010	15.53	128.90	3.03	0.26	3.17	77.66	228.56
	2011	15.92	128.90	2.62	0.28	4.04	79.60	231.36
	2012	16.33	128.90	2.47	0.22	4.18	81.70	233.77
Charnawati sparse	2010	7.30	117.48	2.74	0.25	2.49	36.49	166.75
	2011	7.85	117.48	1.65	0.32	1.61	39.27	168.18
	2012	7.97	117.48	2.42	0.46	3.45	39.87	171.63
Ludikhola dense	2010	19.01	97.01	2.98	0.19	2.03	95.04	216.26
	2011	19.72	97.01	2.66	0.16	2.94	98.58	221.07
	2012	20.39	97.01	2.47	0.25	2.60	101.98	224.52
Ludikhola sparse	2010	10.14	95.70	2.46	0.14	3.85	50.69	162.98
	2011	10.96	95.70	2.90	0.19	3.67	54.81	168.22
	2012	11.63	95.70	2.34	0.33	2.66	58.19	170.88

3.11 Carbon stock increment at CFUG level

Stocks of carbon in each CF in three years are presented in *Annex 7*. The maximum carbon stock increment was observed in Charnawati CFUG of Dolakha (2056 t C) followed by Bhitte CFUG of Charnawati (1464.48 t C), Nibuwatar CFUG of Kayarkhola (868.5 t C) and Ludi Damgade CFUG of Ludikhola (801.64tC). Similarly, the lowest increment has occurred in Paleko ban CFUG of Charnawati watershed (3.99 t) followed by Gahate Baghkhori CF (18.23 t C) and Bhirmuni Devithan CF (20.09 tC).

3.12 Carbon stocks change in three watersheds

Table 15 provides a summary of carbon stock changes in year 2010, 2011 and 2012. In total carbon has increased by 27562 ton which is equivalent to 101152.5 tCO₂.

Table 15: Carbon stock in year 2010, 2011 and 2012

Watershed	Total forest area	Area in two strata		Forest carbon in 2010		Forest carbon in 2011		Forest carbon in 2012		Total carbon stocks in 3 watersheds 2012 (tC)	Total change in strata (2011-2012) in t C
				tC/ha	Total carbon stock(t C)	tC/ha	Total carbon stock(t C)	tC/ha	Total carbon stock(t C)		
Kayarkhola	2382	1902	D	296	564042	298	567029	300	572174	696005	5145
		479	S	256	123008	257	123338	258	123831		492
Ludhikhola	1888	1634	D	216	353507	221	362514	224	367009	410224	4495
		252	S	162	41217	166	42226	170	43215		988
Charnawati	5996	3899	D	228	891212	231	902091	233	911488	1271396	9397
		2097	S	166	349674	168	352862	171	359908		7045

D= Dense and S= Sparse

Table 16 shows that overall carbon stock has increased in all three watersheds. In average, per ha annual increment of carbon stock of the three watersheds is 2.69 between 2011 and 2012. The highest rate of increment (3.33 t C ha^{-1}) is estimated in Ludhikhola watershed whereas the lowest increment (1.86 t C ha^{-1}) in Kayarkhola watershed. In a similar way, in the Charnawati watershed, annual per ha carbon stock increment was estimated to 2.88 t C ha^{-1} .

Table 15: Strata wise per ha forest carbon stocks of three watersheds in two measurements

Watershed/Strata	CF area (ha)	Carbon increment [tC ha-1]			Annual increment (2010-2011and 2011-2012) tC/ha		Mean annual increment of per ha tC (2011 and 2012)		Mean annual increment per ha tC (2011 and 2012)	
		tC/ha (2010)	tC/ha (2011)	tC/ha (2012)						
Kayarkhola- dense	1902.72	296.44	298.00	300.71	1.56	2.71	1.39	1.86	2.67	2.69
Kayarkhola- sparse	479.19	256.70	257.39	258.41	0.69	1.02				
Charnawati- dense	3899.25	228.56	231.35	233.76	2.79	2.41	2.34	2.88		
Charnawati- sparse	2097.00	166.75	168.27	171.63	1.52	3.36				
Ludikhola- dense	1634.64	216.26	221.77	224.52	5.51	2.75	5.31	3.33		
Ludikhola- sparse	252.90	162.98	166.97	170.88	3.99	3.91				
Total CF area (Ha)	10266									

3.13 Changes of carbon stock in leakage belt

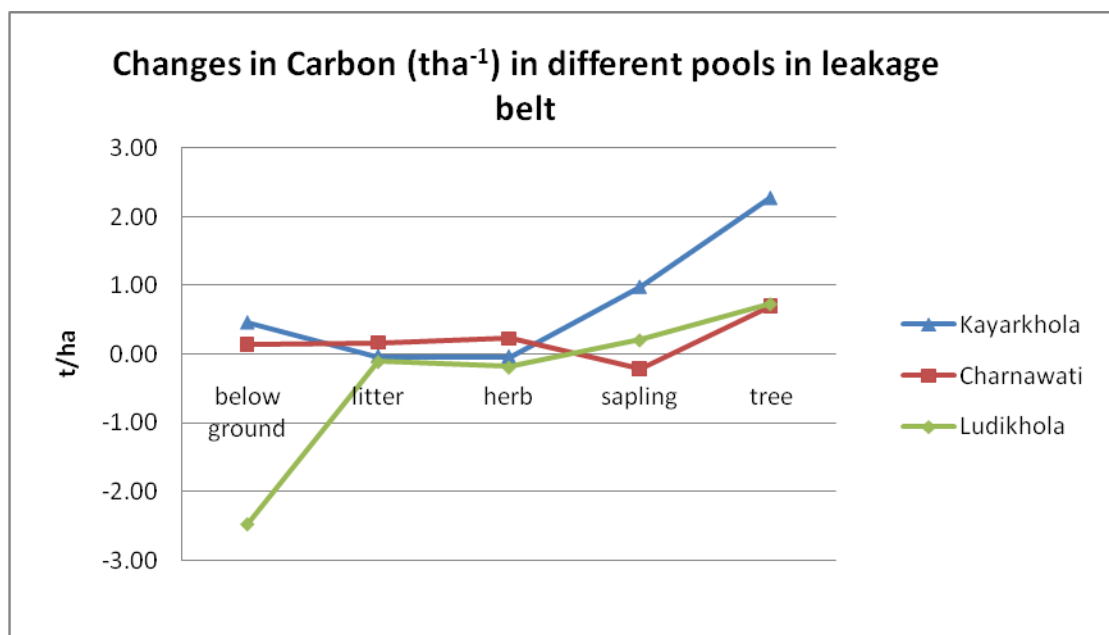


Figure 11: Changes in carbon stock (t C/ha) in leakage belt in different carbon pools

The total Carbon stock in leakage belt has increased in Kayarkhola (3.55 t C ha⁻¹) and Ludikhola (1.25 t C ha⁻¹) and decreased in Charnawati (0.03 t C ha⁻¹). In the case of Kayarkhola, the below ground, litter and tree carbon pool increased except the herb carbon pool which decreased in 2012, while in Charnawati watershed the herb and litter pools seem to have increased the carbon values but shows a decrement in tree saplings and below ground carbon pools in the 2012. Similarly in Ludikhola the herb, litter and below ground pools, the total carbon stock was decreased and in the rest of the pools the carbon stock was increased for the year 2012 (Table 17).

Table 16: Tone per ha carbon stock in various pools in leakage belt in three watersheds

Forest Carbon Pools	Kayarkhola			Charnawati			Ludikhola		
	2010	2011	2012	2010	2011	2012	2010	2011	2012
Below ground (t dm ha ⁻¹)	3.54	4.07	8.22	6.39	5.92	5.87	20.12	22.94	20.32
Litter(t dm ha ⁻¹)	0.97	2.70	2.67	1.98	0.87	1.04	2.40	2.04	1.93
Herb (t dm ha ⁻¹)	0.11	0.10	0.061	0.30	0.47	0.70	0.13	0.92	0.73
Sapling (t dm ha ⁻¹)	3.00	3.39	4.37	2.72	5.69	5.48	0.73	0.80	1.005
Tree (t dm ha ⁻¹)	17.69	20.37	22.65	31.93	29.60	29.39	100.61	101.62	101.94

4 Data use and future prospects

Forest carbon data from this monitoring were thus used by CFUGs as evidences in reward claim. Few CFUGs have used data for revising the community forest group constitution and the forest operational plan. Following observation are made based on the findings of the carbon monitoring on which basis future perspspects were also recommended.

- Identified outlier trees from pre-analysis (as presented in Annex 2) need special attention during next measurements. During remeasurements, the attempt should make sure that the outliers are the result of measurement or other human errors.
- Human and instrumental errors are prominent during the field measurements which were not detectable in first year but were observed in year two and three. These little measurement errors in the case of community forests were, however, insignificant as they were compensated and distributed between the two years. Errors in the leakage belt, however, were significant because of lesser number of plots (three in Kayarkhola, five in Charnawati and six in Ludikhola). This provided little opportunity for the errors to be distributed. Thus, the number of plots in the leakage belt should be increased to get better and more accurate results. In order to remove human and instrumental errors more cross checking is required.
- Significant changes are seen in the above ground tree pool, below ground pool and the saplings. Changes in other pools are minimal. Hence it would be better to use the conversion factor for the leaf litters and herbs that have already been developed. This will significantly reduce the cost that communities will have to pay for lab analysis and its data collection.
- Regarding soil organic carbon changes detailed and long term research is required.
- If the changes (increment) are not very significant in the leaf litter, herb and soil organic carbon, it can be discarded in the analysis thus making it simpler and easier for communities. However discarding the increment in these pools will underestimate the saleable carbon credits thus making it more credible to be sold on the market.
- So far, forest carbon measurement is focused on community forests. It is, however, suggested that forest carbon should be measured in other management regimes as well including government managed and religious forests. It would provide a more complete picture of the forest carbon potentiality.

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Annexes

Annex 1: Species parameters details used to estimate sapling biomass (Tamrakar, 2000)

Scientific name	Local name	Intercept (a)	Slope (b)	R square
<i>Alnus nepalensis</i>	Utis	-2.348	2.102	0.978
<i>Casearia graveolens</i>	Barkamle	-1.627	1.520	0.990
<i>Castanopsis indica</i>	Katus	-0.710	1.720	0.970
<i>Engelhardia spicata</i>	Mauwa	-2.142	1.938	0.987
<i>Eurya acuminata</i>	Jhigune	-1.743	1.797	0.981
<i>Ficus neriifolia</i>	Dudilo	-0.986	1.750	-
<i>Ficus semicordata</i>	Khanyo	-1.370	2.010	0.940
<i>Fraxinus floribunda</i>	Lakuri	-2.130	2.082	0.971
<i>Litsea monopetala</i>	Kutmero	-1.880	2.260	0.940
<i>Lyonia ovalifolia</i>	Angari	-2.833	2.010	0.990
<i>Maesa macrophylla</i>	Bhokate	-1.769	1.650	0.766
<i>Melastoma melabathricum</i>	Chulese	3.670	1.050	0.980
<i>Myrica esculenta</i>	Kafal	-2.535	1.403	0.848
<i>Myrsine capitellata</i>	Setokath	-1.859	1.932	0.979
<i>Phyllanthus embilica</i>	Amala	-2.046	1.889	0.968
<i>Pinus roxburghii</i>	Thingure Sallo	-3.985	2.744	0.990
<i>Pinus wallichiana</i>	gobre sallo	-1.816	1.816	0.990
<i>Pyrus pahia</i>	Mayal	-1.863	1.814	0.953
<i>Quercus spp.</i>	Baj	-0.532	0.988	0.786
<i>Quercus spp.</i>	Khasru	2.763	1.166	0.999
<i>Rhododendron spp.</i>	Laligurans	-2.533	1.393	0.698
<i>Rhus wallichii</i>	Bhalayo	-1.954	1.899	0.956
<i>Schima wallichii</i>	Chilaune	-2.220	2.520	0.980
<i>Shorea robusta</i>	Sal	-2.608	2.996	0.982
<i>Wendlandia coriacea</i>	Tilke	-1.280	1.432	0.999
all other species	Mixed species	-0.280	1.510	0.930

Annex 2: Details of outlier trees.

Measurement year	District	Strata	Plot number	Tree number	Species	DBH	height
2010	Chitwan	sparse	5	10	Ashana	95.4	28.1
2010	Chitwan	sparse	10	15	Harra	52.7	26.2
2010	Chitwan	sparse	10	21	Sal	59	32.9
2011	Chitwan	dense	93	11	Sal	92	6.7
2010	Chitwan	dense	128	13	Sal	72	24.0
2010	Chitwan	dense	140	1	Sal	79.7	25.1
2010	Chitwan	dense	140	14	Sal	94.5	17.6
2010	Chitwan	dense	140	15	chilaune	113.3	23.8
2011	Chitwan	dense	156	12	Bakhare	21	9.7
2010	Chitwan	dense	190	2	Sal	67.4	30.9
2011	Chitwan	dense	207	11	Sal	84	56.4
2011	Chitwan	dense	232	8	Sal	91.8	7.8
2010	Dolakha	dense	2	22	thingre salla	79	19.4
2010	Dolakha	dense	5	19	thingre salla	103.5	34.6
2010	Dolakha	dense	13	12	thingre salla	123.8	27.0
2011	Dolakha	dense	14	18	Kamali	98.6	12.3
2010	Dolakha	dense	15	4	gobresallo	47.8	39.9
2010	Dolakha	dense	15	37	gobresallo	46	34.3
2011	Dolakha	dense	15	47	gobresallo	49.3	48.3
2010	Dolakha	dense	17	1	khasru	120.1	25.9
2010	Dolakha	dense	29	3	thingre salla	72	23.6
2010	Dolakha	dense	29	32	gobresallo	68	26.3
2010	Dolakha	dense	38	30	thingre salla	104	18.3
2011	Dolakha	dense	40	6	gobresallo	81.7	25.0
2011	Dolakha	dense	47	23	Angari	46.1	66.6
2011	Dolakha	dense	69	22	gobresallo	106	31.3
2011	Dolakha	dense	72	9	khasru	92.5	19.0
2011	Dolakha	dense	72	13	khasru	68.4	14.7
2010	Dolakha	dense	90	8	thingre salla	71	34.4
2011	Dolakha	dense	90	13	thingre salla	76.1	33.8
2011	Dolakha	dense	100	10	Angari	6	54.2
2010	Dolakha	dense	103	6	gobresallo	118.5	36.4
2011	Dolakha	dense	139	9	Guras	76.5	35.0
2011	Dolakha	dense	213	29	Payu	9.2	51.2
2011	Dolakha	sparse	223	19	khasru	35.3	25.9
2010	Dolakha	sparse	223	27	thingre salla	86.3	21.4

Measurement year	District	Strata	Plot number	Tree number	Species	DBH	height
2010	Dolakha	sparse	232	6	Khote sallo	83.2	35.3
2010	Dolakha	sparse	235	4	mauwa	32.4	45.7
2010	Dolakha	sparse	235	23	chilaune	25.7	38.8
2010	Dolakha	sparse	247	1	Khote sallo	42.4	23.8
2010	Dolakha	sparse	247	10	Khote sallo	31.4	24.9
2010	Dolakha	sparse	247	11	Khote sallo	39	30.0
2010	Dolakha	sparse	247	14	Khote sallo	36.4	30.3
2010	Dolakha	sparse	248	7	khasru	84.6	18.4
2011	Dolakha	leakage	1002	18	Kharani	99	8.7
2010	Gorkha	sparse	20	43	Sal	39	16.1
2010	Gorkha	sparse	20	58	Sal	47.7	24.7
2010	Gorkha	sparse	21	6	Sal	80	32.1
2010	Gorkha	sparse	31	1	Sal	57.8	21.6
2010	Gorkha	sparse	31	22	Sal	39.7	20.7
2010	Gorkha	sparse	37	3	Sal	68.7	17.8
2010	Gorkha	dense	64	23	Sal	65.3	30.5
2011	Gorkha	dense	68	11	Sal	18	53.0
2010	Gorkha	dense	103	10	Sal	51.2	25.2
2010	Gorkha	dense	104	10	Sal	59.4	32.1
2010	Gorkha	dense	141	6	Sal	50.4	25.1
2010	Gorkha	dense	142	2	Sal	74	28.1
2011	Gorkha	dense	180	23	baar	135	27.0
2012	Chitwan	dense	50	5	Chiuri	58.4	37.47
2012	Chitwan	dense	50	5	Chiuri	66.2	47.23
2012	Chitwan	dense	56	1	katus	34.4	36.17
2012	Chitwan	dense	56	6	Sal	40.9	35.43
2012	Chitwan	dense	56	8	Buddharyo	34.3	38.12
2012	Chitwan	dense	60	1	Sal	60.9	36.90
2012	Chitwan	dense	60	2	Sal	50.9	36.20
2012	Chitwan	dense	60	4	Sal	49.6	34.70
2012	Chitwan	dense	60	7	Sal	46.1	33.30
2012	Chitwan	dense	60	8	Sal	65	43.00
2012	Chitwan	dense	80	2	chilaune	72.6	40.90
2012	Chitwan	dense	92	14	Sal	30.6	31.10
2012	Chitwan	dense	95	18	Sal	32.5	31.56
2012	Chitwan	dense	97	19	Sal	40.6	40.00
2012	Chitwan	dense	106	5	Sal	75	41.00

Measurement year	District	Strata	Plot number	Tree number	Species	DBH	height
2012	Chitwan	dense	112	40	Sal	58.5	29.90
2012	Chitwan	dense	113	3	Sal	71	62.76
2012	Chitwan	dense	122	9	Sal	60.1	34.40
2012	Chitwan	dense	128	11	Sal	69.8	37.10
2012	Chitwan	dense	140	2	Saj	50.5	34.10
2012	Chitwan	dense	141	2	Sal	48.6	38.60
2012	Chitwan	dense	144	15	Sal	59.9	53.10
2012	Chitwan	dense	144	16	Saj	23.5	32.50
2012	Chitwan	dense	153	7	Sal	45.3	81.07
2012	Chitwan	dense	162	18	Sal	51	67.59
2012	Chitwan	dense	173	39	Sal	17.5	41.90
2012	Chitwan	dense	189	10	Sirish	24.2	68.03
2012	Chitwan	dense	189	12	maleto	16.2	46.39
2012	Chitwan	dense	190	5	Sal	54.5	41.25
2012	Chitwan	dense	204	21	Sal	55.9	34.30
2012	Chitwan	dense	206	4	Sal	52	31.20
2012	Chitwan	dense	207	2	Sal	46.3	33.90
2012	Chitwan	dense	207	6	bhalayo	48.2	33.90
2012	Chitwan	dense	209	3	Sal	39.4	32.70
2012	Chitwan	dense	220	4	aodane	125	30.00
2012	Dolakha	dense	2	2	Guras	116.3	7.23
2012	Dolakha	dense	2	22	thingre salla	249.9	23.35
2012	Dolakha	dense	54	5	Guras	124.4	9.35
2012	Dolakha	dense	54	11	sisi	125.5	8.80
2012	Dolakha	dense	59	37	angere	116.3	7.61
2012	Dolakha	dense	60	25	thingre salla	238.2	9.34
2012	Dolakha	dense	97	2	bhedamuda	123.7	12.95
2012	Dolakha	dense	103	6	chimal	118.47	49.98
2012	Dolakha	dense	107	11	bhedamuda	150.2	9.35
2012	Dolakha	dense	135	12	patesalla	100	34.50
2012	Dolakha	sparse	239	6	Kharani	155.9	6.37
2012	Dolakha	sparse	239	7	Kharani	115.5	7.30
2012	Dolakha	sparse	239	15	Kharani	122.6	4.65
2012	Dolakha	leakage	1002	17	Kharani	195	11.62
2012	Gorkha	sparse	21	6	Sal	80	34.90
2012	Gorkha	sparse	27	26	bhalayo	90	4.90
2012	Gorkha	sparse	37	3	Sal	71.1	17.10

Measurement year	District	Strata	Plot number	Tree number	Species	DBH	height
2012	Gorkha	sparse	40	4	Sal	64.4	24.20
2012	Gorkha	dense	63	3	kaiyo	63	6.44
2012	Gorkha	dense	64	23	Sal	65.7	28.40
2012	Gorkha	dense	85	6	Saj	61	21.80
2012	Gorkha	dense	118	15	Sal	72.3	52.78
2012	Gorkha	dense	142	2	Sal	73.9	26.14
2012	Gorkha	dense	150	5	chilaune	63.4	19.94
2012	Gorkha	dense	150	6	Sal	65.4	22.30
2012	Gorkha	dense	180	23	baar	140.5	25.27
2012	Gorkha	dense	184	4	Sal	62	25.60
2012	Gorkha	dense	185	31	chilaune	69.8	22.60
2012	Gorkha	dense	60	36	chilaune	30.8	40.50
2012	Gorkha	dense	115	30	Sal	15.2	40.00
2012	Gorkha	dense	116	28	Sal	38.5	40.69
2012	Gorkha	dense	116	55	Sal	42.8	43.57
2012	Gorkha	dense	151	30	Sal	38.6	42.37
2012	Gorkha	dense	141	18	Sal	53.9	27.46
2012	Gorkha	dense	120	39	Sal	32.3	22.40
2012	Gorkha	dense	121	31	Sal	52.2	24.40
2012	Gorkha	dense	103	3	Sal	56.2	23.20
2012	Gorkha	dense	103	4	chilaune	13.3	1.60
2012	Gorkha	dense	103	5	chilaune	10.5	3.80
2012	Gorkha	dense	103	6	Sal	19	3.70
2012	Gorkha	dense	103	7	Sal	5.4	4.70
2012	Gorkha	dense	103	8	botdhangero	8.5	4.80
2012	Gorkha	dense	103	9	botdhangero	8.1	3.50
2012	Gorkha	dense	103	10	Sal	52.7	23.70
2012	Gorkha	dense	104	10	Sal	59.3	29.05
2012	Gorkha	dense	98	14	Sal	56.5	30.10
2012	Gorkha	dense	86	66	Sal	38.1	27.60
2012	Gorkha	dense	78	16	Saj	49.5	33.43
2012	Gorkha	dense	61	6	chilaune	55.3	9.10
2012	Gorkha	sparse	8	72	Sal	35.6	21.90
2012	Gorkha	sparse	20	58	Sal	48.8	30.73
2012	Gorkha	sparse	31	1	Sal	58.1	20.60
2012	Gorkha	dense	130	28	Sal	57.9	28.10

Annex 3: Summary statistics of sampling of trees in different strata

strata	Variable unit	Year	Number of plots	Mean	Std. deviation	half width of confidence interval	max	min	median	sampling precision
Kayarkhola Dense	Biomass [t DM ha-1]	2010	154	322.6	267.7	42.6	1084.7	1.2	242.4	6.7
		2011	154	325.7	250.6	39.9	1286.5	0.5	282.0	6.2
		2012	154	331.8	255.2	40.64	1071.1	2.71	283.0	6.19
	Tree density [ha-1]	2010	154	1092.2	740.8	117.9	4160.0	120.0	960.0	5.5
		2011	154	1094.3	753.0	119.9	3720.0	80.0	880.0	5.5
		2012	154	1180.8	807.1	128.4	4280.0	160.0	1000.0	5.5
	Basal area [m2 ha-1]	2010	154	31.2	18.5	2.9	90.9	0.7	27.4	4.8
		2011	154	32.2	16.9	2.7	79.4	0.5	29.9	4.2
		2012	154	32.6	18.6	2.97	88.7	0.933	29.1	4.6
Kayarkhola Sparse	Biomass [t DM ha-1]	2010	26	197.7	173.9	70.2	526.6	12.0	110.5	17.2
		2011	26	197.0	139.0	56.2	490.6	7.0	158.6	13.8
		2012	26	200.3	181.03	73.1	918.9	18.4	153.6	17.7
	Tree density [ha-1]	2010	26	903.1	669.6	270.5	3120.0	240.0	700.0	14.5
		2011	26	912.3	691.8	279.4	3120.0	240.0	740.0	14.9
		2012	26	930.7	694.0	280.3	3160	280	740	14.6
	Basal area [m2 ha-1]	2010	26	23.2	13.7	5.5	58.6	5.2	19.3	11.6
		2011	26	24.8	12.2	4.9	52.8	4.8	23.7	9.7
		2012	26	24.9	14.9	6.0	79.3	5.9	23.9	11.7
Charnawati Dense	Biomass [t DM ha-1]	2010	164	165.2	122.0	18.8	508.4	4.8	126.8	5.8
		2011	162	169.4	124.4	19.3	512.0	4.9	123.1	5.8
		2012	163	173.8	118.3	18.3	498.0	5.25	137.8	5.3
	Tree density [ha-1]	2010	164	1600.5	1013.6	156.3	4720.0	160.0	1320.0	4.9
		2011	162	1571.9	949.5	147.3	4680.0	160.0	1380.0	4.7
		2012	163	1557.3	1026.3	158.7	4920	80	1360	5.1
	Basal area [m2 ha-1]	2010	164	33.8	19.3	3.0	122.0	3.0	30.2	4.4
		2011	162	34.7	18.2	2.8	86.1	3.7	31.4	4.1
		2012	163	42.2	30.4	4.7	154.1	3.3	34.0	5.6
Charnawati Sparse	Biomass [t DM ha-1]	2010	41	77.6	70.6	22.3	266.2	0.0	48.1	14.2
		2011	39	83.6	76.8	24.9	293.4	0.0	55.6	14.7
		2012	41	84.9	80.0	25.2	353.1	0	62.7	14.7
	Tree density [ha-1]	2010	41	1110.2	854.2	269.6	3560.0	0.0	720.0	12.0
		2011	39	1123.1	833.5	270.2	3640.0	0.0	880.0	11.9
		2012	41	1183	897.4	287.0	3960	160	880	11.9
	Basal area [m2 ha-1]	2010	41	20.1	15.9	5.0	60.7	0.0	15.0	12.4
		2011	39	20.4	15.9	5.2	63.2	0.0	14.8	12.5
		2012	41	23.8	19.4	6.2	96.5	0.575	17.6	12.8
Ludikhola	Biomass [t	2010	144	202.2	137.0	22.6	622.0	0.4	177.4	5.6

Dense	DM ha-1]	2011	144	209.7	130.8	21.5	624.6	0.5	196.6	5.2
		2012	144	217.0	124.3	20.5	536.6	1.1	207.0	4.8
	Tree density [ha-1]	2010	144	1898.3	1033.3	170.2	6360.0	120.0	1680.0	4.5
		2011	144	1914.2	1050.6	173.1	6520.0	120.0	1740.0	4.6
		2012	144	1933.0	1033.7	170.2	6600	200	1740	4.45
	Basal area [m2 ha-1]	2010	144	27.3	12.8	2.1	64.6	0.3	26.5	3.9
		2011	144	28.4	13.1	2.2	79.8	0.3	27.7	3.9
		2012	144	29.1	12.7	2.0	60.4	0.583	29.2	3.6
Ludikhola Sparse	Biomass [t DM ha-1]	2010	41	107.9	84.7	26.7	298.3	0.0	93.0	12.3
		2011	41	116.6	99.1	31.3	375.2	0.0	82.0	13.3
		2012	41	123.8	108.6	34.2	408.5	0.352	97.1	13.7
	Tree density [ha-1]	2010	41	1363.9	873.4	275.7	4280.0	0.0	1160.0	10.0
		2011	41	1390.2	896.7	283.0	4280.0	0.0	1200.0	10.1
		2012	41	1410.7	880.4	277.9	4360	40	1200	9.7
	Basal area [m2 ha-1]	2010	41	17.7	10.2	3.2	39.5	0.0	18.7	9.0
		2011	41	18.6	11.6	3.7	53.8	0.0	18.1	9.8
		2012	41	19.1	12.0	3.8	50.2	0.573	17.9	9.8

Annex 4: Summary statistics of sampling of saplings in different strata

Strata	Variable unit	Year	Number of plots	Mean	Std dev	Half width of confidence interval	Max.	Min.	Median	Sampling precision
Kayarkhola Dense	Biomass [t DM ha ⁻¹]	2010	154	4.5	3.9	0.6	19.0	0.0	3.7	6.9
		2011	154	5.0	3.7	0.6	16.1	0.0	4.2	5.9
		2012	154	4.0	3.0	0.4	13.8	0.0	3.4	6.0
	Tree density [ha ⁻¹]	2010	154	1685.1	1494.6	237.9	6200	0.0	1300	7.1
		2011	154	1788.3	1389.3	221.2	6200	0.0	1400	6.3
		2012	154	1746.7	1297.8	206.6	6500	0.0	1500	5.9
	Basal area [m ² ha ⁻¹]	2010	154	1.1	0.9	0.2	4.6	0.0	0.8	7.2
		2011	154	1.1	0.9	0.1	4.0	0.0	1.0	6.2
		2012	154	0.9	0.7	0.1	3.1	0.0	0.8	6.5
Kayarkhola Sparse	Biomass [t DM ha ⁻¹]	2010	26	2.9	2.7	1.1	9.5	0.0	2.2	17.7
		2011	26	4.6	3.4	1.4	13.1	0.1	3.9	14.5
		2012	26	3.3	2.4	0.9	9.9	0.3	2.9	14.3
	Tree density [ha ⁻¹]	2010	26	1184.6	1261.0	509.3	5800	0.0	800.0	20.9
		2011	26	1523.1	1027.3	415.0	4000	0.0	1250	13.2
		2012	26	1511.5	1032.4	416.9	5200	300	1300	13.3
	Basal area [m ² ha ⁻¹]	2010	26	0.7	0.6	0.3	2.3	0.0	0.5	17.7
		2011	26	1.0	0.8	0.3	3.2	0.0	0.8	15.8
		2012	26	0.6	0.5	0.2	1.9	0.05	0.5	15.2
Charnawati Dense	Biomass [t DM ha ⁻¹]	2010	164	6.7	6.5	1.0	23.5	0.0	4.6	7.6
		2011	162	8.6	13.2	2.1	88.2	0.0	4.4	12.1
		2012	163	8.7	14.4	2.2	123.5	0	4.4	12.8
	Tree density [ha ⁻¹]	2010	164	2070.7	1999.5	308.3	13900	0.0	1500	7.5
		2011	162	2381.5	2397.6	372.0	11400	0.0	1700	7.9
		2012	163	2463.5	2367.2	367.2	14600	0.0	1800	7.5
	Basal area [m ² ha ⁻¹]	2010	164	1.5	1.3	0.2	5.1	0.0	1.1	6.9
		2011	162	1.2	1.2	0.2	7.0	0.0	0.9	7.8
		2012	163	1.2	1.1	0.1	7.2	0.0	0.8	7.7
Charnawati Sparse	Biomass [t DM ha ⁻¹]	2010	41	5.3	4.9	1.5	20.5	0.0	4.4	14.5
		2011	39	3.4	3.6	1.2	14.3	0.0	1.6	16.6
		2012	41	7.3	14.0	4.4	79.9	0.0	2.9	29.8
	Tree density [ha ⁻¹]	2010	41	1670.7	1677.1	529.4	6700	0.0	1100	15.7
		2011	39	1469.2	1453.0	471.0	5100	0.0	900	15.8
		2012	41	1926.8	2232.8	704.7	11800	0.0	1500	18.0
	Basal area [m ² ha ⁻¹]	2010	41	1.4	1.4	0.4	5.4	0.0	1.1	15.6
		2011	39	0.8	0.8	0.2	3.1	0.0	0.6	15.9
		2012	41	0.8	0.9	0.3	4.4	0.0	0.5	17.3
Ludikhola Dense	Biomass [t DM ha ⁻¹]	2010	144	4.3	5.4	0.9	24.1	0.0	2.6	10.4
		2011	144	6.3	5.1	0.8	24.2	0.0	4.7	6.8
		2012	144	5.1	4.3	0.7	24.9	0.0	3.81	7.0

	Tree density [ha ⁻¹]	2010	144	1497.2	1948.6	321.0	11500	0.0	950	10.8
		2011	144	3270.8	2416.6	398.1	13000	0.0	2500	6.2
		2012	144	2531.9	1827.4	301.0	8400	0.0	2150	6.0
	Basal area [m ² ha ⁻¹]	2010	144	1.2	1.5	0.2	7.4	0.0	0.7	10.4
		2011	144	1.7	1.3	0.2	7.5	0.0	1.3	6.7
		2012	144	1.3	1.1	0.1	7.3	0.0	0.9	7.1
Ludikhola Sparse	Biomass [t DM ha ⁻¹]	2010	41	8.2	8.0	2.5	26.4	0.0	6.2	15.2
		2011	41	7.8	6.2	2.0	25.0	0.0	6.4	12.4
		2012	41	5.6	4.6	1.4	19.4	0.0	4.1	12.7
	Tree density [ha ⁻¹]	2010	41	3073.2	3691.8	1165.3	18600.0	0.0	2200	18.8
		2011	41	3997.6	3153.4	995.3	16200.0	0.0	3400	12.3
		2012	41	2553.6	2094.8	661.2	7800	0.0	1600	12.8
	Basal area [m ² ha ⁻¹]	2010	41	2.0	2.0	0.6	7.1	0.0	1.5	15.0
		2011	41	1.9	1.5	0.5	5.8	0.0	1.6	11.9
		2012	41	1.3	1.0	0.3	3.7	0.0	0.9	11.6

Annex 5: Per ha Dry Matter value of f herbs and grass in different strata

Strata	Year	Number of plots	Mean	Standard deviation	Half width of confidence interval	Maximum	Minimum	Median	Sampling precision
Chitwan dense	2010	99	0.42	0.37	0.07	1.77	0.01	0.33	9.04
	2011	154	0.27	0.39	0.06	2.31	0.00	0.15	11.50
	2012	154	0.35	0.52	0.08	4.6	0.00	0.19	12.15
Chitwan sparse	2010	15	0.48	0.54	0.30	1.84	0.05	0.20	28.91
	2011	26	0.42	0.88	0.35	4.08	0.00	0.06	40.48
	2012	26	0.35	0.57	0.23	1.99	0.00	0.09	31.66
Dolakha dense	2010	120	0.56	0.37	0.07	1.71	0.12	0.46	6.01
	2011	162	0.61	0.71	0.11	5.81	0.00	0.41	9.20
	2012	163	0.48	0.58	0.09	3.16	0.00	0.33	9.48
Dolakha sparse	2010	26	0.54	0.44	0.18	1.90	0.08	0.43	15.99
	2011	39	0.67	0.64	0.21	2.70	0.00	0.54	15.27
	2012	41	0.90	1.24	0.39	5.57	0.00	0.47	21.49
Gorkha dense	2010	82	0.40	0.32	0.07	1.44	0.04	0.28	8.78
	2011	143	0.34	0.51	0.08	2.62	0.00	0.15	12.28
	2012	144	0.54	0.87	0.14	5.04	0.00	0.23	13.42
Gorkha sparse	2010	34	0.30	0.23	0.08	0.89	0.06	0.21	13.28
	2011	42	0.40	0.53	0.17	3.21	0.00	0.28	20.73
	2012	41	0.71	0.97	0.30	4.99	0.00	0.35	21.23

Annex 6: Summary statistics of leaf litter biomass sampling in different strata

Strata	Year	Number of plots	Mean	Standard deviation	Half width of confidence interval	Maximum	Minimum	Median	Sampling precision
Chitwan dense	2010	80	5.39	3.69	0.82	15.52	0.19	4.77	7.66
	2011	154	4.68	3.52	0.56	33.13	0.00	4.18	6.07
	2012	154	3.95	2.18	0.34	13.54	0.00	3.70	4.45
Chitwan sparse	2010	13	3.66	2.94	1.77	8.96	0.42	2.40	22.26
	2011	26	4.46	2.87	1.16	11.87	0.00	4.29	12.60
	2012	26	3.90	1.56	0.63	7.49	0.99	3.85	7.83
Dolakha dense	2010	88	6.45	4.05	0.86	18.09	0.06	5.89	6.69
	2011	162	5.57	4.57	0.71	23.20	0.00	4.52	6.44
	2012	163	5.21	4.93	0.76	34.02	0.00	3.76	7.40
Dolakha sparse	2010	9	5.83	5.48	4.22	18.26	1.54	3.19	31.34
	2011	39	3.51	4.13	1.34	20.83	0.00	2.02	18.81
	2012	41	5.15	8.86	2.79	56.84	0.28	3.07	26.87
Gorkha dense	2010	98	6.34	3.41	0.68	14.46	0.79	6.21	5.44
	2011	143	5.67	4.21	0.70	25.83	0.00	4.71	6.21
	2012	144	5.26	3.34	0.55	17	0.00	4.63	5.30
Gorkha sparse	2010	19	5.23	2.80	1.35	12.62	2.00	4.10	12.28
	2011	42	6.17	5.72	1.78	33.66	0.21	4.39	14.32
	2012	41	4.99	3.09	0.97	11.76	0.48	4.43	9.68

Annex 7: CFUG level summary of carbon stock

SN	Watershed	CF name	Total CF area [ha]	Area in dense [ha]	Area in sparse [ha]	Total carbon stock in dense strata [tC]			Total carbon stock in sparse strata [tC]			Total carbon in CF [tC]			Difference in total carbon [tC] in 2011-2012
						2010	2011	2012	2010	2011	2012	2010	2011	2012	
1	Kayarkhola	Nibuwatar	329.18	315.21	13.97	93440.51	93932.58	94786.8	3586.04	3595.74	3610.0	97026.55	97528.32	98396.8	868.5
2	Kayarkhola	Chitramkami nchuli	314.02	233.05	80.96	69085.09	69448.90	70080.5	20782.11	20838.29	20920.9	89867.20	90287.19	91001.3	714.1
3	Kayarkhola	Deujar	278.87	184.06	94.82	54562.55	54849.88	55348.7	24339.92	24405.72	24502.4	78902.47	79255.60	79851.1	595.5
4	Kayarkhola	Devidhunga	189.10	152.03	36.07	45067.77	45304.94	45716.9	9259.17	9284.06	9320.8	54326.94	54589.00	55037.8	448.8
5	Kayarkhola	Chelibeti	64.80	59.61	6.17	17670.79	17763.78	17925.3	1583.84	1588.10	1594.4	19254.63	19351.88	19519.7	167.8
6	Kayarkhola	Kalika	213.77	206.15	7.57	61110.88	61432.70	61991.4	1943.19	1948.44	1956.2	63054.07	63381.14	63947.5	566.4
7	Kayarkhola	Indreni	172.17	155.57	16.61	46117.00	46359.86	46781.5	4263.72	4275.25	4292.2	50380.72	50635.11	51073.6	438.5
8	Kayarkhola	Batauli	155.77	91.29	64.49	27061.91	27204.42	27451.8	16554.33	16599.08	16664.9	43616.24	43803.50	44116.7	313.2
9	Kayarkhola	Dharapani	147.16	142.19	4.96	42150.65	42372.62	42758	1273.21	1276.65	1281.7	43423.86	43649.27	44039.7	390.4
10	Kayarkhola	Janapragati	118.84	97.18	21.66	28807.93	28959.64	29223	5560.04	5575.07	5597.2	34367.97	34534.71	34820.2	285.5
11	Kayarkhola	Pragati	115.48	70.78	44.70	20981.95	21092.44	21284.3	11474.31	11505.33	11550.9	32456.26	32597.77	32835.2	237.4
12	Kayarkhola	Kankali	91.60	78.48	13.12	23264.53	23387.04	23599.7	3367.85	3376.96	3390.3	26632.38	26764.00	26990.1	226.1
13	Kayarkhola	Samfrang	63.90	26.84	37.06	7956.42	7998.32	8071.06	9513.16	9538.87	9576.7	17469.58	17537.19	17647.7	110.5
14	Kayarkhola	Satkanya	58.28	55.95	2.33	16585.76	16673.10	16824.7	598.10	599.72	602.1	17183.86	17272.82	17426.8	154.0
15	Kayarkhola	Jharana	34.53	23.47	11.07	6957.42	6994.06	7057.66	2841.63	2849.31	2860.6	9799.05	9843.37	9918.3	74.9
16	Kayarkhola	Jamuna	34.53	10.86	23.67	3219.33	3236.28	3265.71	6076.00	6092.42	6116.6	9295.32	9328.70	9382.3	53.6
17	Ludikhola	Ludi Damgade	270.71	221.44	49.28	47887.82	49108.75	49717.71	8031.61	8228.28	8420.97	55919.44	57337.03	58138.68	801.64
18	Ludikhola	Ghaledanda Ranakhola	181.66	146.56	35.09	31694.54	32502.61	32905.65	5718.94	5858.98	5996.18	37413.48	38361.59	38901.83	540.24
19	Ludikhola	Gangate Bahunechaur	173.62	156.79	16.83	33906.84	34771.32	35202.49	2742.94	2810.11	2875.91	36649.78	37581.42	38078.40	496.98
20	Ludikhola	Bhalukhola	107.59	106.48	1.10	23026.98	23614.07	23906.89	179.28	183.67	187.968	23206.26	23797.74	24094.86	297.12
21	Ludikhola	Kuwadi	92.27	83.75	8.52	18111.48	18573.24	18803.55	1388.58	1422.58	1455.9	19500.06	19995.82	20259.45	263.63
22	Ludikhola	Taksartari	89.31	83.08	6.23	17966.58	18424.65	18653.12	1015.36	1040.22	1064.58	18981.94	19464.87	19717.70	252.83

SN	Watershed	CF name	Total CF area [ha]	Area in dense [ha]	Area in sparse [ha]	Total carbon stock in dense strata [tC]			Total carbon stock in sparse strata [tC]			Total carbon in CF [tC]			Difference in total carbon [tC] in 2011-2012
						2010	2011	2012	2010	2011	2012	2010	2011	2012	
23	Ludikhola	Birienchok	83.57	69.88	13.69	15112.00	15497.29	15689.46	2231.19	2285.82	2339.35	17343.18	17783.11	18028.80	245.70
24	Ludikhola	Thokane Bhanjyang	76.18	73.54	2.65	15903.50	16308.97	16511.2	431.89	442.47	452.832	16335.39	16751.44	16964.03	212.60
25	Ludikhola	Baghepani	68.16	67.55	0.60	14608.12	14980.56	15166.33	97.79	100.18	102.528	14705.91	15080.75	15268.85	188.11
26	Ludikhola	Lamidanda	61.59	58.98	2.61	12754.80	13079.99	13242.19	425.38	435.79	445.997	13180.18	13515.79	13688.19	172.40
27	Ludikhola	Siraute	60.34	56.20	4.14	12153.61	12463.47	12618.02	674.73	691.26	707.443	12828.34	13154.73	13325.47	170.74
28	Ludikhola	Kyamundan da	58.72	56.60	2.12	12240.11	12552.18	12707.83	345.52	353.98	362.266	12585.63	12906.16	13070.10	163.94
29	Ludikhola	Mahalaxmi	63.96	38.05	25.92	8228.56	8438.35	8542.986	4224.42	4327.86	4429.21	12452.98	12766.21	12972.20	205.98
30	Ludikhola	Shikhar Bhanjyang	55.49	55.40	0.10	11980.61	12286.06	12438.41	16.30	16.70	17.088	11996.90	12302.76	12455.50	152.74
31	Ludikhola	Sandan Bisauni	50.62	48.65	1.98	10520.88	10789.11	10922.9	322.70	330.60	338.342	10843.57	11119.71	11261.24	141.53
32	Ludikhola	Kharko Pakho Bekhpari	51.15	44.35	6.80	9590.97	9835.50	9957.462	1108.26	1135.40	1161.98	10699.23	10970.90	11119.45	148.55
33	Ludikhola	Chisapani	50.04	45.15	4.88	9763.98	10012.92	10137.08	795.34	814.81	833.894	10559.32	10827.73	10970.97	143.24
34	Ludikhola	Shikhar	50.84	42.47	8.38	9184.41	9418.57	9535.364	1365.77	1399.21	1431.97	10550.18	10817.78	10967.34	149.56
35	Ludikhola	Kharkandep akha	47.82	45.82	2.00	9908.87	10161.50	10287.51	325.96	333.94	341.76	10234.83	10495.44	10629.27	133.82
36	Ludikhola	Goldanda	45.99	45.63	0.36	9867.78	10119.37	10244.85	58.67	60.11	61.5168	9926.45	10179.47	10306.36	126.89
37	Ludikhola	Shikhar Danda	30.36	16.28	14.09	3520.65	3610.42	3655.186	2296.38	2352.61	2407.7	5817.03	5963.02	6062.88	99.86
38	Ludikhola	Badahare	25.78	10.69	15.09	2311.78	2370.72	2400.119	2459.36	2519.58	2578.58	4771.14	4890.30	4978.70	88.40
39	Ludikhola	Punche	18.13	15.44	2.69	3339.00	3424.13	3466.589	438.41	449.15	459.667	3777.41	3873.28	3926.26	52.98
40	Ludikhola	Ludi	17.44	5.75	11.69	1243.47	1275.18	1290.99	1905.23	1951.88	1997.59	3148.70	3227.06	3288.58	61.52
41	Ludikhola	Ram Laxman	13.25	12.78	0.47	2763.76	2834.22	2869.366	76.60	78.48	80.3136	2840.36	2912.70	2949.68	36.98

SN	Watershed	CF name	Total CF area [ha]	Area in dense [ha]	Area in sparse [ha]	Total carbon stock in dense strata [tC]			Total carbon stock in sparse strata [tC]			Total carbon in CF [tC]			Difference in total carbon [tC] in 2011-2012
						2010	2011	2012	2010	2011	2012	2010	2011	2012	
42	Ludikhola	Laxmi Mahila	8.72	8.09	0.63	1749.51	1794.12	1816.367	102.68	105.19	107.654	1852.19	1899.31	1924.02	24.71
43	Ludikhola	Patal Chanpe Mahila	8.16	7.44	0.72	1608.95	1649.97	1670.429	117.35	120.22	123.034	1726.29	1770.19	1793.46	23.28
44	Ludikhola	Anapswanra Bhawanipakha	9.14	4.21	4.93	910.44	933.65	945.2292	803.49	823.16	842.438	1713.93	1756.81	1787.67	30.85
45	Ludikhola	Sitalu Pakha	5.69	4.12	1.57	890.98	913.69	925.0224	255.88	262.14	268.282	1146.85	1175.84	1193.30	17.47
46	Ludikhola	Bhangeristan Ghantari	5.24	3.15	2.09	681.21	698.58	707.238	340.63	348.97	357.139	1021.83	1047.54	1064.38	16.83
47	Ludikhola	MajhiKhola Simredanda	6.00	0.33	5.67	71.36	73.18	74.0916	924.09	946.72	968.89	995.46	1019.90	1042.98	23.08
48	Charnawati	Amalekharka CF	6.60	1.51	5.09	345.13	349.34	171502.70	848.75	856.49	14703.54	1193.88	1205.83	1226.5743	20.7443
49	Charnawati	Barkhe dadapari	35.40	11.61	23.78	2653.61	2685.97	88284.14	3965.29	4001.46	28313.80	6618.90	6687.43	6795.315	107.885
50	Charnawati	Bhakare	104.43	76.26	28.17	17430.19	17642.75	45029.19	4697.31	4740.17	39317.00	22127.50	22382.92	22661.3547	278.4347
51	Charnawati	Bhasmepakha	10.93	6.16	4.77	1407.95	1425.12	53650.26	795.39	802.65	19596.71	2203.34	2227.76	2258.6367	30.8767
52	Charnawati	Bhirmuni Devithan	5.98	0.00	5.98	0.00	0.00	57832.22	997.16	1006.25	9930.51	997.16	1006.25	1026.3474	20.0974
53	Charnawati	Bhitteri	542.64	377.67	164.97	86321.27	87373.95	49066.22	27508.55	27759.50	9317.79	113829.82	115133.46	116597.9403	1464.48
54	Charnawati	Bhumethan Shivajung	46.67	16.71	29.97	3819.28	3865.86	42993.14	4997.46	5043.05	3441.18	8816.74	8908.91	9049.8807	140.9707
55	Charnawati	Bichaur	47.71	7.29	40.42	1666.22	1686.54	36894.34	6739.99	6801.47	6793.12	8406.21	8488.01	8641.395	153.385
56	Charnawati	Botlesetidevi	172.10	113.69	58.42	25985.29	26302.18	23598.07	9741.47	9830.33	19605.29	35726.76	36132.51	36602.799	470.289

SN	Watershed	CF name	Total CF area [ha]	Area in dense [ha]	Area in sparse [ha]	Total carbon stock in dense strata [tC]			Total carbon stock in sparse strata [tC]			Total carbon in CF [tC]			Difference in total carbon [tC] in 2011-2012
						2010	2011	2012	2010	2011	2012	2010	2011	2012	
57	Charnawati	Budabhimse n	41.97	9.12	32.85	2084.49	2109.91	34065.84	5477.70	5527.67	4881.16	7562.19	7637.58	7769.9367	132.3567
58	Charnawati	Charnawati	819.35	733.67	85.67	167689.59	169734.55	26576.17	14285.37	14415.69	10026.62	181974.96	184150.25	186206.2413	2055.991
59	Charnawati	Charnawati 1	55.12	43.12	11.99	9855.62	9975.81	19299.23	1999.32	2017.56	11996.94	11854.94	11993.37	12137.5749	144.2049
60	Charnawati	Chhitakunda	51.51	0.00	51.51	0.00	0.00	29449.08	8589.23	8667.59	877.03	8589.23	8667.59	8840.6613	173.0713
61	Charnawati	Chuchhedhunga	8.90	0.00	8.90	0.00	0.00	23726.64	1484.06	1497.60	4136.28	1484.06	1497.60	1527.507	29.907
62	Charnawati	Chyanedada	64.86	33.07	31.79	7558.57	7650.74	3674.71	5300.94	5349.30	21555.01	12859.51	13000.05	13186.5609	186.5109
63	Charnawati	Chyanse Bhagawati	30.32	23.82	6.50	5444.36	5510.76	13810.54	1083.87	1093.76	11205.72	6528.23	6604.51	6683.7582	79.2482
64	Charnawati	Devithan	43.94	14.36	29.58	3282.16	3322.19	17826.54	4932.43	4977.43	4834.82	8214.59	8299.61	8433.609	133.999
65	Charnawati	Dhade	29.17	0.17	29.01	38.86	39.33	20626.98	4837.38	4881.51	1343.86	4876.24	4920.84	5018.7255	97.8855
66	Charnawati	Dhande Singhdevi	343.69	229.51	114.18	52457.42	53097.14	6239.05	19039.38	19213.07	11255.50	71496.80	72310.21	73246.97	936.761
67	Charnawati	Dimal	38.20	34.66	3.54	7921.98	8018.59	13646.91	590.29	595.68	1997.77	8512.27	8614.27	8709.69	95.4218
68	Charnawati	Eklepakha	197.33	157.83	39.58	36074.05	36513.97	3578.87	6599.92	6660.13	9697.10	42673.97	43174.10	43687.45	513.3562
69	Charnawati	Gahate baghkhori	5.54	0.19	5.35	43.43	43.96	7730.44	892.11	900.24	5456.12	935.53	944.20	962.63	18.4349
70	Charnawati	Gairi jungle	131.08	125.98	5.11	28794.33	29145.47	5491.02	852.09	859.86	7486.50	29646.41	30005.33	30326.11	320.7841

SN	Watershed	CF name	Total CF area [ha]	Area in dense [ha]	Area in sparse [ha]	Total carbon stock in dense strata [tC]			Total carbon stock in sparse strata [tC]			Total carbon in CF [tC]			Difference in total carbon [tC] in 2011-2012
						2010	2011	2012	2010	2011	2012	2010	2011	2012	
71	Charnawati	Golmeshor	215.18	100.95	114.23	23073.40	23354.78	9799.22	19047.72	19221.48	2869.65	42121.12	42576.26	43203.36	627.1069
72	Charnawati	Gothpani	23.50	17.40	6.09	3976.99	4025.49	10079.73	1015.50	1024.76	2057.84	4992.49	5050.25	5112.65	62.4007
73	Charnawati	Jugedarkha	125.60	101.50	24.10	23199.11	23482.03	11220.48	4018.65	4055.31	387.88	27217.76	27537.33	27862.92	325.593
74	Charnawati	Jyamire	70.01	58.38	11.64	13343.49	13506.21	10902.57	1940.96	1958.66	691.67	15284.45	15464.88	15644.68	179.802
75	Charnawati	Kalchhe	21.49	16.34	5.14	3734.71	3780.26	1881.77	857.09	864.91	9671.35	4591.80	4645.17	4701.816	56.6466
76	Charnawati	Kamalamai	71.81	15.31	56.50	3499.29	3541.97	3906.13	9421.31	9507.26	5143.75	12920.60	13049.22	13275.96	226.7406
77	Charnawati	Kopila	96.07	88.24	7.83	20168.37	20414.32	0.00	1305.64	1317.55	8840.66	21474.01	21731.88	21970.84	238.9653
78	Charnawati	Kuprisalleri	42.03	1.61	40.42	367.99	372.47	8102.12	6739.99	6801.47	607.57	7107.97	7173.95	7313.63	139.6882
79	Charnawati	Laliguras	35.53	10.33	25.20	2361.05	2389.85	1704.11	4202.07	4240.40	6937.28	6563.12	6630.25	6739.81	109.5668
80	Charnawati	Lodini	50.67	46.64	4.03	10660.16	10790.16	3356.79	672.00	678.13	5076.82	11332.16	11468.29	11594.23	125.9453
81	Charnawati	Mahabhir	50.26	48.00	2.26	10971.01	11104.80	6239.05	376.85	380.29	2177.98	11347.86	11485.09	11608.36	123.2738
82	Charnawati	Mahankal Sahele	39.38	26.69	12.69	6100.34	6174.73	4806.11	2116.04	2135.35	3470.36	8216.38	8310.08	8417.03	106.9591
83	Charnawati	Maithan harisiddi	28.35	3.51	24.85	802.26	812.04	2131.89	4143.71	4181.51	5638.05	4945.96	4993.55	5085.50	91.9531

SN	Watershed	CF name	Total CF area [ha]	Area in dense [ha]	Area in sparse [ha]	Total carbon stock in dense strata [tC]			Total carbon stock in sparse strata [tC]			Total carbon in CF [tC]			Difference in total carbon [tC] in 2011-2012
						2010	2011	2012	2010	2011	2012	2010	2011	2012	
84	Charnawati	Majhkharka Lisepani	174.18	145.73	28.44	33308.44	33714.64	376.35	4742.34	4785.60	6937.28	38050.78	38500.23	38947.00	446.772
85	Charnawati	Mathani	28.28	22.52	5.77	5147.23	5210.00	4270.80	962.14	970.92	2881.67	6109.37	6180.92	6254.58	73.6603
86	Charnawati	Napkeyanmara	152.46	82.56	69.90	18870.14	19100.26	2713.95	11655.74	11762.07	4081.36	30525.88	30862.33	31296.16	433.8326
87	Charnawati	Palung Mahila	10.28	0.32	9.96	73.14	74.03	2414.74	1660.82	1675.97	4325.08	1733.96	1750.00	1784.23	34.238
88	Charnawati	Pauwa	58.64	41.92	16.72	9581.35	9698.19	5568.16	2788.04	2813.47	1115.60	12369.39	12511.67	12668.87	157.2028
89	Charnawati	Pokhari	23.60	18.00	5.60	4114.13	4164.30	5264.28	933.79	942.31	990.31	5047.92	5106.61	5168.80	62.198
90	Charnawati	Ramite	13.60	13.17	0.43	3010.17	3046.88	904.65	71.70	72.36	5057.94	3081.87	3119.24	3152.42	33.1801
91	Charnawati	Salleri	92.27	26.69	65.58	6100.34	6174.73	4207.68	10935.39	11035.15	961.13	17035.73	17209.88	17494.54	284.6698
92	Charnawati	Sanobothle	35.06	18.27	16.79	4175.84	4226.76	4067.42	2799.71	2825.25	1045.23	6975.55	7052.02	7152.46	100.4429
93	Charnawati	Setidevi Dadar	421.71	192.63	229.08	44028.03	44564.95	820.50	38198.82	38547.29	4265.01	82226.85	83112.24	84346.18	1233.949
94	Charnawati	Shankadevi	305.26	247.40	57.86	56546.41	57235.99	39.74	9648.09	9736.10	4978.99	66194.49	66972.09	67762.73	790.6458
95	Charnawati	Simpani	64.40	8.05	56.35	1839.93	1862.37	3819.64	9396.30	9482.01	882.18	11236.23	11344.38	11553.11	208.7385
96	Charnawati	Simsugure	33.35	3.87	29.47	884.54	895.32	2017.35	4914.09	4958.92	2569.30	5798.63	5854.24	5962.58	108.3473

SN	Watershed	CF name	Total CF area [ha]	Area in dense [ha]	Area in sparse [ha]	Total carbon stock in dense strata [tC]			Total carbon stock in sparse strata [tC]			Total carbon in CF [tC]			Difference in total carbon [tC] in 2011-2012
						2010	2011	2012	2010	2011	2012	2010	2011	2012	
97	Charnawati	Sitakunda	141.31	15.72	125.59	3593.01	3636.82	3078.62	20941.98	21133.03	73.80	24534.99	24769.85	25229.71	459.8689
98	Charnawati	Srijana	264.20	209.90	54.29	47975.31	48560.37	1054.26	9052.79	9135.38	1453.71	57028.10	57695.74	58384.01	688.2767
99	Charnawati	Sundarimai	12.98	4.51	8.47	1030.82	1043.39	1439.96	1412.36	1425.25	818.68	2443.18	2468.64	2507.96	39.3237
100	Charnawati	Thansa deurali	124.37	59.08	65.29	13503.48	13668.16	74.80	10887.03	10986.35	1709.43	24390.51	24654.51	25016.26	361.7535
101	Charnawati	Tharlange	203.97	183.92	20.05	42037.25	42549.89	0.00	3343.31	3373.81	1527.51	45380.56	45923.71	46434.32	510.6107
102	Charnawati	Thumkadada	40.78	20.56	20.22	4699.25	4756.56	352.98	3371.66	3402.42	873.60	8070.91	8158.98	8276.46	117.4842
103	Charnawati	Thutemane	23.60	8.63	14.97	1972.50	1996.55	0.00	2496.23	2519.00	1026.35	4468.73	4515.55	4586.64	71.0999
104	Charnawati	Timure tinsalle	67.10	23.49	43.62	5368.94	5434.41	44.41	7273.58	7339.94	918.22	12642.52	12774.35	12977.52	203.173
105	Charnawati	Palekoban	1.49	1.03	0.45	235.42	238.29	240.77	75.04	75.72	77.23	310.46	314.01	318.00	3.9963