ASSESSMENT OF CARBON STOCK AND ESTIMATION OF FUELWOOD CONSUMPTION IN KAJIKO TATHA DHAIRENI COMMUNITY FOREST IN PANCHKHAL, KAVREPALANCHOK

Submitted By

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LETTER OF RECOMMENDATION

This is to certify that **Ms. Ritu Byanju** has prepared this dissertation entitled "**Assessment of carbon stock and estimation of fuelwood consumption in Kajiko Tatha Dhaireni Community Forest in Panchkhal, Kavrepalanchok**" for the partial fulfilment of the requirements for the completion of Master's degree in Environmental Science under our guide and supervision. This work is the candidate's own work and original. To the best of our knowledge this report has not been submitted for any other degrees.

Therefore, we recommend this dissertation to be accepted and approved for the partial fulfilment of Master's Degree in Environmental science.

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LETTER OF APPROVAL

On the recommendation of supervisor “Mr.Sanuraja Maharjan”, this dissertation submitted by “Ms.Ritu Byanju” entitled “**Assessment of carbon stock and estimation of fuelwood consumption in Kajiko Tatha Dhaireni Community Forest in Panchkhal, Kavrepalanchok**” is approved for the examination and submitted to Khwopa College in the partial fulfilment of the requirements of M.Sc. in Environmental Science.

…………………

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DECLARATION

I hereby declare that the work presented in this dissertation entitled "**Assessment of carbon stock and estimation of fuelwood consumption in Kajiko Tatha Dhaireni Community Forest in Panchkhal, Kavrepalanchok**" is a genuine work done originally by myself and has not been submitted elsewhere for the award of any degree. All sources of information have been specifically acknowledged by reference to the author(s) or institution(s).

……………………….

Ritu Byanju

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Ritu Byanju

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ABSTRACT

Carbon sequestrationis the process of capture and long-term storage of atmospheric CO_2.This study was carried out in Kajiko Tatha Dhaireni Community Forest of Panchkhal Municipality to assess total biomass and carbon stock of that forest and to estimate total fuelwood consumption by Community Forest Users Group (CFUG) members. The methods used for the study were Primary data collection and secondary data collections. Random sampling was done for both forest inventory and socioeconomic data collection. A total of 36 circular quadrats of 250 m^2 were used for forest data collection and 96 households were surveyed for socioeconomic information. The above ground tree biomass (AGTB) was measured by using allometric equations (models) developed by Chave et al. (2005) for moist forest types whereas belowground biomass was estimated by using the relationship recommended by FAO(2000). Likewise, Soil Organic Carbon (SOC) was determined by Walky and Black's titrimetric method.

The average tree carbon content of the forest was 98.61 ± 12.19 t/ha and total average biomass of the forest was 146.52 ± 26.48 t/ha. Biomass and carbon content is high in Mixed forest than other type of forests in the study area. The totalfuelwood consumption of users was 4249.24kgper year in summer while in winter, the total fuelwood consumption was 5720.04 kg per year. The total average fuelwood consumption was 4990.775 kgper year.The total fuelwood consumption before installation of any alternative source was7234.35Kgper year. After its installation, total fuelwood consumption is decreased by 31.01% than before. The consumption of fuelwood has decreased due to installation of various types of alternative energy sources.The total supply of fuelwood by CFUGs was only 425 Kg per year.It shows the demand of fuelwood was very high than supplied for the users.

Keywords: Soil Organic Carbon, Tree Biomass, Tree Carbon, Fuelwood consumption

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ABBREVIATIONS, ACRONYMS AND SYMBOLS

%	Percentage
AGTB	above Ground Tree Biomass
AGSB	Above Ground sapling Biomass
BGB	Below ground biomass
BGC	Below ground carbon
C	Carbon
CC	Climate Change
CF	Community Forest
CFUGs	Community Forest User Groups
cm	Centimeter
CO_2	Carbondioxide
DBH	Diameter at Breast Height
et al	and others (from Latin *et al*)
GPS	Geographical position system
g	Gram
ha	Hectare
hr	Hour
ICS	Improved Cooking System
IPCC	Intergovernmental Panel on Climate Change
KCF	Kumvakarna Conservation Community Forest
Km	Kilometre
KTDCF	KajikoTathaDhaireni Community Forest
LHG	Leaf, litter, Herb and Grass
LPG	Liquidified Petroleum Gas
m	Metre
MCF	Manthali Community Forest
min	Minute
No	Number

OC	Organic carbon
ppm	Parts per million
Rs	Rupees
SOC	Soil Organic carbon
t	Ton

CHAPTER I

1. INTRODUCTION

1.1 Background

Carbon stock and Climate change

Global carbon cycle is one link in a causal chain linking human activities to changes in climate. The causal chain includes relations between human activities, emissions of greenhouse gas concentrations, alteration of components of the climate system (greenhouse gas concentration, aerosols, land cover, etc.), changes in the radioactive balance of the atmosphere, and the response of climate. The behavior of global carbon cycle determines the response of the atmospheric concentration of CO_2, the greenhouse gas of greatest concern, to sources and sinks of CO_2 from a wide range of human activities, particularly CO_2 emissions from fossil fuel consumption. Currently, our ability to forecast future climate is in question. Models are used to make projections of future climate, based on scenarios of future human activities and emissions, by simulating each link in the causal chain relating these scenarios to changes in climate. The estimation of the uncertainty of this causal chain remains an important scientific challenge (Kheshgi and Jain,2000).

Global climate change poses a threat to the well-being of humans and other living things through impacts on ecosystem functioning, biodiversity, capitalproductivity, and human health. Climate change economics attends to this issue by offering theoretical insights and empirical findings relevant to the design of policies to reduce, avoid, or adapt to climate change.(Pizer and Goulder,2006)Although studies have shown that forests have adapted to temperature increases of 2-3°C (3.6-5.4°F) in the past, these changes occurred over thousands of years. Current climate predictions suggest that average global mean temperatures could rise 1.5-5.8°C (2.7-10.4°F) over this century alone. Such rapid changes in a relatively short period of time could affect forests significantly. (Sohngen *et.al* 2003)

A key issue in global conservation is how biodiversity co-benefits can be incorporated into land use and climate change mitigation activities, particularly those being negotiated under the United Nations to reduce emissions from tropical deforestation and forest degradation. Protected areas have been the dominant strategy for tropical forest conservation and they have increased substantially in recent decades. Avoiding deforestation by preserving carbon stored in vegetation between protected areas provides an opportunity to mitigate the effects of land use and climate change on biodiversity by maintaining habitat connectivity across landscapes.(Laporte *et.al* 2014)

The carbon sequestration process involved in individual tree is an important concern in environmental system. The carbon sequestrations in trees represent balance between the process of photosynthesis and respiration which uses and releases carbon dioxide respectively. The process of carbon sequestration is the most rapid during the early stage of the life of tree while,as tree reaches maturity the above two process become increasingly similar. Additionally, the rate of carbon sequestration is less particularly in over mature stage of the tree. Hence, the tree or forest expands the capacity of carbon sequestration also increases and vice-versa.(Sedjo et.al. 2003).

Community forest and carbon sequestration

Forests are known to play an important role in regulating the global climate. They play a key role in as both sinks and sources of carbon dioxide. The carbon pool in a forest ecosystemcan be broadly categorized into biotic (vegetative carbon) and pedologic (soil carbon) components. As tree grow, they sequester carbon in their tissues, and as the amount of tree biomass increases (within a forest or in forest products), the atmospheric $CO_2$is mitigated (Shrestha, 2008).

The community forestry policy focuses mainly on handing over accessible forest to the forest user groups(FUG) irrespective of political boundaries.FUG is formed including households living nearby the forest and who have been traditionally using the forest resources. FUG has the legal authority to get all income generated from the community forest resources. As the FUG start management, they get forest products from cleaning, pruning and thinning operations. They are distributed among the users and surplus is sold outside the FUGs. Orientation of the entire forestry department staff to cates for change of their traditional role as policeman to an extension worker.(Joshi,1993).

Forests sequester and store more carbon than any other terrestrial ecosystem and are an important natural `brake' on climate change. When forests are cleared or degraded, their stored carbon is released into the atmosphere as CO_2. Deforestation and forest degradation are the second leading causes of global warming. Tropical forest clearing accounts for roughly 20% of the anthropogenic carbon emissions and destroys significant carbon sinks globally (IPCC,2007). Sustainable management of forest in Nepal could not only increase and stabilize the supply of forest products, but it would also help in contributing the livelihood of the 17,685 CFs and CFUGs and 2.18 million households involved in community forest management (DoF, 2012).

Fuel wood Consumption

The importance of ecological systems in supporting social systems has been identified as one of the most important facets of sustainable development. Consequently, a number of international and local laws and policy interventions have been established to ensure that natural resource use remains sustainable. In rural areas, overdependence on fuel wood has commonly been identified as one of the biggest threat to forestry ecosystems. This in turn has led to environmental degradation that includes among others species depletion, soil erosion and decline in water and air quality (Ndamase, 2012). The rural population works under the community forest policy, but illegal harvesting in natural forests is indiscriminate and results in severe environmental degradation.(Sharma *et.al*,2009)

Fuel wood is a derived demand for energy. Similarly, timber is also a derived demand for houses andbuilding, and for furniture. Demand for these products like other products depends on their respectiveprices and substitutes such Kerosene and LPG for energy, and iron/aluminum/plastic for timber, incomeof the households, and their preferences. Since about 86 percent of Nepal's households use fuelwood andmore than 75% of them collect their fuelwood, the opportunity cost of labor and ease of accessibility offorests also affect the consumption of fuelwood in Nepal. The supply of forests depends on two sources of forests – one for the existing forests and the other from deforestation. Fuelwood is the lowest valued wood everywhere in the world. Out of the total wood supplied, the best or the highly valued wood would be utilized as timber or poles for construction and for furniture. Therefore, fuelwood would be the largest share of total wood in Nepal. However, the allocation of total wood into fuelwood and timber used will vary depending on its production in different ecological zones of Nepal.(Kanel *et.al* 2012)

For the poor in Nepal, urban as well as rural, wood is usually the principal source of energy for cooking food and for keeping warm. (Adhikari,2014).Fuelwood is sufficiently scarce, however, to alter behaviour for those households in the hill region that do not participate in market exchange. These households may be the best targets for public market interventions designed to alter fuelwood supply and deforestation.(Kanel et.al 1998)

1.2 Rationale of the study

As we know, the main problems that occurred in the environment is due to climate change. Climate change is caused naturally as well as due to some certain human behaviour. There is the great role of forest in mitigation of 'Global warming' and 'Climate Change' bystoring carbon in tree biomass. The carbon sequestration has a significant contribution to environmental benefits, any shrinkage of forests have an enormous impact on carbondioxide emission with long term consequences. This study is helpful to get information about the benefits of trees in carbon sequestration and also helpful in management of forest to increase carbon sequestration. Estimation of carbon stock in KajikoTathaDhairaeni Community forest is still a new work to be done.

Fuelwood is the main energy source for local people in developing countries, especially in the rural areas. As forests are declared as community forest, people of community can harvest forest products like timber, fuel wood, litters etc only in certain interval of time and they have to follow some rules for it. This study of estimating consumption of fuelwood is important because it would bring information on demand of fuelwood and the supply from the forest.The information would be helpful for community forest management and regulating fuelwood resources in the studied forest. It also may be helpful for finding alternatives of energy sources if their demand is high than supply.

1.3 Objectives

The general objective of the research is:To assess carbon stock and to estimate fuelwood consumption of Kajiko Tatha Dhaireni Community Forest.

The specific objectives of the study are:

- To determine the Tree density, frequency, basal area of trees in forest.
- To determine the biomass and carbon content of the forest.
- To estimate the annual consumption of fuelwood by community forest users.
- To estimate the annual supply of fuelwood by CFUGs.

1.4 Limitations

- The findings of this report is limited to Kajiko Tatha Dhaireni Community Forest.
- The results were based on respondent's answers.
- The results of the study area may not applicable to other areas.

CHAPTER II

2. LITERATURE REVIEW

2.1 Community Forestry (CF) in Nepal

National Forestry Plan (1976) for the first time encouraged the involvement of local people in participatory natural resource management (Acharya, 2002). With this new paradigm of involving communities in resource management, the community forestry program was formally initiated under the legislative framework of Panchayat Forest Rules (1978) and the Community Forestry Programme (1980) by giving right to local communities to manage forest. Thus, community forestry program was initiated on 1978 on the ground of rapid decline of forests area and biodiversity. It is a partnership between local communities and the government for protection, management, and sustainable utilization of forest products and ecosystem services to meet the daily need of local community.

Master Plan for Forestry Sector (MoFSC, 1988) fully recognized the need of peoples' participation, and Forest Act (1993) provided detailed guidelines and policy framework for community forestry. Main components of the program are: formation of community forest users' groups (CFUGs), preparation of operational plan, approval of the operation plan by District Forest Office (DFO), and hand over of the forest to the community (HMG, 2002).

The Master Plan for the forestry Sector (1989), the Forest Act (1993), the Forest Regulations (1995) and the Forestry Sector Policy (2000) reaffirmed government's policy to implement and strengthen the community forestry program. Remaining within this legal and strategic framework, the CFUGs have been, managing, protecting, and utilizing forests for more than three decades. About 35% of the population of Nepal is involved in community forestry management program managing 25% of the total area of forests (Nurse and Malla, 2005). By the end of December 2013, a total area of 14.7 million ha of national forest has been handed to 17,808 CFUGs involving 2.19 million households. In Bhaktapur district 54 community forests have been registered in District Forest Office (DFO) as record of 2007.These forests have been managed by forest users groups. It is important in community forestry in order to maintain ecosystem, improve livelihood of CFUG members. However, forest management should be guided by sustainable harvest to maintain resource demand and supply (CFD, 2013).

2.2 Carbon sequestration and climate change

In the terrestrial system carbon is sequestered in rocks and sediments, in swamps, wetlands and forests, and in the soils of forests, grasslands and agriculture.There are four components of carbon storage in a forest ecosystem. These are trees, plants growing on the forest floor (understory material), detritus such as leaf litter and other decaying matter on the forest floor, and forest soils(Sedjo et al., 1998). Carbon sequestration can be defined as “the process by which CO2 sinks (removed from the atmosphere) is known as carbon sequestration”, or as “the process where CO2 is pulled from the atmosphere and stored for a long period of time, or simply as “the action of removing carbon from the atmosphere”. Carbon sequestration is the extraction of the atmospheric carbon dioxide and its storage in terrestrial ecosystems for a very long period of time - many thousands of years. Plants store carbon for as long as they live, in terms of live biomass. Once they die, the biomass becomes a part of the food chain and eventually enters the soil as soil carbon. When the biomass is burned, the carbon is back into the atmosphere and is free to move in the carbon cycle (Waran and Patwardhan, 2001). Terrestrial ecosystems are important in the Earth’s carbon (C) balance and, potentially, in offsetting anthropogenic emissions of CO_2 (Beedlow *et al.*, 2004).

Koju(2012) concluded that Increase in carbon dioxide in the atmosphere gives rise to global warming which adversely affect the world climatic pattern. As a result, various problems have arisen to affect us in various manners.In this connection, the vegetation has acted as a vehicle that can absorb carbondioxide and play vital role for the decrement of global warming.Hence,in this current situation, Kenaf has been taken as medicine for the treatment of the environmental ills.The total average biomass of Kenaf plant per season was estimated to be 22.49tons/ha.The seasonal total average aboveground biomass was 20.77 tons/ha which includes 17.60 tons/ha total average of biomass of stem,2.24 tons/ha total average biomass of branches and 0.93 tons/ha total average biomass of leaves. The total average below ground biomass or root biomass per season was 1.72 tons/ha.

Carbon content was found higher in the stem part i.e. 33.36% and lowest in the branch i.e. 14.65%. The total carbon stock from Kenaf stem per season was 5.86 t/ha,from Kenaf branches was 0.33 tons/ha and from Kenaf leaves was 0.19 t/ha.Thus total above ground carbon stock per season was 6.38 tons/ha. The total root carbon stock per season was 0.55 tons/ha.Totalbiomass carbon stock in Kenaf per season was 6.93 t/ha. The dry fiber yield was 4 tons/ha to 5 tons/ha. Kenaf has different uses.

Chaudhary(2009) revealed that climate change caused by emission of increased greenhouse gases and the flux in terrestrial plant carbon stock are real and have serious impact.He found the biomass organic carbon in Pashupati forest was 55.43 tons/ha and average soil organic carbon for both aspect was 18.23 tons/ha.Monetary evaluation of total carbon stock in Pashupati forest was 33147 dollar evaluation 5 dollar.

2.3 Carbon stock on forest and soil of Nepal

Baskota*et al*. (2007) studied rate of carbon sequestration in community managed forest located in different geographical and climatic conditions of Nepal. Their findings are tabulated below.

Table 1: Carbon Stock of community forests in different geographical locations of Nepal

Community Forest	**Carbon Mass (t/ha)**			**Mean Carbon Sequestration Rate (tC/ha/year)**
	Year I	**Year II**	**Year III**	
Illam	57.94	60.75	64.31	3.1
Lamatar	51.19	52.32	54.00	1.42
Manang	30.94	NA	33.19	1.13
Mean Carbon Sequestration Rates across Community Forests				

Source: Baskota *et al.*, 2007

Table 2 :Status of Carbon in Forest and Shrub Land of Nepal

Category	Carbon (million metric tones)		
	1990	2000	2005
Carbon in above ground biomass	278	385	359
Carbon in below-ground biomass	97	135	126
Sub total: in Living Biomass	375	520	485
Carbon in dead wood	56	78	73
Carbon in litter	17	13	13
Sub total: Carbon in dead wood and litter	73	91	86
Soil Carbon to a depth of 100 cm	432	350	326
Total Carbon	880	961	897

Source: *FAO 2006 cited in Oli & Shrestha (2009)*

2.4.Forest and Carbon sequestration

Forests have large pools of carbon, carbon contained in bark, branches, roots, leaves, litter and soils. The carbon dioxide fixed by plants during photosynthesis is transferred to the different carbon pools (Vashum and Jayakumar, 2012). Forest sequesters and stores more carbon than any other terrestrial ecosystem and has potential to stabilize the GHGs concentrations (Gibbs et al., 2007). It absorbs carbon dioxide gas from the atmosphere in the form of biomass during photosynthesis process (Chavan and Rasal, 2012). Its play an important role in regional and global carbon (C) cycles because they can recapture and store carbon dioxide released into the atmosphere (FAO 2005). It is estimated that an average 50% of the biomass is considered as carbon content for all the species of vegetation(MacDicken, 1997).The rate of carbon stock increases in young tree species, while it declines after full growth as the stand ages (Jana et al., 2009). When forested lands are cleared or converted into other land uses such as agriculture, or urban landscapes or by disturbance of such as fire and insects outbreaks, exacerbated by climate extremes and climate change, the carbon earlier stored in forest ecosystem, is released back into the atmosphere(Canadell and Raupach, 2008). It is said that if forest biomass expands, the amount of carbon contained increases otherwise the biomass contracts, the holds less carbon (Sedjo, 2001). The character of reducing carbon source and increasing carbon sink can be carried through effective protection and conservation of carbon pools in the existing forest (Khanal et al., 2010).(Bass et al., 2000) identified three carbon management strategies in forests. The three strategies, namely are, carbon sequestration, carbon conservation and carbon substitution.

Kumpakha(2012) found that the rate of carbon sequestration was least at the eastern aspect of Nagarkot forest. The average northern aspect showed highest rates of carbon sequestration 3.28 t/ ha/ yr. In average elevation wise the rates of carbon sequestration is of 2.57 t/ ha/ yr. *Alnus nepalensis* forest, *Pinus roxburghii* forest and *Pinus wallichiana* forest demonstrates sequestrated carbon at the rates of 3.76 t/ha/yr,3.30 t/ha/yr and 1.57 t/ha/yr respectively.The mean for the studied Nagarkot forests sequester carbon at the rate of 2.57 t/ha/yr.

Basukala(2012) revealed that the Tree Species Richness and Shannon Diversity Index was found higher in Broad leaved forest compared to Pine forest,affirming greater diversity of Broad leaved forest. The Evenness and Simpson's Dominance index were found high in Pine forest compared to Broad leaved forest because the pine plantation was dominated by a single species *Pinus roxburghii*.The mean aboveground woody biomass and hence the carbon stock was found to be high in Pine forest(130.20± 17.60 tC/ha) compared to broad leaved forest(87.96 ± 9.21 tC/ha).This study concludes that the Pine forest has more mean above ground carbon stock than broad leaved forest because pine forest is a 30 year old plantation forest protected from human disturbance since plantation hence has been able to accumulate more carbon stock while the broad leaved forest is a naturally regenerating forest which has faced disturbance and degradation previously and has ben protected under community management than a decades.

Mishra (2010) found that anthropogenic emissions have increased the atmospheric level of CO_2 from 280 ppm at the pre industrial to the present level of 390 ppm and the global mean temperature has increased by 0.6ºC during the 20th century.The biomass carbon of the community forest was found to be 119.742 tons/ha. Out of which, aboveground biomass carbon and belowground biomass carbon was found to be 106.747 tons/ha and 12.995 tons/ha respectively. Soil organic carbon was found to be 32.29 tons/ha. The soil organic carbon found decreasing with depth. Total CO2 stored in the forest was found to be 557.465 tons/ha.This study shows that there is potential of storing and sequestering carbon in the community forest. However, human interferences have negative impact on average carbon stock. Inadequate information about the status of biomass and carbon stock in the community managed forest has been a major problem to estimate total contribution of forests on carbon sequestration. Community managed forests, if managed properly, can restore carbon and contribute to climate change mitigation.

Kamelarczyk, 2009 found that by applying different estimation methods on field inventory data the totalcarbon stock in Zambian forest amounts to between 2652 and 3323 mega tonnes. Aboveand below ground biomass in forest is estimated to be in the range of 960 and 1561 megatonnes of carbon, which translates into between 15 and 24 tonnes of carbon per hectare.Semi-evergreen forest (miombo) makes up the main bulk of woody biomass in Zambia. Thecarbon pool in soil is also suggested to contribute considerable to the total carbon stock inforest with an estimated quantity of 1549 mega tonnes (based on IPCC default values). Landuse categories outside forests have insignificant importance relative to forest in terms ofcarbon storage in woody biomass. The study provides forest carbon stock estimates inbiomass pools that are distinguishable different from previous estimates in the literature,which is here argued to be caused by overestimation in the latter.

Subedi, 2009 found that the estimated total biomass organic carbon sequestration was higher in North West aspect than that of South East aspect of Suryabinayak community forest.The above ground and below ground carbon sequestration in North West aspect was found 1.06 and1.10 times higher than the South East aspect.The soil carbon carbon sequestration was found 1.32 times as higher as total biomass carbon sequestration in Suryabinayak Community forest.Moreover,carbon sequestration potential was found higher in both aspects of middle altitude as compared to lower and higher altitude. As carbon sequestration rate found to be 1.9TC/ha/yr,the total carbon sequestrated by the forest is estimated to be 128.59TC/yr and the carbon credits in monetary value ranges from US dollar 2357.75 to US dollar 5658.

2.5 Fuelwood consumption

Sambo*et. al*, 2013 revealed eight fuelwood consumers. The consumers are households, bakeries, meat roasters, fish fryers,hotels/restaurants, food vendors, tea shades, and beans cake fryers. The major sources of fuel wood to the study area were identified to be natural forests(70%), farm land (8.3%), and tree plantation (20.8%). The results also revealed that the most common tree species utilized for fuelwood are *Prosopis africana*(2.9%), *Terminalglaucescens* (2.1%), *Azadirachta indica* (19.2%), *Tormarindus indica* (12.1%), *Anogeissusleio carpus* (58.3%) and *Parkiabi globosa* (5.4%).The study shows that 78.6% of the consumers used other forms of energy while21.4% depend solely on fuel wood. Furthermore, the result indicated that 81.2%of the respondents ascribed their reasons for the use of fuel wood to availability,76.3% to convenience, 82.3% to cost factor, 54.3% to the reason that some fooddon't cook well with other energy forms, 90.3% to the reason that fuel wood isrelatively faster in cooking, and 65.6% to the high/unstable prices for otherenergy forms.

Aryal*et.al* (2009) found that the demand of fuelwood in CFUGs and the supply of fuelwood from the CF showed heavy deficit of fuelwood in both the CFUG. Only 12.03 % of the fuelwood demand in Santi Community Forest User Group and 8.03 % of fuelwood demand in Barangdikol Community Forest User Groupwas found to be supplied by the sustainable yield fromthe CF. The determination of the growing stock andregeneration rate of the studied forest showed that the SCF was in good condition and BCF was in poor condition.

Fuelwood can be sustainably derived from any unit of land only if therate of growth is equal to or exceeds the rate of extraction. Supply of fuelwood from the forest depends on manyfactors including availability of per capita forest area inthe CFUG, growing stock of the forest, and nature of thespecies growing in the forest. Demand is directly related to the fuelwood consumption activities and patternamong the CFUGs member. Comparison of supply of fuelwood from CF at individual household showed that it washigher in the SCF. Households demand of fuelwood was less inBCF than in SCF. This is partly due to Households size andpartly due to installation of fuelwood efficient ICS and biogas.

Kanel *et.al*(2012) found that In 2011, the demand of fuelwood is estimated to be 5.3 million tons, 4.4 million tons and 0.82million tons in the Terai, hills and mountains respectively. It would change to 5.48 million tons,4.27 million tons and 0.78 million tons for these regions in 2020. Similarly, the total fuelwooddemand in 2030 would be 5.62 million tons, 4.05 million tons and 0.72 million tons in these threeregions. The supply of fuelwood is estimated to be 2.58 million tons, 5.44 million tons and 0.94 milliontons for Terai, hills and mountains respectively in 2011. The supply would increase to 3.72million tons, 6.96 million tons and 1.13 million tons in 2020 and 5.07 million tons, 9.60 milliontons and 1.51 million tons in 2030 for Terai, hills and mountains respectively.

CHAPTER III

3. MATERIALS AND METHODS

3.1 STUDY AREA

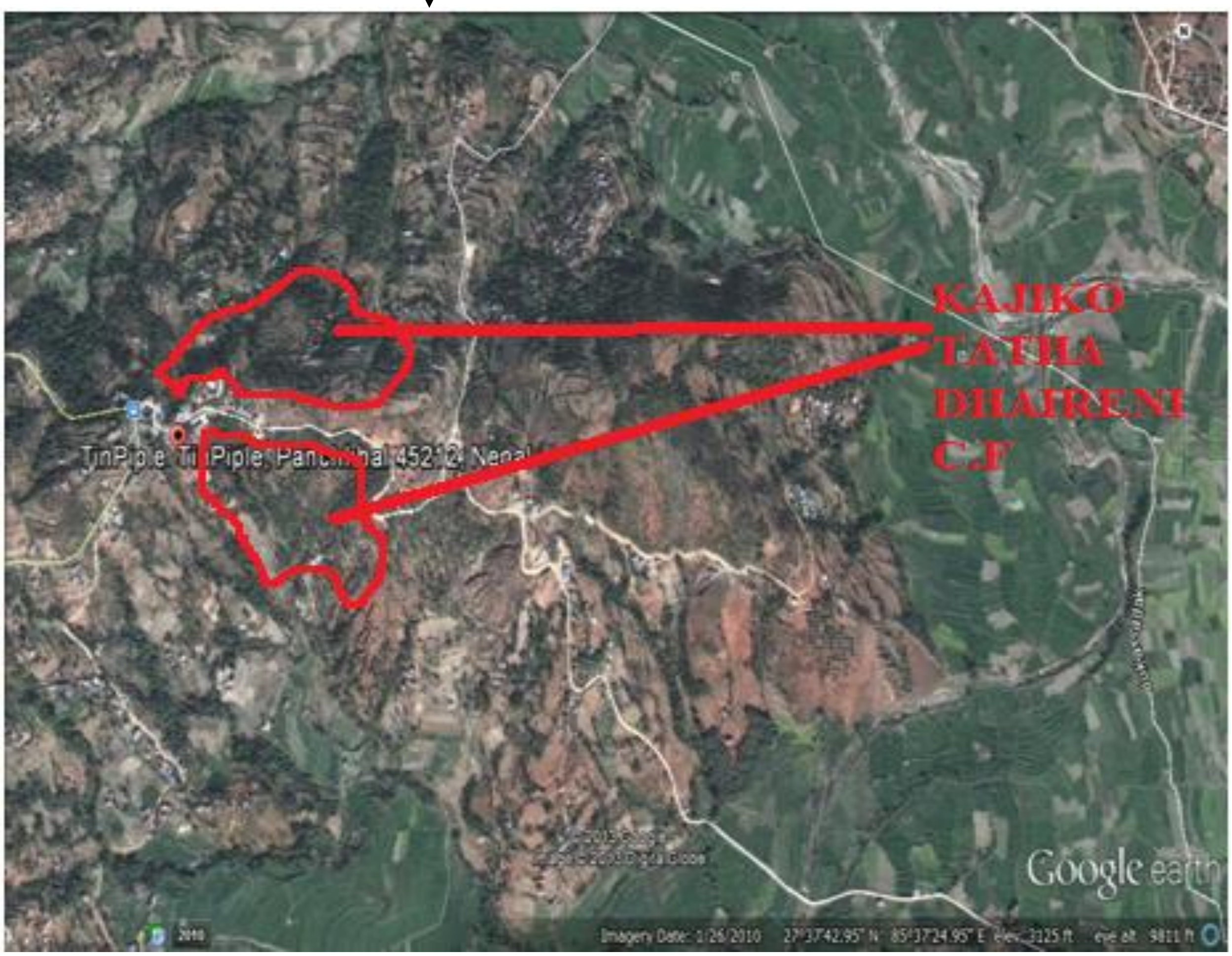
3.1.1 PANCHKHAL

Panchkhal is a Municipality in Kabhrepalanchok District in the Bagmati Zone of central Nepal. Its geographical coordinates are 27° 39' 0" North, 85° 37' 0" East. According to the census of 2011,the total number of people who live in Panchkhal are 33847.The main places of that area is Hoksebazar and Baluwapati deubhumi. The main occupation of the people of Panchkhal is agriculture.

3.1.2 COMMUNITY FOREST

The study area was Kajiko Tatha Dhaireni Community forest of Panchkhal Municipality. It is located at ward.no 8 and 9 of Panchkhal, Kavrepalanchok. Its area is 181.75 hectares. Its slope is 5°-35°.Soil is red, black and rough. The trees mainly found in this community forest are *Shorea robusta, Pinu sroxburghii*, *Schima wallichii*, *Eugenia jambolana, Dalbergia Sissoo* etc.

Kavrepalanchok District



(Source: Google Earth 2015)

Fig 1 : Location map of study area

3.2. Methods of Data Collection

3.2.1 Primary Data Collection

3.2.1.1 Forest Inventory

Preliminary survey was done in the community forest to get some knowledge about that forest like the condition of forest, to know the species composition of trees found there etc.36 sampling plots were taken for the study of forest and for the estimation of carbon, the quadrat of 250m^2 was used in 36 plots. And then, DBH and height of the trees were determined.

The soil samples were collected from three different depth i.e. 0-15 cm, 15-30 cm and 30-45 cm at the center of the each quadrate. Before collecting the soil samples all the vegetation and litter were removed from the surface. Two samples from each layer were collected from each quadrat. Every collected soil samples were well labeled and were brought to laboratory for further processes.

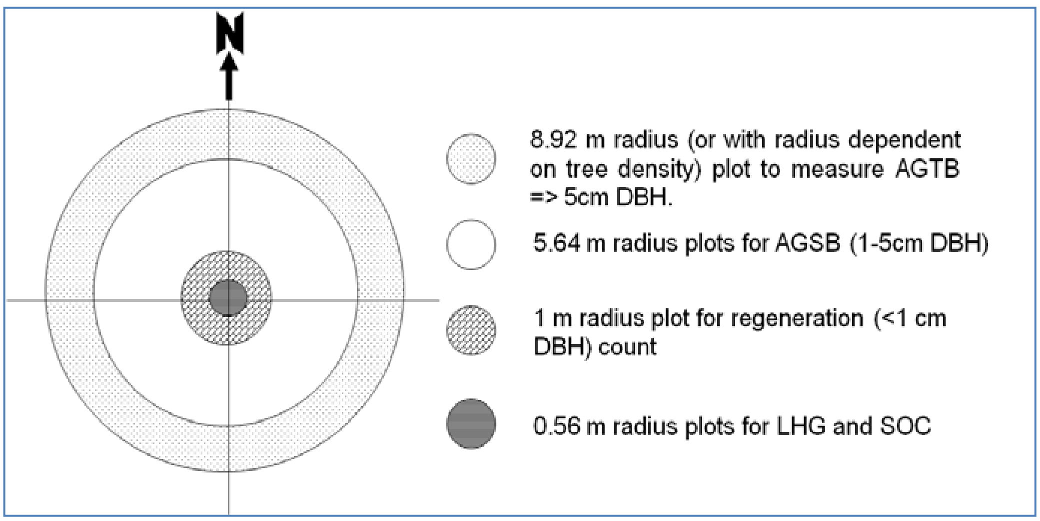


Fig 2:Sampling Design of circular plot(Source: Subedi *et. al* 2010)

3.2.1.2 Questionnaire survey

Questionnaire survey form were made and questionnaire survey was done in 96 households of CFU members.Random sampling was adopted for the household survey

3.2.1.3 Key Informant Interview

Informal interview of key person of community forest management committee, CFUG was taken.

3.2.1.4 Group Discussions

Group discussions were done with CFUG members and community forest users.

3.2.2 Secondary Data Collection

- Literature Reviews.

Study of different case studies, thesis, articles, journals, books etc. were done.

3.3 Data Analysis

- To measure various ecological parameters of trees, density, frequency, basal area and their relative values were determined using formulas given by:

$$\text{Density}\left(\frac{\text{trees}}{\text{ha}}\right) = \frac{\text{Total no of individuals of a species}}{\text{Size of quadrat} * \text{no. of quadrats studied}} \times 10{,}000$$

$$\text{Relative Density}(\%) = \frac{\text{Density of an individual species}}{\text{Total density of all species}} \times 100\%$$

$$\text{Frequency}(\%) = \frac{\text{No. of quadrat in which species occurs}}{\text{Total no. of quadrat used}} \times 100$$

$$\text{Relative Frequency}(\%) = \frac{\text{Frequecy of a species}}{\text{Total frequency of all the species}} \times 100$$

$$\text{Basal Area} = \frac{\pi \times DBH^2}{4}$$

Where DBH = Diameter at breast height(1.37m ht.) of individual species

$$\text{Relative Basal Area}(\%) = \frac{\text{Basal Area of a species}}{\text{Total basal area of all the species}} \times 100$$

For the estimation of the carbon content in biomass and soil, various methods were used.

Above ground tree biomass (AGTB)

For estimating the tree biomass allometric equation given by (Chave et al., 2005) on the basis of climate and forest stands types was used. The allometric equations (models) used was

$AGTB = 0.112 * (\rho D^2 H)^{0.916}$ Where,

AGTB = aboveground tree biomass (kg)

ρ = wood specific gravity (gm cm^{-3})

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

H = tree height (m)

For the estimation of the tree height the equation used was:
$H = b \tan \theta + a$

Where; H = total height of tree in meter
θ = angle of elevation to the top of the tree from observers eyes.
b = distance between the tree base and the observer in meter
a = observer eye height in meter

- By taking the sum of all the individual biomass weights (in kg) of sampling plots and dividing it by the area of sampling plots, the biomass is obtained in kg/m^2.This value were then converted to tons/ha.
- The biomass was converted into carbon stock after multiplication with the (IPCC, 2006) default carbon fraction of 0.47.

Above-ground sapling biomass (AGSB)

To determine the above-ground sapling biomass (AGSB) (1-5cm DBH), national allometric biomass tablewas used. These tables are developed by the Department of Forest Research and Survey (DFRS) and Department of Forest, Tree Improvement, and Silviculture Component (TISC) (Tamrakar, 2000). The biomass values of sapling include foliage, branch, and stem compartments. The following regression model was used for an assortment of species to calculate biomass.

$\ln (AGSB) = a + b \ln (D)$

Where,

ln = natural log(dimensionless)

AGSB = above-ground sapling biomass [kg]

a = intercept of allometric relationship for sapling [dimensionless]

b = slope allometric relationship for sapling [dimensionless]

D = over bark diameter at breast height (measured at 1.3 m above ground) [cm]

Leaf litter, herb, and grass (LHG) biomass

The leaf litter was collected from each plot within the circular plot of area of 1 m^2. Fresh samples were weighed in the field with a 0.1 g precision and a well-mixed sub-sample. The sub-sample was selected and then 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:

$$\mathrm{LHG} = \frac{\mathrm{Wfield}}{\mathrm{A}} \times \frac{\mathrm{Wsubsample, dry}}{\mathrm{Wsubsmple, wet}} \times 1/1000$$

Where,

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

W_{field}= weight of the fresh field sample of leaf litter, herbs, and grass,destructively sampled within an area of size A [g]

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

$W_{subsample}$,dry= weight of the oven-dry sub-sample of leaf litter, herbs, and grass taken to the laboratory to determine moisture content [g]; and

$W_{subsample, wet}$= 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), was calculated by multiplying LHG with the (IPCC, 2006) default carbon fraction of 0.47.

Below-ground biomass (BB)

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

%Organic Carbon Estimation:

For determining soil organic carbon Walkely –Black Method (1934) was used.About 200 gm of fresh soil collected from each plot and stratum were air dried in laboratory and sieved with 50 micron sieve.The sample solution (1gm of soil+10 ml 1N $K_2CR_2O_7$ and 20 ml conc.H_2SO_4) titrated against 0.4 N Ferrous Ammonium Sulphates using diphenylamine as indicator, till end color is changed to brilliant green. Blank is also run with the same quantity of chemicals but without soil. Another three soil samples from each stratum were also collected for calculating bulk density using core sampler with standard volume. Bulk density was determined using core sampling method (Blake and Hartge, 1986). Following formula was used to calculate the bulk density using stone correction (Pearson *et al*., 2005).

$$\text{Bulk Density}\left(\frac{\text{g}}{\text{cm3}}\right) = \frac{\text{oven dried mass of soil}}{\text{core volume(cm3)} - \frac{\text{mass of corarce fragments(g)}}{\text{density of rock fragments}(\frac{\text{g}}{\text{cm3}})}}$$

Where, the coarse fragments are > 2mm. The density of rock fragments is 2.65 g/ cm^3. Finally the soil organic Carbon (SOC) was determined using below equation.

SOC = %SOC X soil bulk density X thickness of the soil horizon

Where;

OC = Organic concentration

And the result obtained was expressed in tons/ha.

Calculation of SOC

The carbon stock density of soil organic carbon was calculated as given by equation Pearson *etal*., 2007.

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

Where,

SOC = Soil organic carbon stock per unit area (t ha^{-1})

%C = Carbon Concentration

ρ = Soil bulk density (gm cm^{-3})

d = the total depth at which sample was taken (cm)

Total carbon stock

The carbon stock density was calculated by summing the carbon stock densities of the individual carbon pools of that stratum using the following formula.

C = C (AGTB) + C (AGSB) +C(HG)+C(L)+ C(BB)+SOC

Where,

C = total carbon stock [tC ha^{-1}]

C (AGTB) = carbon stock in aboveground tree biomass [tC ha^{-1}]

C (AGSB) = carbon stock in aboveground sapling biomass [tC ha^{-1}]

C(HG) = carbon in herb & grass [t C ha^{-1}]

C (BB) = carbon in belowground biomass [tC ha^{-1}]

C(L) =Carbon in litter[t C ha^{-1}]

SOC = Soil organic Carbon[t C ha^{-1}]

CHAPTER IV

RESULTS

4.1 Forest Characteristics

4.1.1 Diameter and height class distribution of trees

The mean dbh of the trees was found to be 17 cm. *Pinusroxburghii* contribute to both large and smaller trees. The highest number of trees was found in the size class 10-15 cm in the forest. Most of the trees had smaller diameter less than 30 cm. Only few trees showed larger girth, 42.5 cm of *Pinusroxburghii* as the biggest tree recorded. Greater number of trees of smaller diameter shows that the forest consists of young stand and is in intermediate stage of development.

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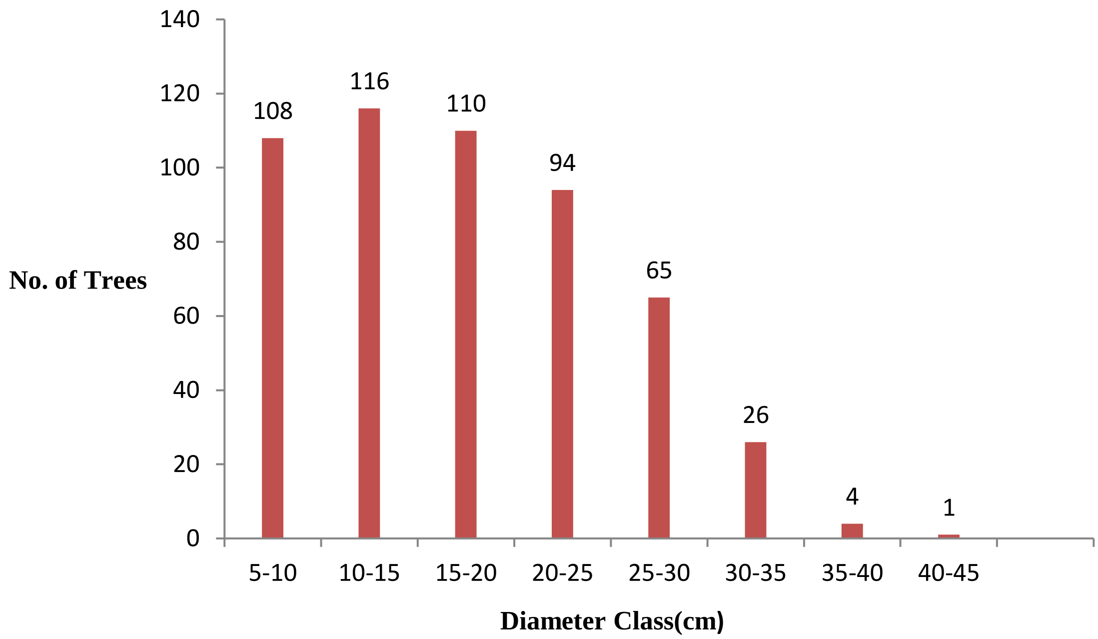

Fig 3:Size class distribution of trees (cm)

Similarly, the tallest tree was of height 24.8m of *Pinusroxburghii*. The highest number of trees were within height class of 15-20 m range in the KTDCF

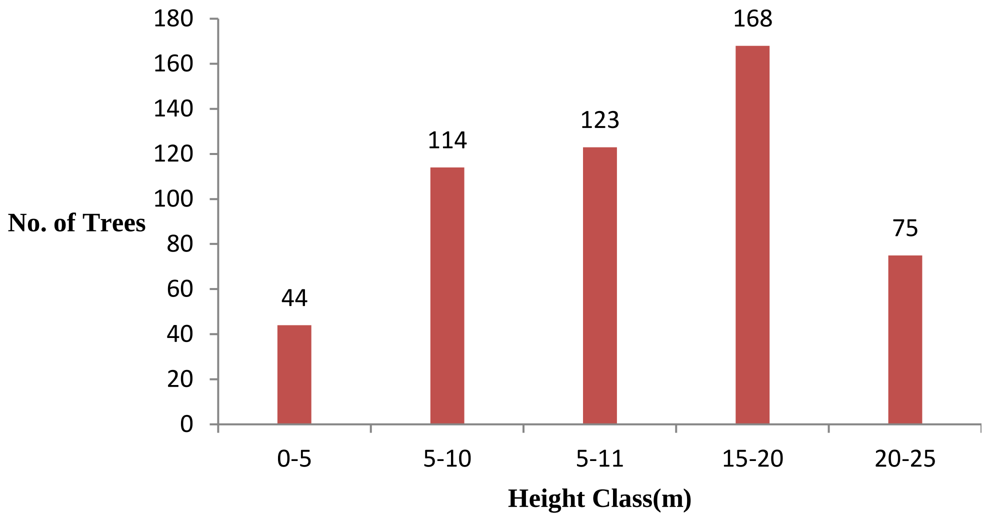

Fig 4: No. of trees in height class

4.1.2 Density, Frequency and basal area

In the studied forest, 10 species of trees were recorded. Among them, 8 belongs to frequency class A(0-20%),1 belong to class B(20-30%) and 1 belong to class E(80-100%). It shows that most of the species have low frequency of occurrence. The high frequency values of the trees*Pinusroxburghii*and*Shorearobusta*show that these species are widespread in the most of the plots.The density of *Pinusroxburghii* was higher in comparison to other tree species. *Engelhardiaspicata*, *Semecarpusanacardium* and *Choerospondiasaxilaris* had very less density. The total density of all tree species was found to be 482 trees/ha.

Pinusroxburghii and *Shorearobusta* were dominant in the KajikoTathaDhaireni Community forest.*Pinusroxburghii*possesshighest basal area of 8.57m^2/ha whereas the basal area of *Semecarpusanacardium*was found to be the least-0.0013 m^2/ha. The total basal area of all tree species was 10.42 m^2/ha.

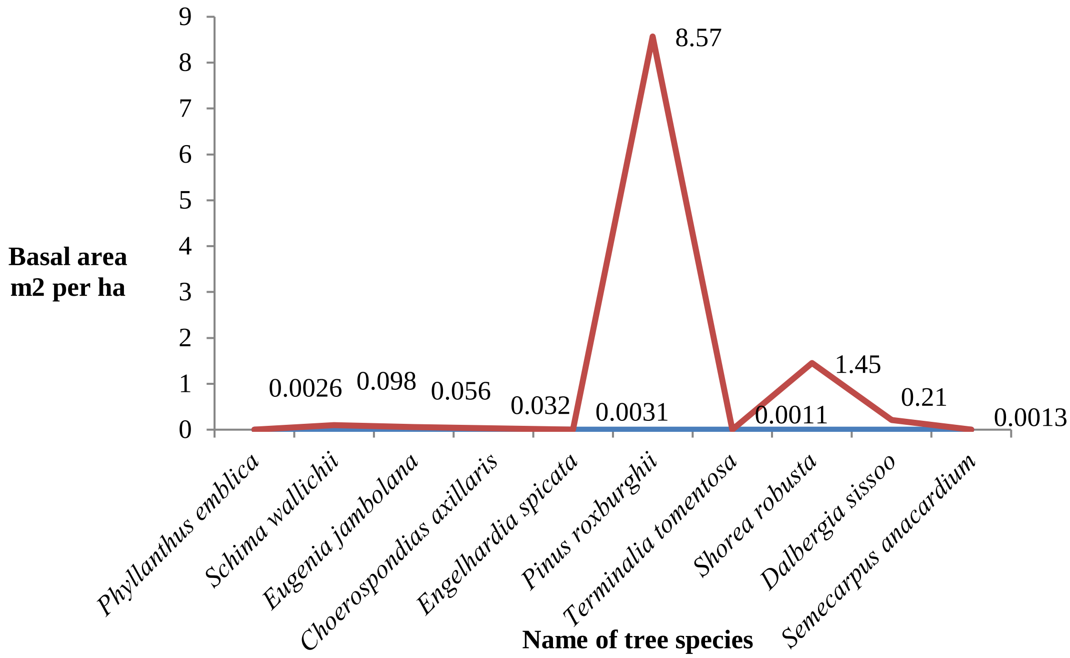

Fig 5: Basal area of tree species

Density of *Pinusroxburghii* is high which was 398 trees/ha.*Shorearobusta* showed density of 126.7 trees/ha.Other trees showed only minor contribution to the total density of trees. The total density of the studied forest was 582 trees/ha.

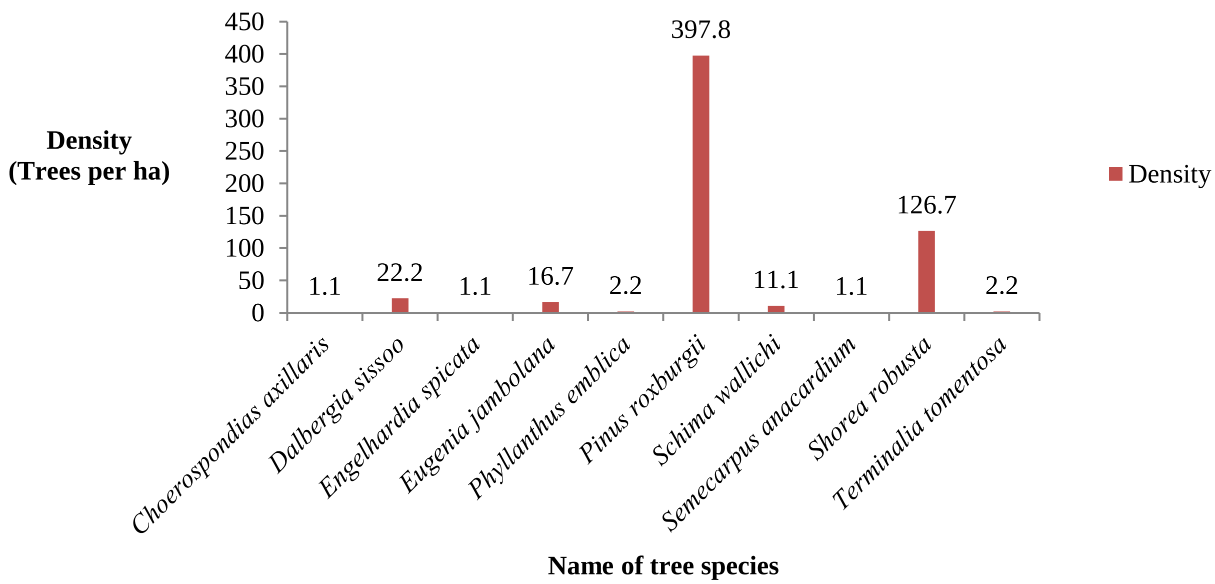

Fig 6: Density per tree species

4.1.3 Dominant trees, forest types and saplings

In 36 plots studied, 10 species of trees and saplings of 9 species were determined. According to the dominance (basal area vales) of trees in each plots, four types of forest were categorized i.e. Pine forest, Sal forest, Sissoo forest and Mixed forest.

Table 3:Name of trees and Saplings found in KTDCF

S.N.	Name of trees	Name of Saplings
1	*Shorearobusta*(Sal)	*Shorearobusta*(Sal)
2	*Pinusroxburghii*(Salla)	*Pinusroxburghii*(Salla)
3	*Semecarpusanacardium*(Bhalayo)	*Semecarpusanacardium*(Bhalayo)
4	*Phyllanthusemblica*(Amala)	*Phyllanthusemblica*(Amala)
5	*Dalbergiasissoo*(Sissoo)	*Dalbergiasissoo*(Sissoo)
6	*Eugenia jambolana*(Jamun)	*Eugenia jambolana*(Jamun)
7	*Engelhardiaspicata*(Mauwa)	*Engelhardiaspicata*(Mauwa)
8	*Schimawallichii*(Chilaune)	*Lyoniaovalifolia*(Angeri)
9	*Terminaliatomentosa*(Sanj)	*Terminaliatomentosa*(Sanj)
10	*Choerospondiasaxillaris*(Lapsi)	

4.2 Biomass and carbon content

4.2.1 Above ground biomass

The highest total above ground biomass content was found in Plot No. 15 (Mixed forest) which was found to be 317.43 tons/ha and the least total biomass content was of Plot No. 28 (Pine dominant forest) which was found to be 28.45 tons/ha.

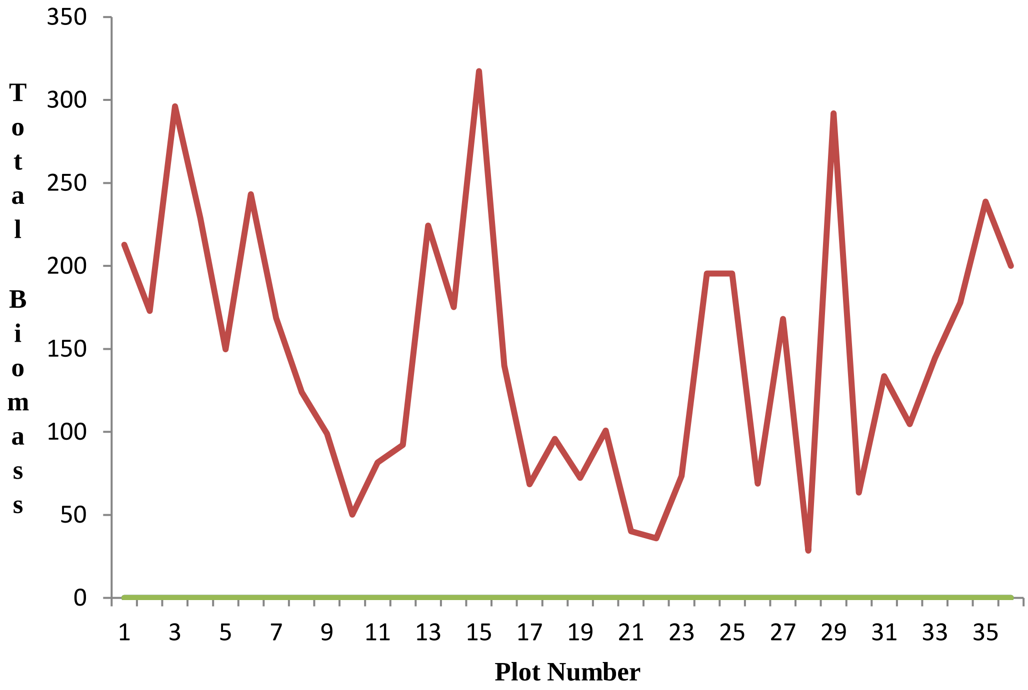

Fig 7: Total Biomass Content (tons/ha) per plot

The average biomass content of Mixed forest was 209.74 tons/ha which is the highest and of Sisso dominant forest is 92.12 tons/ha which is the least among all forest types.The average biomass of all the forest was 146.52 tons/ha.

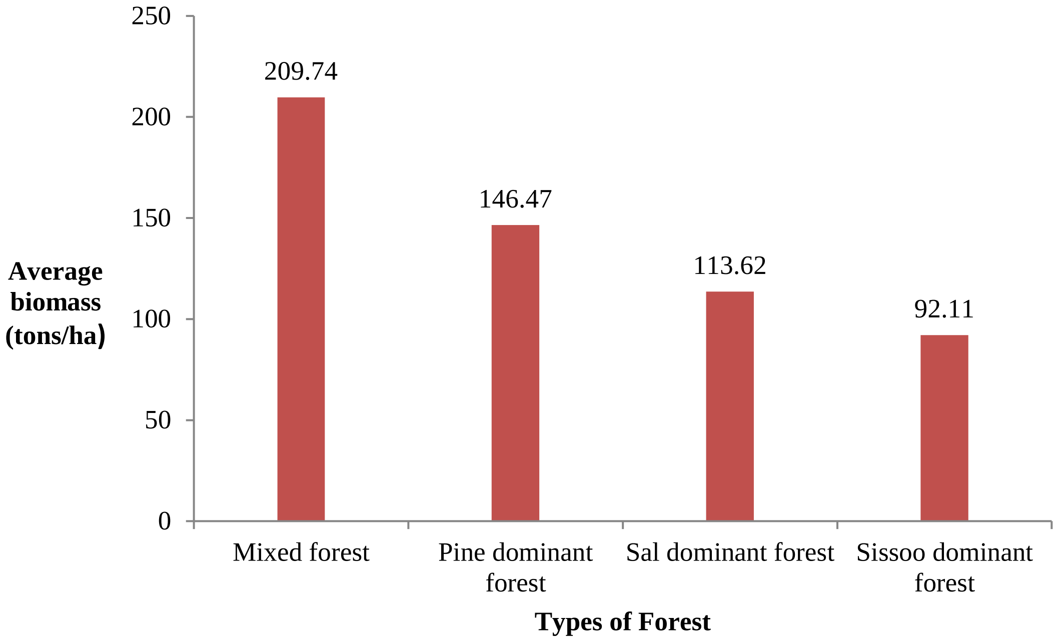

Fig 8: Above ground tree Biomass (tons/ha) as per Types of forest.

4.2.2 Above ground and below ground tree carbon

Total Above ground carbon is high in Plot No. 3(Pine Dominant forest) i.e115.55 tons/ha and least in Plot No. 28 (Pine Dominant forest) i.e10.68 tons/ha. Similarly, Below ground carbon is also high in Plot No. 3 i.e 23.11 tons/ha and least in Plot No. 28 i.e. 2.14 tons/ha.

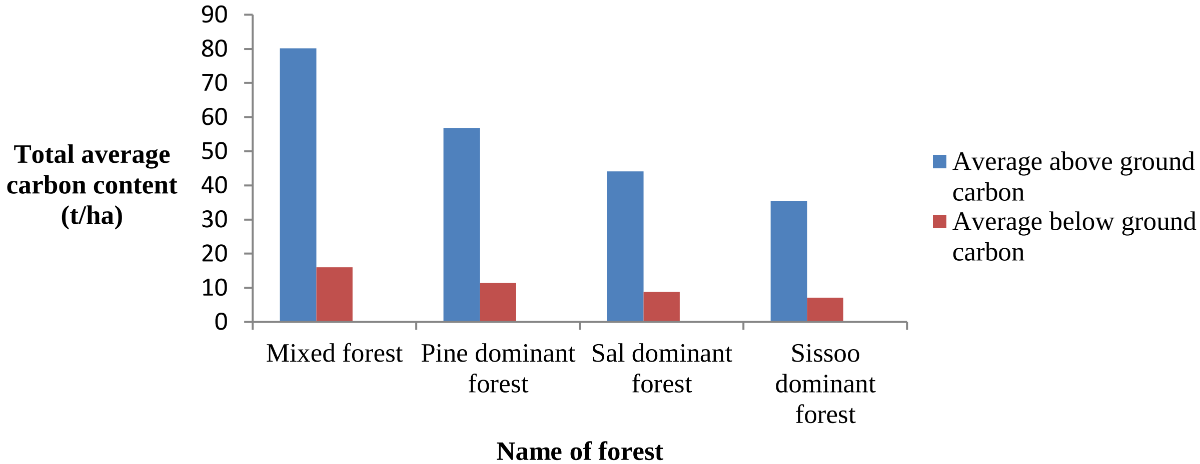

Fig 9: Total above ground and below ground tree carbon per types of forest

4.2.3Above ground sapling carbon

Saplings were not found in all sample plots. It was found only in 15 plots among all plots The highest above ground sapling carbon was found to be 3.62 tons/ha of Plot No.7 (Mixed Forest) and the lowest total sapling carbon was 0.07 tons/ha of Plot No. 32(Pine dominant forest).Carbon content in sapling(AGTC) was found the highest in mixed forest.

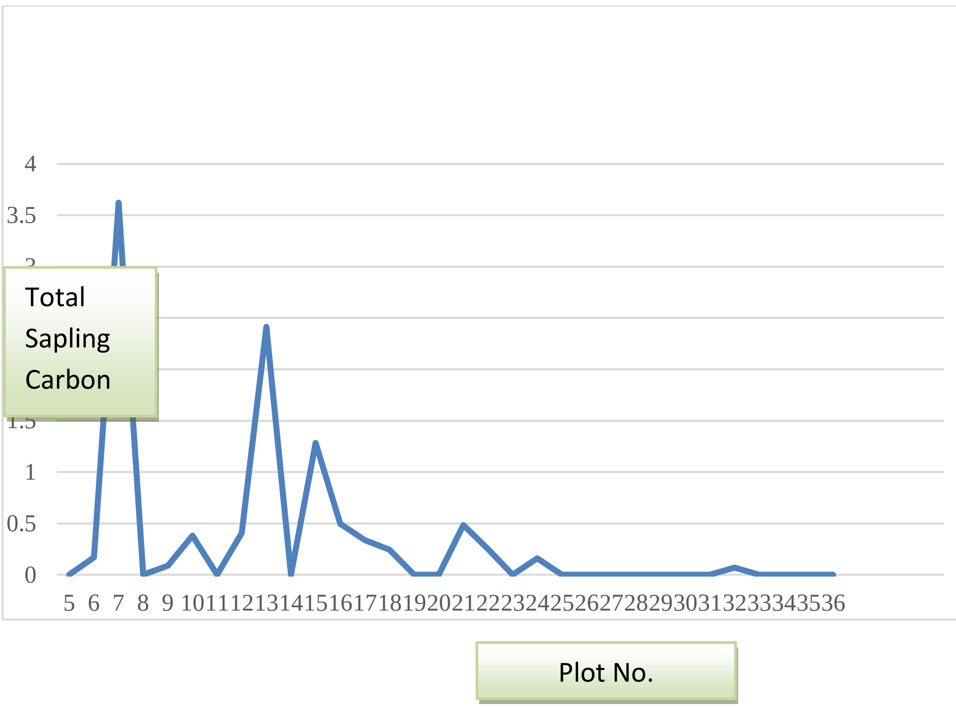

Fig 10: Total above ground sapling per plot

4.2.4.LHG and soil carbon

Total LHG carbon is high in plot No. 6 (Pine forest) i.e0.73 tons/ha and least in Plot No. 24(Sal forest) i.e 0.25 t/ha. And the highest total soil organic carbon was found to be 48.46 t/ha inSissoo forest and lowest was found to be 23.39 t/ha in mixed forest.

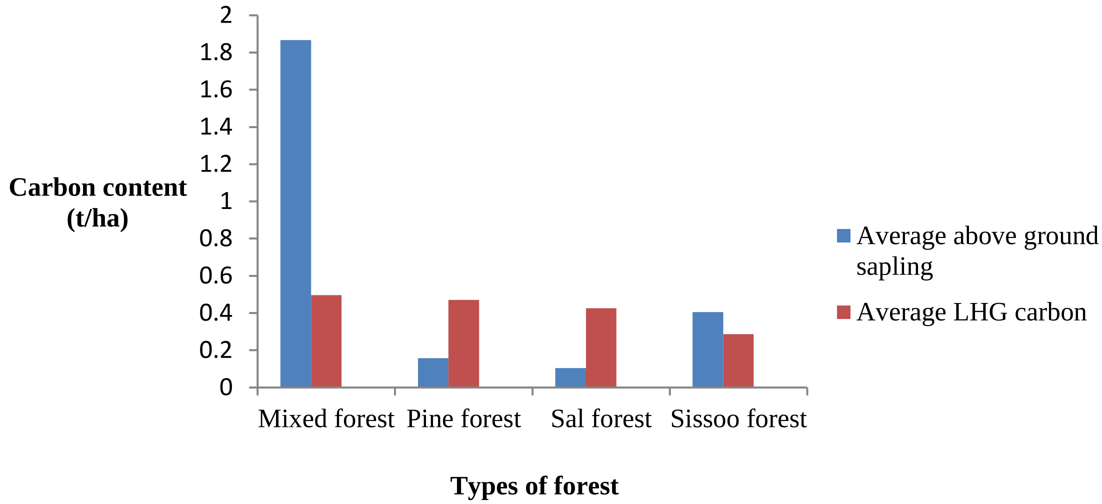

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Fig 11: Total LHG carbon and above ground sapling carbon per types of forest

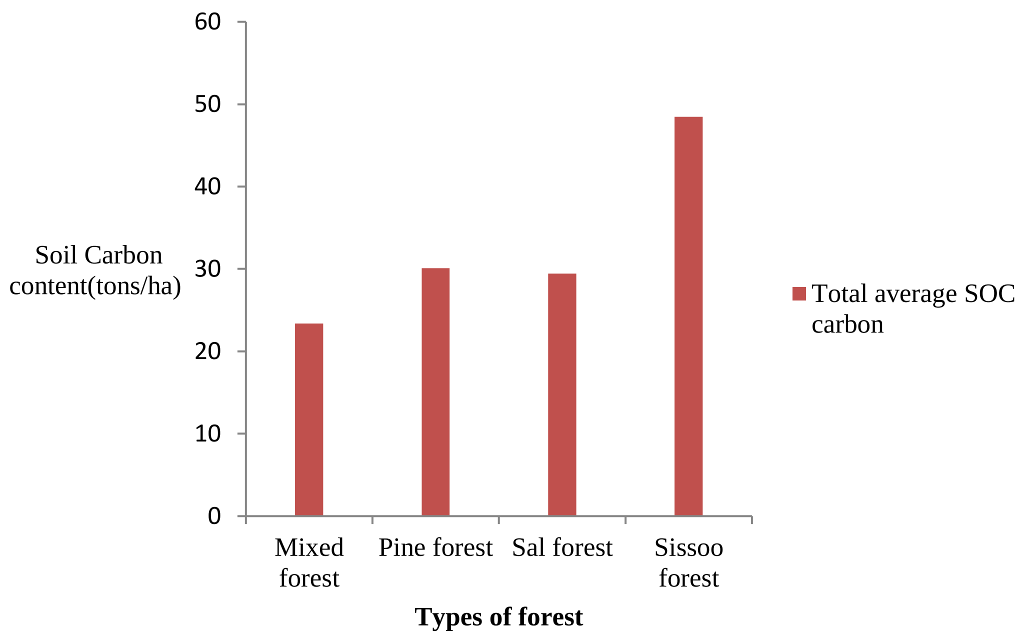

Fig 12: Total SOC in different forest types

4.2.5 Total carbon

Total carbon content varied within the plots in various forest types in forest.The total carbon content was the highest in Pine dominant forest which was 2473.47 tons/haas per types of forest found in KTDCF and lowest in Sissoo dominant tree which was 91.75 tons/ha.

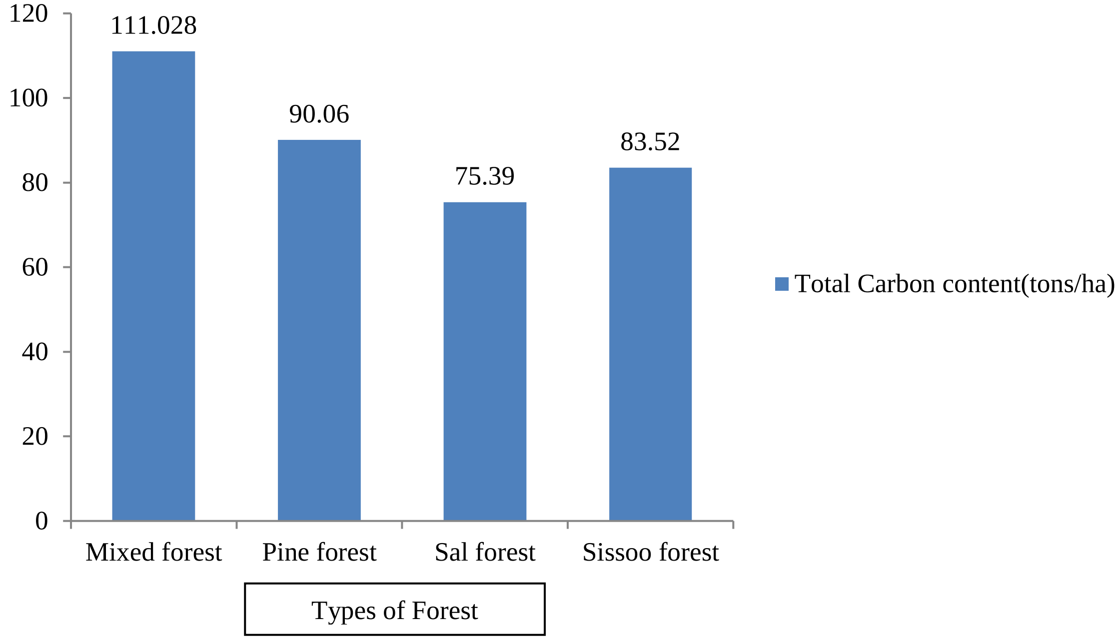

Fig 13: Total carbon content in different forest types

Total average carbon content of the forest was 98.61 ± 12.19 tons/ha and total average biomass of the forest was 146.52 ± 26.48 tons/ha.

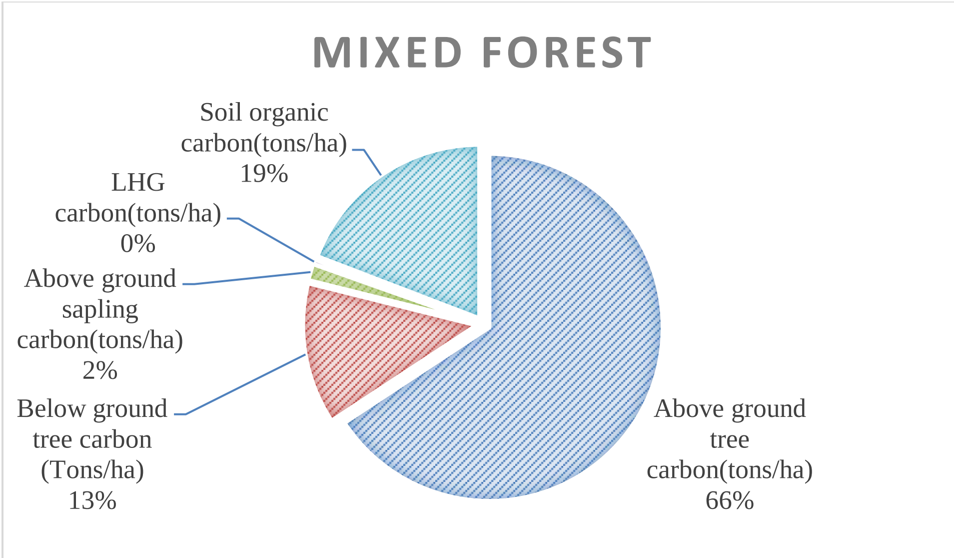

Fig 14: Total carbon content in mixed forest stand

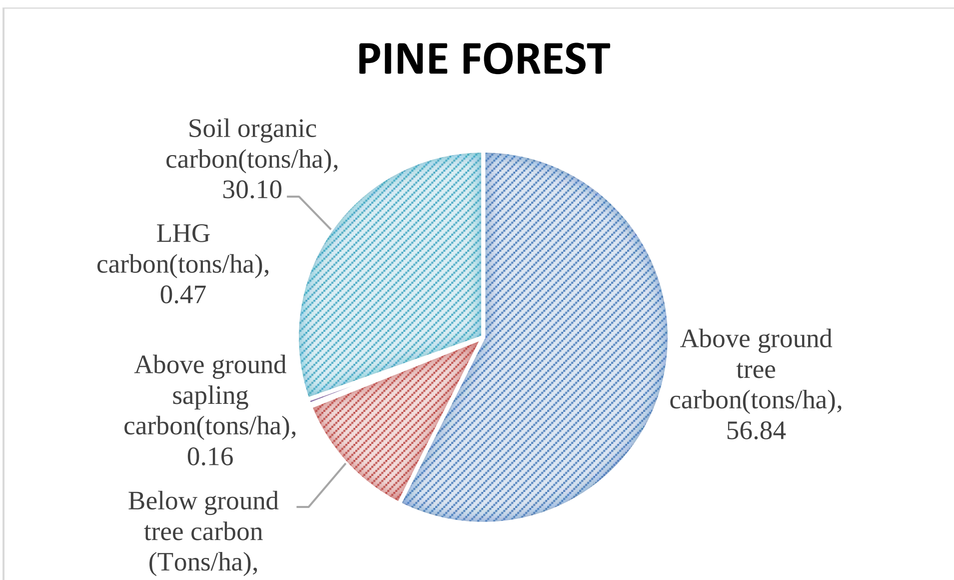

Fig 15: Total carbon content in pine forest stand

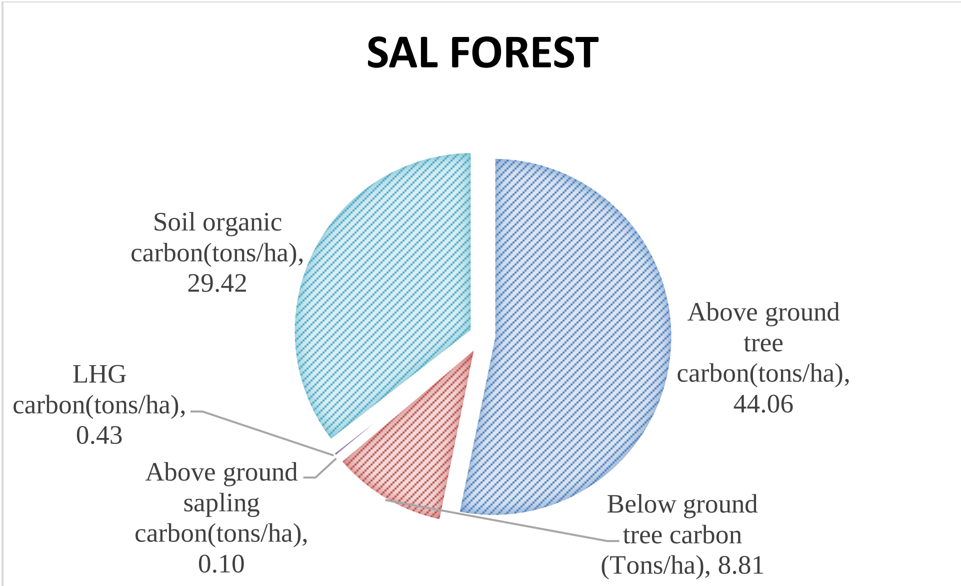

Fig 16: Total carbon content in sal forest stand

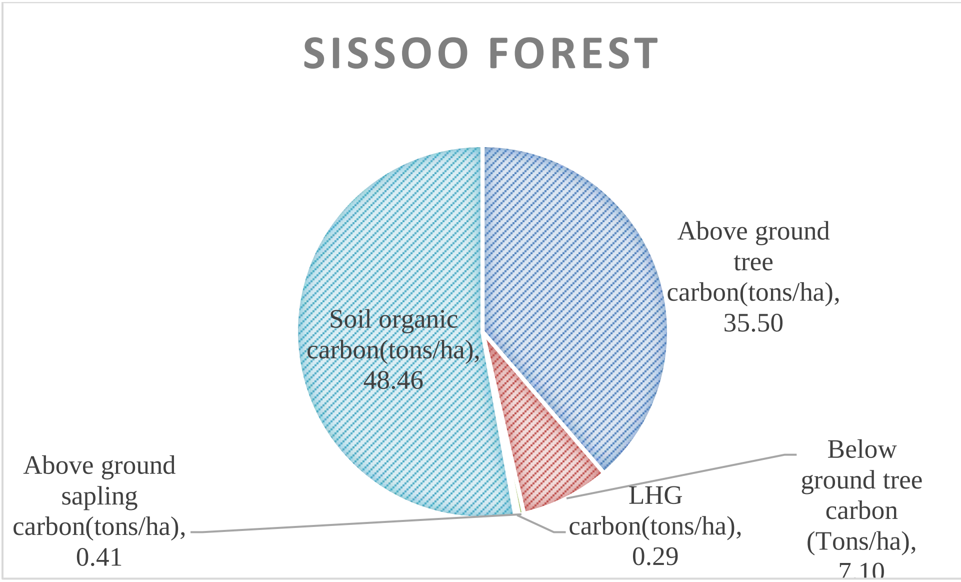

Fig 17: Total carbon content in Sissoo forest stand

4.3 Fuel wood Consumption

The fuelwood demand is high in the studied area as almost all people used the fuelwood as their energy source. But,recently,the fuelwood demand is not fulfilled by the community forest as the cutting of trees for household purposes is stopped since last four years.People have to fulfill their demand from their own crop land and by buying from Dipo and neighbors. About 72.92 % of users get fuel wood from their own land,14.58 % buy from neighbors and 12.5 % get from their own land as well as they buy too.

People who don't have their own crop land to get fuel wood have to buy from outside.In furniture factory,people paid Rs. 6-7 per kg.And people spent Rs. 500 to 5000 for fuelwoodper month as per their demand.People also buy trees from neighbours who don't have their own and they pay Rs.2000 to Rs.4500-5000 for a single tree as per tree size and quality.

Many of the people used alternative sources of energy to decrease the fuelwood demand. They used alternative sources like biogas, LPG gas, electricity etc. Most of people use fuelwood as energy source among whom 10.42% of people usefuelwood as only energy source in stove and 15.625% usefuelwood as only energy source in improved cooking stove(ICS).

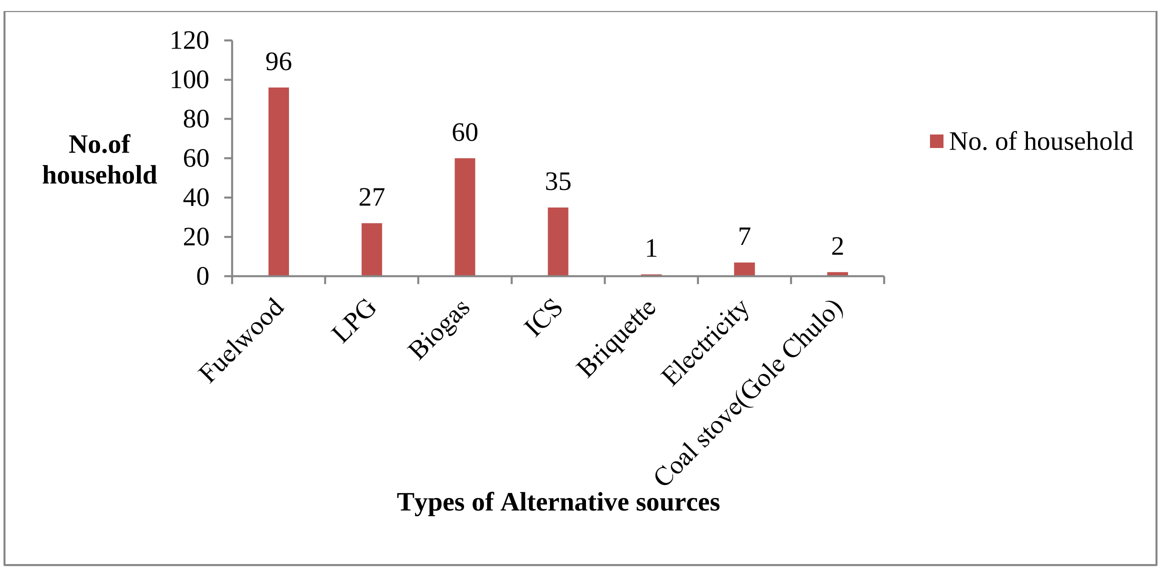

Fig 18: Types of Alternative sources used by household

The fuelwood consumption of community forest user members was 11.48 kg per day in summer while in winter, the total fuelwood consumption was 15.73 kg per day. The fuelwood demand is high in winter season as the production of biogas is less in that season and also people used fuelwood to get warmth. And, the total average fuelwood consumption was 4990.78 kg per year.The total fuelwood consumption before installation of any alternative source was 7234.35 kg per year. Now, after installation of various kinds of alternative sources, total fuelwood consumption is decreased by 31.01% than before.

The community forest lies in different region so the time and distance to reach there is also different.

Table 4: Time and distance to reach community forest

Name of place	Approximate Distance	Approximate Time
Dhunganabesi	1 km	45 min-1hr
EkataBasti	0.5 km	10-20 min
Dhotra	1-1.5 km	1hr-1.5hr

Demand is high but supply from community forest is very less. KTDCF is opened only once for a year in Falgun or Chaitra. Only one member from one permit card can enter the forest during cutting of fuelwood while for other forest products, two members from one card can enter. Community forest is opened for only one day in a year from 10 am to 5 pm. During the opening of forest,one member can take only 450 kg and they have to pay 10 paisa per kg. For, religious purposes,225 kg of fuelwood is given and its cost rate is fixed by User group member. For ritual during death,300 kg of fuelwood is given charging Rs. 100 for it. At present,fuelwood is supplied only for ritual during death.

Almost all people used fuelwood to make *Kudo* (Food of cattles) and some used to cook food and for heating purpose during winter.Most people used fodder and wood found in their own field as fuelwood.

CHAPTER V

DISCUSSION

5.1 Forest Characteristics

About 22% of tree species were found having DBH 10-15 cm which is more among others. It shows that the trees are in growing stage and have potential to absorb more carbon.Jati,2012 estimated that more than 50% of tree species were found less than 10 cm DBH in Kumvakarna Conservation Community Forest. Comparatively both forest are in growing stage and they were newly planted. The forest shows highest density of trees within size class 15-20 m, it shows that the forest is recently established by regeneration.

The density of *Pinus roxburghii* is high in the studied forest i.e397.8 trees/ha, it shows that number of that species is high in comparison to others. It may be due to its adaptability in drysoil conditions or due to the preference selection during plantation. *Pinus roxburghii* is the most frequent tree species occurring in 66.67 % of the sampled plots. The total density 582 trees/ha shows that the forest is not so dense. The trees are young and sparse.

The basal area of *Pinusroxburghii* was found to be 8.57 m^2/ha which showed highest value among all other trees species. Basal area is an important parameter which determines the carbon content by the species. More basal area indicated more biomass and hence more carbon storage. So, in the studiedarea, as basal area of *Pinusroxburghii* was high, ithas major contribution in total carbon storage. But the total basal area is lower than other forests in Kathmandu valley which is due to presence of young and smaller trees as the forest is young recently established by plantation management.

5.2 Biomass and carbon content

The average biomass content of Mixed forest stand was 209.74 tons/ha which is the highest in my studied area while Aryal, 2010 found (31.4 ±6.49) ton/ha in Mixed forest of ToudalChhap Community forest. It shows that the amount of moisture is high and also it consists of undisturbed soil in the Mixed forest stand area.Similarly,the average biomass of Pine forest was found to be 146.47 tons/ha in the forest whereas in pine forest of ToudalChhapCommunity forest, it was (113.29±18.82) t/ha which is less than my studied area.In the studied area, thetotal average biomass was found to be 146.52 ± 26.48 t/ha and Khadka, 2011 found average biomass of 103.82 t/ha in Thulonagi C.F and Chhetri,2010 found average biomass of 127.429±26.344 t/ha in Syalmati Watershed of Shivapuri National Park. which were relatively less than my studied forest area.It may be because of larger girth and also tallest tree with high density compared to TCF and SW .

The total average carbon stock of studied area was found to be 98.61 ± 12.19 tons/ha.Khadka,2011 estimated the average carbon stock of sampling plots of the forests as304.60 tons/ha whereas in similar study done by Jati,2012 in Kumvakarna conservation community forest the average Forest carbon stock found was 258.73 t/ha. Similarly, REDD (2010) pilot project in community forest of Ludikhola(sparse) estimated average total carbon of 162.98 t/ha.It might be due to that KTDCF is good preserved than MCF and also trees and soil structure of KTDCF is better than latter i.e trees are tall with large girth.

While comparing with Kumvakarna conservation community forest and community forest of Ludikhola(sparse),total average carbon of KTDCF showed lower value. It might be due to the disturbance from the peoples' activities in KTDCF or might be KCCF and community forest of Ludhikhola(sparse) were comparatively in more natural condition than KTDCF. Might be KTDCF was younger than both of them.

SOC represents a significant pool of carbon within the biosphere. In the forest ecosystems, the soil carbon is determined by the balance between the litter input and the soil heterotrophic respiration (Lu and Cheng, 2008).

Total average soil carbon of KTDCF was found to be 29.75 tons/ha.While Jati, 2012 estimated 91.93 tons/ha and Chhetri,2011 estimated48.93 ±5.821 tons/haofmean soil carbon. Total SOC found in KCCF and SW was higher than KTDCF.It might be due to slow decomposition of pine needles in dry soils of the forest and hence low SOC. It also might be due to lack of accumulation of decomposed forest litter and dead and decayed logs and litter over the floor as the forest is young.

5.3 Fuelwood Consumption and supply

The fuelwooddemand is high because almost all people used fuelwood as their energy sources. Fuelwood is used for making Kudo by some householdswhile others used for cooking food also.Since,the forest has stopped collection of fuel wood,people have to depend on own land or buy from outsides. The CFUG have banned collection and distribution of fuel wood since four years to promote more growth and regeneration. Also,annual growth in the DBH and height of the tree, or increase in biomass leads to storage of more carbon.

The total fuelwood consumption by user was decreased by 41.26 % after installation of alternative source. It shows people were aware of negative effects of using fuelwoodsuch as in their health as well as environment so alternative energy sources are being preferred.. Most of the households had different cattle in their home to get compost manure from theirdungs and wastages. Also, more than 60 % installed biogas plant in their homes. Respondents thought alternative sources like biogas and LPG have many benefits as do no smoke pollution, no eye irritations, and no health impacts.During cooking, they could be engaged in other works also so they were changing alternative energy resources for cooking.

The forest is not so thick, i.e sparse so it might be closed for fuel wood supply. Harvesting by thinning and singling of treeshad made the forest more degraded. So collection has been banned which is in fact a good step to promote natural growth of forest.

From the survey, it was found that people preferred *Shorea robusta*, *Alnus nepalensis*, *Lagerstroemia parviflora*, Pithauli for fuelwood.It might be because they produce less smoke and these hardhoods last longer while burning while. Other species is not as preferred as it burns fast and produce much smoke.

CHAPTER VI

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Kajiko Tatha Dhaireni Community Forest consists of young forest stands as majority of trees of the forest had less DBH and height .The density and basal area of *Pinus roxburghii* was high which shows its dominance. The total density of trees is 582 trees /ha whereas total basal area is lower 10.42 m^2/ha.

The average biomass was found to be 146.52 ± 26.48 tons/ha and the average carbon stock of studied area was found to be 98.61 ± 12.19 tons/ha. And biomass and carbon content were not uniformly distributed among all type of forest. Mixed forest stand consist of high biomass and carbon content because density of tree species is high in that type of forest.

The total fuel wood consumption was less in summer which was 4249.24 kg per year and it was high in winter season which was 5720.05 kg per year as fuel wood was required for space heating also. The consumption seems less as people started to install various alternative sources in their households. The supply of fuel wood was insufficient, i.e only once a year and also just 425 kg per year per household. It might be due to insufficient fuel wood supply from the forest.

6.2 Recommendations

- Fuelwood collection should be collected in intervals of several years. Collection should not be done from forest stands with less density biomass production.
- Use and development of alternative sources of energy should be increased to reduce fuel wood demand from forest.
- Need to manage the forest effectively and properly as it has huge potential to sequester more carbon.
- Species diversity of trees should be maintained. Special attention should be given to preserve rare trees during forest management practices.
- Plantation should be done mainly in those areas which have low density and low biomass production.

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ANNEXES

Annex I

Geographical positions of sample plots

Plots	Latitude	Longitude	Altitude(m)	Slope
1	27.60933°	085.60933°	1068	11°
2	27.62501°	085.60801°	1058	22°
3	27.62492°	085.60687°	1122	31°
4	27.62467°	085.60581°	1153	24°
5	27.62469°	085.60511°	1169	29°
6	27.62370°	085.60428°	1158	20°
7	27.62019°	085.60656°	1038	70°
8	27.62742°	085.62875°	917	28°
9	27.62751°	085.62726°	908	31°
10	27.62786°	085.62598°	934	34°
11	27.62844°	085.62476°	959	20°
12	27.62769°	085.62385°	931	5°
13	27.62773°	085.62292°	918	9°
14	27.62701°	085.62244°	913	11°
15	27.62577°	085.62110°	898	3°
16	27.62644°	085.62046°	906	4°
17	27.62723°	085.62096°	916	17°
18	27.62790°	085.62085°	937	23°
19	27.62404°	085.61018°	1066	19°
20	27.62385°	085.60910°	1017	18°
21	27.62223°	085.60823°	1034	27°
22	27.62135°	085.60793°	1027	13°
23	27.62074°	085.60713°	1013	12°
24	27.62012°	085.60676°	1016	32°
25	27.62789°	085.62006°	909	12°
26	27.62852°	085.61974°	940	21°
27	27.62808°	085.61925°	938	19°
28	27.62540°	085.61920°	930	20°
29	27.61741°	085.61915°	925	12°
30	27.61751°	085.62016°	902	17°
31	27.61780°	085.62057°	906	11°
32	27.61825°	085.62100°	913	8°
33	27.61842°	085.62108°	917	10°

34	27.61834°	085.62149°	913	9°
35	27.61872°	085.62162°	913	8°
36	27.61903°	085.62195°	906	11°

Forest Inventory Data Sheet

For Trees Species:

S.N	Name of Species	DBH(cm)	Height(m)		
			Base	**Angle**	**Height**

For Saplings:

S.N	Name of Species	DBH(cm)

For Seedlings:

S.N	Name of Species

List of trees in the study area

S.N	Scientific Name	Common Name	Family

1	*Choerospondias axillaris*	Lapsi	
2	*Dalbergia sissoo*	Sisoo	
3	*Engelhardia spicata*	Mauwa	
4	*Eugenia jambolana*	Jamun	
5	*Phyllanthus emblica*	Amala	
6	*Pinus roxburgii*	Pine	
7	*Schima wallichi*	Chilaune	
8	*Semecarpus anacardium*	Valayo	
9	*Shorea robusta*	Sal	
10	*Terminalia tomentosa*	Sanj	

Types of forest of each plot

Plot No.	Types of forest			
	Pine dominant forest	Sal dominant forest	Sisso dominant forest	Mixed forest
1				√
2		√		
3	√			
4	√			
5	√			
6	√			
7				√
8	√			
9		√		
10		√		
11	√			
12			√	
13	√			

14	√			
15				√
16				√
17	√			
18	√			
19	√			
20		√		
21	√			
22	√			
23	√			
24		√		
25	√			
26	√			
27	√			
28	√			
29	√			
30		√		
31	√			
32	√			
33	√			
34	√			
35	√			
36	√			

Total carbon content as per plot and forest types

Plot No.	Types of Forest	Above ground carbon (tons/ha)	Below ground carbon (tons/ha)	LHG carbon	SOC	Above ground sapling carbon	Total carbon contents(tons/ha)
1	Mixed forest	81.17	16.24	0.57	31.80	2.07	131.84
2	Sal forest	67.29	13.46	0.49	41.65	-	122.88
3	Pine forest	115.55	23.11	0.53	37.53	-	176.72
4	Pine forest	89.14	17.83	0.69	35.16	-	142.82
5	Pine forest	58.21	11.64	0.54	35.64	-	106.04
6	Pine forest	94.50	18.90	0.73	36.71	0.17	151.01
7	Mixed forest	62.52	12.51	0.61	39.84	3.62	119.10
8	Pine forest	48.17	9.64	0.49	0.38	-	58.67
9	Sal forest	38.30	7.66	0.40	8.74	0.09	55.19
10	Sal forest	18.82	3.77	0.64	45.92	0.38	69.53
11	Pine forest	31.54	6.31	0.48	36.17	-	74.50
12	Sissoo forest	35.50	7.10	0.29	48.46	0.41	91.75
13	Pine forest	85.51	17.10	0.45	4.61	2.41	110.09
14	Pine forest	68.33	13.67	0.34	32.76	-	115.09
15	Mixed forest	123.04	24.61	0.27	7.63	1.28	156.82
16	Mixed forest	53.98	10.80	0.54	14.30	0.50	80.11
17	Pine forest	26.22	5.24	0.34	37.47	0.34	69.62
18	Pine forest	36.90	7.38	0.48	32.26	0.24	77.26
19	Pine forest	27.96	5.59	0.45	38.09	-	72.09

20	Sal forest	39.20	7.84	0.36	5.84	-	53.24
21	Pine forest	14.94	2.99	0.48	30.98	0.48	49.87
22	Pine forest	13.54	2.71	0.39	38.24	0.25	55.12
23	Pine forest	28.22	5.64	0.68	38.41	-	72.96
24	Sal forest	76.20	15.24	0.25	33.98	0.16	125.82
25	Pine forest	76.12	15.22	0.48	0.78	-	92.60
26	Pine forest	26.55	5.31	0.46	33.74	-	66.06
27	Pine forest	65.54	13.11	0.32	36.04	-	115.00
28	Pine forest	10.68	2.14	0.56	30.43	-	43.80
29	Pine forest	113.99	22.80	0.43	22.96	-	160.18
30	Sal forest	24.52	4.90	0.42	40.41	-	70.26
31	Pine forest	52.06	10.41	0.34	35.28	-	98.09
32	Pine forest	40.56	8.11	0.50	31.67	0.07	80.91
33	Pine forest	56.29	11.26	0.39	20.45	-	88.39
34	Pine forest	69.27	13.85	0.49	32.91	-	116.53
35	Pine forest	93.21	18.64	0.42	34.84	-	147.12
36	Pine forest	78.09	15.62	0.32	38.89	-	132.92

Questionnaire for Socio-economic Survey

Name of the respondent: ______________________ Age:____ Sex: ____

Family Size: ____ Male:____ Female: ____

Address: ______________________ Ward No: ____

Occupation: ______________________

Detail Questionnaires:

- Which energy sources do you use for your house hold purpose?

  Fuelwood ☐ Biogas ☐ LPG gas ☐ Stove ☐

  Electricity ☐ Others ☐

- If fuelwood,

  How much of fuelwood is required for a day?

  For Summer Season: ……………...Bhari (1 Bhari = ……. Kg)

  For Winter Season: ……………..... Bhari

- In which season, the demand of fuelwood is high?

  Summer ☐ Winter ☐ Why?.........................,,,,,

- Where do you get your fuel wood supply from?

  Community Forest ....

  National Forest ....

  Own Forest/Land ....

- How many of you are members of KTDCF User group?

  1 ☐ 2 ☐ 3 ☐ 4 ☐

- How far is the forest from here?

  Approximate Distance ....

- How much time it will take to you to bring fuelwood from forest to your house?

  Approximate Time ....

- Does the fuelwood consumption from the community forest fulfil your total fuelwood demand?

  Yes ☐ No ☐

- If No,

  How you fulfil the fuelwood demand?

  Buy ☐ Collect from own Land ☐ Others ☐ What? ....

- If you have to buy from outside, how much you have to pay?

  ....

- Do you have to pay to get fuelwood from community forest?

  Yes ☐ No ☐

  If yes, how much? ....

- How many times a year, community forest is opened to harvest fuelwood and When?

  ....

- How do you harvest fuelwood?

  ....

- Which species do you prefer mainly for fuel wood and why? Rank in descending order.

Tree Species	Reason

- Do you use any alternative sources of energy as substitute for fuelwood?

Yes ☐ No ☐

- If yes, what are they? Rank them in the order of most used at first?

S.N	Alternative sources of energy

- Does the use of Alternative energy have reduced the consumption of fuelwood ?

Yes ☐ No ☐

- If yes, how much fuelwood is reduced?

Before using any Alternative energy(In Bhari)	After uing Alternative energy(In Bhari)

- Which you think is the better energy source ?And Why?

Fuelwood ☐ Alternative sources of energy ☐

....

- What are the impacts of Alternative source of energy over Fuelwood?

Positive Impact	Negative Impact

- What change have you noticed in forest coverage of KTDCF in the last few years?

Increased ☐ Decreased ☐ No significant change ☐

- What you think should be done to decrease the consumption of fuelwood?

  ....

- For what purposes,did you use fuelwood?

  ....

Name list of respondents

S.N	Name of Respondent	Sex	Age	Locality	Family Size	Occupation
1	Shyam Kumar Shrestha	Male	21	Ekata Basti	5	Teacher
2	Jhala Maya Shrestha	Female	45	Ekata Basti	5	Agriculture
3	Ratna Bahadur Shrestha	Male	64	Ekata Basti	8	Agriculture
4	Nanu Maiya Shrestha	Female	71	Ekata Basti	9	Agriculture
5	Hari Bahadur Shrestha	Male	44	Ekata Basti	6	Agriculture
6	Ramji Bika	Male	46	Ekata Basti	5	Agriculture
7	Surya Maya Shrestha	Female	49	Ekata Basti	7	Agriculture
8	Jaga Lal Shrestha	Male	48	Ekata Basti	7	Poultry Farming,Agriculture
9	Karna Bahadur Mijar	Male	42	Ekata Basti	4	Agriculture
10	Gopal Mijar	Male	40	Ekata Basti	5	Agriculture,Shop
11	Ganga Kumari Shrestha	Female	49	Ekata Basti	6	Agriculture
12	Ram Kumar Kayastha	Male	21	Ekata Basti	4	Teacher
13	Indra Bahadur Mirja	Male	36	Ekata Basti	4	Agriculture,Dakarmi
14	Batuli Shrestha	Female	65	Ekata Basti	2	Agriculture
15	Lal Bahadur Shrestha	Male	84	Ekata Basti	6	Agriculture
16	Bil Bahadur Mijar	Male	51	Ekata Basti	7	Agriculture
17	Kedar Adhikari	Male	41	Ekata Basti	5	Agriculture
18	Rudra Bahadur Shrestha	Male	42	Ekata Basti	6	Agriculture
19	Arjun Shrestha	Male	58	Ekata Basti	3	Agriculture
20	Ramji Shrestha	Male	41	Ekata Basti	6	Agriculture

21	Sanu Kaji Shrestha	Male	38	Ekata Basti	5	Agriculture
22	Chin Bahadur Shrestha	Male	42	Ekata Basti	6	Agriculture
23	Buddhi Lal Shrestha	Male	71	Ekata Basti	6	Agriculture
24	Ganesh Bahadur Shrestha	Male	72	Ekata Basti	6	Agriculture
25	Sanu Nani Mijar	Female	50	Ekata Basti	2	Agriculture
26	Sita Devi Banjara	Female	25	Ekata Basti	2	Teaching
27	Bal Kumari Chaulagain	Female	49	Ekata Basti	15	Agriculture
28	Ram Bahadur Gautam	Male	63	Ekata Basti	2	Agriculture
29	Rana Bahadur Pandey	Male	80	Ekata Basti	11	Agriculture,Job
30	Rudra Bahadur Karki	Male	64	Ekata Basti	8	Agriculture
31	Rajesh Chaulagain	Male	23	Ekata Basti	6	Agriculture
32	Chandra Bahadur Khadka	Male	55	Ekata Basti	6	Agriculture
33	Januka Dhungana	Female	64	Dhotra	2	Agriculture
34	Urmila Danuwar	Female	35	Dhotra	6	Agriculture
35	Krishna Bahadur Danuwar	Male	35	Dhotra	4	Agriculture
36	Mithu Danuwar	Female	50	Dhotra	2	Agriculture
37	Thuli Maya Danuwar	Female	72	Dhotra	3	Agriculture
38	Ramesh Danuwar	Male	38	Dhotra	6	Agriculture
39	Sher Bahadur Danuwar	Male	36	Dhotra	6	Agriculture
40	Urmila Danuwar	Female	49	Dhotra	6	Agriculture
41	Devi Maya Danuwar	Female	41	Dhotra	3	Agriculture
42	Parvati Danuwar	Female	40	Dhotra	3	Agriculture
43	Kalika Danuwar	Female	65	Dhotra	9	Agriculture
44	Pitambar Danuwar	Male	35	Dhotra	4	Agriculture
45	Kancha Danuwar	Male	61	Dhotra	2	Agriculture
46	Sabitri Danuwar	Female	40	Dhotra	1	Agriculture
47	Man Bahadur Danuwar	Male	71	Dhotra	6	Agriculture
48	Shova Danuwar	Female	26	Dhotra	14	Agriculture
49	Chandrawati Danuwar	Female	35	Dhotra	4	Agriculture
50	Shanti Danuwar	Female	46	Dhotra	5	Agriculture

51	Dilip Kumar Danuwar	Male	42	Dhotra	5	Agriculture
52	Gita Danuwar	Female	27	Dhotra	7	Agriculture
53	Rama Danuwar	Female	42	Dhotra	4	Agriculture
54	Sameer Danuwar	Male	18	Dhotra	7	Agriculture
55	Sanu Nani Danuwar	Female	60	Dhotra	6	Agriculture
56	Abhiwadan Dhungana	Male	18	Dhotra	3	Agriculture
57	Kanchi Danuwar	Female	70	Dhotra	7	Agriculture
58	Sudarshan Sapkota	Male	45	Dhotra	6	Agriculture
59	Sita Ram Sapkota	Male	50	Dhotra	5	Agriculture
60	Menuka Sapkota	Female	33	Dhotra	6	Agriculture,Driver
61	Uma Sapkota	Female	40	Dhotra	4	Agriculture,Driver
62	Bidur Sapkota	Male	55	Dhotra	6	Agriculture
63	Ganga Sapkota	Female	66	Dhotra	4	Agriculture
64	Tika Devi Sapkota	Female	80	Dhotra	6	Agriculture
65	Nirmala Parajuli	Female	58	Dhungana besi	2	Agriculture
66	Arjun Parajuli	Male	60	Dhungana besi	10	Agriculture
67	Tirtha Raj Shrestha	Male	45	Dhungana besi	3	Agriculture,Shop
68	Lal Bahadur Shrestha	Male	80	Dhungana besi	5	Agriculture
69	Amar Bahadur Shrestha	Male	52	Dhungana besi	3	Agriculture
70	Gyani Kayastha	Female	39	Dhungana besi	5	Agriculture
71	Rita Dhungana	Female	26	Dhungana besi	5	Agriculture
72	Shiva Maya Kayastha	Female	52	Dhungana besi	7	Agriculture
73	Saraswoti Kafle	Female	70	Dhungana besi	7	Agriculture
74	Sanu Bhai Parajuli	Male	29	Dhungana besi	4	Agriculture
75	Sabitri Parajuli	Female	49	Dhungana besi	2	Agriculture
76	Cheta Kumari Parajuli	Female	59	Dhungana besi	3	Agriculture
77	Shova Parajuli	Female	42	Dhungana besi	9	Agriculture
78	Sita Devi Parajuli	Female	49	Dhungana	4	Agriculture

				besi		
79	Babu Kaji Parajuli	Male	52	Dhungana besi	4	Agriculture,Teaching
80	Kedar Prasad Parajuli	Male	46	Dhungana besi	5	Agriculture
81	Prahlad Prasad Parajuli	Male	40	Dhungana besi	5	Agriculture
82	Bidur Prasad Parajuli	Male	35	Dhungana besi	4	Agriculture
83	Tilaka Adhikari	Female	40	Dhungana besi	3	Agriculture
84	Laxmi Parajuli	Female	61	Dhungana besi	9	Agriculture
85	Badri Prasad Adhikari	Male	70	Dhungana besi	6	Agriculture
86	Anita Dhungana	Female	29	Dhungana besi	4	Agriculture
87	Ram Hari Dhungana	Male	38	Dhungana besi	6	Agriculture
88	Bhim Kumari Neupane	Female	50	Dhungana besi	9	Agriculture
89	Bharat Prasad Neupane	Male	47	Dhungana besi	7	Agriculture
90	Ramesh Dhungana	Male	49	Dhungana besi	4	Agriculture
91	Sita Bhujel	Female	44	Dhungana besi	6	Agriculture
92	Rajan Bhujel	Male	35	Dhungana besi	6	Agriculture
93	Nanda Bahadur Bhujel	Male	65	Dhungana besi	2	Agriculture
94	Laxmi Sapkota	Female	32	Dhungana besi	4	Agriculture,Maize Mill
95	Ganga Bahadur Shrestha	Male	51	Dhungana besi	5	Agriculture
96	Chandra Lal Shrestha	Male	40	Dhungana besi	11	Agriculture

Fuelwood Consumption per Household

Sample No.	Total fuelwood consumed (Bhari per year) in summer	Total fuelwood consumed (Bhari per year) in winter	Total fuelwood consumed (kg per year) in summer	Total fuelwood consumed(kg per year) in winter	Total fuelwood consumed (Bhari per year)before using alternative resources	Total fuelwood consumed (kg per year)before using alternative resources
1	12.00	14.60	510.00	620.50	73.00	3,102.50
2	12.00	14.60	510.00	620.50	91.25	3,878.13
3	45.63	60.84	1,939.28	2,585.70	243.34	10,341.95
4	182.50	182.50	7,756.25	7,756.25	365.00	15,512.50
5	12.00	14.60	510.00	620.50	73.00	3,102.50
6	182.50	243.34	7,756.25	10,341.95	365.00	15,512.50
7	91.25	182.50	3,878.13	7,756.25	182.50	7,756.25
8	182.50	365.00	7,756.25	15,512.50	365.00	15,512.50
9	730.00	365.00	31,025.00	15,512.50	121.67	5,170.98
10	52.14	73.00	2,215.95	3,102.50	91.25	3,878.13
11	52.14	60.84	2,215.95	2,585.70	73.00	3,102.50
12	36.50	40.56	1,551.25	1,723.80	45.63	1,939.06
13	36.50	45.63	1,551.25	1,939.06	45.63	1,939.06
14	91.25	121.67	3,878.13	5,170.98	121.67	5,170.98
15	12.00	14.60	510.00	620.50	36.50	1,551.25
16	24.34	36.50	1,034.45	1,551.25	182.50	7,756.25

17	52.14	60.84	2,215.95	2,585.70	91.25	3,878.13
18	52.14	73.00	2,215.95	3,102.50	20.28	861.90
19	121.67	182.50	5,170.98	7,756.25	182.50	7,756.25
20	91.25	121.67	3,878.13	5,170.98	182.50	7,756.25
21	121.67	182.50	5,170.98	7,756.25	182.50	7,756.25
22	73.00	91.25	3,102.50	3,878.13	121.67	5,170.98
23	91.25	121.67	3,878.13	5,170.98	182.50	7,756.25
24	73.00	91.25	3,102.50	3,878.13	121.67	5,170.98
25	91.25	121.67	3,878.13	5,170.98	365.00	15,512.50
26	91.25	182.50	3,878.13	7,756.25	182.50	7,756.25
27	91.25	182.50	3,878.13	7,756.25	182.50	7,756.25
28	60.84	73.00	2,585.70	3,102.50	91.25	3,878.13
29	73.00	91.25	3,102.50	3,878.13	365.00	15,512.50
30	73.00	91.25	3,102.50	3,878.13	121.67	5,170.98
31	365.00	730.00	15,512.50	31,025.00	243.34	10,341.95
32	52.14	73.00	2,215.95	3,102.50	73.00	3,102.50
33	121.67	182.50	5,170.98	7,756.25	121.67	5,170.98
34	182.50	365.00	7,756.25	15,512.50	121.67	5,170.98
35	91.25	121.67	3,878.13	5,170.98	121.67	5,170.98
36	73.00	91.25	3,102.50	3,878.13	243.34	10,341.95
37	24.34	36.50	1,034.45	1,551.25	60.84	2,585.70
38	91.25	121.67	3,878.13	5,170.98	121.67	5,170.98

39	91.25	121.67	3,878.13	5,170.98	121.67	5,170.98
40	73.00	91.25	3,102.50	3,878.13	52.14	2,215.95
41	73.00	121.67	3,102.50	5,170.98	365.00	15,512.50
42	73.00	91.25	3,102.50	3,878.13	121.67	5,170.98
43	52.14	73.00	2,215.95	3,102.50	121.67	5,170.98
44	24.34	36.50	1,034.45	1,551.25	52.14	2,215.95
45	365.00	365.00	15,512.50	15,512.50	365.00	15,512.50
46	73.00	91.25	3,102.50	3,878.13	121.67	5,170.98
47	121.67	182.50	5,170.98	7,756.25	121.67	5,170.98
48	52.14	73.00	2,215.95	3,102.50	60.84	2,585.70
49	121.67	182.50	5,170.98	7,756.25	121.67	5,170.98
50	73.00	91.25	3,102.50	3,878.13	73.00	3,102.50
51	18.25	24.34	775.63	1,034.45	45.63	1,939.06
52	182.50	365.00	7,756.25	15,512.5	365.00	15,512.50
53	91.25	121.67	3,878.13	5,170.98	91.25	3,878.13
54	52.14	60.84	2,215.95	2,585.70	91.25	3,878.13
55	121.67	182.50	5,170.98	7,756.25	182.50	7,756.25
56	24.34	73.00	1,034.45	3,102.50	73.00	3,102.50
57	73.00	91.25	3,102.50	3,878.13	91.25	3,878.13
58	365.00	365.00	15,512.50	15,512.50	730.00	31,025.00
59	182.50	365.00	7,756.25	15,512.50	182.50	7,756.25
60	52.14	60.84	2,215.95	2,585.70	91.25	3,878.13

61	73.00	91.25	3,102.50	3,878.13	121.67	5,170.98
62	73.00	91.25	3,102.50	3,878.13	182.50	7,756.25
63	91.25	121.67	3,878.13	5,170.98	121.67	5,170.98
64	91.25	121.67	3,878.13	5,170.98	365.00	15,512.50
65	182.50	365.00	7,756.25	15,512.50	182.50	7,756.25
66	73.00	91.25	3,102.50	3,878.13	121.67	5,170.98
67	12.00	18.25	510.00	775.63	52.14	2,215.95
68	36.50	45.63	1,551.25	1,939.06	121.67	5,170.98
69	36.50	40.56	1,551.25	1,723.80	91.25	3,878.13
70	73.00	91.25	3,102.50	3,878.13	52.14	2,215.95
71	121.67	182.50	5,170.98	7,756.25	365.00	15,512.50
72	36.50	45.63	1,551.25	1,939.06	91.25	3,878.13
73	60.84	91.25	2,585.70	3,878.13	182.50	7,756.25
74	24.34	36.50	1,034.45	1,551.25	73.00	3,102.50
75	52.14	60.84	2,215.95	2,585.70	91.25	3,878.13
76	182.50	365.00	7,756.25	15,512.50	365.00	15,512.50
77	365.00	365.00	15,512.50	15,512.50	730.00	31,025.00
78	182.50	243.34	7,756.25	10,341.95	365.00	15,512.50
79	91.25	121.67	3,878.13	5,170.98	182.50	7,756.25
80	60.84	73.00	2,585.70	3,102.50	121.67	5,170.98
81	91.25	121.67	3,878.13	5,170.98	182.50	7,756.25
82	73.00	91.25	3,102.50	3,878.13	121.67	5,170.98

83	18.25	20.28	775.63	861.90	73.00	3,102.50
84	73.00	121.67	3,102.50	5,170.98	182.50	7,756.25
85	121.67	182.50	5,170.98	7,756.25	365.00	15,512.50
86	91.25	121.67	3,878.13	5,170.98	121.67	5,170.98
87	52.14	52.14	2,215.95	2,215.95	365.00	15,512.50
88	73.00	121.67	3,102.50	5,170.98	121.67	5,170.98
89	52.14	60.84	2,215.95	2,585.70	91.25	3,878.13
90	52.14	52.14	2,215.95	2,215.95	91.25	3,878.13
91	36.50	45.63	1,551.25	1,939.06	73.00	3,102.50
92	121.67	182.50	5,170.98	7,756.25	182.50	7,756.25
93	36.50	45.63	1,551.25	1,939.06	73.00	3,102.50
94	121.67	182.50	5,170.98	7,756.25	365.00	15,512.50
95	30.42	36.50	1,292.72	1,551.25	91.25	3,878.13
96	365.00	365.00	15,512.50	15,512.50	243.34	10,341.95
TOTAL	**9,598.29**	**12,920.58**	**407,927.2**	**549,124.44**	**16,340.67**	**694,478.26**
MEAN	**99.98**	**134.59**	**4,249.24**	**5,720.05**	**170.22**	**7,234.15**

Annex II

Kajiko Tatha Dhaireni Community Forest

Measuring DBH of tree **Measuring height of tree using clinometer**

Questionnaire survey

Key Informant Interview

Alternative source of energy