Introduction

1. Background

About 36% of the land of world is composed of mountains, highlands and hill country (Fairbridge, 1968). Mountain occupies about 1/5 of it in which about 10% of world population is inhabited. Among them 40% people depends upon mountain resources for water, food, livestock food, heat and light, electricity, and industrial raw material.

Nepal covers 1, 47,181 km^2 of land, of which 76.69% (i.e.35.02% of mountain and 41.37% of hill) of the total land area of the country which is covered by mountain and hills (JAFTA, 2001). There are all together 14 protected areas in Nepal which roughly cover 12% of the surface area. Among these 14 protected areas, 9 are in the hill and mountain areas.

From the time immemorial, the natural resources of the mountain are utilized by the local people to meet their basic needs of fuel, fodder and water on a sustainable basis and without disturbing the natural balance. Mountains have various natural conditions and people have lived every where in that varied land which has strongly impressed the people by the harmony of nature and man.

Environment and economic change is a constant and familiar factor in mountains, but the magnitude and rate of change and its influence on social system in recent times threatens to overwhelm mountain communities as well as hundreds of millions of people downstream. Mountain systems are changing more rapidly than at any time in human history. The core issue is that more of the half humanity of world depends on mountain resources for development of people with new philosophy based on commercialization of economy. In addition, mountain ranges represent important challenges for transportation, communications, and access.

Land use in Nepal Mountain is characterized primarily by the practice of subsistence farming. The basic unit of subsistence farming is the individual farm, which consists of four main components: the farm households, the land it cultivates, livestock it holds, and forest lands. An average of 2.5 ha of support land is needed to maintain one ha of agriculture land (Pratap and Watson, 1994). As Population in the mountain

region is increasing at the rate of 1.6% (CBS, 2003), the household family size has increased, this has direct effect on the marginal land of the mountain and its forest and pasture resources. In mountain areas of Nepal, mountain forests are destroyed as population increases in the low lands, forcing poorer into the mountains, where they cultivate marginal land and for livelihood they directly depends upon the forest products for subsistence. This has converted the support land into agriculture land and the ratio of support land to agriculture land has gone down to 0.5 ha: 1 ha from 4 ha: 1ha (Shrestha, 1992).

1.2 Langtang National Park

The Langtang valley of Rasuwa District of Nepal was first expedited by Major H.W. Tilman's in June 1949 after then it received increasing attention by scientists, climbers and trekkers. The park was gazetted in 26 March 1976 by His Majesty's Government of Nepal with assistance from the UNDP/FAO to preserve the Himalayan flora and Fauna of Central Nepal in its natural state as this area of Nepal is a meeting point for eastern and western plant species

Langtang National Park is situated in the north-central region of the High Himalaya region (85^0 15'- 86^0E and 28^0-28^0 20'N) which covers 1710 km^2 with 15 VDCs. Among them 11 are in Rasuwa, 3 in Nuwakot and 1 in Sindhupalchowk. The head quarter of the Park is situated at Dhunche. Its area extends from 32.2km north of Kathmandu to Nepal-China (Tibet) border in the north-east and the Bhote Koshi-Trisuli Rivers in the west. The Park area encloses the catchments of two major river systems: one draining west into the Trisuli and the other east to the Sunkoski and is bisected east-west by the Gosaikunda Lekh and Dorje Lhakpa range in north. Langtang Lirung (7,245m) is the highest point in the Park area where as Gosaikunda Lake (4,988m) lies in the south-west and Dorje Lhakpa (6,988m) lies in the east.

The Park includes 56% of the land area of the administrative districts of Rasuwa, 38% of the Sindhupalchowk and 6% of the Nuwakot (DUHE, 1977). The area of 420 sq km in and around the Park of three districts (i.e. Rasuwa, Nuwakot, and Sindhupalchowk) was declared as Buffer Zone in 1998 to mobilize local communities in conservation and utilization of natural resources to ensure a sustainable supply of resources to local development.

Two Cheese factories by Dairy Development Corporation (DDC) were established in 1952 in the Park area before the Park was gazetted. The partly governmental, partly private organization was established with co-operation from the Swiss Association. One is situated at Chandan Bari in the southwest region of the Park at an altitude of 3254m and the other is situated at Kyangin at an altitude of 3840m in the Langtang Valley. Apart from being processed in these two factories, milk is also processed in several smaller units, following the movement of cattle.

1.2.1 Floral diversity

More than 1000 plant species (21 are endemic species) are found in LNP. The Park is rich in vegetation, is characterized by SAL (*Shorea robusta*) forest in the southern section of the Park and it is gradually taken over by hill forest (2000-2600 m) consisting of chirpine (*Pinus roxburghii*), Rhodendron and Nepalese alder (*Alnus nepalensis*). The temperate zone (2600-3000 m) is covered mainly by oak forest fading to old growth forest of silver fir, hemlock and larch in the lower sub-alpine zone (3000-3600m). The Nepalensis Larch (*Larix nepalensis*) is the only deciduous conifer in the region, is found in the park and few places elsewhere. Throughout these zones, different species of Rhodendron are found such as *R. arboretum, R. barbatum, R. campanulatum, and scrubs of R. lepidotum* which from a colorful under-story. Tree species such as *birch, silver fir, Sorbus microphylla* and twisted *Rhodendron campanulatum* are found near tree line. At the 4000 meter elevation, Juniper and Rhodendron shrubs (*R. anthopogon*) slowly dissolve into the expansive alpine grassland meadows.

1.2.2 Faunal Diversity

Langtang National Park has a lower diversity of mammals (46 species with many rare mammals such as wild dog, wolf, red panda, musk deer and clouded leopard) than in the eastern and western Himalayas because after the origin of the Himalayas, the Central Himalayas became a barrier between the east and west faunal gateways and the radiation amphitheaters (Khanal, 1993 cited in Yonzon, 1989:21). Under enormous ecological stress some 19,000 inhabitants in 47 villages and another 58,000 people living around the park rely on the forests for food, fodder and fuel wood. The

low density of larger mammals is an indication of the extent of intrusions by human (Yonzon *et.al*, 1991). The Park has recorded a total of 345 bird species including residents and migrants. The park is rich in almost 37 bird families of the world, 58 species of fish and 11 species of herpeto-fauna. The Park harbors more than 1000 species of plants including endemic plants like *Larix nepalensis*, *Rhododendron cowaniannum* and *Rhododendron Lowndessi* (Karki and Thapa, 2001).

1.2.3 Socioeconomic aspect

Livestock farming is the main occupation of people of Langtang National Park for economy. Unlike other part of Nepal, agriculture is the alternative occupation to make the living of the people because the crop production is too low. Establishment of two cheese factories with in the park (one in Kyangin and another in Chandanbari) by Dairy Development Corporation with technical assistance from United Nations Food and Agriculture organization (FAO) (Nembang 1987) has encouraged the herders to increase the livestock for their subsistent needs.

Protected areas of Nepal are the major tourism destinations for foreign visitors, while the mountain protected areas attract tourists with their scenic splendors and the cultural diversity of mosaic of ethnicity (DNPWC 2002). Mountain tourism is growing in Nepal at a very faster rate; all of the tourist destinations are being almost the protected areas of mountain. The three protected areas are Annapurna Conservation Area, Sagarmatha National Park and Langtang National Park (CREST, 1995). Protected areas in the country generate revenue from different sources such as by issuing filming license, entrance fees, royalties from hotels and lodges in and around the national parks, elephant riding and by issuing license for regulating hunting. Langtang National Park is one of the most popular mountain tourism areas and collects much more revenue than other protected areas of the country (Regmi, 2006). The flow of tourist in the Fiscal year 2057/058 was 13,166 in the Park but this has decreased in the fiscal year 2059/60 i.e. 6660 only (Tourist record of LNP).

1.2.4 Climate

The seasonal climatic pattern is dominated by the southerly monsoon which occurs between June and September. The arrival and departure of the monsoon varies spatially and temporally within the park.

The incidence and type of precipitation is mainly related to aspect, altitude and the presence of a rain shadow effect (e.g. Lende and Langtang valley). The Langtang and Lende Valleys are sheltered from southerly airstreams by Gosaikund Lekh-Dorje Lhakpa range and Langtang Himal respectively. Consequently, the monsoon arrives later and departs earlier from the Inner valleys (Hagen, 1969). At higher altitudes the importance of orographic precipitation is greater.

Summer snow accumulates only above 5,500m. In the autumn, storms from the northwest occasionally bring deep snow down to 4,000m and onto slopes north of the main ridges, which are otherwise sheltered in the monsoon. During the winter, precipitation is generally sparse with little snow smelting below 4,000m (Fox 1974b). However in the late spring, snow is able to build up on the upper south slopes of the main ridge due to the greater incidence of cloud which reduces the effective isolation. Temperatures vary considerably with aspect, altitude and cloud cover .There is a 6^0C drop in temperature for every 1000m rise in elevation (DUHE, 1977).

The nearest meteorological station from Chandan Bari is situated at the Dhunche, 28^0 06' latitude and 85^0 18' longitudes at an elevation of 1982 m. By analyzing the 18 years data from 1989 to 2006 of Dhunche, the mean maximum temperature of the hottest month was found to be 18.76^0C (June) and that of coldest month was 9.58^0C (Jan). Similarly the mean minimum temperature of the coldest month was 2.7^0C (Jan) and that of the hottest month was 13.02^0C (July) (DHM, 2007).

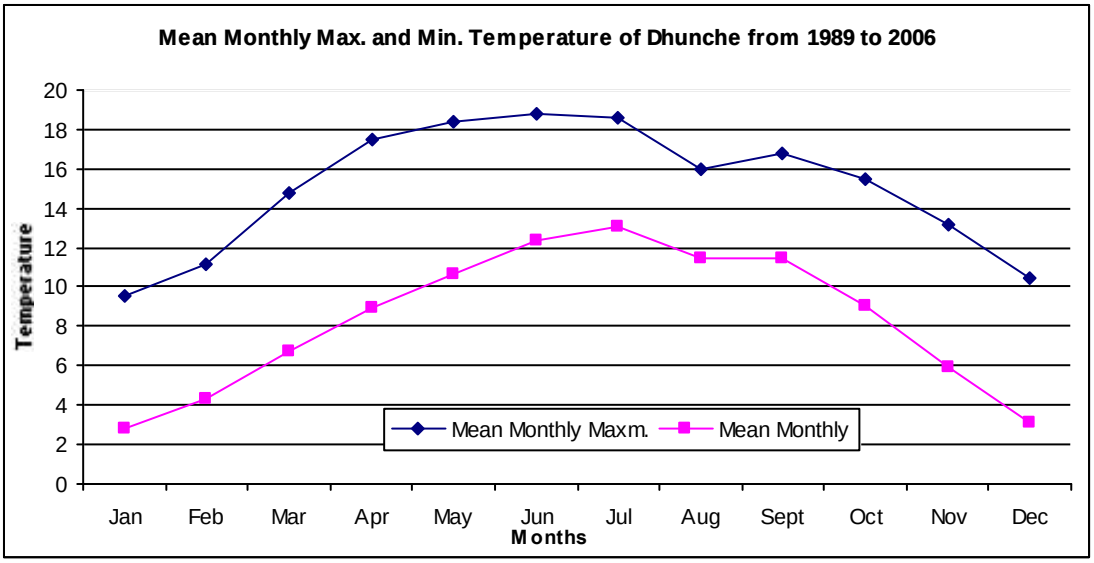


Fig 1:- Mean monthly maximum and minimum temperature of Dhunche

The average annual precipitation over the past 18 years from 1989 to 2006 was 117.6 mm. The maximum annual average rainfall was found to be 207.39 mm in 1999. Similarly the minimum annual rainfall was 11.06 mm in 1991 (DHM, 2007).

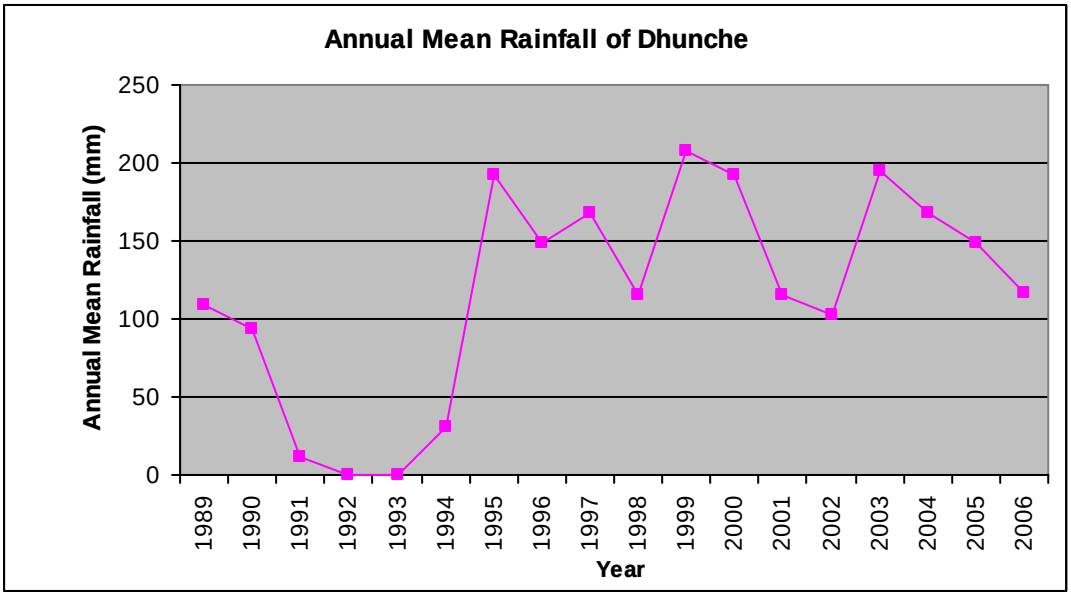


Fig. 2:- Annual mean rainfall (mm) of Dhunche

The maximum mean monthly rainfall was found in the month July (369.08 mm) and the minimum was found in the month November (10.47mm) (DHM, 2007).

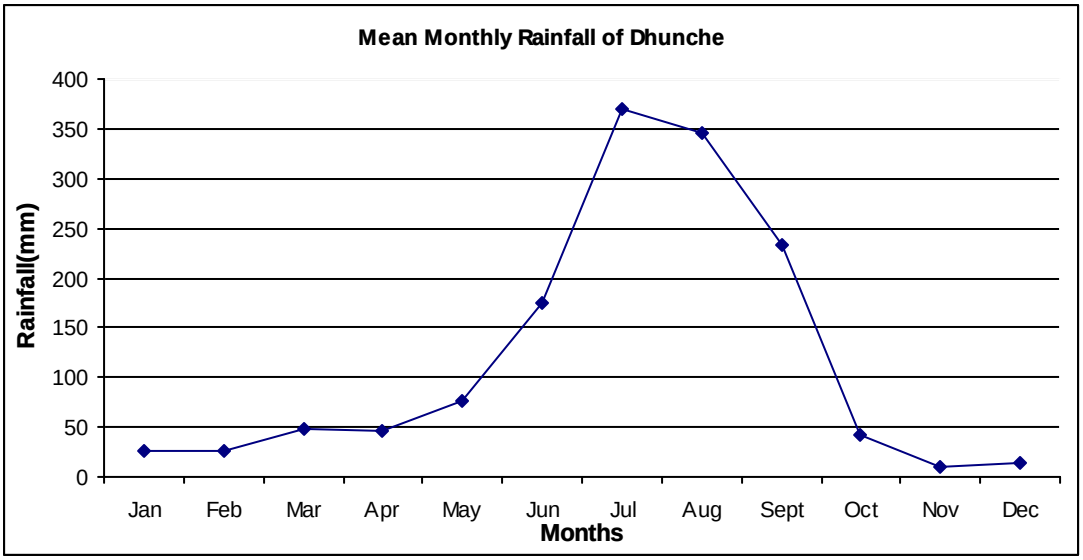


Fig. 3:- Mean rainfall (mm) of Dhunche

1.2.5 Drainage and Hydrological Regime

Due to topography, all the rivers in the park are torrential and are flowing swiftly over rock and boulder substrata. There are two major sources; those fed partially by glacier (Langtang khola and Bhotekoshi) and those which do not have glacier origins (e.g. Trisuli, Phalangu, Tadi kholas).

The drainage of the park can be divided into two main parts. South of the Gosaikunda Lekh-Dorje Lhakpa range drainage is southwards and then east into the Sunkoshi (which confluence point is Saptakoshi) but the Phalangau and Tadi Kholas drain south-westwards into the Bhotekoshi (which confluence point is Narayani). North of this range drainage is initially westwards into the Bhotekoshi- Trisuli river and then southwards again into the Narayani.

Major standing water bodies in the Park include the three main lakes at Gosaikund (Gosaikund, Bhairav kund, Sarasawati kund), two at Naukund, five at Panch Pokhari, and one at Garwang chho (Ganesh kund). In addition there are numerous small lakes and ponds in most valley systems usually restricted to higher altitudes (i.e. 3,600 m).

1.2.6 Geology and Soil

Geology

The Park occupies a tectonically interesting and important position with in the Nepal Central Himalaya. The fore Himalaya occurs between 3,000-4,000 m along the south margin of the park. The Langtang and Jugal Himals are considered integral parts of the Great Himalaya Range. The region between the Langtang Ri and Shisha Pagma is the transition zone linking the Great Himalaya and Tibetan Marginal Ranges (Hagen, 1969).

Igneous, metamorphic and migmatite rock types are found with in the Park. Hot springs occurring near Timure and Syabrubensi along the Bhotekoshi are an indication of deep-seated tectonic activity, and is still present in these relatively young mountains.

Soil

Young skeletal soils are found in the upper valley where weathering rate is high. Matured soils are found in the lower forested area, mainly of fertile loams. The mean proportion of sand has decreases with elevation and loamy-sands become predominant below 2,440 m.

1.2.7 Study Area

There are 18 VDCs in the Rasuwa district among which 11 lies with in the National Park and the buffer zone of the Park. My study area is located in the Syafru VDC of the Rasuwa district i.e. Chandan Bari. It lies at an altitude of 3254 m elevation which falls in the Sub-alpine region. The vegetation type is mixed-conifer forest of Abies *spectabilis, Rhodendron and Acer caudatum.*

There are 4 hotels in the Chandan Bari of which 3 are on privately owned land and 1 is leased by the Park. Two hotels have their branch too; one is situated at Dhunche and another at Mulkharka way to Thulo Syafru. One teashop is also situated in Chandan Bari which remained close till my study period.Transhumance gazing is practiced in the Park (Gurung 1988). Livestock movement is between 3000-5000 elevation from May to September and in winter they come down to lower elevation at 2000 m. Four Goths are allowed to graze in the Chandan Bari from the Syafru VDC

of the Bharku Village. They travel the distance from Bharku to Lauribinayak for livestock grazing which lie in the Syafru VDC. Cheese factory is situated in the study area which collects the milk from the herders to produce the milk products mainly cheese. The factory collects the milk from cowsheds around 50 km^2 areas near by.

The economy of the Chandan Bari is highly dependent on two factors one is the cheese factory i.e. from the collection of milk from herders to produce cheese and the second one is the tourism i.e. the flow of tourist to visit the Gosaikund which take rest on Chandan Bari. National tourist as well as Indian tourist visit Gosaikuda in Janipurmnima; the holy place of Hindu and western tourist visit for viewing the panoramic beauty of mountain.

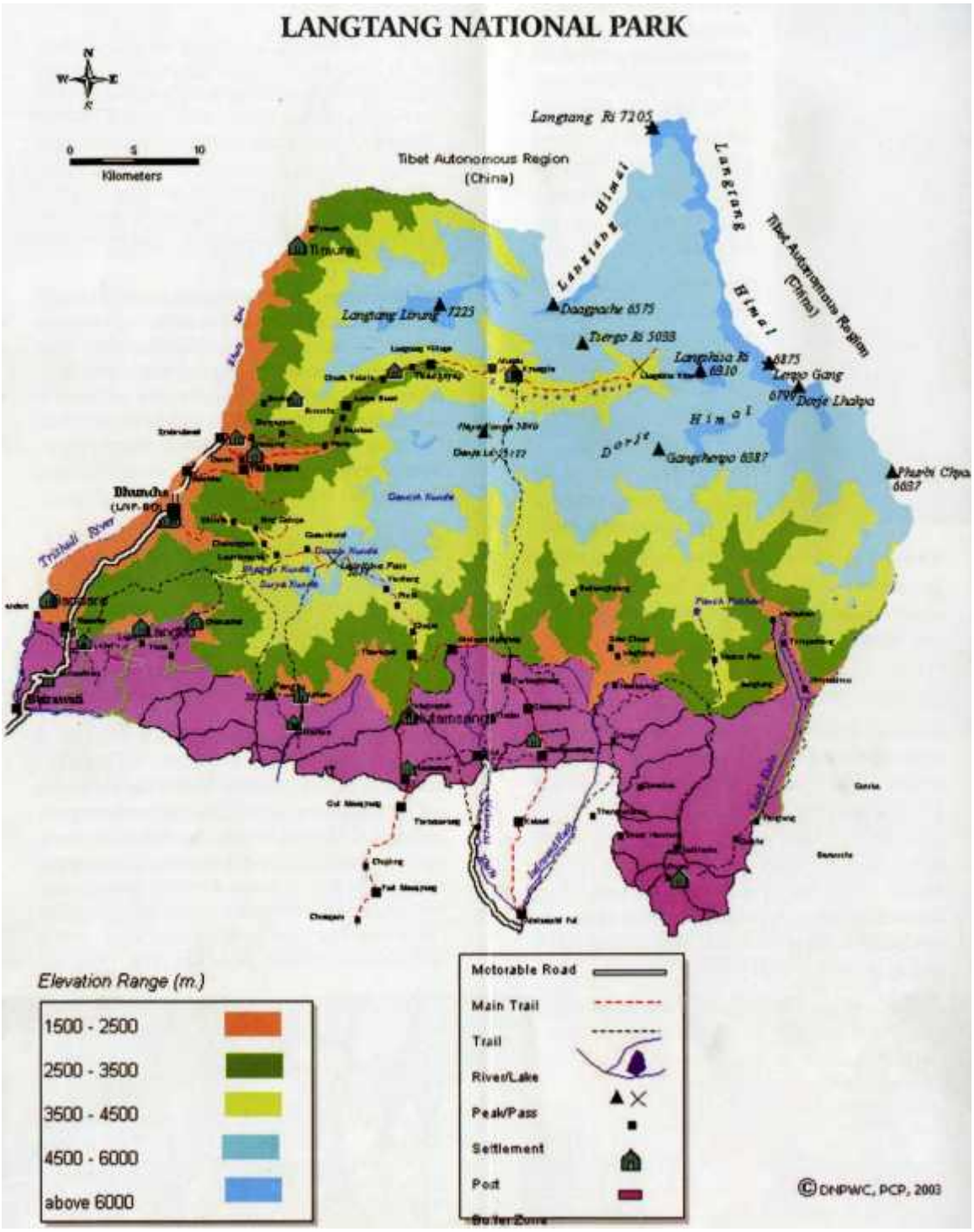


Fig 5: Langtang National Park

1. Literature Review

Staszewskis (1957) conducted a study on "The influence of altitude upon population distribution of the world at the end of the second world war". His study demonstrated that at the time only 8.2% of mankind lived on the 21.5% of the earth surface lying above 100m and only 10.5% above 2000m and surely these percentages have declined subsequently with the drift from mountains to lowland.

Berzuchka (1985) conducted a study on "A guide to trekking in Nepal" in LNP. According to him the main source of Langtang people was livestock because in Rasuwa people own not more than 30 ropani (1.5 ha) of land. Yak grazing occurs all over the park. Yak owners in Rasuwa have been benefited considerably from cheese factories run by Dairy Development. But over optimistic production targets, fuel wood shortage to make cheese, deteriorating pasture and acute shortage of winter feeds have indicated that there are more cattle than the land could support and thus, the environment is seriously threatened.

Timmerman and Platje (1987) conducted a study "Environmental impact assessment of energy requirements of the cheese factory in Kyangin" of Langtang National Park. According to his study, Cheese factory used 1,46,000kg of wood, villagers use 1,69,000kg of wood and tourist & their porters use 44,000kg of wood annually, whereas the annual growth increment of the upper Langtang forest was estimated to be 2,13,000Kg, thus it is estimated that 1,00,000kg of wood are over harvested as fuel every year.

Gurung (1988) conducted a study "Socio-economics, development and conservation in Syabru and Langtang". According to him 60% of the active population (excluding those too young or too old) participates in non sustainable farming directly and food deficit prevails. Agriculture-livestock system dominates way of life. Low food production can support families in Syabru for 3.13 months on average and in Langtang 3.5 months where as livestock economics supports families for 3.04 and 4.54 months in Syabru and Langtang respectively. Rest is met with various kinds of odd and off-farming employments.

Kharel (1993) conducted a study “Park people conflict in LNP”. According to him there was no place in the Park where grazing was prohibited. In Langtang area more than 30,000 people extract 1, 31, 4700 tons of fodder/year and their grazing livestock needs depend on Park resources.

Shrestha (1988) conducted a study “The vegetation study of the Red panda habitat in the LNP”. According to him livestock damages through grazing and cow path was found to affect the regeneration adversely (i.e. *Abies spectabilis* was found to be dominant) and cow path was associated with grazing and not transhumance.

DUHE (1977-1982) in conjunction with HMG/UNDP/FAO Project (NEP/72/002) conducted a survey in Langtang National Park to prepare the management plan of the park. According to the survey 6,861 to 13,147 Grazing Livestock Units (GLU) were dependent on the Park fodder resource, which equals consumption of 6, 86,100 to 13, 14,700 tons of green fodder each year. This overgrazing is causing degradation of pasture throughout the region and giving the selective advantage to unpalatable species.

Khadka, Ghimire & Karki (1977) conducted the study “The environment of Khumbu (A brief ecological reconnaissance on the impact of human activities on mountain ecosystem)”. According to their study almost all of the Khumbu village streams, brooks and ditches were found contaminated with fecal materials as indicated by the presence of E.coli in all the samples of water tested in the laboratory. And the total annual wood consumption was approximately 4,913 tons/year where as the forest production was nearly 3,878 tons/year which indicates deficit in wood consumption by 1,035 tons/year.

Pradhan, Pariyar & Adhikari (2003) conducted a study “Nepal case study: High altitude pastoral systems of Sailung and Thodung regions, Ramechap District, Nepal”. According to their study Sailung had the herd size 20 of *chauri* and milk is made into Chhurpi and butter by the local level where as in Thodung, the herd size was 22 and milk was collected by three private dairies. In case of Sailung average annual income was US$ 984 to 2460 depending upon the herd size where as in Thodung, the annual

income from milk sales was US$ 3057, with almost half of it spent on management, feed and medicine, giving a net profit of US$ 1259 from a herd size with 22 *Chauri*.

Yonzon, Royce & Fox (1991) conducted a study "Geographic Information System for assessing habitat and estimating population of Red panda in Langtang National Park, Nepal". According to their study the core habitat of Red panda is 68 Km^2 which is fragmented into a minimum of 17 patches and 60% of the core habitat (45 Km^2) was in high risk due to human related activities such as cattle grazing and fire wood collection. These areas support 24 Red pandas isolated into small groups by physical barriers such as rivers and high ridges.

Fox, Yonzon & Podger (1996) conducted a study "Mapping conflict between biodiversity and human needs in Langtang National Park, Nepal". According to their study, herders from Bharku had 6 *Chauri* herds & usufruct rights over 44 pastures between 1200 m to 4000 m, Gomba had 6 *Chauri* herds & usufruct rights to 16 pastures and Syabru had 20 herds- 4 yak/hill cow, 16 *Chauries* & usufruct right over 39 pasture. Out of 99 pastures land, 28 lies above 2500 m, on average these 28 pastures were grazed 22 days per season by an average 159 head of cattle. Gomba and Syabru graze in each other pasture by agreements between them where as Bharku herders on several occasions cautioned Gomba herders that they had grazed their animals on Bharkhu's pasture. And herders from Syabru and Gomba, despite their agreement to share pasture often confront each other when their cattle grazed in each others pastures. This has raised the conflict among residents of different hamlets over issue of pasture access.

IBRAD / IDA (1976) conducted a study "Appraisal of the rural development project, Nepal". According to their study, there is an average 2 % annual decrease of fodder supply from Rasuwa and Nuwakot district. Thus, livestock are becoming progressively under nourished, both as population increase and as fodder supply is diminishing. Over grazing results in localized thickets of unpalatable, spiny bushes which greatly reduce pasture value and makes available soil nutrients and moisture for less desirable plants.

According to ICIMOD (1998) “Issue in mountain development”, the livestock population in Nepal in relation to the arable land per person is highest in Asia which is 7.02 millions cattle, 3.36 millions buffaloes, 0.86 millions sheep, 5.92 millions goats and 0.72 millions pigs. And according to Miller (1993) “Rangeland in northern Nepal: Balancing livestock development and environmental conservation”, under subsistence agricultural system 90 % of the population reliance is based on livestock rearing.

Yonzon & Hunter (1991) conducted a study “Cheese, Tourist and Red pandas in the Nepal-Himalayas” of Langtang National Park. According to them the Langtang National Park is site of two cheese factories that produces 14,000 Kg of cheese per year which is marketed in the Kathmandu valley for tourist and is the third tourist destination of Nepal. Both of these consume the fuel wood for processing cheese and luxury for tourist and is having both direct effect, primarily exacerbating the over harvest of fuel wood and indirect effect, supporting an unsustainable cheese production scheme.

Nepal and Weber, (1992) found that the intensity and magnitude of conflicts are highest in the settlements located close to the park because they are heavily dependent on the resources of park. The patches of forest outside the park are degraded due to the human pressure.

Wildlife conservation in Nepal has been quite successful in terms of achievements in safeguarding the habitat of several threatened species (Mishra et al. 1992). However, increasing number of wildlife within protected areas damages the agricultural crops. Besides this, human death injuries, livestock depredation and human harassment by these wild animals have increased the conflict (Heinen 1993).

The study on different fields of freshwater environment (Physiochemical parameters of water, macro-invertebrates, planktons and fishes) of Nepal was carried out by various researchers only after 1950. Brehm (1953) is considered as the pioneer school in the field of freshwater zooplanktons of Nepal. He studied the occurrence of three genera of zooplankton in Kali Pokhari pond of Eastern Nepal. Rundle et al. (1993), conducted physio-chemical and micro-invertebrates investigation in 58 streams in

three different parts of the Himalayan Region i.e. Annapurna, Langtang, and Everest. In their study, forty seven macro-invertebrates taxa were identified and their community structure found to be related to physio-chemistry, physiographic and land use.

Woli, (2006) studied the effect of livestock grazing on rangeland vegetation and large mammalian wildlife in Khaptad National Park. His study shows that livestock grazing changed species composition by decreasing palatable species and productivity of the grassland vegetation but it did not significantly affect diversity and density of vegetation. Similarly, it has affected the distribution of large mammals by reducing abundance, occurrence and diversity due to disturbance and competition imposed by livestock. Singh (2003) reported frequent use of trails by leopard in high human leopard conflict areas followed by low conflict zone. Livestock grazing can affect feeding ecology of carnivores either directly by becoming potential prey or indirectly by modifying selection of other prey (Pia et al. 2003). Livestock grazing can directly impose resource limitation by declining their primary prey such as small mammals and birds. Pastoralist is responsible for livestock depredation. Livestock depredation results conflict between predators, livestock and pastoralist. Livestock depredation by predators is 1.5% in KNP which is the indication of interaction between pastoralist and predators. Graham et al. (2005) from the extensive literature review also found average 0.02-2.6% losses of livestock through out the world. Khatiwada and Adhakari (2004) shows that 60% of the livestock was killed by predators (snow leopard) among the total livestock loss in Langtang valley which cost NRs 2202500 for villagers i.e NRs 40045 per household and 50% of the local people have negative attitude towards snow leopard because the predator cause the heavy livestock loss, which shows the conflict between herders, wild predators and livestock in the rangeland area of the Park.

Banskota and Sharma, (1988) conducted a case study “Mountain tourism for local community development in Nepal of Syaphrubesi, Langtang National Park”. Their study shows that, LNP is the third most popular trekking destination in the mountain areas after Annarpurna and Sagarmatha National Park (SNP), and it attracts 13% of the total trekkers visiting Nepal. These three areas together account 85% of the accommodation facilities in the mountain districts. As percentage of all over all

establishments, these three regions account for 39% of the establishments in Nepal which is very high percentage. In Langtang region (Rasuwa and Nuwakot district) there are 77 (8%) of such establishments (ICIMOD 1995/7). These three regions account 77% of the total employment in the accommodation industry.

Mountain tourism has been able to alleviate poverty in many places i.e. the total revenue generated from mountain tourism in 1992 is about Rs 640,622 million compared to 73.911 million in 1975 representing an annual growth rate of 22% (ICIMOD 1995/7), as well it has affected in agricultural practices and land use practices. Upadhyay 1984, study in Sagarmatha National Park shows that, many households have abandoned their traditional cropping practices of buckwheat and barley to cultivate more potatoes because potatoes find a ready cash market. Some land use changes are reported from ACAP in the Tatopani region (Friend, 1983). Chettri et al. (1992) also discusses the impact of tourism on land use in terms of horticultural activities in Jomsom- Marpha area.

Shrestha (2007) conducted a study on assessment of threatened medicinal plants in Langtang National Park. His study shows that, out of 51 species of MAP's prioritized by CAMP workshop, 20 species are found in LNP which include 11 species under IUCN threat category, 4 species under CITIES Appendix II, 8 species under DPR prioritization and 18 species under HNCC prioritization and the total amount of NTFP's traded from Rasuwa district in the fiscal year 2062/63 was about 91,000 Kg with revenue collection of NRs 396,000. Malla et al. 1976 reported 911 species of vascular plants from LNP and adjoining areas. Out of these, 132 species have been found to be medicinal value.

2. Objective

To contribute our knowledge about the human encroachment by studying socio-economic structure, subsistent activities of community and surrounding ecology and biodiversity in the buffer zone of the LNP. Specific objectives are:

- To study socio-economic status (livelihood, fuelwood need and energy consumption) of survey households.
- To study the forest vegetation composition of the study area.
- To study the agricultural practices and livestock grazing practices in the study area.
- To study the soil samples of agriculture land and forest land of study area.
- To study the physio-chemical parameters of the drinking water of the study area.

3. Rational of the Study

The basic life-support systems of soil, water, and biota are the limiting factors in mountain ecosystem obliging hill communities to use their environment and resources thoughtfully without drying out the resources capital. The soil is fragile because of the slope and rapid weathering, the forest is also fragile as the plant life has delicately adapted to the harsh environment and the growing period is too short. The animals are vulnerable because they can survive only with in narrow range of conditions and the people are also vulnerable because their simple life style and isolation have not molded them to withstand the outside pressures. All this makes the life more difficult and therefore population is very sparse who subsisted on minimum resources from the nearest area. The small change in the life pattern (i.e. withdraw of resources beyond carrying capacity and increase in population) of this area has a greater impact in the mountain ecosystem which cannot be restored for generations.

In the Langtang National Park, barren wilderness accounts for more than half of the parks 1,710km^2. Some 27% of the park area is covered by forest, 15% by pasture and 5% shrub. Agriculture accounts for just 1.6% and per land holding in Langtang averages 0.06 ha barely enough to produce a quarter of their annual food requirement

(Yonzon, 1993). Thus, the steadily growing human and cattle populations will rely more on the Park's forest.

To sustain livelihood, they use marginal and sloping lands for agriculture, fodder and fuel wood from the forest resources and large number of livestock are grazed in grazing lands beyond their carrying capacity. Tourists are also the source of income for the local people and for their facility too they depends on forest resources. Since mountain area is very fragile and vulnerable, these are directly affected by the subsistent activities of the people. My study will find out the existing environment of the Chandan Bari area of LNP area with the resource use pattern of the people.

4. Limitation of the Study

- Resources were not adequate.
- E-coli, pH, conductivity, phosphate and nitrogen content of water could not be measured due to lack of instrument in the remote field area.
- The texture analysis of the soil could not be conducted.

Methodology

3 Study Methods

The study was conducted on the basis of primary and secondary data. In order to collect primary data quantitative and qualitative information were obtained from the field using various research tools in the year 2007 from June 15- July 5 in Chandan Bari of Langtang National Park as: questionnaire from hotels and cowsheds, vegetation analysis, soil collection from forests land and agriculture land, physio-chemical parameters of drinking water and soil from lab analysis. The secondary data were collected from the study maps, tabular data, and information from reports from International Center for Integrated Mountain Development (ICIMOD), Central Bureau of Statistics (CBS), Tribhuwan University Central Library (TUCL), Department of National Parks and Wildlife Conservation (DNPWC), Department of Forest (DOF), and various websites.

3. 1 Household survey

A household survey was done by questionnaire method. Four hotels and five cowsheds (byre) in and around the Chandan Bari were interviewed and filled in semi structured questionnaire. Questionnaire with three parts was developed (for detail see Appendix 1) including information on household, grazing pattern of livestock and issues related with management of National Park Forest Resources.

Household information

This part mainly focused on the household information to identify the livelihood support mechanism through occupation of respondent and family members, land holding, crop types and its production, livestock holding (including feeding types), resources need (fuel wood and fodder) and their access, energy use and consumption pattern and annual income and expenditure.

Grazing pattern of livestock information

Since the grazing pattern of livestock is transhumance, this part mainly focuses the route of transhumance and the mean days of cowsheds (byre) in specific place.

Issues related with management of National Park Forest Resources

This part was designed to obtain the information ongoing management practices of recourses and their effective and suggestions / recommendations for future initiatives for the better management of national resources.

Data Analysis

Data from questionnaire were first entered into MS Excel program in database form. Some necessary calculations were completed with this program. Qualitative form of data and information were also coded and entered for analysis. Once the basic calculation and modification were completed, variables were categorized according to needs of analysis.

3.2 Vegetation analysis

The vegetation analysis was conducted according to the methods mention in the Zobel et al. (1987) (for detail see Annex I). A total of 20 vegetation sampling was done i.e. 10 plots in northern slope and 10 plots in southern during the month of June 2007.

Trees

Plants with diameter greater than 10cm were classified as trees. 25m x 25m quadrate was laid for tree plot. The aspects, slope, cut stem number were noted at each plot. Heights of all trees were measured with the help of clinometer and trees with diameter at breast height (DBH) ≥10cm were measured with the help of DBH tape.

Shrub

Plants with diameter < 10cm and height > 10cm were considered as shrubs. At one corners (north –east in the study area) of 10m x 10m sampling plots were made to measure for all shrubs.

Herb

Plants with height < 10cm and also all types of grass, pteridophytes and orchids were considered as herbs. Within the same corner of each 25 cm x 25 cm tree plot, quadratic plots of 25 cm x 25 cm at four corners were established and numbers of herbs were counted. All herbs, including seedlings of trees and shrubs with height ≤

10cm, were recorded and their coverage was estimated. In cases of grasses and ferns, every single tiller was counted.

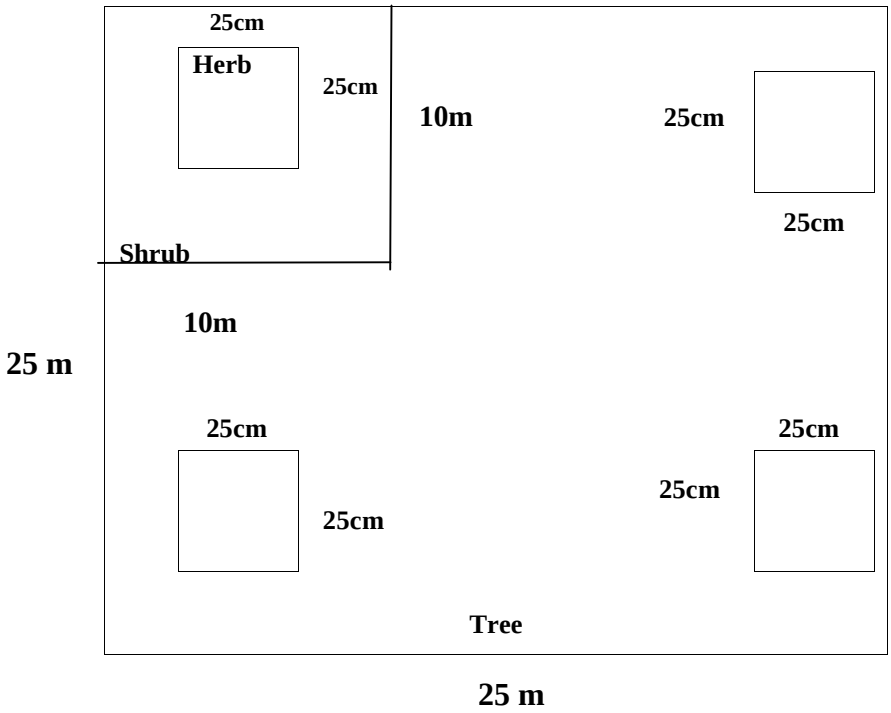


Fig 6: Plot Design

3.3 Soil Analysis

3.3.1 Soil Sampling

Soils on the slope of Mahabharat lekh, Middle Mountains as well as Himalayan spurs are shallow in depth except in terraced conditions (Shah, 1999). So soil samples were collected from each site from the surface up to 15 cm. Around half Kg of soil samples were drawn with *kuto* and prepared composition sample from each sampling sites suggested by Khatri-Chetri (1990). Collected samples were well labeled in sample bag and were tightened by the rubber band immediately in order to preserve the soil moisture. The collected samples were later brought to the laboratory of Department of Environmental Science, T.U and different physical and chemical parameters of soil were analyzed by air drying, crushing and passing through 2mm sieve for performing tests. Soil samples from agricultural land were also collected as same depth as of soil samples from forested area. The agriculture lands of three hotels were selected and two samples from each hotel agriculture land was sampled and tested as the parameters of forest soil.

3.3.2 Physio-chemical Analysis of soil

All the physio-chemical parameters of soil except total nitrogen were determined according to the methods described in Trivedy and Goel (1984) and total nitrogen was determined according to the methods described in Pradhan (1996).

Table 1: Methodology for the Physio-chemical Analysis of soil

Parameters	Methods of Analysis
Moisture content	-
Water holding capacity	-
pH	pH meter
Conductivity	Conductivity meter
Organic matter content	Walkey and black method
Nitrogen content	Kjeldahl method
Nitrate	Phenoldisulphonic acid method
Available phosphorous	Spectrophotometric method
Potassium	Flamephotometric method

3.4 Drinking-Water Analysis

3.4.1 Water Sampling

The drinking water source for Chandan Bari is Stream which is situated on the southern slope. Cemented tank was constructed to collect the water from the stream and distributed to four hotels and five cowsheds (byre) through pipeline. Drinking water analysis was carried out from the pipeline junction just before it is distributed to hotels and cowsheds. Clean bottles were used for the collection of water sample from the experimental sites. The parameters like temperature, chloride, free carbon dioxide, total alkalinity, total hardness, calcium hardness were analyzed with in an hour after the collection of sample water. The drinking water analysis was done three times in a gap of a week in the morning time at 11AM.

3.4.2 Physio-chemical Analysis of drinking water

All the physio-chemical parameters were determined according to the methods described in Trivedy and Goel (1984).

Table 2: Methodology for Physio-chemical Analysis of DW

Parameters	Methods of Analysis
Temperature	Thermometric
Free Carbon dioxide	Argentrometric
Chloride	Potentiometric
Dissolve Oxygen	Wrinkles idometric
Total Alkalinity	Titrometric
Total Hardness	Titrometric
Calcium Hardness	Titrometric

Result

4.1 Socio-economic Study

4.1.1 Demography

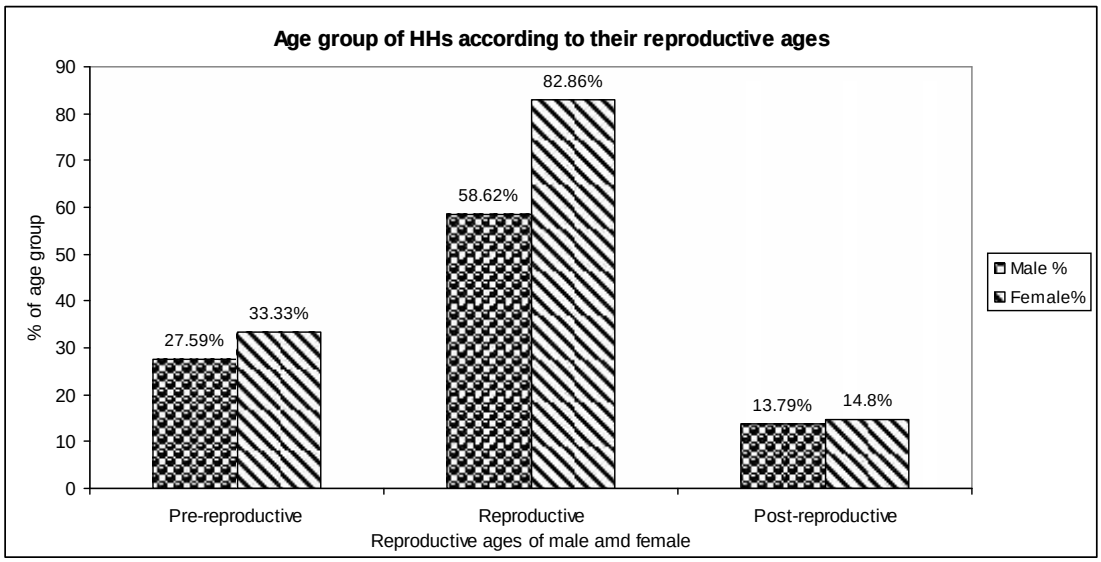
The study area (Chandan Bari) was inhabited by the ethnic people belonging to the caste Tamang. A total of 56 people (9 household) live in Chandan Bari of which, four were hotels (who stay over 10 months except 2 months in winter) and remaining five cowsheds owner which practice transhumance grazing system. The mean number of days of stay was 44 for going up and down. Of the 9 sampled households, majority was of male (29) (i.e. 27 were females).

4.1.2 Age Structure

The age structure of sampled households was found to be highest in the range of 20-24 years for male and in the range of 10-14 years for female and lowest was found in the range of 75-79 years for both male and female.

Each age structure of household was differentiated into three reproductive ages as Pre-reproductive age (1-15 years), Reproductive age (15-49 years) and Post-reproductive age (45+years). The age structure of sampled households by reproductive ages lay in reproductive ages of both male and female (male: 58.62%; female: 51.85%).

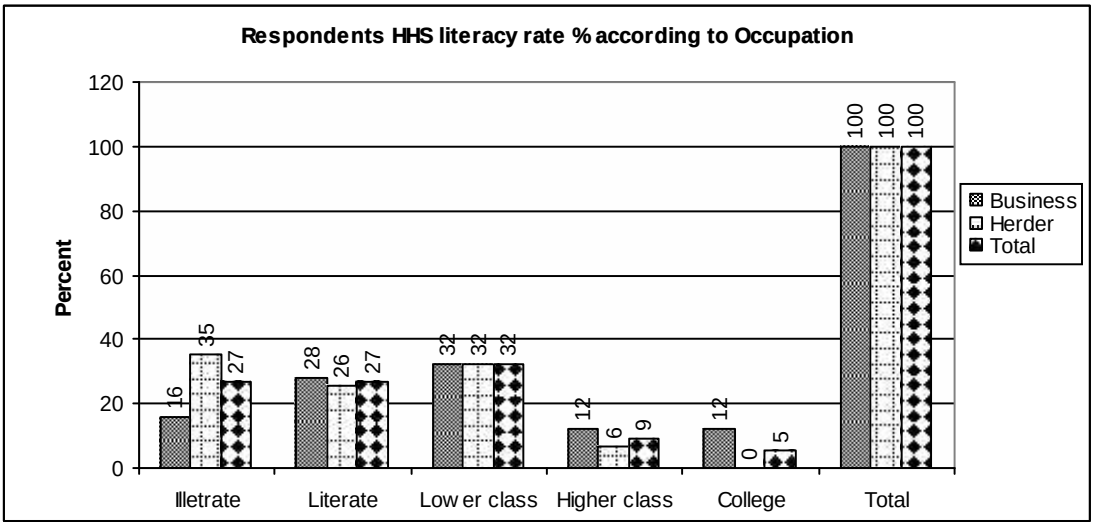
Fig 7: Percent of Reproductive Age Structure of Total households



4.1.3 Literacy Rate

The households surveyed (9 households) were differentiated into two categories i.e. tourism and animal husbandry. In case of tourism, 4 (16%) were illiterate, 7 (28%) were literate, 8 (32%) were of lower class (<5), 3 (12%) were of higher class (5-10) and 3 (12%) were in college level whereas in case of animal husbandry, 10 (35.49%) were illiterate, 8 (25.81%) were literate, 10 (32.25%) were of lower class (<5), 2 (6.45%) were of higher class (5-10) and no one in college level. It means more literates were engaged in tourism activities whereas most illiterates in animal husbandry and other agricultural activities.

Fig 8: Household Literacy Rate according to Respondent Occupation



4.1.4 Occupation

The majority of respondents practiced animal husbandry (55.56%) whereas 44.44% were engaged in tourism activities. Of the total households engaged in tourism, major occupational group observed were students (9) whereas in case of animal husbandry households 8 were students. Out of 56 people, 17 were students. 4% people were engaged in service sector of tourism related household but in case of animal husbandry, no one was engaged in service sector.

Table 3: Occupation of the respondent households

Occupation	T	T %	AH	AH %	T + AH pop^{n}	Total %
Agriculture	2	8	6	19.35	8	14.28
AH	A	A	11	35.48	11	19.64
Dependent Population	3	12	3	9.6	6	10.71
Foreign Earning	2	8	2	6.45	4	7.14
Service	1	4	A	A	1	1.78
Student	9	36	8	25.82	17	30.35
Tourism	8	32	A	A	8	14.28

(T=tourism, AH= animal husbandry, T + AH= tourism & animal husbandry, A=Absent)

Among the households sampled, 44.44% people have kept staff mainly for tourism activities whereas the staff hired for animal husbandry was negligible (1%).

Among the households sampled, 55.36% people were economically active and 44.64% were economically dependent upon their family members who include young and old aged people (Table 4)

Table 4: Economically dependent Population

Economically Dependent Population	%
Population involved in occupation	55.36
Economically dependent population*	44.64
Total population	**100**

(*= less or more than age group of 15-59).

4.1.5 Land Holdings

The average land holding was 1.041 ha per household and per capita holding was 0.173 ha. The maximum percentage (33.33%) of households owned 0.5-1 ha and 1.0-2 ha of land whereas 11.11% of households have more than 2 ha (Table 5).

Table 5: Percentage of households land ownership in the study area

Land holding (ha)	HH No.	HH %
< 0.5	2	22.23
0.5 - 1.0	3	33.33
1.0 - 2.0	3	33.33
> 2.0	1	11.11

(Conversion: 1 ropani = 0.05 ha, 19.65 ropani = 1 ha)

4.1.6 Land tenure

About 44.45% of households have their land shared to others for agriculture whereas 33.33% households have self tilled and 22.22 % households have left their land barren. All of the tourism related households have been sharing their land to others for tilling whereas 60% of animal husbandry households have self cultivated and 40% have left the land barren.

Table 6: Percentage of Land tenure

Status of Land	**%**
Self tilted	33.33
Shared tilted to others	44.45
Land barren	22.22

4.1.7 Migration of Household to Chandan Bari

Almost all of the households living in Chandan Bari have migrated from Bharku of Syafru VDC except one. Five households of animal husbandry groups graze their livestock each and every year in the same place and period. On average for animal husbandry purpose, herders stay at one spot for about 22 days whereas in tourism related households, people lived there for 8 months except in winter season.

4.1.8 Production of food crops

The growing season was too short. Only two crops were produced through out the year. So, many of the households were attracted towards vegetable plantation. The average amount of production of different crops of all households was calculated.

Table 7: Average Production

Crops	**Average Production**
Maize	255.56
Millete	89.78
Barley	70.33
Buckwheat	45.56
Karu*	66
Pulses	31.67
vegetables	672.22
Total	**1231.11**

(local name)*

4.1.9 Food Sufficiency

The average food production sufficiency lasted only for 2.6 months. All of the surveyed households have food deficit, 55.56% of households manage deficit by tourism where as 44.44% of households manage from animal husbandry.

4.1.10 Livestock

During the study only three types of domestic animals were considered important. They were *Chauri*, Cattle and Goat. Each type of livestock were counted and converted into Grazing Livestock Unit. Each type of Livestock Unit was calculated by using the conversion factors as given by DUHE (1977-1982, pp.49).

Table 8: Livestock Conversion Factor as given by DUHE (1977-1982)

Livestock type	Conversion type
Chauri	0.6
Low land cattle	0.5
Horse	0.8
Goat	0.116

Chauri, Cow, Goat and horses covered 72.12%, 11.91%, 11.91% and 3.96% of the total livestock respectively present in the study area. Household holding livestock ranged from 0-32 with mean value of 21. Only 1 household didn't possessed livestock. 5 household have *Chauri*, 1 household have cow, 1 household have goat and 3 household have horse. *Chauri* was of great importance for subsistence households. Out of 91 *Chauri*, 80.22% were milking ones. On average *Chauri* gave 3 liter /day of milk. 12.5% of livestock were practiced stall feeding where as 87.5% of livestock were both grazed and stall-feed in winter season. For 8 months (April to November), *Chauri* were practiced under transhumance grazing system and for four months in winter, they were stall-feed.

4.1.11 Fuelwood Consumption

The entire household was depended upon National Park forest for fuelwood as well as for grazing purposes (only 55.56% households' used fodder). On average 13,340 kg/year of fuelwood was consumed by total households of which 19,581 kg/year of fuel wood was used by tourism sector households and remaining 8,347 kg/year of fuel wood was used by animal husbandry households.

Table 9: Average fuelwood Consumption

Households	Average FW consumption (kg/year)
Used by all households	13340
Used by tourism HHs	19581
Used by animal husbandry HHS	8347

4.1.12 Fuelwood Consumption of Chandan Bari Forest Area

The hotel owners of the study area shift down in the winter season for three months closing the hotels, the herder's practices transhumance grazing pattern so they remain in the study area for 44 only days (while moving up and down) and the Cheese factory was operated only for six months. So, the demand of fuel wood for hotels for 9 months, herders for 20 days and cheese factory for 6 months was calculated in order to find out the actual demand of fuel wood in the Chandan Bari forested area.

Table 10: Fuelwood Consumption at Chandan Bari Forest Area

Fuel Wood demand on Chandan Bari Area	kg/year
Hotels	16800
Herders	800
Cheese factory	17710
Total	45310*

(* Source-Durham University Himalayan Expedition, 1977)

4.1.13 Alternative Sources of Energy and its Consumption

Petroleum gas, Kerosene, solar energy, battery and candles were considered as alternative sources of energy. From the survey, almost all households used fuel wood as the major source of energy for cooking and heating purpose. About 22.22% of households used petroleum and kerosene as alternative energy for cooking and kerosene for lightning as well. About 55.56% used solar energy for lightning, of which 20% used for heating water. About 77.78% used battery for lightning and 44.44% used candles for lightning purpose.

Table 11: Sources of energy

Percent of Household using different sources of energy						
	Fuel wood	Pet. Gas	Kerosene	Solar energy	Battery	Candles
Used HHs	100	22.22	22.22	55.56	77.78	44.44
Unused HHs	0	22.22	77.78	44.44	22.22	55.56
Total	100	100	100	100	100	100

4.1.14 Annual Income

Most of the respondents were hesitated to answer about their income status so exact income could not be figured out. The supporting questionnaires helped for estimation of average income. The average annual income ranged NPR 13, 600, 00 in tourism sector and NPR 2, 705, 00 in animal husbandry sector respectively (Table 12). Tourism was the primary source of income for 44.4% of the households and 11.1% household as tertiary source of income where as animal husbandry was the primary source of income for 55.59% of households but it didn't share its percentage on secondary and tertiary source of income. Service shares 11.11% of secondary income of the households sampled where as foreign earning shares 11.11% on secondary source and 11.11% on tertiary source of income.

Fig 9: - Source of income of households

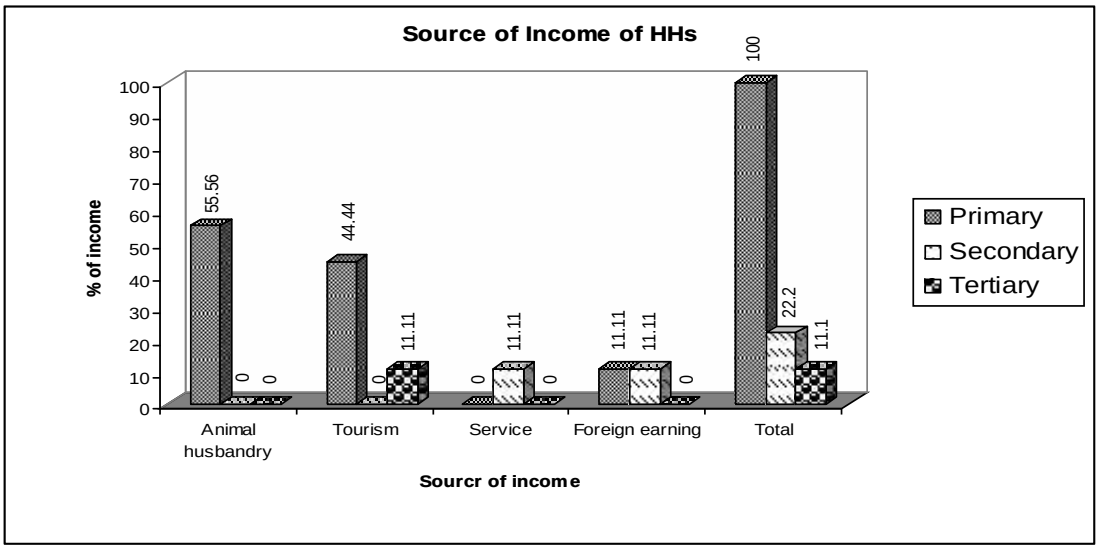


Table 12: Annual income with their Median Values

Variables	Annual income (NPR) of Tourism	Annual income (NPR) of cowsheds house
Range	1360000	270500
Average	752283.5	210340
Median	918267	143400

4.1.15 Resource use from forest

Forest resources were harvested from the National Park forest in different forms like fuelwood, fodder, leaf litter and timber (Table 13).

Table 13: Different Resources Use from Park Forest

Resource use	% of household
FW	0
Fodder	0
Leaf litter	0
Timber	0
FW+F+L	55.56
FW+F+T	44.44
FW+T	0
All	0

(FW-fuel wood, F-fodder, L-litter, T-timber)

4.1.16 Condition of National Forest

Majority of respondents gave good view (for abundance of flora and fauna) about the national forest in past i.e. cent percent as good. However 55.56% of responded gave poor view on condition of national forest at present in terms of availability of grass for grazing purposes, whereas 22.22% of responded gave view as very good condition and remaining 22.22% of sampled responded have good view about present condition of national forest than before.

Table 14: Responses Related with the Condition of National Park Forest

Response of HHs	Perception on Condition of National Forest	
	Past (%)	Present (%)
Very Good	0	22.22
Good	100	22.22
Satisfactory	0	0
Poor	0	55.56
Remains same	0	0
Don't know	0	0

3.1.17 Problem in National Forest

Majority of households' respondent denied the presence of any strong management for the National Park Forest. 55.56% of the sampled household gave view as insufficient resource in forest as well as they didn't have knowledge about conservation. On specific resource type, they gave their experience that there was not sufficient grasses for livestock as before.

Table 15: Response Related with the problem of National Park Forest

Problem in National Forest	HHs %
Insufficient resources in NF	55.56
Stealing at NF	100
No problem	0
Unknown about problem	0
Insufficient area	0
Fire blazing	100*
Excessive litter collection	0
No fencing	0
Forest Dying due invasive species	55.56
Not strong management	100
No knowledge about conservation to people	55.56

(- fire had cleared the southern slope forest in past)*

4.1.18 Management of the Park

Cent percent of the sampled households had negative response towards the management of National Park manpower, fencing it for better security and on present National Park Policy for better management of National Park. Likewise cent percent of the respondents had hearty accepted on utilization of dead and fallen logs, alternative energy promotion, awareness and education, enforcing strong management team having transparency, tourism development and utilization and conservation of resources in the Park for the better management.

Table 16: Response related for better management of NP Forest

Suggestion for better management for NP	HHs Response %
Utilization of dead trees / fallen logs	100
Increase in price of milk from Cheese factory	55.56
Alternative skill development promotion for livelihood support	55.56
NP population management	100*
More plantation	33.33
Control of livestock grazing	11.11
No suggestion/Don't know	22.22
Control on litter collection	11.11
Alternative energy promotion	100
Awareness/Education needed	100
Fencing/More security	100*
Enforce strong management team with having transparency	100
Tourism development	100
Better protection measures for Wildlife	44.44
Conservation with utilization	100
National Park Policy change	100*

(negative attitude of respondents)*

4.2 Vegetation Analysis

4.2.1 Trees of northern slope

The Chandan Bari forest area consists of Fir (*Abies spectabilis*), *Rhodendron barbatum* and Mapple (*Acer caudatum*) dominated by Fir-Rhodendron. The study area covered 6250 m^2 on which only two trees of *Acer caudatum* were found. The total density of tree was 169.6 per hectare. *Abies specabilis* was the most dominant tree species in the study area with highest density (108.8 per hectare), relative density, frequency, relative frequency, basal area, relative basal area and importance value of index (Table 17). In the southern slope only three *Rhodendron barbatum* trees were found.

Table 17: Tree Plot Survey

S.N	Name of the species	Abu.	F.C	Den	R.D (%)	Freq	R.F	BA (m^2)	RBA (%)	IVI (%)
1	*Abies spectabilis*	6.3	E	101	59.43	100	55.6	56.91	92.94	207.9
2	*Acer caudatum*	1	A	3.2	1.89	20	11.1	0.56	0.91	13.9
3	*Rhodendron barbatum*	6.8	C	66	38.68	60	33.3	3.76	6.15	78.2

(Abu. - abundance, F.C-frequency class, Den-Density, Freq.-frequency, R.F-relative frequency, BA-basal area, RBA-relative basal area, IVI- important value index)

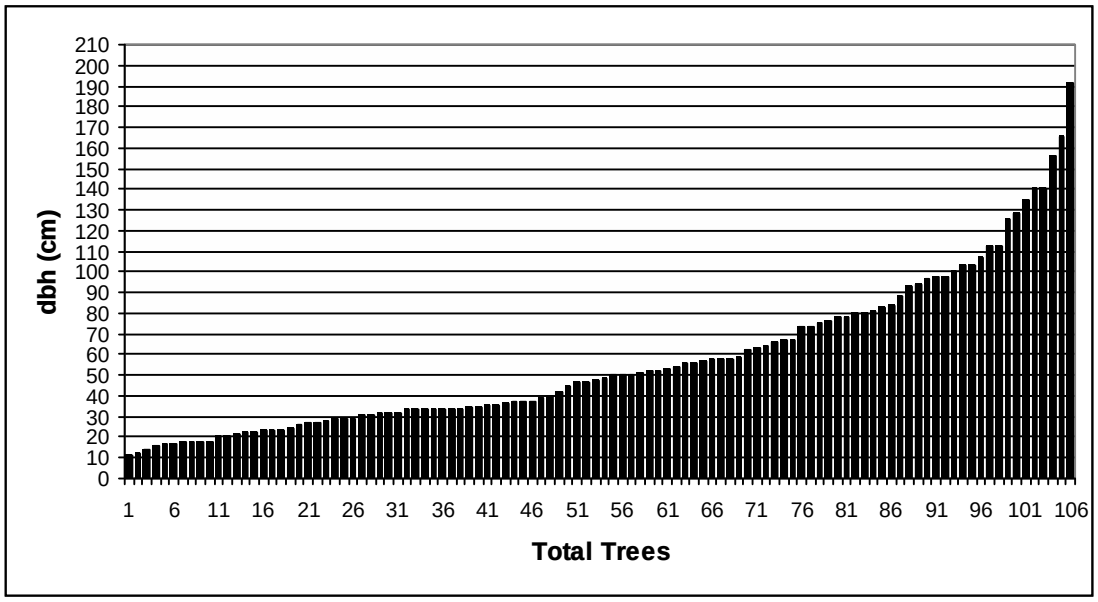
The majority of trees were of large saw timber (Table 18). This shows that the forest of the Chandan Bari area was old growth forest.

Table 18: Tree stands size

Stand Size	DBH (cm)	Number of Trees
Sapling	< 12.5	29
Poles	12.5 - 25	17
Small saw timber	25 - 50	36
Large saw timber	> 50	51

Among the entire individuals tree, the maximum number of trees was of DBH more than 30 cm (Figure 10).

Fig 10: Total trees of all species and their DBH classes



The DBH of *Abies spectabilis* were mostly found above 30 cm where as the DBH of *Rhodendron barbatum* were evenly distributed from 10 cm to 40 cm (Fig. 11 and 12).

Fig 11: All *Abies spectabilis* trees and their DBH class

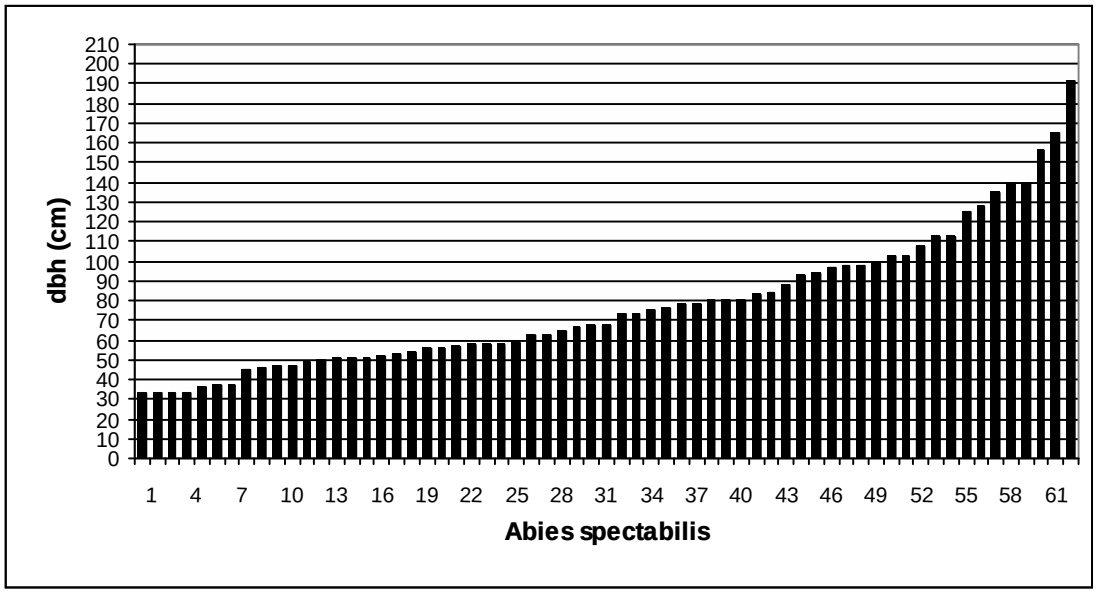
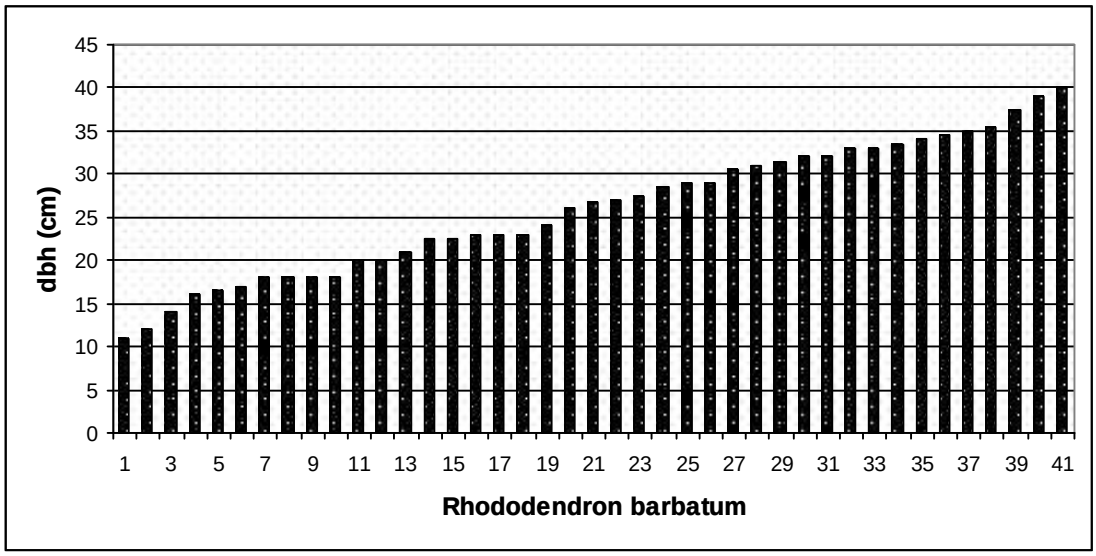


Fig 12: All *Rhodendron barbatum* trees and their DBH class



4.2.2 Human Disturbance:-

Very high numbers of trees were cut down in the north facing slope. In the first quadrate only one tree was standing and 23 were cut down. The density of cut stems was 165 / hectare where as the live tree density was 175 / ha. A carpenter work place was found in the second quadrate and many stacks of wood covered by plastics were also found. In south facing slope, the forest caught the fire 60 years ago. The density of burned stems was 124 / ha and the density of live trees was only 4.8 / ha, only three live trees of *Rhododendron barbatum* was found in first quadrate. The half burned stems of southern slope were not even touched and were left at its place to be decayed where as the fresh stems of northern slope were cut down for heating and cooking purposes.

Table 19:- Cut and burned stems in study area

Quadrate No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Density (trees / ha)**
Cut stem in NFS	23	14	13	14	13	18	5	2	0	1	165
Live trees in NFS	1	8	28	6	10	14	7	15	10	7	170
Burned stem in SFS	8	4	4	4	11	15	18	22	21	17	124
Live trees in SFS	3	0	0	0	0	0	0	0	0	0	4.8

(NFS- north facing slope, SFS- south facing slope)

3.2.3 Tree Volume and Biomass

The total volume of tree species was 74.2 m^3/ha, of which Abies spectabilis (71.53 m^3/ha) had the highest volume and *Acer Caudatum* (0.39 m^3/ha) had the lowest

volume of trees. The biomass of stem, branch and foliage was found to be 57096.95 kg/ha, 20376 kg/ha and 6319.56 kg/ha respectively.

Table 20: Volume and Biomass of Tree Species

Species	Volume (m^3/ha)	Stem Biomass (kg/ha)	Branch Biomass (kg/ha)	Foliage Biomass (kg/ha)
Abies spectabilis	71.53	54935.88	19547.5	5971.36
Acer caudatum	0.39	314.4	114.27	39.12
Rhododendron caudatum	2.28	1846.67	714.22	309.08
Total	**74.2**	**57096.95**	**20376**	**6319.56**

4.2.4 Annual Yield, Sustainable Fuel wood, Fodder and Timber Yield of Tree Species

The total annual yield of stem, branch and foliage was estimated as 6.28 t /ha /yr, 2.24 t /ha /yr and 0.70 t /ha /yr respectively. The highest annual yield of stem was found of *Abies spectabilis* (6.043 t /ha /yr) and the least yield was of foliage of *Acer caudatum* (0.035 t /ha /yr). In case of sustainable yield, the highest amount recorded was of *Abies spectabilis* for fuel wood (6.56 t/ha /yr), fodder yield (0.59 t /ha /yr) and timber (0.816 t /ha /yr) respectively (Table 21).

Table 21: Annual Yield, Sustainable Fuel wood, Fodder and Timber Yield of Tree Species

Species	Annual Yield (t/ha/yr)			Sustainable Yield (t/ha/yr)		
	Stem	Branch	Foliage	Fuelwood	Fodder	Timber
Abies spectabilis	6.043	2.150	0.657	6.56	0.59	0.816
Acer caudatum	0.035	0.013	0.004	0.04	0.59	0.005
Rhododendron caudatum	0.203	0.079	0.034	0.23	0.03	0.027
Total	**6.28**	**2.24**	**0.70**	**6.82**	**1.21**	**0.85**

Table 22: Condition of Fuelwood and Fodder Supply in Chandan Bari

Forest area (ha)	31.5*
Sustainable fuelwood yield (ton/year)	214.83
Fuelwood demand (ton/year)	45.31
Surplus (ton/year)	169.52

(The area of the studied area was estimated by the Grid line method of DFRV, 2060)

4.2.5 Shrubs on Southern Slope

The 1000 m^2 area covered 20 species of shrubs covering total density of 38440 / ha. *Leontopodium jacotianum* had the highest density, relative density, abundance, coverage, relative coverage and important value of index than other species i.e. 17530 / ha, 45.6%, 256.42, 41%, 23.29% and 77.89% respectively where as *Berberis spp* had the highest frequency and relative frequency i.e. 80% and 41% respectively (Table 23).

Table 23: Results of Shrubs Survey Southern Slope

Name of the Species	F. O	Ab	Density	R.D	Fre.	R.F	C	R.C	IVI
Berberis spp	8	14	1130	2.94	80	10.39	22	12.5	25.83
Leontopodium jacotianum	7	250	17530	45.60	70	9.09	41	23.30	77.99
Fern	4	38	1520	3.95	40	5.19	9	5.11	14.26
Sorbus sp	3	2	70	0.18	30	3.90	3	1.70	5.78
Desmodium elegans	6	4	260	0.68	60	7.79	8	4.55	13.01
Aconitum heterophyllon	6	12	710	1.85	60	7.79	9	5.11	14.75
Himalayan dendrocalamus	3	2	60	0.16	30	3.90	9	5.11	9.17
Rubia manjith	3	5	140	0.36	30	3.90	5	2.84	7.10
Artemisis gmelinii	3	107	3210	8.35	30	3.90	13	7.39	19.63
Himalayacalamus falconeri	1	12	120	0.31	10	1.30	2	1.14	2.75
Juniperus recurva	3	2	60	0.16	30	3.90	5	2.84	6.89
Clemantis montana	4	1	50	0.13	40	5.19	6	3.41	8.73
Viburnum sp	3	154	4620	12.02	30	3.90	19	10.80	26.71
Polygonatum cirrhifolium	4	3	100	0.26	40	5.19	4	2.27	7.73
Rhodendron barbatum	2	3	50	0.13	20	2.60	3	1.70	4.43
Arisaema intermedia	4	7	280	0.73	40	5.19	6	3.41	9.33
Rosa macrophylla	4	3	100	0.26	40	5.19	1	0.57	6.02
Smilex sp	2	2	30	0.08	20	2.60	3	1.70	4.38
Angelica cyclocarpa	2	55	1090	2.84	20	2.60	6	3.41	8.84
Unindentified (succesional plant)	5	146	7310	19.02	50	6.49	2	1.14	26.65
Total			**38440**		**770**		**176**		**300**

(F.O- frequently occurring, Ab- abundance, R.D- relative density, Fre.- frequency, R.F- relative frequency, C-coverage, R.F- relative coverage, IVI- importance value index)

4.2.6 Shrubs on Northern Slope

The 1000 m^2 area covered 10 species of shrubs covering total density of 13750 / ha. *Abelia sp* had the highest density, relative density, abundance, frequency, relative frequency, coverage, relative coverage and important value of index than other species i.e. 6750 / ha, 49.38%, 256.42, 90%, 17.30%, 33%, 27.73% and 94.42% respectively (Table 24).

Table 24: Results of Shrubs Survey Northern Slope

Name of the species	F.O	Ab.	Density	R.D	Fre.	R.F	C	RC	IVI
Cotoneaster acuminatus	3	73.7	2210	16.07	30	5.77	9	7.56	29.40
Abies spectabilis	4	6.5	260	1.89	40	7.69	4	3.36	12.94
Rhodendron barbatum	7	10.7	750	5.45	70	13.46	24	20.17	39.08
Angelica cyclocarpa	6	34.0	2040	14.84	60	11.54	10	8.40	34.78
Arisaema intermedia	8	7.4	590	4.29	80	15.38	8	6.72	26.40
Abelia sp	9	75.4	6790	49.38	90	17.31	33	27.73	94.42
Sorbus sp.	6	3.7	220	1.6	60	11.54	5	4.20	17.34
Berberis sp	5	3.8	190	1.38	50	9.62	15	12.61	23.60
Fern	3	13.0	390	2.84	30	5.77	4	3.36	11.97
Unidentified (succesional plant)	1	31.0	310	2.25	10	1.92	7	5.88	10.06
Total			**13750**		**520**		**119**		**300**

(F.O- frequently occurring, Ab- abundance, R.D- relative density, Fre.- frequency, R.F- relative frequency, C-coverage, R.F- relative coverage, IVI- importance value index).

4.2.7 Herbs in Southern Slope

40 quadrates of 10 cm^2 x 10 cm^2 area were plotted for the study of herb. The 10 m^2 area covered 19 species of herbs covering 5352000 /ha of total density. *Stellaria sp* had highest density, relative density and abundance i.e. 1132000 /ha, 21.15 % and 15.7 respectively. *Fragaria nubicola* had the highest frequency, relative frequency and important value index i.e. 55%, 11.16% and 36.93% respectively. *Fragaria nubicola, Anemone obustiloba and Stellaria sp* had the highest coverage and relative coverage (Table 25).

Table 25 Results of Herbs Survey Southern Slope Herbs Survey

Name of the species	F. O	Ab.	Density	R.D	Freq.	R.F	Cov.	R.C	IVI
Allium wallichii	8	2.38	76000	1.42	20	4.06	10	2.20	7.68
Androsace strigillosa	8	5.25	168000	3.14	20	4.06	9	1.98	9.18
Anemone obtusiloba	15	3.40	204000	3.81	37.5	7.61	55	12.09	23.51
Delphininum kamaonense	5	4.00	80000	1.49	12.5	2.54	10	2.20	6.23
Charispora sbulosa	9	1.78	64000	1.20	22.5	4.57	30	6.59	12.36
Cynadon Sp	19	10.53	800000	14.95	47.5	9.64	45	9.89	34.48
Fern	6	3.17	76000	1.42	15	3.05	8	1.76	6.22
Fragaria daltoniana	14	4.14	232000	4.33	35	7.11	50	10.99	22.43
Fragaria nubicola	22	8.32	732000	13.68	55	11.17	55	12.09	36.93
Angelica cyclocarpa	5	3.20	64000	1.20	12.5	2.54	15	3.30	7.03
Iris kemaonensis	9	4.00	144000	2.69	22.5	4.57	15	3.30	10.56
Leontopodium jacotianum	12	3.58	172000	3.21	30	6.09	17	3.74	13.04
Leontopodium Sp	5	2.40	48000	0.90	12.5	2.54	8	1.76	5.19
Mosses	6	25.50	612000	11.43	15	3.05	3	0.66	15.14
Polygonum hydropiper	4	5.50	88000	1.64	10	2.03	5	1.10	4.77
Ranunculus spp	14	4.86	272000	5.08	35	7.11	20	4.40	16.58
Stellaria sp.	18	15.72	1132000	21.15	45	9.14	55	12.09	42.38
Unidentified (Succesional plant)	4	7.00	112000	2.09	10	2.03	25	5.49	9.62
Trifolium sp	14	4.93	276000	5.16	35	7.11	20	4.40	16.66
Total	**197**		**5352000**	**100**	**492.5**	**100**	**455**	**100**	**300**

(F.O- frequently occurring, Ab- abundance, R.D- relative density, Fre.- frequency, R.F- relative frequency, C-coverage, R.F- relative coverage, IVI- importance value index)

4.2.8 Herbs on Northern Slope

The 10 m^2 area covered 21 species of herbs with a total density of 11020000 /ha. *Veronica sp* had the highest density and relative density, frequency and relative frequency i.e. 2440000 /ha and 34.25 %, 72.5% and 12.44% respectively. Succession plant had the highest abundance i.e. 34.25 where as *Fragaria nubicola* had the highest coverage and relative coverage i.e. 16.49 and 43.42% respectively (Table 26).

Table 26: Results of Herbs Survey Northern Slope

Name of the Species	F. O	Ab	Density	R.D	Fre	R.F	C	R.F	IVI
Fragaria nubicola	28	14.68	1644000	14.92	70	12.02	63	16.49	43.43
Trifolium sp.	10	13.00	520000	4.72	25	4.29	15	3.93	12.94
Primula geraniifolia	2	2.00	16000	0.15	5	0.86	2	0.52	1.53
Ranunculus brotherusii	20	9.40	752000	6.82	50	8.58	30	7.85	23.26
Cynadon sp	19	7.47	568000	5.15	48	8.15	18	4.71	18.02
Fern	7	3.29	92000	0.83	18	3.00	12	3.14	6.98
Anemone obtusiloba	21	6.05	508000	4.61	53	9.01	23	6.02	19.64
Potentilla atrosanguinea	5	5.60	112000	1.02	13	2.15	7	1.83	4.99
Medicago falcautta	8	8.00	256000	2.32	20	3.43	10	2.62	8.37
Galium hirtifolium	18	5.06	364000	3.30	45	7.73	10	2.62	13.65
Mosses	23	22.96	2112000	19.17	58	9.87	70	18.32	47.36
Potentilla pedincularis	3	2.00	24000	0.22	7.5	1.29	5	1.31	2.81
Veronica himalensis	29	21.03	2440000	22.14	73	12.45	38	9.95	44.54
Anderosace strigillosa	5	10.00	200000	1.81	13	2.15	9	2.36	6.32
Bupleurum longicaule	12	11.83	568000	5.15	30	5.15	22	5.76	16.06
Incarvillea arguta	6	3.50	84000	0.76	15	2.58	8	2.09	5.43
Oxalis sp.	7	6.29	176000	1.60	18	3.00	9	2.36	6.96
Abelia sp	3	1.67	20000	0.18	7.5	1.29	3	0.79	2.25
Geranium grandiflorum	1	2.00	8000	0.07	2.5	0.43	2	0.52	1.03
Abies spectabilis	2	1.00	8000	0.07	5	0.86	1	0.26	1.19
Unidentified (succesional plant)	4	34.25	548000	4.97	10	1.72	25	6.54	13.23
Total			**11020000**		**583**		**382**		**300**

(F.O- frequently occurring, Ab- abundance, R.D- relative density, Fre.- frequency, R.F- relative frequency, C-coverage, R.F- relative coverage, IVI- importance value index)

Table 27: Species diversity, ecological dominance and evenness index of trees, shrubs and herbs

	Sp. Richness	E. D.	SDI	E. I.
Trees (NF)	3	0.55	0.32	0.68
Shrubs (SF)	20	0.11	1.13	0.87
Shrubs (NF)	10	0.16	0.9	0.9
Herbs (SF)	19	0.078	1.19	0.93
Herbs (NF)	21	0.094	1.14	0.86

(E .D- Ecological dominance, E .I - Evenness index, SDI - Shannon diversity index)

The species richness, Shannon diversity index and Evenness index of shrubs and herbs was higher in the southern slope where as Ecological dominance was higher in case of northern slope.

4.3 Physio-Chemical Parameters of Soil of Southern and Northern aspect of forest and Agriculture land

Moisture Content: - In the southern slope of burned forest, the maximum value of moisture content recorded during the study period was 19.4 % at site 4 and the minimum value recorded was 14.3 % at site 1 (Table 28).

In the northern slope, the maximum value of moisture content recorded was 26.58 % at site 5 and the minimum value recorded was 21.2 % at site 9 (Table 29).

And in agricultural land maximum value recorded was 20.1 % at site 5 and the minimum value recorded was 15.9 % at site 1 (Table 30).

Water Holding Capacity: - In the southern slope of burned forest, maximum value of water holding capacity of soil recorded during the study period was 83.7 % at site 3 and the minimum value recorded was 68.5 % at site 9 (Table 28).

Likewise in northern forest, the maximum value of water holding capacity of soil recorded was 93.25 % at site 1 and the minimum value recorded was 84.5 % at site 10 (Table 29).

And in the agricultural land, the maximum value of water holding capacity of soil recorded was 80 % at site 5 and the minimum value recorded was 63.3 % at site 3 (Table 30).

pH:- In the southern slope of burned forest, the pH value was between 5.1 to 5.5 during the study period having maximum value 5.5 at sites 3rd and 6th and the minimum value 5.1 at site 9 (Table 28).

Likewise in the northern forest, the pH value of soil was between 4.4 to 5.1. The maximum value of pH recorded was 5.1 at sites 3rd and the minimum value recorded was 4.4 at site 2nd of the study area as in (Table 29).

And in the agricultural land, the pH of soil samples ranged between 5.6 -7.1. The maximum value of pH recorded was 7.1 at sites 5 and the minimum value recorded was 5.6 at site 1 of the study area (Table 30).

Conductivity:- In the southern slope of burned forest, the maximum and minimum value of conductivity recorded during the study period was 53 µS / cm at site 3rd and 103 µS / cm at site 9 which showed variation of conductivity of soil in different sites (Table 28).

Likewise in the northern slope, the maximum and minimum value of conductivity of soil recorded was 186 µS / cm at site 5 and 108 µS / cm at site 3rd, which showed a large variation in different sites (Table 29).
And in the agricultural land, the maximum and minimum value of conductivity recorded was 150 µS / cm at site 5 and 39 µS / cm at site 3 which showed variation of conductivity of soil in different sites (Table 30).

Organic Matter Content:- :- In the southern slope of burned forest, the maximum and minimum value of organic matter content of soil recorded during the study period was 15.77 % at site 3rd and 10.13 % at site 5th & 8th which showed weak variation of organic matter content of soil in different sites (Table 28).
Likewise in the northern slope, the maximum and minimum value of organic matter content of soil recorded was 19.02 % at site 9 and 16.83 % at Site 3rd which showed weak variation of organic matter content of soil in different sites (Table 29).
And in the agricultural land, the maximum and minimum value of organic matter content of soil recorded was 16.2 % at site 5 and 6.21 % at site 2nd which showed variation of organic matter content of soil in different sites (Table 30).

Available Phosphorous: - In the southern slope of burned forest, the maximum and minimum available phosphorous content recorded during the study period was 1.7 mg / 100 gm of soil at site 3rd and 0.2 mg / 100 gm of soil at site 4th which showed weak variation of available phosphorous of soil in different sites (Table 28).
Likewise in the northern slope, the maximum and minimum value of available phosphorous recorded was 0.54 mg / 100 gm of soil at site 8 and 0.1 mg / 100 gm of soil at site 9 which showed strong variation of available phosphorous of soil in different sites (Table 29).
And in the agricultural land, the maximum and minimum value of available phosphorous content recorded was 17.6 mg / 100 gm of soil at site 5 and 6.2 mg / 100 gm of soil at site 1 which showed variation of available phosphorous of soil in different sites (Table 30).

Total Nitrogen:- In the southern slope of burned forest, the maximum and minimum value of total nitrogen percent of soil recorded during the study period was 0.25 % of soil at site 1st & 7th and 0.2 % of soil at site 4th , which showed very weak variation of total nitrogen of soil in different sites (Table 28).

Likewise in the northern slope, the maximum and minimum value of total nitrogen percent of soil recorded was 0.392 % at site 1st and 0.154 % at site 2nd which showed weak variation of total nitrogen of soil in different sites (Table 29).

And in the agricultural land, the maximum and minimum value of total nitrogen percent recorded was 0.29 % of soil at site 4th and 0.21 % of soil at site 1st which showed very weak variation of total nitrogen of soil in different sites (Table 30).

Potassium:- In the southern slope of burned forest, the maximum and minimum value of potassium was recorded as 0.1 mg/100gm of soil at site 6th during the study period and 0.092 mg/100gm of soil at site 8 which showed variation of potassium on soil in different sites (Table 28).

Likewise in the northern slope, the maximum and minimum value of potassium recorded was 0.08 mg/100gm of soil at site 4th and 0.07 mg/100gm of soil at site 2nd which showed variation of potassium in different sites (Table 29).

And in the agricultural land, the maximum and minimum value of potassium recorded was 0.17 mg/100gm of soil at site 5 and 0.12 mg/100gm of soil at site 1st, which showed weak variation of potassium in different sites (Table 30).

Table 28: Physio-Chemical Parameters of Burned Forest Soil at Southern aspect

Site / Parameters	M.C. (%)	WHC (%)	pH	Cond. (µS/cm)	OMC (%)	AP (mg / 100 gm)	TN (%)	Pot. (mg/100gm)
1	14.3	81	5.4	72	12.91	0.6	0.25	0.096
2	16.1	72	5.2	99	10.42	0.8	0.23	0.094
3	17.7	83.7	5.5	53	15.77	1.7	0.21	0.097
4	19.4	70	5.3	64	11.66	0.2	0.24	0.093
5	16.2	78	5.2	93	10.13	1.2	0.22	0.98
6	18.5	82.3	5.5	54	15.01	1.6	0.2	0.1
7	19.3	78.8	5.4	76	13.1	0.9	0.25	0.095
8	17.1	78.8	5.2	98	10.13	1.4	0.21	0.092
9	15.7	68.5	5.1	103	9.76	0.8	0.22	0.099
10	16.4	82.3	5.3	68	11.57	0.7	0.22	0.096

Table 29: Physio-Chemical Parameters of Forest Soil at Northern aspect

Site / Parameters	M.C. (%)	WHC (%)	pH	Cond. (µS/cm)	OMC (%)	AP (mg / 100 gm)	TN (%)	Pot. (mg/100gm)
1	24.1	93.3	4.5	181	18.83	0.12	0.392	0.074
2	23.4	91	4.4	128	18.16	0.114	0.154	0.07
3	23.1	92	5.1	108	16.83	0.31	0.32	0.075
4	25	92.5	4.8	153	17.69	0.6	0.266	0.08
5	26.6	88.8	4.8	186	18.64	0.22	0.28	0.076
6	25.8	89.8	5.2	109	18.45	0.38	0.273	0.074
7	23.9	92.5	4.8	144	17.11	0.6	0.27	0.072
8	24.2	90.3	4.7	164	18.55	0.54	0.259	0.075
9	21.2	89.3	4.6	173	19.02	0.1	0.28	0.071
10	21.6	84.5	4.9	145	17.4	0.2	0.226	0.073

Table 30:- Physioi-chemical Parameters of Agricultural land Soil at Chandan Bari

Site / Parameters	M.C. (%)	WHC (%)	pH	Cond. (µS/cm)	OMC (%)	AP(mg / 100 gm)	TN (%)	Pot.(mg / 100 gm)
1	15.9	63.5	5.6	86	7.36	6.2	0.21	0.12
2	18.9	69.8	5.8	66	8.51	7.8	0.25	0.15
3	16.7	63.3	5.9	39	6.21	8.2	0.27	0.14
4	17.6	75.8	5.9	108	10.7	8	0.29	0.13
5	20.1	80	7.1	150	16.2	17.6	0.22	0.17
6	18.4	72.8	6.8	164	13.9	10.6	0.25	0.16

(M.C.-Moisture content, WHC-water holding capacity, OMC-organic matter 0.16 content, AP-available phosphorous, TN-total nitrogen, N-nitrate and Pot.-potassium)

4.4 Physio- chemical Parameters of Drinking water

Temperature: - Maximum value of temperature of drinking water of Chandan Bari during the investigation period was 19^0C in the 3rd week of July 2007 and minimum temperature recorded was 13^0C in the 4th week of July 2007 indicated weekly variation. The average value of temperature was 15.33 ± 2.6^0C.

Chloride: - Maximum value of chloride content of drinking water sample recorded was 11.36 mg/l in the 4th week of July 2007 and the minimum value recorded was 9.94 in both 2nd and 3rd week of July. The average concentration of chloride recorded during the investigation period was 10.41 ± 0.67 mg/l.

Free Carbon dioxide: - Maximum value of free CO_2 recorded during the investigation period was 0.00792 mg/l in both 3rd and 4th week of July and the minimum value recorded was 0.00704 mg/l in the 2nd week. The average concentration of free CO_2 recorded during the study period was 0.007627 ± 0.000415 mg/l.

Dissolve Oxygen (DO): - Maximum value of DO recorded during the investigation period was 8.1 mg/l in both 2nd and 4th week of July and the minimum value recorded was 7.7 mg/l in the 3rd week. The average concentration of free DO recorded during the study period was 7.96 ± 0.2 mg/l.

Total Alkalinity: - The recorded value of Total Alkalinity of drinking water samples ranges between 12.5 to 15 mg/l in the month July 2007. During the investigation period the maximum value of Total Alkalinity recorded was 15 mg/l in both 2nd and 4th week and the minimum concentration recorded was 12.5 mg/l in the 3rd week of the study period.

Total Hardness: - Maximum value of Total hardness recorded during the investigation period was 6 mg/l in both 3rd and 4th week of July 2007 and the minimum value recorded was 5.2 mg/l in the 2nd week of July. The average concentration of Total hardness recorded during the study period was 5.73 ± 0.37 mg/l.

Calcium Hardness: - Maximum value of Calcium hardness recorded during the investigation period was 2.56 mg/l in 2nd week of July 2007 and the minimum value recorded was 2.4 mg/l in the 3rd week of July. The average concentration of Calcium hardness recorded during the study period was 2.48 ± 0.06 mg/l.

Table 31: Weekly Variation of Physio-Chemical Parameters of Drinking Water

Date / Parameters	**Temp.**	**Chloride**	**Free CO2**	**DO**	**Total alkalinity**	**Total hardness**	**Calcium hardness**
11-Jul (2nd week)	13	9.94	0.00704	8.1	15	5.2	2.56
18-Jul (3rd week)	19	9.94	0.00792	7.7	12.5	6	2.4
25-Jul (4th week)	14	11.36	0.00792	8.1	15	6	2.48
Average	15.33	10.41	0.007627	7.96	14.16	5.73	2.48
SD	2.6	0.67	0.000415	0.2	1.2	0.37	0.06

(SD-Standard deviation)

Discussion

5.1 Socio-economic survey of households

Heinen and Metha (2000) stated that 70% of the protected areas of the world were inhabited by indigenous people. In the study area (Chandan Bari) all the respondents were among the indigenous community the Tamangs.

The study showed the dominancy of the reproductive age group of both male and female followed by the pre-reproductive age group. This figure indicates the rapidly growing population of the study area. The sex ratio between male and female in the age group 0-14 was dominated by female population which could be an indication of the preference of a boy child to avoid economic burden in the future.

Of the total surveyed household (56), 55.36% were economically active group (Table 4) of which 44.44% of respondent were engaged on tourism sector and 55.56% in animal husbandry. Though 55.56% of the respondents were engaged on animal husbandry, they were indirectly related with tourism. The milk they get from *Chauri* was sold to the Cheese factory situated in Chandan Bari for six months. This factory was established by Dairy Development Corporation (DDC), which manufactured cheese from the milk of which tourists were the sole consumers. Yonzon and Hunter (1991) states, current cheese prices was already too high for Nepali consumers (US $4.30 / kg), but cheap by the standards of the Western tourists who were the sole consumers. As well as the horses they have, were hired by external as well as by internal tourist for their easiness.

The literacy percentage of respondent households (73.21%) was higher than that of Syafru VDC which was only 50% (EIA Study 2000). Tourism related households especially hotel and lodges have greater percentage of literacy than that of herders family. The college level educated people were present in tourism related household which was absent in herders family. It might be the influence of occupation on their household in terms of education level. CREST (1995) states that the level of literacy among the younger generation of the Sherpa people was relatively high in Sagarmatha National Park. Some basic understanding of a second language (mostly English) among local people was more around the area where tourism was practiced

(Sagarmatha, Annapurna and Langtang); relative to other similar mountain people area where there was no tourism.

The percentage of vegetable production was found to be higher i.e. 54.60 % followed by maize 20.76 % and millet 7.3% (Table 8). This trend as a whole was followed by district too i.e. vegetables (27.71 %), maize (26.83 %) and millet (15.14 %) DDC, Rasuwa (1997). The practice of vegetables production was higher because of its market value. Upadhyay (1984) stated that in many parts of Sagarmatha National Park, many households have abandoned their traditional cropping practices of buckwheat and barley to cultivate more potatoes as they find the ready cash market because of tourism. Chettri et al. (1992) have also discussed the impact of tourism on land use in terms of horticulture activities in the Jomsom – Marpha area. EIA Report of Langtang Khola Hydropower Project (2001) stated that the cultural reason for cropping maize and millet was that the majority of Tamang and Sherpa have been traditionally utilizing alcohol as part of their life, and non of their rituals are completed without local beer (Jad) and wine (Raksi). Maize and millet were the best grains to brew wine and beer. Thus, the selection of such crops was culturally compatible even if the production was relatively lower (millet 729/ha and maize 1067/ha).

Chandan Bari is the center point for tourist as it was the way to Gosai kunda and the tourist coming from Lauribinayk to visit Langtant Valley. Tourists coming from both ways had one day rest at Chandan Bari. The number of tourist has increased since 1977 though it was decreased in insurgence period (Annex II; Table 4) but after agreement on peace by seven democratic parties the number of tourist visiting Nepal has been increased which has direct influence on Langtang National Park as it comes in third rank in area most visited by tourist Banskota and Sharma (1988). Among four hotels owners, three are of blood relation i.e. brother and sisters. Before 25 years they were too involved in animal husbandry occupation to fulfill their subsistent needs. CREST (1995) states that the Sagarmatha National Park, Langtang National Park and Annaurnapurna Conservation Area has diversified the local economies from a below subsistence farming and animal husbandry system to a tourism based economy within the last twenty years or so.

Annually hotels and lodges have to submit Rs 15,000 per year as National Park fee but since last seven years from the time of insurgence they have not paid because Maoist have given force not to pay any sum to National Park. LNP fact sheet, 2006 (Annex II; Table 5) showed the royalty from hotels of Langtang National Park has decreased from the fiscal year 54/55 to fiscal year 59/60 where as the royalty has been increased from number of tourists visiting the park from fiscal year 54/55.

Five herds family from Bharkhu area with 91 *Chauri* practice transhumance grazing system by their traditional management rules below 2000 m from November to April up to elevations as high as 4200 m (up to Lauribinayak) during April to November which was the prime grazing season. Fox et al. (1996) has stated that in 1992 herders from Bharkhu had 6 herds with 125 *Chauri* and had usufruct rights over 44 pastures between 1200 and 4000 m, many with in a kilometer of each other. Throughout the grazing seasons herders move the livestock from lower land to higher elevations in a definite pattern systematically. The low land pasture consists of privately owned land of Bharku which remains unfarmed during the winter season and moved regularly during this period as winter fodder becomes scared. Herders graze their livestock in mid- altitude pastures (2000-3000 m) during the upward migration in May and in the downward migration in September and October. Livestock migrate to high altitude pastures above Chandan Bari (above 3000 m) between June and August. Dates for moving herds upward were determined through group consultations a week in advance of the move. On the return trip downward, herdsmen were free to move according to their individual convenience. Decisions on where and how long herds may graze were based on the availability of forage in both summer and winter pastures, including all accessible forests and pastures.

From the survey, almost all households used fuelwood as the major source of energy for cooking and heating purpose as it was easily accessible. Petroleum gas, Kerosene, solar energy, battery and candles were considered as alternative sources of energy but they were used in few percent in comparison to fuel wood.

5.2 Vegetation Analysis

The different landforms with varied climate and soils support array of vegetation types characterized by sub-tropical to temperate and alpine condition. Further more vegetation with in forest type is greatly affected by differences in microclimate, aspect and altitude (Pandey et al. 1996). The vegetation of an area is the outcome of various geological, physical, chemical and biological factors. These factors interact among themselves and determine the distribution pattern of various plant species. In a community, all the species of plant do not usually show uniform distribution, especially, where there is variation in altitude, aspects and edhapic factors. These factors in general determine the distribution pattern of plants in community (Brooks 1969). More frequent species are more important than less frequent or rare ones. The common species have greater effect on distribution of the species.

The north facing study area contained mixed conifer forest with the dominancy of *Abies spectabilis*. HMG (1976) has indicated same type of forest in different parts of the Central Development Region in height between 3100m-3300m. The higher number of large saw timber in the study sites showed that the forest was in old growth stage. The southern slope of the study area had fire 60 years ago and only three *Rhododendron* barbatum in the first quadrate was found so the further calculation of the trees was not carried out. Odum (1971) said, in the area of crown fire all the vegetation will be destroyed and the biotic community must start to develop all over again, more or less from scratch , and it might be many years before the area was productive from mans point of view.

Density

Various factors like soil, altitude, vegetation type and anthropogenic activities influence the plant density. Among, trees, shrubs and herbs, herbs had the highest density than that of trees and shrubs. *Abies spectabilis* had the highest density 101 individual/ha of the study area. The total tree density recorded was 170 individual/ha which was less than Silori (2001) in Chamoli (174.81 tree/ha) and Pithoragarh (243.40 tree/ha) and greater than of Almora (144.60 tree/ha) of Nanda Devi Biosphere Reserve in Western Himalaya of India.

Basal Area

The total basal area recorded of the study area was 61.23 m^2/ha which was less than Shrestha (2001) value recorded in Annapurna Conservation Area which was 72.87 m^2/ha. *Abies spectabilis* had the highest basal area than that of *Rhodendron barbatum* and *Acer caudatum* i.e. 56.91 m^2/ha which was less than Byers (1996) value recorded in *Yangle Kharka* of Makalu- Barun National Park and Conservation Area which was 111.5 m^2/ha. The basal area was an indicator of the natural fertility of the site (Bruening 1968).

Important Value Index

Important Value Index (IVI) showed clear picture of the forest as well as of an individual species. *Abies spectabilis* had the highest IVI 207.9 % than that of *Rhodendron barbatum* and *Acer Caudatum.* So *Abies spectabilis* was the important species of the study area which value was greater than the value found by Byers (1996) 93.0 % for *Abies spectabilis* in *Yangle Kharka* of Makalu- Barun National Park and Conservation Area. Important Value Index (IVI) was quite understandable because of their higher values of relative frequency, relative density and relative dominance (Sullivan and Nixon 1971: and Adhikari et al. 1991). Shrub *Leontopodium jacotianum* (Table 22) and herb *Stellaria sp* (Table 24) had the highest IVI in the southern slope. Herb *Fragaria nubicola* and shrub *Berberis spp* were the most frequently occurring species of southern slope. *Berberis spp* and *Iris sp* present in southern slope might be the indication of heavy grazing. Baurer (1990) found that, in over grazed area unpalatable species (e.g. *Rhodendron anthropogon, Berberis spp*) and herbs (*Euphorbis wallichii, E. longifolia, Iris sp*) increases and the graminees decreases. As well as the presence of *unidentified plant (Successional plant)* in both northern slope and southern slope was unpalatable by herbivore which was found almost in all quadrate near by cowshed of heavy grazed area. Harper (1969) found, in severe grazing area, grazing acts as a stress and reduces the number of species to a few that are palatable. South facing slope had the highest intensity of grazing as compare to north facing slope as it lack trees which support for high dominance of herbs and shrubs. The IVI of *mosses* (Table 25) and shrub *Abelia sp* (Table 23) were found to be highest in north facing slope as it was the most important species in that community where as herb *Veronica himalensis* and *Abelia sp* were the most frequently occurring species. The northern facing slope gets less intensity of sunlight

and has greater moisture contents so the trees and ground vegetation was mostly covered with mosses, which absorbs water from the surrounding.

Species Richness

Variability of a natural community is well known. In the northern hemisphere, the intensity of sunlight is high as well as it has larger concentration of rainfall so the species composition of the south facing slope is greater. In north facing slope the species richness of the shrub and herb was found to be greater where as in south facing slope fire might have affected the species richness. Shrestha (2001) found 30 trees species and 15 shrubs species in Annapurna Conservation Area of which tree richness was greater than the study area but shrub richness was less.

Species Diversity

Diversity is applied to represent the variability (Pielou 1975). Species diversity is the function of number of species present in a given area and of the evenness with which the individuals are distributed among the species (Sai and Mishra, 1986). Values of Shannon diversity index for the real communities were found between '1.5 to 3.5' (Stilling, 2004) but the Shannon diversity index of the studied area of trees, shrubs as well as of herbs (Table 27) in both south facing and north facing were found to be below as given by Stilling (2004) and greater than the value of Shrestha (2001) for shrubs (0.86) and less for trees (3.58) of Annapurna Conservation Area. For any information-statistic index, the maximum diversity of a community is found when all the species equally are abundant (Stilling, 2004). Species diversity tends to be low in physically controlled ecosystem (i.e. Subject to physiochemical limiting factors) and high in biologically controlled ecosystem (Odum, 1971). The higher species diversity is an indication of maturity in the ecosystem (Marglef 1963, Odum 1969). The lower species diversity is as a result of incorporation of same species through competition. The species diversity of the study area has been affected by two factors; first by human disturbance i.e. fuelwood consumption and livestock grazing and second, the study area was situated in sub-alpine region where the growing period was short.

Dominance and Evenness Index

Dominance of the plant species is dependent on the ground coverage of the plant. In tree, due to large girth size dominance value was found to be higher than the shrub and herb. The studied period was conducted during the heavy grazing period so it might be the reason for the lower dominance of the herb than the tree and shrubs. Evenness index of the species was expressed as relationship of species to each other. Evenness index of tree, shrub and herb was found to be greater than ecological dominance as well as of Shannon diversity index (Table 27). The high value of evenness index of species indicated the low concentration of dominance (Odum 1969) and species were evenly distributed. Shrestha (2001) found evenness index of trees (0.73) and shrub (3.36) which was greater than the study area trees and shrubs of both slopes.

5.3 Human disturbance

All the hotels from Chandan Bari were insulated with timber to make the rooms warm as the study area lay in sub-alpine region. The density of cut trees density in the northern slope was found to be higher than the total tree density as well as the burned stem density in the southern slope was found to be greater than the live trees. The density of cut trees of study area was found to be higher than that of found by Silori (2001) in Chamoli, Almora and Pithoragarh of Nanda Devi Biosphere Reserve in Western Himalaya, India (Annex II Table 7).

5.4 Sustainable Yield of Fuel and Fodder

The sustainable fuel wood from the Chandan Bari forest area was estimated as 6.82 tons/year and the demand on the Chandan Bari area was estimated as 45.31 tons/year which shows there was surplus of fuelwood in the study area by 169.52 tons/year. In the mountain area (Chandan Bari), the growing season is very short and the forest growth rates is extremely slow, the rate at which forest biomass was consumed might be increased in future and the resources might be in crisis if undermined.

5.3 Analysis of soil

Living organisms, both microscopic and macroscopic helped to alter the parent material and make it into soil. Vegetation, no doubt is one of the obvious factors among them. Although, the forest growth is under the influence of climate, but it has a direct relation with the soil. According to Eyre (1966) the soil development is intimately connected with the vegetation. The fact that different kinds of plants have different effects upon the soil properties, is due to strong influence of microclimate at that level of soil because no two vegetation types provides exactly the same kinds of native forests. Therefore the study has been conducted to determine the nutrients content in the forest of Chandan Bari area. The physiochemical properties of the forest soil vary in space and time due to variation in topography, climate, weathering process, vegetation cover, microbial activities and several other biotic and abiotic variables.

Plant tissues are the main source for soil organic matter (OM), water holding capacity, texture and availability of the nutrients. Nutrient supply varies widely among ecosystems (Binkely and Vitousek, 1989), resulting the differences in the community structure and production. The vegetation zones of Nepal clearly reflect edhapic variations (Bhatta, 1981).

The moisture content of soil in the northern slope ranged from 21.2% - 26.6% and 14.3% - 19.4% in southern slope which was lower than Acharya (2004) found in the range of 11.22-16.47% in Mustang in Site I. It might be due to more ground cover with higher density of trees and shrub in the northern slope. The southern slope was more open with lesser canopy cover so the radiation effect was high, resulting the lower moisture content. The agricultural land possesses moisture content ranged from 15.9% - 20.1% which might be because of higher radiation.

The water holding capacity of the soil is an important factor for the good regeneration of trees and the saplings. The water holding capacity value was also higher in regenerating areas due to high litter content. The water holding capacity ranged from 84.5 % - 93.3% in the northern forested area, 70% - 83.7% in the southern burned forest and 63.3% - 80% in the agricultural area. The higher water holding capacity of the study area might be due to the presence of higher organic matter content. In

general, soils with higher organic matter contents have higher water holding capacities than soil with low organic matter content (Brady, 1974). Daubenmire (1968) had reported that organic matter may soil as much as 9 times its own weight of water.

The pH of the soil revealed that the northern slope study area possesses strongly acidic soil in the range between 4.4 - 4.9 where as Site III and Site VI possesses fairly acidic soil i.e. 5.1 and 5.2. The southern slope soil possess fairly acidic then northern slope in the range between 5.1 – 5.5 where as the agriculture soil posses fairly acidic to neural type of soil in the range 5.6-7.1. Such less acidic nature of soil was usually believed to be caused by the presence of ash accumulation due to burning and by the resulting release of soluble mineral salts especially those containing calcium (Griffith, 1943). The agricultural land on Chandan Bari was made on the burned remaining of forest. Agricultural Research Station Dhunche, Rasuwa Annual Report 2004/05 found the pH of the soil of Rasuwa District in the range 5.2-5.5. HMG (1976) found pH in the range of 6.0-6.8 in Kalingchowk and 6.7 in of the Central Development Region. Howell 1987 found the soil pH range between 5.5 – 6.06 for Mountain forest soil, 4.4 – 5.8 reported by Juwa 1989 in Nagarkot Hill. Singh and Singh 1989 found pH in the range 4.4-5.8 in Central Himalayas.
According to Singh and Singh 1989, pH range of 4.5-5.5 is good for the sapling growth and the value of the present study of both southern and northern slope also fall near to this range except agricultural soil.

Organic matter (OM) is an important parameter of soil that determines the nature of soil and vegetation distribution. Organic matter is the chief source of minerals return to soil and contributed by dead bodies of plants and animals as well as micro- and macro- organisms living in the soil. The organic matter ranged from 9.76% to 15.77% in the burned forest of southern slope and 17.11% to 19.02% in the northern forest area. The higher organic matter content in the northern forested area could be due to the accumulation of leaf litter and humus (black) content as well as the presence of dense tree canopy. It was also supported by Shrestha (1999) that less disturbed forest with dense tree canopy has highest value of organic matter. And in the southern slope it might be due to the remaining burned vegetative materials.

The agriculture land of the Chandan Bari's organic matter contents ranges from 6.21 – 16.2% which might be because of the utilization of *Chauri* manure. Where as its value was found to be lower than forested area of northern and southern slopes, which might be the effect of cultivation.

According to Suoheimo (1995a) the value of organic matter in the range of 1.7-2.33%, is an indicator of low fertility status of soil and value of the present study of both southern and northern slope as well as of agriculture land was higher than this value indicating high fertility status of soil. Organic matter is high in poor regenerating area (Bhatnager, 1965). Soil under the dense tree canopy used to be significantly higher in organic matter and nitrogen (Isichei and Monghalu, 1992).

Nitrogen content in southern slope contained in the range 0.2% – 0.25% and in the northern slope in the range 0.154% - 0.392%. This value was higher than the value 0.18-0.28% as reported by Juwa (1989) in Nagarkot, 0.148-0.1835% as reported by Acharya (2004) in Manang in the northern slope and more or less equal in the southern slope. The agriculture land possesses nitrogen in the range of 0.21-0.29. The higher value of nitrogen of northern slope might be due to the higher amount of organic matter. Nitrogen fixation and mineralization was limited by low pH (Greene, 1963) which also agrees with present findings. High value of nitrogen in southern slope might be due to the increase in the organic matter in the burnt soil. The condition in which nitrogen increased after burning results from rapid mineralization of litter and associate enrichment of the soil (Stark, 1979). Pandey (1976) also found that the burn plots indicated higher nitrogen in the soil. Total nitrogen was found to be higher than available phosphorous and potassium in northern and southern slope and as well as in agriculture land of the study area.

Available Phosphorous was found to be higher in south facing slope (Table 31); this might be the effect of fire. Similar results were obtained by Gentle (1996) in the Sal (*Shorea robusta*) forest in Bara District of Nepal. At higher pH values, uptake decreases as the concentration of $H_2PO_4^-$ goes above pH 5. It is generally believed that phosphate concentration is higher in soil with pH 6 to 6.5 (Russel, 1988). The low amount of phosphorous in northern slope might be due to the rapid utilization by large

sized trees for the production above ground biomass. The low value of phosphorous was also due to the formation of iron and aluminum phosphate (Donahue, 1970).
Potassium was found to be higher in agriculture land than that of southern and northern slope. Burned forest of southern slope possesses high value of potassium than northern forest. Soil potassium increases as the soil pH decreases (Black, 1968). This exchangeable potassium ion may also loss through continuous runoff and leaching under land of uneven topography (Allen, 1964).

4.4 Drinking Water Quality

The temperature of drinking water measured at stream of Chandan Bari showed slightly week variation. The temperature of water was considered as major controlling factor of some water parameters like dissolved oxygen, metabolic activities of aquatic life either flora or fauna and others.

The chloride concentration of drinking water of Chandan Bari was found to be below the USPH standard, ISI standard and WHO guideline 250 mg/l (WHO, 1993).

Dissolve oxygen shows slightly variation in three weeks. DO, COD and BOD has the inverse relation i.e. when BOD and COD increase the value of DO decreases. DO, BOD and total solid contains of water are considered as the most important parameters in defining water quality (Wolverton and Mc Donald, 1975). According to WHO guideline water having DO lower than 5 mg/l is not suitable for drinking (WHO, 1971). According to USPH and ISI standard domestic supply water should contain DO between 4 to 6 mg/l respectively. As Chandan Bari drinking water had average DO 7.96± 0.2 mg/l, it showed the absence of organic waste and it was suitable for drinking as well as for domestic uses.

Amount of free CO_2 was directly influenced by the respiratory activities of the organisms and the degradation of organic waste present in water. The degradation of organic matter requires oxygen and this phenomenon lowers the amount of dissolved oxygen so, the amount of free CO_2 was inversely related with DO. Anonymous (1973) has pointed out aquatic organisms are greatly affected when CO_2 content of water exceeds 25 mg/l. All the values recorded have lower free CO_2, indicating the absence of organic matter in the water which was suitable for drinking purpose.

Alkalinity is considered by three different groups as hydroxyl group, carbonate group and bicarbonate group. Alkalinity is also responsible for changing pH level of water, since CO_2 present in air readily soluble in water forming a weak carbonic acid which is unstable and dissociated into bicarbonate and hydrogen ion, these hydrogen ion change the pH of water. During the study period of Chandan Bari area, phenolphthalein alkalinity was obtained zero which showed absence of hydroxyl ions and carbonate ions in the drinking water. Total alkalinity obtained in water might be due to the presence of bicarbonate ions.

Hardness was due to the carbonate and bicarbonate compounds of calcium and magnesium. Water having 45 ppm hardness value is said to be very soft and more than 230 ppm is said to be very hard. The water of Chandan Bari lay with in 6 mg/l, not exceeding the minimum value of hardness, which indicates the water of Chandan Bari was very soft. Water having hardness value lower than 500 mg/l is considered as portable water (WHO, 1993 & DWSS, 2006). All the values recorded during the investigation period lay with in WHO guideline so it is safe for drinking purpose.

Conclusion

In the study area the subsistent need of the people is fulfilled by animal husbandry, tourism and agriculture. The establishment of cheese factory in Chandan Bari and Langtang valley by DDC in 1952 (before LNP was gazeted), has flourished animal husbandry (especially *Chauri*) in the Rasuwa district for the production of cheese, of which foreign tourists are the sole consumers as cheesed produced there is transported to Kathmandu mainly for western tourists. The herders of the study area practice transhumance grazing system from the sub-tropical Bharku to Lauribinayak above tree line. The revolution has been taken place in the field of profession from animal husbandry to tourism by the expedition of the LNP area by Major H.W. Tilman's (June 1949). Many of the households involved in animal husbandry before are hotel owner of Chandan Bari nowadays. The agricultural production pattern has been changed from crops to vegetables which were also for the tourist.

People inhibiting Chandan Bari are directly or indirectly dependent upon tourism as income generating sources which is directly dependent upon forest resources for fuel wood, timber as well as fodder for *Chauri* of the study area.

The human disturbance is found to be very high, as density of cut stems (165 indi. /ha) are found more or less equal to live trees (170 indi. /ha) and the grazing area has been invaded by wild species like Berberis spp as well by poisonous species.

Though human disturbance was found to be higher, fuelwood demand is lower than sustainable supply. The sustainable fuelwood supply was higher because the number of trees having DBH greater than 25 cm was higher. The fuelwood demand might be in crisis in future because the sapling and pole size trees were very few in number than small saw timber and large saw timber trees. This is because the study area is situated in the sub-alpine region where the growing season is very short and the people inhabiting Chandan Bari cut down the trees of sapling and pole size as it is very easier for them to cut down than big size trees.

In northing facing slope the forest is in old growth stage as it has higher number of large saw timber of mixed conifer of *Abies spectabilis, Rhodendron barbatum* and *Acer caudatum*. The south facing slope was without the seedlings of the tree species (e.g. *Abies spectabilis, Rhodendron barbatum* and *Acer caudatum*) which indicates that the regeneration of forest might took several years to be in its original stage before it caught fire.

The soil of both agricultural land and forest land of Chandan Bari was found to be in virgin condition which might be the baseline for further investigation of soil quality.

Although the biological Parameter of drinking water could not be conducted but the physical-chemical parameters of water was found to be with in WHO, USPH, ISI, and DWSS limit which indicates the available water is useful for drinking purpose as well as for the domestic purposes and might be the baseline for further investigation of water quality.

Recommendations:

1. Electricity for lighting as well as heating the room (as maximum fuel wood is used for heating purpose) and solar power for lighting and heating the water, which decreases the demand on fuel wood.
2. For the better management and conservation of national park public participation is very necessary. So the collaboration of local people and park must be promoted for equal distribution of resources which helps in better management and conservation of the resources.
3. The tourist's carrying capacity of the area in terms of environment, social and economical situation should be investigated. Tourist numbers should be limited according to the capacity of the areas.
4. Both local and foreign tourists should be charged equally and avoided discrimination.
5. Opening of hotels and lodges above Chandan Bari should be discouraged as the area is in tree line and the regeneration of the forest resources is very slow.
6. The price of the milk/liter should be increased by the DDC so herders can maintain the minimum number of *Chauri* so there will be sufficient resources for them to feed.

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Annexes

Annex I

Vegetation Analysis

Density: Density or population density is population size in relation to some unit of space. Density represents the numerical strength of species in the community.

Density (ind. per hectare) = {I/(AxN)} x 10000

Where,

I = Total number of individuals

A = Area of each sampling plot

N = Total number of plot

Relative Density (%) = (D/T.D.) x 100

Where,

D = Density of species A

T.D. = Total density of all species.

Frequency: It simply refers to the number of times a certain species occurs thus it shows the degree of dispersion of a species in terms of percent of occurrence.

Frequency (%) = (F / T.F.) x 100

Where,

F = Frequency of species A

Relative Frequency (%) = (F / T.F.) x 100

Where,

F= Frequency of species A

T.F. = Total frequency of all species.

Coverage: The amount of surface area occupied by a species is estimated in quantitative terms. The estimation of the range value covered by a species is done by visual is converted into a scale given in Zobel et. al (1987.) as shown in table below. This is applicable for shrubs and herbs only.

Table 1: Coverage Classification

Scale Value	Range of Cover (%)	Mid Point of Cover (%)
1	0 - 1	0.5

2	1 - 5	2.5
3	5 - 25	15
4	25 - 50	37.5
5	50 - 75	62.5
6	75 - 95	85
7	> 95	97.5

Relative Coverage (%) = (C / T.C) x 100

Where,

C = Coverage of a species

T.C. = Total coverage of all species

Basal Area: The size of a tree is usually described by the size of its trunk (i.e. circumference diameter of basal area) and by its total height. Trunk size is usually determined at a height of 1.37m above the average level at the base of the tree called the breast height. Often tree trunk size is expressed as the area of its cross section at breast height called basal area.

Basal Area (B.A) $= \Pi r^2 = \frac{\Pi d^2}{4}$

Where,

d (m) = mean diameter at breast height of the individuals of that species

Relative Basal Area (%) = (B.A. / T.B.A.) x 100

Where,

B.A. = Basal Area of species A

T.B.A. = Total basal area of all species.

Height of tree (H) = $d \cos \alpha (\tan \theta_1 - \tan \theta_2)$

Where,

d= distance between tree and the person

α = middle angle from the clinometers

θ_1 = top angle from the clinometers

θ_2= bottom angle from the clinometers

Stand size: the following stand size classes as used by Forest Inventory Division (FSDD 1988 a/b) were adopted in this study area for stand size classification.

Table 2: Stand size classification

Symbol	Stand Size	DBH (cm)
1	Sapling	< 12.5

2	Poles	12.5 - 25
3	Small saw timber	25 - 50
4	Large saw timber	> 50

Tree Volume

The computerize calculation system called inventory (INV) developed by the Forest Inventory Section, Ministry of Forest and Soil Conservation, Nepal (FSDD,1991 b) was used for the calculation of resources of the Chandan Bari area forest. INV was used to estimate the volume of each individual tree. The system estimates for computing the total volume of the whole stem is

$$Ln (V) = a + b \times Ln (d) + c \times Ln (h) s$$

Where, Ln refers to logarithm

V = total stem volume with bark

D = diameter at breast height

H = total height

a, b and c are the volume parameters, which are constant for each species but different between specie. The volume parameters were obtained from the study carried out by Forest Survey and Statistical Division (FSDD, 1991a).

Biomass of stems, branches and foliage

INV can also compute the biomass of stems, branches, foliage and whole tree. Stem biomass is obtained by multiplying the stem volume by wood density. Wood density was obtained by multiplying the stem by wood density. Wood density was obtained from Forestry Sector Master Plan, 1988 (HMG, 1988). For obtaining the biomass of branches (fuel wood) and foliage (fodder), ratio of branch to stem biomass and foliage to stem biomass were applied for various species (HMG, 1988).

Estimates of Annual Yield

The Master Plan for the forestry sector of Nepal (MPFSN) has estimated the annual yield of different forest types of High Himal for the Central Development Region. The percent annual yield estimated by the Master Plan in similar forest types of Central Development Region were applied to estimate the annual yields of forest in the study area. The annual yield of the High Himal fir forest and mixed / other conifer

forest was used for the annual yield of the tree species (*Abies Spectabilis, Acer caudatum and Rhodendron barbatum*).

Estimation of Sustainable Supply

Sustainable wood harvest of the stem and branch growth, and stem and branch mortality with only 15 % of the stem growth allocated for timber and rest (85 %) for fuel wood assuming recovery factor for High Mountain is 90 % (HMG, 1988). The annual accumulation of dead wood is 4.9% of the annual yield, (HMG, 1988). Hence, for the calculation of fuel wood from dead wood, 4.9 % of the total wood was considered as fuel wood.

Table 3: Growing stock and annual yield (tons/ha) in the natural forest of High Himal of Central Development Regions, Nepal (Source: HMG, 1988)

Forest Type	**Forest Biomass (T / ha)**			**Annual Yield (T / ha)**			**Percentage Yield (%)**		
	Stem	Branch	Leaf	Stem	Branch	Leaf	Stem	Branch	Leaf
Fir forest	19.01	7.83	3.45	0.21	0.09	0.04	1.12	1.15	1.10
Mixed /other conifer forest	9.26	3.31	1.02	0.11	0.04	0.01	1.22	1.17	1.26

The yield from leaf biomass can be used as fodder if the tree is fodder species.

Importance value: Importance Value Index (IVI) was proposed by Curtis (1959) as an index of vegetation importance with in a stand. The dominancy of any species in an area is estimated with respect to its importance value which is the combined effect of relative density, relative frequency and relative basal area. The basal area is replaced by coverage in case of shrubs and herbs.

IVI (%) = R.D. + R.F. + R.B.A. (for trees)

IVI (%) = R.D. + R.F. + R.C**.** (for shrubs and herbs)

Where,

R.D. (%) = Relative Density

R.F. (%) = Relative Frequency

R.B.A. (%) = Relative Basal Area

R.B.A. (%) = Relative Coverage

Indices of Species Diversity: A large number of rare species determine the species diversity in a community. Species diversity is the ratio between the number of species and importance value of individual (Odum 1971). They are calculated by the formula as given in the Odum (1971),

The Shannon's diversity index of general diversity (H) is an overall index of diversity.

$H = - \Sigma(ni / N) \log (ni / N)$

Where,

ni = importance value for each species

N= total of importance values

Species Richness and Evenness index (e): species richness is simply the number of species per unit area (Pielou, 1975). Evenness index stated by Maguran (1988) as another component of diversity is calculated by using diversity index:

$E = H / \log S$

Where,

H= Shannon's diversity index

S= number of species

Index of Dominance: All organisms in a community are not equally important in determining the nature and the function of the whole community out of hundreds and thousands of organisms that might be present in a community. A relatively few species or species groups which largely control the energy flow and strongly affect the environment of all other species are known as ecological dominants.

$C = \sum (ni / N)$

Where,

C = index of dominance

ni = importance value for each species

N = total of importance value

H values behave inversely with the index of dominance. Higher the value of 'H' indicates a low concentration of dominance. Higher diversity means longer food chains and more cases of symbiosis, which reduces oscillations, and hence increases

stability. Species diversity tends to be low in physically controlled ecosystems and high in biologically controlled ecosystems.

Soil Analysis

Moisture Content

Procedure: - Fresh weight of 50 gm was taken and oven dried at temperature 110^0 C for 24 hours. The soil was weighted again to obtain the dry weight of the soil.

Calculation:

$$\text{Moisture Content of the soil (\%)} = \frac{\text{Fresh wt.} - \text{Dry wt.}}{\text{Fresh wt.}} \times 100$$

Water Holding Capacity

Procedure: - 20 gm of oven dry soil was taken in the saturated filter paper kept in funnel. The water was poured in it from above, drop wise, till the soil was just saturated. The ml of water consumed was noted to find out the WHC of the soil.

Calculation:

$$\text{Water Holding Capacity (\%)} = \frac{A - B \times 0.05 \text{ ml} \times 100}{\text{gm of soil taken}}$$

Where, A = ml of water consumed just before drop of water fall

B = drops of water fall from the funnel

pH

Procedure: - An air dried soil was dissolved in distilled water at 1: 5 soil-water ratios in a clean beaker taking 20 gm of soil and 100 ml of distilled water. The soil suspension was stirred for half an hour at regular intervals. The pH of the unfiltered soil suspension was measured by an automatic digital pH meter (HI 8314 portable pH meter, HANNA instrument with an accuracy of ± 0.0. at 20^0C/ 68^0F).

Conductivity

Procedure: - An air dried soil was dissolved in distilled water at 1 : 5 soil-water ratio in a clean beaker taking 20 gm of soil and 100 ml of distilled water. The soil suspension was stirred for half an hour at regular intervals. The conductivity of the unfiltered soil suspension was measured by using a digital conductivity meter (Model 4150 by Wagtech with accuracy of ± 0.5%).

Organic Matter Content

Procedure: - 0.25 gm of soil sample passed through 600 µm was taken in a clean 500 ml conical flask. 10 ml of 1N $K_2Cr_3O_7$ and 20 ml of conc. H_2SO_4 was added on the conical flask and was mixed by gentle rotation. The mixture was then allowed to stand for 30 minutes to react. After 30 minutes, the mixture was diluted with 200ml of distilled water and 10 ml of phosphoric acid was added followed by 1 ml of diphenylamine indicator. Then the sample was titrated with 0.4 N ferrous ammonium sulphate; at the end point color changes to brilliant green. A standardization blank (without soil) was run in the same way.

Calculation:

a. $\% C = \frac{3.951}{g} \times 1 - \frac{T}{S}$

b. % Organic matter= % C x 1.724

Where, g= weight of sample in gram

T= ml ferrous solution with sample titration

S= ml ferrous solution with blank titration

Nitrogen content

Procedure: - 1 gm of soil sample passed through 200 mm sieve was kept into the Kjeldahl flask. 10 ml of distilled water was added and was leaved for 30 minute to moisten the soil. 2 gm of catalyst digestion and 10 mi of conc. H_2SO_4 was added and mixed gently by swirling. The mixture was left for few minutes to be cooled. The flask was digested for one and half hour until the mixture changes to green-blue or grey color with proper care during digestion not to allow the flame to touch the flask above the part occupied by the liquid to avoid any undue loss of NH_3 by decomposition of ammonium sulphate at high temperature. The digest was cooled and 20 ml of distilled water was added before the solution starts crystallizing and transferred into the beaker. 20 ml of sample from the digested mixture and 20 ml of 4% NaOH was kept in the Kjeldhal flask. A 100 ml beaker containing 10 ml of 4% boric acid and 2 drops of mix indicator was placed below the condenser. The heat was given until the mixed indicator in the beaker turned blue. This was titrated against 0.01 N HCl until the color changed to light brown-pink. . A standardization blank

(without soil) was run in the same way. Total nitrogen content of the soil was calculated by the formula given by Pradhan, 1996.

Calculation:-

$$\% N = \frac{7 \times n \times (T-B)}{S}$$

Where, T = ml of HCl used with sample

B = ml of HCl used with blank

n = normality of acid

S = weight of soil taken

Nitrate

Procedure: - 50 gm of air dried soil was taken in a 500 ml of conical flask and 250 ml of nitrate extract solution was added and the flask was shaken well for 10 minute. 0.4 gm of $Ca(OH)_2$ was added and shaken well for 5 minute followed by the addition of 1 gm $MgCO_3$.These two reagents were added to precipitate Cu and Ag and the suspension was clarified. The solution was filtered through filter paper and first 20 ml of filtrate was discarded. 50ml of filtrate sample was taken in porcelain basin and evaporated to dryness. The porcelain basin was cooled and 2 ml of phenol disulphonic acid was added and the content was diluted to 50 ml adding distilled water. 6 ml of liquid ammonia was added to develop a color. The reading was noted down using spectrophotometer at absorbance 410 nm. The concentration of the nitrate nitrogen is calculated from the standard curve. A standardization blank (without soil) was run in the same way.

Calculation:-

$$\% \text{ nitrate-N} = \frac{NO_3\text{-N mg / L of soil extract} \times V}{1000 \times S}$$

Where, V = volume of total soil extract prepared (ml)

S = weight of soil taken

Available Phosphorous

Procedure: - 1gm of air dried soil was taken in a 500 ml of conical flask and 200 ml of 0.002 N H_2SO_4 was added. The suspension was shaken for half an hour and filtered using filter paper. In 50 ml of filtrate ammonium molybdate was added followed by 5 drops of stannous chloride giving blue color to sample. The reading was noted down

at 690 nm absorbance using spectrophotometer using distilled water as blank with same amount of chemicals. The reading of the sample was noted down after 5 minute but before 12 minute of the addition of the last reagent. The concentration of the phosphorous was found out with the help of standard curve.

Calculation:-

$$\% \text{ of available phosphorous} = \frac{\text{mg P / L soil solution}}{50}$$

To convert the values in mg / 100gm, the result in % was multiplied by 1000.

Potassium

Procedure: - 25 gm of soil was taken and mixed with ammonium acetate solution. The solution was mixed thoroughly with the help of glass rod for fifteen minutes then the solution was filtered. The filtrate was washed with alcohol for three times. The washed filtrate was mixed with ammonium acetate and left for 24 hours. Again the filtration process was carried out and washed with ammonium acetate. 250 ml of filtered solution was taken and the concentration of potassium was taken at 768 nm with the help of flame photometer.

Calculation:-

$$\text{Potassium, mg / 100gm} = \frac{\text{mg K / L of soil extract x V}}{10 \text{ x S}}$$

Where, V = Total volume of soil extract prepared (500 ml in each case)

S = Weight of soil taken (50 gm)

Drinking Water Analysis

Temperature

Drinking water temperature was measured with the help of a mercury thermometer of -10^0C to 50^0C range with 0.2^0C least count. The bulb of the thermometer was dipped in the sample bottle filled with water for about 2 minutes and the reading was noted down.

Free Carbon dioxide

Procedure: - 50ml of water sample was taken in a conical flask and a few drops of phenolphthalein indicator were added. The sample remained colorless indicating the

presence of free CO_2 so the sample water was titrated against 0.05N NaOH. The end point was noted down by the appearance of pink color.

Calculation:-

$$\text{Free } CO_2 \text{ (mg/lit)} = \frac{(\text{ml} \times \text{N}) \text{ of NaOH} \times 1000 \times 44}{\text{Volume of sample taken}}$$

Dissolve Oxygen (D.O.)

Procedure: - The water sample was collected in a 300ml BOD bottle avoiding any kind of bubbling and trapping of air bubbles in the bottle after placing the stopper. To the sample, 2ml of alkaline KI solution were added. Then the stopper was placed tightly and the bottle was shaken well in '8' shaped. Then the bottle was left for a while to allow the precipitate to settle. 2ml of concentrated H_2SO_4 was added to dissolve the precipitate by shaking the content well. Then 50ml of the content of BOD bottle was titrated with standard sodium thiosulphate (0.025 N) using starch as an indicator. At the end point, initial blue color changed to colorless.

alculation:-

$$\text{D.O. (mg/lit)} = \frac{(\text{ml} \times \text{N}) \text{ of titrant} \times 8 \times 1000}{V2 \times \frac{V1-V}{V1}}$$

Where, N= strength of sodium thiosulphate

V2= volume of content titrated

V1= volume of sample bottle (BOD bottle)

V= volume of $MnSO_4$ and KI added

Chloride

Procedure: - 50ml water sample was taken in a conical flask and 2 ml of potassium chromate was added to it as an indicator. Then it was titrated against 0.02 N $AgNO_3$ until persistent red tinge appear.

Calculation:-

$$\text{Chloride (mg/lit)} = \frac{(\text{ml} \times \text{N}) \text{ of } AgNO_3 \times 1000 \times 35.5}{\text{Volume of sample taken}}$$

Total Alkalinity

Procedure: - 50ml of water sample was taken in a conical flask and a few drops of phenolphthalein indicator were added to it. The sample remained colorless so 2 to 3 drops of methyl orange indicator was added on it and titrated against 0.1N HCl. At the endpoint, yellow color changed to pink.

Calculation:-

Phenolphthalein alkalinity as CaCO3 (mg/lit) = $\frac{(A \times N) \text{ of HCl} \times 1000 \times 50}{\text{Volume of sample taken}}$

Total alkalinity as CaCO3 (mg/lit) = $\frac{(B \times N) \text{ of HCl} \times 1000 \times 50}{\text{Volume of sample taken}}$

Where, A = volume of HCl used only with phenolphthalein

B = volume of HCl used with phenolphthalein and methyl orange

N = Normality of HCl used

Table 4: Concentration of carbonate, bicarbonate, hydroxyl ions for determined from the table using data of PA and TA.

Result of Titration	OH alkalinity as $CaCO_3$	CO3 alkalinity as $CaCO_3$	HCO3 alkalinity as $CaCO_3$
P = 0	0	0	T
P < 1/2 T	0	2P	T - 2P
P = 1/2 T	0	2P	0
P > 1/2 T	2P - T 0	2(T - P)	0
P = T	T	0	0

Source: Trivedi and Goel., 1984

Where, P = Phenolpthalein alkalinity

T = Total alkalinity

Total Hardness

Procedure:- 50ml of water sample was taken in a conical flask and 1ml of buffer solution was added. A small pinch of Erichrome Black-T indicator was added and the content was titrated against standard EDTA solution. At the endpoint the wine red color of the solution changed into blue.

Calculation:-

Total Hardness as CaCO3 (mg/lit) = $\frac{\text{ml of EDTA used} \times 1000}{\text{Volume of sample taken}}$

Calcium Hardness

Procedure: - 50ml of water sample was taken in a conical flask and 2ml of NaOH (1N) solution was added which was followed by murexide as an indicator. Then the content was titrated against EDTA solution. At the endpoint, pink color changed to purple.

Calculation:-

Calcium hardness as CaCO3 (mg/lit) = $\frac{\text{ml of EDTA x strength of EDTA x 40.08 x 1000}}{\text{Volume of sample taken}}$

Annex II

Table 1: General Introduction of Langtang National Park

Head Quarter	**Dhunche, Rasuwa District**
Development Region	Central
Gazetted Year	1974
Area Covered	1719 km^2
Altitude	1000m - 7245m
Latitude	$85^0$15' - $86^0$0' E
Longitude	$28^0$0' - $28^0$20'
Sacred Himalaya Landscape	
Floral Diversity	**> 1000 plant species**
Endemic Flora	21 species
Faunal Diversity	
Mammals	48
Birds	345*
Amphibians + Reptiles	11
Fishes	30
Speders	10
Butterfly	58
Buffer Zone Declaration	**1998**
Buffer Zone Area	420 km^2
District	3
VDC	15
User Committee	21
User Group	315

(Source: LNP Fact Sheet, 2006)

Table 2: Approximate area encompassed by different vegetational zones within the Park

Vegetation Zone		**Area (km^2)**	**% of Park's Area**
I	Tropical	2.8	0.2
II	Subtropical	34.4	2
III	Hill	82.9	4.8

IV	Montane	168.6	9.9
V - VI	Subalpine	368.6	21.5
VII	Alpine	428.1	25
VIII	Snow and Ice	546.7	31.9
Cleared Forest		9.1	0.5
Burnt Vegetation		26.7	1.6
Cultivations		43.5	2.5
Total		**1711.7**	**99.9**

(Source: DUHE, 1982)

Table 3: Land Use Pattern of Buffer Zone Area

Land Use Type	**Area (km^2)**	**% Coverage**
Cultivation	118.35	28.9
Forest	129.8	31.04
Grassland	58.45	13.97
Shrub Land	106.12	25.36
Others (Rock/Ice)	5.59	1.34
Total	**420**	**100**

(Source: LNP Fact Sheet, 2006)

Table 4: Tourist Record in LNP

Fiscal Year	**No. of tourists**
035/036	883
036/037	1377
037/038	1398
038/039	2376
039/040	1865
040/041	2107
041/042	2448
042/043	3151
043/044	3796
044/045	5089
045/046	6162
046/047	6318
047/048	7180
048/049	8674
049/050	8677
050/051	6342
051/052	8637
052/053	7934
053/054	7066
054/055	8808
055/056	10889
056/057	12754
057/058	13166
058/059	8880

059/060	6660

(Source: LNP fact sheet, 2006)

Table 5: Income of LNP (FY 2054/55 – 059/60)

Type of Income	FY 54/55	FY 55/56	FY 56/57	FY 57/58	FY 58/59	FY 59/60
Tourist entry fee	1058850	1395225	5919650	7259900	4369200	3327300
Helicopter landing fee	-	-	-	6000	36000	26000
Royalty from hotel	1167560	273159.8	521227	446121.4	401621.2	400767
Permit for timber, stone, bamboo & rattan	405670.6	167567.7	595433	697689.8	2182295	328388
Punishment	8831	500	66926.52	2167	50425	7475
Others	200	600	14325	72214.5	25906	400
Vat	-	-	16488.08	66175.84	22675.53	32738
Total	**2641112**	**1837052**	**7134050**	**8550268**	**7088123**	**4123068**

(Source: LNP fact sheet, 2006)

Table 6: Fire Wood Consumption by Tourists

Destination	Local Population	% Increase of trekkers	Demand over local needs
SNP	3000	1968*	85.2
LNP	6588	4322*	18
ACAP	7000	4592*	4.7

(Source- ERL (1989): Annex C Table 1)

*-annual fuel wood consumption (000kg)

(SNP- Sagarmatha National Park, LNP- Langtang National Park, ACAP- Annapurna Conservation Area)

Table 7: Wood cutting in the study area and in the buffer zone of NDBR

Pressure Parameter	LNP (Chandan Bari)		NDBR		
	Northern slope	Southern slope	Chamoli	Almora	Pithoragarh
Total tree density (tree/ha)	170	4.8	174.81	243.4	144.6
Density of cut trees (tree/ha)	165	-	45.67	12.5	25.78
Density of burned trees (tree/ha)	-	124	-	-	-

Annex III

Table 1: Vegetation Sampling Sites Description of South Facing Slope

Site	Altitude (m)	Slope (^{0})	Direction (^{0})
1	3250	28	S 40 E
2	3248	37	S 15 W
3	3250	27	S 20 W
4	3250	24	S 10 W
5	3250	31	S 12 W
6	3250	26	S 20 W
7	3250	28	S 15 W
8	3250	25	S 20 W
9	3250	30	S 25 W
10	3250	32	S 15 W

Table 2: Vegetation Sampling Sites Description of North Facing Slope

Site	Altitude (m)	Slope (^{0})	Direction (^{0})
1	3108	14	N 40 W
2	3108	23	N 20 E
3	3105	22	N 30 W
4	3102	13	N 45 W
5	3108	19	S 40 W
6	3109	24	N 14 W
7	3108	16	N 15W
8	3108	18	N 12 W
9	3108	15	N 14 W
10	3108	17	N 13 W

Appendix-1

Questionnaire:

Date of interview:

1. Name of the respondent……
2. village name
3. Ward no.
4. Elevation
5. Respondent gender
6. Age
7. Family no
8. A group of family number

No./ Age group	> 15	15-60	60+
Male			
Female			
Total			

9. Education of family member

No./ Level	Illiterate	Literate	LSS	HSS	CE
Male					
Female					

(LSS-lower secondary school, HSS-higher secondary school, CE- collage education)

10. Are there certain times of the year when dropout rates go up?
    □ No □ yes
11. If yes when?
    ……..
12. Where does your family get its drinking water?
    ……..
13. Do you have toilet facility in your house?
    □ pit method □ traditional □ open space
15. What is your family member occupation?

Occupation	Family number
Agriculture	
Animal husbandry	
Business	
Dependent population	
Foreign earning	
Service	
Skilled labor	
Student	

16. How much total agricultural land is owned by your family?
    □ < 0.5 □ 0.5-2 □ 1.0-2 □ > 2

17. Do you use fertilizer?

☐ no

☐ yes → what kind? ☐ manure
☐ compost
☐ chemical
☐ mixed
☐ other ……..

18. What are the main agricultural crops?

Crop	Value (kg/year)
Barley	
Buckwheat	
Karu*	
Maize	
Millet	
Pulses	
Vegetables	

(*-local name)

19. Does your household agricultural production meet your annual food needs?

☐ no → a) for how many months is your family food defecit?
☐ > 1 month ☐ 6-9 months
☐ 1-3 months ☐ 9-12 months
☐ 3-6 months

→ b) how do you compensate?
☐ agricultural labor ☐ animal husbandry
☐ portering ☐ business / trade
☐ loan ☐others

☐ yes → is there a surplus?
☐ No
☐Yes → how it is used? ☐ given away
☐ Exchanged/bartered
☐ Sold for cash

20. In last five year did you change your crop grain?

Year	Name of the crop	Reason
1		
2		
3		
4		
5		

21. Livestock types, number and feeding type?

Type	Feed type		
	Stall feeding	Grazing	Both

Cattle			
Sheep			
Goat			
Yak			
Nak			
Chauri			

22. Products from milk

Cheese	Butter	Yogurt	Ghee	Buttermilk	Churpi *	Sayar *

(*- local name)

23. Where do you mostly graze your livestock and how far it is?

……..

24. In which season do you graze your livestock in pasture land?

……

25. How many days you graze your livestock in certain area?

…….

26. Do you have herder committee?

□ Yes □ No

27. How does the herder committee perform their task?

…….

28. Please identify which of the following you use, how much, where you get from, what you use it for and in what amount you get it?

Type	Amount/Use	Price/Stack or Unit	Uses
Fuel wood			
Kerosene			
LPG			
Solar power			
Electricity			
Batteries			
Cow dung cakes			
Crop residues			

Fuel wood=per stack
Kerosene=per liter

1= cooking
2= heating
3= lighting
4= other

29. What is your family's main source of income? Please rank them in order of importance.

Income source	Primary	Secondary	Subsidiary	Yearly income (Rs.)

Agriculture				
Animal husbandry				
Agriculture labor				
Portering				
Hunting				
Business/trade (Specify)				
Tourism (Specify)				
Service (Specify)				
Penson (Specify)				
Medicinal herbs				
Forest products (specify)				
Cottage industry (Specify)				
Other (Specify)				

30. Where do you get the forest products from?
    a) CF b) leasehold c) private d) national

31. What are the resources you use from the forest?
    a) Fuel wood b) Fodder c) Leaf litter
    d) Timber e) FW+F+T f) FW+F+L
    g) FW+T h) All

32. Do you have any participation for national forest management?
    □ Yes □ NO

33. What was the condition of the forest in the past?
    a) Poor b) Remain same c) Satisfactory
    d) Good e) V. Good

34. What is the present condition of the forest?
    a) V. Good b) Good c) Satisfactory
    d) Poor e) Remain same

35. What is the problem in national forest?

Problem in NF	Yes	No
Insufficient resources in NF		
Stealing at NF		
No problem		
Unknown about problem		
Insufficient area		
Fire blazing		

Excessive litter collection		
No fencing		
Forest Dying due invasive species		
No strong management		
No knowledge about conservation to people		

36. What is your suggestion for the better management of the forest?

Suggestion for better management of NF	Yes	No
Utilization of dead trees / fallen logs		
Increase in price of milk from Cheese factory		
Alternative skill development promotion for livelihood support		
NP population management		
More plantation		
Control of livestock grazing		
No suggestion/Don't know		
Control on litter collection		
Alternative energy promotion		
Awareness/Education needed		
Fencing/More security		
Enforce strong management team with having transparency		
Tourism development		
Better protection measures for Wildlife		
Conservation with utilization		
NP Policy change		