CHAPTER I

Introduction

1.1 Background

Land is the principal resource of Nepal and constitutes about 97% of its total area. But the country's topography is rugged with over 3/4 th of the total area made up of hills (Himalayas, Mahabharat, and Churia) and mountains and intermontane Valleys. Cultivated land is the second largest categories in terms of land use with 21% share after forest, 29% of the country's land use types. Similarly other land uses comprises Scrubland and degraded forest (10.6%), grassland (12%) uncultivated (7%), water (2.6%) and others (17.8%) respectively (NBS 2002).

Soil is a dynamic natural body composed of mineral and organic solids, gases, liquids and living organisms which can serve as a medium for plant growth. It is the collection of natural bodies occupying parts of the Earth's surface that is capable of supporting plant growth and that has properties resulting from the integrated effects of climate and living organisms acting upon parent material, as conditioned by topography over periods of time (Brady and Weil 2002).

1.1.1 Soil fertility:

Soil fertility is defined as ‘the status of soil with respect to the amount and availability to plants of elements necessary for plant growth’ (Soil Science Society of America 1973). It is a frequently used but often poorly defined term. Soil fertility is concerned with the inherent capacity of soil to provide nutrients, in adequate amounts and in proper balance, for the growth of specified plants when other growth factors such as light, water and temperature, and the physical condition of the soil are favourable. It is an aspect of the soil-plant relationship that is, plant growth with reference to plant nutrients available in soil (Biswas and Mukherjee 1994). Use of nutrient basis for this definition doesn't imply that soil fertility has an exclusively chemical basis because physical and biological factors can have major effects on soil nutrient status. It depends upon a number of physio-chemical and biological properties of soil: texture, structure, pH, water holding capacity, porosity, soil organic matter, soil nutrients (macro and micro- nutrients), soil flora and faunas etc.

Plants are known to need at least 16 essential elements to grow, although more than 90 elements can be absorbed by plants (Miller and Donahue 1990). From the air and water, plants utilize hydrogen, oxygen, and carbon. The other macronutrients, those absorbed in large amounts from soil and fertilizers, are nitrogen, phosphorus, and potassium (the three primary plant nutrients) plus calcium, magnesium and sulfur. The micronutrients, those absorbed in lesser quantities (trace elements), are chlorine, copper, boron, iron, manganese, molybdenum, and zinc. All of these elements have been found to be essential for plants. Maintaining a balance between potassium and other nutrients (especially nitrogen, Phosphorus, Ca & Mg) is an important goal in managing soil fertility (Brady and Weil 2002). Therefore, the assessment of nutrient supplying capacity of the soil is nothing but soil fertility evaluation.

Soil productivity is basically an economic concept and signifies the capability of soil to produce specified plant or plant parts or a sequence of plants under well defined and specified systems of management inputs and environmental conditions that means climatic conditions. It is measured in terms of outputs or harvests in relation to production factors for a specific kind of soil under a physically defined system of management.

The hill farming system can be described in general as being comprised of a complex arrangement of soils, water, crops, livestock, forest and other resources within an environmental setting that the farm family manages in accordance with its preferences, capabilities and available technologies.

1.1.2 Fertility Status of Nepal:

Out of 9,827 farmland soil samples collected and analyzed by 5-regional soil testing laboratories and the Soil Testing Service Section of the department of agriculture in 1998/1999, 48.2% of the samples were medium in N-content (DoA 2000). Similarly, out of 7,520 soil samples analyzed, 64% had low organic matter content. As Nitrogen and OM are required for plant growth, these figures reveal a serious soil infertility problem on Nepal’s farmlands. The K-content however was at medium to high levels, and only 35% of the samples analysed for phosphorus showed low levels (ADB/ICIMOD 2006). Organic matter depletion, acidification, erosion, vulnerability, siltation, degradation of forest and marginal land, cropping intensification, environmental pollution, red soil problems etc. are the reasons for poor soil fertility status. Similarly, Soil Fertility Status of Nepal as reported from various sources as follows:

Table 1: Soil Fertility status of Nepal based on the sample-analysis done by the laboratories of Department of Agriculture:

S. No.	Organic matter status			Phosphorus status			Potassium status			pH status		
	Rank (%)			Rank (%)			Rank (%)			Rank (%)		
1	58.5	33	8.5	29	23	48	29	32	39	63	27	10
*2	58.3	33.3	8.4	28.6	22.1	49.3	30	34	36	61	27	12

Source: 1 – Jaishy and Manandhar (2004) *2- DoA (2000/01).

1.1.3 Agriculture:

All over the world, more than 854 million people have suffered from food scarcity and famine. Over 40% of the land of the earth had been occupied by the Agricultural sector. Therefore development of agriculture is very important for food production. Agricultural land is the second largest category in terms of land use with 21% after forest (29%) excluding shrubland of the Nepal’s land use types (NBS 2002). Each year, the increasing population has no other way but to count on agriculture and its related activities due to very limited opportunities in terms of non-farm activities. Agriculture constitutes the base of Nepal's economic growth and over 80% of the active population is dependent upon agriculture. The percentage of people dependent on agriculture has declined gradually from 81.2 % in 1991 to 65.7 % in 2001/2006 (MoAC 2006).

The agriculture sector accounts for approximately 42 % of the GDP. Though about 25% of Nepal's development budget is expended in this sector, the production rate only averages to 3 % per annum (MoPE 2001).

The number of landholdings has reached 3.36 million in 2001/02 and same for 2005/06 as against 2.19 million in 1981/82. The number of land parcels has increased from 9.51 million in 1981/82 to 10.99 in 2001/02 and 2005/06 indicating 3.3 average parcels per holdings for years 2001/02 and 2005/06 too (MoAC 2006).

Urban agriculture refers to the production and management of crops, poultry and or, livestock products in the urban or periphery area, especially to meet the local needs including urban greenery management. Urban areas are exacerbating serious problems such as scarcity of food, fuel, water, employment and shelter (Devkota and Pradhan 2006). Agriculture is still the fundamental basis of urban development in developing countries like Nepal. Urban development or urbanization seems to be different from agriculture development but for the fulfillment of human needs in the urban and peri-urban areas, agricultural activities or functions are increasingly practised.

1.1.4 Forest:

In 2000, the world had some 3870 million hectare of forests covering 30% of its land area. Tropical and sub-tropical forests comprised 56% of the forest area while temperate and boreal forests accounts for the rest (FAO 2002). The forest, according to the Department of Forest Research and Survey, refers to all land having trees with more than 10% crown cover and not used primarily for purposes other than forestry. This also includes temporarily cut forest area (DFRS 1999).

A direct link exists between the welfare of the local communities and the use of forested land. The forest supply the hill rural population with their essential basic needs: fuelwood, fodder, leaf- litter, poles, timber etc. These represent the most important contribution of forestry to the generally subsistence types of hill farming economies of the region (Mahat 1987). Also, the Agriculture Perspective Plan (APP) acknowledges the high dependence of hill farming system on forest resources (Tiwari 2002).
Forest provides about 14% of the gross domestic product (GDP), 80% of the fuel, and 50 % of livestock fodder (Uprety 2003). The hill forest area has both the largest area (381,000ha) and the largest share of forest and shrub land. The forest in the Terai is more productive and relatively more accessible than that in other areas. Forests are an integral part of the farming system in Nepal. Most hill farmers rely heavily on maintaining a flow of nutrients and energy from the forests to their farms. Forests are also the major sources of fuel for cooking and heating (Gilmour 1989).

Studies on nutrient cycles in forest have shown nutrient losses associated with logging. The input of nutrients must equal the outflow for any ecosystem, or it will deteriorate over the long run. Logging can result in high nutrient losses even if erosion is absent. An undisturbed forest site recycles nutrients efficiently.

The pressure on the forest varies with geographical region. From 1978-1994, the rate of estimated annual deforestation varied greatly between the Hills (2.3%) and 1.3% in Terai (DFRS 1999a). These forests need to be managed intensively, preferably based on local people's participation for wood, ecosystem and genetic resources conservation, soil conservation, and watershed management (Kanel 2000).

1.1.5 Community Forest:

The forests of Nepal are classified into National forest and Private forest. Five Sub-categories of National forests are recognized under the Forest Act, 1993; Community Forest is one of them. FAO (1978) defined Community forest as the forest management activity or situation, which closely involves local people in a forestry activity and free growing activities, for which rural people assume part of the management responsibility and from which they derive direct benefit through their own efforts. According to Forest Act of Nepal, 1993, "CF is a part or parts of National forest area handed over to a user groups for its development, conservation and utilization for collective benefit of the community". It is an institutional innovation of empowering local communities in managing forest resources for their benefit in co-ordination with the government. The government started community forestry program from 1978.

The 3rd national workshop organized in 1999 made a clear long term vision with the slogan of 'Community Forest for all and forever'. HMGN has recognized Community Forestry as a strategy to improve the condition of forests in the mid-hills as well as satisfy the basic needs of forest products of rural people. However, HMGN's policy is to adopt CF for all accessible mid-hills and high mountain forests as well as in some Terai districts. Tamrakar and Nelson (1991) calculated that there are 3.5 million hectares with the potential for community forest in Nepal. (NBS, 2002). Nepal’s community forestry has been widely accepted as a successful forest management approach. Indeed the program has resulted in rural farmers gaining increased access to forest resources, together with improvements in rural livelihood and biodiversity & landscape values. In a gist, the current situation of community forestry in Nepal can be illustrated by the following table 2.

Table 2: Present situation of community Forest in Nepal:

Total area of National Forest	58,28,800 ha
Total area handed over CF	11,89,100 ha
Avg. size of the C.F	> 83 Ha
Total no. of FUGs	14,305
Total no. of household involved	16,44,587
Total no. of districts in which CF has been launched	74
% of total Pop. Associated with CF	39%

Source: (Shrestha 2006)

Nepal's Tenth 5-years plan aims to reduce rural poverty through four strategies: broad based economic growth; social sector and infrastructure development; targeted programs especially for marginalized community and region; and good governance. Community forest has the potential to contribute all these strategies for achieving the national goal of poverty reduction, through sustainable forest management, livelihood improvement and good forest governance and respond to the imperatives of Millennium development goals.

1.1.6 Livestock:

Livestock plays a number of important roles within the system. It provides food in the form of meat, eggs, milk and milk products, draught power for the cultivation, manure to regenerate soil fertility of the cropland. It also provides hides and wool for the production of shoes, clothing and other articles and the most important of all, livestock provides for the resilience of the system in the face of harvest fluctuations by serving as a store of wealth. Forest biomass, when mixed with animal excreta, yields organic compost manure which forms the principal source of soil nutrients for hill agricultural land. In fact, it provides almost the only manorial inputs to crop production in the hills. To the extent that livestock cannot be maintained exclusively on the by-products of agricultural production on the cultivated area, it competes with cultivation for space.

1.1.7 Carbon stock:

Carbon occurs in the ocean, in soils, fossil carbon reserves, bedrocks, the atmosphere and plant biomass. The carbon cycle therefore is thought of as four interconnected reservoirs or pools; the atmosphere, the terrestrial biosphere (including fresh water systems), the oceans and the sediments (including fossil fuels). The major pathways of the exchange of carbon are photosynthesis, respiration and oxidation. The exchange rate of carbon between pools is referred to as flux. These reservoirs are either carbon sources or sinks.
Carbon sequestration is the process of removing additional carbon from the atmosphere and depositing it in other reservoir principally through changes in land use. In practical terms carbon sequestration occurs mostly through the expansion of the forests (Houghton, 1996). Carbon sequestration also occurs in cultivated land but the quantity is greater in the managed field. Therefore, the terrestrial carbon sequestration is the net removal of CO_2 from the atmosphere and storing it in terrestrial ecosystem (Sedjo and Marland 2003).

The greenhouse effect is the retention of heat in the lower atmosphere due to absorption and re-radiation by clouds and certain gases. The earth receives its energy from sun as solar radiation. Short wave (visible) solar radiation received from the sun passes through the atmosphere with little or no interference and warms the earth’s surface. Long thermal radiation emitted by the warmed surface of the earth is partially absorbed by a number of trace or GHGs. These gases reflect the long wave thermal radiation in all directions. Some of the radiation is directed downwards towards the earth’s surface. If these gases were to increase, temperatures could rise (Ciesla 1995).

1.1.8 Vegetation and GHGs

Green plants remove CO_2 from the atmosphere through photosynthesis. The carbon is stored in the foliage, stems, root systems and, most important, the woody tissue in the main stems of trees. Because of the long life span of most trees and their relatively large sizes, trees and forests are the storehouses of carbon. i.e. Carbon is sequestered and stored in the form of plant biomass, both above and below ground. The world’s forests have been estimated to contain up to 80% of all above ground terrestrial carbon and approximately 40% of all below ground terrestrial carbon (soil, litter and roots). Forests vary considerably in their capacity to absorb and store carbon depending on factors such as temperature, precipitation, stocking, soil, slope, elevation, site conditions, growth rates, species, length of growing period, longevity, and age. Generally, closed forests have a greater capacity to store carbon than open forests and woodlands. Undisturbed forests store more carbon than degraded forests. Wet or moist forests store more carbon than dry or semi-dry forests and mature forests store greater quantities of carbon than do young forests. Annual rate of carbon fixing is highest in young plantations. The ratio of dry total biomass to carbon is roughly 2:1 (Ciesla 1995).

The estimates of the total carbon held in plants and soils suggest that these pools may hold about three times the amount of carbon that is in the atmosphere at present, and a change in the flows between the pools of carbon held in plants and soils and the pool in the atmosphere affects the atmosphere significantly. The amount of carbon in the atmosphere is about 750 billion tons; the amount in soils and forests and terrestrial plant communities globally is at least 2,000 billion tons. Similarly, a large stock of carbon is held in the fossil carbon deposits of oil, coal, and gas. This stock is estimated to exceed 10,000 billion tons (Woodwell 1992).

Uncontrolled timber harvesting operations result in excessive soil disturbance, logging residues and damaged residual trees. This causes increased emissions of CO_2 and other GHGs and decreases the capacity of the residual forest to sequester carbon (Pinard 1994). While alive and growing forests and other plant biomass absorb the green house gas CO_2 in quantities broadly equivalent to the amounts emitted when plant materials decay or are burned. They thus represent ‘carbon-neutral’ fuel sources or, under certain growth conditions, carbon ‘sinks’. Growing forest can therefore be regarded as a potential antidote to the global warming and climate change syndrome.

1.1.9 Soil and GH-effect

Although the burning of fossil fuels is a major contributor, much of increase in atmospheric CO_2 levels come from a net loss of organic matter from the world's soils. Soils have only a finite capacity to assimilate C into stable soil organic matter. Therefore, carbon sequestration in soils can only buy time before other kinds of actions (shifts to renewable energy sources and increased fuel efficiency.) are fully implemented to reduce carbon emission to levels that will not threaten climate stability. Globally, at one time, approximately 2400 petagrams (pg, 10^{15}) of carbon are stored in soil profiles as soil organic matter (excluding surface litter), about 1/3rd of that at depths below 1m. An additional 700 pg are stored as soil carbonates, which can release CO_2 upon weathering.

Altogether, about twice as much carbon is stored in the soil than in the world's vegetation and atmosphere combined. This carbon is not equally distributed among all types of soils (Brady and Weil 2002). In a mature natural ecosystem or a stable agro ecosystem, the release of carbon as CO_2 by oxidation of soil organic matter (mostly by microbial respiration) is balanced by the input of carbon into the soil as plant residues and, to a far smaller degree, animal residues. However, certain perturbations of the system, such as deforestation, some type of fires, tillage, and artificial drainage result in a net loss of carbon from the soil system. Forest soil also store carbon. A recent study indicates that 84.3 % of the total carbon content of high latitude forests is stored in soil, for mid latitudes forests, 63 % is stored in the soil and for low latitude forests, the proportion is 50.4 % (Dixon *et al*. 1994).

Globally, the release of carbon from soils into atmosphere is about 62 pg / year, while only about 60 pg / year enter the soils from atmosphere via plant residues. This imbalance of about 2pg / year, along with about 5 pg / year of carbon released by the burning of fossil fuels (in which carbon was sequestered from the atmosphere millions of years ago) is only partially offset by increased absorption of atmospheric CO_2 by the ocean. Gases produced by biological processes such as those occurring in the soil, account for approximately half of the rising GH-effects. Therefore, soil science has the potential to contribute greatly to our ability to deal with global warming and the increasing levels of GHGs.

1.2 Justification/Rational of Study:

Community forestry has resulted in the extension, protection and conservation of forest land. It has shown the potential to expedite community development through capacity building, enhancing livelihood security options, infrastructural development, good governance and poverty alleviation. Thus the benefits of social forestry could help to uplift the condition of people living in remote areas. Therefore, the fragile hill forest as a resource base has to be brought into efficient management and sustained utilization.

The earth's ecological sinks to absorb GHG's, are oceans, soil and vegetation. Forests absorb CO_2 and convert it into biomass comprising of tree-trunks, branches, and leaves. Managed forests sequester more carbon than unmanaged forests (mature) where trees die and decay. Therefore active management and restoration of the degraded forest will not only check soil erosion but enhance carbon, revitalize soil nutrients and increase the levels of soil organic carbon.

Till the time, no much research works in the fertility status of forest soil has been carried out, although deforestation rate is high and erosion is prominent. And also, more or less productivity of farmland is dependent on forest thus the quantification of forest and interrelationships needs to be determined (Karki *et al*. 2005).

Though remaining within the periphery of polluted city, Kathmandu and providing service to the metropolis; the status of the contiguous forest is still unknown. Similarly, the peri-urban agriculture has been given little priority in spite of its great contribution in feeding urban population and especially in the case of blockades due to political movements and call for strikes. The enormous role of forest & soil and other land uses as carbon sink is neglected. Therefore, the present study imparts fertility status of hill farmlands and forest soil as well. The role of forest & soil and other land uses as carbon sink has also been explored.

Global warming is becoming a real threat to agriculture and forestry. To combat against it, more lands needs to be forested and sustainable farming has to be enhanced. In this respect, fertility of cultivated lands under proper management will increase lands' productivity, carbon sequestration and agricultural sustainability on one hand and conserve forest and in turn carbon sink by discouraging encroachment on account of supplement production, good enough for sustenance of farm families. Therefore, the status of fertility in farm and forest was also explored in the Hasantar and contiguous areas aiming at examining the carbon content in these land uses.

Thus, Hasantar community forest's efficiency for carbon sequestration and relation with the nearby farmlands has been rigorously explored. Also, It has derived understanding in the role of community managed forest in lessening the abrupt change in the local climate and in global phenomena and strongly recommend to rectify the shortcomings in community forests from study to benefit from Clean Development Mechanism(CDM) Scheme of Kyoto Protocol.

1.3 Objectives:

Broad Objective: The prime objective of the study is to determine the soil fertility status and carbon stock capacity of the Hill forest.

Specific Objective:

- To determine the pH, NPK and soil organic carbon content of forest floor and its adjoining farmland.
- Determination of above ground tree biomass (through DBH & Height measurement method).
- Determination of Carbon Stock Capacity of the forest.
- To study societal response to soil fertility.

1.4 Limitations:

1) Above Ground biomass (esp. herbs and shrubs) were excluded due to time constraints.
2) Only limited work was carried out on account of limited time period for study.

1.5 Study area

Seuchatar is one of the VDC falling on the peri-urban area of the Kathmandu city. It is situated to the west of Kathmandu city approx. 7 kms away from the centre of the city. It has a total area of 2.493 sq. km, extending from 27^o 42' N to 27^o 43' 4" N latitudes and 85^o 15' E to 85^o 16' 8" E longitudes. It has 9 wards, ward no. 1 being nearest and the ward 9 the most remote from the Kalanki Bazar. However, the study is confined to Hasantar Community Forest, its contiguous areas and its stakeholders, most of whom are the inhabitants of ward no. 9 and others of its adjoining areas (Fig. 1).

The study sites are located within the study area, Hasantar Community Forest of seuchatar VDC, almost covers the area of ward no.9. The forest is bounded by Pancha Kanya Secondary School in the east, Tin Pokhari (Sugure Pokhari) in the West, Neupane Kholsi in the North and Joghi Ko Gufa in the south sharing its boundry with Raniban community forest.

1.5.1 Soil:

The history of Seuchatar VDC reveals that the soil type of Seuchatar is Red soil as "Seucha" in Newari meant red soil and tar is a water-scarce land. Therefore, it was commonly known by the name Seuchatar. In the past, the Newar community sold the red clays in the market of Kathmandu city. Thus, the Hasantar community forest (HCF) and its adjoining areas on the lower slopes and terraces have red soils. Such types of soils have low plant nutrients but productive with irrigation and addition of plant nutrients and judicious amount of organic manure.

1.5.2 Climate:

The temperature of study area is moderately mild with warm and wet summers and cool and dry winters and thus can be termed as warm temperate monsoon climate. The climate is suitable for cultivation of summer crops such as rice, maize and soyabean during monsoon season and wheat, mustard and potato in winter. The average maximum and minimum temperature of the study area was found around 25^oC and 13^oC respectively with minimum temperatures in December to February and maximum in June to September as recorded in Panipokhari climatological station and the average annual rainfall was around 1789 mm as recorded from nearest Thankot precipitation station. Almost 80% of the rainfall occurs in monsoon (June-Sept.).

1.5.3 Forest:

The total area of the Kathmandu district is 41,200 ha of which 14, 118 ha is forested land. (Sharma, 1999). The forest of Kathmandu districts can be categorized under six dominant types as mentioned below:

i) *Schima wallichii- Castanopsis indica* forest.

ii) *Pinus roxburghii* forest

iii) *Pinus roxburghii- Schima wallichii* forest

iv) *Quercus lanata and Pinus excelsa* forest

v) *Quercus lanata and Rhododendron arboreum* forest and

vi) *Quercus semecarpifolia* forest.

Of the total forest area, the natural forest comprises 37%, plantation- 9% and natural & plantation (both) - 54%. The total no of Forest User Groups (FUGs) formed in the district were 150. The following table 3 shows the situation of community forest (CF) of Kathmandu District and the study area.

Table 3: Situation of CF in Kathmandu District and Study Area

	CF in Kathmandu district	Hasantar CF
Area Handed over	4907.54 ha	64 ha
No.of Household involved	18,832	259
Average Size of CF	33 ha	

Source: DFO (2062).

1.5.4 History of Hasantar Community Forest (HCF):

There are six range-posts in Kathmandu district to look after the 150 CFUGs. Sitapila range post is responsible for monitoring and assisting HCF.

During 2000 B.S, the forest was dense and plenty of native flora and fauna were found. But, the high demand for building material in the Kathmandu city and the firewood as well as building material in adjoining villages: Ramkot, Naikap, Seuchatar lead to logging and consequently to the heavy destruction of the natural forest vegetation (especially *Schima wallichi*, *Castanopsis spp*. and *Myrica esculenta*).

It was only then in 2017 B.S that conservation need was felt and efforts being made. However effective forest conservation committee was formed in 2047 B.S for the purpose of forest protection and conservation. It was only in 2050/51, 42.5 ha forest was for the first time handed over to Hasantar community as Hasantar Community Forest. Till to date, 3rd operational plan has also came into effect since 2062 so as to keeping pace with the changing scenario and management aspect for the next 10 years (DFO 2006).

1.5.5 Farming System:

The agriculture system in the valley originated as a part of the hill farming system which is characterized by poly-cultural farming, integrating forests, rearing of domestic animals and crop production. Polyculture is a more complex form of intercropping in which many different plants maturing at various times are planted together (Miller 1996). The farmers of the Kathmandu Valley adopt a mixture of improved and traditional production practices.

Paddy-wheat is the major cropping pattern in the lowlands where as, maize is still the major crop in the uplands. Vegetable production has been attracting the farmers as it provides good returns. The crop husbandry practices commonly adopted in the study area are:

a) Intensive use of human labour and

b) Heavy application of chemical fertilizers.

1.5.6 Geology:

The basement of Kathmandu Valley is reported to be that of metamorphic rock of pre-Cambrian age. The Valley deposit has been found to be fluvio-lacustrine terraces of Pleistocene age (Yoshida and Igarashi, 1984). Previous workers reported that terrace-forming sand dominant fluvio-deltaic or fluvio-lacustrine sediments are extensively distributed in the northern and central parts of the Kathmandu Valley. The basement of Kathmandu Valley is composed of the upper part of the Kathmandu Nappe known as the Phulchauki Group, resting on the Precambrian rocks of the Bhimphedi Group. The

Phulchauki group consists of 5-6 km of early-middle Palaezoic rocks that have been divided into 5-formations (Stocklin and Bhattarai 1980). Among these the study area falls within Tistung Formation and its adjacent ones are Sopyang Formation, Chandragiri Formation, Kalimati Formations (Fig 2, Menris 1999) etc.

The Phulchauki group begins with about 3 kms of unfossiliferous slates, siltstones, calc-phyllites and metasandstones known as the Tistung Formation. It is Late Precambrian to Early Cambrian in age (Kumar, 1985 cited by Paudel 2002). The characteristic of it is the greenish grey to brown fine grained phyllites and slates inter-bedded with meta-sandstone and quartzite with thin bands of argillaceous limestone. Its total thickness is about 3000m and are locally weathered. It is exposed in the western to southwestern part of the Kathmandu Valley. It is followed by Sopyang Formations and Chandragiri Formations respectively (Fig 2).

CHAPTER II
LITERATURE REVIEW

2.1 Soil Nutrients and agricultural productivity

Devkota and Pradhan (2006) studied the urban agriculture in terms of urban food security and employment in Tokha, Kathmandu. He found that above 50 % of the households of peri-urban area are engaged in agriculture supporting 45% of family income. The study revealed that 75 % farm family reported declining soil fertility and only 12% reported no change in productivity.

Singh and Paroda (1994) examined the sustainability and productivity of rice wheat system in Asia Pacific region. They found that although rice and wheat crops are typically grown sequentially in a rice-wheat cropping system in Nepal, the total productivity of the system is declining in mid-hills regions. And, these trends are related to cropping intensification and mismanagement of plant nutrients particularly the nitrogen, in package of practices for crops. This situation of stagnant or declining yield under rice-based wheat cropping system with high levels of chemical Nitrogen fertilization have raised concerns about the long term sustainability and possible adverse environmental impacts of practice. The heavy use of industrial N-fertilizer may result on nutrient imbalance.

According to Abington (1998) Hill agriculture in Nepal is small holders and subsistence oriented. Alteration to traditional hill farming practices to increase productivity must consider the interdependency of crops, livestock, forests, social and economic status within the farming system. The ability of hill farming households to accept risk in changing tried and tested livelihood practices is crucial for successful adoption of new agricultural practices.

According to White (1983), Soil, climate, pests, diseases, genetic potential of the crop and man's management are the main factors governing productivity, as measured by the yield of crop or animal produce per hectare where the variables other than soil remain reasonably constant, one expects a direct dependency of yield on soil fertility. It is often the case that the ability of the soil to supply one nutrient, especially N, P or K has an overriding effect on fertility. The yield then increases linearly with the supply of that nutrient, until the supply of another nutrient becomes limiting. This concept is embodied in Liebig's law of the minimum.

Singh and Singh (1988) analyzed the soil chemical properties of an abandoned riparian land (site I) and another cultivated system (site II) on the banks of River Pili at Jaunpur in different months, Zones and depths. They come out with the result that Soil pH of both sites were on alkaline side from 7.2 to 8.6. Also, marked decrease in organic carbon contents with respect to three different depths and zones were observed during all the months for both the sites. The values were higher in upper soil zone. Organic carbon contents of the site II were higher than site I. Similarly, total N-contents of soil at different months and depths in all three zones on both sites had shown distinct variations (0.135-0.468 mg / g). Available Phosphorus contents were more or less similar. The overall available P-values varied a little between the sites but more distinctly among the depths. The cultivation of riparian lands in winter had shown very little difference in soil chemical properties although organic carbon increased slightly due to microbial decomposition of plant materials.

Mian (1998) carried out experiments in silt loam soil to assess the impacts of intensive fertilization and cropping on soil environment. Results of 20 years of experiments indicated that besides the beneficial effects the intensive fertilization practices have also some adverse effects on soil environment. Application of phosphorus fertilizer increased the heavy metal concentrations in soil while application of gypsum decreased their levels both in soil, soil solution and plants. The concentration of non-sulfate sulfur and bicarbonates and losses of nitrogen were higher in gypsum treated plot than the control plots. Small soil aggregates, fine pores, EC and water retention capacity also increased due to cultural practices and fertilization but decreased air content and nitrifying activity. The unhealthy soil environment produced from intensive agricultural practices may be one of the reasons for the so-called yield stagnation/ declination.

The soil fertility research: NARC/ ARS Lumle/ QMW (2000) made an understanding of the circumstances that lead to high susceptibility to erosion and soil nutrient losses from cultivated Bariland in the middle hills of Nepal. The conclusions of this study indicated that measured rates of soil erosion are for the most part relatively low in "Average" monsoons (generally 5 tons ha^{-1} yr^{-1}) as determined in 100 m^2 plots. Furthermore the majority of rain falling on the soil infiltrates to depth-runoff usually accounts for less than 10 %. Nutrient losses resulting from runoff and erosion are much less than losses incurred from leaching, mostly in June and July as nitrate nitrogen.

According to Karki *et al*. (2005), the soils in the Kathmandu Valley are deep and rich in organic carbon and Nitrogen. Nanskota and sharma (1993) claimed there is an ample room for the increment of crop yield in the valley with respect to the present rate of production, provided that farmers use mineral fertilizer judiciously and in combination with organic manure.

Lottermoser (1997) come up with the result that top soils are characterized by low pH. and acidity decreases with the depth. Most soils pH values fall within 3.5-5.4 (extremely acidic to moderately acidic), indicating pH problems to be more serious than reported from other middle hill areas (Sapkota and Andersen, 2005). LRMP (1986) estimated pH around 5.4 for cultivated upland soil.

Khadka (2002) studied nitrogen dynamics in rice under rice-wheat cropping system at rain fed lowland condition at Khumaltar. He observed highest rice grain and highest fresh straw weight in the field treated with balanced application of nitrogen, P_2O_5, K_2O_5 and lowest grain in control treatment. In general rice grain yield was affected due to chemical fertilizers and organic manures. The NO_3^--N and NH_4^+-N in the soil were also higher in soyabean incorporation treatment than in other treatments. On the other hand, higher amount of NO_3^-N ions concentration was observed in the lower depths (30-60 cm) due to leaching and higher NH_4^+-N was absorbed at maximum tillering stage than after rice harvest.

Pokhrel (1999) analysed Soil samples from Kathmandu (Central: Champadevi) and Terai. He found that majority of the Nepalese soils are light colour slightly acidic to near to neutral pH, low organic matter content (0.3 % to 4.21 %), low total nitrogen (0.02 %

to 0.21 %), low available phosphorus (0.07 gm/100g to 0.2 gm/100gm). However, level of potassium was found to be high in both regions. All soils showed high potentiality of N-mineralization. It was found that Nepalese soils have lower amount of the nutrient elements and low fertility. There was deficiency of nutrients and other physical properties of the soil in Paddy soil of both places compared to the nearby forest soil, which shows that the soils are being degrading, while it changes from forest to cultivated land.

2.2 Forest and soil nutrients

The Hill Forest Development Project (HFDP) - Kathmandu Project area prepared a guide to assess the soil nutrient status for forestry soils of Nepal. It concluded that the soils, in general, can be considered infertile with consistently low available Phosphorus levels (< 4 ppm); low- medium exchangeable potassium (0.1- 0.2 meq / 100g) and low- high nitrogen (0.02-0.15 %). Surface horizons have higher values for nitrogen and percent organic carbon but these decrease quickly down the profile, becoming limiting often by 25 cm. pH values range from 4.6 – 5.9 although commonly pH 5.0- 5.5 was observed.

Prajapati (1981) made an analytical study on the effects of nutrition (NPK), temperature and light on the growth and development of Chir Pine seedlings. He found that Nitrogen requirement was more important than phosphorous and potassium although N, P & K all three are necessary for the good growth of the pine seedlings.

Bajracharya (1982) made an ecological analysis on the nutrient content of soil and its relationship with vegetation in Phulchowki Hill. The nutrient contents were higher in the west facing slope than the south facing slope which was due to the water regime, organic matter of soil and exposure to light. The soil nutrients showed their effect on density and basal areas of trees as well as on the relative dominance of ground vegetation.
Ingram and Teare (1986) conducted an analysis of soils from a wide variety of potential planting sites in the hills of western Nepal. The study revealed that they were generally poor in major nutrients.

Loach (1962) studied on the effect of soil nutrient on vegetation in wet heath. This showed that not only physical but also chemical soil environment (Nutrients- NPK) determines the vegetation distribution. In a separate study he analysed the nutrient content of soils to understand the relationship between soil nutrients and vegetation in wet heath. The result proved that besides soil moisture and porosity, the vegetation distribution was mainly affected by the nutrient content of the soil (NPK) therefore, the richer the soil in those nutrients the better was the growth of vegetation.

Li-Feng *et al*. (1998) studied the effect of organic matter on N and P of northwest china. The results showed that the total Nitrogen content were correlated positively with organic matter content significantly at 5 % level. However, Available P content was unaffected with increased organic matter content.

Rana Bhat (1978) examined vegetation in relation to the soil characteristics in the Balaju adjoining hills of Nagarjun Royal forest. The study exposed the soil characterstics (Soil pH, moisture and texture) have profound influence on vegetation. Raya Chhetri (1981) made ecological and floristic studies on some adjoining forest of Chandragiri. He identified four types of forests between altitudinal range from 1,380 to 2510 m and these forest types were governed by soil characteristics such as texture, pH, organic matter content etc along with the topographic features.

Sharma (2000) studied the biodiversity in relation to environmental gradients of Shivapuri. He found out that the tree diversity decreased with rise in altitude. He concluded that soil nutrient, organic matter, pH and moisture have inverse relation with the altitude.

Pokharel (2002) studied edapho-vegetation linkages in Rajnikunja Gokarna Forest. She found positive correlation between the trees versus seedlings, phosphorus versus sapling and potassium versus sapling. She found no significant correlation between studied vegetation, pH and organic matter.

Sigdel (2004) made the vegetation and soil analysis in southern aspect of Shivapuri National Park. Similarly, Adhikari (2006) studied vegetation, soil and litter analysis along elevation gradient in Shivapuri Hill. Niroula (2004) examined the phyto-diversity and soil of Siwalik Hills of Ilam. He found organic matter was positively correlated with nitrogen at 0.05 level.

2.3 Community Forest

The 1978 legislation gave the department of Forest authority to hand over forest to elected village leaders of the local village unit called panchayat. So, Community based forest management began in Nepal in 1978 under Panchyat Forests and Panchyat Protected Forests (Sharma, 1999). Pioneering in Asia-Pacific region, Nepal has made a tremendous progress in community forestry (Singh, 1998). Community forestry is one example of a viable approach to promote conservation or environmental protection as well as rural development in the Hills of Nepal (Chhetri and Jackson, 1995).

Khanal Chhetri (2005) conducted a study in five selected FUGs in Kaski district through household survey showed that Community forestry income contributed an average of 7.4 % of the total household income, which is equal to 56 % of the total forest income of the user households. The main sources of community forestry income are fuel-wood, fodder, ground grass and leaf litter. The middle class households derived more than twice as much community forestry income compared to the rich and the poor households. Households who own more livestock and have access to larger area of community forestry are extracting higher value of community forestry income. The community forest income is more important for the poor and had a strong equalizing effect on local income distribution.

2.4 Forest biomass

According to Brown (1997), Biomass represents the potential amount of carbon that can be added to the atmosphere as CO_2 when the forest is cleared and or burned. Biomass density estimates also provide the means for calculating the amount of CO_2 that can be removed from the atmosphere by re-growing forests or by plantations because they establish the rates of biomass production and the upper bounds for carbon-sequestrating.

Condori (1985) estimated the above ground biomass in Chalanakhel mixed forest of different species and found out that *Castanopsis tribuloides* and *Myrsin captellata* had 5.95 tons ha^{-1} and 9.92 tons ha^{-1} fresh above ground biomass respectively. The analysis for correlation coefficient of different growth parameters proved that height of the plants are positively correlated with girth bole length and canopy diameter.

Sejuwal (1994) conducted general survey of forest vegetation and estimated the above ground biomass in tropical forest of Royal Chitwan National Park. He estimated above ground biomass for sal forest as 1038.16 tons ha^{-1} and riverine forest 726.37 tons ha^{-1}.

Giri (1997) estimated the total live above ground biomass of five different forest communities to be 1459.33 tons ha^{-1}. in which riverine forests (evergreen and deciduous) contributed highest 41% of total live above ground biomass which was followed by Terai mixed Shorea robusta forest (23%). Terai pure *Shorea robusta* forest stands 22.6 % and least in the Savannah (12.3%).

2.5 Carbon Stock or Carbon Sink

Dixon et al. (1994) estimated the carbon pools and flux of global forest ecosystem. The emission of CO_2 to the atmosphere by land use or land cover change in low altitude forests is estimated at 1.65 +_0.4 pg C yr^{-1}, due to the modification of high biomass forest ecosystems to systems of lower biomass such as secondary and degraded forests, cultivated land and pastures.

According to Sharma (2006), the CO_2 in the atmosphere could be reduced by plantation of *Gmelina arborea* by production of above ground biomass, under ground biomass and standing litter organic carbon. Total biomasses in 1 hectare of plantation were 179.05 tons, 6.4 tons and 4.36 tons respectively. The carbon pools of 1 hectare plantation in the above mentioned mass were 77.53 tons, 2.73 tons and 1.58 tons respectively. The net carbon sequestration potential of a 6-years old plantation was 69.31 tons ha^{-1}. The plantation helped to offset a portion of the carbon-emissions contributing to climate change through the sequestration of carbon by 69.31 tons ha^{-1} which is equivalent to 254 tons CO_2.

FAO (2002) explained that forests store carbon in trees, under storey vegetation, litter and soil. Globally they contain some 1200 billion tones of Carbon just over half the total in all terrestrial vegetation and soils. Measures such as reduced deforestation, forest regeneration and plantation development could reduce CO_2 emission by the equivalent of 12 to15 % of all the emissions from fossil fuels between 1995 and 2050. Similarly, Farming can also be a sink for Carbon. The total amounts that can be stored in crop are location specific and the rate of sequestration decline after a few years of growth before eventually reaching this limit. In 1997-1999, an estimated 590 to 1180 metric tons carbon were locked up in cropland soils alone, in the form of soil organic matter from crop residues and manure. Projections of increased crop production imply that by 2030, this total could rise by 50 %.

According to Schroeder (1994), the earth's terrestrial vegetation plays a pivotal role in global Carbon cycle. Not only are tremendous amounts of carbon stored in the terrestrial vegetation; but large amounts are also actively exchanged between vegetation and the atmosphere. One estimate is that on average the equivalent of the entire CO_2 content of the atmosphere passes through the terrestrial vegetation every 7-year, with about 70 % of the entire exchange occurring through forest ecosystems (Waring and Schlesinger, 1985). This dynamic relationship means that any land use practices that increase vegetative cover, or reduce its removal, could have an influence on the global carbon budget by increasing the terrestrial carbon sink.

Dhakal, (2006) studied the land Use change effect on soil organic carbon (SOC) stock in Balkhu Khola Sub-watershed. She found that forest soil has good potential for sinking SOC having capacity of 8.12 kg C m^{-2}. Upland bariland has sunk 6.12 kg C m^{-2} and lowland cultivation (Khet) has sunk 4.93 kg C m^{-2}. The estimated amount of SOC in Balkhu Khola Watershed was found to be 257.71 MTC among which forest contain 107.61 MTC (41.76 %), and cultivation 146.68 MTC (56.92 %). Bulk density was found less in forest soil compared to bari and Khet in all depth which showed negative correlation with SOC.

Sombroek *et al*. (1993) estimated the amounts, dynamics and sequestering of carbon in tropical and subtropical soils. He stated that in addition to increasing susceptibility of soils to erosion by wind and water, the clearing of forests and woodlands to support agriculture in the tropics can result in a loss of 20 to 50 % of the soil carbon contained in the topsoil. Some estimates indicate that deforestation in the tropics caused a net release of soil carbon between 0.1 and 0.3 G t in the years around 1990 compared with 0.3 and 1.3 G t as a result of burning and decay of vegetation respectively.

Franzluebbers (2005) found that SOC to a depth of 20 cm was rapidly lost following disturbance (i. e., 40 Mg ha^{-1} initially and 20 Mg ha^{-1} at the end of 10 years of disturbance), but also rapidly regained upon cessation of disturbance (i.e., 13 Mg ha^{-1} initially and 28 Mg ha^{-1} following 10 years of undisturbed land use) in Georgia piedmont region. By increasing cropping system complexity, SOC could be increased by 0.22 Mg $ha^{-1}yr^{-1}$, irrespective of tillage management. In longer term studies (5-21 years), poultry litter application led to SOC sequestration of 0.72 +- 0.67 Mg $ha^{-1}yr^{-1}$. SOC sequestration could be optimized at 0.24 Mg $ha^{-1}yr^{-1}$ with application of 107 kg N $ha^{-1}yr^{-1}$ on nitrogen responsive crops, irrespective of tillage management.

Jenny (1980) and Bunnell *et al*. (1977) considered the interaction of temperature and precipitation to be predominant factors controlling faunal and microbial activity, the latter regulating the C dynamics in soils (Mc Gill *et al*., 1986). Considering forest sites as a recent sink and source of CO_2, SOM is an important part of the carbon cycle which is sensitive to changes in climate and CO_2 concentrations (Bohn, 1976).

Application of organic fertilizers improve physical, chemical and microbial properties of soils. Adding compost in particular increases the content of organic carbon (OC) and of microbial biomass, the cation exchange capacity, and the biological activities of soils (Perucci, 1992; Jorgensen *et al*., 1996).

CHAPTER III
MATERIALS AND METHODS

3.0 Methodology:

The research is a non-interventional study and is descriptive. The data collection process includes on-site data collection, laboratory analysis and relevant secondary data acquisition as well. Simple random sampling technique has been applied for sampling. The sampling was done in two consecutive seasons: early summer (pre-monsoon) on the month of July, 2006 and mid autumn, on the month of October, 2006 (immediately after monsoon) and the values obtained from the experiment were pooled together so as to derive mean which represented the annual fertility status of soil.

The social survey employed simple random sampling technique and the sample size chosen was approximately 10 % of the total households. This questionnaire survey was carried immediately after the post harvest of the rice in the lowlands and maize / millet in the highland in the month of October.

3.1 Place and duration of study:

The appropriate study area that meets the purpose of study in the peri-urban area of Kathmandu valley was located in the topographic map and cross-checked by reconnaissance survey on March, 2006. The place choosen for the study was Hasantar Community forest (HCF) and its adjoining areas. The study was carried out for about ten months which involves soil test of two seasons' in pre monsoon (July) and post monsoon (October), biomass study and house hold survey after harvest of staple food crops in the November-December.

3.2 Study area and Sampling sites:

The study area was situated about 7 kms away from Kathmandu in the west. The core study area was located in Hasantar community forest and its adjoining areas of Seuchatar VDC. The Sampling sites along with its GPS location and other attributes of the study area are presented in table 4 and its sampling sites are shown in Fig 3:

Table 4**:** Sampling sites within the study area

Sites	Land Use		GPS Co-ordinates (in & around)	Altitude (m) Measured by GPS	Slope (by compass)	Remarks (belongs to blocks)
A	Forest	1	27^{o}42’53.7”N 85^{o}15’05.2”E	1434	30^{0}-36^{0}	Block 4
		2	27^{o}42’48”N 85^{o}15’16”E	1520	25^{0}-40^{0}	
B	Agriculture		27^{o}42’55.1”N 85^{o}15’07.3”E	1398	5^{0}-10^{0}	
C	Forest		27^{o}42’48.6”N 85^{o}15’16.2”E	1513	20^{0}-25^{0}	Block 2
D	Agriculture		27^{o}42’43”N 85^{o}15’3.2”E	1485	>10^{0}	
E	Forest		27^{o}42’26.5”N 85^{o}15’01”E	1622	25^{0}-30^{0}	Block 3
F	Agriculture		27^{o}42’35.7”N 85^{o}15’14.0”E	1496	5^{0}-15^{0}	
G	Agriculture		27^{o}42’32.8”N 85^{o}15’6.6”E	1556	5^{0}-12^{0}	
H	Barren land		27^{o}42’25.2”N 85^{o}15’4.8”E	1603	21^{0}-25^{0}	
I	Forest		27^{o}42’23.0”N 85^{o}14’59”E	1612	30^{0}-37^{0}	Block 5
J	Agriculture		27^{o}42’13.5”N 85^{o}15’27”E	1515	10^{0}-15^{0}	
K	Forest	1	27^{o}42’20.9”N 85^{o}15’31.9”E	1479	25^{0}-30^{0}	Block 1
		2	27^{o}42’37 ”N 85^{o}15’22 ”E	1504	20^{0}-30^{0}	
L	Agriculture		27^{o}42’21.7”N 85^{o}15’34.7”E	1432	5^{0}-12^{0}	

Note: The sample has been drawn from the soil profile of each site at their three prescribed soil depths 0-15 cm, 15-30 cm and below 30 cm-40 cm at a time respectively.

3.3 Sources of Data:

Data required for this study were accumulated from different sources. The primary data was collected directly by interaction with the concerned people, direct observation and laboratory experiment and the secondary data were collected from the literatures, authenticated documents etc. The secondary data were supposed to facilitate the scientific study by availing the necessary information, not exactly covered by field of study.

3.3. I Primary sources:

3.3.1 Key informants' interview:

Informal interviews were made with the identified key informants: senior citizens, renowned people, farmers, heads of local organizations etc.

3.3.2 Questionnaire Survey:

Structured questionnaires were prepared so as to reinforce the scientific outcomes or cross-check scientific results that are supposed to highlight on socio-economic aspects and farmers' opinion on the research.

3.3.3 GPS and Compass records:

The data recorded by GPS serve to provide basic information regarding the field such as location co-ordinates, altitude etc and Brunton compass measured the slope gradients.

3.3.4 Soil Analysis:

Soils on the slopes of the Mahabharat lekh, middle mountains as well as the Himalayan spurs are shallow in depth except in terraced conditions (Shah 1999). The soil depth considered for the study was therefore just from surface up to 40cm. The samples were drawn with soil Augur and prepared composite samples following the methods suggested by Khatri-Chhetri (1990). A composite soil sample on the basis of homogeneity was drawn out from different depths (0-15; 15-30 and below 30 cm) of each 5-blocks of forest (as categorized by operational plan 2062 of HCF) and the farmland soil next to the forest floor and barren land were also drawn in a similar way as described by AID/ HMGN (1998/99).

The soil samples were brought to the laboratory in a well-labelled sample bag, half a kg. in weight. The samples were then completely air dried, crushed and passed through 2mm sieve for performing physical and chemical analyses.

3.3.4. a pH:

An oven dried soil was dissolved in distilled water at 1:5 soil-water ratios in a beaker**.** The soil suspension with frequent stirring for about half an hour was ready for taking reading. The pH was measured with combined glass electrode.

3.3.4. b Organic Carbon:

The Organic Carbon present in the soil samples were analysed by Walkley-Black rapid titration method. The recovery of the carbon in this method is not 100%. Only about 60-90% of the total organic matter is recovered depending upon the kind.

The organic matter present in the soil is digested with excess of potassium sulphuric acid, and the residual unutilized dichromate is then titrated with ferrous ammonium sulphate with diphenylamine as indicator. The potassium dichromate is used as a catalyst to activate decomposition.

3.3.4. c Total Nitrogen:

Most of nitrogen in the soils is in organic form. Relatively small amounts ordinarily occur in ammonium and nitrate form. Most widely used procedure for N-determination is Kjeldhal method in which organic N compounds are converted into ammonium sulphate by digestion with concentrated H_2SO_4. The digestion of soil with sulphuric acid is facilitated by using sodium or potassium sulphate (raises boiling point) and copper sulphate (catalyses the reaction). The digested solution liberates the ammonia in alkali, which is distilled and collected in the boric acid solution and titrated with standardized dilute acid using mixed indicator.

3.3.4. d Available Phosphorus (Trough method):

Phosphorus in soils is generally determined as available phosphorus, which can be extracted from soil with 0.002N H_2SO_4 (1 soil: 200 H_2SO_4). The molybdenum blue method are most sensitive and as a result, they are widely used for soil extracts containing small amount of P as well as total P determination in soils. The phosphate in solution react with ammonium molybdate and form complex heteropolyacid (molybdophosphoric acid), which gets reduced to a complex of blue colour in the presence of Stannous Chloride. The absorption of light by this blue colour can be measured at 690 nm to calculate the concentration of phosphate by this colorimetric method. (Trivedi & Goel 1986).

3.3.4. e Exchangeable Potassium:

Cation present in the exchange complex of soils can be removed by leaching the soil with Ammonium acetate solution. The potassium extracted by normal neutral ammonium acetate is considered to be available to plants. For most soil the potassium removed is largely that associated with the clay and humus complex as exchangeable ions. For determination of exchangeable K^+ Ions, the soil is first washed with 1 N ammonium acetate and then with ethyl alcohol to remove the soluble fraction and then exchangable potassium is determined in ammonium acetate leachate, following flame photometric method.

3.3.5 Vegetation Analysis:

For sampling vegetation, Quadrat method was adopted. Quadratic studies for biomass estimation were carried out in 5-blocks of forest as defined by DFO (2062). The total area of CF is 64 ha. Therefore, the no. of sample plots of size 500sq.m required at 0.5% sampling intensity was determined by using Community Forest Resource Inventory Guidelines (MFSC 2061) as:

Total Sample plot Area (a) = $\frac{SamplingIntensity(I) * Tot.areaof`Forest(A)}{100}$

=0.5* 64/100

=0.32ha

No. of Sample plot required = $\frac{Tot.Areaof'SamplePlots(a)}{Areaof'eachSamplePlot(P)}$

=0.32 ha /0.05 ha

=6.4~7"

The study adopts non-harvesting method for biomass estimation. For most forests or tree formations, biomass density estimates will be based only on the biomass in trees with diameters greater than or equal to 10 cm which is the usual minimum diameter measured in most inventories or closed forests, However, for forests or trees of smaller stature, lower minimum diameters should be chosen (Brown 1997). All trees (saplings or regeneration) in the sample plots bigger than 3 cm in DBH and at least 1.3 m above ground level were measured. The heights of standing trees were estimated by using Clinometer, measuring angle of elevation and using height and distance formulae. The existing tree biomass was estimated by using the basic regression techniques developed by Yoda (1968), for trunk and branch weight and the generalized allometric function developed by Ogwa *et al*. (1965) as cited by Yoda (1968).

Estimation of Trunk stem weight (Ws), Ws $=0.0396\ (D^2H)^{0.933}$

Estimation of branch weight (W_B), $W_B=0.0055\ (D^2H)^{1.027}$

Estimation of leaf weight (W_L), $1/W_L=\dfrac{23.8}{Ws\,\Gamma\,WB}+0.0250$

Unidentified floral specimens were brought to CDES along with their known local names (if available) and identified with the help of published book flora of Kathmandu Valley.

The basic regression for conifers (Pinus sps.) as used for estimating tree biomass are as follows:

Estimation of Trunk weight (Ws), $Ws=0.0254\ (D^2H)^{0.948}$

Estimation of Branch Weight (W_B), $W_B=0.055\ (D^2H)^{0.924}$

Estimation of leaf (W_L), $1/W_L=\dfrac{7.5}{Ws\,\Gamma\,WB}+0.0125$

Where, D=dbh, H= height of the tree .

Ws in kg, D in cm and H in m.

According to Lasco (1998), the estimation of carbon in forest ecosystems is mainly premised on a simple fact i.e. about 50% of organic matter is composed of carbon.

Carbon (C) generally makes up 50% of the mass of most plant materials and the biomass of forest provides estimates of the carbon pools in forest vegetation therefore C is estimated from an inventory of total biomass (Brown 1997, Keenan *et al*. 2003). Therefore, considering about 50 % of the biomass is carbon, the carbon pools can be estimated as:

Biomass C = Total biomass X % C-content (usually 50%).

3.3. II Secondary Sources:

Informal interviews were conducted with staffs of Seuchatar VDC office, president of community forest, chiefs of local institutions and elder members of society. The Seuchatar VDC introductory book, location map and other literatures related to VDC also reinforced the research work.

CHAPTER IV

Data Analysis - Results

Soil fertility analysis:

The result has been derived from soil profiles of 12 sites and 72 samples i.e. three from prescribed depths 0-15 cm, 15-30 cm and 30-40 cm of a same soil profile of each site in two consecutive seasons and then pooled the data for an average, as per requirement for soil fertility assessment.

4.1 Soil Fertility analysis of different land uses and depths:

The soil profile has been categorized into 3 depths namely: (0-15 cm), (15-30 cm) and below 30 cm respectively and the soil fertility was assessed in each site of agricultural land, forest land and barren land.

4.1.1 Soil fertility of Hasnatar Upland Agriculture land:

Table 5 below shows the soil fertility of agricultural land in the adjoining areas of Hasantar Community Forest (HCF). The samples were drawn from 3-prescribed depths of 0-15 cm, 15-30 cm and below 30 cm respectively.

Table 5: Soil fertility of Hasantar Upland Agriculture (HUA) land

Site	pH	OC (%)	Total N (%)	P ppm	K (me/100g)
B 0-15	5.9	2.427	0.161	8.6	0.385
B 15-30	5.75	1.682	0.161	4.6	0.304
B 30+	5.6	1.65	0.147	17.7	0.288
D 0-15	4.9	2.4	0.336	14.105	na
D 15-30	4.9	2.1	0.21	7.7	na
D 30+	5	1.721	0.172	10.1	na
F0-15	4.6	3.049	0.21	14.855	0.227
F15-30	4.5	2.649	0.149	10.55	0.172
F30+	4.7	1.744	0.167	15.1	0.121
G0-15	5.05	2.072	0.184	5.45	na
G15-30	5.2	1.908	0.153	6.6	na
G 30+	5.2	1.791	0.179	6.735	na
J 0-15	5.05	2.607	0.203	5.8	0.269
J15-30	5.15	2.37	0.191	8.15	0.218
J 30+	5	1.036	0.149	8.5	0.196
L 0-15	4.9	1.409	0.2	6.43	0.205
L 15-30	4.85	1.983	0.245	9.9	0.245
L 30+	4.9	2.325	0.16	6.28	0.346
Agriculture	5.063889	2.051	0.187	9.286	0.248

Note: here, na means not assessed.

Soil profile of each individual sites of agriculture land exhibited their corresponding nutrient content as described below:

4.1.1a pH:

Column 2 of Table 5 shows the pH values as determined in the lab corresponding to each site with their depths. The pH of site B at its pre-assigned depths 0-15 cm, 15-30 cm and below 30 cm was 5.9, 5.75 and 5.6 respectively. Similarly, the pH of site D at these pre-assigned depths was 4.9, 4.9 and 5 respectively. Likewise, the pH values were 4.6, 4.5 and 4.7 respectively at prescribed depths respectively of site F. pH values 5.05, 5.2 and 5.2 were distributed at the respective pre-assigned depths of site J. As such, the pH of Site L in the respective assigned depths was 4.9, 4.85 and 4.9 respectively. Thus, the mean pH of the HUA was 5.06. No distinct pattern of increasing or decreasing pH with depth occurred, therefore, a great variability in soil pH could be noticed from the above Table 5.

4.1.1b Organic Carbon (OC):

Table 5 exhibits the organic carbon content in each site of HUA. The soil profile of site B contained 2.427 %, 1.682 % and 1.649 % organic carbon respectively at three depths 0-15cm, 15-30 cm and below 30 cm. Similarly, site B contained 2.4 %, 2.01 % and 1.721 % organic carbon respectively for each respective pre-assigned depth. Likewise, 3.049%, 2.649% and 1.744% organic carbon was determined at depths 0-15 cm, 15-30 cm and below 30 cm of site F. The OC of site G distributed in these pre assigned depths were 2.072 %, 1.908 % and 1.79 % respectively. Similarly, Site J contained 2.607 %, 2.37 % and 1.036 % organic carbon respectively at these three depths 0-15 cm, 15-30 cm and below 30 cm. The Site L at its respective pre assigned depths contained 1.409 %, 1.982 % and 2.324 % respectively. Therefore, the average soil organic carbon of agriculture land was found to be 2.051%. The highest amount of carbon content was found in the upper 0-15 cm of site F and the lowest in site L of agriculture soil.

4.1.1c Total Nitrogen:

The column 4 of table 5 exhibited the total nitrogen (N) present at various sites and depths of HUA. The total nitrogen of site B in its allotted depths 0-15 cm, 15-30 cm and below 30 cm was 0.161 %, 0.161 % and 0.147 % respectively. Similarly, 0.336 %, 0.21 % and 0.172 % nitrogen was distributed at site D. Likewise, nitrogen of site G at its assigned depths 0-15 cm, 15-30 cm and below 30 cm were 0.21 %, 0.149 % and 0.167 % respectively. Site G contained 0.184 %, 0.153% and 0.19% nitrogen respectively at its allotted depths. As such, the site J contained 0.203 %, 0.19% and 0.149 % respectively at these allotted depths. Lastly, site L contained 0.2 %, 0.25% and 0.16% organic carbon respectively at 0-15 cm, 15-30 cm and below 30 cm depths. In most cases, nitrogen was seen decreasing with increasing depths. The highest amount of nitrogen in the upper 0-15 cm was found in site D and lowest at site G respectively. Although OC was decreasing in some of the depths, it is surprising that no difference in total nitrogen was noticed.

4.1.1d Available Phosphorus (P):

Column 5 of table 5 shows the available phosphorus at pre allotted depths of each sites of HUA. 8.6 ppm, 4.6 ppm and 17.7 ppm phosphorus were distributed at depths 0-15 cm, 15-30 cm and below 30 cm respectively of site B. Similarly, 14.105 ppm, 7.7 ppm and 10.1 ppm phosphorus were distributed at these respective allotted depths of 0-15 cm, 15-30 cm and below 30 cm respectively of site D. As such, site F contained 14.855 ppm, 10.55 ppm and 15.1 ppm phosphorus respectively at allotted depths 0-15 cm, 15-30 cm and below 30 cm. Likewise, 5.45 ppm, 6.6 ppm and 6.735 ppm phosphorus were distributed in site G in these allotted depths. The site J contained 5.8 ppm, 8.15 ppm and 8.5 ppm phosphorus respectively at the respective pre-assigned depths. Similarly, site L contained 6.43 ppm, 9.9 ppm and 6.28 ppm phosphorus respectively at these pre-assigned depths. Phosphorus contained in these soils does not show any definite trend. In depth below 30 cm of sites B, F, G, and J, these lower depth soil contained higher amount of phosphorus. In the upper 0-15 cm depths, the highest phosphorus content was found at site F and lowest at site G.

4.1.1e Exchangeable Potassium (K):

Column 6 of Table 5 showed the exchangeable potassium in the pre- assigned depths of each sites of HUA. The K-content of site B at its 0-15 cm, 15-30 cm and below 30 cm depths were 0.385 Kme/100g, 0.304 K me/100g and 0.288 K me/100g respectively. Similarly, Site F at the respective prescribed depths were 0.227 K me/100g, 0.172 K me/100g and 0.12 K me/100g respectively. Site J contained 0.269 K me/100g, 0.218 K me/100g and 0.196 K me/100g respectively at these prescribed depths. Likewise, 0.205 K me/100g, 0.245 K me/100g and 0.346 K me/100g respectively were distributed at 0-15 cm, 15-30 cm and below 30 cm of site L. therefore, the mean K-content of agriculture land was found to be 0.248 K me/100g. The potassium content in most cases decreased with increasing depths except site L, where the reverse trend was observed.

4.1.2 Soil Fertility of Hasantar Community Forest (HCF):

The soil fertility of Hasantar community forest at its three pre-assigned depths 0-15 cm, 15-30 cm and below 30 cm of each sites were determined. The sites A, C, E, I and K represents the forest sites of HCF. Table 6 shows the nutrient content of forest soil.

Table 6: Soil Fertility of Hasantar Community Forest

Site	pH	OC (%)	Total N (%)	P ppm	K (me/100g)
A 0-15	4.8	2.364	0.193	8.45	0.213
A 15-30	4.85	2.274	0.165	19.05	0.208
A 30+	4.9	1.337	0.095	3.75	0.201
C 0-15	4.85	3.929	0.175	7.605	na
C15-30	5	2.679	0.212	7.07	na
C30+	4.95	2.724	0.2	6	na
E 0-15	4.8	2.737	0.13	23.25	0.191
E15-30	4.85	2.250	0.135	13.005	0.168
E 30+	4.85	1.093	0.114	12.1	0.154
I 0-15	5.1	2.334	0.228	10	0.215
I15-30	5.05	1.951	0.217	8.6	0.191
I 30+	5	1.046	0.203	4.65	0.192
K 0-15	5.1	1.596	0.125	7.98	0.186
K15-30	5.1	1.613	0.139	7.65	0.173
K 30+	5.15	1.582	0.153	6.28	0.195
Forest	4.956667	2.100	0.165	9.696	0.185

Note: na means not assessed.

4.1.2a pH:

The pH of site A at pre-assigned depths 0-15 cm, 15-30 cm and below 30 cm was 4.8, 4.85 and 4.9 respectively. Similarly, the pH of site C at these pre-assigned depths was 4.85, 5.0 and 4.95 respectively. Likewise, Site E had pH values 4.8, 4.85 and 4.85 respectively at respective pre-assigned depths. The pH values at the pre-assigned depths of site I were determined to be 5.1, 5.05 and 5.0 respectively. As such, site K had 5.1, 5.1 and 5.15 pH values at respective depths 0-15 cm, 15-30 cm and below 30 cm. The higher pH was found in the upper 0-15 cm of sites I and K of forest. Forest soil exhibited slightly increasing pH with increasing depth, indicating soil of the forest area is more acidic than cultivated soils.

4.1.2b Organic Carbon (OC):

Column 3 of Table 6 represents the soil OC of HCF. Site A at its pre-assigned depths 0-15 cm, 15-30 cm and below 30 cm contained 2.364 %, 2.274 % and 1.337 % organic carbon respectively. Similarly, site C at these pre-assigned depths contained 3.929 %, 2.679 %, and 2.724 % organic carbon respectively. Likewise, 2.737 %, 2.251 % and 1.093 % organic carbon were distributed at 0-15 cm, 15-30 cm and below 30 cm depths of site E respectively. Site I at its prescribed depths contained 2.334 %, 1.951 % and 1.046 % respectively. As such, site K contained 1.596 %, 1.613 % and 1.582 % organic carbon respectively at the prescribed depths. In this land use site C has the highest OC. The mean OC of forest soil was found to be 2.1 %. Therefore, general pattern of decreasing OC with increasing depth was observed in forest soil. And there was not much difference in organic carbon of agriculture land and forest land.

4.1.2c Total Nitrogen (N):

Column 4 of Table 6 represents the profile wise nitrogen content at the prescribed depths 0-15 cm, 15-30 cm and below 30 cm respectively. Site A contained 0.193 %, 0.165 % and 0.095 % nitrogen respectively at these prescribed depths. Similarly, Site C had 0.175 %, 0.212 % and 0.2 % nitrogen distributed at the depths 0-15 cm, 15-30 cm and below 30 cm respectively. Likewise, site E contained 0.13 %, 0.135 % and 0.114 % nitrogen at these prescribed depths respectively. The nitrogen of site I at its respective pre-assigned depths was 0.228 %, 0.217 % and 0.203 % respectively. Similarly, site K at its prescribed depths contained 0.125 %, 0.139 % and 0.153 % respectively. Therefore, the HCF contained on an average about 0.165 % nitrogen. There was no distinct pattern of nitrogen in response to depths and did not absolutely follow the general trend of OC. Nitrogen was found lower amount in forest than in agriculture land.

4.1.2d Available Phosphorus (P):

Column 5 of Table 6 gives the available phosphorus present in the HCF. The site A at its three pre-assigned depths 0-15 cm, 15-30 cm and below 30 cm contained 8.45 ppm, 19.05 ppm and 3.75 ppm respectively. Similarly, site C contained 7.605 ppm, 7.07 ppm and 6.0 ppm phosphorus at the respective pre-assigned depths. Likewise, 23.25 ppm, 13 ppm and 12.1 ppm phosphorus respectively was distributed at the respective pre-assigned depths of site E. The site I at its prescribed depths contained 10 ppm, 8.6 ppm and 4.65 ppm respectively. Similarly, site K at its pre-assigned depths 0-15 cm, 15-30 cm and below 30 cm contained 7.98 ppm, 7.65 ppm and 6.28 ppm respectively. The highest amount of phosphorus was found in the surface 0-15 cm depths of site E and lowest at site C. The mean phosphorus content of forest was 9.696 ppm. Phosphorus was in accord with the OC. It was higher in forest than in agriculture land.

4.1.2e Exchangeable Potassium (K):

Column 6 of Table 6 presents the potassium content in the various sites and depths of HCF. Site A at its depths 0-15 cm, 15-30 cm and below 30 cm contained 0.213 K me/100g, 0.208 K me/100g and 0.201 K me/100g respectively. Similarly, 0.191 K me/100g, 0.168 K me/100g and 0.154 K me/100g respectively were distributed at these respective pre assigned depths of site E. Likewise, the site I contained 0.215 me/100g, 0.191 me/100gand 0.192 me/100g potassium respectively at its respective pre-assigned depths. At last, site K at its pre-assigned depths contained 0.186 me/100g, 0.173 me/100g and 0.195 me/100g potassium respectively. Therefore, the mean potassium content of the HCF was 0.185 K me/100g. The potassium content of forest soil showed the general trend of decreasing potassium with increasing depth in three sites except site K where the reverse trend was observed. The potassium content of agriculture land was higher than forest land.

4.1.3 Soil fertility of Barren land soil

The soil sample considered of a barren belongs to Site H. The nutrient content of the barren land was assessed and come out with the result as depicted by Table 7.

Table 7: Soil fertility of Barren land

Site	pH	OC (%)	Total N (%)	P ppm	K (me/100g)
H 0-15	4.95	1.728	0.146	6.505	0.246
H 15-30	4.85	1.658	0.156	5.9	0.2
H 30+	4.8	1.334	0.134	4.85	0.221
Mean	4.87	1.573	0.145	5.752	0.222

4.1.3a pH:

The pH of site H at 3 depths 0-15 cm, 15-30 cm and below 30 cm was 4.95, 4.85 and 4.8 respectively. Here, pH as usual decreases as the depth increases. The mean pH of barren land was 4.87. It was more acidic than other land uses.

4.1.3b Organic Carbon (OC):

As presented in table 7 the organic carbon of the barren land shows site H contained 1.728 %, 1.658 % and 1.334 % organic carbon respectively at their respective depths 0-15 cm, 15-30 cm and below 30 cm. therefore, the mean OC was 1.573 %. It had less OC than other land uses.

4.1.3c Total Nitrogen (N):

The column 3 of table 7 shows the nitrogen content of the barren land. The site H at its assigned depths contained 0.146 %, 0.156 % and 0.134 % respectively. Therefore, the mean nitrogen content was 0.145 %. Comparatively, it had less nitrogen content.

4.1.3d Available Phosphorus (P):

Column 4 of table 7 exhibits the phosphorus content of barren land. The site H at its pre-assigned depths contained 6.505 ppm, 5.9 ppm and 4.85 ppm phosphorus respectively. Therefore, the mean phosphorus content of barren land was 5.752 ppm. Similar as above, the barren land soil had less phosphorus.

4.1.3e Exchangeable Potassium (K):

Column 5 of table 7 shows the potassium content of barren land soil. The site H contained 0.246 me/100g, 0.2 me/100g and 0.221 me/100g potassium respectively. Therefore, the mean K-content of barren land was 0.222 Kme/100g. This land use possesses less potassium than agriculture simultaneously, more potassium than forest.

4.2 Assessment of soil fertility status:

For the assessment of soil fertility status, a depth up to only 15 cm from the surface that is, 0-15 cm was considered. The values of soil nutrients of each site of the land uses were tallied with the standard to evaluate its status.

4.2.1 Fertility status of HUA:

The soil of HUA up to a depth of 15 cm showed the pH and nutrient status as mentioned in Table 8.

Table 8: Fertility status of agriculture land (0-15 cm)

Site	pH	Status	OC (%)	Status	N (%)	Status	ppm P	Status	K (me/100g)	Status
B	5.9	Sl.A	2.427	M	0.161	M	8.6	L	0.385	M
D	4.9	MA	2.4	M	0.336	H	14.105	M	na	---
F	4.6	MA	3.049	H	0.21	H	14.855	M	0.227	L
G	5.05	MA	2.072	M	0.184	M	5.45	L	na	---
J	5.05	MA	2.607	M	0.203	H	5.8	L	0.269	M
L	4.9	MA	1.409	L	0.2	H	6.43	L	0.205	L
Mean	5.07	MA	2.327	M	0.216	H	9.207	L	0.271	M

Note: Sl. A= slightly acidic, MA- Moderately Acidic, H= High, M= Medium, L= Low and na= not assessed.

4.2.2 Fertility status of HCF:

Similar as above, the soil nutrient values of forest soil at different sites were tallied with the standard values developed by soil science division (SSD, 2004) of NARC for soil pH, AID (1998/99) for NPK nutrients and F.S.R.O (1986) department of forest, and was rated for soil fertility status as shown in table 9.

Table 9: Soil fertility status of HCF (0-15 cm)

Site	pH	Status	OC (%)	Status	N (%)	Status	P (ppm)	Status	K (me/ 100g)	Status
A	4.8	MA	2.364	M	0.193	M/*H	8.45	L	0.213	L/*M
C	4.85	MA	3.929	H	0.175	M/*H	7.605	L	Na	---
E	4.8	MA	2.737	M	0.13	M	23.25	M/*H	0.191	L
I	5.1	MA	2.333	M	0.228	H	10	L	0.215	L/*M
K	5.1	MA	1.596	M	0.125	M	7.98	L	0.186	L
Mean	4.93	MA	2.592	M	0.17	M/*H	11.457	L	0.201	L/*M

Note: Distinction of F.S.R.O soil fertility evaluation from SSD was denoted by sign'' otherwise common for both and abbreviations (MA, H, M, and L) mean same as in table 8.*

4.2.3 Fertility status of Barren land:

The soil fertility status of barren land soil was also evaluated with the norms developed by Soil Science Division of NARC for the depth 0-15 cm of the soil.

Table 10: Fertility status of Barren land soil

Site	pH	Status	OC(%)	Status	N(%)	Status	)ppm(P	usStat	K(me/100g)	Status
H	4.95	MA	1.728	M	0.146	M	6.505	L	0.246	M

Note: abbreviations (MA, M, and L) represent the same as in table 8

4.3 Soil Fertility Evaluation

Based on the soil analysis result the soil fertility status of Hasantar area was medium. The soil reaction (pH) seems to be acidic. In the Soil with lower than 5.5 pH, phosphorus availability is restricted. Organic matter maintenance is normal. Since most of the farmers rear domestic animals for manure and apply most of the manure to upland crops, total nitrogen seems to be not related with the organic carbon. So, inorganic N seems to be dominating. Since organic and inorganic N is not analysed separately it is difficult to say what proportion of organic and inorganic form.

Available P and exchangeable K are lower so these crops seems to be not getting sufficient amount of mineral P and K. Organic C present in medium level cannot supply the required amount of P and K. Therefore, it can be said that soil fertility level of Hasantar area is medium.

In the Community forest area, soils are much lower in fertility level as was indicated by pH, available P and exchangeable K. Nitrogen level is similar to agricultural soil. For agricultural purpose it is low fertile but in forest it should be normal. The barren land has much lower fertility status as compared to agricultural and forest soils.

4.4 Mean SOC pools and total carbon stocks:

The mean carbon pool was estimated from OC, determined by Walkley-Black method. The product of OC, bulk density (BD) and depths (D) gave the mean OC-pool for each of the land uses.

4.4.1 Mean SOC pool of agriculture land (HUA):

The mean SOC pool of agriculture land was estimated by taking averages of OC pools of each soil profiles (up to 40 cm depth) of agricultural sites. Table 11 provides the mean SOC pools of agriculture land.

Table 11: Estimation of mean carbon pool of agriculture soil

Site	Mean OC (%)	Mean BD (g/cm^3)	Depths (m)	Mean C- pool (kg/m^2)
B	1.92	1.273	0.4	9.892
D	2.074	1.168	0.4	9.858
F	2.481	1.093	0.4	11.185
G	1.923	1.425	0.4	9.661
J	2.004	1.227	0.4	10.330
L	1.905	1.373	0.4	10.174
Avg.	2.051	1.260		10.183

Therefore, the mean C-pool of agriculture land was found 10.183 kg m^{-2}.

4.4.2 Mean SOC pool and Total Carbon Stock of Forest land (HCF):

Similar as above, the mean C-pool of forest was determined by taking averages of C-pools of a soil profile (taken up to 40 cm depths) of each site. Table 12 presents the estimation of mean SOC of forest land.

Table12: Estimation of SOC and Total C-stock of forestland soil

Site	Mean O.C (%)	Mean BD (g cm^{-3})	Depths (m)	Mean C-Pool (kg m^{-2})	C Total-stock (t /ha)
A	1.9915 (3)	1.178 (3)	0.4	9.376	For 64 ha forest area,
C	3.1105 (3)	1.0053 (3)	0.4	12.6239	
E	2.0267 (3)	1.085 (3)	0.4	9.2255	
I	1.7766 (3)	1.1717 (3)	0.4	8.7203	95.357 x 64
K	1.5967 (3)	1.211 (3)	0.4	7.7327	=6102.85
Avg.	2.1004	1.1302		9.5357	

The SOC pool of sites A, C, E, I and K were 9.376 kg m^{-2}, 12.624 kg m^{-2}, 9.226 kg m^{-2}, 8.720 kg m^{-2} and 7.733 kg m^{-2} respectively. Therefore, the mean SOC pool of forest soil was found to be 9.5357 kg m^{-2} which is lower than the agriculture land. Therefore, total SOC of 64 hectare forestland was estimated to be about 6102.85 t /ha.

4.4.3 Mean OC-pool of Barren land

The mean C-pool of barren land was determined as the product of its OC-content, bulk density and depth which is presented in Table 13.

Table 13: Estimation of C-pool of barren land

Site	Mean OC (%)	Mean BD (g cm^{-3})	Depths (m)	Mean C- pool (kg m-^{2})
H	1.573	1.22	0.4	7.782

Therefore, the mean C-pool of barren land was found to be 7.782 kg m^{-2} which is lower than the above agriculture and forest land uses.

4.5 Estimation of Tree Biomass and Carbon stock of the Forest (HCF):

Table 14 exhibits the Diameter at Breast Height (DBH) class and density of trees per sampling plot as well as density of trees per hectare. The DBH classes of the above ground trees disclose that maximum trees fall under DBH class (5-12) and next on class (12-30) and fewer in DBH class (3-5) cm however the contrasting result is that none in the sampling plot were above 30cm in DBH. Therefore, the no. of shrubby trees falling on DBH class (3-5) cm, (5-12) cm and (12-30) cm were 71, 196 and 164 respectively.

The density of trees per hectare estimated for each blocks: 1, 2, 3, 4 and 5 were 1020 trees ha^{-1} (averages of plot1 and plot 2), 1420 trees ha^{-1}, 1380 trees ha^{-1}, 1330 trees ha^{-1} (mean of plot no. 5 and 6), and 1120 trees ha^{-1} respectively. The highest density of trees was found in block no 2 (i.e. 1420 trees ha^{-1}) and lowest in block no. 1 (i.e. 1020 trees ha^{-1}). The highest density of trees among sample plots was found in plot no. 6, having density 1600 trees ha^{-1} and lowest for plot no. 2 of block no.1 with density 960 trees ha^{-1}.

Table 14: DBH class and density of trees referred by dominant species name as forest type

Block No.	Plot No.	Forest type	No. of spp.	No. of trees belonging to DBH-class			Total (trees / plot)	Density (trees ha^{-1})
				3- 5 cm	5 - 12 cm	12-30 cm		
1	1	*Schima wallichii-Castanopsis indica*	5	14	24	16	54	1080
	2	*Pinus roxburghii-Schima castanopsis*	2	1	6	41	48	960
2	3	*Castanopsis indica - Schima wallichii*	5	11	41	19	71	1420
3	4	*Schima-Castanopsis-Rhododendron*	5	10	36	23	69	1380
4	5	*Schima wallichii - Alnus nepalensis*	2	10	23	20	53	1060
	6	*Schima -Castanopsis*	4	14	44	22	80	1600
5	7	*Schima-Castanopsis-Rhododendron*	5	11	22	23	56	1120

Accordingly, the biomass of dominant forest types in different blocks were shown in the Table 15 depicting the above ground dry weight tree biomass which was calculated by allometric regressions between the weights of trunk, branches and leaves as provided by Yoda (1968). The biomass of these five blocks were estimated to be 145.12 t ha^{-1} (includes plot 1 and plot 2), 35.456 t ha^{-1}, 31.370 t ha^{-1}, 32.640 t ha^{-1} (includes plot no.5 & 6) and 27.07 t ha^{-1} respectively. The tree biomass in each blocks along with their assigned area were found to be 1160.96 t ha^{-1}, 425.475 t ha^{-1}, 470.56 t ha^{-1}, 456.965 t ha^{-1} and 406.049 t ha^{-1} respectively. Therefore, the total tree biomass intercepted by forest was found to be 2920 t ha^{-1}.

Table 15: Biomass and C-stock estimation for each blocks of forest

Block no.	Forest type	mean biomass/ sampling plot (kg m^{-2})	Area assign-ned (ha.)	Biomass (kg m^{-2})	Biomas (t ha^{-1})	Biomass (tons) / assigned area (ha)	Carbon stock (t ha^{-1})
1	*Schima – Castanopsis - Pinus roxburghii*	7256	8	14.512	145.12	1160.96	580.48
2	*Schima-Castanopsis-Rhododendron*	1772.814	12	3.5456	35.456	425.475	212.74
3	*Castanopsis-Schima*	1568.532	15	3.1371	31.370	470.56	235.28
4	*Schima-Castanopsis - Alnus nepalensis*	1632.018	14	3.2640	32.640	456.965	228.48
5	*Schima-Castanopsis-Rhododendron*	1353.498	15	2.707	27.07	406.049	203.02
	Grand total		64		Avg.= 54.33	2920	1460

The carbon stock of forest vegetation was also estimated. The estimation was based on the assumption that about 50% of the biomass is carbon. Therefore, the C-content of Blocks 1,2,3,4 and 5 were estimated to be 580.48 t ha-1, 212.74 t ha-1, 235.28 t ha-1, 228.48 t ha-1 and 203.02 t ha-1 respectively. The highest carbon stock corresponding to highest biomass was found in block 1 (580.48 t ha-1) and lowest carbon stock corresponding to lowest biomass was in the block no. 5 (203.02 t ha-1). Therefore, the total C-stock as indicated by the above ground tree biomass in 64 ha forest land was 1460 t C (Table 15).

5.0 House hold (HHs) survey report:

The HH survey through questionnaire method was carried out during the months of Kartik-Mangsir immediately after paddy and maize harvest from lowland and hill farm terraces respectively as the time appeared to be favorable for getting good response towards the questionnaire and questionnaire may bring ground truths about the ongoing processes. The questionnaire have been put forward in 46 households (HH) among them 32 were farm families involved in agriculture and 14 were non- farm families.

5.1 Demographic study and Education state of people:

From the HHs survey in 46 HHs, the total male population was estimated about 51.84 % and female population about 48.16 % respectively as presented in table (Table 16) below. The population in different age groups showed that the highest population was of 15-59 age group i.e.56.73 %, the lowest for elders group, above 60 years of age i.e.10.2 % and youngsters, 0-14 years about 33.06 % respectively. Similarly female fertile age group (fecundity of women), 15-49 were about 43.22 % of the total female population as depicted by (Table 16, Annex 5).

Table 16 also represents the education status among stakeholders' households. About 51.43 % of the total populations in the surveyed HHs were able to get education and rests were deprived of the light of education.

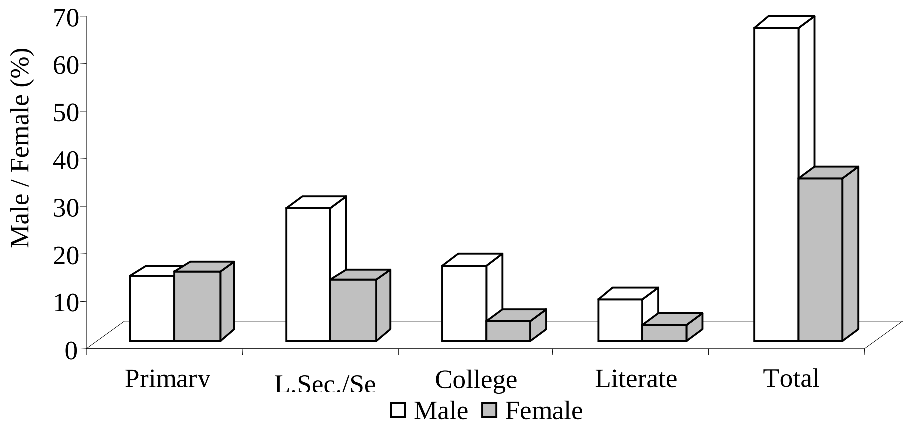

Fig. 4: Education Status between genders

Of the educated ones, 65.87% males had the opportunity of getting education while 34.13 % female were fortunate to have education (Fig.4). But, the no. of school children of age group 0-15 in latter years reveal that girls were equally encouraged and given equal opportunity for acquiring education.

5.2 Animal Husbandry in the contiguous areas of HCF

Hasantar is inhabited by agriculture communities. As livestock in the integral part of farming, they raise cattles and live stocks for agriculture sustainability and economic purposes as well. Therefore, the animal husbandry activity was also being performed in this and surrounding wards. The animals being raised in Hasantar were Cows, goats, Hen and pigs (Fig 5). Of the surveyed HHs, poultry in HH-scale was most prominent industry. Similarly, goats were also preferred from economic prospective. Others animals like cows and pigs were raised with their own purposes.

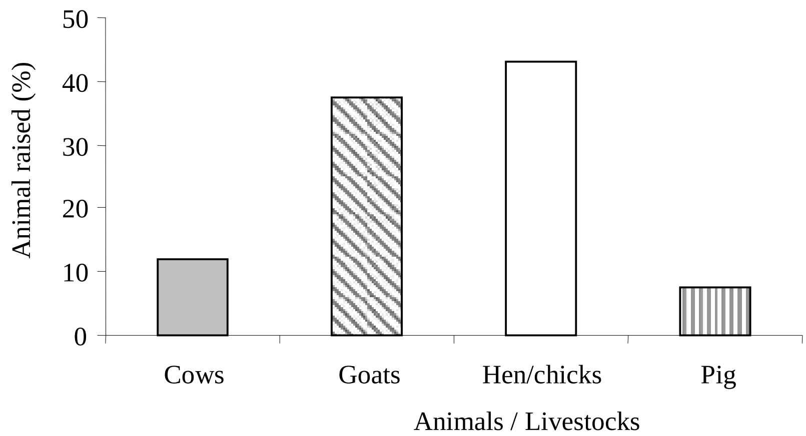

Fig 5: Animal Husbandry in contiguous areas of HCF

5.3 Condition of forest

In response to question no. 4, the respondents' response towards the condition of forest was: 82.6 % of them said that the condition has improved since it was handed over to community in 2050 B.S., 13 % claimed that it has gone no change although few among them reiterated that the imperceptible change is taking place and 4.3% are of the view that the condition had worsened since the handling process had taken place (Fig.6, Annex 5).

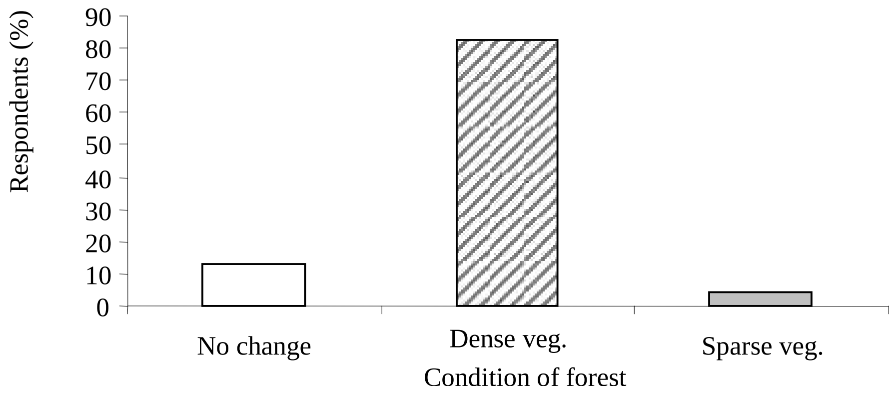

Fig 6: Condition of forest as stated by the Respondents.

5.4 Devices and Wood consumption

The households surveyed through questionnaire method come about with the fact that still the source of fuel for cooking and room heating is the fuel wood / firewood fetched in the traditional chulo (TC) and for energy efficiency, now-a-days traditional chulo have been replaced by improved cooking stoves (ICS). Of the household surveyed, 29 (63 %) used either traditional chulo or ICS i.e. TC (54.3 %) and ICS (8.7 %) respectively. And out of these 26 (56.5 %) used fuel wood to serve dual purposes cooking as well as room heating. Others used kerosene stoves (37%), Gober gas/ LPG (32.6 %) respectively. 20 households (43.5 %) used firewood for room heating especially during winter. And 5 households (10.9 %) used electrical appliances for room heating purposes (Annex 5).

Most people in the hilly terrain have an easy access to forest for fuel wood and building material. The figure 7 presents the percentages of wood consumption in HHs. About 26 HHs (56.5 %) enjoys the benefit of logging fuelwood from community forest as per provision addressed in the operational plan. Similarly, most HHs have their own lands in which trees were grown along with the farming, such agro forestry practice had supplied them with fuelwood as well. Such HHs owning private lands were 27 in numbers (58.7 %). Some households with huge family members demanding more fuelwood for household fuel consumption and others, earning living through wood selling stealth the wood even by chopping live trees. Such households demanding more fuelwood were 4 in numbers (8.7 %). And most households use firewood during winter and for some traditional functions customs and rituals use firewood that were dead, fallen and diseased ones. Therefore the households needing fire woods in lesser quantities were 28 in numbers ~60.9 % (Annex 5).

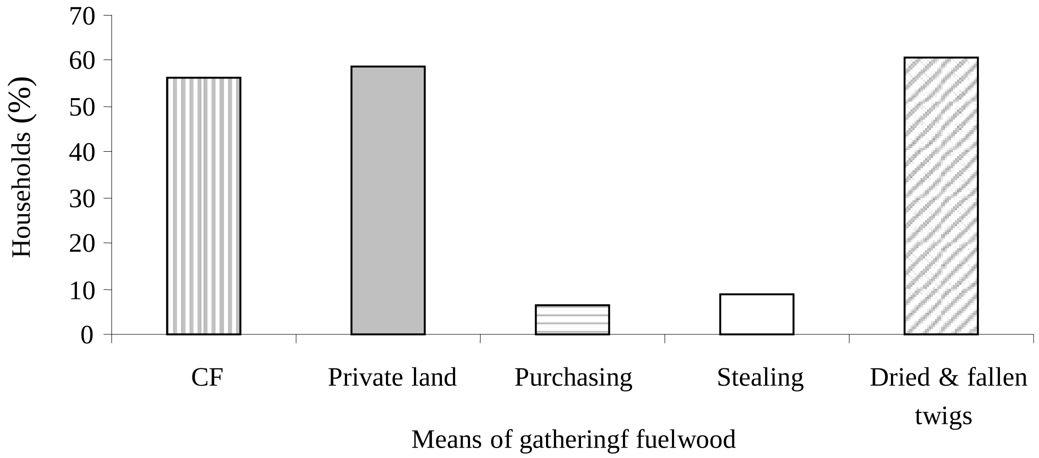

Fig 7: Collection and supply of fuel wood by HHs

5.5 Status of knowledge of HHs

The figure 5 shows the status of knowledge on rules and regulations of CF in a community. Approximately 48% the population admitted that they understand the rules and regulation of community forest and some 39.1% of the respondents told that they know very little about the rules and regulations of their CF. similarly, some 4.3 % polled out for no i.e. they did not have any idea of the present rules and regulations. Few even shown their irritation towards the CF by answering no concern (Fig. 8).

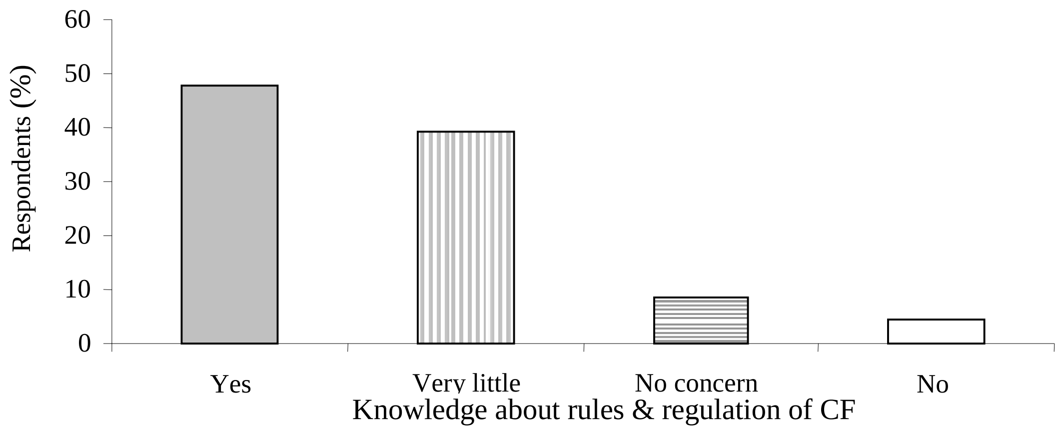

Fig 8: Respondents response towards knowledge on rules and regulation of CF

Likewise, HHs were also interrogated about their opinion on kinds of linkages existing between forest and farmland shown in Fig.9. About 59.4% of the HHs said that there is a positive linkage between forest and farmland and 3.1 % put their view on negative linkages, 9.4% opined for no linkages and 28.1% shown unfamiliarity about it.

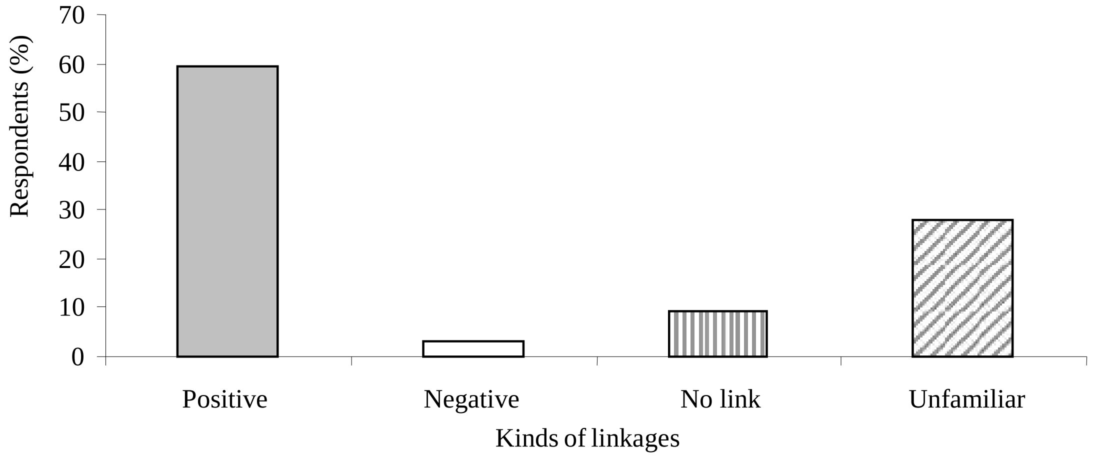

Fig 9: State of knowledge on linkages between forest and farmland

As mentioned above most of the people depend on forest resource for their livelihood. The forest resource is the source of living for living communities. Therefore, the dependence of Hasantar communities on the Hasantar C F is no new to us. About 26.1 % HHs gathers less than half a Bhari of wood for a week period (Considering 1Bhari = 30 kg wood weight). Similarly, 28.3 % of the HHs consumes ½ to 1 Bhari of fuelwood per week, and small majority of HHs i.e. 30.4 % consumes 1-2 Bhari wood per week and 8.7 % of the HHs surveyed consumes 2-3 Bhari of fuelwood per week. However, 6.5 % of the HHs surveyed did not lop off wood, neither use for cooking and room heating purpose.

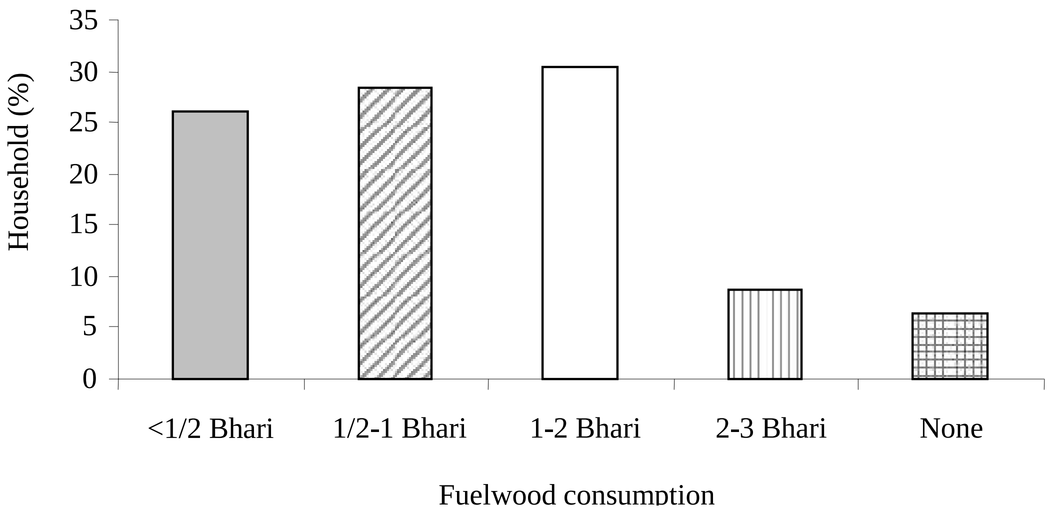

Fig. 10: Fuelwood consumption per household per week.

5.6 Services from forest as acknowledged by the Locals

The local farmers and others stated the major services that they were getting by the presence of community forest (material & non-material both). About 73.9 % of the respondents gave full mark for the fodder and fuelwood that they are frequently getting from the forest. 67.4 % admitted that the forest ensures water availability and purify it, 50 % told the essence of forest for air purification and fresh air blow up. Similarly, 26.1 % viewed its importance for erosion and landslide control and just 10.9 % talked about its role in farm fertility enrichment.

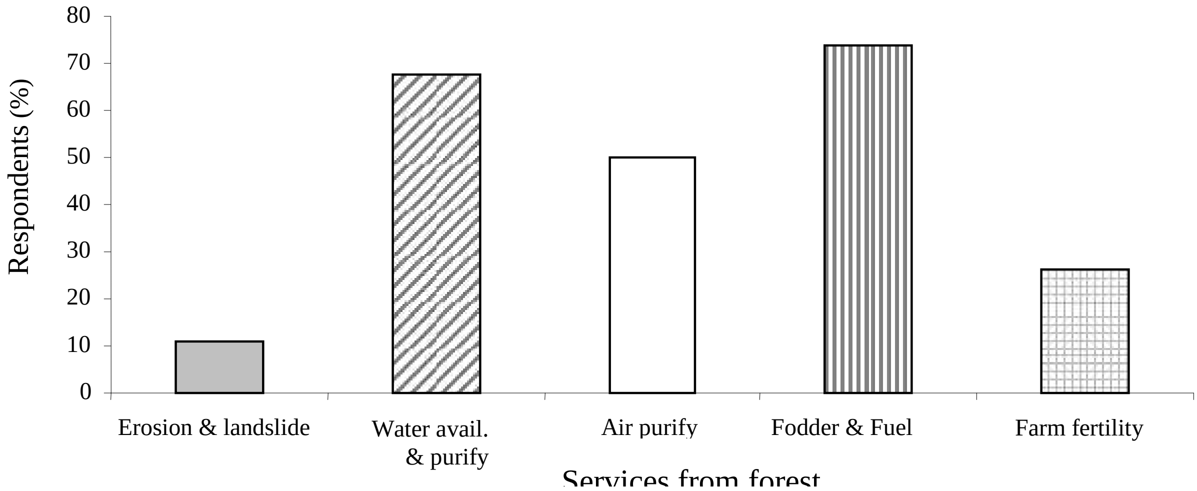

Fig 11: Response towards services obtained from forest

5.7 Family Income:

The Fig. 12 below presents the Range of family income for households. The HHs having less than Rs.2500 income were just 7 %, between Rs 2500-5000 were 41 %, between Rs. 5000- 7500 were 33 % and those falling under the range between 7500-10000 were 17 % and 2 % did not responded to the question.

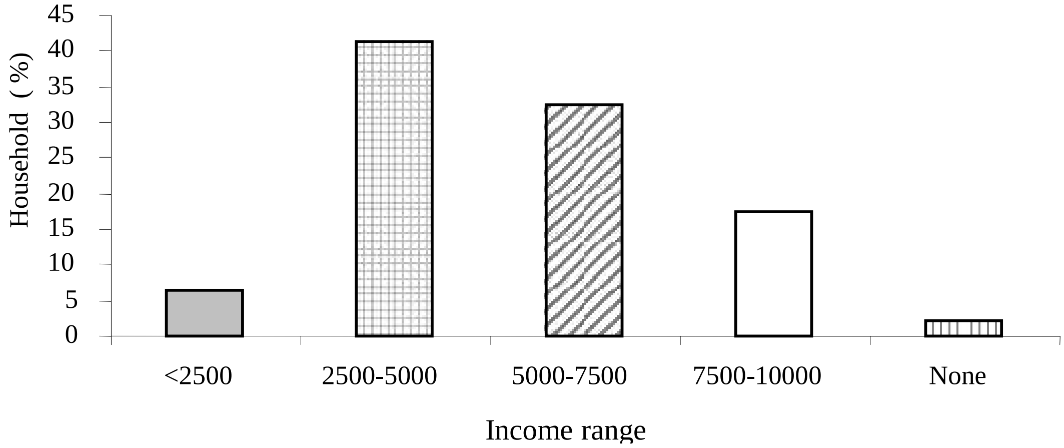

Fig 12: Family income of households

5.8 Productivity of Farmlands

The difference in productivity was enquired with the HHs by the questionnaire method. About 46.9 % of the HHs polled out for similar in production this year compared with previous year and 43.8 % stated that the production was decreased in this year but 9.4 % viewed that the production has increased in contrast to previous year (Fig. 13).

Similarly, when asked for whether the production of this year is different from two years before, 43.8 % reiterated that there was no difference in production. But 46.9 % viewed that the production has tremendously fallen in this year and still 9.4 % said that the production has increased this year compared to two years before.

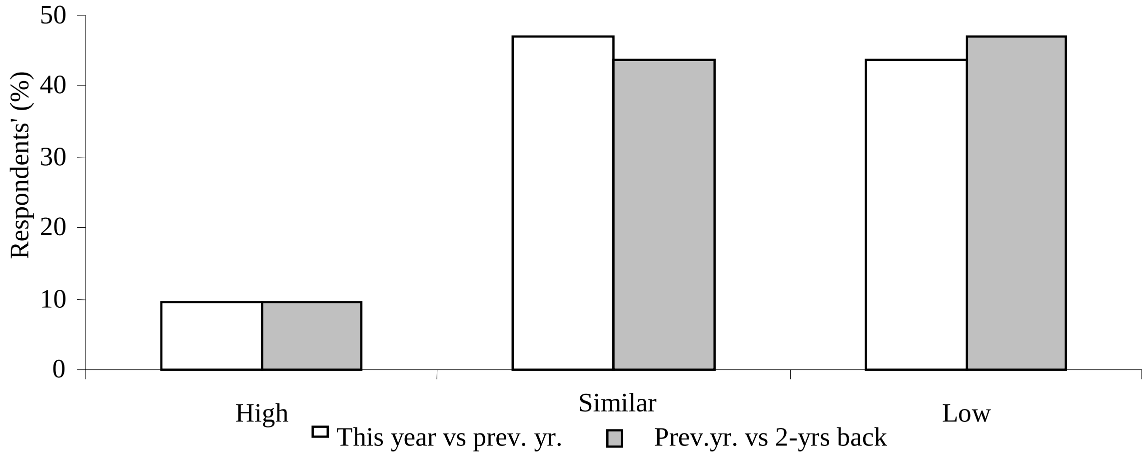

Fig 13: Response on productivity of this yr. as compared to previous yrs and 2-yrs. before

5.9 Fertilizers and Compost Use

So as to feed the increasing mouths, local residents has been using inorganic fertilizers such as Urea, DAP fertilizers and organic compost.

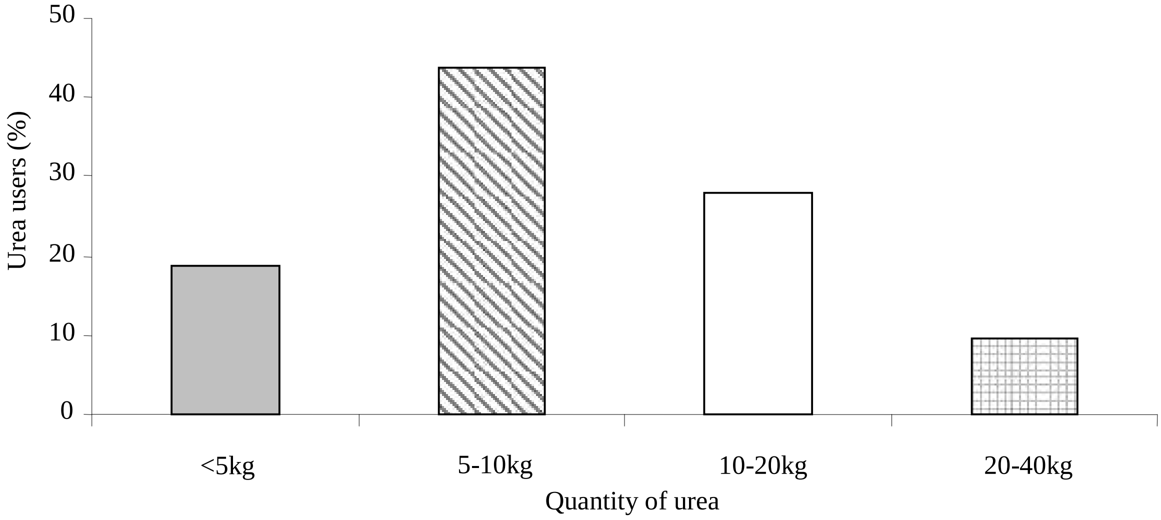

Fig 14: Farm families using urea fertilizers

The consumption of urea in the farmlands by the HHs is shown by the above Fig. 14. Only about 18.8 % were using urea fertilizer less than 5 kg rop^{-1}, 43.8 % of the farm families were using 5-10 kg of urea per ropani per year. Similarly, 28.1 % were using urea in quantities 10-20 kg rop^{-1}yr^{-1} and 9.4 % of the farm families used 20-40 kg rop^{-1} yr^{-1} (Fig 14).

The compost use has decreased in the later years due to the lack of pastures and peoples transition from farming occupation towards off-farm employments. Therefore, about 50% of the HHs used insufficient quantities of compost manure which was less than 5-dokos equivalent to <100 kgs (considering 1 doko= 20kgs). Similarly, 28.1 % used compost 100-300 kg rop^{-1}yr^{-1}, 6.3 % used compost 300-500 kg rop^{-1} yr^{-1} but 15.6 % of farm HH’s did not use compost for crop production as shown by the Fig.15.

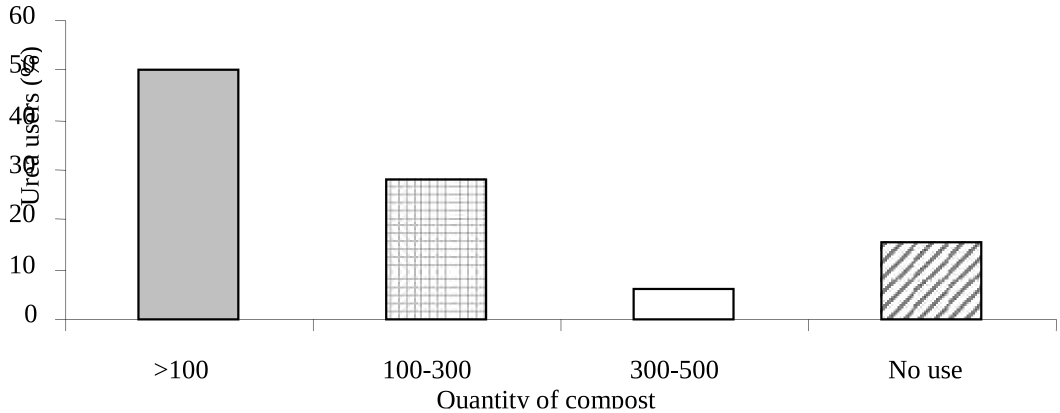

Fig. 15: Compost use by farm families in kg per rop. per year.

5.10 Crop production with Inorganic fertilizers (Urea, DAP and Murate)

The Fig.16 exhibits the crops response to the inorganic fertilizers as the time passes by. In the early stage the crop showed positive response by increasing production by 2-3 folds. About 71.9 % of the respondents told that they found increase in production for few years of its application. Similarly, 21 % did not notice any conspicuous change in production with fertilizer application while, 3.1 % found decrease in production with their frequent application even in the early stages.

Likewise, 18.8 % of the respondents still found the increase in production with their frequent application, 25 % perceived similar production and 56.3 % noticed the decreasing trend in production in latter years with these fertilizer application.

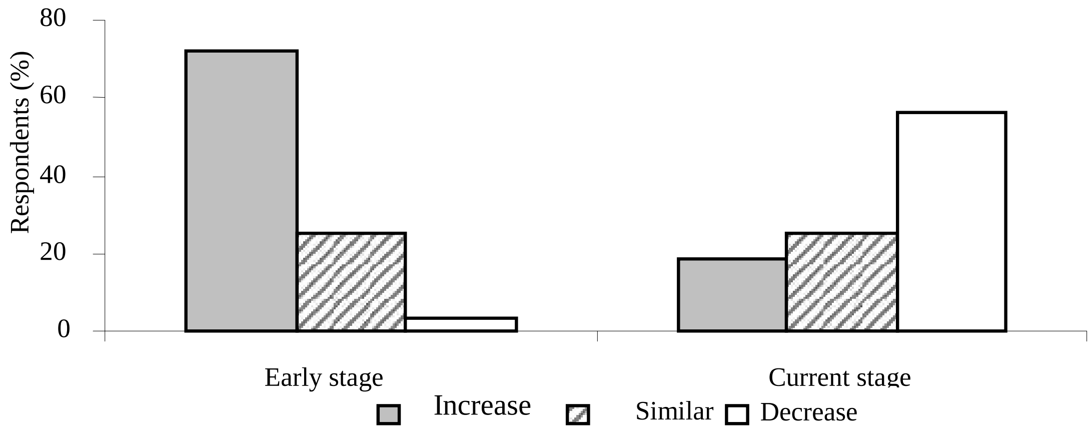

Fig. 16: Respondents' witness of crops response to the inorganic fertilizers

CHAPTER V

Discussion

6.1 Soil Fertility and Nutrient Status

The peri-urban agriculture provides a critical source of livelihood and food for many urban dwellers, particularly low income households in developing countries (ECOSOC 2000). In the peri-urban agricultural system in Kathmandu Valley, a wide spectrum of production systems can be found, ranging from household subsistence to large scale commercial production. Study shows above 50% of the households of peri-urban area are engaged in agriculture supporting 45% of family income (Devkota and Pradhan 2006). Soil fertility and nutrient management influence agricultural productivity. Maintaining soil fertility is an important step in creating sustainable agriculture (Sapkota and Andersen 2005).

Among soil quality parameters soil organic matter (SOM), pH, macro and micro nutrients, soil erosion and soil depth are taken as the core points for sustainable soil management in Nepal (Karki, 2004). Even though Factors of soil formation such as topography, parent material, climate, time, land use, and management have contributed to the poor state of soil fertility in the middle mountains, the human influence must be considered to be a primary factor (Shah and Scherier 1995).

Soil pH:

In the study area soil pH was found to be moderately acidic in almost all sites ranging from above 4.6 to 5.5 (Table 5, 6 and 7). Among land uses higher pH was observed in agriculture land and comparatively lower pH in forest and barren lands. Soil pH was tentatively similar in the assigned depths of each profile (Table 5, 6 and 7). Soil profiles of forest and its adjoining agriculture lands showed an inconspicuous sign of pH increase with depth. Increased acidity is attributed to acidic parent materials like sandstone, granite, schists and phyllites (LRMP 1986, Karki 1986). Plants can grow on soil with a wide range of pH. Generally lower pH increases availability of most micronutrients elements (Karki, 2004). Acid soils results from the presence of either or both H^+ and Al^{3+} as exchangeable cations (Miller and Donahue 1990). Decrease in soil pH was also observed with continuous use of chemical fertilizers (Maskey and Bhattarai 1994).

Soils were acidified over thousands of years by inputs of acids from atmospheric sources (carbonic sulfuric and nitric acid), plant exudates and the decay of plant and animal residues, and removal of basic cations by the natural processes of leaching and crop removal (www. Soil.ncsu.edu /…). Leaching losses is more severe in churia and mid – hills where rainfall rates are very high and soil are porus (Balla and Tiwari 2005). Therefore, barren land was more acidic than other land uses because of the lack of cover crop, vegetation (Table 7). Likewise, HCF is prone to similar losses (leaching and runoff) as it lies on the hill slope. Similarly, the forestland suffers from low nutrient recycling or nutrient return and gradual soil modification by vegetation. Pine tree plantations in HCF have also aggravated this problem. The high pH value in the agricultural soil may be due to the human effort for soil transformation may be by liming input or organic manuring or retention of previous crop residues. However, acidity may be due to high use of acid forming nitrogenous fertilizers (Karki et al. 2005).

The pH of soils from all the soil profile of each land use was low (Table 5, 6, 7) and pH increase with depth at most sites. Lower pH in surface soil than the subsurface may be due to the leaching of basic cations such as Ca^{++}, Mg^{++} which gets deposited in lower horizon (Karki and Dacayo 1990).

The lower pH of HUA is probably due to inherent geology, climate (rainfall), and most probably the use of nitrogenous fertilizers. The estimated average pH in Bhandarkhal forest was 5.38 (Ghimire et al. 2005). The chemical components of the virgin soil are determined by the parental materials and type of vegetation (Baral and Jha 1984). This may have resulted in low pH of HCF along with the combined effect of microclimatic variation and human interferences (as in case of Bhandarkhal, the forest encounters low interference being of religious value).

In the hills, most of the areas are lower in soil pH value (Karki 2004). The results obtained from HUA and HCF was also supported by Schreier et al. (1995) and, Joshy (1997). Acid forming parent materials, leaching of Ca^{++} and Mg^{++}, continuous use of acid forming chemical fertilizers, removal of Ca^{++} and Mg^{++} by crop intake, planting of pine trees and use of their litters have been reported as factors responsible for increasing soil acidity in Nepal (Tripathi 1999). These are also the manifest causes of soil pH in case of HUA as mentioned above.

Organic Carbon (OC):

The Organic matter in soil is taken as a focal point of soil productivity. It plays a major role in soil sustainability (Swift and Woomer 1993). The medium rate of OC in Hasantar area may be due to the effect of two prominent factors: natural factors (climate, soil parent material, land cover and/or vegetation and topography), and (land use, management and degradation) human induced factors (http:// www. Eusoils.Jrc.it/…). Low temperature and high rainfall are conducive to accumulation of organic matter in soil. Natural vegetation contributes to the organic matter of soil. That's why the forest soils and those under grass have higher organic matter content than the cultivated ones; where the farmers generally feed the domestic animals leaving low OC in field (Karki et al. 2005, Joshi 1997). In agricultural systems, there is no efficient nutrient recycling and nutrient inputs are necessary (Paudyal 2000). In comparison with agricultural soils, the forest floor is more or less undisturbed. This may be the reason behind slightly higher OC in forest compared to agriculture land. Apart from it, the high OC may be due to litter fall on the soil surface, above-ground organic inputs along with below ground organic inputs by roots and root exudates in forest ecosystems (Zech et al. 1997).

No adequate amount of organic matter was lounging on the forest floor as a result of which OM built up was inadequate for nutrient cycling. About 50 % of the litter production is removed annually from some forests in the Nepalese middle hills. This seriously interrupts nutrient cycling within the forest (Khadka et al. 1984). As stated, HCF in spite of having higher OM production, compared to other land uses, is medium in OC status (Table 9). Barren land has lowest SOM than other land uses probably due to increased erosion caused by runoff because of lack of land cover (Table 10). Land under cropping almost always has lower SOC concentration than under forest or grass. This is due to the release, redistribution and subsequent decomposition of organic matter protected in aggregates with frequent tillage (Franzluebbers 2005). But in case of HUA the medium status of OC may be due to FYM, compost and fertilizer application to some extent (Table 7).

The roots of trees as well as grasses are concentrated in the top soil and decrease in quantity with depth in the profile. Thus, top 4” or 5” of forest soil are high in OM and the subsurface and sub-soils are low in OM due to leaf litter fall and decomposing roots (Thompson 1957). The surface soil which receives leaf fall, etc. is generally high in organic matter content compared to the layers lying below (Biswas and Mukherjee 1994). These may have resulted in higher OC in HCF soil at the surface 0-15 cm depth. Similarly, most soils under study area showed medium level of OC content of the surface layer ranging between 1.409 % to 3.049 % and OC decreased with the depth. This result of the study is supported by Karki (2005). SOC concentration declines with depth in a logarithmic manner (Franzluebbers 2005) also support the result.

The less value of OC content at site K may be the site specific. Since the Site K is the south east aspect and low-lying hill forest, therefore, is dry. At lower elevation, the pine litter becomes readily available to farmers in dry seasons, which is used for preparing animal bedding for composting (Schreier et al. 1995). Frequent forest fire, absence of ground vegetation in pine forest and leaching may be another reason that restrains OM built ups. Similarly, the low OM content at site H (barren land) may be due to absence of OM or cover crop, subsequent leaching and the inclination of slope. Forest at high altitudes is less disturbed and therefore, it performs its ecological functions efficiently hence have comparative advantage over OM than others. The low OC at the site L of agriculture land may be due to low retention of organic residues, low inputs, erosion and rapid decomposition facilitated by tillage practice.

The OC status of forest and shrubland soils was generally high while those of upland and lowland farm were somewhat low (Bajracharya 2002). The result of the study is quite similar but slightly differs in the status of agriculture land as for the reasons mentioned above.

Total Nitrogen:

In the present study, at most sites nitrogen was seen decreasing with increasing depths. This pattern was more obvious in agriculture soil than in forest soil (Table 5, 6 and 7). Although OC was decreasing in some of the depths, no difference in nitrogen was noticed. Soil nitrogen was found higher in agriculture land followed by forest land and barren land respectively. The nitrogen was at medium to high status in HCF and its contiguous areas (Table 8, 9 and 10).

SOM typically contains about 5% Nitrogen (Brady and Weil 2002). OM is thus taken as an index of N-supplying power of soils. Nitrogen is dependent on soil environmental conditions such as soil temperature, moisture, pH, tillage system, cropping system and the presence of other nutrients and organic matter (www. Soil.ncsu.edu). Large losses of nitrogen can be expected if the soil has a high natural fertility, was recently burned or is barren of crops (Miller and Donahue 1990). This could have resulted in relatively small N-content in forest due to frequent ground fire and barren land lacking any cover over it (Table 5, 6 and 7). Abundant supply of nitrogen should be maintained throughout the growing period on account of plants continue to absorb nitrogen until virtually mature (Millar 1955). Thus immature forest soil may have exhausted of nitrogen due to incessant take-up rather than addition, as was evident from lower nitrogen content in the forest soil than agriculture land (Table 9).

Scientific improvements in agriculture plus a declining content of organic matter have played a greater demand on soils for nitrogen than they deliver through decomposition (Thompson 1957). Farmers do not apply balanced dose of fertilizers, they rather use mostly acid forming nitrogenous fertilizers (Karki et al. 2005). Thus excessive nitrogen fertilization, manuring (compost and suli-mal) and maintenance of organic residues at some plots along with incorporation of nitrogen fixing legumes like soybean, pegion peas and others with staple food crops may have raised nitrogen level in cultivated land.

Mineralization of organic nitrogen in the soil generally brings about a rise in the amount of inorganic nitrogen in the soil owing to high temperature and rainfall (Singh et al. 1979). The nitrogen in the HCF soil was lower in comparisons with the Bhandharkhal forest and Phulchowki hill mixed broadleaved forest. The Bhandarkhal forest was estimated to have on average 0.29 % nitrogen (Ghimire et al. 2005) and an average of 0.306 % in northern face of Phulchowki hill forest (Baral and Jha 1884). This difference may have been due to HCF's major contribution in sustenance livelihood rather than mere protection. While accumulation of high organic matter content, proper cycling and low human interferences at Bhandarkhal forest (being religious forest) and Phulchowki forest (being high altitude protected forest) as well as different geo-environmental conditions, climatic and edhaphic conditions and different floral species composition may be responsible for such differences.

Many studies have been made of the quantities of nitrogen brought to the soil by precipitation. The quantities brought to the earth in precipitation are greater near centers of population and industrial areas (Millar 1955). Probably, this may have resulted in appreciable quantity of nitrogen in barren land contributed to some extent by sparse grasses on it at sometimes of a year.

The relationship of organic matter with nitrogen is positively correlated in this area ($r = 0.289$) (annex 5) because organic matter is one of the major components in fixation of nitrogen in the soils i.e. when organic matter increases in soil, the level of nitrogen also increases. The distribution of soil nitrogen closely parallels to SOM (Allison 1973). Therefore, nitrogen should be higher at the top and lower beneath the deeper layers. This pattern is evident in agriculture land but less evident in forest land. This may be due to different rooting systems and root growths of species of forest trees. Fogel (1983) assumed that roots return 4-5 times more material back to soil than litter. Similarly during forest fires or burning, large amounts of C, as well as N and S, present in the plant residues are lost (Raison 1979). Fires such as ground fires may be possible reason for surface soil retarded of N-nutrient than bottom layers at some of the sites.

All soils of Nepal are low in Nitrogen (Karki 2004). On contrary to this, the study showed that the soil of HUA and HCF had medium to high in nitrogen, as nitrogen balance is positive in the middle mountain region owing to its nutrient management system (Pilbeam et al. 2000). The medium to high N in soils of HCF and HUA is supported by SSD (2005).

Available Phosphorus:

In the study area, the P-content in soil profiles did not show any definite trend with increasing depth in agriculture sites (Table 5). Instead the forest soil profile showed decrease in phosphorus with depth and was almost in accord with organic carbon (Table 6). The Phosphorus was relatively higher in forest (both in 0-15 cm depth and total) followed by agriculture land and barren land respectively. The fertility ratings showed low in almost sites of forest except C and low to medium p-fertility in agricultural sites.

Phosphorous is the second most often limiting nutrient (Miller and Donahue 1990). The quantity of total phosphorus in soils has little or no relationship with the availability of phosphorous in plants. Soil phosphorus (P) originates primarily from the weathering of soil mineral phosphorus such as apatite and from P additions in the form of fertilizers, plant residues, agricultural wastes, or bio-solids (Schreier et al. 1999). It was thought formerly that carbonate apatite [Ca3(PO4)2]3. CaCO3 was not uncommon especially in calcareous soils (Millar 1955). In acid soils, iron and aluminum in solution and in oxide and hydroxide forms react strongly with added P, binding it so that it is unavailable to plants. Higher organic matter levels can help reduce P "fixation" reactions, by binding Al, Fe, and forming soluble complexes with P (www. Soil.ncsu.edu /…). Therefore, acid soils are generally low in available phosphorus. Mineralization of organic phosphorus in soils is subject to many of the same influences that control the general decomposition of SOM namely, temperature, moisture, tillage and so forth (Mengel and Kirkby 1979).

As the plants shed leaves and their roots die, or they are eaten by people or animals, phosphorus returns to the soil in the form of plant residues, leaf litter, and wastes from animals and people (Brady and Weil 2002). P showed positive (r = 0.186) but not statistically significant correlation with OM (Annex 5). The highest phosphorus content at some sites in forest soil perhaps is the result of cool moist condition in the forest floor that helps to accumulate more OM, slow decomposition rates and continuous slow release (Karki et al. 2005). Likewise, in forest there is efficient nutrient cycling (Paudyal 2000). These provide better explanation of relatively higher phosphorus content in forest.

Similarly, the phosphorus content of agriculture land was fairly higher than barrenland but lower than forestland. Phosphorus content of green manures, farm yard manure (FYM), poultry manure and compost supply phosphorus to the crops (Norman 1975). The study showed that forest soil fluctuates highly in P-content and with exception of site C, all sites showed low p-fertility. But with less variation in P-values, the agricultural land use hold low to medium P-fertility. This is in accord with the statement: Soils in the farmland have low to medium p-content (MoPE 2004). The reason may be due to the use of phosphate fertilizers like Diammonium Phosphate (DAP), poultry manure and green manure. Barren land possessed least Phosphorus may be the result of contribution from sparse grasses rarely on its bare surface, inputs from rainwater and its inherent geology. The relatively lower value of phosphorus may be the result of low organic matter in its hill slope.

The base levels of phosphorus in the soils of Nepal are invariably low (Carson 1992). Like OM, Soil organic phosphorus decreases with depth and the distribution with depth also varies among soils (Tisdale et al. 2002). Forest soil followed the similar general trend of decreasing phosphorus with increasing depth as high phosphorus content in soils was found associated with high OM (Thompson 1957). The low P in most sites of forest and few of agriculture land may due to its moderate acidic condition (Joshy 1997).

The reason of low P in the forest may be due to the restriction of animal grazing and human activities after CF-program as a result the faecal discharges and urine containing appreciable amount of P is unavailable to it. Similarly, low phosphorus in HUA is perhaps due to insufficient P fertilization, inadequate collection of forest litter restrained by Rules of CF and losses of P-fertilizers in runoff water. Also, the gradual removal of subsidies for fertilizers, farmers have tried to limit their investment in fertilizers by using urea instead of the more expensive DAP (Weber et al. 2005). Similarly, medium P-fertility at some site may be the result of overall management.

Exchangeable Potassium:

The soil potassium decreased with increasing depth in all land uses (Table 5, 6 and 7). And K-content of agriculture land was relatively higher followed by barren land and

forest respectively. The AIC (1998/99) evaluates low to medium K-fertility in agricultural soil (Table 8), low in forest soil (Table 9) and medium in barren land (Table 10). But, F.S.R.O (1986) soil test guide rated forest soil as low to medium in K-fertility.
The sources of potassium are the primary minerals, such as micas and feldspar. Its behaviour in soil is influenced primarily by soil cation exchange properties and mineral weathering rather than by microbiological processes. Potassium availability is not strongly affected by soil pH. However, K uptake by plants can be limited if soil moisture is insufficient (http:// www.uaf.edu /...). Potassium seems to counteract some of the detrimental effects of excess nitrogen. Some soils containing large amount of non-exchangeable or fixed K releases it continually to the exchangeable forms in amounts enough to replenish loss by plants uptake. If exchangeable form is appreciable, fixation takes place, otherwise there is release on drying (Khatri Chhetri 1990).

It is generally believed that FYM application on bariland is higher depending on the nature of crops grown and proximity of homesteads where livestock are kept (Vaidya et al.1995). Except for nitrogen, potassium is required by plants in much greater amounts than all the other soil-supplied nutrients (http:// www.agr-11). Farmers collect leaves to make compost. A doko of compost can contain up to 1-2 dokos of leaves (Heuch 1986) Therefore, low K-content of forest soil was perhaps by one way flow of nutrients (Lekhak and Lekhak 2003) in the form of compost to farms and potassium mining by plant uptake, even from deep subsoil horizons. The former has decreased K-content of forest land and in stead increased K-content of the HUA. The negative topography of lower slopes receives runoff water and fertilizing products of erosion- mineral colloids, humus and soluble salts (Wilde 1958). This may have resulted in high K-content of low-lying agriculture land.

Agriculture soil though high among land uses, had K-content just close to the desirable level, >0.25 meK/100g, an evaluation with Schreier et al. (1999). This low to medium status of K (Table 7) in depths 0-15 cm of agriculture soil may be the result of maintenance of some of the loss from mining and leaching by compost addition, poultry manuring, FYM additions and slow K release from mineral source. The reason behind higher K-content in barren land may be due presence of unutilized potassium and decomposition of underlying mineral source.

However, the forest soil had low K-content perhaps by being associated with significant period of leaching and subjected to continual nutrient uptake. Although the exchangeable potassium level was quiet low, tree growth was not adversely affected. The upper horizon may be depleted somewhat of non exchangeable K, but the deep tree roots were able to use the potassium released from the non exchangeable form in the lower horizons (Richter et al. (1994).

The K-content was at high to medium levels in Nepal (DOA 2000). Nepalese soils are generally endowed with high base levels of potassium and major deficiencies aren't readily observed (Carson 1992). On contrast to this, the forest soil was low or low to medium in K-fertility and agriculture land was low to medium in K-fertility. This is explained by its geology. Since Tistung formation consists of calcarious phyllites (consists Ca++), and argillaceous limestones (CaCO3), Cations like Ca++and H+ reduces K-fixation (Biswas and Mukherjee 1994) and permits luxury consumption resulting K-deficiency. This may have resulted in low potassium level in Hasantar and the agriculture soil holds low to medium levels perhaps because K-fertilizer is seldom applied in Kathmandu due to unavailability in the local market and lack of knowledge of its importance (Joshi 1997). But, intense cropping without allowing fallow period for K-release from the parent material deplete its reservoir (Karki et al. 2005) which was reflected by low to medium adjustment of K-fertility in HCF and its adjoining areas.
In case of individual sites of agriculture land, the nutrient level was variable and changes continuously. Site specific values are referred due to the influence of fertilizer addition, nutrient losses by leaching, crop removal and over all management (Bajracharya 1988). The regional variation of soil nutrients in a forest soil is influenced by soil texture, parent materials and altitudinal gradients (Baral and Jha 1984).

6.2 Carbon content in Forest Soil and Tree Biomass:

6.2.1 Soil Organic Carbon (SOC):

The most important factor or constituent of soil, which significantly impacts upon biological, nutrient and structural status, is soil organic matter or more specifically, the organic carbon (SOC) component (Bajracharya et al. 1998). Accurately quantifying SOC stored in soil is fundamental to global climate change modeling, because the soil C reservoir is estimated to be about 2.5-3 times greater than the total available in the standing biomass of the terrestrial ecosystem (Post et al. 1990, Houghton and Skole 1990). Nitrogen fertilization is a management practice that may increase SOC content by increasing inputs of plant residues to the soil (Glendining and Powlson 1991).

The mean SOC pool of HCF and its adjoining areas were estimated (Table 11, 12 and Table 13). This estimation of HCF, HUA and Barren land SOC pool did match with Shrestha et al. (2003) which rendered greater mean SOC for upland cultivated land (16.1 kg/m2) and lower SOC for forest (4.1 kg/m2) of Mardi watershed than the study area (upland agriculture land.: 10.183 kg/m2; Forest: 9.536 kg/m2). Similarly, the barrenland of study area had still low SOC as compared to the shrubland / grassland of Mardi watershed, Kaski in spite of having sparse grasses over it. The SOC storage is related to elevation, landscape position, aspects, land use, farming system and management practices (Bajracharya et al, 2004). The difference in SOC of upland cultivated land may be governed by difference in intensity of cultivation, cultivation history, soil depth, fertilizer use, climate, geology and others. Similarly, the slightly higher SOC of HCF may be the result of better condition of forest, inherent geology, vegetation types (species), aspect of forest land, climate etc.

Similarly, SOC in the 0-50 cm of soil layer at Pakhribas was estimated to be 49.83 t / ha (DFID/DSS 1997-1999). This estimation is however lower than HUA, 0-40 cm depth for the reasons mentioned above. The median soil C content is 13.2 kg / m2 for productive forest land and is assumed to be 12.5 kg / m2 for non-productive forest land (UNFCCC 2000). Thus, SOC of HCF was definitely low on account of its growing stage. In a mature ecosystem or a stable agro ecosystem, the release of carbon as CO2 by oxidation of soil organic matter (by microbial respiration) is balanced by the input of carbon into the soil as plant residues (and animal residues). However certain perturbations of the system, such as deforestation, some types of fires, tillage, and artificial drainage, result in a net loss of carbon from the soil system (Brady and Weil 2002). Cropping system and farm management has significant effect on total C especially in the surface 0-15 cm of hill soil (SSD 1999). Therefore, vegetation cropland, substantial mineral nutrient and organic matter supplementation may have contributed to the good content of SOC in HUA.

South and Southwest facing slopes tend to notably warmer and drier and therefore depleted in OC, while north and north east aspects are cooler, more moist, with slower growth and decomposition rates, hence greater accumulation of OC (Bajracharya et al. 2004). SOC contents of soils tends to be low, due to warmer conditions and rapid decomposition rates at lower elevations (<1000 m) and significantly higher at elevations of 1600-2200 m (Bajracharya et al. 2004). These explain the reason for appreciably high SOC pool at C and E. Similarly, site A though at comparatively low elevation had higher SOC, because of being cool remaining at northern face and moist with kholsa (drainage) close by it. Site I is west to south west aspect of the forest and site K is south east face therefore, low SOC pool for site I and K. Relatively high SOC at I can be explained on the basis of forest type, as site I is a mixed broad leaved forest, higher in nutrient (Baral and Jha, 1984) and rich in OM such as leaves of Schima wallichii, ground vegetation such as Eupatorium adenophorum, Artemisia vulgaris, Sapium insignia and others (Bhandari et al. 1982). Where as, Site K is the pine plantation forest therefore imperils the growth of other ground vegetation.

The carbon pool of forest soil was lower than agriculture land despite its high OC-content due to low bulk density of forest soil (Bajracharya et al. 2004). The forest soils have good potential for carbon sequestration because more SOC is concentrated in microaggregates (< 1mm), which are more stable and less subjected to OC decomposition (Shrestha et al., 2003). Data indicates that soil sequester carbon at > 0.2 t C/ ha/ yr for >100 years and on average about 0.6 t C/ ha/ yr for the first 50 years. Therefore, Forest soils of HCF can act as a promising sink for carbon emission under

good management. Thus, the total SOC stock of forest in the total area 64 ha of HCF was estimated to be 6102.84 t ha-1.
The national average of china, 10.53 kg C m-2 (Zhou et al. 2003) was higher than the Hasantar average excluding barren land (Table 11 and Table 12).

6.2.2 Biomass and Carbon Stock:

Biomass is often defined as the total amount of above ground living organic matter in trees expressed as oven-dry tons per unit area (Brown 1997). However, the above definition considers only above ground living organic matter (trunk, branch and foliage). The biomass of forest provides estimate of carbon-pools in forest vegetation because about 50% of it is carbon (Brown 1997, Lasco 1998).

Biomass stock per hectare in Nepal's forestland varies from 115 to 178 tons (WECS 2001) and the total biomass is about 428.5 million tones (MoPE 2004). In Nepal, commercial harvest is not in practice. Forestland, in general, is changed in two-step process, the first from forestland to shrub land and the second from shrub to cultivation. The biomass in shrub land after conversion is assumed to be 16.1 tons per ha (WECS 2001) whereas average biomass in the cultivation land is assumed to be 10 tons per ha (IPCC 1996).

The greatest biomass of block 1 (Table 15) may be due to greater DBH of tall pine stands in south- eastern face, the position of which rendered optimum condition for pine growth. The formulae also imparts pine branch a fairly high biomass than for other species which may have contributed to highest biomass content of pine planted forest site. Similarly, high biomass of block 3 perhaps is due to large number of greater DBH trees (Table 14) and cool and humid north facing slopes.

Block 4 had large number of shrubby (5-12 DBH) trees and is a north facing slope. Block 2 also had large numbers shrubby trees having DBH 5-12 and is a south facing slope which therefore leaves lower biomass than above blocks. Block 5 though is a north east facing slope had fewer number of trees due to its steepness along with scars of landslide effect.

The average estimated biomass of HCF was 54.33 t ha-1 which do not match perfectly with Joshi (1998). He estimated biomass in forest block between Godawari and Phulchowki, 82.99 t ha-1 in 1993 and 100.4 t ha-1 in 1996. The low biomass in HCF may be due to low altitude hill forest with easy access to people, low people participation in conservation and being immature forest (as evidenced from table 15), needing tender care through efficient forest management. On the other hand, the Phulchoki forest was mature forest with stringent protection and was inaccessible due to its high elevation.

Thus the carbon stock of the forest was estimated by summing up the carbon content of each blocks of the HCF which was found to be 1460 t C with an average of 54.33 t ha-1 dry biomass. Since the estimation of total C in present land use should include the carbon stock as biomass and the SOC present in the SOM (http://www.fao.org/…), the total C-stock of HCF found to be 7562.85 t ha-1 (SOC- 6102.85 t C and Biomass- 1460 t C). From the observation it reflects that forest soil stocked more carbon than the vegetation. The result so obtained is in accord with and Brady and Weil (2002) that the soil C reservoir is over four times as large as biomass C reservoir.

Carbon pool size estimated from the above ground plant (tree) biomass in hills (churiya), Mid Hills and high mountain were 51t ha-1, 45 t ha-1 and 28 t ha-1 respectively (Karky 2005). The HCF has lower carbon storage in the vegetation as compared with mid hills region. Though falling in the same topography i.e. mid hills, the carbon storage in HCF was lower, may be due to less efficient management, incompatible species selection, human intervention and illicit logging to some extent. However, in recent years the protection of natural regeneration has been adopted in forest management activity therefore, rejuvenation will deliver best consequences in later years as the CHEA Report for 2005 suggests that annual increment of 3 t ha-1yr-1 could be achieved from community managed forest.

7.0 Interpretation of Household survey Report

In household survey, interrogation was made with the 46 household. The data analyzed using software SPSS 10.0 can be interpreted as follows.

The average household size was estimated to be 5.33 which were above the 2001 census of Katmandu district, 5 for Ktm (ISRSC 2004) and Seuchatar VDC- 4.91(ISRSC 2004). Similarly, male population were dominant in number than female. The age group classification showed that the most dominant age group was 15-59, which comprise above half a population (table 14) in surveyed HHs. This is categorized as an independent group of population however the unemployment and associated problems had proved them not as a nation's assets but as a problematic group. The dependent groups (0-14) comprised 33 % of the surveyed HHs. Therefore, they should be provided with necessary support to make them proficient and skilled ones on the shoulders of whom the fate of the kingdom rely. And a small bunch of people were elders, who were also a dependent group, poor, sick and needy ones requiring special care with respect. Therefore, the dependency ratio was determined to be 76.25 of HCF adjoining areas which was higher than the national dependency ratio of 0.5019. About 43 % of the female population belongs to the fertile age group (15-49) who bear the capability to give birth (Table 14).

Almost 52% of the population of this and adjoining wards were better off by getting education (Table 15) which is lower than its own VDCs average which was about 74 % (ISRSC 2001). In the Kathmandu district, the literacy rate is 77 % (or, 74 % in Seuchatar VDC), of which male literacy rate is 77.0 % and female is 66.4 % (DSCO 2062/63). In terms of percentage almost half of the total male literate, was the female literacy rate (Table 14). But the numbers of females were appreciable in primary section (Fig 4), this suggests the equal opportunities being provided by the parents in later years which could be the result of arousing awareness in people. Also the infrastructural development, change in perception, numbers of schools establishments near by villages may be other factors guiding the people in education.

The basic units of hill farming system are: the farm household, the land, the livestock and the non-privately owned forests, pastures or other common lands (Rieger 1999). The intensification of agriculture through deforestation or rearing small herds of livestocks cannot sustain the agriculture nor do they able to harness economic benefits. Realization of this fact on one hand and arrogance on the other hand had led to intensification of land and infrastructural development within the forest territory diminishing the forest area. Similarly, the off- farm business (non agricultural occupation) had allured the educated young generation (Aryal 2005-06), leading to reduced numbers of farmers, animal husbandry and farm- business.

Community Forestry enhancing greenery and improving the condition of forest has directly contributed to the seventh millennium goal of ensuring environmental sustainability (Kanel 2004). About 83 % of respondents put their view that the forest has improved from its historical condition (before 2050 B.S) since it was protected and conserved by the community (Fig.6, Annex 5). The probable reason could be restriction in illegal felling of trees, routined forest management activities, forbiddance of grazing animals and illegal lopping of wood biomass and equal sharing of benefits.

Most of the people were of middle income neither economically sound nor poor. Their current status was maintained mostly by agriculture however vegetable and fruit farming (horticulture) could be the viable options since few people got better earning by exploring potentiality of the region. The communities living in rural areas are economically so weak that the energy from refined fuels such as LPG and kerosene is not an option (Thukari and Zahnd 2006).

About 80 % of total energy consumption in Nepal is obtained from fuel wood, of which about 63 % comes from forestland (WECS 2001). The Per capita fuelwood consumption in the hills is estimated to be 640 kg / yr. (ADB/ ICIMOD 2006).They prefer to use the traditional devices (traditional cooking stoves now being substituted by improved cooking stoves/ kerosene stoves and gas, in economically strong families) since it utilizes easily available fuel wood in their private land and from CF (Fig. 7) thus save money from commercial fuel consumption. These agricultural communities have their private land, or agro forest land from which they have their partial fuelwood supply however depend on CF for most of the time. More wood was consumed in room heating in the winter periods than cooking purposes. The fuelwood demand for space heating is 40% and cooking is 36% in hills (Thukari and Zahnd 2006).

The biomass fuels have met the largest portion of the energy needs of Nepalese people that is yet increasing (MoPE 2003). The consumption of quantities of CF products (leaf litter and Fuelwood) depends on a range of factors including the size of the households and landholding, the number of domestic animals kept, the availability of labour, the availability of substitutes (such as agricultural residues and kerosene) and the season (RECOFTC 1992). Thus, fuelwood consumption was higher in big family size especially joint families and low in nuclear family. However, the small majority of the population used fuel wood about 1-2 Bharis (equivalent to 30-60 kg) per week. Similarly, another small fractions 26.1 % and 28.3 % Consumes less than half a bhari of fuel wood and ½ to 1 bharis a week (Fig. 10; Annex 5). The fraction comprising 26.1% need firewood especially in winter season so as to keep away from cold and occasionally in festival and ceremonies. Similarly, large fuel wood user groups are those who need it for daily cooking and heating. A daily use of firewood in cooking, space heating and lighting consumes 20 kg-40 kg firewood (Thukari and Zahnd, 2006).

The most preferred species for fuelwood as mentioned by the respondents were: chilaune (Schima wallichii), Katus(Castanopsis indica / C. tribuloides), Bakaino (Melia azedarach), Phalant (Quercus glauca), Banjh (Q. lanata), Gurans (Rhododendron arboretum), Lapsi (Choerospondias axillaries), Kande Bayer (Zizyphus incurva) etc.

When enquired of their knowledge about CF rules and regulation (Fig. 8; Annex 5), nearly 48 % of the respondents told that they know it. 39 % reiterated that they have little knowledge and rests shown either no concern over the matter and few had negative response. This reflects that the user groups or stakeholders' participation on the forest management activities were minimum and their inclusion in the group was only purposive. i.e. for benefit sharing only.

The linkages between farming, forestry, animal husbandry and human society and the importance of forests are sufficiently understood by the rural communities of the hills of Nepal (Chhetri 1994, Mahat 1987). Therefore when interrogated about the kinds of linkages of forest and farm (Annex 4 and 5), about 59% did not hesitate to say positive linkage (Fig.9). Among them, most opined that the relation is due to the collection of organic matter (litter, fodder and bedding material) and incorporation in field in the form of farm yard manure and compost. Forest biomass, when mixed with animal excreta, yields organic compost manure which forms the principal source of soil nutrients for hill agricultural land (Mahat 1987). Few reasoned that Forests preserve atmospheric moisture and therefore prevails good farming environment. Very small fraction polled for negative linkages such as the uphill forest damages the dwellings at the adjacent areas, calls for storm and rain thus siltation in the field. Even more percentage shown unfamiliarity on it (Fig.9, Annex 5).

In a query about the types of services, they were entertained by the forest; most people responded that they were getting fuel and fodder from it. Others reiterated that forest are the sources of water in its natural purification process, others even stated that forest purify air but only small fraction of the respondents gave their verdict for the control of landslide and erosion and even fewer for the farm fertility enrichment (Fig.11, Annex 5). Therefore, its multiple use and income generating source for poor has proved it as a safety net for poor people (MoPE 2002).

Analysis of current productivity trends reveals that it is erroneous to consider the sustainability of soil fertility in isolation without understanding the related biophysical and socio-economic factors (Joshy and Pandey 1996). Therefore, here soil fertility and productivity issues are attempted to identify with the help of socio-economic tools.

About 69 % of the HHs in Puldol and Hasantar wards were indulged in agriculture in one or other way. Majority of the hhs in Hasantar were agricultural communities. Study shows above 50% of the household of periurban area are engaged in agriculture supporting 45% of the family income (Devkota and Pradhan 2006). The lowland farmers grow three three crops viz. (rice, maize and wheat) and upland farmers grow two to three crops viz. (maize, millet, wheat).

The farmers has gone through an episodes of productivity decline i.e. previous year lower in production than two years before, this year still lower than previous year and thus this year also lower than two years before (Fig.13, Annex 5). The reason for decreasing trend in productivity they had figured out were: delay cropping, disease, climate: untimely rain/ drought, heavy fertilization, lack of improved seeds, and lack of irrigation respectively (Annex 5). The finding of the study is similar to Chitrakar (1990). Of the 64 households surveyed at Tokha, about 75% of the farm family reported that soil fertility is declining and 12 % reported no change in productivity (Devkota and Pradhan 2006). The primary causes of declining soil fertility and crop productivity are a decrease in available manure, increased cropping intensity, low use of chemical fertilizers, and change in climate (Tripathi and Jones 2005). Unavailability of appropriate technology, rain water erosion in the hills and mountains and nutrient mining, and increasing cropping intensities without judicious fertilizer application has been the major technical problems. Small landholding, subsistence farming and poverty are soil constraints (Sherchan and Karki 2006).

However, only three among the respondent farmers did not think that the productivity of land has decreased. The reasons for increasing production were: favorable climate, balanced fertilization and sowing of hybrid/ improved seeds (Annex 5). Few farmers also put their view on stagnation in production. In above cases the percentage may be higher due to multiple choices. Farmers have identified soil hardening as a major problem. Others like disease, soil acidity and poor drainage/ water logging were also perceived by farmers as their land degrading factors (Annex 5).

In response to the query on fertilizers used in their field (Fig.14, Annex 5), 43 % of farm families were reported using 5-10 kg of urea rop-1 yr-1, 28.1 % using 10-20 kg, 18.8 % using 20-40 kg rop-1 yr-1and small numbers of farmers using small quantity of urea fertilizer. Few farmers even used Diammonium phosphate (DAP) fertilizers. However, most farmers were used to nitrogenous fertilizers for maximizing yields. The fertilizers available for farmers in the hill are predominantly urea, DAP (di-ammonium phosphate), and MOP (muriate of potassium); potassium is rarely used (Basnyat 1999). External sources of plant nutrients particularly the chemical fertilizers depends on imports from outside purchasing capacity of farmers and availability on right time (Sherchan and Karki 2006). More over, gradual removal of subsidies for fertilizers, low purchasing capacity of farmers may have lead to low use of DAP fertilizer in Hasantar.

In the study area, compost and farm yard manure application was decreasing in farmers' field. The use of organic manure was replaced by inorganic fertilizers with different brand names. Most farmers apply less than 100 kg compost in a ropani of land. Even some had abandoned the traditional farming system of compost or manure application, relying on inorganic fertilizer only (Fig. 15, Annex 5). This must be because of abandoned animal (cattle) husbandry and instead rearing only small animals like goats and hens in many households (Fig. 5, Annex 5) and HHs abandoning animal husbandry activities were increasing rapidly which in turn, may be due to prohibition of grazing in CF land and lacking other pastures and grazing grounds. The average quantity of compost commonly applied to croplands is 10 t ha-1 which is only half of the recommended rate (Reed 1987). If higher use of organic manure (28 t ha-1) is applied, positive balance has been observed but the release of these elements depends on the mineral of the nutrients from the organic sources (Karki 2006). As a result of declining fertility profitable off – farm businesses may be alluring the people which led to decreased interest in low income occupation (Karki 1986).

On one hand, the low attraction in the farming occupation drove the people in off-farm businesses while on the other hand, the farmers in the name of keeping pace with population growth were turning towards so-called modern farming practices by the overuse of inorganic fertilizers. The consumption of fertilizers (NPK) increased from 7 kg ha-1 yr-1 in 1980 to 25 kg ha-1 yr-1 in 1993. The average use of fertilizer by district ranges from less than 10 kg ha-1 to more than 100 kg ha-1 (ADB / ICIMOD 2006). Due to this, the consumption of inorganic fertilizers like $(NH_4)_2SO_4$, $(NH_4)_2PO_4$ etc. were increased in the later years which has raised acidic concentration and soil hardening in the field. Similarly, the respondents have figured out that the decline in fertility and hence productivity may have been due to overuse of these nitrogenous fertilizers as evidenced from the retarded production in later years and soil hardening than those increased in early years of application (Fig. 16, Annex 5). This resembles the findings of Weber et al. (2005) that is; farmers have observed a decline in soil fertility and soil hardening under the continuous use of inorganic fertilizer.

Thus, the decline in crop productivity has been noticed in the study area. It may be conjectured that the decline in productivity was because of cropping intensity, decreasing number of animals and thus, continuous application of fertilizers with little or no addition of farm yard manure/ compost, nutrient losses by leaching and washed with runoff water or gaseous emission from exposure, divergence from farming to off- farm activities, climate change and uphill forest degradation etc. Therefore, the declining productivity could be the effect of Continuous application of chemical fertilizers without addition of Farm yard manure (Mathema 1999) or the use of contaminated manure (Karki et al. 2005) and toxic materials in soils (MoPE 2002). Similarly, indiscriminate encroachment of forest as well as sloping lands together with continuous soil nutrients mining through high yielding varieties, intensive cropping, inadequate and imbalanced fertilization (Nakarmi and Shah 2000; Shreier and Shah 2000; Karki et al. 2005) and intense pre-monsoon rain storms on sloping upland farms (Joshy and Pandey 1996) bring such consequence.

Similarly, the main source of nutrient input (especially forest) is precipitation and rock weathering. Therefore if harvest occurs more frequently than nutrient replacement time, the forest will deplete its nutrients unless fertilizers are used. The decline in HCF productivity may be attributed to the higher demand for fuel wood, forage and fodder and increasing practice of collecting litter and fodder from the forest floor as pointed out by Shah and Schreier (1995). Therefore, this one way flow of nutrients from forest soils will have repercussions for future sustainability of forest ecosystem and agronomic system. The steeper slope also promotes soil erosion and draining away of nutrient content stored in organic deposition onto the low lying belts or agriculture soils. A variety of interacting causes associated with air pollution, nutrient imbalances, fungal diseases or insect attacks may cause further decline in forest (Krebs 1994). Thus the nutrient losses from the forest will further deteriorate it. This may result in declining fertility and productivity of forest if not considered of this fact and taken further steps to improve it.

The terrestrial carbon sequestration is the net removal of CO2 from the atmosphere and storing it in terrestrial ecosystem. Thus, expansion of forest brings environmental benefit & its degradation brings misery, the recently observed climate change is one of them. To fight against this insurmountable environmental problem, Kyoto protocol (UN 1992) has a provision of Clean Development Mechanism (CDM) that assist non industrialized countries in achieving their sustainable development and can generate private sector investment from industrialized countries towards climate friendly projects such as investing on afforestation/ reforestation related activities, switching to carbon free technology. Biogas support program activity 1& 2 has been generating revenue from CDM provision. During 1990s the handed over forests to communities were degraded ones in hills. Their initiative and management effort has raised the forest status that fully meets the sustainability criteria of the CDM better than the afforested/ reforested monoculture plantations. However, in practice only afforestations or reforestations are accounted as additive gain under CDM. Another criterion of monitoring and verification of carbon under CDM includes the guarantees of no leakage (anticipated carbon suffering unexpected loss due to displacement activities). Lagging behind in these criterions, community forests of Nepal are not qualified under CDM (Karky 2005). This ambiguity state is the consequence of lacking advocacy of the government and forest user groups' institutions in the international arena.

Therefore, HCF Carbon stock looks promising in that adequate carbon was stored in the small forest patch of 64ha. In a gist, HCF has a global role in reversing the process of deforestation and sequestrating carbon, and a local function of promoting rural development activities.

CHAPTER VI

CONCLUSION AND RECOMMENDATIONS:

8.1 Conclusions:

Community forestry has been a successful policy initiative in controlling land degradation. Local control of CF is meaningless unless people actively participate in conservation activities so as to increase its productivity and biomass. Growing vegetation is a carbon sink because it removes CO_2 from the air and stores it, through photosynthesis, in plant biomass, both above and below the ground. Simultaneously, maintaining SOM in the farm and forest could provide substratum for net sinks for carbon. Therefore, for agriculture soils to act as a sink instead of source, organic farming and conservation tillage may be a viable option. Soils have only finite capacity to assimilate carbon into stable SOM. Therefore, C-sequestration in soils can only buy time before other adjustment, abatement or adaptation could be made. Thus the study was carried out to create general awareness about SOC and vegetation, as a invaluable commodity that not only benefits the owner or community by enriching the fertility and productivity but also mitigates global warming by reducing the atmospheric concentration of CO_2. Hence, the total C-stock of HCF (including both soil and vegetation) was substantial in a small forest area of 64 ha. Which was estimated to be 7,562.85 t C. the result also suggests that the carbon stored in forest soil was almost 4 times more than that in tree biomass (dry matter).

The carbon content of forest soil tends to have low SOC pools than agriculture land despite high OC-content due to low bulk density of forest soil. There was also pronounced carbon content in barrenland land and still have opportunities for greater carbon sequestration on amendment such as reforestation.

Soil fertility can be maintained only by increasing SOM on its surface. Nitrogen application does not contribute to a build up of soil fertility as evidenced from decline in agriculture productivity even with its application. Therefore, balanced fertilization with nitrogen, phosphorus and potassic fertilizers in combination with organic manures helps in maintaining soil fertility. The upland agriculture though had medium OC, medium to high N content, had low to medium exchangeable potassium nutrients and low phosphorus fertility. Similarly forest was medium in OC medium to high in N-fertility, almost low or low to medium in K-fertility and low in phosphorus fertility. Therefore, the fertility of whole HCF and its contiguous areas could be assigned medium level of fertility for having good amount of OC and total nitrogen but low to medium status of P and K-fertility and high acidity. Therefore, the estimated biomass and the DBH classification reflected the degraded status of HCF or young forest but the number of regeneration up to pole sized trees in sequence gives the impression of growing forest. Most probably, the deficiency of phosphorus nutrient and other nutrients due to unavailability in the forest soil may have direct relation with the low forest biomass. However, as the forest communities become stable with time, the input of nutrients would equalize the output then the forest in its full-fledged condition will perform its eco-systemic functions.

The questionnaire survey revealed declining soil fertility and productivity of farmland. The current immature stage of forest and abandoned husbandry may have imperative on declining fertility and productivity. Increased cropping intensity, reduced fallow period, high fertilizer input (improper and injudicious), change in climate, decreased manure availability (compost, FYM) , lack of irrigation, air pollution all affected on the soil fertility and productivity.

9th plan has realized that crop productivity has declined because of soil degradation caused by overuse of soil for cropping with adequate supplies of manure or fertilizer. However, policy approach to address this problem is inadequate. Therefore vigorous policy needs to be formulated and implemented.

6.2 Recommendations:

1) Conservation and utilization of forest should go hand in hand as one overweighs another, then imbalance results in unsustainability of the system.

2) Carbon sequestration in the degraded land and agriculture land could be increased by small modification in land use cover change and or sustainable agriculture practice.

3) Integrated plant nutrient management system (IPNMS) should be employed along with soil conservation activities. IPNMS incorporate all the fertility adding materials which increase Carbon Sequestration.

4) An essential element cannot be replaced by substitute substance therefore, careful husbandry of nutrient resources as a part of any long term nutrient management program should be designed.

5) Community should take steps to improve deteriorating situation of forest by active participation.

6) Soil should be tested in efficient soil laboratories for identifying the problems in field and follow suggestion thereof to improve the fertility status.

7) Use of fertilizers is not always harmful therefore; judicious application of adequate quantities of fertilizers (especially NPK) and lime is suggested.

8) Organic farming and conservation tillage will impart high organic deposition in the soil and hence enriches soil with essential nutrients.

10) Forest standing biomass should be managed properly so as to increase carbon sequestration and hence forest biomass stock.

11) Integration of selective species of trees in the farm (Agro-forestry) with crops may execute the functions like nutrient pump and also enrich farm fertility by biological fixing of nutrients.

12) Potential Carbon sinks have to be enhanced through aggressive reforestation afforestation and also through management of cultivated fields.

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Annex-1

SOIL FERTILITY RATING TABLE:

General guidelines for interpretation:

Table for analysis of soil pH:

pH Range	Rating
<4.5	Strongly Acidic
4.6-5.5	Moderately Acidic
5.6-6.5	Slightly Acidic
6.6-7.5	Nearly Neutral
8.5-7.6	Moderately Alkaline
>8.5	Strongly Alkaline

Source: NARC, Soil Science Division, Khumaltar

Table for soil fertility status interpretation:

Nutrient Status	OC (%)	Total N (%)	P ppm	K (me/100g)
Low	< 1.45	<0.1	<13.1	0.24
Medium	1.45-2.9	0.1-0.2	13.1-24	0.24-0.6
High	>2.9	>0.2	>24	>0.6

Source: Conversion after AIC (1998/99).

F.S.R.O soil test report interpretation:

Qualification	pH	OC (%).	Total N (%)	P ppm	K (me/100g)
Low	<6.0	<1.5	<0.08	<14	<0.2
Medium	6.0-7.5	1.5-3.0	0.08-0.15	14-22	0.2-0.4
High	>7.5	>3.0	>0.15	>22	>0.4

Source: After F.S.R.O. (1986) , Soil section, Dept. of Forest, HMGN

Annex-2

General Procedures implemented during lab Works:

General principles involved in the estimation of respective soil parameters of the study were already mentioned in the methodology (Chapter-3). Therefore, here only procedure has been described.

Procedures for Carbon analysis:

Soil sample weighing 0.2-0.5gm (on the basis of expected organic carbon content) was taken in a 250ml conical flask. Then added 10ml 1N $K_2Cr_2O_7$, 20 ml conc. H_2SO_4 and mix by gentle swirling. Keep the flask to react the mixture for about 30minutes. A standardization blank (without soil) is run in the same way.

After the reaction was over, diluted the content with 200ml of distilled water and added 10ml phosphoric acid followed by 1ml of diphenylamine indicator. Then titrated the sample with 0.4N ferrous ammonium sulphate. At the end point the colour changes to brilliant green.

Finally organic carbon is calculated by using formula.

% Carbon= $\frac{3.951}{g} \quad 1 \text{Z} \frac{T}{S}$

% O.M= %C x 1.724

Where,

g=Weight if sample,

T= ml ferrous solution with sample titration.

S= ml ferrous solution with blank titration.

Procedure for the estimation of Total Nitrogen:

Weighed 1 gm of soil was kept in 50 ml djeldhal flask. 10 ml of distilled water was poured in it and left still for 30 minutes. Then, added 2gm catalyst digestion mixture followed by 10 ml conc. H_2SO_4 and few pieces of porcelain.

Throughly mixed the soil with H_2SO_4 by swirling the flask and heated in low heat until frothing stops and raised heat until the acid boils taking care of the flame, not to touch the bottom of the flask, containing liquid. In this way the mixture was digested for 1-1.5 hours more. Then cooled the flask and added about 20 ml of distilled water before the solution starts crystallizing.

Transferred the solution in a 100 ml volumetric flask, discarding the sand in the digestion flask and made the volume. 20 ml of aliquot was taken in the distilling flask with 20 ml of 40% NaOH. Distilled the content at one end of condenser while connecting a conical flask containing 10 ml of 4% boric acid solution and 2 drops of mixed indicator on the other limb so as to collect the liberated NH_3. Then, titrated it with 0.01 N HCl. Same procedure was repeated for blank.

Calculation:

$$\% \text{ N} = \frac{7xnx(T\ \mathrm{Z}B)}{S}$$

Where, n= normality of acid.

T= Volume of acid used in titration

B= Volume of acid used in Blank

S= Sample weight.

Procedure for the estimation of Available Phosphorus:

1 gm of oven dry soil was taken in a 500 ml conical flask and added 200 ml of 0.002N H_2SO_4. The suspension was shaken for at least half an hour and filtered it to get a clear solution. Added 2 ml of ammonium molybdate followed by 5 drops of Stannous Chloride solution, blue colour appeared. Finally, readings of absorbance was taken at 690 nm on a spectrophotometer 5 minutes after and 12 minutes before the addition of $SnCl_2$ and the concentration of phosphorus was determined with the help of standard curve.

Calculation:

$$Mg\ {}^{P}\!/_{L}\ \mathrm{X}\ \frac{\text{mgP (in approx.104.5 ml final volume) X 1000}}{\text{ml. of sample}}$$

Procedures for the estimation of Exchangeable Potassium:

25g of air dried soil was taken in 250 ml beaker and added 50 ml of 40% alcohol; shaken and kept still for 15 minutes. Filtered the suspension through Whatman 50 filterpaper and washed it twice with 50 ml of 40% alcohol & finally with 25 ml absolute alcohol. The filter paper was removed by scraping soil and washing it with 50 ml 1N ammonium acetate solution for removing any adhered portion of the soil. Then, stirred the suspension and kept overnight.

Filtered the supernatant and finally the soil with additional ammonium acetate through whatman No. 42 filter paper. Then, leached the soil three times more with portions of ammonium acetate and made the final volume of the filtrate, 250ml in a volumetric flask. The concentration of exchangeable K^+ was determined from the curve of flame photometer readings.

Calculation:

Potassium, meq/ 100g = $\frac{mgK/l, Soilextract \mid V}{10 \mid S \mid 390}$

Where, V=Volume of Soil extract prepared

S= Weight of Soil taken.

Annex 3:

Table: Estimation of mean carbon pool of agriculture soil w. r. to depth 0-15cm

Site	OC (%)	BD (g cm^{-3})	Depths (m)	C-pool (kg m^{-2})
B 0-15	2.427	1.245	0.15	4.532423
D 0-15	2.4005	1.15	0.15	4.140863
F0-15	3.049	1.067	0.15	4.879925
G 0-15	2.072	1.229	0.15	3.819732
J 0-15	2.607	1.19	0.15	4.653495
L 0-15	1.4085	1.317	0.15	2.782492
average	2.327333	1.199667	0.15	4.134821

Table: Estimation of mean carbon pool of agriculture soil w. r. to depth 15-30cm

Site	OC (%)	BD (g cm^{-3})	Depths (m)	C-pool (kg m^{-2})
B 15-30	1.682	1.273	0.15	3.211779
D 15-30	2.0995	1.165	0.15	3.668876
F15-30	2.649	1.097	0.15	4.35893
G 15-30	1.9075	1.248	0.15	3.57084
J 15-30	2.3695	1.229	0.15	4.368173
L 15-30	1.9825	1.352	0.15	4.02051
average	2.115	1.227333	0.15	3.866518

Site	OC (%)	BD (g cm^{-3})	Depths (m)	C-pool (kg m^{-2})
B 30+	1.6495	1.302	0.1	2.147649
D 30+	1.721	1.19	0.1	2.04799
F30+	1.744	1.116	0.1	1.946304
G 30+	1.7905	1.268	0.1	2.270354
J 30+	1.036	1.263	0.1	1.308468
L 30+	2.3245	1.45	0.1	3.370525
average	1.710917	1.264833	0.1	2.181882

Table: Estimation of mean carbon pool of agriculture soil w. r. to depth 30-40 cm

Table: Estimation of mean carbon pool of agriculture land

Site	OC (%)	BD (g cm^{-3})	Depths (m)	C-pool (kg m^{-2})
B	1.9195	1.2733	0.4	9.8912
D	2.0737	1.1683	0.4	9.8577
F	2.4807	1.0933	0.4	11.1852
G	1.9233	1.4248	0.4	9.6609
J	2.004	1.2273	0.4	10.3301
L	1.9052	1.373	0.4	10.1735
mean	2.051	1.26		10.1832

Annex-3

Table: Estimation of mean carbon pool of forest soil with respect to depth 0-15cm

Site	OC (%)	BD (g cm^{-3})	Depths (m)	C-pool (kg m^{-2})
A 0-15	2.364	1.058	0.15	3.751668
C 0-15	3.9285	0.979	0.15	5.769002
E 0-15	2.7365	1.058	0.15	4.342826
I 0-15	2.3335	1.155	0.15	4.042789
K 0-15	1.5955	1.195	0.15	2.859934
Mean	2.5916	1.089	0.15	4.153244

Table: Estimation of mean carbon pool of forest soil with respect to depth 15-30 cm

Site	OC (%)	BD (g cm^{-3})	Depths (m)	C-pool (kg m^{-2})
A 15-30	2.274	1.116	0.15	3.806676
C 15-30	2.679	1.009	0.15	4.054667
E 15-30	2.2505	1.087	0.15	3.66944
I 15-30	1.951	1.175	0.15	3.438638
K 15-30	1.6125	1.214	0.15	2.936363
Mean	2.1534	1.1202	0.15	3.581157

Table: Estimation of mean carbon pool of forest soil with respect to depth 30-40 cm.

Site	OC (%)	BD (g cm^{-3})	Depths (m)	C-pool (kg m^{-2})
A 30+	1.3365	1.36	0.1	1.81764
C 30+	2.724	1.028	0.1	2.800272
E 30+	1.093	1.11	0.1	1.21323
I 30+	1.0455	1.185	0.1	1.238918
K 30+	1.582	1.224	0.1	1.936368
Mean	1.5562	1.1814	0.1	1.801286

Site	OC (%)	BD (g cm^{-3})	Depths (m)	C-pool (kg m^{-2})
A	1.9915	1.178	0.4	9.376
C	3.1105	1.0053	0.4	12.6239
E	2.0267	1.085	0.4	9.2255
I	1.7766	1.1717	0.4	8.7203
K	1.5967	1.211	0.4	7.7327
Mean	2.1004	1.1302	0.4	9.5357

Table: Estimation of mean carbon pool of Forest soil

Site	OC (%)	BD (g cm^{-3})	Depths (m)	Total

Table: Estimation of mean carbon pool of barren land soil

H0-15	1.7275	1.185	0.15	7.78171
H15-30	1.658	1.219	0.15	
H30+	1.335	1.258	0.1	
Mean	1.5205	1.22	0.4	

Annex: 4

Questionnaire:

Head of the Family: Date:

Name of Person(respondent):

Sex:

Ethnicity:

Occupation:

Name of VDC:

Q.1) Age, Sex and Education

Age group	Sex		Education-Male				Education-Female				
	Female	Male	Primary	L.Sec. /Sec.	College /+2	literate	Primary	Sec.	College /+2	literate	total
0-14											
15-59											
60+											
Total											
15-49		For Female Only									

Q.2)How long have you been in this VDC?

Q.3) What difference do you notice in the condition of this forest after being handed over as C.F?

a) No Change b) Sparse vegetation c) Denuded d) Growing forest e) Dense forest

Q.4) What do you use for cooking and room heating (esp. winter)? Devices(stoves, ICS, chulo, heater, LPG etc.)

Cooking:

Room heating:

Q.5) (If fuel wood/firewood) from where do you collect fuelwood ?

a)C.F as per provision b) Stealthing from C.F C)Purchasing d)Private land

e) Other means: hey/straw/saw dust/dried & fallen leaves, branches.

Q.6)How much fuel wood do you use :In Bhari(~5kg /5-10kg/ 10-15kg/ 15-20kg)

In a day:

In a month:

Q.7)How many livestocks/domesticated animals do you posses?

Cattle: goats: Hens/chicken: Others:

Q.8) Which tree species is mostly preferred as:

Fuelwood:

Fodder/Forage:

Other purpose: Furniture / building etc.

Q.9) Do you know the Rules and Regulation of this Community forest?

a) Yes b) No c) very little d) no concern

Q.10) What are the services this community forest/ Forest has provided to you?

Q.11)How much is your monthly income and source?

HH With farmland:

Q.12) How much land do you own? (in ropanies)

Cultivated:

Uncultivated/marginal:

Q.13)What was your previous crop? And existing to crop?

Previous(already harvested):

Existing/present:

Q.14) What you notice, increase or decrease in your production for the previous crop?(quantify in kg/quintal/tons or other metric units)

a) Similar:-a year ago/current year:

b) Increase/ Decrease: In previous year:

At current year:

Q.15) (If difference in yields), what do you think is the reason behind it?

a) abandon farming b) disease infestation c) delay cropping d)natural calamity: Prolonged drought, untimely rain, storm fell down plants, foggy days etc.

e) heavy fertigation(specify)-

f) or, Organic manure/ naturally:

g) Pesticidal use(specify)-

h)Irrigation i)hybrid/improved variety of seeds

j)Others:

Q.16) (If soil tested) What is the major problem in your agricultural field? (acidity, bacisity , disease)

Q.17) What were the fertilizers/treatment used in the production of previous crop? Specify & quantify.

Pesticide:

Inorganic fertilizers:

Organic manure:

Treatment: liming/fallowing/recharging water

Q.18)Any anomaly in productivity with the application of fertilizers?(previous experience)

Early stage:

Current stage:

Q.19) How can we increase the productivity of the land? And an absolute need of this community?

Annex-5

Frequency table of Respondents' response to questionnaire:

Table 16: Age, Sex and Education state of the households in adjoining areas of HCF

Age group	Sex		Education-Male				Education-Female				
	Female	Male	Primary	L.Sec. /Sec.	College /+2	literate	Primary	Sec.	College /+2	literate	total
0-14	41	40	17	11			14	6			48
15-59	65	74	0	24	20	10	4	10	5	4	77
60+	12	13	0	0	0	1				0	1
Total	118	127	17	35	20	11	18	16	5	4	126
15-49	51	For Female Only									

Condition of forest after being handed over as Community forest			
Options	No change	Dense veg.	Sparse veg.
Respondents in favour	6 (13 %)	38 (82.6 %)	2 (4.3 %)

Cooking devices used by local people				
Options	Traditional chulo	Kerosene stoves	Gober / LP gas	Improved cooking stoves
Responded in favour	25 (54.3%)	17 (37%)	15 (32.6%)	4 (8.7%)

Services harnessed from forest by locale:					
Options	Erosion & Landslide Control	Water Availability & Purity	Air Purification	Fodder & Fuelwood	Farm fertility Enrichment
Respondents in favour	5 (10.9%)	31 (67.4%)	23 (50%)	34 (73.9%)	12 (26.1%)

Status of Knowledge on rules and regulations of Community forest				
Options	Yes	No	Very little	No concern

Respondents in favour:	22 (47.8%)	2 (4.3%)	18 (39.1%)	4 (8.7%)

Materials with which devices are fetched:			
Options:	Firewood	Fuel wood	Electricity
Responded in favour	20 (43.5 %)	26 (56.5%)	5 (10.9%)

Collection of fuelwood from:					
Options:	CF as per provision	Stealing from CF	Purchasing	Private land cultivation	Dry fallen twigs
Respondents in favour	26 (56.5%)	4 (8.7%)	3 (6.5%)	27 (58.7%)	28 (60.9%)

In response to animal husbandry in Hasantar Community forest area				
Animals/ live- stocks raised	Cow	Goat	Hen/chick	Pig
Nos. of Respondents possessing	17 (11.8%)	54 (37.5%)	62 (43%)	11 (7.6%)

Average monthly income generation through different activities					
Options	<2,500	2,500-5,000	5,000-7,500	7,500-10,000	Missing
Nos. of Respondents in favour	3 (6.5%)	19 (41.3%)	15 (32.6%)	8 (17.4%)	1 (2.2%)

Fuelwood used by local people (in Bhari ~ 30 kg)				
Options	>1/2 Bhari	1/2 -1 Bhari	1-2 Bhari	2-3 Bhari
Respondents in in favour:	12 (26.1%)	13 (28.3%)	14 (30.4%)	4 (8.7%)

<u>Farmers with Farmlands (n=32)</u>

Production situation of food crops, this year compared to previous years			
Options	High	Similar	Low
Nos. of Respondents	3 (9.4%)	15 (46.9%)	14 (43.8%)

Reasons given by the respondents for high yield				
Reasons	Favourable climate	Heavy fertilization	Hybrid/ improved seed	Modern imple-ments & techno.
Nos. of Respon-dents in favour	2 (6.3%)	3 (9.4%)	1 (3.1%)	----

Reasons given by the respondents for decreased yield						
Reason	Disease	Delay cropping	Climate-untimely rain/drought	Lack of improved seeds	Heavy fertilization	Lack of irrigation
Respondents in favour	10 (31.3%)	13 (40.6%)	12 (37.5%)	3 (9.4%)	7 (21.9%)	5 (15.6%)

Problems identified by farmers in their farm field					
Problems	Soil acidity	Alkalinity	Disease	Soil hardening	Water logging
Respondents in favour	7 (21.9%)	-----	8 (25%)	19 (59.4%)	3 (9.4%)

Farmers response towards link if any, found between farm & forest				
Options	No link	Positive	Negative	Unfamiliar
Nos. of Respon -dents in favour	3 (9.4%)	9 (28.1%)	1 (3.1%)	19 (59.4%)

Quantity of Urea used in farmers field over a years period (in kg / ropani)				
Quantity	<5 kg/rop.	5-10 kg / rop.	10-20 kg / rop.	20-40 kg / rop.
Users	3 (9.4%)	14 (43.8%)	9 (28.1%)	6 (18.8%)

Quantity of compost used in farmers field over a year (in kg / ropani)				
Quantity	1-100 kg/rop.	100-300 kg/rop.	300-500 kg/rop.	none
Respondents in favour	16 (50%)	9 (28.1%)	2 (6.3%)	5 (15.6%)

Production situation of food crops, Previous year compared to two years before			
Options	High	Similar	Low
Nos. of Respondents in favour	3 (9.4%)	15 (46.9%)	14 (43.8%)

Response of fertilizers on productivity at early stage:

Options	Increase	Similar	Decrease
Nos. of Respondents	23 (71.9%)	8 (25%)	1 (3.1%)

Response of fertilizers on productivity at later years:

Options	Increase	Similar	Decrease
Nos. of Respondents in favour	6 (18.8%)	8 (25%)	18 (56.3%)

6

):

Table : Correlation between OC and different soil nutrients	
Soil Properties	r-value
OC-pH	-0.27357
OC-N	0.289267
OC-P	0.185624
OC-K	-0.17618

Soil Property	Agriculture Land			Forest land		
	Mean (n=6)	Rating	Values (Min.-Max.)	Mean (n=5)	Rating	Values (Min.-Max.)
pH (soil: water 1:5)	5.07	MA	4.6-5.9	4.93	MA	4.8-5.1
OC (%)	2.327	M	1.409-3.049	2.592	M	1.596-3.926
Total N (%)	0.216	H	0.161-0.336	0.17	M/*H	0.125-0.228
Available P (ppm)	9.207	L	5.45-14.855	11.457	L	7.605-23.25
Exch. K (me /100g)	0.271 (n=4)	M	0.205-0.385	0.201 (n= 4)	L/*M	0.186-0.215

here n stands for no. of sampling sites Note:
MA= Moderately Acidic, H= High, M= Medium, L= Low