Carbon poll and sequestration scenario of Sunaulo Ghaympe Danda Community Forest, Kathmandu.

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Abstract

Sequestration activities can help prevent global climate change by enhancing carbon storage in trees and soils, preserving existing tree and soil carbon, and by reducing Green House Gases emissions. Human activity is causing climate change a real threat to humans, wild life and other forms of life as well., The removal of atmospheric CO2 through sequestration is a primary mitigation measures that has received primary attention globally. Present study was carried out to estimate carbon sequestration rate for eight years (2004-2011). by using standard methods. The study result revealed biomass organic carbon as 23.5ton /ha, 25.95ton /ha, 27.24ton /ha and 28 ton /ha for the respective years 2004, 2007, 2009 and 2011. Similarly, the average yearly carbon sequestration rates starting form 2004 to 2011 was 0.65 ton /ha/yr.

Keywords: Biomass organic carbon; carbon sequestration, climate change , community forest,

1. INTRODUCTION

Globally, deforestation, forest degradation, forest fires and burning of fossil fuel are playing a significant role in producing the Green House Gases (GHGs) (IPCC, 2000). Hence, deforestation and forest degradation, caused by increasing population and land degradation, are major problems in developing countries; whereas burning of fossil fuel from industries is major problem mainly in developed countries. The conversion of forest area into non-forest area, which leads to the additional GHGs in the atmosphere, was recorded as 12.3 million ha between 1990 and 2000 in the tropical countries (FAO, 2004).

The increasing amounts of GHGs adversely affect the global environment. These effects are climate change, global warming, rising of mean sea level, alteration of weather and they threaten the life of living beings. Hence, the relationship between the increasing amount of GHGs in the atmosphere and climate change was taken seriously in 1990 and many efforts were made to create awareness globally. One of the major achievements of such efforts was the third Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC), held in 1997 in Kyoto, Japan which issued a protocol, known as Kyoto Protocol (UNFCCC, 1998). Its central concern was how to deal with the mitigation of the climate change for betterment of the global environment.

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For mitigation of climate change, the Kyoto Protocol has three different mechanisms out of which the most important flexible mechanism of Kyoto Protocol is the CDM, which primarily deals with the interest of developing countries. The first aim of the CDM is to account the carbon credit (positive as well as negative) through emission reduction and removal. So, the emission reduction projects primarily deal with energy efficiency and fuel substitution. Moreover the emission removal projects also have afforestation, reforestation and deforestation activities. Though community forests have major activities similar to afforestation and reforestation project, community forests still do not qualify under CDM. In order to addresses those issues and activities, REDD+ is working on it. This new mechanism will intrinsically help to reduce the atmospheric carbon dioxide gas from atmosphere. REDD+ mechanism not only includes the afforestration and reforestation but it also includes the management of the degraded land which contribute for additional carbon sink. Most of the developed nations have welcomed the CDM and approved the Kyoto protocol.

1.1 **CONCEPT OF CARBON SEQUESTRATION**

Carbon dioxide has a vital role in environmental system. Proportional increase in CO2 results in steadily rising amount of GHGs. So, to check the GHGs is global grave concern and one of the significant measures is to sequester the carbon which is possible by either expanding forest resource or conserving them (Houghton, 1996).

In fact, carbon is held in the terrestrial ecosystems as vegetation and in soils. In addition oceans hold a large volume of carbon so does atmosphere. Carbon sequestration is the process of removing additional carbon from the atmosphere and depositing it in other reservoir principally through changes in land use. The terrestrial carbon sequestration is the net removal of CO_2 from the atmosphere and storing it in terrestrial ecosystem (Sedjo and Marland, 2003). Forestry is only the major option for carbon sequestration in the terrestrial ecosystem among agricultural systems and agroforestry systems (Kalpan, 2003 cited from Singh, 2005) and has concluded that the total carbon was found highest in the naturally grown forest. . In practical terms carbon sequestration occurs mostly through the expansion of the forests (Houghton, 1996). Forest has a prime role in sequestering carbon from the atmosphere. In reality, the forest is a reservoir, a component or components of the climate system where a green house gas is stored, as well as sink, any process which removes a green house gas from the atmosphere (Pearce *et al*., 2003). Thus the forest is the complement of carbon sequestration. So, the forest expansions and sustainable forests, as mitigation measure, have a significant contribution to the environmental benefit but any shrinkage of forests, as emission, has a long term influence and impact. Therefore, the sustainable forest , as a carbon sinks, is the key factor to balance the GHGs emission (Levy *et al*., 2004).

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

Conclusively, sustainable forests are reliable sinks of GHGs (Levy *et al*., 2004). Hence, the sustainable forest and the management system is key concern as sinks. Generally, there are three broad categories of interventions such as management of the existing forest and trees source for instance community forest management in developing countries, expanding the forest area and tree cover for example afforestation and reforestation as well as using the renewable energy sources as a substitute for fossil fuel (Baral *et al*., 2004). Among these, the community forest management which is a successful example of sustainable forest management, is the preferable option of carbon sequestration, primarily in developing countries (Klooster *et al*., 2000). Carbon is store in the terrestrial ecosystem in vegetation as biomass and in soil as soil organic carbon (SOC). The long term conversion of grass land and forest land to cropland and grazing lands has resulted in the historic losses of biomass carbon and SOC world wide but there is a major potential for increasing forest carbon by adopting soil conservation practices and by restoring forested areas.

1.2 The role of community forestry of Nepal in carbon sequestration

Community forestry program in Nepal officially started in late 1970s. For more than two decades, local communities have been involved in the management and utilization of forests in Nepal. About a million hectares of national forests have been handed over to 12,725 Community Forest User Groups (CFUGs) involving over a million households. About 32 percent of the total population of the country has been benefited from Community Forestry Program (Khanal et. al., 2004)

Table 1. Community forestry national profile

Total area of the Community Forests handed over	10,10,740 ha.
Average size of the community forest	79.43 ha.
Total number of CFUGs	12,725
Total number of households involved	14,22,301
Percent of total population benefited	31.86
Average size of executive committee	11.2
Average size of CFUG	111.77 HH
Average number of women in committee	2.66

Percent of women in the committee	23.74
Number of CFUGs with only women members in committee	617

Source: (Khanal et. al., 2004)

Although Nepal had ratified the Kyoto Protocol, but due to the lack of proper data on carbon sequestration done by the community forest of nepal, yet we are not receving its benefit. Different study is going on for the estimation of carbon sequestration rate by the community forest of Nepal. Nepal is receiving benefit from the biogas as CDM projects in Nepal (Pokhrel, 2005) and can get benefit from the conservation of forest through community forestry model if we will be able to collect proper data.

From land-use data, 1978/79 to 1994, the total forest area decreased from 38% of the national land area to 29% [5616.8 thousand hector (ha) to 4268.8 thousand ha], while shrub land increased from 4.7% to 10.6% (1559.2 thousand ha from 689.9 thousand ha).

Table 2. Comparison of carbon sequestration in Nepal's standing forest (except shrub land)

Year	Forest ('000 ha)	Above ground biomass (M T)	Total biomass (MT)	Total Carbon (MT)
1978/79	5616.8	238.7	302.0	151.0
1994	4268.8	279.6	353.7	176.9
Change (78-94)	- 1348	+ 40.9	+51.7	+ 25.9

Source:(MFSC,1999)

Between 1978 to 1994, the carbon in forests (standing stock) increased from 151 megaton (MT) to 176.9MT with the net increase of 25.9 MT. Moreover, the carbon sequestered in under-storey trees of less than 10 cm diameter and shrubland, whose area increased by 869.3 thousand ha during the same period, the actual amount, would be higher than this. Furthermore, if the amount of carbon retention in varieties of harvested products[i] and pools from 1978-94 was counted the net sequestration would be higher again (MFSC, 1999).

2. STUDY AREA

The study area Sunaulo Ghyampe Danda Community Forest lies on Seti Devi VDC located at Katmandu valley, on the way of Pharping. It is situated in between the latitude 27º37′22" to 27º38′48" and longitude 85º16′35" to 85º17′10" and elevation ranges from 1100m to 1600m above the sea level. The climate of this area is temperate i.e. neither so cold nor so hot. The average annual rain fall recorded at the study area was 1490.79mm and maximum and minimum rainfall recorded at the month of June and November respectively. The average annual temperature and relative humidity recorded at the study area ranges from 25.61°C to 11.97°C and 1027.40 to 803.15 respectively.

The study area was surrounded by Hattiban Community Forest in the West, Hattiban Forest in East and North and in the south dashinkali highway passes. This Sunaulo Ghaympe Danda community forest was declared as community forest on 1999 with occupying an area of 51.4 ha of which 31.4 ha area was occupied by Mixed Broad forest. Pine and Mixed Broad Leaf Forest were two forests with in this community forest. Pine forest lies on southeastern part where as northeastern part was covered by Mixed Broad Leaf forest. The major dominant tree species of Mixed Board Leaf forest are *Schima wallichina, Rhododendron arboreum, Castanopsis tribuloides, C. indica, Myricia esculanta, Engelhardia spicata, Lyonia ovalifolia, Quercus glauca, Acer oblongum* followed by *Myrsine capillellata, M. semiserrata, Albezzia lebbek, Celtis australis, Fraxinus floribundus, Alnus nepalnensis, Zizyplus incurva, Semicarpus anacardium*. This forest was lies from the altitude of 1100m to 1500m

Total population of Seti Devi VDC was 3636 with male and female population of 1806 and 1830 respectively with total 746 household. The major economic activity in the study site was agriculture followed by poultry, business and government job. 90.2% of the people depend on the agroforestry for the fuel wood, timber and fodder (CBS, 2006).

3. METHODOLOGY

The study aim was to estimate the carbon sequestration status of Sunaulo Ghaympe Danda community forest, Katmandu, Nepal. The study addresses the following issues. 1).quantitative analysis of biomass carbon of Community Forest. 2). to estimate the carbon sequestration status of. Community Forest.

3.1 Field sampling

The sampling was done during January to March, for each collected Data i.e 2007, 2009 and 2011. By the use of Geographical Positioning System (GPS) and Geographic Information System (GIS), total 15 sampling plots were identified.

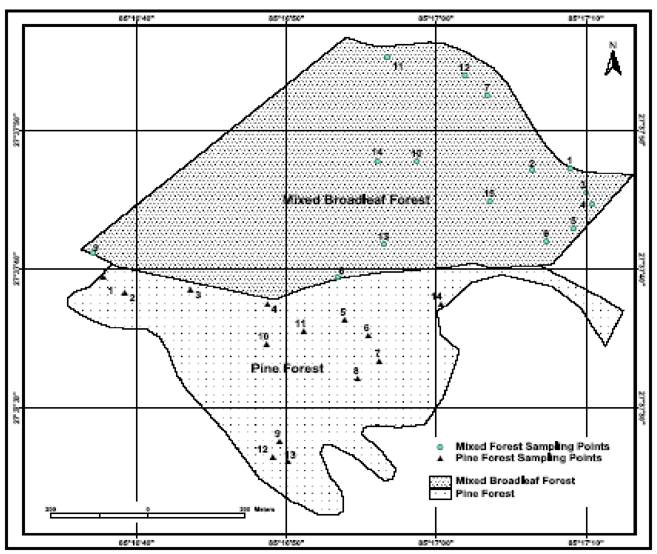


Figure 1. Location Map of Study Area with Sampling Point

The samling plot was designed based on the tree density and slope of the area. Furthermore, on southeast part of the Mixed Broad leaf forest, most of the land is opened so no sampling was conducted. The sampling plot was designed such that the difference on the length between the sampling plots is 100m.

Only 15 sampling plot were taken for sampling in Mixed Broad Leaf Forest which was shown on the above figure. Once the plot centre was identified, the radius of 8.92m was measured to make circular quadrat with an area of 250m.sq.

For the measurement of carbon pool, the methodology given by MacDickhen,1997 was followed.

Biomass calculation. Estimation of above and below (root) ground biomass.

Following regression model was used to calculate above ground biomass of trees (NARMSAP, 2000).

Regression model was: Ln W = a+ b X Ln (DBH)

Where:W = Green weight of tree component (biomass) in kg.

a=intercept, b=slope and DBH = diameter of the tree at breast height.The root biomass was assumed to be 15% of total aboveground biomass as suggested by (MacDickhen, 1997).

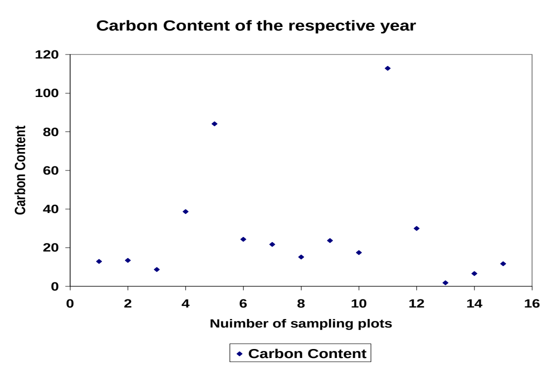
Total above ground biomass and root biomass were multiplied by carbon expansion factor, i.e. 0.5 (Brown, 1997; Montagnini and Porras, 1998) to get the biomass carbon stock of tree.

Total above ground biomass organic carbon =Total above ground biomass of tree X 50%.

Total below ground organic carbon = Total root biomass of tree X 50% + total SOC

TOTAL BIOMASS ORGANIC CARBON OF THE TREE IS= Total above ground biomass organic carbon + Total below ground organic carbon

Carbon sequestration rate as biomass = (carbon stock of this year- carbon stock of previous year)



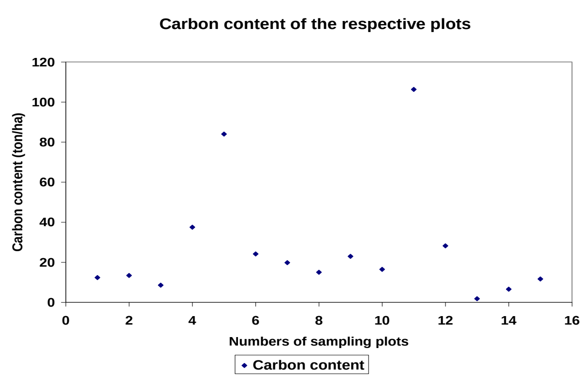
4. RESULT AND DISCUSSION

For the year 2007, the total carbon content of the Mixed Broad leaf forest was found to be 389.44 ton from total sampling plot. The average carbon stock of this forest was found to be 25.95 ton/ha. The analysis of the carbon content in each plot, shows that the distribution pattern of the

Graph-1: Carbon Content for the year 2007

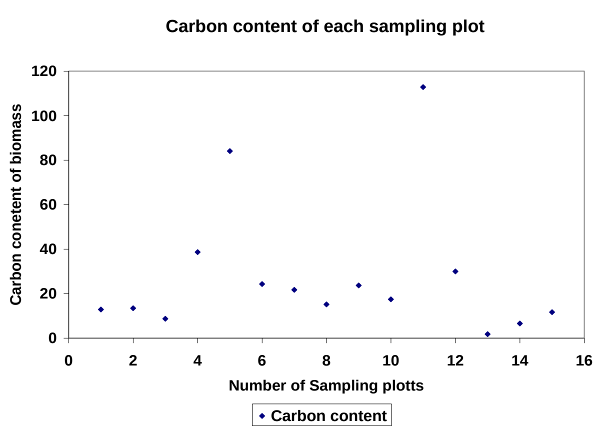
biomass carbon content was some how similar expect few plots. The maximum carbon content was found to be 100.37 ton C and 79.56 ton C on sampling plot no. 11 and 5 respectivily. In plot number 11 and 5, their was mature tree with the average DBH of 25cm. Along with this in some sampling plots, their was tree with DBH more than 25 cm but the other tree's DBH value is very low, so on those sampling plots the carbon content was found in average amount. But in sampling plot number 13, there were no big trees with high DBH value, so the minimum carbon content was found to 1.78 ton C on it.

Consequently, the result for the year 2009 also matches with_the year 2007. The total carbon content for this year was_found to be 408.61 ton in total sampling plot. Again average carbon stock of this forest was found to be 27.24 ton/ha. The carbon content in each plot seems to be similar as that of year 2007, but in some cases it was fluctuated. The range of carbon content starts from 106.29 ton to 1.77 ton. i.e. the maximum carbon content was found to be 106.29



Graph-2: Carbon Content for the year 2009

ton C and_83.99 ton C on sampling plot no.11 and 5 respectively. Again, the minimu carbon was content



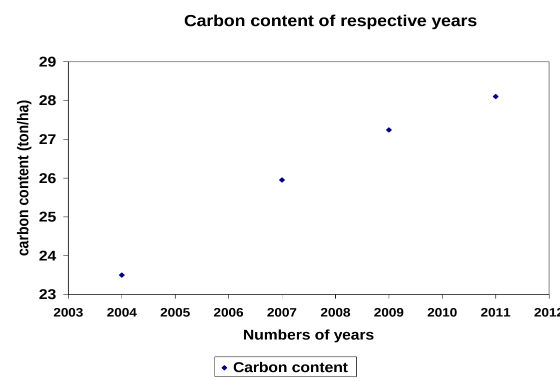
found to be 1.77 ton in samplig plot number 13. Due to the difference in DBH value of tree in each plots, such inconsistency of carbon content was observed.

Similarly, for the year 2011, the result was also similar to that of year 2007 and 2009. In same sapling plot maximum and minimum carbon content value was observed. The total carbon content value was continuously increasing. In this sampling year its value was found to be 422.69 total

Graph-3: Carbon Content for the year 2011

sampling plots. Again, the average carbon stock was found to be 28.1 ton/ha which was continuously increasing since the year 2007. The distribution of the carbon content in each sampling plots was found to be fluctuated i.e. the maximum carbon content was found to be 112.83 ton C and 84.06 ton C on sampling plot no.11 and 5 respectively, similar to the sampling plots than that of the year 2007 and 2009. Again, similar results also resembles with the minimum carbon content which was found to be 1.78 ton in sampling plot number 13.

The average carbon content of the respective year was calculated and found to be 23.5ton/ha, 25.95 ton/ha, 27.24ton/ha and 28.1ton /ha for the year 2004, 2007, 2009 and 2011 respectivey, which was shown in graph no 4. Each year

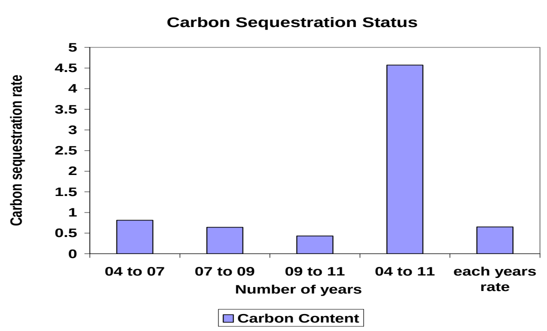


Graph-4: Carbon Content for the year 2011

the average carbon content was increased. The maximum average carbon content was found in the year 2011 and minimum carbon content was found in the year 2004. The carbon stock/ha present in the older forest was higher than that of regenerative forest (Banskota and Karky, 2006). This study also reveals with this findings, i.e. the average carbon content in the year is lower than that of respective year and the average carbon content was gradually increased and found highest value in the year 2011. From the graph the increase in the average biomass carbon is linear which implies that the rate of growth of average biomass was nearly constantly.

Furthermore, the regenerative community forest of temperate zone, their is impressive growth of biomass carbon stock which was about 10% of its total weight in a year; which is largely due to regeneration and protective measures (Dahal, 2006). The present study compared with these find findings, the increment in the biomass carbon stock per year was found lower. The increment in the biomass carbon for the year 2004 to 2007 was 23.5 ton/ha to 25.95ton/ha, i.e. 3.5% per year. Similarly 5.96% of the biomass carbon was increased for the year 2007 to 2009. Finally, 3.14% of the biomass carbon was increased for the year 2009 to 2011. Accordingly, the rate of biomass increment will decreases consequently when time passes on (Banskota and Karky, 2006). This study also shows such trend, i.e. even though the biomass carbon was increasing each year but the percent of increment of biomass wass decreasing each year.

The carbon sequestration rate of the respective conjugative year i.e. 04 to 07, 07 to 09 and 09 to 11 was calculated and found to be 0.81 ton/ha/year, 0.64 ton/ha/year and 0.43 ton/ha/year respectively which was shown in the graph no 5.. Furthermore, the total carbon sequestration status of the Mixed Broad Leaf Forest was found to be 25.43 ton C/year, 20.09 ton C/year, 13.5 ton C/year for the respective conjugative year. The total carbon sequestration status of



Graph-5: Carbon Sequestration status of each year

this Mixed Broad Leaf Forest from the year 2004 to 2011 was found to be 4.57 ton/ha. Again, the carbon Sequestration rate for each individual year was found to be 0.65 ton/ha/ year. The average carbon sequestration rate was slightly higher than the carbon sequestration rate of the year 07 to 09 and 09 to 11, and lower than that of year 04 to 07. From the graph, the carbon sequestration rate for the year 04 to 07 was higher than that of year 07 to 09 and 09 to 11. The average carbon content of the biomass for the respective year was increasing but the rate of increasing carbon stock was decreasing with each year. The carbon sequestration status for the respective year was found to be slowly decreasing stating from the year 2004 to 2011. Accordingly, the carbon sequestration rate of the regenerative forest was higher as compared with mature forest and the carbon sequestration rate of the mature forest is constant (Banskota and Karky, 2006). This study also shows such trend i.e. the total carbon stock of the forest was increasing each year but the rate of carbon sequestration is gradually decreasing with the time period. The average carbon sequestration of the Mixed Broad leaf forest was 0.65 ton/ha/year, but Maraseni et.al. (2005) estimated that the carbon sequestration by the Nepal's forest was found 1.62 MT/yr, which is lower than this study.

5. CONCLUSION: Carbon sequestration rates can be maintained by afforestation, reforestation, forest preservation and cultural operations on existing forests. Human activity is causing climate change a real threat to humans, wild life and other forms of life as well. The removal of atmospheric CO_2 through sequestration is a primary mitigation measures that has received primary attention globally. Present study reveals that, each year above and underground biomass organic carbon including carbon sequestration rate was calculated , and the results obtained was 23.5ton /ha, 25.95ton /ha, 27.24ton /ha and 28 ton /ha for the respective years 2004, 2007, 2009 and 2011. Similarly, the average yearly carbon sequestration scenario from the year 2004 to 2011 was found to be 0.65 ton /ha/yr. Hence, the community forest of Nepal can contribute to reduce atmospheric CO_2 from atmosphere.

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REFERENCE

Adhikaree, K. (2005). *Estimating Carbon Dynamics in a Nepalese Community Forest*, M.Sc Thesis. Central Department of Environmental Science, Kirtipur, Katmandu, Nepal.

Bajracharya, R.M., Situla,B.K., Shrestha, B.M., Awasthi, K.D., Balla, M.K and Singh, B.R. (2004). Soil organic carbon status and dynamics in the Central Nepal, Middle Mountains.Ecological Nepal 12:28 44.

Banskota.K and Karky, B.S. (2006).Constraints faced by community managed forest in qualifying under the Kyoto protocol. *Conversation biology in Asia* 27:401-412.

Baral, A. and Guha, G. S. (2004). "Trees for carbon sequestration or fossil fuel substitution: the issue of cost vs. carbon benefit." *Biomass and Bioenergy 27*(1): 41-55.

Baruah,T.C., and Barthakur, H.P. (1999). A Text Book of Soil Analysis. Vikas Publishing House. Pvt Ltd. P13-14.

Brown.S. (1997). Estimating biomass and biomass change of tropical forest: *a Primary Forestry paper* 134, FAO, Rome, Italy.

CBS (2006). Population census 2001: His Majesty's Government of Nepal/ National Planning Commission, Central Bureau of Statistics, Thapathali, Katmandu, Nepal.

Chhabra, A., Palria, S and Dadhwal, V.K. (2002). Soil organic carbon pool in Indian forest. *Forest ecology and Management* 5877:1-13.

Dahal, N. (2006). Review of operation plan of Kafle community forest, Lamatar, Nepal. Kyoto: think Global: act local, NTNC: submitted to ICIMOD; long frame activity no 2-4:

FAO.(2004). Global Forest Resources Assessment Update 2005: Terms and Definitions. Retrieved 31st Jan, 2005, from http://www.fao.org/ forestry/foris/webview/forestry2/index .jsp?siteId=4261&sitetreeId=13629&langId=1&geoId=0.

Houghton, R. A. (1996). "Converting terrestrial ecosystems from sources to sinks of carbon." *Ambio 25*(4): 267-272.

IPCC.(2000). Land Use Change and Forestry, in a Special Report of the Intergovernmental Panel on Climate Change.

Keshav R. Kanel and Bala Ram Kandel. (2004). **"**Community Forestry in Nepal: Achievements and Challenges", Journal of Forest and Livelihood 4(1) July, 2004**:** 55

Klooster, D. and O. Masera (2000). "Community forest management in Mexico: carbon mitigation and biodiversity conservation through rural development." *Global Environmental Change 10*(4): 259-272.

Levy, P. E., M. G. R. Cannell and A. D. Friend (2004). "Modelling the impact of future changes in climate, carbon dioxide concentration and land use on natural ecosystems and the terrestrial carbon sink." *Global Environmental Change 14*(1): 21-30.

MacDicken,K.G.(1997). A Guide to Monitoring Carbon Storage in Forestry and Agroforestry Project., Forest Carbon Monitoring Program, Win rock International Institute for Agricultural Development.

Maraseni, T.N., CockFiled, G. and Apan, A. (2005). Community Based Forest Management Systems in Developing countries and Eligibility for CDM. *Forest Action, Forest and livelihood* **4**(2): 33-35.

MFSC. (1999). National Report to the Third Session of the United Nations Forum on Forests. Ministry of Forest and Soil Conservation, Singhdurbar, Kathmandu, Nepal.

Montagnini, F and Porras, C. (1998). Evaluating the role of plantation as carbon sinks: an example of an integrative approach from the humid tropics. *Environment management* 22 (3): 459-470.

NARMSAP (2000). Biomass and Volume Tables with Species Description for Community Forest Management, Tree improvement and Silviculture Component. HMG/N, Ministry of Forest and Soil Conservation, Department of Forest, Katmandu, Nepal.

Pearce, D., F. E. Putz and J. K. Vanclay (2003). "Sustainable forestry in the tropics: panacea or folly?" *Forest Ecology and Management 172*(2-3): 229-247.

Pokhrel, S. (2005). Nepal Ratified Kyoto Protocol, Who Benefits? Development Nepal, Development and stability, Sunday, October 30, 2005(spokhrel2000@hotmail.com)

Sedjo, R.A. and Marland, G. (2003). "Inter-trading permanent emissions credits and rented temporary carbon emissions offsets: some issues and alternatives." *Climate Policy* **3**(4): 435-444.

Shrestha, B.M. (2002). Land effects on soil carbon sequestration and green houses gases flux in the mountain watershed of Nepal. Noragic M.Sc THESIS, Management of Natural Resources and Sustainable Agriculture, Agriculture University of Norway, Norway.

Singh, P.B. (2005). *Carbon Sequestration in Community Forest System*. Research report, Bachelor's Degree in forestry, Institute of Forestry, Pokhara Campus Tribhuvan University, Phokhara, Nepal.

UNFCCC.(1998). Report of Conference of the Parties on its Third Sessions, Held at Kyoto from1 to 11 december 1997. Retrieved 15, November 2004, from http://unfccc.int/cop3/07a01.pdf

WRI (1994). Evaluating the carbon sequestration benefits of forestry project in the developing countries.