Comparison of Carbon Stocks in Community Forests of Lamahi Corridor, Kailali in Terai and Basanta Corridor, Dang in Inner Terai

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ABSTRACTS

The main objective of the study is to estimate carbon stock in community forests Terai and Inner Terai, which can be simplified by demonstrating differentiation in the average carbon stocks in two CFs of each district Terai and Inner Terai and Comparision in the carbon stocks between community forests of each district of Terai and Inner Terai. The study area was selected Tulsipur CF and Radhakrishna CF from Kailali (Terai) compared with Deki CF and Kalika CF, study area from Dang (Inner Terai), simple random sampling was applied maintaining 1% sample intensity. Total number of sample plot was 29 out of this 6 plots were established in Kalika CF, 9 in Deuki CF, 6 in Tulsipur CF and 8 in Radhakrishna CF. The plot of 750 sq.m was selected so that 15.45 m radius was formed. Measurement of individual plants having DBH> 5cm lying within the plots was taken. And diameter at breast height i.e. at 1.3m above the ground level, of each plant with DBH> 5cm within each plot was measured using diameter tape. Samples of shrub was collected from the sample plot of 25 sq.m at 9m from central point in north direction. Litter sample was collected from the sample plot of 1 sq.m at 9m distance from central point in all 4 directions. Bulk density was measured by the help of core sampler from the center of each plot, and for the organic matter 500gm soil sample was collected from the center of each sampling plots from 30 cm. The result showed that the highest carbon stock was 526.38 tC/ha in Tulsipur community forest of (Terai) and followed by Radha Krishna community forest (Terai) with 273.66 tC/ha, Deuki community forest (inner Terai) with 156.94 tC/ha and least in Kalika community forest(Inner Terai) with 141.99 tC/ha. Total Carbon stocked in Terai is higher in comparison to that of Inner Terai this is due to the trees and big sized plants and species it seemed that fast growing species seem to store large amounts of carbon. The further research should be focused on the effect of disturbances such as grazing, fire, erosion and invasive species on carbon stock of community forest and also in plan and policy and also to show the variation in carbon stock according to season.

ACRONYMS AND ABBREVIATIONS

AGB	**Above ground biomass**
AGTB	**Above ground tree biomass**
ANSAB	**Asia Network for Sustainable Agriculture and Bioresources**
BGB	**Below ground biomass**
C	**Carbon**
CBS	**Central Bureau of Statistics**
CFD	**Community Forestry Division**
CS	**Carbon Sequestration**
DoF	**Department of Forest**
DFO	**District Forest Office**
DBH	**Diameter at breast height**
DDC	**District Development Committee**
FAO	**Food and Agriculture Organization**
GPS	**Global Positioning System**
GIS	**Geographic Information System**
Ha	**Hectare**
IPCC	**Intergovernmental Panel on Climate Change**
ICIMOD	**International Center for Integrated Mountain Development**
LHG	**Leaf litter, herb, grass**
MoF	**Ministry of Finance**
REDD	**Reducing Emissions from Deforestation and Forest Degradation**
SOC	**Soil organic carbon**
t C	**Ton carbon**
t C/ha	**Ton carbon per hectare**
UNFCCC	**United Nations Framework Convention on Climate Change**

VDC	**Village Development Committee**
et al.	**and others**
°C	**degree celsius**
Asl	**above sea level**
C	**carbon**
CFUGs	**Community Forest User Groups**
cm	**centimeter**
GHGs	**green house gases**
GoN	**Government of Nepal**
Gt	**billion tones**
ha	**hectare**
km	**kilometer**
m	**meter**
ml	**milliliter**
N	**nitrogen**
ppm	**parts per million**
SOC	**soil organic carbon**
sp.	**Species**
sq	**km square kilometer**
t	**tonne**
Tg	**teragram, 1012 gram**

CHAPTER I: INTRODUCTION

1.1 Background

The climate change is global burning issues (Ferrarini 2012; Zhang and Lui 2012) and REDD+ is considered as effective and efficient mechanism to address it (Skutch and Laake 2009). Considering the size of global carbon pool in forest and its potential climatic effects on natural and anthropogenic emission, reducing emission for deforestation and forest degradation (REDD+) has received much attention in recent years (WWF 2011).

Climate Change is a phenomenon due to emission of Greenhouse gases from fuel combustion, deforestation, urbanization and industrialization (Upreti 1999) resulting variations in solar energy, Temperature and precipitation (Malla 2008). "Waring of the climate system is unequivocal, as is now evident from observation of increases in global average air and ocean temperature, widespread melting of snow and ice, and rising global mean sea level." (IPCC 2007) The atmospheric concentrations of major log model predicts that these buildup of gases is likely to lead to surface air temperature rises of 1.5°C to 4.5°C and changes in precipitation and cloud pattern over the next century (Milillo *et al.* 1993).

In Nepal average temperature increases was recorded as 0.06°C per year and that in Terai and Himalayas was 0.04°C and 0.08°C/year respectively (Shrestha *et al.* 1999 cited by Malla, 2008) Another report of Government of Nepal (GoN), based on analysis of the temperatures recorded between 1981 and 1998, shows an increase of 0.41°Celsius per decade (GoN 2004). Although the analysis is based on data for relatively a short period, it shows that Nepal is warming as a significantly higher rate compared to the global average of 0.74°Celsius, recorded in the twentieth century (IPCC 2007)

Forest is the integral part of the farming system in Nepal. It was reported that 84% of the total energy is consumed for firewood in Nepal (WEC 2006). Over 28% of the country's land is estimated to be in degraded condition in Nepal (DFRS 2008/MOEST 2008). Forest carbon sinks are now an integral element of international greenhouse gas (GHG) policy under the United Nations Framework Convention for Climate Change (UNFCCC 1992) and its Kyoto Protocol (KP-UNFCCC 1997). About eight million tons of greenhouse gases (GHGs) are emitted into the atmosphere annually of which developed countries are emitting 70% and the rest is shared by developing countries (Shakya 2005). The population

of Nepal is less than 0.4% of the world population and is responsible for only about 0.025% of annual greenhouse gas emissions. The connection between poverty and environmental degradation is a central issue in developing country like Nepal. Annual consumption of biomass resources has increased by about 2.4% since last decade. Consumption of commercial forms of energy is annually increasing by about 10%.

Water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and CFCs are the major gases that play important role in the greenhouse effect. Among the GHGs CO_2, CH_4 and N_2O are the 3 major gases which contribute about 88% roles in global warming (IPCC 1996).

According to Third Assessment Report (IPCC 2001), anthropogenic CO_2 concentrations have increased by 29%, CH_4 by 150% and N_2O by 15% since the Industrial Revolution. Human activities are thought to be mainly responsible for the changes observed today and those predicted in the future. Some of the activities identified as having led to increased concentration of carbon dioxide (CO_2) in the atmosphere include those that involve: 1) burning of fossil fuels, which has increased manifold since the start of the industrial revolution, and 2) loss of forested areas.

Terrestrially, carbon is stored in vegetation and in the soil. Plants store carbon for as long as they live, in terms of live biomass. Once they die, the biomass become a part of the food chain and eventually enters the soil as soil carbon. If the biomass is incinerated, the carbon is reemitted into the atmosphere and is free to move in the carbon cycle.

Global carbon is held in a variety of different stocks. Natural stocks include oceans fossil fuel deposits, the terrestrial system and the atmosphere. In the terrestrial system carbon is sequestered in rocks and sediments, in swamps, wetlands and forests, and in the soil of forest, grasslands and agriculture. About two-thirds of the globe's terrestrial carbon exclusive of that sequestered in rocks and sediments, is sequestered in the standing Forests, forest under-storey plants, leaf and forest debris, and in forest soils. In addition, there are some non-natural stocks. For example, long-lived wood products and waste dumps constitute a separate human-created carbon stock (Waran and Patwardhan 2001).

Carbon sequestration is the removal of C from the atmosphere by storing it in the biosphere (IPCC 2000). It is the process of removing additional carbon from the atmosphere and depositing it in other reservoir principally through change in land use (Mandal *et al* 2005). The process of transforming carbon in the air (CO_2), into soil carbon, long term storage of Carbon in the terrestrial biosphere, underground or the oceans reduces the buildup of carbon dioxide concentration in the atmosphere.

The forest is reservoir, a component of climate system where a greenhouse gas is stored, as well as sinks (IPCC 2000). Forest acts as carbon reservoir large amounts of carbon in trees, under storey vegetation, forest floor and soil (Rotter and Danish 2000). Forest acts as the interface between the atmosphere and soil. The trees themselves can store carbon as they grow and forests can transfer carbon from the atmosphere to the soil (Clement *et al.* 2000) As the tree experience growth, the carbon held by the plant also increases carbon stock. The rate of carbon storage increases in young stands, but then declines as the stand ages. An observation from a study on pine species planted on cropland in the southeastern U.S, the rate of carbon storage begins to decline at approximately age 20 and close to zero by age 100 (Veld and Planting 2005 cited by Jana *et a.l* 2009). The role of forest in carbon sequestration is probably best understood and appears to offer the greatest near-term potential for human management as a sink. Unlike many plants and most crops, which have short lives or release much of their carbon at the end of each season, Forest biomass accumulates carbon over decades and centuries. Furthermore, carbon accumulation potential in forests is large enough that forests offer the possibility of sequestration significant amounts of additional carbon in relatively short periods- decades (Waran and Patwardhan 2001).

Forest is vitally important for global carbon cycle. As much as 283Gt of carbon (Gt C) is estimated to be stored in global forest vegetation and an additional 38Gt in dead wood.

Soils (up to 30cm) and litter are estimated to contain 317 Gt of carbon. Therefore, the total carbon content of forest ecosystem is 638 Gt of carbon (FAO 2006) This represents around 70% of the global terrestrial carbon and is more than the amount of carbon in the whole atmosphere (Dixon *et al.* 1994; Lal 2005 cited by Shrestha 2008) Tress, both in above and

below ground biomass, continue to accumulate carbon until they reach maturity; at the point half of the average tree's dry weight will be carbon (Anonymous 2004). About 43-50%of the dry biomass of trees in carbon (Malhi *et al.* 2002; Negi *et al.* 2003 cited by Shrestha 2008). On the other hand, trees are long lived plants that develop a large biomass, thereby capturing large amounts of carbon over a growth cycle of many decades.

According to the IPCC'S fourth Assessment Report, reducing and/or preventing deforestation is the mitigation option with the largest and most immediate carbon stock impact in the short term.

The total forested area of Nepal is estimated to be about 5.83 million hectors or 39.6% of the total geographic area of the country (DoF) Nepal's master plan for the Forestry Sectors (1989) strongly advocates community participation in forest management and the Forest Act-1993 made it the highest priority. Community forestry in Nepal formally commenced in 1978with enactment of progressive legislation (Panchyat Forest Rules 1978 and Panchyat Protected Forest Rules 1978), enabling government forests to be handed over to the Village panchyat for protection and management. Nepalese Forest Users' Groups are independent corporate with powers to buy or sell property. They are given the right to negotiate and sell timber as well as to hold separate bank accounts.

In 2003, the total area of Community forest in Nepal was 955,358 ha, and total number of Community Forest Users Group (CFUGs) were 12,079 (DoF 2003). Forestry Ministry data shows that this number has significantly increased in recent years. In 2014, there were 18133 CFUGs across all 75 district, and Community Forestry managed areas covered 1700048 ha of the total forest area of Nepal (DoF 2013).

Reducing Emissions from Deforestation and Forest Degradation (REDD+) which includes the role of conservation, sustainable management of forest and enhancement of carbon (C) stocks are proposed as an incentive mechanism for developing countries, for the post-Kyoto climate regime, to reduce C emissions from forested land and achieve low-carbon sustainable growth. C stocks in the forests of participating countries have to be estimated and monitored to determine financial incentives and compensation under this mechanism. However, the foremost challenge is to quantify C emissions from deforestation and forest

degradation, which requires information on C stocks and deforestation rates (Gibb *et al.* 2007).

Anticipating inclusion of on REDD+ in post 2012 climate regime, several countries and organizations have initiated programs to support efforts to reduce emissions from deforestation and forest degradation. Though, REDD+ mechanism ultimately has to be operated at national scale, baseline information of the landscape levels plays vital role to accurately estimate the net emissions reduction for the payment.

There are some basic requirements for the REDD program like legally binding emissions limits for developed countries and global carbon trading mechanism, financing mechanism in global and national level, national legal and policy framework, potential and capacity for reducing deforestation and degradation rates, benefits sharing mechanism in national to local level for implementation. In these issues the concern stakeholder should be well aware. We are in the prior stage on the REDD/REDD+ implementation.

The record of carbon stock of different types of forest representing different geographical areas is essential to implement the REDD+ in Nepal effectively. The monitoring reporting and verification system (MRV system) and reference emission level (REL) needs sufficient records of carbon which may support to REDD+ mechanism in Nepal. Thus, assessment and comparison of carbon stock of different community forests specifically of Terai and Inner Terai are essential. These can be valuable to prepare the REDD+, REDD+ strategy and carbon trade policy in Nepal. This study may be valuable for preparation of such types of policy documents. Therefore, this study is essential.

In addition, the carbon stock may vary in forest of different locations. The carbon stock of forests of Terai and Inner Terai may differ. However, there is no any or very limited studies on comparison of carbon stock of Terai and Inner Terai. Thus, this study is important.

1.2 Objectives
1.2.1 General objective

The main objective of the study were to estimate carbon stock in community forests of Terai and Inner Terai.

1.2.2 Specific objectives

- **To assess and differentiate the average carbon stocks in two Community Forest of each Terai and Inner Terai district.**
- **To compare the Carbon stocks between community forests of each district of Terai and Inner Terai.**

1.2.3 Research Questions

- **What are the differences in mean carbon stocks of two CFs of each Districts of Terai and Inner Terai?**
- **What are the difference between the average Carbon stock in CFs in Terai and Inner Terai?**

1.2.4 Research Hypothesis

- **Differentiation in the carbon Stock in two CFs of each District of Terai and Inner terai**

H_{0}: There is no significant difference between mean carbon stocks in two Cfs of each District.

H_{1}: There is significant difference between mean carbon stocks in two Cfs of each District.

- **Comparison of carbon stock in Cfs in Terai and Inner Terai**

H_{0}: There is no significant difference in average carbon stocks in CFs in Terai and Inner Terai

H_1: There is significant difference in average carbon stock in CFs in Terai and Inner Terai

1.3 Rationale of the study

In 1997, the Kyoto Protocol of the UN Framework Convention on Climate Change laid out target emission reductions and the different mechanisms by which countries could achieve those targets. To achieve the targets, countries had two options: either reduce their own domestic emissions, or pay someone else to reduce their emissions and thus offset the country's domestic emissions with reductions somewhere else (Madeira2008). With recent developments, REDD+ has drawn more attention towards activities related to the conservation and sustainable management of forests and enhancements of forest carbon stocks. The REDD+ is developed through the stepwise process from RED and REDD. Community Forestry is regarding as a highly successful community-based forest management practice in Nepal. Estimation of forest carbon stock in such forests is essential to link biological sequestration of carbon from forest to international payment systems through carbon markets for GHGs emissions reductions. Estimation of forest carbon stock is a new approach in Nepal as very few studies have been done on this sector (Shrestha and Singh 2008). Scientific study on carbon estimation of forest could add strong information to advocators for international negotiation through REDD.

In Nepal, most studies have been conducted in forests for their tangible economic benefits whereas few studies have been done on intangible benefits like carbon sequestration, eco-tourism, biodiversity and ecosystem services are some of them. Information on carbon stocks at different forest ecosystem is generally insufficient/lacking in Nepal (Shrestha and Singh 2007). Nepalese community forestry is one of the most potential area for the REDD. We need to improve the quality of the forest and robust scientific data of the forest for the better negotiation in the UNFCCC meetings. Our national agenda should be based on the practical and scientific records. Therefore we need to focus our research towards the carbon stocks assessment which has great scope under REDD/REDD+. Here, this dissertation also focused on the carbon assessment of Terai and inner Terai. Regarding all this fact, this study can play significant role to generate data on carbon stock and through this study the potential of CF to sequester carbon will be known. Difference of Carbon Stocks between Terai and Inner Terai will be known. Therefore, this research study will be

a database for the planners, stake-holders for decision making and negotiating for carbon trading in international arena.

1.4 Scope and Limitation

Only two districts each with two CFs from each district were included in this study. A limited technique of data analysis is employed and no multivariate data analysis was done. In view of limited area and relatively small size of sample, generalization of the findings was done little prudently. Carbon stocks present in dead wood and trees DBH less then 5cm were not estimated.

CHAPTER II: LITERATURE REVIEW

Carbon dioxide is one of the major contributors for global warming, Aeehenius, a Swedish scientist, was the first to advance the theory that emission of CO_2 would intensify the earth's natural greenhouse effects and thus warm the planet (IPCC 2000). The atmospheric concentration of CO_2 has increased rapidly since the beginning of industrialization (Kirschbaum 2003)

The global atmospheric concentration of methane (CH_4) has increased from a pre-industrial value of about 715 ppb to 1732ppb in the early 1990s, and was 1774 ppb in 2005. Similarly, the NO_2 increased from a pre-industrial value of about 270 ppb to 319 ppb in 2005 (IPCC 2007)

After the UNFCCC meeting in December 2007, forests in developing countries has been identified as an important source of carbon sink under the concept of REDD and may be the potential source of extra benefits brought about by carbon conserved in them. This would obviously add monetary value to the existing community forest in Nepal (Dahal and Baskota 2009).

The forest is a reservoir, a component of the climate system where a greenhouse gas is stored, as well as sink, any process that removes GHGs from the atmosphere (IPCC 2000). The role of forests in carbon sequestration is probably best understood and appears to offer the greatest near-term potential for human management as sink.

Soil carbon is an potentially viable sinks for atmospheric carbon (Lal and Kimble 1997) and soils of the world are potentially viable sinks for atmospheric carbon (Lal *et al.* 1998).

According to National Forest Inventory (NFI) of Nepal, Forest and shrub together cover about 5.83 million ha, which is 39.6% of the total land area of the country. The growing stock of Nepal's forest is as shown in table.

Table 2.1: The growing stock of Nepal's Forest

FRA Category	**Carbon (Million metric Tons)**	
	Forests	**Other wooded land**
Carbon in above ground	359	32
Carbon in below ground	126	11
Carbon in litter	3.45	3.45
Total	488.45	46.45

(Source: FAO 2010)

2.1 Related Abroad Studies
Ashutosh 2007 estimated the carbon stock in India's forests which was 7290 million tons.

Ramachandran *et al.* 2007 estimated the carbon stock in natural forests using geospatial technology in the Eastern Ghats of Tamil Nadu, India. The total above and below ground biomass carbon stock in different forest types was estimated 2.74 Tg and the total SOC was estimated 3.48 Tg.

Terakunpisut *et al.* 2007 studied the carbon sequestration potential in aboveground biomass of Thong Pha Phum National forest, Thailand. The total above ground biomass carbon stock in tropical forest, dry evergreen forest and mixed deciduous forest were estimated 137.73 tons, 70.29 tons and 48.14 tons.

Nizami 2010 estimated the carbon stocks in subtropical managed and unmanaged forests of Pakistan. The mean carbon stock in managed forests was estimated 114 ± 2.26 tC/ha which comprises of 92 percent in tree biomass and only 8 percent in the topsoil. However, the mean carbon stock in unmanaged forests was estimated 27.77 ± 1.66 tC/ha which comprised of 80.8 % of total tree carbon and soil component represented only 19.2 %.

2.2 Related Studies in Nepal
Aryal 2010 studied carbon stock in biomass and soil of two forest type i.e pine forest and mixed broadleaf forest of toudal chaap Community Forest,sipadol, Bhaktapur.

Condori 1985 estimated the above ground biomass in chalnakhel mixed forest of different species and found that *Castanopsis tribiloides* and *Myrsin captellata* had 5.95 tons/ha and 9.92 tons/ha of fresh above ground biomass respectively. The analysis for correlation coefficient of diffrent growth parameters proved that heights of the plants were positively correlated with girth bole length and canopy diameter.

Dutta *et al.* 2011 studied the monetary contribution of carbon stock and forest products in community forests of Mahottary district. The total carbon stock of forests was estimated 115027.959 tons. The more amount of SOC was estimated for upper layer 0-10cm than the lower layer 60-90cm.

Malla 2003 conducted study in fallow land (without trees), Sal stand-1 (planted in 1977) and Sal stand -2 (planted in 1972) to determine the sol nutrients. It was found to be higher in sal stand than in fallow land which was attributed to regular addition of nutrients in the form of litter in Sal stand due to presence of trees. Similarly, soil nutrients was found to be high in Sal stand-2 than in 1 which was attributed to higher quantity of litter deposition in stand 2 due to its relatively old age.

Upadhyay *et al.* 2005 revitalizing degraded forest land and their soil in the global terrestrial ecosystem can sequester 50-70% of the historic losses. Degraded forests have emitted their carbon pool and now have the potential capacity to sequester greater volumes. Managed forests sequester more carbon the unmanaged forests nearing their climax stage as decay, burning and die-back are balanced by the growth of plants.

According to Lal 2005 there are four component of carbon storage in as forest ecosystem. These are trees, plants growing on the forest floor (under story material), detritus such as leaf litter and other decaying matter on the forest floor, and forest soils.

Banskot *et al.* 2007 carried out the annual variation in carbon stock in three community managed forests of the Nepal Himalaya and their mean carbon sequestration rates under the "Think global-act Local" carbon Projects of International Center for Integrated Mountain Development (ICIMOD). They found mean carbon sequestration rate in the studied community forests to be 1.88 $tha^{-1}yr^{-1}$ The mean carbon sequestration rate in the studied community forests to be 1.88tha^{-1} $yr^{-1.}$ The mean SOC pool was found to be 151tha^{-1} up to 90 cm depth.

Dahal 2007 estimated the carbon sequestration rate of Sunaulo Ghyampe Danda Community Forest at Kirtipur, Kathmandu. He found that the carbon sequestration rate of mixed broad leaf forest was 2.95 ton/ha/yr while that of pine was 1 ton ton/ha/yr. He further estimated that the user groups of the community forest could generate an additional $535 (at the rate of $5 per ton C per year) from trading as an ecosystem service to the global community.

Khanal 2007 estimated the carbon stock as 24.72 ton Cha^{-1} in the above ground biomass of Champadevi community forest in Chandragiri hill of Kirtipur. He illustrated the potentiality of community managed forest in storing and sequestration carbon.

Khanal 2008 carried out valuation of carbon sequestration in community forests (CF) of Palpa district, Nepal. Total carbon stock in Jarneldhara Community Forest was 168.5 ton/ha and Lipindevi Thulopakha community forest was 146.2 ton/ha. The economic value of carbon sequestration in Jarneldhara CF ranged from US$ 4086 ha^{-1} to US$ 4776 ha $^{-1}$ and Lipindevi CF was US$3544 ha^{-1} to US$4144^{-1}

Thapa 2007 estimated 118.17 ton/ha of biomass carbon and SOC at Hasantar Community Forest. The study also showed that the carbon stored in the forest soil was 4 times more than that in tree biomass. He suggested that more carbon could be sequestrated and stored in forest soil and above ground biomass with efficient management.

Gurung and Joshi 2010 evaluated the carbon stock by using remote sensing and ground based inventory methods for western Nepal. Total stocking of carbon stock in the five carbon pools is 230.78 tC/ha. In his study soil constitutes 142.83tC/ha followed by tree, below ground, litter and shrub having value 68.02tC/ha, 18.14tC/ha,1.36tC/ha and 0.42tC/ha with respectively.

Ranabhat *et al.* 2008 has estimated the carbon stock (186.05 t ha-1) of Alnus nepalensis in the Kaski district, mid hill of Nepal. They found that above ground carbon sequestration in Alnus nepalensis forest, southern aspect was found 1.29 times higher than northern aspect of the same forest and the below ground carbon sequestration is also 1.49 times higher in southern aspect of the forest. Soil carbon sequestration was found 3 times as higher as total biomass carbon sequestration. According to them carbon sequestration potential was found higher in both aspects of middle altitude as compared to lower and higher altitude (Ranabhat *et al.*, 2008).

Dhakal *et al.* 2010 reported that land use have significant impact on carbon stocks of soil as well as when converted into other land SOC would be lost from land. They found forest soil have high SOC than other land use types. They estimated forest soil has 8.12kgC/m2 of its

total SOC stock, while it was5.35kgC/m2 in Khet, 5.29kgC/m2 in Bari and in grassland 3.8 kgC/m2.

Poudel 2008 studied the prospect of generating ecosystem services in Suryabinayak Community Forest through carbon sequestration. The total organic carbon contained in biomass and soil was estimated to be 154.28 ton/ha.

Shrestha *et al.* 2000 carried out research on vegetation analysis of natural and degraded forests in Chitrepani, Siwalik region of Central Nepal by using circular plots based on IFRI (International Forestry Resources and Institutions Research Program, Indiana University) methodology (1994).The aboveground live biomass (AGB) was highest in natural forest (807 tC/ha while degraded site, had (160 tC/ha).

Shrestha 2007 conduted a study in pokhare khola, a mid hill watershed in Nepal to determine the historic land use change dynamics and its relation to vegetation and SOC pools. Mainly four types of forest; managed dense *Shorea* forest (DS) , Degraded forest grazing land (DF), pine mixed forest (PS) and *Schima Castanopsis* (SC) forest and two types of cultivated lands (rain fed upland (bari) and irrigated low land (khet) were selected for the study. In the period 1976-2003, there was a net increase in agricultural area by 84% and decrease of total forest area by 24%. However DS forest area was significantly increased by 174% but degraded forest was decreased by 35%relative to the base year 1976, suggesting a remarkable contribution of the community forestry program. Conversion of forest to cultivated land resulted into net increment of SOC pool (highest 22.7kg c m^{-2}) but the same change resulted in the loss of vegetation carbon pools (highest 22.7 kg C m-3) from the system. The existing vegetation carbon pool was found to be highest in DS (219±34 Mg ha^{-1}) and lowest in the SC forest (36 ± 5 Mg ha^{-1})

Shrestha 2008 in his study at Palpa district found highest biomass carbon in *Pinus roxburghii* forest (155.62 ton/ha) followedby *Shorea robusta* (105.3 ton/ha) and *Schima castanopsis* forest (47.08 ton/ha) similarly soil carbon sequestration in *Schima castanopsi*, *Shorea robusta* and *Pinus roxburghii* forest was found to be 131.43, 130.65 and 122.62 ton/ha. Total carbon sequestration was found to be 1.55 and 1.09 times higher than *Schima*

***Castanopsis* and *Shorea* forest respectively. The study found that aspect, elevation and forest types played an important role on total carbon sequestration.**

Shrestha, 2009 has estimated the carbon stock in Community forests of Palpa district, his study showed that Carbon sequestration in *Schima- Castanopsis* forest is high in northern aspect (high elevation) followed by western aspect. Study found that aspect and elevation play an important role on carbon sequestration.

Shrestha *et al.* 2012 assessed the net above-ground carbon stock in six community forests of the Dolakha district, Nepal. They noted that, community forests accumulate approximately 2 ton/ha of carbon annually which is equivalent to 117.44 tons of carbon in total. They measure all trees greater than 10 cm in diameter and taking ten plots randomly in each forest except Sitakunda community forest (16 plots were sampled due to its larger area) used (25 m×10 m) rectangular plots. They have used allometric equation developed by Sharma and Pukkala (1990).They found the value 91.04tC/ha (Simsungure), 87.42tC/ha (Mahankal), 36.41tC/ha (Mathani), 411.32tC/ha (Sitakunda), (21.83tC/ha)Barkheand 56.6tC/ha (Chyansi). According to them, if community forests were actively managed leading to a sustainable forest institution, which acts as a carbon sink.

2.3 Policy, Act, Rules, Regulations and Guidelines related to the DoF

The Master Plan for the Forestry Sector, 1989 is considered as a basic policy document. The following are the major documents related to the Forest policy, Act, Rules and Regulations.

- **National Conservation Strategy 1988**
- **Master Plan for the Forestry Sector Nepal 1989**
- **Forest Act 1993**
- **Community Forestry Directives 1994**
- **Forest rules 1995**
- **Revised Forestry sector Policy 2000**

- **Leasehold Forest Policy 2002**
- **Five- year Periodic Plans (Current 10th: 2002- 07)**
- **Operational Guidelines (revised) 2002**
- **National Biodiversity Strategy 2002**
- **Monitoring and Evaluation concept and strategies 2002**
- **Collaborative Forest Management Guideline 2003**
- **Forest Products Auctioning Procedure 2003**
- **Non Governmental Service Providers Guideline 2003**
- **Terai Arc Landscape-Broad Strategies 2004**
- **Forest Nationalization Act 2013 Bikram Sambat(B.S.)**
- **Plant Protection Act 2029 B.S.**
- **Environment Protection Act 2053 B.S.**
- **National Parks and Wildlife Protection Act 2029 B.S.**
- **Local Self Government Act 2055 B.S.**
- **Land Act 2019 B.S.**
- **Plant Protection Rules 2031 B.S.**
- **Environment Protection Rules 2054 B.S.**
- **Local Government Rules 2056 B.S.**
- **Forest Inventory Guidelines 2057 B.S.**
- **Land Revenue Act 2034 B.S.**

- **Procedural Guidelines for the sale of Forest Products 2060 B.S.**
- **Non-Government Service Provider's Service and Procurement Guidelines, MFSC, 2004**
- **Wetland Policy 2059 B.S.**
- **IEE/EIA Review Guidelines for Forestry Sector 2060 B.S.**

Salient Features of the Forestry Sector Policy 2000

- **Forests in Terai and Inner- Terai will be categorized, delineated and published in the Gazette;**
- **Terai and Inner Terai forests will be managed in Blocks and each block will be further divided into Compartments for Sustainable Forest Management**
- **A Collaborative Forest Management approach would be applied to improve forest and bio-diversity largely following natural processes;**
- **As existing stocks of timber together with fallen trees can meet the present demand of timber, green trees from such forest blocks will not be felled for commercial purpose at least for 5 years;**
- **The open forest land and shrub land detached from large blocks of forests of Terai, Inner- Terai and Siwaliks would be gradually handed over as CF. Forest products will be harvested on annual increment;**
- **Siwaliks (Churia Range) will be managed as protected forest as these areas are geologically fragile and absorb rainwater to recharge ground water of Terai. An Integrated Watershed Conservation Program will also be continued in the Siwalik.**
- **A legal measure will be taken up so that 25% of the income of government managed forests would go to VDC and DDC;**

- **Surplus timber (Sal and Khair) in the Terai districts from CF after fulfilling communities demand will be sold and the 15% of the revenue would be collected by GoN.**

- **Forest User Group will be formed from among the households residing nearby forests and community development programs will be initiated. Fuelwood and fodder would be easily available to such groups free of costs. Opportunities of income generation will also be provided.**

Source: (DoF 2014)

CHAPTER III: MATERIALS AND METHODS

3.1 Study Area

3.1.1 Basanta Corridor (Kailali) Terai

Kailali district lies in Seti zone of Far western development region with regional headquarter Dhangadi. Kailali district covers 3284 km^2 area and is located between 80^{0}30' - 81^{0}18' E Longitude and 28^{0}22' - 29^{0}05' N Latitude (DDC Kailali, 2002). Terai region experiences tropical to sub-tropical climate whereas there is temperate climate in the Churia hills. Maximum temperature reaches 46^0 Celsius in summer and the minimum drops to 5^{0}Celsius in winter. Average annual precipitation is around 1550-1650 mm with the maximum precipitation during July-September and the average relative humidity is 74%. The elevation ranges from 150 to 1520 masl.

Basanta forest locally called "Badhkaban" is the largest chunk of Kailali district with 17,500 hectare. It serves as an important wildlife corridor connecting Churia hills in north and Dudhwa National Park of India in south. The area is endowed with rich biodiversity resources. It is a dispersal habitat of endangered wildlife species, like tiger, rhinoceros, and wild elephants. Besides, Ghodaghodi Lake, a Ramsar Site of Nepal is also situated adjacent to Basanta Corridor. Dolphins and 43 species of fish species are available in various river systems around the Corridor. The forest is a source of various products like firewood, timber and non timber resources for over 50,000 households of 14 VDC of Kailali district. Forest composition of the corridor varies from dense Sal forest to highly degraded forest with overgrazed grasslands.

3.1.2 Lamahi Corridor (Dang) Inner Terai

Dang Valley lies north of these hills, at elevations from 600 meters along the Babai River with alluvial slopes gradually rising northward to 700 meters along the base of the Mahabharat Range. Then the district extends upslope to the crest of the Mahabharats at 1,500 to 1,700 meters elevation. Mixed forested as indicated by species composition of the Lamahi Corridor. Various species of forest trees seedlings like Sal (*Shorea robusta*), Sisso (*Dalbergia sisso*), Khair (*Acacia catechu*), bamboo (*Dendroclamus spp*), Kapok (*Bombax cieba*), Siris (*Albizia sp*), cane (*Calamus sp*) are found in Lamahi corridor.

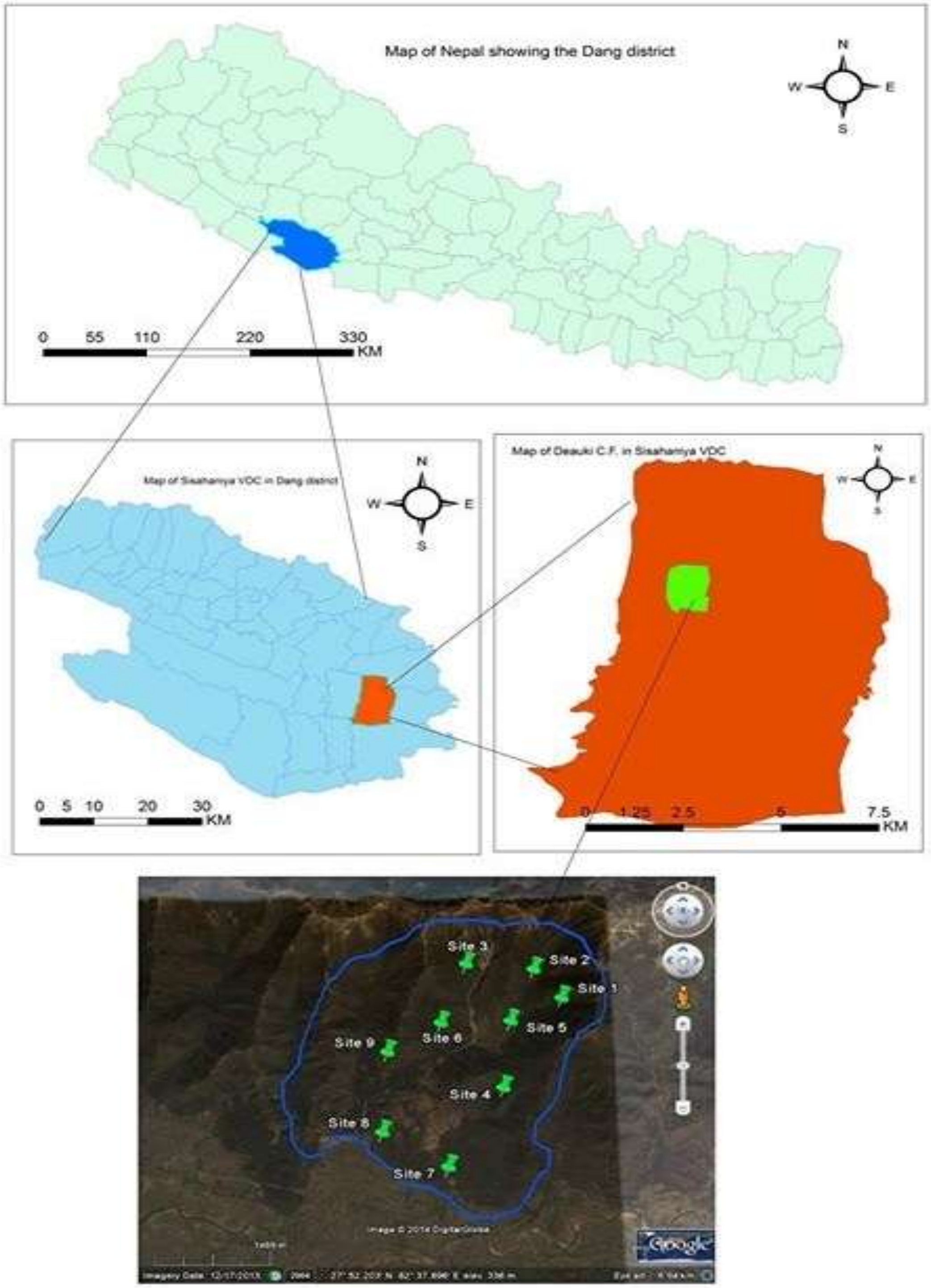

Figure. 3.1. Map of Study Sites of Deauki C.F

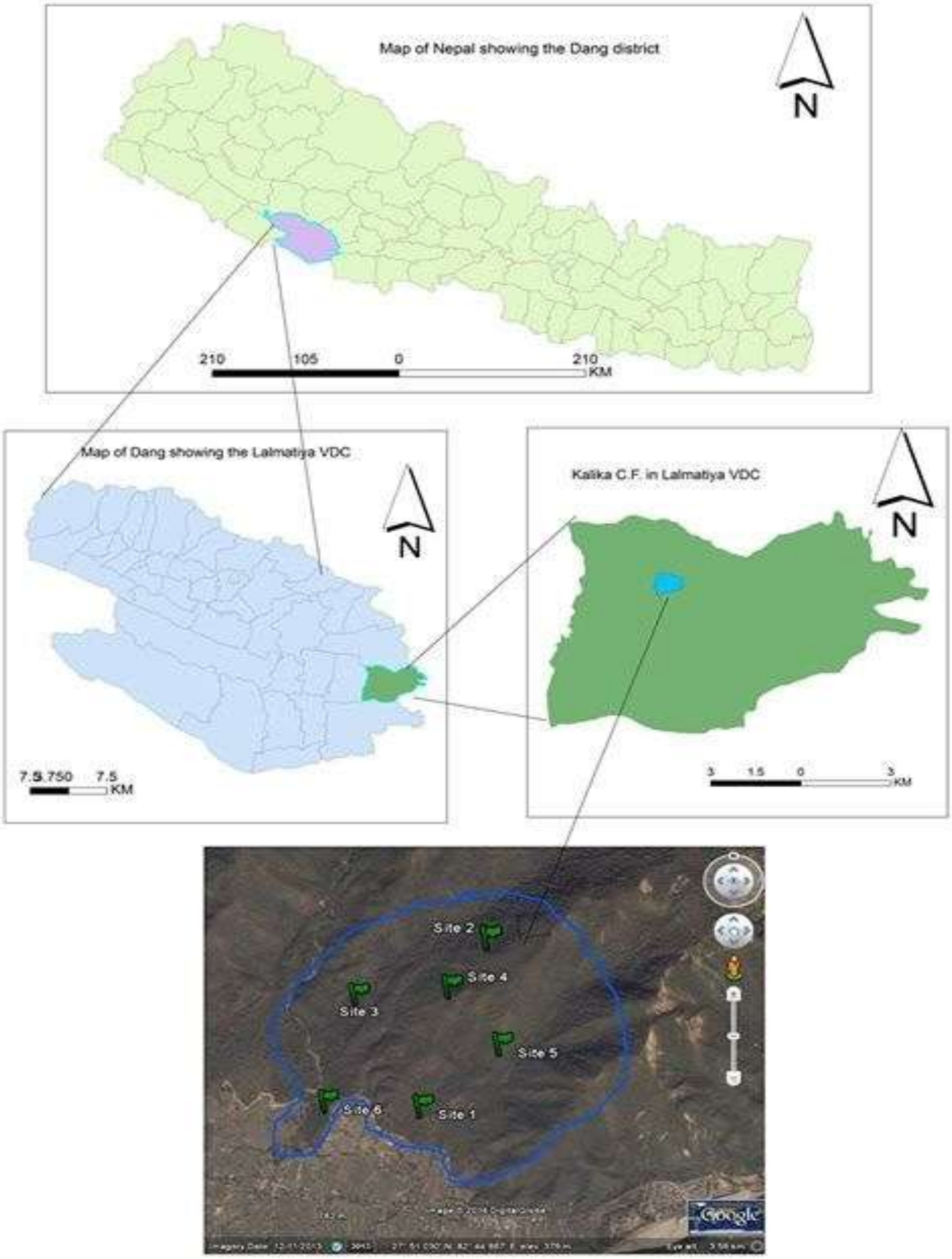

Fig. 3.2. Map of Study Sites of Kalika C.F

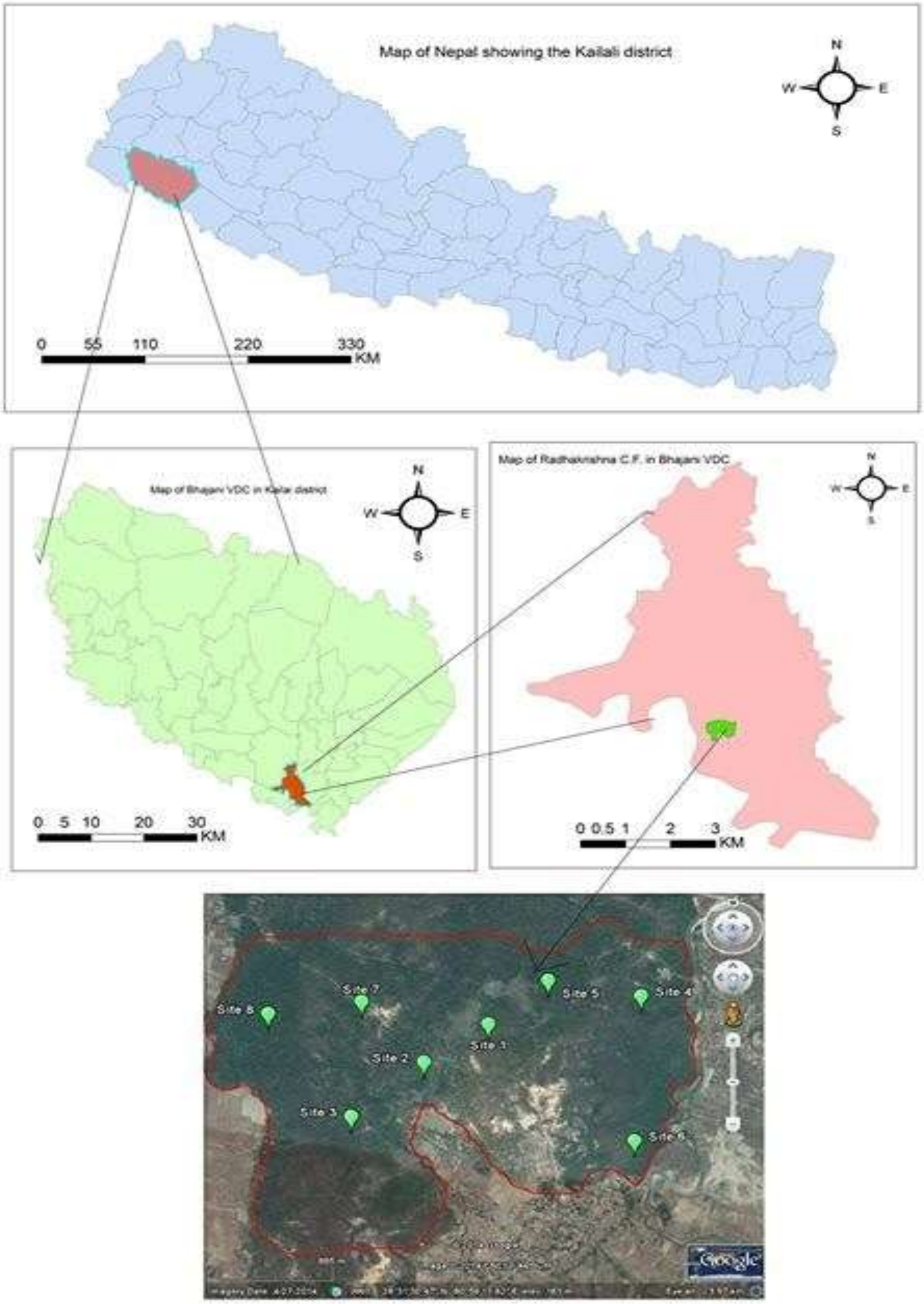

Fig. 3.3. Map of Study Sites of Radhakrishna C.F

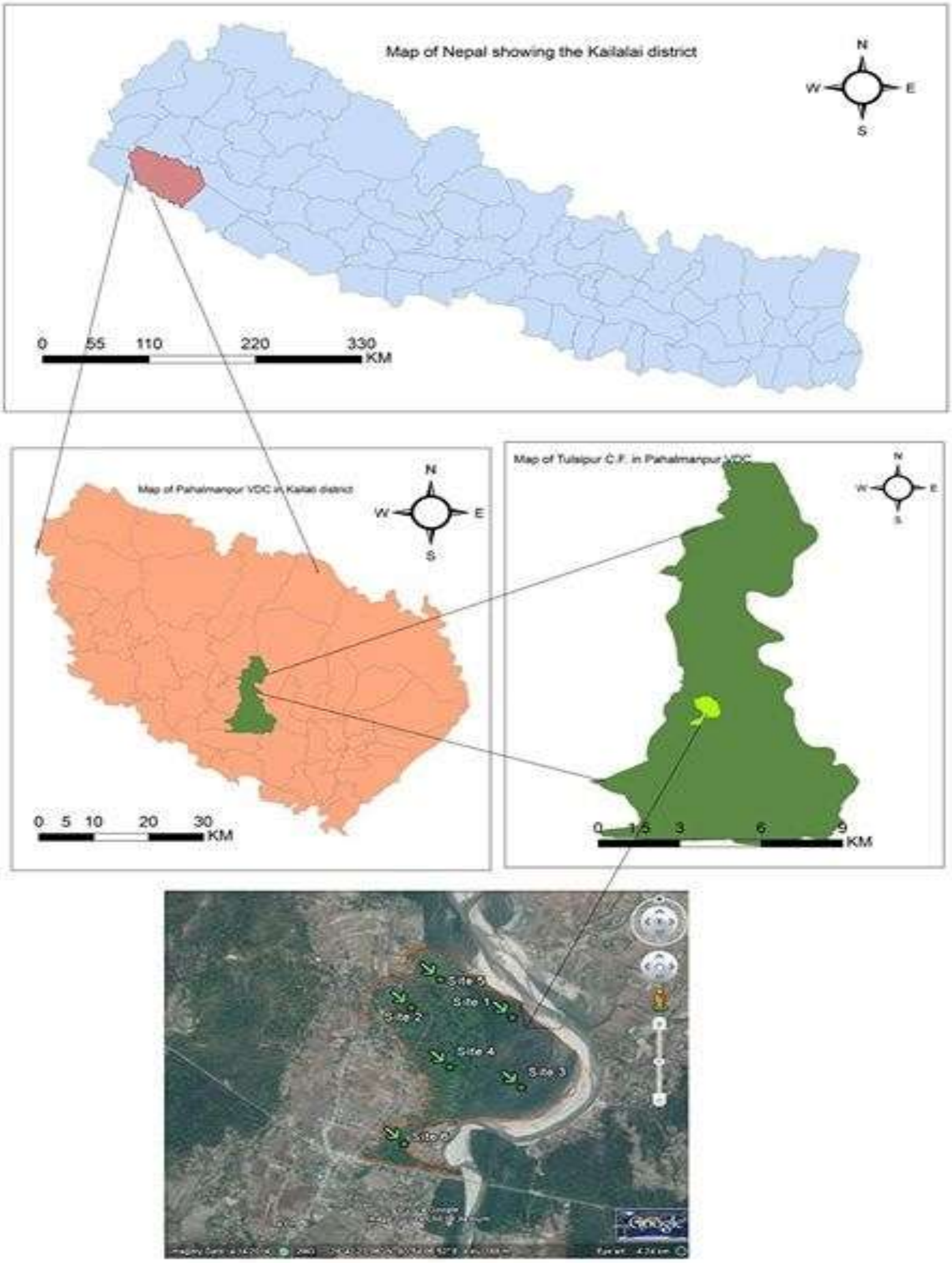

Fig. 3.4. Map of Study Sites of Tulsipur C.F

3.2 Methods of Data Collection

3.2.1 Primary Sources

The data collected from the field survey such as Height and DBH of the tree species, regeneration, sapling and all vegetation were recorded in the field. Along with soil sample were collected from different depth. Besides, the data of Geographical position system (GPS), altitude were collected with the help GPS.

3.2.2 Secondary sources

Secondary data were collected from secondary sources such as related articles, books, dissertation papers and journals. These collected data were used in analysis of primary data.

3.3 Research Design

The research was conducted through scientific design to fulfill the objectives with regular consultation of supervisor and other experts. The Following Schematic (Research Design) (Fig. 3) shows the step wise methods of data collection and analysis.

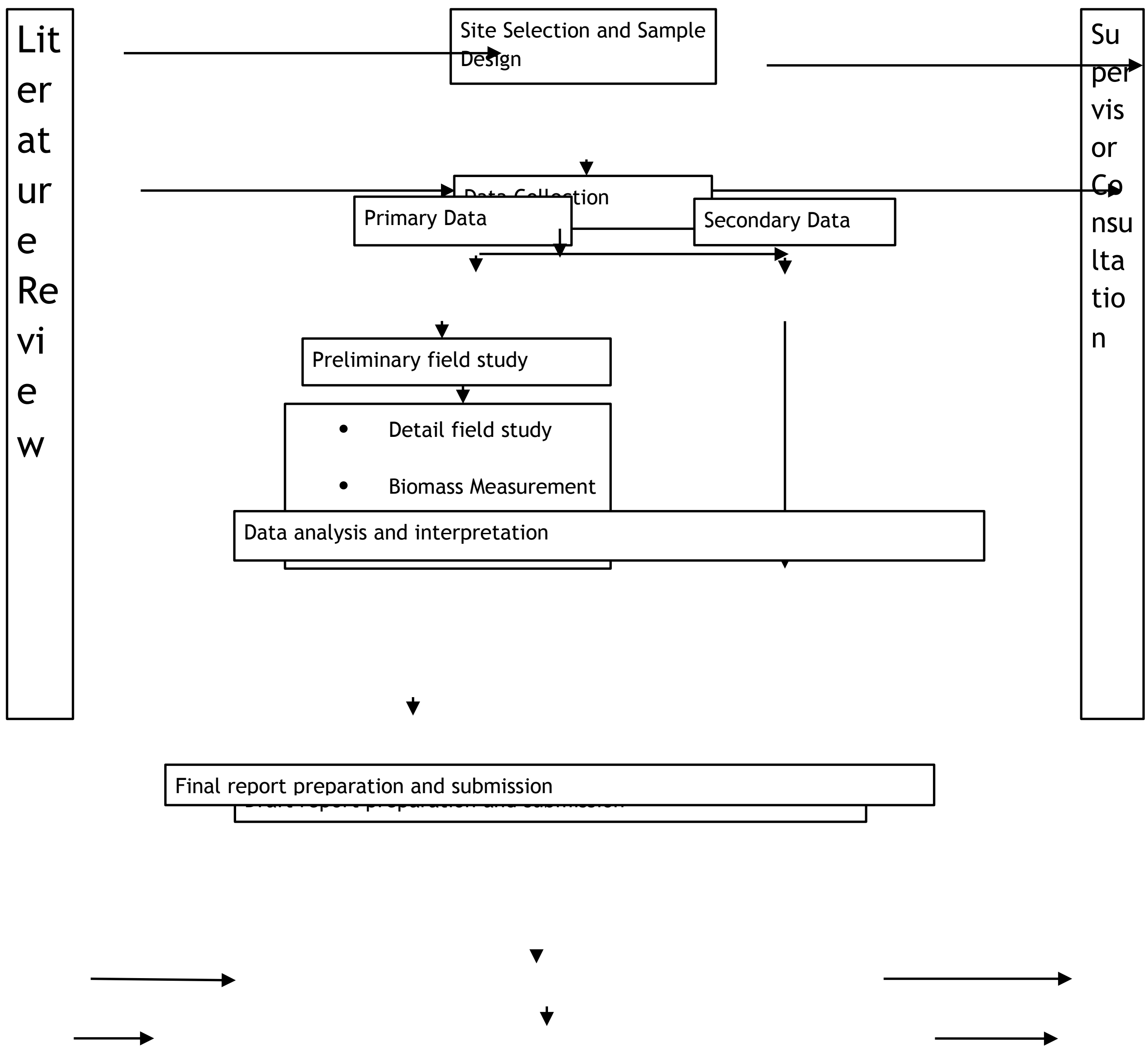

Fig. 3.5 Schematic (Research Design)

3.4 Methodology

3.4.1 Sampling Design and Sampling Plot

To fulfill the objective of the study, Community forest of Terai and Inner Terai were identified during the preliminary survey and with the help of topographical map. After the CF was identified in the respective area sampling points were located and the Random Selection was done in regarding to the GPS (longitude and latitude) and also canopy cover was considered.

Simple random sampling was applied maintaining 1% sample intensity. Total number of sample plot was 29 Out of this 6 plots were established in Kalika CF, 9 in Deuki CF, 6 in Tulsipur CF and 8 in Radhakrishna CF shown in Table no 2. In GPS coordinates of sample plots were randomly distributed on the map which was navigated in the field during data collection.

Table.3.1: Number of Plots established for the study

S.N	Name of Community Forest	Corrido r	District	Areas (Ha)	0.1% of total hac(a)	(a)/ 0.075	Sampling Plot number
1	Kalika CF	Lamahi	Dang	449	0.449	5.99	6
2	Deuki CF	Lamahi	Dang	690	0.69	9.2	9
3	Tulsipur CF	Basanta	Kailali	198	0.198	2.64	6
4	Radhakrishna CF	Basanta	Kailali	409	0.409	5.45	8
	Total			**1746**	**1.746**		**29**

The plot of 750 sq.m was selected so that 15.45 m radius will be formed. Measurement of individual plants having DBH> 5cm lying within the plots was taken. and diameter at breast height i.e. at 1.3m above the ground level, of each plants with DBH> 5cm within each plot was measured using diameter tape. Samples of shrub were collected from the sample plot of 25 sq.m at 9m from central point in north direction.

Litter sample was collected from the sample plot of 1 sq.m at 9m distance from central point in all 4 directions (East, West, North and South).

Bulk density was measured by the help of core sampler from the center of each plot, and for the organic matter 500gm Soil Sample was collected from the center of each sampling plots from 30 cm. for this purpose, all the litter and ground vegetation were cleared before sampling. Every data were collected in the questioner form provided by WWF which is in annex I.

3.5 Instruments

Following instruments were used to collect the data from the field. Some of the major instruments like GPS was used for locating and collecting geographical data of the plot, Meter tape was used for measuring distance, likewise DBH Tape for measuring diameter of tree and breast height, Compass for measuring bearing, similarly, clinometers for measuring tree height and slope, Vertex for measuring height of tree and measuring distance and other instruments for their function accordingly to the table 3.

Table 3.2: Instrumentation

S.N	Equipment	Purpose
1	GPS	For locating and collecting geographical data of plot
2	Meter Tape	For measuring Distance
3	DBH Tape	For measuring Diameter of tree at breast Height

4	Compass	For measuring Bearing
5	Clinometer	For Measuring tree height and slope
6	Vertex	For measuring Height of tree and distance
7	Transponder	For marking plot and measuring height of tree with vertex
S.N	Equipment	Purpose
8	Stand	For marking plot and marking 1.3 m from ground
9	Number Tag	For marking trees
10	Spring Scales	For Weighing destructive Samples
11	Cloth Bags	For collecting samples and storage
12	Large Plastic Sheet	For mixing Samples
13	Soil Sampling auger	For Sampling Soil
14	Core Sampler	For Soil Sample (bulk Density)
15	Rubber Mallet	For inserting Soil probes
16	Hand saw/ Sickles	For cutting destructive Samples

17	Forms and stationeries	For Recording Data
18	Map with Co-ordinates	For locating Sample Plots
19	Densiometer	To determine forest canopy class
20	Camera	To capture photo of plot

3.6 Data Analysis

Above ground biomass and below ground biomass were calculated for carbon stock estimation.

3.6.1 Above Ground Tree Biomass

The aboveground tree biomass includes all parts of the trees such as stem, branches, foliage of the trees. Diameter at Breast Height (DBH) of the trees was measured by using DBH tape. Heights of the trees were calculated by the help of Vertex and for alternative clinometers was also used.

For estimating the tree biomass the method develop by (Chave *et al.*, 2005) on the basis of climate and forest stands types is used. The allometric equations (models) is used

.

Where,

AGTB = above-ground tree biomass (kg)

= wood specific gravity (g cm-3)

D = tree diameter at breast height (cm); and

H = tree height (m).

3.6.2 Leaf litter, herb, and grass (LHG) and Shrub biomass

For this the litter sample was collected from the each plot within the area of the circle within a small area of 1 m2 whereas shrub sample were collected from the sample plot of 25 sq.m at 9m from central point in north direction Fresh samples are weighed in the field with a 0.1 g precision; and a well-mixed sub-sample. The sub-sample collected and brought to laboratory. Next oven dried sample. The dry weight was taken and the biomass was calculated. For the forest floor (herbs, grass, and litter), the amount of biomass per unit area is given by:

Where,

LHG = biomass of leaf litter, herbs, and grass [t ha-1]

Wfield= weight of the fresh field sample of leaf litter, herbs, and grass, destructive sampled within an area of size A [g]

A= size of the area in which leaf litter, herbs, and grass were collected [ha];

Wsubsample , dry = weight of the oven-dry sub-sample of leaf litter, herbs, and grass taken to

the laboratory to determine moisture content [g]; and

Wsubsample, wet= weight of the fresh sub-sample of leaf litter, herbs, and grass taken to the

laboratory to determine moisture content [g].

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

3.6.3 Below-ground biomass (BGB)

To calculate below-ground biomass, it is recommended that (MacDicken 1997) root-to-shoot ratio value of 1:5 is used; that is, to estimate below-ground biomass as 20% of above –ground tree biomass.

3.6.4 Soil Sampling

The soil sample was collected from the center of the plot. 500gm of soil was collected from each plot. The collected soil samples were brought to laboratory to determine the density and carbon content. Carbon content in soil was determined through modified Walkey-Black 1958 method. Detail procedure of this method is described in Annex III.

3.6.5 Soil Bulk Density

Soil sampler of length 10 cm and of diameter 5.5 cm was used for the soil sample collection. The fresh weight as well as oven dried weight of soil for 24 hr. at 100°C was taken to find the bulk

density. Bulk density was determined as:

Where,

Wds= Weight of oven dry soil

Vcs= Volume of core sampler

3.6.6 Soil Organic Carbon

Soil sample collected from the depth up to 30cm was mixed thoroughly and was passed through 2mm sieve to prepare the sample needed for the determination of soil organic carbon. Titrimetric method based on Walkley and Black method was used for SOC determination. Detail procedure is included at Annex III.

Total soil organic carbon was calculated using the formula:

Total SOC = Organic carbon content% x soil bulk density (kg/m3) x thickness of horizon (m) (Chabbra *et al.* 2002).

Total biomass was converted into carbon using the multiplying factor 0.47 (Mac Dickhen 1997),

Total carbon = Above ground carbon + below ground carbon (root + soil)

CHAPTER IV: RESULTS

4.1 Contribution of carbon in total carbon stocks

Total carbon stock is the compilation of above ground and below ground carbon stock. The above ground carbon was of tree, shrub and litter while below ground carbon was of root and soil. The percentage carbon stock was dominant tree. The carbon in tree was maximum about 71.50% in Tulsipur Community Forest and it was minimum about 53.55% in Deuki Community Forest. The least carbon contribution was noted from Shrub and Litter biomass. However, the soil carbon was higher after carbon of tree. The record showed 38.89% highest carbon in Deuki Community Forest and it was the lowest 19.06% only in Tulsipur Community Forest. In addition, it is interesting to show the above ground and below ground carbon stock in figure, thus they are described below under sub title. Detail Carbon content in each CF is in annex IV.

Table 4.1: Contribution of carbon in total carbon stocks

Community forests	Above ground C stock (%)			Below ground C stock t ha^{-1}	
	Tree	Shrub	Litter	Root	Soil
Deuki Community Forest	53.55	0.06	0.70	6.79	38.89
Kalika community Forest	58.45	0.11	0.94	7.43	33.05
Tulsipur Community Forest	71.50	0.01	0.41	8.99	19.06
Radha Krishna Community Forest	70.99	0.02	0.29	8.91	19.77

4.1.1 Above Ground Carbon Stock:

The total Above Ground Carbon Stock (Tree, shrub, and Litter) was found to be highest in Tulsipur CF with 378.68 tC/ha, followed by Radha Krishna CF with 169.48 tC/ha , Deuki CF with 85.25 tC/ha and Kalika CF with 84.49 tC/ha

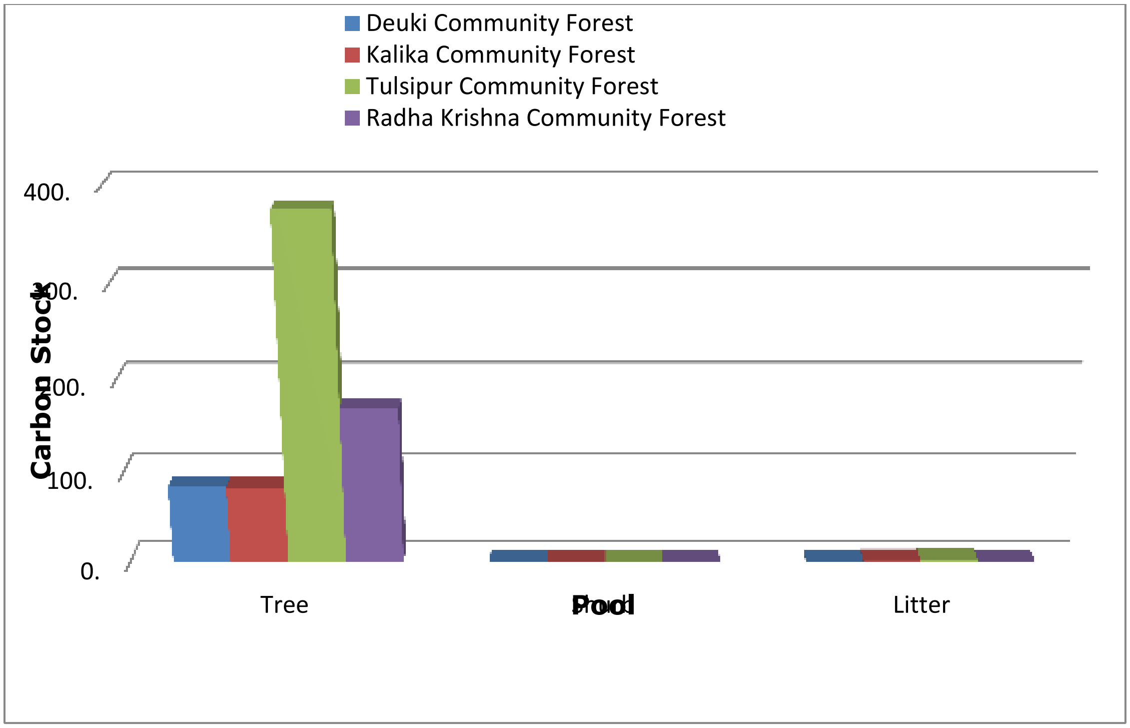

Fig. 4.1. Above Ground Carbon Stock

The highest carbon stock was found in trees staged plants of Tulsipur community Forest (Terai, Kailali) with 376.38 tC/ha followed by carbon in tree of Radha Krishna with 168.72 tC/ha, carbon in tree Deuki CF with 84.04 tC/ha and carbon in tree of Kalika CF with 82.99 tC/ha. The carbon in litter of Tulsupir CF was recorded 2.21 tC/ha, that of Kalika CF was 1.34 tC/ha, that of of Deki CF was 1.10 tC/ha, that of Radha Krishna CF was 0.70 tC/ha, The carbon in shrub of Kalika CF was 1.16 tC/ha, that of Deuki CF was 1.10 tC/ha,, that of Tulsipur CF was 0.08 and that of Radha Krishana CF was 0.05 tC/ha.

4.1.2 Below Ground Carbon stock

The total Below Ground Carbon Stock (Root and SOC) was found to be highest in Tulsipur CF with 147.70 CtC/ha, followed by Deuki CF with 71.69649 CtC/ha , Deuki CF with 68.17933 CtC/ha and Radha Krishna CF with 68.18 CtC/ha.

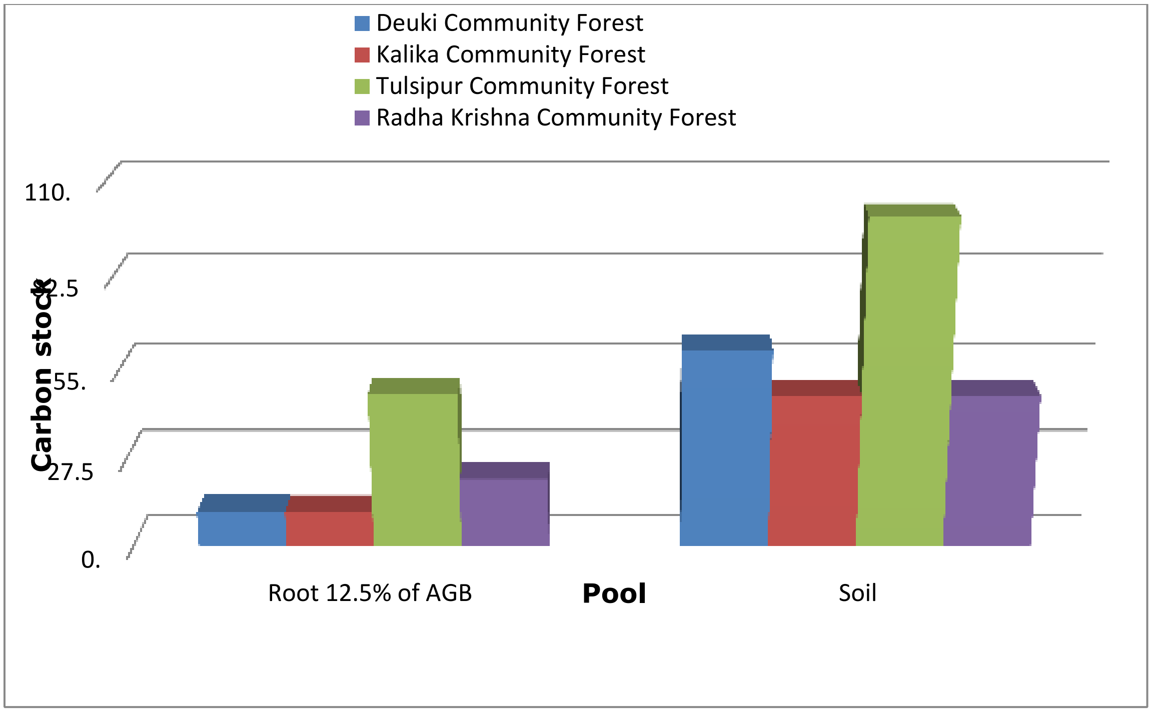

Fig. 4.2. Below Ground Carbon Stock

The estimated soil carbon was found to be highest 100.37 t ha^{-1} in Tulsipur Community Forest, it was followed by 61.04 t ha^{-1} in Deuki Community Forest, 46.99 t ha^{-1} in Radha Krishna Community Forest and 46.94 t ha^{-1} in Kalika community Forest. Similarly, the carbon of root was found to be highest 47.33 t ha^{-1} in Tulsipur Community Forest, it was followed by 21.19 t ha^{-1} in Radha Krishna Community Forest, 10.66t ha^{-1} in Deuki Community Forest and 10.56 t ha^{-1} in Kalika community Forest.

4.2 Total carbon stock of community forests

Here, it is shown that highest Carbon is stocked in Tulsipur Community Forest of (Terai) with 526.38 tC/ha and followed by Radha Krishna Community Forest (Terai) with 273.66 tC/ha, Deuki Community Forest (inner Terai) with 156.94 tC/ha and least in Kalika Community Forest(Inner Terai) with 141.99 tC/ha.

Table. 4.2. Total carbon Stock of Community Forest

Community forests	Above ground C stock t ha^{-1}			Below ground C stock t ha^{-1}		Total C t ha^{-1}
	Tree	Shrub	Litter	Root	Soil	
Deuki Community Forest	84.05	0.10	1.10	10.66	61.04	156.95
Kalika community Forest	82.99	0.16	1.34	10.56	46.94	141.99
Tulsipur Community Forest	376.37	0.09	2.21	47.33	100.37	526.38
Radha Krishna Community Forest	168.72	0.05	0.70	21.19	46.99	237.66

4.3 Descriptive analysis of carbon in community forests

The statistical analysis showed that, the mean carbon stock of Deuki CF was 71.73 tC/ha. It was deviated with value 68.29 from the mean and the sample variance was 4663.86 . The value of standard error was 22.76, Range was 220.25, minimum and maximum value of this Deuki CF was 6.79 tC/ha and 227.04CtC/ha respectively and Confidence level (95%) was 52.49.

Likewise, The mean carbon stock of Kalika CF was obtained 70.84 tC/ha. It was deviated with value 117.07 from the mean and the sample variance was 13706.49. The value of standard error was 47.79, Range was 297.92.And minimum and maximum value of this Kalika CF was 7.85 tC/ha and 305.77 tC/ha respectively and Confidence level (95%) was 122.86.

Similarly, the mean carbon stock of Tulsipur CF was obtained 321.19 tC/ha. It was deviated with value 103.65 from the mean and the sample variance was 35028.07 . The value of standard error was 76.41 Range was 490.19. And minimum and maximum value of this Tulsipur CF was 83.86 tC/ha and 574.05 tC/ha respectively and Confidence level (95%) was 196.41.

Finally, the mean carbon stock of Radha Krishna CF was obtained 150.38 tC/ha. It was deviated with value 103.65 tC/ha from the mean and the sample variance was 10743.22. The value of standard error was 36.65 t/h, Range was 245.36.And minimum and maximum value of this Tulsipur CF was 38.13 tC/ha and 283.49 tC/ha respectively 86.65.

Table. 4.3: Descriptive analysis of carbon in community forest

District	**Community Forest**	**Mean**	**Standard Error**	**Standard Deviation**	**Sample Variance**	**Range**	**Minimum**	**Maximum**	**Confidence Level (95.0%)**
Dang (Mid Terai)	Deuki CF	71.73	22.76	68.29	4663.86	220.25	6.79	227.04	52.49
	Kalika CF	70.84	47.79	117.07	13706.49	297.91	7.85	305.76	122.86

Kailali (Terai)	Tulsipur CF	321.19	76.41	187.16	35028.07	490.19	83.86	574.05	196.41
	Radha Krishna CF	150.38	36.65	103.65	10743.22	245.36	38.13	283.49	86.65

4.4 Comparison of Carbon Stock in CF of Terai and Inner Terai
4.4.1 Normality Test

Data here are normal since Kolmogorov-Smirnov and Shapiro-Wilk test showed that P values were greater than 0.05. Thus, it can be seen that, data regarding carbon stock of these community forests were normal. So, parametric test was applied for statistical comparison

Table. 4.4.Tests of Normality

Community Forest	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.P	Statistic	df	Sig. P
Deuki CF	0.205	9	.200*	0.849	9	0.073
Kalika CF	0.355	6	0.18	0.634	6	0.01
Tulsipur CF	0.249	6	.200*	0.928	6	0.568
Radha CF	0.243	8	0.182	0.853	8	0.103

4.4.2 Comparison carbon stock differences in CFs of Inner Terai (Dang)

Since the P-value< 0.05 the paired two tail t-test statistic showed that there was a significant difference at in mean carbon stock of Deuki and Kalika CFs at 5% level of significance (Table 4.5).

Table. 4.5. Comparison carbon stock differences in CFs of Inner Terai (Dang)

CFs	df	t Stat	P(T<=t) one-tail	P(T<=t) two-tail	t Critical two-tail
Deuki and Kalika	13	0.02	0.49	0.99	2.16

4.4.3 Comparison of carbon stock differences in CFs of Terai (Kailali)

The paired two tail t-test statistic showed that there was a significant in mean carbon stock of Tulsipur and Radha Krishna CFs at 5% level of significance because the P-value< 0.05 (Table 4.6).

Table. 4.6: Comparison carbon stock differences in CFs of Terai (Kailali)

CFs	df	t Stat	t Critical one-tail	P(T<=t) two-tail	t Critical two-tail
Tulsipur and Radha Krishna	12	2.19	1.78	0.05	2.18

4.4.4 Comparison of carbon stock differences in CF of Terai and Inner Terai

As P-value< 0.05, the paired two tail t-test statistic showed that there was a significant difference in mean carbon stock of CFs of Terai and Inner Terai.

Table. 4.7: Comparison of carbon stock differences in CF of Terai and Inner Terai

CFs	df	P(T<=t) one-tail	t Critical one-tail	P(T<=t) two-tail	t Critical two-tail
CF of Terai and CF of Inner Terai	27	0.001	1.70	0.003	2.05

CHAPTER V: DISCUSSION

5.1 Above Ground Carbon stock

The highest Carbon stock was found in tree of Tulsipur community Forest, Terai, Kailali with 376.3765 tC/ha and it was followed by carbon of tree staged plants of Radha Krishna Community Forest, Terai, Kailali with 168.7239 tC/ha, because the above ground tree and pole biomass of Terai CF was found to be dominant due to occurrence of majority of tree and pole size stand having species like as Sissoo (*Dalbergia sissoo*), Khair (*Acacia catechu*), Sajh (*Terminalia tomentosa*), Sal (*Shorea robusta*),, Barro (*Terminalia bellirica*), Rohini (*Mallotus philippensis*) Asidha (*Lagerstroemia parviflora*) Dhau/Dheuti (*Anogeissus latifolia*), etc. The wood densities of these species were high. The present study was also supported by the study conducted by Khanal (2008) in Jarneldhara community forest and Lipindevi Thulopakho community forest of Palpa district. The above ground carbon stock of tree in Lipindevi Thulopakho community forest was found to be higher (38.6± 3.9 C /ha) than that of Jarneldhara community forest (35.5 ± 3.4 tC/ha). It may be due to larger sized trees which consequently have higher biomass and carbon. The difference in carbon stock in these community forests might be due to forest age, forest type and geographical regions (Guo *et al.* 2010). The biomass of the vegetation depends up on the diameter and age of the tree.

The highest carbon stock of litter was 2.21 tC/ha in Tulsupir CF (Terai), and it was followed by carbon stock 1.34 tC/ha of Litter of Kalika CF (inner-Terai) and that of Kalika CF (inner Terai) was about 1.33 tC/ha, Similarly, the carbon stock of Shrub of Kalika CF (inner Terai) was 1.16 tC/ha, which was very low. As it is understood the quantity of leaf litter and herbs biomass depends greatly up on the plans and available litter on the ground of the community forest. If the CFUG members regularly collect leaf litter and grasses, then there are less litter and grass. There was no such rule to restrict the collection of litters and grasses. This may be the reliable reason having low carbon stock in leaf litter and shrubs. The carbon quantity in litter and grasses in Kalika CF was higher than that of Shyalmati watershed (0.283 ton/ha), (Chhetri 2010). The collection of litter at any time can be good in a sense and it can be bad in other sense. It may be that the over deposition of the

litter may increase the forest fuel loads which may cause severe forest fires. But, during the collection of litter the crushing and trampling may happen to the sapling and small plants which may directly affect on the growing stock of forest. Further, it may have the chance in natural regeneration of the forest.

5.2 Below Ground Carbon stock

The soil carbon depends upon various biotic and abiotic factors, such as micro-climate, faunal diversity, land use, and management. Leaf litter and root litter inputs play a major role in forest soil (Shrestha and Singh 2008).

The estimated soil carbon was found to be highest 100.37 tC/ha in Tulsipur Community Forest. It might be due to micro climatic condition of the forest. The soil organic carbon of forest depends on types of climate, moisture, temperature and variation in soil types (Shrestha 2008). The difference in carbon in other CF might be due to forest age, forest type (Guo *et al.* 2010) and geographical regions. Soil is the largest carbon reservoir of the terrestrial carbon cycle. Soil contents about three times more carbon than vegetation and twice as much as that present in the atmosphere (Batjesh 1996 cited in kumar *et al.* 2006) Using the georefrence database Batjesh 1996 found that most of the SOC are accumulated in the upper 100cm. It is reported that SOC might be high when there is high growth of vegetation (Bationo *et al.* 2005).

The Soil Organic Matter Carbon pool is the result of the non-living plant and animal residues decomposing within the soil and has a large influence on the sustainability of the ecosystem. In addition, generally more than 70% of carbon stock was contributed by below ground carbon where as only 28% was contributed by above ground biomass carbon in total carbon (Bird *et.al* 2000 cited from Hulchens 2011).

According to FAO, 2010 report, soil carbon of Asia was 59.6 ton/ha which was lesser than that of 100.37 tC/ha in Tulsipur CF (Terai) and 61.04 t / ha in Deuki CF (Inner Terai) but higher than that of 46.99 t /ha in Radha Krishna CF (Terai) and 46.94 t /ha in Kalika CF (Inner Terai).

Similarly, the carbon of root was found to be highestt 47.33 t/ ha in Tulsipur CF (Terai) and it was followed by 21.19 t/ ha in Radha Krishna CF(Terai), 10.66 t/ ha in Deuki CF (Inner Terai) and 10.56 t/ ha in Kalika CF (Inner Terai).

5.3 Total Carbon Stock

According to the study conducted by ANSAB, ICIMOD, FECOFUN (2010) in community forests of Charnawati watershed of Dolakha showed that, the total estimated carbon stock was 124894.72 ton including above ground tree carbon, below ground carbon, above ground sapling carbon, leaf litter, herb, grass carbon and soil carbon. In Nepalese forest, an average carbon stock estimated account to 203 ton/ha (including shrub soil) which is higher than the world's average i.e. 161.1 ton/ha (FAO 2006). The carbon stock in Tulsipur Community Forest of (Terai) was 526.38 tC/ha and that of Radha Krishna Community Forest (Terai) was 273.66 tC/ha are higher than both Nepalese and world's average whereas the carbon stock of Deuki Community Forest (Inner Terai) was 156.94 tC/ha and that of Kalika Community Forest (Inner Terai) was 141.99 tC/ha are lesser.

Both CFs of Terai stored more quantity of carbon in comparison to those of Inner Terai. This may be due to the large number of trees and big size. The evident shows that there was higher carbon 70 Mg/ha in *Shorea robusta* forest that are more than 100 years old (Singh 1979). My study sites are dominated by *Shorea robusta* plant species.

Similarly, the mean carbon stock of Tulsipur CF (Terai) was obtained by statistical analysis which was 321.19 tC/ha, this was followed by Radha Krishna CF (Terai) with 150.38 tC/ha, Deuki CF (Mid Terai) with 71.73 tC/ha, and Kalika CF(Mid Terai) with 70.84 tC/ha .

The mean carbon of Tulsipur CF (Terai) was 321.19 tC/ha, higher than that 245.95 tC/ha in pine forest of a Nepalese community forests (Adhikaree 2005) and 256.4 tC/ha in broadleaf mixed forests and 247.7 tC/ha in *Picea-Abies* forest of Northeast China (Zhu *et al.* 2010, 152.04 tC/ha in a Chapako community forest of Kathmandu (Mishra 2010); 163.99 tC/ha in Broad-leaved forest of a Nepalese community forests (Adhikaree 2005); 57.90 tC/ha in a community forest of mountain watershed of Nepal (Singh 2005); 126.5

tC/ha in pine forest and 49.76 tC/ha in broad-leaved forest of a community forest in mid hills of Central Nepal (Dahal 2007); 220.30 tC/ha in alder forest of mid hill of Nepal (Ranabhat *et al.* 2008); 178.52 tC/ha in *Schima-Castanopsis* forest in mid hills of Western Nepal (Shrestha 2009). On the other hand it was lower than 351 tC/ha of harvest-age *Tectona grandis* plantations of Panama (Kraenzel *et al.* 2003); 599.58 tC/ha of lower temperate forest of Shivapuri Nagarjun National Park (Ranjitkar 2010). The higher value in present study might be due to larger sized trees, type of species of forest, and older aged forest than the similar community forest types.

Similarly, carbon stock of Radha Krishna CF (Terai) with 150.38 tC/ha is similar to 152.04 tC/ha in a Chapako community forest Kathmandu (Mishra 2010) and higher than 57.90 tC/ha in a community forest of mountain watershed of Nepal (Singh 2005); 126.5 tC/ha in pine forest and 49.76 tC/ha in broad-leaved forest of a community forest in mid hills of Central Nepal (Dahal 2007). but lower than 245.95 tC/ha in pine forest of a Nepalese community forests (Adhikaree 2005); 256.4 tC/ha in broadleaf mixed forests and 247.7 tC/ha in *Picea-Abies* forest of Northeast China (Zhu *et al.* 2010); 163.99 tC/ha in Broad-leaved forest of a Nepalese community forests (Adhikaree 2005), 220.30 tC/ha in alder forest of mid hill of Nepal (Ranabhat *et al.* 2008); 178.52 tC/ha in *Schima-Castanopsis* forest in mid hills of Western Nepal (Shrestha 2009), 351 tC/ha of harvest-age *Tectona Grandis* plantations of Panama (Kraenzel *et al.* 2003); 599.58 tC/ha of lower temperate forest of Shivapuri Nagarjun National Park (Ranjitkar 2010).

In contrast, Deuki CF (Mid Terai) with 71.73 tC/ha, and Kalika CF (inner Terai) with 70.84 tC/ha possessed higher carbon than 57.90 tC/ha in a community forest of mountain watershed of Nepal (Singh 2005), 49.76 tC/ha in broad-leaved forest of a community forest in mid hills of Central Nepal (Dahal 2007) but lower carbon stock than 245.95 tC/ha in pine forest of a Nepalese community forests (Adhikaree 2005); 256.4 tC/ha in broadleaf mixed forests and 247.7 tC/ha in *Picea-Abies* forest of Northeast China (Zhu *et al.* 2010, 152.04 tC/ha in a Chapako community forest Kathmandu (Mishra 2010); (163.99 tC/ha) in Broad-leaved forest of a Nepalese community forests (Adhikaree 2005); 126.5 tC/ha in pine forest; 220.30 tC/ha in alder forest of mid hill of Nepal (Ranabhat *et al.* 2008); 178.52 tC/ha in *Schima-Castanopsis* forest in mid hills of Western Nepal (Shrestha 2009). But lower than

351 tC/ha of harvest-age *Tectona grandis* plantations of Panama (Kraenzel *et al.* 2003); (599.58 tC/ha) of lower temperate forest of Shivapuri Nagarjun National Park (Ranjitkar 2010).

CHAPTER VI: CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

This study estimated that highest carbon was stocked in Tulsipur Community Forest of (Terai) with 526.38 tC/ha and it was followed in descending order by carbon stock of Radha Krishna Community Forest (Terai) with 273.66 tC/ha, Deuki Community Forest (inner Terai) with 156.94 tC/ha and lastly carbon stock in Kalika Community Forest(Inner Terai) with 141.99 tC/ha.

Total Carbon stock in community forest of Terai was higher in comparison to that of Inner Terai.

6.2 Recommendations

- **This study was only focus on four community forests in two districts it needs to extend in other sites too in order to generalize the carbon stocks of community forests in Terai and inner Terai.**

- **Upcoming study should be focused on to show the variation in carbon stock according to species and DBH in community forests of inner Tarai and Tarai.**

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ANNEX I

Comparison of Carbon Stocks in Community Forests of Lamahi Corridor, Kailali in Terai and Basanta Corridor, Dang in Inner Terai

(Source:WWF-Nepal)

1. General Information (cfwf/e"t hfgsf/L)

Date (ldlt): ___________

Crew (6f]nL ;b:ox?): ________________________________

District (lhNnf): ___________ **Land use (e"pkof]u):** a. Forest (ag)_______ b. Agro-forestry (s[lif ag) _____ c. Other (cGo If]q) _______

Strata (jgsf] efu): a. 1-10% b. 11-40% c. 41-70% d. 71-100%

Type of Forest (jgsf] k|sf/, Joj:yfkgsf] cfwf/df): a.CF (;fd'bflos ag) b. National Forest (/fli6«o ag) c. Private Forest (lghL ag) d. Protected Area (;/+lIft If]q)

Type of Forest (jgsf] k|sf/, lj?jfsf] cfwf/df): a. Broadleaves forest (rf}8f kft] ag) (sf]0fwf/L] ag) b. Conifer Forest c. Mixed Forest (ldl>t ag)

Location (GPS Coordinates) cjl:ylt (lh=lk=P;=):

Longitude (b]zfGt/): ________________ Elevation (m) (prfO): a. < 1000 b. 1000-2000 c. 2000-3000 d. 3000-4000

Latitude (cIff+z): __________________________ **Average slope** (cf};t le/fnf]kg) _______

Aspect (df]x8f): N (pQ/) S (blIf0f) E (k"j{) W (klZrd) SW (blIf0f klZrd) SE (blIf0f k"j{) NE (pQ/ k"j{) NW (pQ/ klZrd)

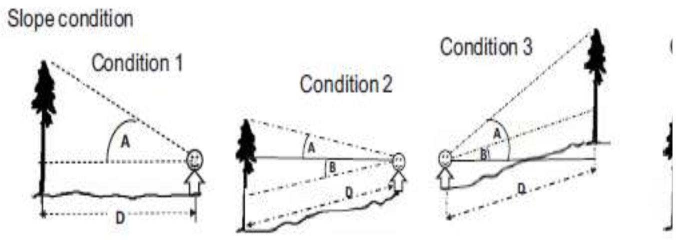
Canopy Cover (5qn] 9fs]sf] 3gTj k|ltztdf):

North (pQ/):__________ South (blIf0f):__________ East(k"j{):__________ West(klZrd):__________

Ground Cover (hdLgsf] 9sfO{): a. Grass (3fF;) b. Bush (emf8L) c. Leaf Litter (kts/) c. No vegetation (s'g} ag:klt gePsf])

Dominant Species in Ground Cover (hdLgdf /x]sf d'Vo k|hftLx?) : _______________

Soil Color (df6f]sf] /+u): ________________



2. Pilot Inventory Form (jg ;e]{If0f kmf/d)

Tree (Diameter with 5 cm and more) ?vx? -% ;]=dL= / ;f] eGbf al9 Jof; ePsf]_								
Tree Number (?v g+)	**Species (k|hflt)**	**Diameter in cm (Jof; ;]=dL=)**	**Top Angle (?vsf]] 6'Kkfdf ag]sf] sf]0f)**	**Base Angle at Eye Height (?vsf]] km]bdf ag]sf] sf]0f)**	**Slope Condition** (See Figure) **(le/fn]fsf] cj:yf lrq x]g'{:f)**	**Distance to the Tree (?v ;Ddsf] b'l/)**	**Tree Height (?vsf] prfO)**	**Condition of Tree (?vsf] cj:yf)**
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								

13								
14								
15								
16								
17								
18								
19								

Tree (Diameter with 5 cm and more) ?vx? -% ;]=dL= / ;f] eGbf al9 Jof; ePsf]_

Tree Number (?v g+)	Species (k|hflt)	Diameter in cm (Jof; ;]=dL=)	Top Angle (?vsf]] 6'Kkfdf ag]sf] sf]0f)	Base Angle at Eye Height (?vsf]] km]bdf ag]sf] sf]0f)	Slope Condition (See Figure) (le/fn]fsf] cj:yf lrq x]g'{:f)	Distance to the Tree (?v ;Ddsf] b'l/)	Tree Height (?vsf] prfO)	Condition of Tree (?vsf] cj:yf)
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								
31								
32								
33								

34								
35								
36								
37								
38								
39								
40								

Shrub (diameter <5 cm) in 25 square meter (jf]6 - %;]=dL= eGbf sd Jof; ePsf], sf7 gx'g] k|hftL_ pkKn6 !, @% ju{ dL=_

Total fresh weight (xl/of] tf}n) (sf6]sf] hDdf) [u|fd]	Sample fresh weight (xl/of] tf}n) -gd"gf_ [u|fd]	Sample dry weight (;'Vvf tf}n) -gd"gf_ [u|fd]
		Nofa glthf

Litter, grass in 1 square meter -´f/kft, xfËfljËf / 3fF; -! ju{ dL=_

pk Kn6 g+=	Total fresh weight (xl/of] tf}n) (sf6]sf] hDdf) [u|fd]	Sample fresh weight (xl/of] tf}n) -gd"gf_ [u|fd]	Sample dry weight (;'Vvf tf}n) -gd"gf_ [u|fd]
1			Nofa glthf
2			
3			

Regeneration in 25 square meter (k'g?Tkfbg pkKn6 ! @% ju{dL6/sf] Kn6)

qm=;+= (SN)	hft (Species)	;+Vof (Number)
1		
2		
3		
4		
5		
6		

7			4				
8							
9							
10							

agsf] x}l;ot dfkgsf nflu tof/ ul/Psf] k|ZgfjnLx?
tn pNn]lvt ;a} sfdx? Kn6leq dfq} ug'{xf]nf -aGohGt' afx]s_ . ;xL hjfkmdf √ lrGx nufpg'xf];\ . ;+Vof elgPsf] :yfgdf clgjfo{ ;+Vof pNn]v ug'{xf]nf .

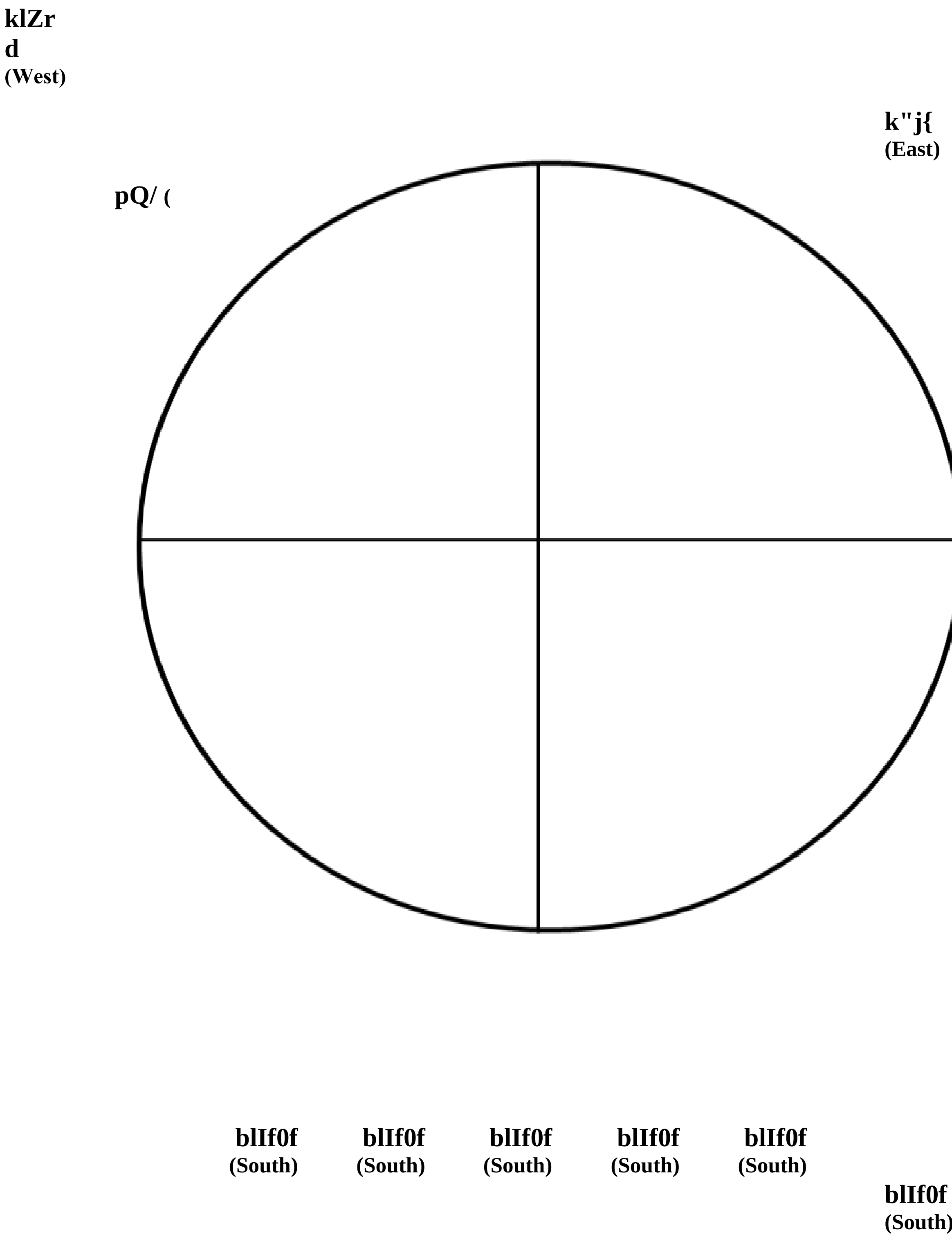
Kn6leq ug'{kg]{ sfdx?

sfl6Psf ?vx?sf] 7'6fsf] ;+s]t	5 - _	5}g - _	5 eg] slt 5 -;+Vof_ - _
xfuf+ eflrPsf ?vx?sf] ;+s]t	5 - _	5}g - _	5 eg] sltj6f ?v 5g\ -;+Vof_ - _
3fF; sfl6Psf ?vx?sf] ;+s]t	5 - _	5}g - _	5 eg] sltj6f ?v 5g\ -;+Vof_ - _
sfl6Psf a'6fx?sf] jf emfl8x?sf] ;+s]t	5 - _	5}g - _	5 eg] sltj6f ?v 5g\ -;+Vof_ - _
;'v]sf ?vx?sf]] ;+s]t	5 - _	5}g - _	5 eg] sltj6f ?v 5g\ -;+Vof_ - _
/f]u jf ls/fx? nfu]sf] ?vx?sf]] ;+s]t	5 - _	5}g - _	5 eg] sltj6f ?v 5g\ -;+Vof_ - _
rl/r/0fsf ;+s]tx?	5g\ - _	5}gg\ - _	
5g\ eg] s] b]Vg'eof] <	ufO{a:t' rl//x]sf - _ uf]a/ - _	vfO{Psf] 3f;Fsf d'gfx? - _	cGo - _
bfp/f ;+sngsf ;+s]tx?	5 - _	5}g - _	

ag 89]]nf]sf] ;+s]tx?	5 - _	5}g - _	
ag clts|d0fsf ;+s]tx?	5 - _	5}g - _	
e"Ifosf ;+s]tx?	5 - _	5}g - _	
5g\ eg] e"Ifosf lsl;dx? - ;+Vofdf_	;fgf -df6f]sf] tx au]sf]_ - _	dWod - wsf{ au]/ ;fgf ;fgf s'nf] ePsf] _ - _	7'nf uN5L -vf]N;fx?_ - _
olb ;fgf s'nf]x? - dWod e'Ifo_ 5g\ eg] gfKg'xf]nf - dL6/df_	s'nf] -dWod_ ! @ # cf};t rf}8fO M - _ - _ - _		
	cf};t ux/fO M - _ - _ - _		
olb 7'nf uN5Lx? 5g\ eg] gfKg'xf]nf - dL6/df_	7'nf ulN5x? ! @ # cf};t rf}8fO M - _ - _ - _		
	cf};t ux/fO{ M - _ - _ - _		
df6f]sf] lsl:fd	!= afn'jf ePsf] @= s[lifI]fqsf] h:tf] b'd6 #=agsf] h:tf] sfnf] $= afn'jf / anf}6]sf] ljrdf		
:tgwf/L aGohGt'sf ;+s]tx? - hftLsf] gfd yfxf eP tn n]Vg'xf];\ < _	5 - _	5}g - _	slt hftLsf] b]Vg'eof] < - _
!+ @= #= $= %= ^= &= *= (= !)=			
r/fsf ;+s]tx? - hftLsf] gfd yfxf eP tn n]Vg'xf];\ < _	5 - _	5}g - _	slt hftLsf b]Vg'eof] < - _
!+ @= #= $= %= ^= &= *= (= !)=			
3;|g] aGohGt'sf ;+s]tx? -	5 - _	5}g- _	slt hftLsf b]Vg'eof] < - _

hftLsf] gfd yfxf eP tn n]Vg'xf];\ < _			
!+ @= #= $= %= ^= &= *= (= !)=			
aGohGt'sf rf]]/L lzsf/Lsf ;s]tx?	5 - _	5}g- _	
:yfgLo k|hftL afx]ssf g+of lj?jfx? b]Vg' ePsf] 5 < - hftLsf] gfd yfxf eP tn n]Vg'xf];\ < _	5 - _	5}g - _	slt hftLsf b]Vg'eof] < - _
!+ @= #= $= %= ^= &= *= (= !)=			
glhssf] df]6/af6f] b]lv Kn6 ;Ddsf] b'/L	! 306f eGbf sd - _	! b]]lv % 306f;Dd - _	% 306f b]lv !) 306f;Dd - _
glhssf] ufp+b]lv Kn6 ;Ddsf] b'/L	! 306f eGbf sd -lx8]/_ - _	! b]]lv % 306f;Dd -lx8]/_ - _	% 306f b]lv !) 306f;Dd -lx8]/_ - _
glhssf] :yflgo ahf/b]lv Kn6 ;Ddsf] b'/L	! 306f eGbf sd -lx8]/_ - _	! b]]lv % 306f;Dd -lx8]/_ - _	% 306f b]lv !) 306f;Dd -lx8]/_ - _
lhNnf ;b/d'sfd b]lv Kn6 ;Ddsf] b'/L	! 306f eGbf sd -lx8]/_ - _	! b]]lv % 306f;Dd -lx8]/_ - _	% 306f b]lv !) 306f;Dd -lx8]/_ - _

pQ/ (North)


klZr
d
(West)
k"j{
(East)
pQ/ (
blIf0f
(South)
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blIf0f
(South)
blIf0f
(South)
blIf0f
(South)

ANNEX II

List of Key Informants

S.N	Name
1	Ugan Manandhar
2	Tilak Dhakal
3	Yadav Kandel
4	Laxmi Choudhary
5	Maya Yogi
6	Laxman Lakhe

ANNEX III

Detail procedure of lab analysis in determining SOC
Reagents Used
Sodium Fluoride (NaF): AR grade sodium fluoride powdered was used.
1N $K_2Cr_2O_7$ Solution: 49.04gm of AR $K_2Cr_2O_7$ was kept at 105^0C in hot air oven for 1 hour. As it cools down, it was diluted to 1000ml VF.
0.5N FAS: 196gm of FAS was dissolved in 800ml of distilled water and added 20ml of conc. sulfuric acid, cooled and diluted to 1000ml.
Diphenylamine Indicator: Approximately 0.5gm of diphenylamine was dissolved in 20ml of distilled water and added 100ml of conc. sulfuric acid.
Procedures

- **Soil sample collected from the depth up to 30cm was mixed thoroughly and was passed through 2mm sieve to prepare the sample needed for the determination of soil organic carbon. Titrimetric method based on Walkley and Black method was used for SOC determination.**
- **1gm of dried soil was, passed through 2mm sieve, was taken and transferred to the well labeled dried 500 ml conical flask.**
- **10ml 1N potassium dichromate solution and 20ml conc. Sulphuric acid was added and mixed by gentle swelling.**

- The flask was kept for 30min to react with the mixture. After 30min, the mixture was diluted with 200ml of distilled water followed by addition of 10ml of phosphoric acid and 1ml of Diphenylamine indicator.
- The sample was titrated with 0.4N ferrous ammonium sulphate till the end point which was indicated by the change in colour to the brilliant green end point was noted down.
- The blank was also run as followed by above procedure.

Calculation

% Organic Matter:

$$\frac{\textbf{0.67* Normality of FAS*Volume of FAS consumed}}{\text{Weight of soil sample}}$$

Normality of FAS (N):

$$\frac{\textbf{Volume of potassium dichromate taken* Normality of dichromate}}{\text{Volume of FAS consumed by blank}}$$

% Organic Carbon:

$$\frac{\textbf{Soil organic matter}}{1.724}$$

Bulk density was determined as:

Where,

Wds= Weight of oven dry soil

Vcs= Volume of core sampler

Total SOC = Organic carbon content% x soil bulk density (kg/m3) x thickness of horizon (m) (Chabbra, et al., 2002).

Total biomass was converted into carbon using the multiplying factor 0.47 (Mac Dickhen (1997),

Total carbon = Above ground carbon + below ground carbon (root + soil)

ANNEX IV

Detail Carbon Content in each CF

District	Community Forest		Plot								
			1	2	3	4	5	6	7	8	9
Dang (Mid Terai)	Deuki CF	Tree	266.04	81.392	59.69	24.56	7.949	8.189	73.195	113.08	122.33
		Shurb	0.189	0.1222	0.0908	0.105	0.0517	0	0.2328	0.0885	0.0479
		Litter	1.4544	1.1701	0.0903	1.066	1.0081	0.432	0.6634	1.4305	2.5992
		BGB	70.947	21.706	15.919	6.55	2.1204	2.184	19.519	30.157	32.622
		SOC	91.828	204.98	84.976	38.67	25.382	14.54	38.302	44.211	6.473
	Kalika CFt	Tree	10.543	9.1845	75.618	12.98	31.358	358.3			
		Shurb	0.0576	0.2042	0.1131	0.203	0.3156	0.076			
		Litter	3.1225	0.9345	0.6282	1.448	0.483	1.423			
		BGB	2.8121	2.4519	20.166	3.464	8.3664	95.55			
		SOC	2.0165	45.546	57.283	104.6	38.173	34.02			
Kailali (Terai)	Tulsipur CFt	Tree	330.57	237.81	672.7	98.26	317.61	601.3	376.38		
		Shurb	0.0825	0.1137	0.1346	0.129	0.0408	0.035	0.0893		
		Litter	1.9937	1.959	2.5545	1.032	1.1771	4.543	2.2098		

		BGB	88.154	63.417	179.39	26.2	84.696	160.4	100.37	
		SOC	2.1044	57.76	112.43	23.69	78.887	97.15	62.003	
	Radha Krishna CF	Tree	44.675	332.22	96.934	77.05	307.19	47.38	241.59	202.76
		Shurb	0.0663	0	0.0755	0	0.0566	0.03	0.0358	0.1633
		Litter	0.8704	0.2795	0.4397	0.782	0.7383	1.126	0.7474	0.6762
		BGB	11.914	88.591	25.85	20.55	81.917	12.63	64.425	70.072
		SOC	21.39	32.996	46.651	45.88	75.266	24.6	1.5185	3.4182

ANNEX V

PHOTOGRAPHS

Instruments used in research

FIELD WORK

Digging and taking out Core Sampler for bulk density (Soil Sample)

Calculating Canopy Cover

Center of the plot

Measuring Tree height using Vertex

Walking towards plot in jungle

Measuring DBH of tree

Measuring DBH of large tree

Filling Questioner Form to collect data of the field

Collecting and weight litter sample

Measuring direction of the plot

Measuring slope angle

Taking fresh sample weight

Making radius for sample collection

LAB WORK

Reagent

Titration

Unpacking Core Sampler

Measuring Grinded soil

Drying sample in oven

Measuring dry sample