Estimating the Potential of Community Carbon Forestry:

A Case from Champadevi Community Forest

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Letter of Recommendation

This is to certify that Mr. Ananta Khanal has prepared this thesis entitled " Estimating the Potential of Community Carbon Forestry: A Case from Champadevi Community Forest" for the partial requirement for the completion of Master's Degree in Environmental Science under my guide and supervision. He has successfully completed the course of research during his thesis work. This thesis is the result of his own dedication, interest and work and is in the form as required by Central Department of Environmental Science, T. U. for completion of Master's Degree course. I therefore recommend the dissertation for acceptance and approval by the University.

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Letter of Approval

The dissertation entitled " Estimating the Potential of Community Carbon Forestry: A Case from Champadevi Community Forest " submitted by Mr. Ananta Khanal has been approved for the partial fulfillment of requirement for the completion of master's degree in Environment Science.

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Abstract

Climate change is a global concern. Carbon dioxide (Co_2) in the atmosphere is regarded as the most important gas that causes climate change. This gas cycles among three major reservoirs, the land (soil, rock and biomass), the water and the air. Forest biomass plays important role in this cycle as the forest has the potential to store large amount of carbon as a carbon pool. The concern of the present world is that the areas of these forests are decreasing day by day in an alarming rate. The aim of the study was to explore the condition of forest, to determine the total carbon pool in a community managed forest and to identify the tree species with high carbon storing capacity. So in this study, carbon content in forest biomass was calculated. The association of carbon pool with biodiversity was determined by significance test. Besides, the condition of existing forest was also determined.

The study area is Chandragiri hill that lies in the south western part of the Kathmandu valley. Champadevi community forest in Chandragiri hill is about 12 km in south west direction from Kathmandu city covering an area of about 136.2 ha. For the calculation of biomass and carbon, non-destructive field measurements were made using diameter at breast height (dbh) measurement method developed by NARMSAP and DoF, 2000. Measurements were made for different elevation ranging from 1500m to 2300m with definite number of plots at each elevation. To acquire knowledge on existing forest management practices, interview with the chairman of Forest Users Group(FUGs) and discussion with two different focus groups; one with women group only and other with mixed group i.e. male and female both, were made. Total carbon content in the forest was estimated to be 24.72 tonC/ha. The result shows that there is greater species density of *Quercus glauca* (Phalat); while Quercus *floribunda* has the higher carbon stock capacity. Carbon stock in biomass is high at an elevation of 2300m and is low at an elevation of 1800m. In regard to the management of forest, most of the issues are related to the lack of awareness among the members of FUGs and illegal smuggling of the timbers and forest products. Constraints that are most often faced by the FUGs in management of forest are either from the local people or from government authority in different aspects.

In conclusion, it is found that there is a potential of storing and sequestering carbon in the community managed natural forest. Community managed forest if managed properly, can restore carbon and contribute to climate change mitigation.

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List of Figures and Tables

Acronyms and Abbreviations

ACIAR	: Australian Centre for International Research on Agriculture
ADB	: Asian Development Bank
AIJ	: Activities Implemented Jointly
ANSAB	: Asia Network for Sustainable Agriculture and Bioresource
AR	: Afforestation and Reforestation
CBFM	: Community Based Forest Management
CDM	: Clean Development Mechanism
CERs	: Certified Emission Reductions
COP	: Conference of the Parties
DFOs	: Districts Forest Offices
Dm	: Dry Mass
DoF	: Department of Forest
ENFOR	: Environmental Forestry Programme
FAO	: Food and Agriculture Organisation
FECOFUN	: Federation of Community Forestry Users
GCMs	: Global Circulation Models
GHGs	: Green House Gases
GoN	: Government of Nepal
GtC	: Giga Tonnes of Carbon
Ha.	: Hectare
HWWA	: Hamburgisches Welt-Wirtschafts-Archiv
ICIMOD	: International Centre for Integrated Mountain Development
IEA	: International Energy Agency
INSA	: Indian National Science Academy
IPCC	: International Panel on Climate Change
KP	: Kyoto Protocol
Kt	: Kilo Tonnes
LULUCF	: Land Use, Land-Use Change and Forestry
MAI	: Mean Annual Increment
MPFS	: Master plan for the forestry sector
Mt	: Million Tonnes

NARMSAP	: Natural Resource Management Sector Assistance Program
NTFPs	: Non Timber Forest Products
NTNC	: National Trust for Nature Conservation
OECD	: Organization for Economic Co-operation and Development
PgC	: Petagrams of Carbon
TgC	: Teragrams of Carbon
UNFCCC	: United Nations Framework Convention on Climate Change

Conversion Table:

1 Kt = 10^3 Tonnes

1 GtC = 10^9 Tonnes of Carbon = 3.67 Giga Tonnes of Carbon dioxide

1 PgC = 1 GtC

1 Mt = 10^6 Tonnes.

1 TgC = 1 MtC

Chapter One

1. Introduction

1.1General Background

The earth receives short wave radiation from the sun, one third of which is absorbed by the atmosphere, ocean, ice land and living organisms. The energy absorbed from solar radiation is balanced, in the long term, by the outgoing radiation from the earth and atmosphere. While short wave radiation from the sun can easily pass through the atmosphere, the long wave radiation emitted by the warm surface of the earth is partially absorbed by trace gases in the atmosphere called greenhouse gases(GHGs). The main natural greenhouse gases are water vapor(H_2O),carbon dioxide(CO_2) and methane(CH_4). In absence of these gases the temperature of the earth should have been 33^{o}C lower than it today. About 34 percent of solar radiation energy reaching the troposphere, which is the upperpart of the atmosphere covering 16 km thickness, is reflected to the space and remaining 66% of solar radiation not reflected away is degraded into low quality infra-red radiation. Air atmosphere thus acts like a glass in a green house maintaining warm layer of air in contact with the earth.(Miller,2002).

Normal levels of green house gases in the atmosphere are essential for life on earth and for maintaining climatic stability. However, their excessive concentration makes the earth warmer. This enhanced green house effect, with its implication for global warming and climate change, has a late become an area of major international concern. This is because; a significant warming of a globe could have far reaching impacts. It would affect rainfall patterns, the sea level and the volatility of climate, and thus impinge on agriculture, forestry, trade and economic activity in general. In addition to its wide ranging and diverse implication for the principal sectors of the economy, the effect of global warming and resultant climate change would be particularly acute for low lying countries and coastal areas as a rise in the mean sea level will endanger their very survival.

Global warming 125,000 years ago was caused by eccentricities in earth's orbit around the sun, leading to the solar heating of the northern hemisphere in summer that was 10% higher than today. Today's global warming is being caused by a shift in the earth's energy balance. (A World of Science, 2007). Accompanying the build up of the green house gases ,surface temperature around the globe is raised. Study of temperature records, the composition of long lived glaciers and other sources shows that earth has warmed about 0.5^{o}C over the past 100 years. (Field and Field,2002). Predictions are that global warming will cause significant variation climatic pattern over the next century that may have negative impacts on regional and global biomes. Some scientific models predict that over the next century, temperature could rise about 1.5^{o}C to 4.5^{o}C. The rate of heating is put at about 0.3^{o}C per decade. (Field and Field,2002).

1.2 Carbon and Forest as Carbon Sink

Planet earth's capacities for dispersing ,diluting and degrading most human generated pollutants are large, but limited. As pollution rates increase, the natural processes that absorb and assimilate pollutants are eventually overwhelmed. This leads to rising concentration of pollutants in the environment. The rates of release of atmospheric carbon are steadily increasing over their natural levels. The higher the natural rates of greenhouse gas releasing resulting from fossil fuel and biomass combustion are boosting carbon dioxide and methane levels at greater rates than has occurred in recent earth history.(Hayes and Smith,1993). Among six GHGs, carbon dioxide is regarded as the major green house gas which cause the climate change at the global level. Climate change is a global concern. Natural sink for carbon dioxide already play a significant role in reducung the concentration of carbon dioxide in the atmosphere. Examples of natural sink that might be used for purpose include forest and soil.(IPCC,2005). Forest acts as carbon sink as they absorb carbon dioxide from atmosphere retain carbon and release oxygen. When wood is burnt, the process is reversed, burning wood uses oxygen from the atmosphere and carbon from wood and then emits carbon dioxide. Forest acts both as carbon sink and carbon source depending on how and for what purposes they are managed. Living trees continue to store the carbon as woody biomass. Mature forests are therefore storehouse of carbon. The young trees grow at faster rates than the mature tree and in this state they work as carbon sink. Thus managed forest contributes to the reduction of carbon at atmosphere. However, under natural conditions soil contains more carbon than in the biomass. (Brady, 1999). Carbon stocks in an ecosystem are a function of inputs from photosynthesis (net primary production) and losses from heterotrophic decomposition. When photosynthetic inputs exceed losses, C accumulates; when they fall short of losses, stored C wanes. During early stages of ecosystem development, C inputs predominate, so that C gradually accumulates until decomposition eventually approaches inputs (Odum, 1969 as cited by Janzen, 2004).

1.3 Rational of the Research Work:

Global carbon cycle is important for regulation the carbon dioxide concentration in atmosphere. Many silvicultural and forest management practices have been reported to enhance carbon mitigation. As forest land use plays a significant role in stabilizing the accumulating concentration of carbon dioxide in the atmosphere, the present study attempts to identify the existing condition of the community managed forest which is significant in representing the forest condition of the mid hills of Nepal and helps in formulation of policy for effective management of forest. Forest, as a major carbon pool, it is essential to identify the status of forest management and carbon storing capacity of the forest. This study mainly focuses on estimating carbon content in the content in the forest and identifying the species that has more carbon storing capacity. The result also identifies the role of forest in mitigation of the global warming and climate change by storing carbon in biomass. This type of community based forest management program results gets importance due to the identification of additional carbon sequestration through avoided deforestation and degradation. The research also has its significance for packaging carbon sequestration as an environment service which is payable in emerging global market.

1.4. Objectives of the study

Generally, the main objective of the study is to estimate the carbon pool level in the forest.

Specifically, the objectives are:

- To determine the carbon stock at different elevation.
- To determine the individual species carbon storage capacity and their density in the forest.
- To observe the biodiversity condition at different elevation.
- To show the relation between biodiversity condition with carbon stock.
- To identify species with high carbon storing capacity and show the relation of density of species with the carbon stock of that particular species.

1.5 Site Description:

Chandragiri hill lies in the Mahabharat range forming a portion of southwestern border between Kathmandu –Makwanpur and Kathmandu –Dhading districts. This is the main source of catchment basin for Panighat khola (Small River) and matatirtha khola toward Kathmandu valley. Champadevi community forest lies in the Chandragiri hill which is about 12km in North West direction from Kathmandu city. Aspect of almost all forest is north facing.

Champadevi community forest lies in the ward no. 8 of Kirtipur municipality. This forest has the natural boundary by Bagh Bhairab community forest in the east, Chun Paharo community forest in the west, Pushpalal Pratisthan and Bagh Bhairab High School in the north and from contour line of 2190m to Bhasmasur hill in the south, covering an area of about 136.2ha.and slope ranging from 0 to 70^{O}. The elevation ranges from 1400m to 2500m from the mean sea level. For effective management with consideration of slope, aspect, forest condition, natural boundary, area and altitude, the overall forest area is divided into nine blocks and one sub blocks. The most distinct block is the first block(or block-1), containing one sub block with *Pinus species*, *Schima wallichi* and *Alnus nepalensis* as most dominant species..

1.6 Limitation of the study

- As the whole forest area is large, only about 1% of the sample area was studied for the research.
- Slope correction was not done for locating plot

Chapter Two

2. Review of the literatures:

2.1. Carbon and Global Warming

Arrhenius, a Swedish scientist, was the first to advance the theory that emissions of carbon dioxide would intensify the earth's natural green house effects and thus warm the planet (IPCC, 2000). Carbon dioxide is the most important green house gas which has higher atmosphere warming potential while others are methane, nitrous oxide, and carbon monoxide. The main green house gases, their approximate proportionate contribution to global warming, and their major sources are shown as:

Table: A: Greenhouse gases and their nature

S.No	Gas	Proportionate rate	Major source
1	Carbon dioxide(CO_2)	49	Fossil fuel combustion, deforestation, cement production
2	Methane(CH_4)	18	Landfill, agriculture
3	Nitrous oxide(N_2O)	6	Fertilizers, land clearing, biomass burning, fossil fuel combustion
4	Others(CO,NOx …)	26	Various

Source : Field and Field,2002

Studies have shown that energy sector contribution to the potential warming is 49% and the deforestation 14%. Energy sector's contribution to carbon dioxide emission is 70% and deforestation is 20%.(Wang Zhishi,1992 as cited by Field and Field,2002). The cycle of carbon on earth is the story of life on this planet. The carbon cycle is all inclusive because it involves the soil, higher plants of every description and all animal life including humans.

The concentration of carbon dioxide in the atmosphere has risen close to 280 ppm (parts per million) in 1800, at first slowly and then progressively faster to a value of 367ppm in 1999, echoing the increasing pace of global agricultural and industrial development. This is known from numerous well replicated measurements of the composition of air bubbles trapped in Antarctic ice. Atmospheric carbon dioxide concentration has been measured directly with high precision since 1957; these measurements agree with ice- core measurements and show a continuation of the increasing trend up to the present. Present interpretation of the history of our planet show that it has experienced and survived large but slow fluctuation in carbon dioxide and temperature and that life has survived these fluctuations. Due to the combined influence of fossil fuel and deforestation, carbon is now being mobilized into the atmosphere from a very large geological reservoir (coal, petroleum gas etc). There is about ten times as much carbon readily accessible in fossil fuel deposits as there is in atmospheric carbon dioxide, suggestion the potential for a major change in atmospheric composition when a significant fraction of the fossil fuel deposits are combusted.(UNU and the W.B.,1995). The following table depicts general trend of carbon dioxide and temperature increment;

Table:B :Global estimates of climate change.

Date	Global population(billions)	Global GDP(10^{12} US$/yr)	Per capita income ratio	Ground level ozone (O_3) conc. (ppm)	CO2 conc. (ppm)	Global temp Change (°C)	Global Sea level rise(cm)
1990	5.3	21	16.1	-	354	0	0
2000	6.1-6.2	25-28	12.3-14.2	40	367	0.2	2
2050	8.4-11.3	59-187	2.4-8.2	60	463-623	0.8-2.6	5-32
2100	7.0-15.1	197-550	1.4-6.3	>70	478-1099	1.4-5.8	9-88

Source: Climate Change 2001, Synthesis Report .IPCC.

The present atmospheric carbon dioxide concentration has not been exceeded during 420000 years and likely not during past 20 million years. The rate of increase over the past century is unprecedented, at least during past 20,000 years. (IPCC, 2000). The rate of increase of atmospheric carbon dioxide content was 3.3+-0.1 PgC/yr during 1980 to 1990 and 3.2+-0.1 PgC/yr during 1990 to 1999. Individual years show different rates of increase. For example, 1992 was low (1.9 PgC /yr) and 1998 was the highest (6.0 PgC /yr). This variability is mainly caused by variation in land and ocean uptake. (IPCC, 2000). It is likely that the rate and duration of warming of the 20th century is larger than any other time during last 1000 years. New analysis indicates that global ocean heat content has increased significantly since the late 1950s. More than half of the increase in heat has occurred in the upper 300m of the ocean, equivalent to the rate of temperature increase in this layer of about 0.04°C/decade. Analysis of daily maximum and minimum land surface temperature for 1950 to 1993 continues to show that this measure of diurnal temperature range is decreasing very widely, although not everywhere. On average, minimum temperatures are increasing at about twice the rate of maximum temperature (0.2 versus 0.1^{o}C/decade). (IPCC,2001).

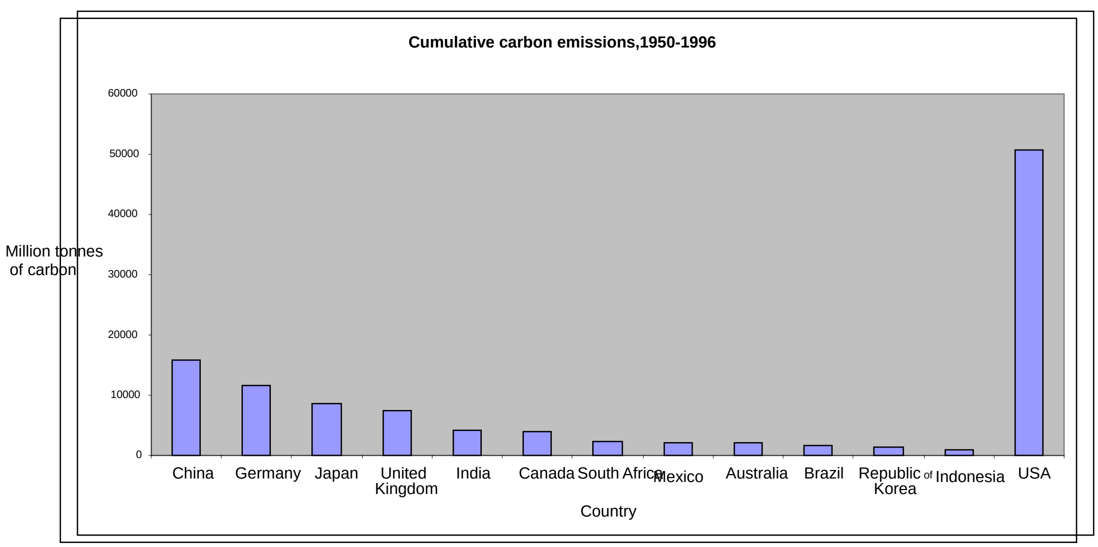
Industrialized countries are mainly responsible for the mess of climate change. They owe their present prosperity to years of historical emissions that have accumulated in the atmosphere since the start of the industrial revolution and extremely high level of current emissions. Developing countries, meanwhile, have only recently set out on the path of industrialization, and their per capita emissions are still comparatively low, though increasing. In 1990, out of 21 billion tonnes of emission globally 14 billion tones were emitted by rich developed countries, home to only one-fifth of the world's population. Of this 14 billion tones of carbon, the US alone contributed 5 billion tones of carbon. India emits 159 million metric tones of carbon. This is only 10 percent of the US emission (1,511) million tones) despite a population nearly four times over. A simplified model for carbon emission is as;

Emission of 1 American=11 Asians=9 Latin Americans=13 Africans

(Source; Gobar Times, Down to Earth Supplement,2002.)

The following figure shows the cumulative carbon emissions from 1950 to 1996 by different developed as well as developing countries countries.

Figure 1: Contribution of different countries in generating carbon



Source: Gobar Times,Down to Earth Supplement. 2002

Urban form and function also help define the nature of interactions between cities and local climate change. For example, the "urban heat island effect" results from the impact of different land uses in urban areas, creating microclimates and health consequences. The urban heat island effect is an increase in temperatures in the urban core compared to surrounding areas. As villages grow into towns and then into cities, their average temperature increases 2 to 6^{o}c above that of the surrounding countryside (UNFPA, 2007).

According to the Australian Greenhouse Office (2003), between 1850 and 1990, an estimated 212 000 Mt of carbon was emitted to the atmosphere from fossil fuel combustion and 121 000 Mt of carbon from forest clearing. About 82 000 Mt of carbon was removed from the atmosphere in regrowth, resulting in an estimated net source from forests over this period of 39 000 Mt.(Australia's state of forests report,2003).

Nepal's population comprises less than 0.4 percent of the global count and is responsible for emitting only about 0.025 percent of green house gases annually. (WWF, 2004). In Nepal, elevation generally increases from south to north and is accompanied by decreasing temperature. Temperature observation in Nepal 1977-1994 showed a general warming trend with significantly greater warming at higher elevation in the northern part of the country than at the lower elevation in the south (ADB and ICIMOD, 2006). This finding is reinforced by observation by Liu and Chen in 2000 on the other side of the Himalayas on the Tibetan plateau. Significant glacier retreat as well as significant expansion of several glacier lakes has also been documented in recent decades, with an extremely high likelihood that such impacts are linked to the rising temperature. Except for small pockets in the eastern region and far western Terai, most of the Nepal showed a positive trend of between 0^{o}C and 0.5^{o}C per decade. (ADB and ICIMOD, 2006).

2.2 Impacts of temperature on environment:

Climate change and its ramification on urban processes cover a wide spectrum. Climate related natural disasters are increasing in frequency and magnitude. Their consequences depend on a number of factors, including the resilience and vulnerability of people and places.

2.2.1 Impacts on glaciers and sea level rise:

Climate conditions have always shaped the built environment. The use of new architectural and urban forms, new materials and innovation such as air conditioning have driven up both energy costs and cities contribution to green house gas emissions and climate change. One of the alarming prospects of climate change is its impact on sea level rise and its potential consequences for coastal urban areas. Many of the world's largest cities are on seacoasts and at the mouths of the great rivers. Both urban and rural areas of coastal ecosystems are the most densely populated in the world. Sea level rise, especially if combined with extreme climatic events, would flood large parts of these areas. The first systematic assessment shows that low elevation coastal zones currently account only 2 percent of the world's land area but 13% of its urban population (UNFPA, 2007).

Global mean sea level is projected to rise by 0.09 to 0.88m between years 1990 and 2100, with significant regional variations. This rise is primarily due to thermal expansion of the oceans and melting of glaciers and ice caps. For the periods 1990 to 2025 and 1990 to 2050, the projected rises are 0.03, 0.14m, and 0.05and 0.32m respectively. Despite the higher temperature change projection in the IPCC special report on emission scenario, the sea level projections are slightly lower, primarily due to the use of improved models, which give a smaller contribution from glaciers and ice sheets. (IPCC, 2001). New data indicate that there likely has been an approximately 40% decline in Arctic sea-ice thickness in late summer to early autumn between the period of 1958 to 1976 and the mid-1990s , an substantially smaller decline in winter. Based on the tide gauge data, the rate of global mean sea level rise during the 20th century is in the range 1.0 to 2.0 mm/yr, with a central value of 1.5mm/yr. Since the last glacial maximum about 20,000 years ago, the sea level in locations far from present and former ice sheets has risen by over 120m because of loss of mass from these ice sheets. Over the past 3000 to 5000 years oscillation in global sea level on time scales of 100 to 1000 years are unlikely to have exceeded 0.3 to 0.5m. (IPCC, 2001).

2.2.2 Impacts on Agricultural production:

Recent studies on changes in climate predicted by global climate models (GCMs) suggest that in addition to thermal stress due to global warming, stress on water availability in tropical Asia is likely to be exacerbated in future. Dynamic crop growth simulation models CERES- wheat and CERES-rice for wheat and rice respectively were used to study the effect of climate change on growth and yield of these crops under non-limiting water and nitrogen availability in different states of India. Analysis of recent 30 years historical weather data from different location in the state revealed that the minimum temperatures have decreased or increased (-0.02 to +0.07oC), maximum temperatures decreased (-0.005 to -0.06^{o}C/yr) and rainfall increased (2.5 -16.8mm/yr). Keeping in view the observed trends in climate variability, growth and yield of crops were simulated under plausible synthetic climatic scenarios of changes in temperature and solar radiation. In general, with an increase in temperature above normal, the phenological development in wheat was advanced, but that of rice was not much affected. With an increase in temperature up to 1.0^{o}C the yield of rice and wheat decreased by 3 and 10% respectively. On the other hand, crops yield decreased with decreased with decrease in radiation and vice versa. When the maximum temperature decreased by 0.25 to 1.0^{o}C, while minimum temperature increased by 1.0 to 3^{o}C form normal, the yield in rice and wheat decreased by 0.8 and 3.0% respectively. (Hundal and Kaur, 2007).

2.2.3 Impacts on health:

A growing body of work links climate to the spread of human and animal infectious diseases, but the relationships between pathogens and their hosts are complex. Prediction of how there dynamics will play out over the long run in a changing climate remains controversial. Dengue fever, not considered a major public health problem in the mid 20th century, now strikes 50-100 million people each year. More than 3000 children die from malaria each day, according to the World Health Organization(Environmental Science and Technology, 2006). Many scientists suspect that global climate change may be a major contributor to the emergence and resurgence of at least some of these infectious diseases. Climate change has altered patterns of a fungal infection, leading to the extinction of two- thirds of tropical harlequin frog species in the Central and South America according to the new research. (Nature, 2006 as cited in Environmental Science and Technology, 2006). With the solid scientific consensus on the reality of global warming, the next research hurdle is to describe the impact and what can be done to mitigate them.

2.3 Forestry and Clean Development Mechanism under Kyoto Protocol

From the last century, the temperature of the globe has been abruptly increased and impact has started to seen in the present world. With the threat caused by global warming, environmentalists from all over the world decided to call for the convention to avoid the negative impacts of global warming, which is known as United Nations Convention on Climate Change (UNFCCC). Carbon dioxide is regarded as major greenhouse gas and the convention also dealt with natural as well as the anthropogenic source of mitigation option for increased carbon dioxide which is mainly responsible for climate change. In this convention forest was considered as more important alternative for mitigating climate change as it stores carbon as biomass.

In June 1992, over 180 countries adopted the United Nations Convention on Climate Change (UNFCCC), a framework aimed at stabilizing climate-altering green-house gases in the atmosphere. The Kyoto Protocol, which was adopted under the UNFCCC, and entered into force on February 16th 2005, commits industrialized countries to reduce their Greenhouse Gas (GHG) emissions by an average of 5.2 percent below their 1990 levels by 2012. To meet these commitments in the most cost-effective manner, the Protocol contains provisions allowing industrialized countries some flexibility to meet their obligations through projects that generate Emission Reductions (ERs) elsewhere. The Clean Development Mechanism (CDM), proposed under article 12 of the Kyoto Protocol, is most important instrument that allows industrialized countries to finance emissions-avoiding projects in developing countries and receive credit for doing so. An important goal of the mechanism is to contribute to the reduction of GHG emissions, while supporting sustainable development in host countries through the mobilization of financial resources and the transfer of cleaner technologies.

Under the CDM, Land Use, Land-Use Change and Forestry (LULUCF) projects can contribute to the reduction of greenhouse gases while providing significant benefits to rural communities in developing countries. Clean Development Mechanism was to assist Parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the Convention, and to assist Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments under Article 3. Under the clean development mechanism:

(a) Parties not included in Annex I will benefit from project activities resulting in certified emission reductions; and

(b) Parties included in Annex I may use the certified emission reductions accruing from such project activities to contribute to compliance with part of their quantified emission limitation and reduction commitments under Article 3.

The clean development mechanism would assist in arranging funding of certified project activities as necessary. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall ensure that a share of the proceeds from certified project activities is used to cover administrative expenses as well as to assist developing country Parties that are particularly vulnerable to the adverse effects of climate change to meet the costs of adaptation. Certified emission reductions obtained during the period from the year 2000 up to the beginning of the first commitment period can be used to assist in achieving compliance in the first commitment period(2008-2012).(United Nations ,1998). Essentially, the CDM allows industrialized countries with emission reduction targets under Annex B of the Kyoto Protocol (often referred to as the "Annex I" countries) to invest in projects in developing countries and to use the emission reductions yielded to comply with their climate protection targets. The specific rules on the CDM operation will be provided by the Conference of the Parties serving as the meeting of the Parties (COP/MOP) to the Kyoto Protocol (which met for the first time in early December 2005), but the rules have actually already been laid down by the Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC) in various decisions, subject to confirmation by the COP/MOP, which is not expected to alter these rules in any significant way. The Kyoto Protocol itself makes no distinction between energy-related (i.e. emission avoiding) and carbon sequestration or storage projects ("sinks" or "Land use, land use-change and forestry, LULUCF" in climate change), such as afforestation and reforestation. The most significant difference between CDM AR projects and energy-related CDM projects is the temporary nature of carbon storage, the so-called non-permanence of biologically sequestered carbon. While avoided emissions in energy CDM projects will not reoccur so easily and are therefore considered permanently avoided emissions, carbon stored in biomass and soils can be re-emitted to the atmosphere through decomposition and mineralization, fire, pests etc. This particularity of LULUCF carbon sequestration activities required specific arrangements for the accounting of emission reductions: while CDM energy projects), which are tradable once they are verified, CDM AR projects generate either temporary CERs (tCERs) or long-term CERs (lCERs). Both reflect the specific nature of temporary carbon storage through biomass. With respect to the types of activities, three broad categories of LULUCF projects can be distinguished:

(i) emission reductions through conservation of existing carbon stocks,

(ii) carbon sequestration by the increase of carbon stocks, and

(iii) substitution of fossil fuel through sustainably grown biofuels.

12 Projects for all these categories have been implemented under the UNFCCC's pilot phase for Activities Implemented Jointly (AIJ;). However, only the second and third project categories are eligible under the CDM for the first commitment period

(2008–2012). Possible types of CDM AR projects include agro forestry, monocultural or mixed industrial plantations, forest landscape restoration projects on degraded or protected lands, community forest projects, and other AR projects which focus on timber production, biomass energy, and watershed management. (IUCN, 2003).

2.4 Concept and Emergence of Community Forestry; An Overview

Community forestry is small scale, village level forestry practice where decisions and actions are often made on a collective/communal basis and where the rural population participation planning, establishment, management and harvesting of forest crops and receive a major proportion of the socio-economic and ecological benefits from the forests. Conceptually, community forestry can range from pure cropping on one extreme to combining tree and food crops agro forestry on the other.

In many developing countries, traditionally forestry has been geared towards commercial exploitation of natural forests and development of industrial plantation to meet national and export demands. Their forest policies and legislation stressed on managing the forests to increase state revenue and prescribed stringent measures against interference from the local people, often debarring people from access to forest. The role of forestry in meeting the local demands of rural communities was not given due consideration or assumed as unimportant. As a result, the major financial benefits from the forest went to a handful of contractors or industrialist and the government but not so much to the local people. The continued denudation of forests to earn more revenue and to meet ever increasing demand of forest products has created ecological degradation, desertification, and environmental degradation. As consequences, food and energy crisis has become a major world issue in recent years. Fortunately more and more countries have realized the value of forests in protection the environment and enacted legislation emphasizing the social and economic significance of he forests. Following such legislation, new programmes have been developed and implemented embracing participatory approach. One such programme aimed at developing rural communities is known as social forestry or community forestry. (Kayastha, 1991).

In Nepal Community forestry strategies gained greater definition from the mid 1970s onwards. The concept of people's participation in forest management was raised with greater clarity in the National Plan of 1976. In 1978, community based forest policy was enacted with operational by laws. The new guidelines included the leasehold forestry rules, Panchayat Forest Rules and the Panchayat Protected Forest Rules. This legislation clearly required the "handing over" of forest to local user groups identified by Panchayat leaders. The panchayat forest rules and panchayat protected forest rules (1978) had provision of forest hand over and management to the political units (village panchayat) which, after the dissolution of all panchayat units in 1990 were handed over to Forest User Groups (FUGs). The establishment of a multiparty democracy in Nepal in 1990 resulted in the abolition of the panchayat structure, making it easier for the Forest Department to work directly with forest user groups. Under the new constitution of 1990, panchayats are replaced by village development committees comprised of democratically elected representatives. (WG-CIFM, 2006).

Community forestry policy is an institutional innovation of empowering local communities in managing forest resources for their benefit in co-ordination with the government. The initial phase of community forestry was geared toward assigning responsibilities and rights of local forest management to the village level political bodies. It was based on protecting and planting trees to meet the forestry product needs of the local people based on the principle of ' gap analysis'. Three years of rigorous study and consultation on the preparation of the Master plan for the forestry sector (MPFS), and the first national level workshop on community forest held in 1987 laid the foundation for handing over forests to groups of traditional forest users so that they could meet their basic forest product needs and at the same time conserve these forests. Reorientations of foresters were also considered essential for the sustainable management of these community forests. The MPFS further stressed that participation of local communities in decision making and benefit sharing was essential for the conservation of forest management. The endorsement of MPFS in 1988 and the political regime change in 1990 were instrumental in the formulation of new Forest Act in 1993 and Forest Regulation in 1995. The focus of the new act and regulation was on institutionalizing community FUGs an independent and self governing entity, expanding community forest not only in the hills but also in Terai providing utilization and management rights to these community FUGs and making Districts Forest Offices(DFOs) the 'gate keepers' of community forests.(Kanel 2004).

The forest act of 1993 and forest regulation 1995 ,provided a sound legal and institutional footing of the FUGs and empowered District Forest Office to hand over accessible forests to the extent that communities are willing to a large extent, accelerated handing over process of community forest to the traditional forest users.(Banko Jankari,1998). As thousands of Forest Users Group spread through Nepal during the 1990s, a number of individuals involved in the community forest movement together with FUGs leaders decided to establish an umbrella organization to link local management organization. The Federation of Community Forestry Users (FECOFUN-Samudaik Ban Upabhokta Mahasangh) is an association formed by the FUGs of Nepal established to expand and strengthen their role in management of the country's forest. The national federation of FUGs was registered in 1995 and held its first national assembly in March 1996. (WG-CIFM, 2006).

The economy largely depends on the use of its natural resource base and is dominated by the agrarian sector. More than 80 percent of the people depend on subsistence farming. Forest provides food, medicine, energy, shelter, bedding materials, wood and non-wood products to maintain and sustained subsistence-farming system in rural areas of Nepal. Rural people, because of their dependence on a variety of forest products to maintain their subsistence agriculture, have for a long time played an important role in the use and management of the forests (Gilmour and Fisher 1991; Fisher 1989; Fox 1983 as cited by Acharya ,2004). As there is complex relations between the forests, agriculture and human subsistence, the subsistence economy, increasing population, and demand threaten the forests and impact on biodiversity, which in long run ultimately, threatens the livelihoods. The reasons for the loss of biodiversity in Nepal is described as low levels of public awareness and participation, population pressures and poverty, weak institutional, administrative, planning and management capacities, lack of integrated land and water use planning, inadequate data and information management and lack of policies of strategies for biodiversity conservation. (Acharya, 2004). The hand over of forests to the community has reduced the rate deforestation in natural forests, although they are provided the full rights for conservation, management and utilization of the forest resources. In these days, the importance of the forest in terms of natural way of climate change mitigation is paid more attention from the community level, although at the small level, it can be taken as positive part for the conservation of forests especially in the country like Nepal where there are numbers of community forests. Nation can take better advantage of community forests either in terms of measure for climate change mitigation or medium for sustenance of livelihood.

2.5 Literatures on carbon storage in forest:

Carbon in the Earth system moves between four major reservoirs: fossil and geological formations, the atmosphere, the oceans, and terrestrial ecosystems including forests. Transfers between these reservoirs occur mainly as carbon dioxide CO_2 in processes such as fuel combustion, chemical dissolution and diffusion, photosynthesis, respiration, decomposition, wild fire, and burning of biomass in the open and in furnaces. If a component of the biosphere such as woody biomass, shrinks, carbon is released into the atmosphere. If biomass expands, it becomes a sink, and thus removes carbon from the atmosphere.Through photosynthesis plants absorb carbondioxide from the atmosphere, store the carbon in sugars,starch and cellulose, and release the oxygen into the atmosphere. A young forest, composed of growing trees, absorbs carbon dioxide and acts as a sink. Mature forests, made up of a mix of various aged trees as well as dead and decaying matter, may be carbon neutral above ground. In the soil, however, the gradual buildup of slowly decaying organic material will continue to accumulate carbon, but at a slower rate than young forest. Forests are home to about 80% of the global biodiversity and have similar proportions of biomass and carbon-stock. Forests are not only for timber and non-timber products, but also for a number of ecosystem services. In spite of the importance of the forest ecosystem to provide all these services, deforestation (loss in forest area) and forest degradation (reduction in biomass of forest stands) in Tropics remains an environmental challenge with global ramifications. Forest ecosystems are deemed to be an important factor in climate change because they can be both sources and sinks of atmospheric CO_2. They can assimilate CO_2 via photosynthesis and store carbon in biomass and in soil The main pools of actively cycling carbon are atmospheric CO_2, biota (mostly vegetation), soil organic matter (including detritus), and the ocean. Of these, the oceans contain the largest reserves of C about 39,000 Pg C. though most of this (all but about 1000 Pg C) is in deep ocean layers and not in active circulation, at least in times measured in human generations.

2.5.1 On a global level:

According to the estimates, the global forest vegetation stores 283 Gt C in its biomass, and an additional 39 Gt C as deadwood, for a total of 322 Gt C. This is slightly less than the prior estimate by IPCC (2000) of 359 Gt C in these pools. Soils to a depth of 30 cm and litter contain 312 Gt C. Thus, even to a depth of only 30 cm, they store about the same amount of carbon as forest vegetation. Expanding carbon content in soils to a depth of 1m, litter and soil together contain 448 Gt C. This is considerably less than the 787 Gt C that IPCC (2000) estimated in forest soils and litter. (FAO, 2006).

According to IPCC 2001, Carbon stocks in biota are somewhat less certain, but are almost comparable to the atmospheric pool: about 400–600 Pg C. (Janzen, 2004). Most of this, about 75%, occurs in forests (as in Table D).Oceanic plants, mainly algae, account for less than 1% of global biomass C (Falkowski, 2002; Körner, 2000; Smil, 2002as cited in Janzen, 2004). The largest pool of actively cycling C in terrestrial ecosystems is the soil. To a depth of 1m, it contains about 1500–2000 Pg C in various organic forms, from recent plant litter to charcoal to very old, humified compounds (as in table C). (More C exists as carbonates and in organic forms below the 1m depth, but these are often assumed, perhaps natively, not to be in active circulation.) About a third of the soil organic C occurs in forests, another third is in grasslands and savannas, and the rest is in wetlands, croplands, and other biomes. (Janzen, 2004).

Table. C:Summary of C stocks: plants, soil, atmosphere

Biome	**Area (10^9ha)**	**Global carbon stocks (PgC)**			**NPP (Pg C per year)**
		Plants	Soil	Total	
Tropical forests	1.76	212	216	428	13.7
Temperate forests	1.04	59	100	159	6.5
Boreal forests	1.37	88	471	559	3.2
Tropical savannas and grasslands	2.25	66	264	330	17.7
Temperate grasslands and shrub lands	1.25	9	295	304	5.3
Deserts and semi- deserts	4.55	8	191	199	1.4
Tundra	0.95	6	121	127	1.0
Croplands	1.60	3	128	131	6.8
Wetlands	0.35	15	225	240	4.3
Total	15.12	466	2011	2477	59.9

Source: IPCC, 2001: In Janzen (2004).

According to the FAO,2005,carbon stock in whole world is estimated to be 161.1 tonnes/ha. Regionally the distribution of carbon stock is as shown in table below for the year 2005.

Table:D :Regional distribution of carbon stock for the year 2005

S.No	Region	Total Carbon (Carbon in living biomass, dead wood ,litter and soil)(tonnes/ha)
1	Total Africa	160.8
2	Total Asia	132.9
3	Total Europe	176.9
4	Total North and Central America	120.6
5	Total Oceania	173.1
6	Total South America	194.6
World(Global Average)		**161.1**

Source: Global Forest Resources Assessment . FAO,2006.

IPCC (2000) estimated an average carbon stock of 86 tonnes per hectare in the vegetation of the world's forests for the mid-1990s. The corresponding carbon in biomass and dead wood in forests reported here amounts to 82 tonnes per hectare for the year 1990 and to 81 tonnes per hectare for the year 2005. Each cubic meter of growing stock equals different amounts of biomass and carbon in biomass in the regions. Table 2.9 provides average conversion factors compiled from country submissions. Globally, each cubic meter of growing stock equals, on average, 1 ton of above-ground biomass, 1.3 tonnes of total biomass and 0.7 tones of carbon in biomass. The country reports indicate that global forest vegetation stores 283 Gt of carbon in its biomass, and an additional 38 Gt in dead wood, for a total of 321 Gt.(FAO,2005). In contrast, the oceans absorb from the atmosphere approximately 2 more gigatons of carbon than they release, and the earth's ecosystems appear to be accumulating another 1.2 gigatons annually. In all, the atmosphere is annually absorbing approximately 3.4 gigatons of carbon more than it is releasing. (Stavins et al.2005).

2.5.2 On a Regional and National level:

There is considerable interest on the role of terrestrial ecosystems in the global carbon cycle. It is estimated that about 60 Gt C is exchanged between terrestrial ecosystems and the atmosphere every year, with a net terrestrial uptake of 0.7 ±1.0 Pg1 C (Schimell *et* al., 1996 as cited by lasco,2001). The world's tropical forests which cover 17.6 M km2 contain 428 Pg C in vegetation and soils. On the other hand, land use change and forestry activities, mainly tropical deforestation, are significant net sources of CO_2, accounting for 25% emission from forestry sector i.e.1.6 Pg/yr out of the total anthropogenic emissions of 6.3 Pg/yr (Houghton *et al*., 1996; Watson *et al*., 2000 as cited by Lasco,2001). However, tropical forests have the largest potential to mitigate climate change amongst the world's forests through conservation of existing carbon (C) pools (e.g. reduced impact logging), expansion of C sinks (e.g. reforestation, agro forestry), and substitution of wood products for fossil fuels.

In tropical Asia, it is estimated that forestation, agro forestry, regeneration and avoided deforestation activities have the potential to sequester 7.50, 2.03, 3.8-7.7, and 3.3-5.8 Pg C between 1995-2050 (Brown *et al*., 1996). In the United States, in 2004 (the most recent year for which EPA statistics are available), forests sequestered 10.6% (637 teragrams) of the carbon dioxide released in the United States by the combustion of fossil fuels (coal, oil and natural gas; 5988 teragrams).

Tropical forests make up 80% of the total world forests and are recognized as having the greatest long-term potential to sequester atmospheric carbon, via protecting forested lands, slowing deforestation, reforestation and agro forestry (Brown et al., 1996 as cited by Shin et al.,2006). Another study showed that Southeast Asian countries the potential to sequester 9.0 Pg to 21.0 Pg of C from 1995-2050 in 66 M ha through forest regeneration, farm forestry and plantation development (as in Table E).

Table: E: Carbon stored in different Southeast Asian countries.

COUNTRY	REGENERATION(000ha)	Farm forestry (000ha)	Plantation (000ha)	Total (000ha)	C stored (Tg C) LOW/HIGH	
Indonesia	20,000	5,000	10,000	35,000	5,400	14,000
Laos	10,000	1,000	2,000	13,000	530	1,000
Malaysia	6,000	500	400	6,900	1,000	1900
Myanmar	13,000	1,000	500	14,500	390	950
Philippines	5,000	3,000	1,000	9,000	840	1,600
Thailand	4,000	4,000	1,000	9,000	170	630
Vietnam	8,000	0	4,000	12,000	620	1300
Total	66,000	14,500	18,900	99,400	8,950	21,380

Source: Potential C sequestration of regeneration, farm forestry and plantation development activities in Southeast Asia from Trexler and Haugen, 1994 as cited by Lasco, 2001).

There are limited data on C densities of natural forests in the specific Southeast Asian countries. According to Lasco 2002,Indonesian forests have been estimated to have a C density ranging from 161-300 Mg C/ha in aboveground biomass, 150-254 Mg C/ha in above ground biomass and upper 30 cm of soil and 390 Mg C/ha in above ground biomass and below ground pools. Recent studies showed that Philippine natural forests contain 86-201 Mg C per ha in aboveground biomass. The IPCC Revised Guidelines estimates that old-growth forests in the Philippines contain 370-520 Mg/ha of aboveground biomass equivalent to about 185-260 Mg C/ha at 50% C content. Pasa et al.,2006 conducted the research on the carbon stock of the three forest of Philippines. A study was carried out in the 2,236-ha Community-Based Forest Management (CBFM) project in three site Barangay Gabas and Barangay Kilim, Baybay, Leyte, Philippines The CBFMP site had three land use classifications, namely:

1) protected zone, 2) buffer zone, and 3) multiple-use zone. The protected zone, located in the northeast portion covering 1,229.8 ha or about 55 percent of the whole project site, was a wilderness area protected against human interventions. Actually what was found is, the buffer zone had the highest upper storey biomass carbon density because such zone had the highest volume of standing trees among the three. The multiple-use zone, on the other hand, having the lowest upper storey carbon stock had less volume of standing trees among the three. The under storey biomass carbon also showed considerable variation. The multiple-use had slightly more carbon stocks among the three zones which could be attributed to some understorey plants. The floor litter carbon stocks showed varied trends as well. This time, the buffer zone had the highest amount of carbon among the three. The buffer zone had the thickest floor litters followed by the multiple-use zone and then the protected zone. In addition, the multiple-use zone had the highest root biomass carbon. It was possible that the laid sampling plots fell on areas with high root biomass concentration. The observation was like the following:

Table: F: Carbon pool in different land use

CARBON POOLS	LOCATION/ CARBON STOCKS (Mg/ha)		
	Protected Zone	Buffer Zone	Multiple-Use Zone
Upperstorey Biomass	177.89	223.73	96.82
Stem/Twigs (Understorey)	1.34	1.49	1.72
Leaves (Understorey)	0.54	0.37	0.35
Floor Litter	1.38	2.75	2.31
Roots	11.03	13.57	17.43
Soil	221.73	114.96	111.14
Total	413.91	356.87	229.77

Source: Environmental Services and Reward Opportunities under the CBFM Project in Midwestern Leyte Province, Philippines,2006.

Similarly Sales et. al,2006 in Australian Centre for International Research on Agriculture (ACIAR) carried out the research on prediction of the carbon storage and sequestration potential of common tree farm species in Leyte Island, the Philippines. Data gathered from field measurements was used to fit the Chapman-Richards growth function to predict the volume and biomass increment of *Gmelina arborea* and *Swietenia macrophylla* tree farms until they reached their respective rotation ages. Biomass and carbon density values were found to vary with age, type of species, site conditions and silvicultural treatments applied in the stand. Although differences in year when the trees were planted had no relation with its soil carbon storage, this pool had greater storage capacity than the above-ground biomass and roots. The average maximum growth was attained after 10 years for *G. arborea* and 13 years for *S. macrophylla*. Volume growth started to slow down when the tree species reached almost half its rotation age. The same trend was observed for the biomass and carbon density of each farm. The maximum mean annual increment of both species was attained before the expected maximum growth year. Growth increment decreased as the species reached their rotation age. The total C storage capacity of a 15-year-old *G. arborea* tree farm was estimated at 64 MgC/ha while that of a 25–year-old *S. macrophylla* was estimated at 159 MgC/ha. The average carbon sequestration rate of both species was 5 MgC/ha/yr which is lower than the average rate of most tree plantation species in the Philippines (Sales et al, 2006).

More recently, there were attempts to estimate the C mitigation potential of some countries in Southeast Asia. For example, Boer, 2001 stated that Indonesia is estimated that an additional 546 TgC will be conserved and sequestered from 2000-2012 under certain development and investment conditions (Lasco, 2001). While Lasco and Pulhin, 2001 stated that, in the Philippines, an additional 35TgC will be conserved and sequestered during the same period (Lasco,2001).

Likewise, Researchers investigating how Australian vegetation has changed since European settlement, taking into account the rapid rise in atmospheric (CO_2) concentration over the last two centuries, have found that the total carbon stock in the living vegetation may have doubled. The vegetation should also have become more drought tolerant as a result of the increasing (CO_2).Using theoretical model, and given certain assumptions, they have been able to estimate the total mass of carbon, in roots, stems and leaves, in the living vegetation across Australia in both 1788 and 1988. ‘According to the model, Australian vegetation has changed a great deal since European settlement with the total carbon stock in all living vegetation increasing, on average, by 50 million tonnes (Mt) of carbon per year for the continent (approximately a 0.35 per cent per year increase, compounded annually). The model and resulting maps indicate that carbon stock has, not surprisingly, declined in regions where woody vegetation (trees and shrubs) has been cleared for agriculture, but increased in the forests and remained pretty well unchanged in arid parts of the country. (Berry SL and Roderick ML, 2006).

In Northern Spain, forest surface has increased considerably, mainly due to reforestation of former agricultural land. This fact supposes a chance to accumulate C. Anyway, biomass and carbon stock are not easy to estimate. Estimation of the carbon stock of the forest was made in a pilot zone for year 1987 to 1998 that could represent the whole forest of the Northern Spain, pilot zone selected covered 48,000 ha and was quite representative of the whole of the region in terms of type of forest and forest productivity. The main types of forest were plantations of *Pinus radiata*, *Eucalyptus globulus*, *Pinus pinaster* and natural stands of oaks (*Quercus robur*). Data from the second and third Spanish forest inventories (1987-1998) were used in the calculations of this study. Biomass equations results showed that total C-stock in the living tree biomass was assessed at around 628,000 Mg C in 1987 and 1,300,000 Mg C in 1998. This increase was mainly due to the increases of surface area distributed to *Eucalyptus globules* (35.5%), *Pinus pinaster* (27.9%) and *Pinus radiata* (18.3%), which implies an increase of 1.3 Mg C ha^{-1} $year^{-1}$. The use of expansion factors overestimates the C amount by 12 to 17% in relation to the use of predictive equations of biomass for each species (FORSEE,2006).

As natural forests in the Southeast Asian region have been one of the world's foremost sources of tropical hardwoods, different factors affect the carbon content of in the forest. For Thailand, various forest types have a C density in aboveground biomass ranging from 72 to 182 Mg/ha. Malaysian forests have C density ranging from 100 to 160 Mg/ha and from 90 to 780 Mg/ha in vegetation and soils, respectively. As natural forests in the Southeast Asian region have been one of the world's foremost sources of tropical hardwoods, different factors affect the carbon content of in the forest. The net productivity of the earth is 45×10^{15} to 65×10^{15}gC, about 59% of which comes from the terrestrial ecosystem. In addition, the annual carbon sequestered by forest is 36.6×10^{5} gtC, about 60.8% of which is fixed by terrestrial ecosystem. Cheng Zhongxin, 2000 states that as forest only occupy 6.41% of the total global area but can sequestrate 35.9% of carbon globally. (Lansheng et. al. 2000, as cited by Jianmin and Zhiping, 2007).

Jianmin and Zhiping(2007) carried out the research in the Miyun watershed surrounding the Miyun reservoir at the north east of Beijing, China. The original vegetation was composed of conifers and broad-leaved trees. Due to the destruction by human activities, the existing forests were the secondary forests at different successive stages. The main tree species were cypress, oak pine, acacia, poplar and birch. Carbon sequestration of the cypress forest (14526 ha.), pine forest (17615 ha.), oak forest (20132 ha.) and broad-leaved forest (12467 ha.) was studied at every 10 years. The pine forest had largest biomass i.e. 339.17 t/ha, oak forest i.e. 260.05t/ha, cypress forest i.e. 148.33t/ha and shrub 65.04t/ha. The mean biomass increase was simulated by using 10 years as a growth stage. Since the life span of the main forest types in the study area were about 100 years, timber accumulation was calculated up to 100 years in study. Analysis showed that in a rotation of 100 years, pine forest could sequestrate more carbon than others can. And the shrub ha the lowest carbon sequestration as shown in the table below:

Table: G: Carbon sequestered during 100 years by different forests.

S.No.	Vegetation types	Quantity of carbon sequestered (t/ha)
1	Pine forest	145.8-196.7
2	Cypress forest	63.8-86.0
3	Oak forest	117.7-158.8
4	Other broad leaved forest	111.8-150.8
5	shrub	52.8-66.3

Source: Jianmin and Zhiping, 2007

In Chittagong region, Bangladesh, plantations of 13 tree species comprising six exotic and seven indigenous species, with ages ranging from 6 to 23 years, managed by Chittagong University, were studied. The study showed that the highest total carbon content (255 t/ha, S.E. 7.21) was found in the *Aphanamixis polystachya* plantations, followed by concentrations of 247 (S.E. 31.96), 224(S.E. 25.76), 211(S.E. 22.77) and 203 (S.E. 31.45)t/ha for the *Lagerstroemia speciosa*, *Tectona grandis*, *Albizia procera* and *Eucalyptus camaldulensis* plantations, respectively. The lowest carbon content (140 t/ha, S.E. 12.42) was found in the *S. grande* plantation. The average carbon content for all the stands studied was 190 S.E. 5.72)t/ha. Considering the stands of different ages and species, it was shown that 12-year old Aphanamixis polystachya had the highest total carbon content (269 t/ha, S.E. 6.12) followed by 8-year old *A. auriculiformis* (268 t/ha, S.E. 66.49); while the lowest (96 t/ha, S.E. 5.74) was observed in the 6-year old *D. turbinatus* stand. (Shin et al.,2006).

Under the farm forestry programme in state of Uttar Pradesh in India, nearly 1906.8 million trees have been planted during the period 1979-94. Of which 1525.44 million were estimated to be surviving. In terms of land coverage, this works out to over one million hectare. It was estimated that nearly 20 million tonnes of carbon has been sequestered by these farm forestry plantation.(The Indian Forester,2000). Dewar and Cannel(1991) as cited by Sharma (2000), developed one model of plantation species that periodically harvested and replanted carbon fixation during plantation growth cycle is represented by the increase in biomass of woody(branches ,stems and woody roots) and non-woody (foliage and fine roots)parts which have different growth dynamics and decay characteristics. At the end of rotation and each thinning, a proportion of biomass is transferred to carbon pool, and eventually decays to carbon dioxide. Throughout each rotation, the forest continuously receives carbon in form of dead wood and non-woody litter as well in thinning harvest also. A portion of this litter decomposes to carbon dioxide.

According to Dewar et al. (1991) as cited by Sharma, 2004, carbon growth function is dominated by woody parts of trees (stems, branches and woody roots) and has a sigmoidal form. The estimated rates of carbon storage in different plantations were on the range of 2-5MgC/ha/yr. They fond relatively small contribution of 4-6% on foliage, and fine roots were ignored. So from a growth model of a tree, we can learn that carbon is increasing every year until Mean Annual Increment (MAI) culminates. (Sharma, 2004). They found the following results in the general magnitude of plantations.

Components	**Amount of carbon**
1. Trees	40-80MgC/ha
2. Above and belowground litter	15-25 MgC/ha
3. Soil organic matter	70-90 MgC/ha
4. Harvested products	20-40 MgC/ha
Total	**145-235 MgC/ha**

A case study of forestry mitigation project in semi-arid community grazing lands and farmlands in Kolar district of Karnataka, India was undertaken with regard to baseline and project scenario development, estimation of carbon stock change in the project, leakage estimation and assessment of cost-effectiveness of mitigation projects. Further, the transaction costs to develop project, and environmental and socio-economic impact of mitigation project were assessed. Among the stocks of five C-pools; Aboveground Biomass (AGB), Below Ground Biomass (BGB), litter, dead wood and Soil Organic Carbon (SOC) ,only AGB, BGB, SOC and woody litter pools were selected for estimating carbon stock changes, since dead wood doesn't exist. From the result it was observed that, community forestry from an area of 8,625 ha was found to contain 196,630 tC and for farm forestry with an area of 5,381 ha to be 81,750 tC. Thus, the overall carbon stock in Kolar for a total area of 14,000 ha under various mitigation options is 278,380 tC at a rate of 20 tC/ha for the period 2005-2035, which is approximately 0.67 tC/ha/yr.(N.H,2005).

Study carried out in Uttaranchal, India (ANSAB, 2006), relatively undisturbed forests carbon sequestration rates in total biomass (above ground plus below ground) generally ranged between 4 and 5.6 t c /ha/yr, which are similar to those reported for tropical forests. However, the average values of sequestration were about half as much as above. This gave a total amount of sequestration in entire forest area of Uttaranchal - about 6.6 million t c per year. Among the forest types, the major contributors were temperate broad leaved forests, temperate conifer forests, and sub-tropical pine (*Pinus roxburghii*) forests. The temperate broadleaved forests generally include oaks (Quercus spp), and temperate conifer forest silver fir (*Abies pindrow*), deodar (*Cedrus deodara*), and blue pine (*Pinus wallichiana*). The total amount of carbon in soil up to 150 cm depth was estimated 263.6 million ton which is similar to carbon contained in forest biomass, 267 million tonnes.

Forests of Nepal are quite similar to those of Uttaranchal, particularly in the western part. Domination of sub-tropical pine (*Pinus rosxburghii*), Oaks (*Quercus spp*), Sal (*Shorea robusta*), and silver fir (*Abies pindrow, A. spectabilis*) can be seen also in much of Nepal. A total amount of carbon in entire forest area of Nepal is also about 126 million ton. (ANSAB,2006).

ANSAB,2006 project team assessed forest carbon and quantified contribution of forests to carbon-sequestration in Nepal and Uttaranchal based on the existing data and growing stock estimation. This was the best alternative to the more precise estimation in the given time limitation to make periodic assessments of tree growth over the years, financial resources, and scope and nature of the pilot study. The formation of community forest user groups (CFUGs) in Nepal has played a significant role in restoring degraded forests.

In Uttaranchal the government has taken an initiative to put community forest in place. In terms of carbon sequestration of community forests, Tewari and Phartiyal (2006) taking two cases in Nepal and three cases in Uttaranchal recorded that an average of 2.1 t C/ha/yr (Nepal) and 3.7 t C/ha/yr (Uttaranchal) is sequestered. At this rate, a community forest area of 100 ha can yield about US $3,953 (IRs 166,000) in Uttaranchal, and US $2,730 (N.Rs. 196,560) in Nepal (estimated at the rate of US $13 per ton carbon). In Kumaun region of Uttaranchal, Chirpine (*Pinus roxburghil*) forest was the largest contributor to sequester carbon, but at the state level temperate broad leaved forests, in which various Oaks dominate, account for the largest fraction of carbon accumulation. Estimation showed approximately 126 million t C was stored in the tree stems of Nepal forests. The yearly C sequestration from all forest comes to about 10 million t, contributions being large from Sal forests, oak forests, pine forests and fir forests. Present forests in Nepal sequester about 20-25 million t C each year, which gives a value US $260-325 million.(ANSAB,2006).

Estimation of Department of Forest Research and Survey(DFRS),HMGN,1999 indicates that the total stem volume of the reachable forest of Nepal is 387.5 million m^3 and the total biomass about 428.6 million tons. The area of reachable forest is about 2179.3 thousand ha; and the mean stem volume is 178m^3/ha.therefore for the whole country the projection of the total volume is estimated at 795 millionm^3 and the total biomass is about 873million tons which comes to about 436 million tons of carbon. (Amatya and Shrestha, 2002).

Adhikari, 2005, conducted research on carbon stock capacity of a community forest named Sunaulo Ghyampe Danda community forest in Chandragiri hill. Analysis on carbon stock of two different forest; pine forest and mixed broad leaved forest was done. It concluded that pine forest has higher carbon storage capacity than the mixed broad leaved forest. (Adhikari, 2005).

According to the estimates of HMGN/MOPE(Ministry of Population and Environment)(2004),total carbon uptake by he woody biomass of Nepalese forests is 5640.21kt as given the following table(Adhikari,2005):

Table:H: Forest Area, Growth Rate, Annual Biomass Increment and Carbon Uptake(1994/95)

IPCC Defined Categories	Corresponding Physiographic Zones	Area(K ha)	Annual Growth Rate(tdm/ha)	Annual Woody Biomass (Kt dm)	Total Carbon Uptake(KtC)
Moist with long dry season	Terai and Siwaliks	1716.1	2.34	4032.84	2016.42
Montane Moist	Middle Mountain and High Mountain	2434.5	1.64	3992.58	1996.29
Montane Dry	High Himal	118.1	1.75	206.68	103.34
Shrub		1559.2	0.59	919.93	459.96
Grass		1765.9	0.085	150.10	75.05
plantation		99	2.71	268.29	34.15
Trees outside forest		300 million trees	0.0057/1000 trees	1710.00	855.00
				11,280.42	5640.21

Source: HMGN/MOPE,2004 as cited by Adhikari,2005.

On the coordination of ICIMOD, National Trust for Nature Conservation (NTNC), 2006, implemented the project on carbon sequestration of a community forest in Lamatar, Lalitpur by diameter at breast height measurement (dbh) method. This research concluded that total 96 ha of the forest could sequester 122tc at the rate of 2.54 ton/ha. (Karky and. Banskota. 2006).

One research was carried out at mixed broad leaved forest of Phulchowki watershed, Lalitpur. Carbon content of under storey vegetation and upper storey vegetation i.e. aboveground biomass, ground vegetation, soil organic carbon and litter carbon was determined in two forest; one in the natural forest and another in the community managed forest. Result of that study showed that natural forest has higher carbon storage than the community managed forest. This was further supported by the study which was carried out during field observation on consumption of forest products. This concluded the low carbon storage on community forest was due to high consumption and encroachment of people in community forest than in the natural forest. (Bhatt, 2005).

Chapter Three:

3 Materials and Methods:

There are many characteristics of the forest stands, which is useful to know for their management and also for its inventory. The most common and generally the most important characteristics are related to the volume of wood; gross or net or extractable classes, by species or groups of diameter classes, by quantity classes , down to a minimum diameter, estimated at the time of the inventory or subsequently(through the estimation of volume increment) etc.

In most forest inventories, volume information is obtained from the field inventory, although stratification by photo interpretation may be bases on items in relation with the total volume of the stands (such as density and height of he dominant trees). However, in some temperate countries, when species identification is feasible on aerial photographs, most of the volume information is taken from the photographs through photogrammetric measurements. The remaining part of this information being obtained from a few field samples. This method, which has proved efficient for some temperate forests, is not applicable to the mixed tropical forests. (FAO, 1981).

3.1 Location and duration of the study:

The entire study was carried out during May to September 2007 in Champadevi community forest, which lies at Kirtipur municipality ward no.8. Kirtipur municipality lies in the southern west side of the Kathmandu valley. (GoN, 2002).

3.2 Sampling design

Quadrat size was taken as 20 x 20 m^2 for the sampling of vegetation. The aspect of forest is north facing which extends from east to west. For sampling, Line Transect Method was applied as given by Sharma, P.D., 2004. From the westward boundary of the forest, at each 50 m horizontal distance sampling plot were allocated. At first the altitudinal range of forest was stratified into consecutive nine contours from bottom of the forest. As forest elevation ranges from 1400m to 2500m, the stratification transect was made for every 100m difference from 1500m to 2300m considering that the lowest part and the top of hill is encroached with human interference; at bottom by people for fodder and other forests products and at the top due to temple of goddess Champadevi .

From the 50m distance from the westward boundary of the forest at 1500m elevation, first quadrat was located. For the estimation of biomass of the trees within the quadrat, diameter at breast height (dbh) i.e. 1.3m from the ground, of the trees species were noted and diameter with less than 5cm diameter were excluded as most of the allometric equations starts from diameter which is greater than 5cm in diameter. In addition plants numbers were also counted. In the 1500m elevation, second quadrat was located at same line 50m apart from first plot and diameter measurement was done. Similarly other two plots were fixed and diameter was measured. Consequently in the next 1600m, 1700m, 1800m, 1900m, 2000m, 2100m, 2200m and 2300m , similar procedure was applied to make 36 plots in total which become 1% of the total area of forest.

3.3 Biomass analysis:

The cut branches of unidentified plant species were brought for herbarium preparation. But most of the plant species were made identified with the help of local people and remaining unidentified were brought for herbarium preparation for identification. Then prepared herbariums were identified with the help of the respected teachers. With the collected values of dbh, the biomass of each tree species in each quadrat was determined with the help of guidebook prepared by GoN, Ministry of Forest, and Soil Conservation, Department of Forest (DoF) and Natural Resource Management Sector Assistance Program (NARMSAP), 2000.

The estimation of carbon in forest ecosystem is mainly premised on simple fact that 50% of the biomass is composed of carbon. (Mac Dicken, 1997).

3.4 Species Diversity Analysis:

Vegetation composition on every elevation was analyzed and species diversity at each elevation was determined by using Shannon-Wiener's Index as given by Zobel et.al. , 1987.

$$H = 3.3219 \left\{ \frac{N\log_{10}N - \sum_{i=1}^{i=k} n_i \log_{10} ni}{N} \right\}$$

Where, N = total number of individuals

n_i = number of individuals of species

k = number of species. And,

3.3219 is a factor converting $\log_{10}$ values to $\log_2$

However the magnitude of H is affected also by he number of categories. Theoretically the maximum possible diversity for a set of data consisting of k categories is:

$H_{max} = \log_2 k$. (or $H_{max} = 3.3219 \log_{10} k$)

Where ,

k = number of species present at the site .and,

H_{max}= maximum species diversity.

Therefore, many users of Shannon-wiener's Index prefer to calculate;

$$J = \frac{H}{H_{max}}$$

J represents the index of diversity to compare different communities.

3.5 Species Density Analysis:

Individual species density was calculated using simple formula as given by Sharma ,2004.

$$\text{Species density} = \frac{\text{Total no. of individual of species}}{\text{Area of quadrat x no. of quadrat laid down}} \quad (\text{indiv. /m}^2)$$

Similarly , Dominance of the community was determined using simple formula of dominance index.

$$C = -\sum \left\{ \frac{ni}{N} \right\}^2$$

Where ,

C = dominance index

ni = individual number of plant species

N = total number of individual of plant species.

3.6 Management of the Community Forest:

The existing management practice of the community forest was observed using scheduled question with the Forest Ranger who is also acting head of the forest users group of the Champadevi community forest. Group discussions were also held amongst CFUGs members. Two group discussions were held, one with 10-15 members, the other with 10-12 women CFUGs.

3.7 Statistical Analysis

1. Significance test:-

To assure the results obtained form the field data, Chi –Square test was carried out at 95% confidence interval. For this following hypothesis was set:

H_o = There is no significant association between species diversity at different elevation and carbon content in biomass.

H_1 = There is an association between species diversity at different elevation and carbon content in biomass.

Chi-Square test was carried out by using following formula referred by Zobel et. al. 1987.

$$\text{Chi Square } (\chi^2) = \sum \frac{(O-E)^2}{E} \sim \chi^2 \text{ distribution with}$$

(r-1) (c-1) df,

Where O= observed value of species diversity ad carbon content.

$$E = \text{expected value} \quad \frac{(\text{Row total X Column total})}{100}$$

df= degree of freedom

r= number of rows.

C= number of columns.

Value of chi-square was calculated and tallied with table value of chi-square.

2. Correlation Analysis:

To show the results of carbon content of individual species in relation to density of species, correlation between species density and carbon stock of that species was determined to study whether these relation are correlated or not.

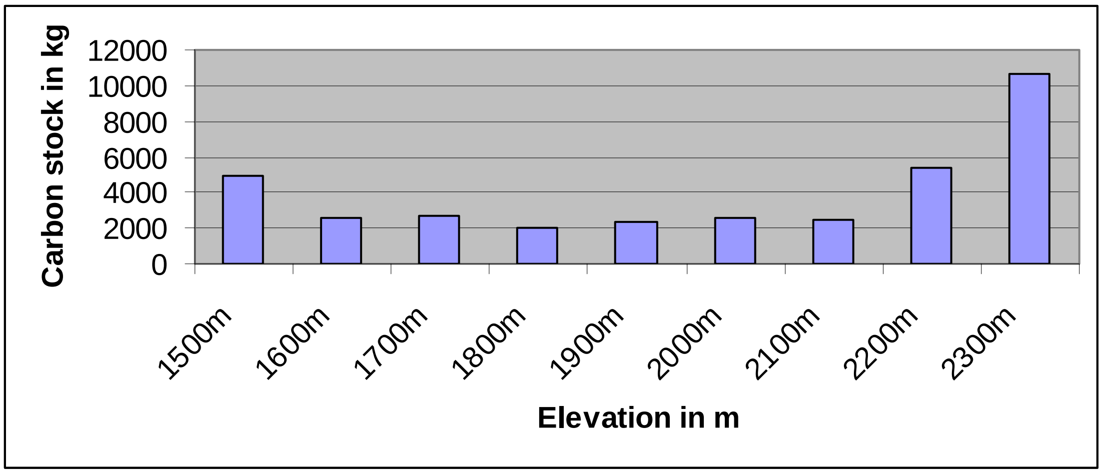
Chapter : Four

4. Observation and Results

4.1 Carbon content in biomass

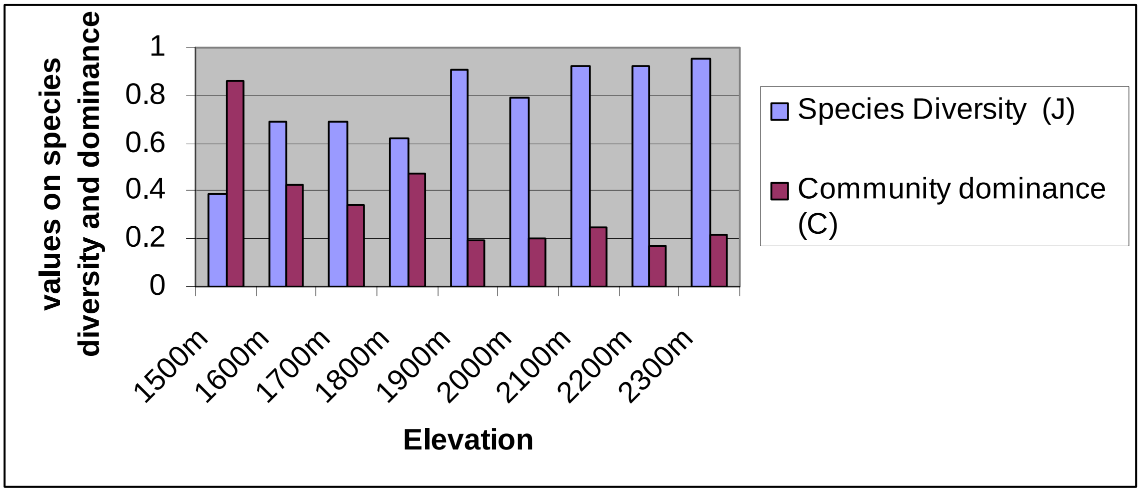
Carbon content in the forest biomass was found to be 24.72 ton/ha. As carbon pool was determined on different elevation, carbon content of studied plot at 1500m elevation was found to be 4988kg (3.11 kg/m^2). Similarly 2543kg(1.58 kg/m^2) at1600m, 2681kg(1.67 kg/m^2) at 1700m,1968kg(1.23 kg/m^2) at 1800m, 2377kg(1.48 kg/m^2) at 1900m, 2579kg(1.61 kg/m^2) at 2000m, 2477kg (1.54 kg/m^2)at 2100m, 5393kg(3.37 kg/m^2)at 2200m and 10604kg(6.62 kg/m^2) at 2300m was found at respective elevation.

Figure 2: Carbon Stock at different elevation



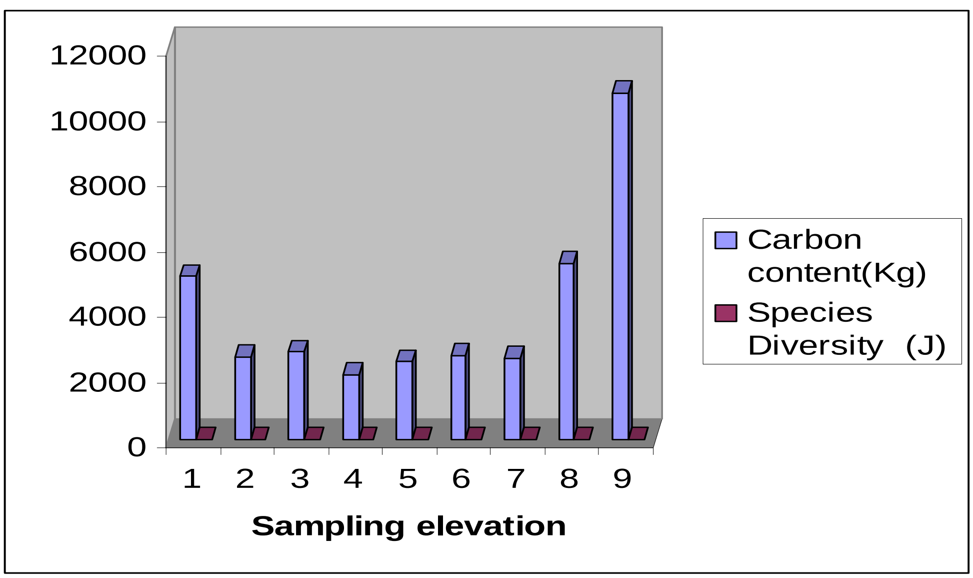
Twenty different plant species were found in the forest. These include *Schima wallichiana* (chilaune), *Pinus roxburghii* (sallo), *Myrica esculenta* (kafal), *Pyrus pashia* (mayal), *Quercus glauca* (phalat), *Myrsine capitellata* (seti kath), *Eurya accuminata* (jhingane), *Rhus wallichi* (bhalayo), *Rhododendron arboreum* (lali gurans), *Quercus floribunda* (seto khasru), *Alnus nepalensis* (uttis), *Quercus spicata* (arkhaulo), *Machilus odoratissima* (bokre kaulo), *Machilus gamblei* (kathe kaulo), *Pinus patula* (patale sallo), *Prunus cerasoides* (painyu), *Zizyphys incurva* (hade bayer), *Erithrina stricta Roxb*. (faledo), *Leucaena leucocephala*(ipil ipil) and *Celtis australis* (khari). Among these all plant species, *Quercus floribunda* has the highest carbon content and *Rhododendron arboreum* has the lowest .(Appendix 2, Table 11). Species diversity index calculated showed that at 2300m, there is the higher species diversity and lowest at the 1500m. in contrast community dominance was highest at elevation 1500m with 0.86 value whereas at 2200m community dominance was lowest with 0.17 value.

Figure:3 Variation of species diversity and community dominance at different elevation.



The density of the *Quercus glauca* was found highest whereas that of *Machilus odoratissima* was lowest.(Appendix 2 ,Table11).The relationship between species diversity and carbon stock showed that at 2300m elevation species diversity was high i.e. 0.95 and at 1500m elevation it was *0.386.* Carbon stock was found highest i.e. 10604 kg at 2300m elevation and lowest 1968kg at 1800m.(Appendix 2, Table 10).

Figure4: variation of carbon content with species diversity .



Statistical analysis showed that the Karl Pearson's correlation coefficient (r) between species density and species carbon stock is 0.688. It represents that the species density

and species carbon stock is positively correlated or there is a positive association between species density and species carbon stock.(value in Appendix 2 ,Table11)
From significant test between carbon stock and species diversity at different elevation, the critical value of $\chi^2_{0.05}$= 2.26 at 8df. As the calculated value of χ^2 is smaller than that of tabulated value $\chi^2_{0.05}$ 8df=15.507, the hypothesis is accepted, i.e. alternative hypothesis is rejected and null hypothesis is accepted. It shows that there is no significant association between species diversity and carbon stock.

4.2 Management practice of Community Forest:

4.2.1 Composition of the forest users group

There are altogether 1232 members in the forest users group(FUGs). Members includes people from the ward no. 7 and 8 of the municipality. In regards to the user's committee representatives are only from the ward no.8. Currently, there are 231 households in the forest user's group. One interesting thing is that more than 50 persons has requested for membership for enrollment into the forest users group. And those request has not been addressed as this type of decision is made only in the user's meeting because no any addition of the member in the group has taken since the formulation of operational plan during the registration of forest in the district forest office in 2061 B.S. The present status of the composition of forest user's group is as follows:

Table: Composition of users group

Tole /community	**Number of household**	**Female population**	**Male population**
Godam tole	78	183	198
Khadka tole	63	174	181
Tusal tole	65	187	177
Gamcha tole(ward no.07)	25	68	64
Total	231	620	612
		Total=1232	

Peoples from different ethnic community, caste are there in this FUG, which includes Brahmin, Chhetri, Sarki, Damai, Tamang and Newar. Most of the members are from lower caste background.

4.2.2 Conservation of the forest:

According to the view of the members of FUGs, it is felt that lack of awareness in greater extent and ignorance in a bit less amount is the most lagging thing among the FUGs for conservation of forest. Despite of these above mentioned lagging things, different programmes on forest fire mitigation, ban on illegal smuggling of timbers, notice on the public notice board for the conservation of forest is done timely. There is a provision of punishing by fining to those people for doing illegal activities which are prohibited within the forest. For this, groups of members are trained timely for the protection of forest in which they patrol within the forest time to time.

Women's participation and contribution in conservation activities of forest is comparatively more than that of males. But male and female population is about equal in forest users committee. Socially, women mostly involved in the forest activities for many purpose which may be for either fodder collection or firewood collection. But on the decision making part, male participation and views is generally higher than women, as most of the women members of FUGs are uneducated some. Priority of utilization of forest products is also explained in the forest action plan 2061. Decision at local level for the utilization and distribution of forest products was made to increase the production of forest products from year 2062. With regard to the maintenance of office expenses of forest users committee, income from the utilization of forest and non timber forest products(NTFPs) is utilised. There is no any biasness in distribution of forest products. One example is that Kami community can easily get ningalo for making baskets, doko, nanglo etc from the forest on a routine basis. While talking about wild faunal population ,it is committed to conserve birds and animals in the action plan of forest. There is an experience of nabbing deer poacher. To have gun, poisons ,trap an any kind of weapons within the forest is strictly prohibited. As there is no bare land and open land in this forest, afforestation is not prioritized currently. But depending upon its necessity, it can also be done in the future. In the past, there is a record of plantation during 2024 to 2029 B.S. intensively as well as in 2042 B.S. also. Besides conducting some general training at different time ,support from governmental sector is found not so satisfactory. So the people's expectation is only that it will be better for the future of forest that if government would help them in conservation and management of forest through support either technically as well as financially as CFUGs require financial and technical support from government.

4.2.3 Constraints in community forest management:

As per the conclusion made by chairman of FUGs, lack of awareness is the most serious problem that hurdles creating awareness for conservation of forest. Lack of knowledge on legal provisions and vision for conservation is also the constraint causing factor for conservation. There are some instances where decision making at government sector has created problem for the effective management of community forest. There are bitter experiences about that, when government declared to establish Pushpalal Smriti Pratisthan within the territory of community forest. Similarly camp of armed police is already there inside the forest. And these decisions had not consulted the local people and all level of the local people FUGs before commencing such activities. Recently, the part of forest land for establishment of National Ethnic Museum was handed over to concerned authority and even it also didn't consider the participation of the any members from forest users committee during that decision. These are the constraints faced due to the national decisions by government. Besides these, local problems such as smuggling of timbers and illegal hunting of wild flora and fauna is the most sensitive and serious problem which the forest is facing for conservation.

Locally regular and emergency meetings are organized to deal the problems and to make solutions and to make decisions that come in the conservation and management of forest. Stakeholders also take part in the meetings as and when necessary.

Chapter Five

Discussion, Conclusions and Recommendations

Discussion:

Forests act as carbon reservoir by storing large amount of carbon in trees, under storey vegetations, forest floor and soil. Change in forest ,such as growth of trees can remove carbon dioxide from the atmosphere. Conversely, human activities also degrade forest, both sink and pool are damaged and consequently forest acts as the source of carbon dioxide emission. Human interferences and degradation generally reduces the amount of carbon on land when deforestation or forest degradation takes place. Besides human activities, natural phenomenon like light penetration to forest floor, slope, soil types, vegetation type etc also causes less carbon pool in the forest. If we could take part in carbon trading, that links forest conservation with economic incentive, it could generate awareness and incentive among forest users to protect forests by undertaking sustainable management.

Despite the less amount of carbon sink in the forest, only the natural way of mitigating climate change is conservation of natural carbon pool. Among all, one of these pool is forest and the forests are under threat especially in developing countries due to demand of energy. If forestry project qualify under forestry project of CDM, people themselves start to conserve forest and look for alternative energy source in spite of using fuel wood. But it is not simple as said, as there are a lot of challenges for this.

The continued rise in atmospheric CO_2 concentration and its probable effect on global climate through the greenhouse effect make it necessary to explore all possible mitigation strategies. One possibility is to cut the rate of emissions, by curtailing either fossil fuel combustion or tropical deforestation - the 2 main sources of anthropogenic CO_2 emissions. Another is to enhance the natural carbon sequestration capabilities of vegetation on lands whose vegetation is currently degraded or otherwise underproductive, but large areas of land will be needed for this to have any significant mitigating impact. There is a need of a research project which can develop new techniques for determining the area of present forest lands, types of plant species which could sequester more carbon. . For example, in China, study carried out at Miyun watershed showed that pine forest has greater carbon storing and sequestering capacity than other forest. (Jianmin and Zhing, 2007). The potential for increasing biotic carbon sequestration can be assessed in 2 main ways: carbon store approach and the carbon sink approach. The carbon store approach focuses on merely increasing the total amount of carbon stored in the terrestrial biota relative to that in the atmosphere. Lands with a degraded vegetation cover, and hence a lower carbon biomass density than the maximum potential value for that site and type of vegetation, are identified as having potential for restoration. Existing degraded (secondary) forests, for example, could, with proper protection, sequester more carbon by natural or artificial regeneration. The mean net herbaceous biomass on cropland could also be increased by greater productivity (though if this requires fertilizers and pesticides produced from fossil fuels, it could be of limited net value from a carbon perspective). Alternatively, the tree cover on cropland or pastures could be increased, or new forests and plantations established on deforested lands. The carbon store approach is convenient for large-area surveys, but treats forests only as a stock resource rather than a renewable resource. The disadvantage is that increasing the carbon biomass density of an existing forest to make it as close as possible to the potential value only produces a net carbon sequestration over a limited period, which is less helpful in the longer term given the fact that the need to offset anthropogenic carbon dioxide emissions is expected to continue indefinitely. In this condition the alternative way of carbon restoration through forestry is required especially in case of the developing countries whose natural community forests are not eligible to qualify under CDM of Kyoto Protocol.

Experiences has shown that many communities in developing countries have sustainably managed natural forests, under a variety of community based forest management(CBFM) programs and policies. This type of management results in additional carbon sequestration through reduced emissions from deforestation (i.e. avoided deforestation). Payment of carbon services may help the balance in such a cases and provides the incentives for many more communities to practice Community Based Forest Management (CBFM). Such multipurpose CBFM serves sustainable development goals and provides on-going income opportunities for poor communities and other benefits. One reason for not recognizing the sink capability of CBFM has been the difficulty of measuring the leakage as well as carbon saved and the high transactions costs involved in measuring carbon.

As forest under CDM qualify the afforestation and reforestation activities as carbon sink project, community based forest management practices over the developing countries cannot qualify under CDM. This is due to the fact that almost all community forests are natural forests.So, only the way to get carbon credit is to identify the carbon pool in the existing forest from avoided deforestation. But it also didn't work because, CDM doesn't provide any provisions regarding the natural carbon pool from avoided deforestation. Markets and market mechanisms to curb emission currently do not exist in many of the developing countries and abatement actions generally rely on the state's command and control mechanisms.

The current data on forestry and deforestation in developing countries can be questioned because these data are provided by the country themselves. For technically effective evaluation of the carbon pool or stock of the forest, satellite imagery will be the suitable alternative. But in context to the poor countries like Nepal, it will be more expensive to use imagery. And also due error margin is higher for Nepal's mountainous topography. Not only the reduced deforestation, afforestation on the degraded land and its recognition into the carbon market may create good opportunity under CDM of Kyoto Protocol.

Conclusions:

From the present study, it was found that, carbon stock of the forest is low relatively as compared to the carbon stock at Lamatar community forest which is 46.53tc/ha. (Karky and Banskota, 2006). This low carbon may be due to the existing condition of the forest i.e. well managed or human encroached. And also due to the different methodological application for Lamatar and this study, like the biomass of forest litter, soil carbon etc. From this result, it can be concluded that more human interference, i.e. cutting of ground vegetation from community forest for the fodder and fuel purpose which is one of the main causative factors for less carbon content in forest if reduced, then it can possess high potential to store carbon. As the forest mainly composed of two distinct patches i.e. one pine forest and other mixed forest type, due to the inaccessibility in the forest for monitoring in the upper reach of forest, deforestation has led to the less carbon in the upper part of the forest.

Carbon sequestration is a means for reducing atmospheric carbon dioxide, and important green house gas. A major constraint to successful forestry –based carbon offset program is the lack of reliable, accurate and cost effectiveness methods for monitoring carbon storage. Quantitative monitoring of carbon pool and sequestration over time, and to a lesser extent verification of estimates, requires a series of carbon inventories. To maximize the utility of information collected in an inventory and to reduce monitoring costs, forest managers should define the various objectives for and inventory early in advance planning. Although community forestry does not qualify under the CDM, inventory of carbon storage can be a major forestry research activity as it allows data on management condition of forest as well as provide and idea of implementation of small carbon project through voluntary carbon market. This is simple example but effort at global level is essential that does the accounting of carbon of all the countries. Trade of carbon stored in forest has opened the way of earning money by protecting environment by planting trees. So encouragement to forest plantation especially in developing countries has become necessary as these countries do not emit as much emissions as developed industrialized countries and can easily earn money for protecting their environment.

If the forestry projects get focused toward storing carbon only rather than its utilization, then only such plant species which has higher carbon storing capacity will be used and local people depending on forest get affected. For example it is not practical to allow plant only pine trees because lot of people depend on other plant resources through which they spend their life utilizing fodder ,fuel wood and other forest products. Although the focus is mainly concentrated with the analysis and estimation of static carbon pool, environmental condition which affects the existing condition of forest is often ignored. Integration of several other factors in forest management can lead to the improvement in carbon forestry project. Management policy and implementation of such policy is the most essential part for research at practical level. Because it will allow the way to get admitted into the international carbon market. In this forest , *Quercus floribunda* was found to contain large amount of carbon , so this type of species need to identify and what factors affect these plants is also needed to be known. And in these days, carbon content in forest has become an indicator for analyzing the condition of forest. Species density, diversity and composition of species also reflect the existing condition of forest. In this study only baseline information on carbon stock was observed and species composition was identified in terms of small research work. Carbon stock at different elevation is influenced by elevation; temperature, humidity, rainfall etc. So there was fluctuation in carbon stock in forest. Identification of species with higher carbon stock was done which may be useful in future carbon project to use such species. Higher carbon stock at upper elevation shows that the place is less disturbed by human activities. Therefore reduction in human interference to forest also increases the carbon stock of the forest.

Study on management practice for conservation and utilization of forest resources showed that there is the complication regarding to the effective management of forest. These complications are either by local community or by government sector. To develop the opportunity in community forest through carbon project, economic assessment of forest in terms of timber production, fodder, mean annual increment, biomass estimation and stored carbon in trees is needed. Despite these difficulties, the practice of management is found good and need to improve in different aspect like growing awareness among users and work in field by themselves along with looking for efforts from government sector..

Recommendations:

On the basis of the result and observation during the research , following recommendations are made:

- Plant species which has more carbon stock capacity should be identified and the objective of forest conservation and management should be clear.
- Research on carbon sink and carbon sequestration should be done and it should be motivated by the government.
- Human interference and encroachment into the community forest should be controlled and only sustainable use of forest products recommended..
- Support either technical or financially from government sector for the effective management of the community forest is strongly recommended.
- Transformation of degraded land into rehabilitated land by forestation program should be initiated.
- As indigenous users have obviously better knowledge of plant and animal environment around them, they should be included while implementing the management initiatives in the forest.

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Appendix 1

Table 1:Estimation of carbon content in forest. (20 x 20 m^2)

Elevation:1500m		
Plot No.	Biomass(kg)	Carbon content(kg)
Plot no. 1	3004.7	1502.35
Plot no. 2	2343.7	1171.85
Plot no. 3	4521	2260.5
Plot no. 4	105.6	52.8

Table 2: Estimation of carbon content in forest.(20 x 20 m^2)

Elevation:1600m		
Plot No.	Biomass(kg)	Carbon content(kg)
Plot no. 1	337.2	168.6
Plot no. 2	598.2	299.1
Plot no. 3	1778.2	889.1
Plot no. 4	2372.3	1186.15

Table 3: Estimation of carbon content in forest.(20 x 20 m^2)

Elevation:1700m		
Plot No.	Biomass(kg)	Carbon content(kg)
Plot no. 1	1484.2	742.1
Plot no. 2	2122.5	1061.25
Plot no. 3	1190.2	595.1
Plot no. 4	564.83	282.41

Table 4: Estimation of carbon content in forest.(20 x 20 m^2)

Elevation:1800m		
Plot No.	Biomass(kg)	Carbon content(kg)
Plot no. 1	197.5	98.75
Plot no. 2	3248.1	1624.05
Plot no. 3	410.7	205.35
Plot no. 4	79.2	39.6

Table 5: Estimation of carbon content in forest.(20 x 20 m^2)

Elevation:1900m		
Plot No.	Biomass(kg)	Carbon content(kg)
Plot no. 1	141.8	70.9
Plot no. 2	1780.8	890.4
Plot no. 3	1749.3	874.65
Plot no. 4	1080.9	540.45

Table 6: Estimation of carbon content in forest.(20 x 20 m^2)

Elevation:2000m		
Plot No.	Biomass(kg)	Carbon content(kg)
Plot no. 1	1292.44	646.22
Plot no. 2	1201.5	600.75
Plot no. 3	1206.7	6033.35
Plot no. 4	1457	728.5

Table 7: Estimation of carbon content in forest.(20 x 20 m^2)

Elevation:2100m		
Plot No.	Biomass(kg)	Carbon content(kg)
Plot no. 1	1116.6	558.3
Plot no. 2	1821.3	910.65
Plot no. 3	895.1	447.55
Plot no. 4	1121	560.5

Table 8: Estimation of carbon content in forest.(20 x 20 m^2)

Elevation:2200m		
Plot No.	Biomass(kg)	Carbon content(kg)
Plot no. 1	1657.7	828.85
Plot no. 2	2514	1257
Plot no. 3	2860.1	1430.05
Plot no. 4	3753.5	1876.75

Table 9: Estimation of carbon content in forest.(20 x 20 m^2)

Elevation:2300m		
Plot No.	Biomass(kg)	Carbon content(kg)
Plot no. 1	5873.5	2936.75
Plot no. 2	4675.6	2337.8
Plot no. 3	4836.2	2418.1
Plot no. 4	6122.5	3061.25

Appendix 2

Table 10: Biomass and Carbon Stock at different elevation.(20 x 20 m^2)

S.No	Elevation (m)	Biomass(Kg)	Carbon content(Kg)
1	1500	9975	4988
2	1600	5086	2543
3	1700	5361	2681
4	1800	3935	1968
5	1900	4752	2377
6	2000	5157	2579
7	2100	4954	2477
8	2200	10785	5393
9	2300	21207	10604
		TOTAL	**35610 Kg**

Table 11: Carbon Stock and Species Density

S. No.	Scientific Name	Local Name	Carbon Content(kg)	Species density(indiv/m2)
1	*Alnus nepalensis*	Uttis	1540	0.0078
2	*Celtis australis*	Khari	3010	0.0079
3	*Erithrina stricta Roxb.*	Faledo	106	0.0002
4	*Eurya accuminata*	Jhingane	384	0.0047
5	*Leucaena leucocephala*	Ipil ipil	549	0.0015
6	*Machilus gamblei*	Kathe kaulo	132	0.00006
7	*Machilus odoratissima*	Bokre kaulo	76	0.0005
8	*Myrica esculenta*	Kafal	17	0.0002
9	*Myrsine capitellata*	Seti kath	549	0.0026
10	*Pinus patula*	Patale sallo	2039	0.0026
11	*Pinus roxburghii*	Sallo	5198	0.0065
12	*Prunus cerasoides*	Painyu	175	0.0002

13	*Pyrus pashia*	Mayal	138	0.0004
14	*Quercus floribunda*	Seto khasru	9624	0.0058
15	*Quercus glauca*	Phalant	5548	0.012
16	*quercus spicata*	Arkhaulo	1370	0.0024
17	*Rhododendron arboreum*	Lali gurans	13	0.0002
18	*Rhus wallichi*	Bhalayo	644	0.0027
19	*Schima wallichi*	Chilaune	4116	0.0041
20	*Zizyphus incurva*	Hade bayar	382	0.0007
		Total	**35610**	

Table 12: Variation between species diversity , community dominance and carbon stock.

S.No.	Elevation(m)	Carbon stock(kg)	Species Diversity (J)	Community dominance (C)
1	1500	4988	0.386	0.86
2	1600	2543	0.688	0.43
3	1700	2681	0.690	0.34
4	1800	1968	0.62	0.47
5	1900	2377	0.91	0.19
6	2000	2579	0.79	0.20
7	2100	2477	0.92	0.25
8	*2200*	5393	*0.92*	0.17
9	2300	10604	0.95	0.22

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