CHAPTER -I

INTRODUCTION

1.1 General Background

Nepal, a Himalayan Kingdom comprising diverse flora and fauna, is located between China on the North and India on the East, South and West. It is located between latitudes of 26º 22’ to 30º27’ North and between longitudes 80º4’ to 88º 12’ East with an average width of 193 Km ranging from 145 to 242 Km with average length of about 885Km which gives it a rectangular shape. The total area of the kingdom is 1, 47,181 Km^2 which makes about 0.3% of the total land surface of the earth. Nepal is rich in bio-diversity, due to its diverse topography, altitude and climate and its position on the junction of indo-Himalayan and paleoarctic bio-geographical realms.

Loss of bio-diversity is one of the most profound global crises (Wilson, 1988). It is due to poverty, inadequacy of education and awareness, over-population, improper coordination between economic development and environmental protection. The rate of loss of topsoil in the country has been estimated to be 240 million cubic meters per year (MPFS/ HMG, 1988). The richness of biodiversity on the planet as a whole is undergoing reduction as a result of unfriendly environmental activities. Reduction in forest-cover often involves fragmentation of species habitat and resulting in the loss of genetic diversity.

Forest in Nepal is very important from a socio-cultural and economic point of view. Nearly 75 percent of household energy, 40 percent of livestock nutrition and a substantial amount of soil nutrition in the form of organic manure come from the forest (HMG, ADB, FINNIDA, 1988). The forestry sector contributes 15 percent to the gross domestic products (GDP). If this trend of forest harvesting continues, then more forest has to be cleared to meet increasing annual government expenses (Parajuli, 1994).

The generation and the use of hydropower energy have environmental repercussions at local, regional and global levels. These impacts extend through the cycle of the entire chain of activities from generation, transmission, distribution and final conservation to end-use. The impacts could also take place over short medium or long time scales, or have cascading effects by combining with other environmental problems. Electricity is one of the most essential needs of people to overcome the aforesaid problem. Supplying electricity not only improves its living condition and status, but also contributes significantly towards socio – economic development.

1.2 Vegetation Resources of Nepal

Vegetation is the mosaic of plant communities (phytocenoses) in the landscape, and the spatial distribution pattern of the growth forms as trees, shrubs and grass as in aphytocenose is called the structures of the plant community (Kuchler, 1967). Vegetation is the term used to designate the plant cover of a region and generally made up of one or more plant communities or aggregations of plants, usually forming a complex. Many ecologists, view vegetation as a component of ecosystem which displays the effects of other environmental conditions and historic factors in of others environmental conditions and historic factors in and obvious and in easily measurable manner (Goldsmith and Harrison, 1976).

Nepal comprises only about 0.09 percent of the terrestrial area of the earth, but it harbours high share of bio-diversity. A total of 118 ecosystems have been identified with 75 vegetation types and 35 forest types (Stainton, 1972). About 5160 species of flowering plants have been enumerated by Hara and Williams (1979); Hara *et al.* (1978, 1982) and altogether 5988 species of flowering plants have been recorded by Koba *et al.* (1994). Shrestha and Joshi (1996) documented 60 non-endemic plant species and 47 endemic species under threatened category. Out of the endemic plants, 8 species are extinct, 1 endangered, and 7 are vulnerable, while 31 species falls under IUCN rare species category. The non-endemic plants categorized as 22 species rare, 12 species listed as endangered, 11 species are listed under endangered and 11 species as vulnerable categories. Species richness among floral diversity comprises of lichens with 465 species (2.3% of the global diversity), fungi with 1,822 species (2.4%), algae with 687 species) (2.6%), bryophytes with 853 species (5.1%), pteridophytes with 380 species (3.4%), gymnosperms with 28 species (5.1%) and angiosperms with 5806 species (2.6%) (HMG/N-MFSC 2002). The estimated number of flowering plants in Nepal is 6500 species of which about 4% species are endemic to the country and 30% species are endemic to the Himalayan. Nepal has been ranked as 10th highest flowering plant diversity in Asia and 17th position in the world in biodiversity richness (Shrestha, 2001). About 300 endemic species of angiosperms belongs to 134 genera and 51 families have been reported from Nepal (Chaudhary, 1998).

Vegetation analysis is the basis of analytical tool provides understanding the environment. It is an overall expression of various environmental factors, which operate continually or in cyclic fashion. Soil, topography, aspect, altitude and season are very impartment in determining the types and nature of vegetation in a particular area.

Stainton (1972) broadly divided Nepal's forest into the following categories.

- Tropical and sub-tropical
- Temperate and alpine-broad-leaved
- Temperate and alpine conifers
- Minor temperate and alpine associations.

Tropical forests are predominated by Sal (*Shorea robusta*), while khair (*Acacia catechu*) and Sissoo (*Dalbergia sissoo*) dominated riverine habitats. The vegetation is dominated by semi-evergreen type of forest in the middle hills of Nepal.Lower central middle hills have mixture of deciduous and semi evergreen like *Schima-Castanopsis* are found in the northern slopes. The lower forests of western mid-mountains are dominated by *Pinus roxburghii, Quercus* spp., *Shorea robusta* and *Schima wallichii,* in dry exposed sites and *Aeculus* spp, *Juglans* spp. and *Alnus nepalensis* are associated with mixture in the moist sites. The upper slopes are predominated by coniferous spp. such as *Abies spectabilis*, *Tsuga dumosa, and Pinus excelsa*. The subtropical forests are also found in lower valleys of middle hills of Nepal. It is dominated by *Shorea robusta* in association with *Schima wallichii*, *Quercus* spp. But above 900 masl sal gives way to pines and oaks. Above 3000 masl temperate forest is found dominated by oak, walnut, wild cheery, horse chestnut, birch, rhododendron, larch, fir and bamboo species. Southern dry slopes have oak, sal and other broad-leaved species while shady-moist north slopes have coniferous and oak up to 3300 masl.

Nepal within its territory of 147,181 sq. km. comprises around 4.27 million hectors (representing 29% of total land area) of forest, 1.65 million hectares (10.6%) of shrubland and degraded forest, 1.7 million hectors (12%) of grassland, 3.0 million hectors (21%) of farmland, about 1.0 million hectares (7%) of uncultivated inclusions (HMG/N-DFRS 1999).

Nepal has been divided into five administrative regions from west to east. Following table shows the forest and shrub cover by development regions.

Table 1.1: Forest and shrub area by development region (1000 hectors)

Regions	**Total land area**	**Forest Area**	**Shrub Area**	**Total Forest and Shrub Area**
FWDR	1953.9	687.4	263.9	951.3
HWDR	4237.8	1192.4	442.0	1634.4
WDR	2939.8	734.3	256.9	991.2
CDR	2741.0	918.6	233.8	1152.4
EDR	2845.6	736.1	362.6	1098.7
Total	147181	4268.8	1559.2	5828.0

Source: HMGN-DFRS (1999a)

1.3 Hydropower Development in Nepal

Due to the steep topography, abundant precipitation and perennial nature of most of the rivers, which originate from the Himalayas and Tibetan plateau, there exists a tremendous hydropower potentiality in Nepal. Nepal has vast network of waterbodies consisting of about 6000 rivers and streams with an approximate total length of 45000 Km with an average annual precipitation of 1503 mm and annual runoff about 224 billion cubic meter (WEC, 1998). The theoretical potential based on average flow is estimated to be 83,000 MW out of which 44600 MW (53.5%) has been assessed to be technically and economically feasible (WEC 1998). However, Shrestha (1966) estimated that the economic hydropower potential in Nepal is only 42000 MW.

Table 1.2: Basin Wise Hydropower Potential in Nepal

Basin	**Theoretical Potential (GW)**			**Economic Potential (GW)**
	Major Rivers	**Small Rivers**	**Total**	
Koshi	19	4	23	11
Gandaki	18	3	21	5
Karnali and Mahakali	32	3	35	25
Others	3	1	4	1
Total	72	11	83	42

Source: Shrestha, 1966.

However, Nepal has harnessed only about 556.4MW (NEA 2006) (excluding thermal power), which is only 0.67 percent of the total potential of the country.

The energy production and peak load in Nepal Electricity Authority (NEA) have grown at an annual rate of 7.71 percent and 7.99 percent over the last ten years. The annual growth rate will continue to be about 8 percent. The share of energy consumption for FY 2000/01 for household customers, industrial customers and others were 37 percent, 37 percent and 26 percent respectively. The electrification ratio of Nepal still remains at 15 percent. According to the demand forecast in the annual report of the fiscal year of 2000/01, the energy demand is expected to reach 2,598 Gwh and 3855 GWh in FY 2005 and FY2010, and the peak power, 570 MW and 846 MW in 2005 and 2010 respectively. The middle Marsyandi Hydroelectric project of 70MW capacity was planned to be complete in 2007. Currently NEA proposed Chamalaya and Kulekhani III hydropower projects for construction. However, both of these projects jointly generate only 44 MW energy after 4 to years. No other projects have been planned and proposed to be constructing now.

1.4 Environmental Impact Assessment in Nepal

The concept of Environmental Impact Assessment in Nepal is relatively new. However, the realization of the need for the environment impact assessment (EIA) in development projects has increased lately. The sixth plan (1980-85), for the first time in the planning history of Nepal, recognized the need for EA study for infrastructure projects (NPC, 1980). EIA was realized as a means for integrating environmental aspects in development programs and projects. At the beginning, the multilateral donor agencies and/or development partners encouraged and provided fund to carry out projects specific EAs. The initiatives prompted the government to include EA requirements in policies. In mid- 1980s, the environmental assements of some infrastructure projects were carried out through “learning by doing approach”, i.e. through limited knowledge and skill. However, it contributed a lot to realize its importance and enhance public awareness on the importance and benefits of this tool (Uprety, 2003). The national conservation strategy (NCS, 1987) recognized the urgent need for the adoption of EIA, and has made the establishment of a national system of EIA a priority. This system entails the requirement of an EIA before major development projects, which are approved by the relevant government departments. The seventh plan (1986-90) stated a policy that the development programs will be implemented only after EIA study. The plan outlined the need for carrying out EIA of industrial, tourism, transportation, water resources, urbanization, agriculture, forests and other development programs to identify adverse impacts on the environment (NPC, 1985). The interim Government (1990-91) made a policy commitment for not implementing any project that will likely pose adverse impacts on the environment and natural balance. The eighth plan (1992-1997) reiterated the need for carrying out EIA of both central and local level projects before their implementation. In order to implement the policy, the plan included programs for the formulation of EIA guidelines for different sectors, conduct EIA study of large-scale development projects in road, hydropower, industry, irrigation, settlement, drinking water and sewage sectors include environmental mitigation costs into the total project cost. The plan also included programs for environmental monitoring (NPC, 1992). The ninth plan (1997-2002) introduced policies to promote participatory EIA system, carry out EIA study in order to ensure biodiversity conservation while implementing remote area development projects, and make necessary procedure for stakeholders participation in EA process (NPC, 1997). The tenth plan (2002-2007) has reemphasized to make the EIA system effective and monitor the implementation status of the projects, which carried out EIA study. The plan has for the first time recognized the need for carrying out SEA (Strategic Environmental Assessment) to any policy before adoption (NPC, 2003). One of the priority areas in the field of environmental management in the tenth plan is on EIA. Besides, the introduction of EIA system in the periodical plans, the sectoral policies and strategies have also given due attention on the application of EIA procedure (Uprety, 2003).

1.5 Nyadi Hydroelectric Project- A short Introduction

Lamjung Electricity Development Company (LEDCO) has developed Nyadi Hydroelectric project since 1994. The proposed project is a "runoff-the-river", hydropower scheme that will be located on the Nyadi River, a tributary of the Marsyandi River. The project structures (i.e. intake, settling basins, tunnel, adit and powerhouse sites) will be located in the Bahundanda village development committee (VDC), Lamjung District, Western Development Region of Nepal. The potentially affected communities by the project will be located in Bahundanda VDC (i.e. right bank of Nyadi River) and also across Nyadi River at Bhulbhule VDC.

Figure1.1: General Layout of the project

The NHP will generate 20MW of power and 127 GWH of energy annually. The project is designed to possess an intake, 2.5m high diversion weir, a 4 km long headrace pressure tunnel, an underground inclined penstock, an underground powerhouse and a tailrace canal.

In 1997, LEDCO and Butwal Power Company (BPC) jointly conducted a desk study for the NHP, the initial step of the detailed feasibility study. In June 1997, HMG/N's Ministry of Population and Environment (MOPE) passed new Environmental Protection Regulations (First Amendment) 2055 (1999) requiring all hydropower schemes exceeding 5 MW to conduct an Environmental Impact Assessment (EIA) conforming to the new regulations. Consequently, LEDCO hired BPC hydro-consult for the execution of an extensive feasibility study, within which LEDCO retained responsibility for the EIA portion.

1.6 Justification of the Study

Even if the hydropower is "clean" in its use in comparison to the use of other traditional and commercial sources of energy, the construction of the project and the existence of the reservoir itself have the severe environmental consequences. Dam and reservoir projects are the most sensitive in terms of pervasiveness of their influence of altering environmental resources. Because they usually cause a major altering in the hydraulic regime of the involved watershed area. They often result in a marked alteration of the project and these effects may continue for downstream to the area of final discharge of the stream. Dam and reservoir projects also usually result in establishment of new access routes and acceleration of encroachment into upstream area in the watershed, resulting impacts on the forests, wildlife and mineral development and agricultural practices throughout the watershed.

In Nyadi project, certain areas of forestland will be lost during construction period. Frequencies of different species will also change. Due to construction of reservoir, ecological changes are going to be created. So, change in vegetation at the time of construction has great importance. The study concerning vegetation pattern helps to discern the status of plant species, identify the vegetation types and priorities for the habitats according to the location of rare, endangered, endemic, medicinal and economically important species. This type of study helps in the proper documentation of flora, to access their conservation values and identify the areas of the habitat management. The hydropower project needs to have relevant information, policies and management plants to prevent environmental degradation, encroachment and illegal activities. Vegetation management requires a profound knowledge of plant species and their communities and the associations. Such study is particularly important for protection and enhancement of the environment. Hence, this type of study is able to generate and disseminate information relevant for minimization and conservation of vegetation resources and also helps to adopt effective mitigation measures.

Further more, the national EIA guide lines, 1993 have made EIA a legally mandatory condition for the hydropower project with generation capacity of 5 MW and above and the transmission line above 66 KV and requires Initial Environmental Examination (IEE) for the hydropower projects with generating capacity of less than 5 MW and transmission line up to 66 KV. So, such type of study is important from legal, environmental conservation as well as developmental aspects. The results from such studies may helpful, as a lesson, to acheive sustainable development, minimising adverse effects on the environment

1.7 Objectives of the Study

The broad objective of this study is to assess the status of forest resources and soil properties of Nyadi Hydropower Project. The specific objectives are as follows:

1. To determine composition, type and condition of forest within the project area.
2. To carry out Quantitative analysis of the surrounding vegetation of NHP.
3. To identify the common, endangered, rare and threatened plant spesis of the project area.
4. To study the ethno-botanical (economic/social/medicinal) uses of existing species.
5. To analyze the different soil parameters in the project area

1.8 Limitations of the Study

Due to financial costraints, resources and accessibility, the study has faced several limitations. The main limitations are as follows:

- Seasonal variation in the existing vegetation conditions could not be assessed.
- Vegetation analysis of the steep slopes could not be carried out.
- Specific area was choosen on the basis of accessibility.

CHAPTER - II

LITERATURE REVIEW

2.1 Studies on the impacts of Hydropower Development

Although, Hydropower development in Nepal began from 1911 by the construction of 500 KW hydropower plant at Pharping, Kathmandu but the analysis of environmental impacts of power development after the effectiveness of EPR 1997 were started to analyze only since 1993 during construction phase in upper Bhotekoshi hydropower project. Government of Nepal endorsed the national conservation section 24 of electricity act 1992 forbids negative impacts such as soil erosion, flooding, landslides and air pollution on the environment, while generating, transmitting or distributing electricity.

NEA (1993) on proposed Arun III Hydroelectric project described about 30ha of land including some patches of pristine forest that would be inundated by the construction of the project. The biodiversity of the area is under severe pressure due to people's activities. Some 14 endangered or potentially threatened plant species are known or suspected to occur in the immediate vicinity of the access road and powerhouse sites. The impacts of road construction on vegetation will include loss of vegetation throughout the whole 30m right of way and the total area falling within R-O-W is estimated at 106 ha, but vegetation clearance within this area will be strictly limited to the area of permanent work.

MKI (1996) on EIA of Kaligandaki 'A' Hydroelectirc project described the abundance of plant diversity in the project area including the head works and power plant site. More than 500 species occurring at the Dam, reservoir, power plant and Access road sites of KGA. Similarly, the transmission line alignment crosses several additional ecosystems and vegetation zones. Virgin forest is very rare near the Kaligandaki and Andhi Khola, but a secondary riverine forest has been reported in between two and four kilometers up the kaligandaki from the dam site affected by the project. The project area (16,880 ha) consists of approximately 6000 ha of forests representing 35 percent of the total land area.

CIWEC (1997) on Tamur-Mewa Hydropower Project reported direct loss of 12ha mixed hardwood type of forest during the construction phase of the project. It leads to the loss and fragmentation of vegetation cover as well as disturbance to the associated wildlife habitat. An important consideration is that the project structures habitat is common to the region so it did not represent the unique habitat. Special provision was made for the six species of endangered plants and wildlife species identified by the EIA team.

CIWEC (1998) on upper Karnali Hydroelectric project stated that the project needs to be 214 ha land for the construction. It describes that approximately 60 ha. Of partly forested land will be affected when the water level rises to 631m high. Out of this 60 ha (40%) was sal forest, 20% chirpine forest and 10% khair-sissoo and other forests. The total loss of forestland has been estimated as 44 ha in the head works and reservoir area. It has been predicted that there will be an increasingly indirect negative of the projects on the forest resources in the general area during the construction of the projects on the forest resources in the general area during the construction of the project, by harvesting of forest for fuelwood, for domestic cooking, timber for the construction of temporary shelter for labours and potentially illegal felling of the commercial timber species etc. Additionally, 57 Km long 33KV construction power transmission line having 6m R-O-W as well as 100 Km long 220KV transmission line having 70m wide R-O-W that passed on the north-east side of the Surkhet-Jumla road which affecting the forest cover of the Royal Bardia National Park boundary.

LEDCO (1999) on Environmental Impact Assessment of Nyadi Hydropower Project reported that, 113 plant species were enumerated in the project area. Tropical Deciduous, Riverine subs tropical shrub land and sub-tropical evergreen forest were the three habitat types identified within the forest area. Ethno-botanical uses of some plant as *Arundo donax*, *Bridilia retusa* and *Madhuca butyraca* were identified. Biodiversity value at these sites was mostly low to moderate (ranging from 3 to 26 plant species/ sampling site of 3m×3m. Only 7 species (6.2%) were listed either as threatened rare, or vulnerable. None of them occurred at the specific sites of construction, for the intake powerhouse and adit.

LEDCO (2001) on Environmental Impact Assessment report of Khudi Hydropower Project reported that a total of 128 plant species were recorded in the area including 2 types of endangered ground orchids and 5 types of epiphytic orchid species also found endangered. These endangered species were found to be located close to planned project infrastructures. A local forest user group (FUG), formed under ACAP rules, manages one of the forests while the other forest and existing patches of trees are privately managed. Firewood is very scarce in the area and people mostly get their firewood from the FUG managed forest while a lot of them rely on driftwood from the river.

Pandey (2001) carried out study on the environmental impact of Kaligandaki "A" hydroelectric project on vegetation resources in dam and reservoir area. This study revealed that the tree density of the study area was decreased by 42.72% than the pre-project and found 146.38 trees/ ha. Similarly, the basal area and the volume were also decreased by 26.66% and 28.57% than the pre-project phase. This study also reported, altogether 9 species of endangered flora were found in the study region and suggested that shrubs and herbs were also adversely affected.

Environmental Impact Assessment of Langtang Khola hydroelectric project (2001) revealed that the forested part of the project area particularly at the intake, upstream/ downstream access road site, powerhouse site and proposed staff quarter sites have been found occupied by a total of 108 species, comprising highest number of herbs (51 spp.) followed by trees (32 spp.), Shrubs (12 spp.), climbers (5spp), ferns; lichen (2 spp.), and fungi and algae (1 spp.). Out of the total number of trees species, 1 sp. comes under cactus category, and 1sp. (Climbers) comes under parasitic type. In the project area, highest number of species richness was recorded at the proposed access road followed by proposed intake site (60spp.), downstream of intake site (45 spp.), powerhouse downstream site (37 spp.), upstream of intake site (35 spp.), proposed alternative access at the road living opposite flank of Langtang khola (31 spp.), power house site (29 spp.) and lowest species richness was recorded at the proposed staff quarter site (20 spp.). This indicates that the forest area lying near to intake and access road have high species diversity than at the grazing and cultivated land located near the powerhouse and staff quarter sites. Evidently, almost three times lower species richness occurs at the steep rock within the alternative access road site lying outside the park area as compared to the accessible road site lying within the national park area. The density and volume of trees in the forest area at the proposed intake and across road sites will be subjected to loss of vegetation cover during the construction phase. The average density of trees per $100m^2$ sample plot is slightly higher at access road (43.75 trees/plot) as compared to intake site (42.57 trees/ plot). But the average Basal Area ratio (BAR) is higher at intake site (0.00875) as compared to access road site (0.00391). The volume of trees per ha. is higher at the propose access road ($132.4m^3$/ha) as compared to the intake site (127.75 m^3/ha). However, the net loss of volume of trees due to the project construction activity, will be higher at the intake site ($195.46m^3$), which covers an area of 1.53 ha (1.80 m length and 85m breadth) as compared to $8.8m^3$ of proposed access road site which covers an area of 0.9 ha (2.8 km length and 3m width).

EIA of Middle Marsyandi Hydroelectric project conducted by NEA (2001) reported that the project would bring land use changes in 64.176 ha of land of which 31.28% is agricultural land. Similarly, riverine zone including flood plain comprises 46.48% of its total land use and the remaining consists of grasslands and Shrubland area. A total of 3475 numbers of trees may potentially need clearance during construction from the occupied agricultural, grassland, shrubland areas which include fruit trees as well as timber and fodder trees. Except for the few trees of champ and simal rest of the other trees are not legally protected trees that require felling is from the riverine areas of reservoir sites.

GEOCE (2001) on Environmental Impact Assessment (EIA) report of upper Modi "A" hydroelectric protect reported that about 77 trees, 581 pole sized trees and 187 samplings in a hectare of forests would affected due to the project activities. The major impacts on forests will be created by the access road. Hence based on the average number of plants/ha considering the construction width of 15m, and also considering the homogenous distribution of plants, it is estimated that a total of 410 number of timber quality trees are likely to be affected along the proposed access road and about 3091 pole-sized trees, and 995 saplings are also likely to be affected along the access road. However, this in the powerhouse site will be about 88 trees, 662 pole-sized trees and 213 saplings. Hence, a total of about 498 trees of timber value may be lost during the project construction. Similarly, based on total standing wood volume of about 136 m^3/ha or average standing wood volume of 0.98/ha, about 402 m^3 of timber may be extracted through site clearance along the access road.

Sharma (2004) made study on the post project evaluation of environmental mitigation measures of kaligandaki "A' hydroelectirc project and 132 KV transmission line. The study revealed that around 97 ha of land was disturbed during the project construction. 6.2 million tons of excavated materials were generated. Total numbers of 6093 trees of different species were removed in different project component areas and proper land reinstatement and bioengineering measures, appropriate disposal of muck, plant nursery and plantation of 338000 seedlings were the major mitigation programs successfully implemented for minimizing the impacts on natural vegetation and watershed.

GEOCE (2005) on Environmental Impact Assessment of upper Marsyandi "A' (UM-O) Hydroelectric project indicated that a total of 183 species had to be felled as a part of site clearance along the access road. Based on the inventory information, the quantity of wood totals to 225m^3 and the net volume is 177m^3.These volumes of wood obtained from community forests (CFs), and private land. This impact is directly intentional and inevitable with high magnitude, site specific, extent and long-term duration. Destruction of the forest is an irreversible loss so the impact could not be corrected. To minimize the permanent loss of the forest compensatory mechanism can be adopted by planting the 4575 samplings at appropriate places in the around the project areas and even by purchasing about 3 ha of land, managing for 5 years with the projects own cost.

Main report of environmental impact assessment of upper Tamakoshi Hydropower Project (2005), reported the major impacts of vegetation and forest resources include the total number of trees to be felled for the access road and project facilities has been estimated as 8420 out of which 5290 are above pole size having 2380 m^3 vol. of wood. Other major impacts would includes pressure on local forests due to increased demand for fuelwood and timber for the large number of work force involved directly or indirectly during the project construction. Similarly, the settling basins, spoil deposits, connecting road to surge tank and access road will affect 48 ha of forest including shrub-land assuming an average 20m wide rights of way for the access road. The project construction will cause to decline tree fern (*Cythea spinulosa*) and orchids of 15 species so far. Similarly, it gives rise pressure on existence of rare plants of medicinal value like chiraito, Githa, pakhanbed, kutki and Jatamansi.

Environmental Impact Assessment study of Solu khola small hydropower project (2006) revealed that due to the construction activities 14.31 ha of land with trees was encroached. During the construction phase of the project 4074 trees of 14 different species had to be cleared. And 15560 pole size trees had to be felled having 1758m^3 wood volume. Similarly, 70m^3 volume of fodders as well as 244 mton. Fuelwood was obtained. More likely, *Dalbergia sissoo, Alnus nepalensis, Rhododendron arboreum* and *Lyonia ovalifolia* had been affected. In the project area 13 Okhar trees and 2650 national flower Laligurans need to be cleared up.

2.2 Review of Policies, Laws, Rules, Regulations and Guidelines

Environmental management is relatively a new subject in Nepal, no comprehensive environmental act exist so far. However, efforts are being made to create sound legal basis for environmental management. The current policies of government of Nepal stress the importance of environmentally sound economic development and growth of private sector through economic liberalization. Some of these policies regarding the objectives of the study that are relevant to the proposed project are described below:

2.2.1 Hydropower Development Policy (1992)

The hydropower development policy emphasizes the need to develop environmentally friendly hydropower to meet the countries energy needs and to encourage private sector to invest in hydropower. This policy focuses more on electricity generation. It also reflwcts realization of the need for the utilization water resources for hydropower generation enacted through the electricity act of 1992. It is necessary to study and build medium scale hydropower project to meet the countries growing power demand in different part of the country. A part from this, it is utmost necessary to extend proper distribution system in riral areas where electrification has not been done also to develop hydropower of nthe country by motivating country national and foreign private investors in the electrification sector.

2.2.2 National Environmental Impact Assessment Guidelines (1993)

The National planning commission, GON in collaboration with IUCN the world conservation union, prepared this guideline. The national EIA guidelines was endorsed by GON in September 1992 and gazetted in June 1993. According to the guideline an EIA is mandatory for hydroelectric projects with generating capacities of over 5 MW. The guidelines also provide clear directions on how EIAs are to be conducted in Nepal, and specify the responsible agencies. This guideline was developed in the process of establishing a national system of EIA in Nepal. This guideline is frequently used and quite helpful right from making terms of reference to preparing impact matrix and assigning values on impacts ranking. The other important feature of the guideline is description on community participation. Clause 49 deals with methods for ensuring public participating during the preparation of the EIA report.

2.2.3 EIA Guideline for Forestry Sector (1995)

HMG/N in keeping with the sprit of the National Environmental Impact Assessment Guideline (EIA) 1993-framed EIA guidelines for the forestry sector 1995. The guideline aim to facilitate the sustainable use of forest resources for socio-economic development and for meeting basic needs of the communities for forest products, to make proposals socio-culturallly acceptable, economically feasible and environmentally begin to coserve genetic resources and bio-diversity and minimize environmental damage in forest areas and facilitate in identification of positive and negative impacts of programmes to be implemented by other agencies in forest ares. The guideline emphasizes the need to carryout EIA study of development programmes proposed for implementation in forest areas.

2.2.4 Water Resources Act (1992)

The water resources act, 1992 has been enacted to make arrangement for the rational utilization, conservation, management and development of water resources in Nepal.

According to section 8, subsection 1 of the Act, a person or corporate body who desire to conduct survey or to utilize water resources shall be required to submit an application to the prescribed officer or authority along with the economic, technical and environmental study report and with other prescribed particulars.

Section 9 of this act which deals with the utilization of water resources for hydroelectricity states that not withstanding anything written in section 8, the license relating to the survey of water sources and its utilization for the generation of hydropower shall be government by prevailing laws.

Section 18, 19 and 20 of the act deal with water quality standards, water pollution and adverse effect on the environment. Section 18 and 19 allow HMG/N to prescribe pollution tolerance limits and water quality standards of water resources beyond the prescribed tolerance limits.

Section 20 of the act states that while utilizing water resources, it shall be done so in such a manner that no substantial adverse effect be made on the environment by way of soil erosion, flood, landslide or similar other cause.

2.2.5 Environment Protection Act (1996) and Environmental Protection Rule (1997)

The ministry of population and environment enacted environmental protection act. This legislation enforced since January 1996 contains provision for carrying out IEE and EIA for development project in different sectors. Consequently for the elaboration of the attitudes in the act, environmental protection rule 1997 (EPR) was also forced. The EPR, 1997 obliges the proponent to make public on the contents of the proposal twice in order to ensure the participation of different stakeholders. The proponent should issue a public notice to seek comments and suggestions on the proposal. The EPR, 1997 also obliges the proponent to include all relevant environmental issue in the scoping report before submission for approval. The proponent is also obliged to make draft report public before its finalization.

In addition, the ministry of population and environment which is legally mandated approving agency for all types of EIAs must also make the final EIA report public for about a month long period to seek comments and suggestions before approval. Legal provision such as the EPR, 1997 helps the general public and interested parties to know about the proposal, its likely impacts on the environment, alternative actions and mitigation measures recommended. It could serve to encourage participation of different stakeholder’s right from the planning stage to implementation monitoring and evaluation of the proposal. The EPR is a precursor to making the public consultation process in EIAs. More effective in due course time.

MOWR is the concerned Ministry in the cases of Water Resources Projects and irrigation. A proponent shall have to carry out IEE and EIA of the proposals as prescribed in schedule 1 and 2 respectively were amended published on 20th Aug. 2007 in Nepal Rajpatra (clause 5, Section 57, No.19). According to this amendment IEE shall have to conduct for the hydropower project with generation capacity of less than 10 MW and transmission line 33 KV of more than 20 km, 66 KV of 5 km and 132 KV of less than 3 km long. Similarly, EIA shall have to conduct for the hydropower project with generation capacity of 10 MW and above, and transmission line 132 KV and above of more than 3 km long.

2.2.6 Electricity Act (1992)

The Electricity Act 1992 has been enacted to manage the survey, generation, transmission and distribution of electricity and to standardize and safeguard electricity services.

Article 3 No license is required to survey, generate, transmit or distribute electricity from 100KW to 1000KW projects. However, information should be provided to the designated authority about such a project.

According to section 4 subsection 1 of the Act, any person or corporate body who wishes to conduct survey, generation, transmission or distribution of electricity over 1 MW shall be required to submit an application to prescribed officer along with economic, technical and environmental study report. The authority will issue survey license with in 30 days and generation, transmission or distribution license within 120 days after the submission of application. The validity period of survey license is 5 years and generation, transmission and distribution license is 50 years.

Section 24 of this act states that "while carrying out electricity generation, transmission or distribution, it shall be carried out in such a manner that no substantial adverse effect be made on environment by the way of soil erosion, flood, landslide, air pollution etc".

2.2.7 Electricity Rules (2050)

The rules have been formulated for the practical implementation of the provision made in the electricity act, 2049. Section (chha) of Article12 and section (chha) of Article 13 of electricity rules 2050 are important from environmental viewpoint. The environmental impact assessment report should address the environmental issues, measures required to mitigate the significant adverse impact, socio-economic impacts of the project on the locality, use of local labor sources and equipment, benefits that the local people receive after the project completion, training to be given to the local people about the construction, operation, and maintenance of the project, facilities required for contractor's camp, safety measures and impacts on the local land holders due to project implementation and estimates of displaces population and resettlement and rehabilitation measures these must be elaborated and clearly explained.

2.2.8 Forest Act (1993) and Forest Regulation (1995)

Forest Act (1993) and forest regulation (1995) recognizes the importance of forest in maintaining a healthy environment. The act requires decision makers to take account of all forest values, including environment services and bio-diversity not just the production of timber and other commodities. The basis of the forest act is to consider forest as "resources oriented" rather than "use oriented".

Section 23 of the Act empowers the government to delineate any part of a national forest, which has "specially environmental, scientific and cultural importance", as a protected forest. Section 49 of the Act prohibits sectioning lands, setting fires, grazing, removing or wearing forest, products, felling trees of plants, wildlife hunting and extracting boulders, sand and soil from the National forest without the prior approved of Department of Forest.

The act empowers the government to permit the use of any part of government managed forest community forest, leasehold forest, if there is alternative except to use the forest area for the implementation of a plan or project of national priority without significantly affecting the environment.

Rule 65 of the forest regulation stipulates that in case the execution of any project having national priority in any forest area cause any loss or harm to any local individual or community, the proponent of the project itself shall bear the amount of compensation to be paid. Similarly, the entire expenses required for the cutting and transporting the forest products in a forest area to be used by the approved project should be borne by the proponent of the project. The Act and Regulation are effective but required continuous monitoring, liaison and coordination with other line agencies.

2.2.9 Ninth Five Year Plan (1998-2003)

The plan emphasizes the importance of hydropower generation of agriculture, irrigation, and industry as well as regional development of the country. Article 3.2.10 (Electricity Development Emphasized the need of expansion of rural electrification program. The plan targeted to develop 1718 MW electricity generation through development of medium scale projects. Similarly the plan is aim to construct 1024Km high tension line and 6067Km low voltage line to electricity 110000 population of the country.

Ninth five year plan focus the agro-forestry program and establishment of prasodhan industry and bio-diversity. The plan emphasized the need of conservation of 17% land declared as conservation area. The article 3.2.12 focuses on bio-diversity conservation while developing hydropower, industry and tourism etc.

2.2.10 Soil and Watershed Conservation Act (1982)

The article 2 (B) of the act defines the soil and water conservation. According to article 3 HMG/N can acquire area / land by giving written notice for the purpose of water conservation. But for such acquisition compensation shall be paid in case of private land in consultation with local authorities (VDC/Municipality). Article 10 of the act elaborates the activities that are considered illegal in the area which are suspected for natural disaster.

2.2.11 Local Self-Governance Act (1999)

Local self-governance act empower the local authorities and make more responsible towards local development. The act highlights the participation of private sector in local development. Article-6 of VDC deals with the environment conservation and management while design the project program. Article-8 deals with penalty if any body/person/institution is found polluting the environment.

The act empowers municipality to control and manage different type of pollution, forest resources and other natural resources. Article-6 municipality clearly mentions that project shall be selected based on local participation and environmental conservation. Article 4 (Ga) of DDC mention that DDC is responsible for identification, design and implementation of micro hydro-schemes and their management Article 4 (Chha) deals with forest and environment.

2.2.12 Local Self Governance Regulation (2000)

Local self-governance regulation empowers the local bodies to coordinate and implement development program and for rationale utilization of local natural resources. Article-7 (68) empowers the VDCs for monitoring and supervision of development work implemented in the VDC. The Article-4 of DDC has provision of three members' agriculture, forest, and environment committee to look after the concerned issues. Article-6 (206) specifies the need of social, economic, environmental and public facilities should be considered while planning the project. Article-7 (210) focus on environmental studies and due consideration while implementing the project like sand, quarry, stone quarry and coal mine etc.

2.2.13 Water Resources Regulation (1993)

It is mandatory under rule 17 (e) of the regulation that any person or corporate body, who desires to obtain a license for utilization of water resources, must state in his application that appropriate measure will be taken to lessen the adverse effects due to the project on the overall environment measures are to be taken for the conservation of aquatic life and water environment and for mitigating social and economic effects of the project in the concerned area. Local labor should be utilized and the local people should get benefits after the completion of the project. The regulation also emphasizes training to the local people in relation to construction, maintenance and operation of the project. Rule 10 stipulates that the water resources committee shall publish a notice giving detail information about the project to the people. If any person finds that the construction and operation of concerned project is likely to cause adverse effects, he or she may furnish his/her reactions stating the reason with in thirty-five days from the date of publication of the notice. If the committee is satisfied with the reason given by the people, the proponent will be asked to revise the plan.

CHAPTER - III

DESCRIPTION OF THE STUDY AREA

3.1 Location

Nyadi Hydroelectric project is located within the Bahundanda VDC, Lamjung district, western Development Region of Nepal (Fig.3.1). The project is geographically located at the latitude of 84º25' 40" N and longitudes of 28°19'00" E. The NHP is located on the right bank of the Nyadi River (i.e. Bahundanda VDC), which is one of the tributaries of the Marsyandi River. The project area's altitude varies between 1020m and 1380 m above mean sea level.

The nearest road-head to the project site is at Besisahar, Lamjung's district headquarter. Besisahar is approximately 40km North of Dumre, a town along the Prithivi Highway.The proposed intake is located approximately 1 Km upstream from the village of Naije, which is approximately 7 Km upstream of the Nyadi-Marsyandi confluence. The powerhouse is located 3 Km downstream from Naije, below Thulo Bensi.

Figure 3.1: Location map of study area

3.2 Land use

Land use in project area consists of agriculture, forest, grazing, residential and public service. Most of the area consists of forest and cultivated land. Forestland in project area is utilized for collection of firewood, fodder, timber, forage and collection of medicinal plants and their parts and pasture land, which is utilized for livestock grazing. Rice fields (Khet) are the major farming plots in the project area and following by upland terraces (Bari). Major crops grown in the project area are rice, wheat, maize, millet etc

3.3 Climate and Hydrology

Climatically the project area lies in the sub-tropical zone (1000 masl to 2000 masl) and the river basin extends though the warm temperate (2000 masl to 3000 masl) to cool temperate (above 3000 masl) climatic zones. The wet monsoon commences generally around mid June, and lasts till mid August. Usually some pre-monsoon precipitation occurs during the month of May. From the data obtained so far the average annual discharge is estimated to be 12.20 m^3/sec with the least flow occurring in March (2.97 m^3/sec) and the highest discharge in August (36.99 m^3/sec) (EIA report of Nyadi HEP 1999). Four distinct seasons are found here namely pre-monsoon from March to May, Monsoon from June to September, post monsoon in October and winter from November to February. The Nyadi River is a snow-fed river, which originates from the Himalayas at the elevation greater than 7000 m and flows south-west to join the Marsyandi River approximately 7 km downstream of the proposed intake area and has a total area of 177 km^2. Average annual temperature and rainfall of Khudi station since 1987 to 2005 are shown in Table 3.1 below.

Table3.1: Monthly data of temperature and rainfall of Khudi Station (Average value of 1987-2005)

S.N.	Month	Temperature (^{0}C)		Rainfall (mm)
		Maximum	Minimum	
1	January	18.95	5.44	30.27
2	February	21.03	8.57	49.37
3	March	24.97	10.97	75.83
4	April	28.65	13.94	101.45
5	May	30.84	16.84	240.96
6	June	31.17	20.99	578.75
7	July	30.28	21.58	870.00
8	August	30.41	19.39	875.76
9	September	29.83	17.13	505.98
10	October	28.06	12.56	87.06
11	November	25.17	9.68	12.73
12	December	20.14	6.74	23.82

Source: Department of Hydrology and Meteorology, Government of Nepal

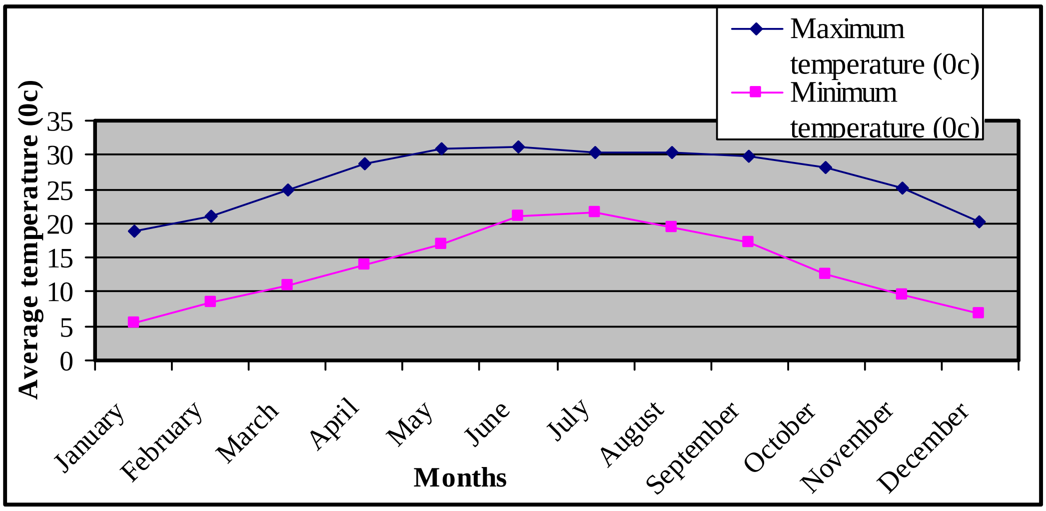


Figure3.2. Average Monthly Temperature of Khudi Station from 1987-2005

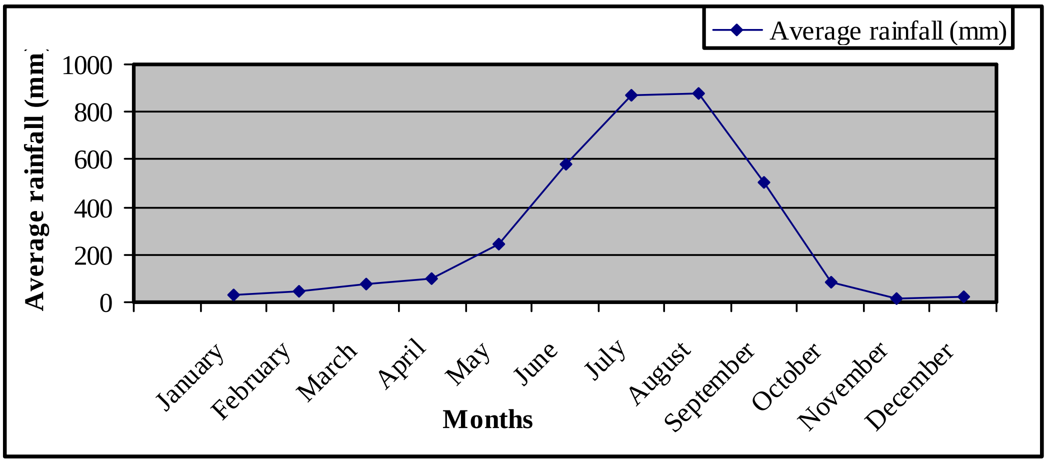


Figure3.3. Average monthly Rainfall of Khudi Station from 1987-2005

3.4 Geology and Soil

The project area lies in the lesser Himalayas of western Nepal. The general rock type of the region is composed of quartzite layers with well-developed ripple marks. There are no major landslides along the powerhouse and access road areas, which are indication that the geology of the area is stable. The soil in an around the project area are thin and comprises of loamy sand mixed with fragments of adjoining country rocks.

3.5 Vegetation

Vegetation within the project area differed because of variation of altitude (1020-1380 m), steepness of slope and aspect of mid hills. Consequently, three habitat types have been identified based on the species recorded within NHPs area.

They include:

a) Tropical Deciduous Riverine forest: This type of forest mainly composed of tall tree species including *Albizzia procera, Bombax ceiba* and *Engelhardtia spicata*.

b) Sub-tropical shrub (Grassland with scattered trees): Grassland vegetation consist of herbaceous species such as *Cynodon dactylon, Cyperus* Spp., *Imperata cylindrical* and *Typha* Spp.Small trees of *Bridelia retusa, Mallotus philippinensis* and *Phyllanthus emblica* were recorded in some areas. Trees of *Bombax ceiba* and *Myrica esculenta* were also distributed in certain areas. The shrubby vegetation was dominated by *Innula cappa, Hypericum chisia, Mimosa rubicaulis, Butea minor* and *Woodfordia fruticosa*.

c) Sub tropical Evergreen forest: This type of forest included *Castanopsis indica, Cedrella toona, Macaranga indica, Myrica esculenta* and *Alnus nepalensis*.

CHAPTER - IV

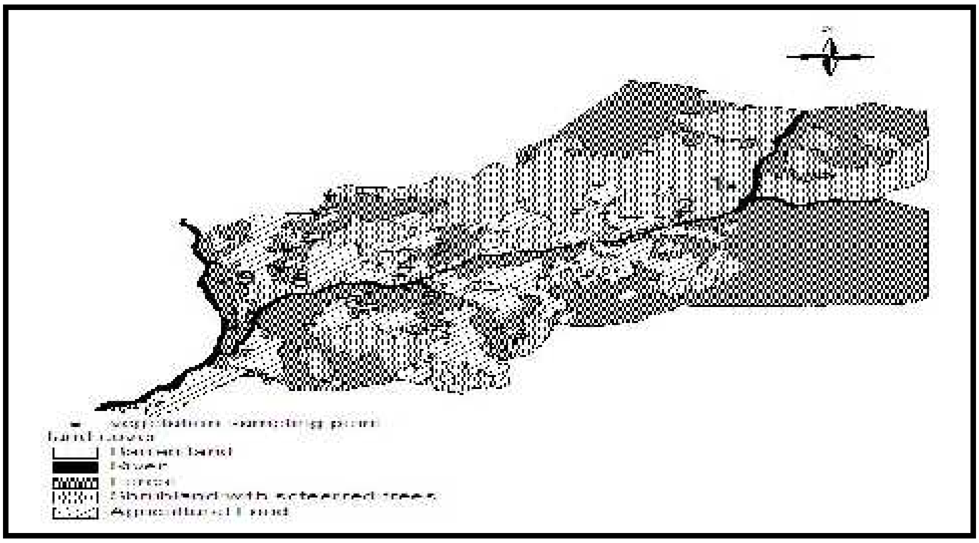
MATERIALS AND METHODS

4.1 Research Design

This study was made to carry the quantitative analysis of floral diversity and impacts of hydropower on vegetation. Extensive field survey was carried out from 7th July 2007 to 16th July 2007 for the collection of information about the status of forest. Questionnaire survey, key informants interview, direct observation primary and secondary data from review of published and unpublished reports were used for this study.

4.2 Reconnaissance of the Various Study Sites

On the basis of baseline study of Nyadi Project and the accessibility, ten study sites were selected for the vegetation sampling in Nyadi Hydropower project (Figure 4.1).



Note: 1= Near Intake, 2= App. 500m d/s of intake, 3= Access Road app. 200 m u/s power house, 4= Near powerhouse, 5= Near power house (left flank of Nyadi River), 6= Near power house (left flank of Nyadi river), 7= Access road app. 200m d/s of power house, 8= Access road app. 200m d/s of power house, 9= Access road near Dovan Chaur, 10= Access road near Dovan Chaur.

Figure 4.1: Study Area Showing Vegetation sampling sites

4.3 Nature and Source of Data

Both primary and secondary data, quantitative and qualitative were used for the study. The primary data were collected from the field survey. The secondary data were collected from various sources like NEA, central library of T.U., Department of forest, Butwal Power Company, many related journals, articles, dissertations, project reports and books were reviewed as the source of secondary data.

4.4 Data Collection Technique

4.4.1 Primary data collection

Primary data were collected with following ways:

4.4.1.1 Field Survey:

Field survey include as described below

4.4.1.1.1 Vegetation Sampling

Data collection was done with quadratic method to analyze the vital statistics of forest. The stratified random sampling method was used in all transects. Analysis on the floral diversity of each quadrate was carried out in randomly laid quadrates. Requisite size and number of the quadrates were determined by species area curve method (Mishra, 1968). To make the study the quadrate of size 20 m x 50 m for trees, 3 m x 3 m plot within the quadrate for shrubs and 1mx1m plot with in the quadrate for herbs were laid down.

Diameter at breast height (DBH) of each tree was measured 1.37m above the ground by using DBH tape (Kinglon tape) and population of each tree species, shrubs and herbs were counted in each plot. Specimens of all the trees, shrubs and herbs from the quadrate were collected for identification. Most of the plant species were identified at the field with the help of local names provided by local people and standard reference (Stainton and Polunin, 1987, Stainton, 1988 and Shrestha, 1998). Unidentified species were collected, tagged and identified by consultation with taxonomist correct scientific names and other citation were made with the help of Hara *et al*. (1978), Hara and Williams (1979) and Press *et al.* (2000).

4.4.1.1.2 Questionnaire Survey:

The structured questionnaires mostly with open-ended questions were developed. To conduct the survey random sampling techniques was applied. Twenty five percent households were selected for the study.

4.4.1.1.3 Key Informant Survey

Key informants were contacted to solicit relevant information. Visits were made to key informants like past and incumbent executive members of community forestry inhabitant and discussed on various aspects of forest and the intervention from project, their perception on adoption of project despite of some adverse impacts created by project.

4.4.1.1.4Direct Observation

The photographs, people's opinion about forest and other relevant information, which supported the information of questionnaires, were obtained from the direct observation on site. The onsite problems were also identified by visiting the site.

4.4.2 Secondary Data Collection

Various publications including project reports, dissertation reports, journals, government policies and plans and electronic materials were collected and studied to gather additional information supporting the primary data.

4.5 Vegetation Analysis

4.5.1 Density, Frequency and Basal Area of Plant Species

Density is the number of individuals per unit area. It represents the numerical strength of the specie in the community. It is usually expressed as number of plant per hectare (Pl/ha).

Frequency as introduced by Raunkiaer (1934) indicates the number of sampling units in which the particular species occur, thus expresses the dispersion of various species in a community. The frequency refers to the degree of dispersion of a species in terms of percentage occurrence. It is expressed in percentage.

Basal area is the aerial space covered per unit area by plant stem which is estimated by measuring diameter at breast height (DBH). It is expressed in m^2/ha.

These quantitative parameters were calculated by the following formula (zobel *et al*. 1987).

$$\text{Frequency (F) (\%)} = \frac{No.\ of\ \ plots\ in\ which\ \ species\ \ occured}{Total\ number\ of\ \ plots\ studied} \times 100$$

$$\text{Density (D) (pt/ha)} = \frac{No.\ of\ \ individuals\ \ of\ a\ \ species\ \ in\ \ all\ plots}{Total\ \ number\ of\ \ plots\ studiedx\ size\ of\ \ the\ \ plot} \times 10000$$

$$\text{Basal Area (BA)} = ® r^2 = ® \frac{(Dbh)^2}{4}$$

Where, r= radius, Dbh= Diameter at breast height

® = 3.1416

$$\text{Standing wood Volume (V)} = \frac{1}{2} BA \times Height$$

4.5.2 Canopy Coverage

Coverage of species in the percentage is an area of the soil surface covered by the vertical projection of the plant canopy. It is determined by ocular method. The scale used is as follows:

Table4.1: Percentage of crown coverage

Scale volume	**Range of coverage %**	**Mid point of cover**
1.	<1	0.5
2	1-5	3
3	5-25	15
4	25-50	37.5
5	50-75	62.5
6	75-95	85
7	>95	97.5

Source: Jha, 1997

4.5.3 Importance Value Index (IVI)

Importance Value Index (IVI) was proposed by Curtis (1959) as an index of vegetational importance within a stand. In any community of plant the quantitative value of each of the frequency, density, and basal area has its own importance. However, the total picture of ecological importance cannot be obtained by any one of these. Therefore, in order to have an overall picture of ecological importance of a species with respect to the community structure, the percentage value of the relative density (RD), Relative Frequency (RF) and relative basal area (RBA) for trees or relative coverage (RCO) for shrubs and herbs are added together. RD is the density of a species with respect to the total density of all the species. RF is the frequency of a species in relation to the total frequency of all the species. RBA is the proportion of the basal area of a species to the sum of basal area of all the species. RCO is the coverage of a species in relation to the total coverage of all the species.

Relative Frequency (RF) (%) = $\frac{Frequency\ of\ a\ species}{Sum\ of\ frequency\ of\ all\ species} \times 100$

Relative Density (RD) (%) = $\frac{Density\ of\ a\ species}{Total\ density\ of\ all\ species} \times 100$

Relative Basal Area (RBA) / (RDo) (%) = $\frac{BA\ of\ a\ species}{Total\ BA\ of\ all\ species} \times 100$

Relative canopy coverage (RCO) (%) = $\frac{Cover\ of\ a\ species}{Total\ Cov.of\ all\ species} \times 100$

IVI=RD+RF+RBA (RDo) for trees

IVI=RD+RF+RCO for shrubs and herbs

4.5.4 Index of Dominance

Those species which have strongest control over energy flow and the environment in given habitat are known as ecological dominants. Simpson (1949) has given the following formula to estimate the index of dominance.

$$Cd = \sum\left(\frac{ni}{N}\right)^2$$

Where, ni = Importance value of the species

N= total importance value of all the species

4.5.5 Index of Diversity (H)

Species diversity index is the ratio between the number of species and importance value of individual (Odum, 1971). It is important to recognize that species diversity has a no. of components, which may respond differently. Major components are species richness or variety component and species evenness or equitability. The following formula is used to calculate index of diversity (Zobel *et al*. 1987)

Shannon index (H) $= -\sum\left(\frac{ni}{N}\right)\log_e\left(\frac{ni}{N}\right)$

Where, ni = Importance value of each species

N= Total importance value of all species

4.5.6 Species Richness and Evenness

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

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

Where, H_{max} =lnS

and ln = log base n

S= total number of species

4.6 Methodology for Soil Analysis

Soils on the slopes of the Mahabharat lekh, middle Mountains as well as the Himalayan spurs are shallow in depth except in terraced conditions (Shah, 1999). The soil depth considered for the study was therefore just from surface upto 40cm. The soil samples were drawn with *Khurpi* and prepared composite sample from each sampling sites following the methods suggested by Khatri-Chhetri (1990). From each sampling sites the soil samples were brought to the laboratory in a well-labelled sample bag, half a kg in weight. The samples were then completely air dried, crushed and passed through 2mm sieve for performing physical and chemical analysis. The soil analysis was done in the laboratory of Department of Environmental science, T.U.

(a.) Water Holding Capacity:

Water holding capacity is defined as the amount of water retained by a unit weight of soil. For this purpose at first the filter paper was put into a funnel and 10ml of water was poured into it to wet the filter paper. After that 10gm of dry soil was put into the funnel and water was poured slowly until the whole soil became just wet. The amount of water used was noted. WHC was calculated as:-

$$\text{Water Holding Capacity (WHC)} = \frac{water\ retained\ by\ the\ soil}{weight\ of\ dry\ soil} \times 100$$

(b.) Soil texture: -

Soil texture is defined as the relative proportion of various size groups of individual soil particles. Soil particle size group are as follows:

Table 4.2: Soil Texture Classification

Soil Texture	Size
Coarse gravel	>5cm
Fine gravel	2mm to 5cm
Coarse sand	0.2 mm to 2 mm
Fine and	0.02 mm to 0.02
Silt	0.002 mm to 0.02 mm
Clay	<0.002 mm

Source: Zobel *et al., 1987*

Texture was determined by simple method No.4 (Thakur and Panthee 2004).

The percentage values of Sand, Silt and Clay were calculated as:

Sand fraction=level of soil settle out for 40 second.

Silt fraction= Level of soil settle out for 6 hours Level of soil settle out for 40 sec.

Clay fraction=Level of soil in the jar- (fraction of sand and silt)

Then the percentage of sand, silt and clay were calculated and soil texture can be determined from percent sand, silt and clay using the soil triangle.

(c.) pH

Soil pH is defined as the degree of acidity or alkalinity of soil. An oven-dried soil was dissolved in distilled water at 1:5 soil water ratios in a beaker. The soil suspension with frequent stirring for about half an hour was ready for taking reading. The pH was measured with combined glass electrode pH meter.

(d.) Chloride

An oven dried soil was dissolved in distilled water at 1:5 soil water ratios in a beaker stirring the soil solution mechanically for about one hour at a regular interval. Filter the suspension through whatman No.5 filter paper. Then, chloride content was determined by direct titration of the soil solution with $AgNO_3$, using K_2CrO_4 as an indicator.

(e.) Organic carbon

The organic carbon present in the soil samples were analyzed by Walkley-Black rapid titration method. The recovery of the carbon in this method is not 100% only about 60-90% of the total organic matter is recovered depending upon the kind. The organic matter present in the soil is digested with excess of potassium sulphuric acid, and the residual unutilized dichromate is then titrated with ferrous ammonium sulphate with diphenylamine as indicator. The potassium dichromate is used as a catalyst to activate decomposition. Organic carbon is calculated by using formula:

$$\% \text{ carbon} = \frac{3.951}{g}(1 - \frac{T}{S})$$

$$\% \text{ OM} = \%\text{C} \times 1.724$$

Where,

g=weight of sample

T= ml. of ferrous ammonium sulphate with sample titration

S= ml. of ferrous ammonium sulphate with blank titration

(f.) Total Nitrogen

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

Calculation:

$$\%\text{N} = \frac{(\text{T} - \text{B}) \times 7 \times \text{N}}{\text{S}} \times 100$$

Where,

T=Volume of acid used with sample titration

B=Volume of acid used with blank titration.

N=Normality of acid

S=Sample weight

(g.) Available phosphorous

Phosphorous in soil is generally determined as available Phosphorous, which can be extracted from soil with 0.002 M H_2SO_4 (1 Soil: 200 H_2SO_4). The Molybdenum blue method is most sensitive and as a result, they are widely used for soil extracts containing small amount of P as well as total P determination in soils. The phosphate in solution reacts with ammonium molybdate and form complex heteropolyacid (Molybdophosphoric acid), which gets reduced to a complex of blue colour in the presence of Stanous Chloride. The absorption of light by this blue colour can be measured at 690mm to calculate the concentration of phosphate by this colorimetric method (Trivedi and Goel 1984).

Calculation:

$$\% \text{ available p} = \frac{mgP / l \; soil \; solution}{50}$$

4.7 Ethno botanical study technique

The assessing of ethno botanical value has been carried out by using an anthropological field technique involving direct interview and discussion with local people. The documented information has been verified by relevant literature. The economic use of locally important species including medicinal use has been listed. The importance and use of these plants had been described on the basis of local use and purpose.

4.8 Survey of Rare and Endangered Species

Rare species have been categorized on the basis of their past and present distribution, their declination in numbers over course of time, their abundance and their potential biological value plants and wildlife species found in the project area have been grouped into different categories based on IUCN (1978), CITES (1985), NRDB appendices and Shrestha and Joshi (1996).

4.9 Data Processing and Analysis

The collected data were systematically processed and analyzed using MS Word and Excel computer programme.

CHAPTER-V

DATA ANALYSIS AND RESULT

5.1 Analysis of Density and Frequency of Tree Species

Total density for trees was 2700 plant per hectare. The density of individual tree species ranged from 10pl/ha to 430 pl/ha (Table5.1). Among the tree species *Engelhardtia spicata* had the highest density (430 pl/ha) followed by *Schima wallichi* (360pl/ha). Frequency of trees ranged from 10% to 100% (Table5.1). The highest frequency among the tree species was for *Schima wallichii* (100%). Which was followed by *Myrica esculanta, Engelhardtia spicata* and *Bombax ceiba* each with the frequency of 90%. The density and frequency of the tree were analyzed and tabulated in table 5.1.

Table 5.1: Analysis of Density and Frequency of the Tree Species.

S.N.	Botanical Name	Total no of individuals in the Quadrates										Density (P/ha)	Frequency (%)
		1	2	3	4	5	6	7	8	9	10		
1	*Phyllanthus emblica*	-	-	-	1	-	1	-	2	4	2	100	50
2	*Spondias pinata*	-	-	-	-	-	-	-	-	-	1	10	10
3	*Lyonia ovalifolia*	-	-	2	-	1	-	-	-	-	-	30	20
4	*Artocarpus lakoocha*	-	-	-	-	-	-	-	1	-	-	10	10
5	*Ficus sarmentosa*	-	-	-	-	-	-	-	1	-	-	10	10
6	*Rhus wallichii*	2	-	1	1	-	-	-	-	1	-	50	40
7	*Macropanax undulatus*	-	-	-	-	3	-	-	-	-	-	30	10
8	*Schima wallichii*	5	1	8	3	2	2	3	4	5	3	360	100
9	*Madhuca butraceae*	-	-	-	-	-	-	-	-	-	3	30	10
10	*Boeheria rugulosa*	-	1	-	1	2	-	-	1	-	-	50	40
11	*Garuga pinnata*	-	-	-	-	-	-	-	1	-	-	10	10
12	*Bridelia retusa*	-	1	-	-	-	-	-	1	-	-	20	20
13	Ghokro *	-	-	-	1	-	1	-	-	-	-	20	20
14	*Premma latifolia*	-	-	-	1	-	-	-	-	-	-	10	10
15	*Elaegnus parvifolia*	-	-	-	-	-	-	-	-	2	-	20	10
16	*Terminalia chebula*	-	-	-	1	-	-	-	1	2	2	60	40
17	*Syzium cumini*	-	-	-	-	-	-	-	-	-	1	10	10
18	*Eurya acuminata*	-	-	2	-	-	-	-	-	-	-	20	10
19	*Myrica esculenta*	1	1	4	-	2	4	3	2	2	2	210	90
20	*Myrsine semiserrata*	-	1	-	1	-	1	-	-	-	-	30	30
21	Kande*	2	-	-	1	1	5	2	3	-	-	140	60
22	*Persea gamblei*	1	-	-	-	-	-	1	1	-	-	30	30
23	*Castanopsis indica*	-	-	6	-	-	-	-	-	5	-	110	20

24	*Ficus lacor*	-	-	-	-	-	-	-	1	-	-	10	10
25	*Grevillea robusta*	-	-	-	-	1	-	-	-	-	-	10	10
26	*Ficus semicordata*	-	1	-	-	-	-	1	1	1	1	50	50
27	*Acacia catechu*	-	-	-	1	-	-	-	-	-	-	10	10
28	*Sapium insigne*	-	2	-	-	1	4	-	1	2	1	110	60
29	*Litsea monopetala*	-	1	-	-	-	-	-	-	-	-	10	10
30	*Fraxinus floribunda*	-	1	-	-	-	-	-	1	-	-	20	20
31	*Macaranga indica*	4	-	-	-	-	-	-	-	-	-	40	10
32	*Engelhardia spicata*	3	2	-	1	7	1	10	5	8	6	430	90
33	*Quercus glauca*	-	-	-	-	-	-	-	1	-	-	10	10
34	*Erythrina stricta*	-	-	-	-	1	-	-	-	-	-	10	10
35	*Betula alnoides*	-	-	-	-	-	-	-	1	-	-	10	10
36	*Bombax ceiba*	-	3	6	4	2	3	3	4	2	5	320	90
37	*Mallotus philippinensis*	-	1	-	-	-	-	-	-	-	2	30	20
38	*Albizia spp.*	-	2	-	1	2	-	2	5	-	1	130	60
39	*Ficus racemosa*	-	-	-	1	-	1	-	-	-	-	20	20
40	*Cedrella toona*	-	-	1	1	-	-	-	1	-	-	30	30
41	*Cyatheae capitata*	1	-	-	-	-	-	-	-	-	-	10	10
42	*Alnus nepalensis*	1	2	-	-	4	-	-	-	-	-	70	30
Total		20	20	30	20	29	23	25	39	34	30	2700	1220

Note: * indicates local name of the plant species

5.2 Relative Density (RD), Relative Frequency (RF), Relative Dominance (RDo), and Importance Value of Index (IVI) of Tree Species

The relative density, relative frequency and relative dominance for tree species ranged from 0.33% -15.93%, 0.83% -8.20%, and 0.25%-9.52% respectively. Among the tree species *Engelhardtia spicata* had the highest relative density (15.93%). Similarly, *Schima wallichii* had the highest relative frequency (8.2%) and relative dominance (9.52%) table 5.2.

IVI gives an over all importance of a species in the plant community. Higher the value of IVI, the larger the role of the species in the plant community. IVI value of tree species ranged from (1.44%-31.05%) (Table 5.2). Among the tree species the highest IVI was calculated for *Schima wallichii* (31.05%) followed by *Engelhardtia spicata* (28.89%). In the same way, the least IVI value among tree species was calculated for *Premma latifolia* (1.44%) followed by *Grevillea robusta* (1.51%) and *Ficus lacor* (1.69%). The species wise RD, RF, RD, and IVI were analyzed and tabulated in table 5.2.

Table 5.2: Analysis of IVI of Tree Species

S.N.	Local Name	Botanical Name	R.D. (%)	R.F. (%)	R.Do. (%)	IVI (%)
1	Khayar	*Acacia catechu*	0.37	0.82	3.81	5.00
2	Sirish	*Albizia spp.*	4.81	4.92	3.76	13.49
3	Utis	*Alnus nepalensis*	2.59	2.46	1.12	6.17
4	Badahar	*Artocarpus lakoocha*	0.37	0.82	3.33	4.52
5	Saur	*Betula alnoides*	0.37	0.82	5.55	6.74
6	Daar	*Boeheria rugulosa*	1.85	3.28	1.72	6.85
7	Simal	*Bombax ceiba*	11.85	7.38	8.66	27.89
8	Gayo	*Bridelia retusa*	0.74	1.64	0.85	3.23
9	Katus	*Castanopsis indica*	4.07	1.64	6.40	12.11
10	Tooni	*Cedrella toona*	1.11	2.46	1.18	4.75
11	Tree fern	*Cyatheae spinulosa*	0.37	0.82	1.18	2.37
12	Goyali	*Elaegnus parvifolia*	0.74	0.82	0.96	2.52
13	Mauwa	*Engelhardtia spicata*	15.93	7.38	5.51	28.82
14	Phaledo	*Erythrina stricta*	0.37	0.82	0.82	2.01
15	Jhayanu	*Eurya acuminata*	0.74	0.82	0.78	2.34
16	Kavro	*Ficus lacor*	0.37	0.82	0.50	1.69
17	Timala	*Ficus racemosa*	0.74	1.64	0.25	2.63
18	Bello	*Ficus sarmentosa*	0.37	0.82	0.82	2.01
19	Khaniyo	*Ficus semicordata*	1.85	4.1	1.30	7.25
20	Lakuri	*Fraxinus floribunda*	0.74	1.64	1.38	3.76
21	Dabdabe	*Garuga pinnata*	0.37	0.82	3.18	4.37
22	Kayio	*Grevillea robusta*	0.37	0.82	0.32	1.51
23	Kutmiro	*Litsea monopetala*	0.37	0.82	1.71	2.90
24	Angeri	*Lyonia ovalifolia*	1.11	1.64	2.64	5.39
25	Malath	*Macaranga indica*	1.48	0.82	2.10	4.40
26	Chichinde	*Macropanax undulatus*	1.11	0.82	2.74	4.67
27	Chiuri	*Madhuca butraceae*	1.11	0.82	1.69	3.62
28	Sindure	*Mallotus philippinensis*	1.11	1.64	0.49	3.24
29	Kafal	*Myrica esculenta*	7.78	7.38	2.80	17.96
30	Kalikath	*Myrsine semiserrata*	1.11	2.46	2.46	6.03
31	Kathe kaulo	*Persea gamblei*	1.11	2.46	3.00	6.57
32	Amala	*Phyllanthus emblica*	3.70	4.1	0.68	8.48
33	Golaunri	*Premma latifolia*	0.37	0.82	0.25	1.44
34	Phalant	*Quercus glauca*	0.37	0.82	3.74	4.93
35	Bhalayo	*Rhus wallichii*	1.85	3.28	0.88	6.01
36	Khirro	*Sapium insigne*	4.07	4.92	1.85	10.84
37	Chilaune	*Schima wallichii*	13.33	8.2	9.52	31.05
38	Amaro	*Spondias pinata*	0.37	0.82	0.80	1.99
39	Jamuna	*Syzgium cumini*	0.37	0.82	2.25	3.44
40	Harro	*Terminalia chebula*	2.22	3.28	1.81	7.31
41	Ghokro	-	0.74	1.64	0.70	3.08
42	Kande	-	5.19	4.92	4.54	14.65
Total			100.00	100.00	100.00	300.00

5.3 Site Wise Basal Area and Wood Volume per Hectare

In site 1 Basal area of the species ranged from 0.1910 m^2/ha-0.8275, m^2/ha (Table 5.3). Among the tree species the highest basal area was calculated for *Schima wallichii* (0.8275m^2/ha) and was followed by *Macranga Indica* (0.6949m^2/ha) and *Engelhardtia spicata* (0.4166m^2/ha). Similarly, the lowest basal area and volume among tree species were found out for *Alnus nepalensis*, which were 0.1910m^2/ha and 0.4394 m^3/ha respectively. The volume ranged from 0.4394m^3/ha-4.2034m^3/ha. Among the tree species *Macaranga indica* had the highest (4.20 34m^3/ha) volume followed by *Schima wallichii* (3.2356 m^3/ha). From the analysis it should be considered that in site (1) *Schima wallichii* and *Macranga indica* were the most dominate species indicating the favorable environmental condition for this species.

Table 5.3: Basal Area and Wood Volume per Hectare in Site 1

S.N.	Name of Plant Species	Basal Area (m^2/ha)	Volume (m^3/ha)
1	*Alnus nepalensis*	0.1910	0.4394
2	*Cyatheae capitata*	0.3904	0.8979
3	*Engelhardtia spicata*	0.4166	1.5622
4	Kande*	0.2375	0.7957
5	*Macaranga indica*	0.6948	4.2034
6	*Myrica esculenta*	0.3171	1.5223
7	*Persea gamblei*	0.5145	2.8297
8	*Rhus wallichii*	0.3033	1.9186
9	*Schima wallichii*	0.8275	3.2356
Total		3.8927	17.4048

Note: * indicates local name of the plant species

In site 2 altogether 14 tree species were recorded. Among 14 species of tree, *Bombax ceiba* had the highest value of Basal area and volume which were found to be 4.9904 m^2/ha and 71.3628, m^3/ha respectively (Table5.4). Basal area followed by *Engelhardtia spicata* (0.7738m^2/ha) and volume was followed by *Myrsine seminserrate* (4.4470 m^3/ha). In this site *Bombax ceiba* and *Engelhardtia spicata* were the dominant tree species.

Table 5.4: Basal Area and Wood Volume per Hectare in Site 2

S.N.	Name of Plant Species	Basal Area (m^2/ha)	Volume (m^3/ha)
1	*Albizia spp.*	0.4726	3.3909
2	*Alnus nepalensis*	0.4645	2.2295
3	*Boeheria rugulosa*	0.7112	2.9516
4	*Bombax ceiba*	4.9904	71.3628
5	*Bridelia retusa*	0.3047	0.8226
6	*Engelhardtia spicata*	0.7738	3.0950
7	*Ficus semicordata*	0.4828	1.7140
8	*Fraxinus floribunda*	0.3904	1.2297
9	*Litsea monopetala*	0.5680	2.3573
10	*Mallotus philipppinensis*	0.1056	0.3591
11	*Myrica esculenta*	0.6693	2.1084
12	*Myrsine semiserrata*	0.7350	4.4470
13	*Sapium insigne*	0.5788	2.0980
14	*Schima wallichii*	0.2629	2.1425
Total		11.51	100.3084

In site 3 among 8 species of trees, *Schima wallichii* had the highest of basal area (107962m^2/ha) and *Bombax ceiba* had the highest value of volume (92.2590m^3/ha). The value of basal are was followed by *Bombax ceiba* (8.1705 m^2/ha) and volume by *Schima wallichii* (62.8878m^3/ha) (Table5.5).

Table 5.5: Basal Area and Wood Volume per Hectare in Site 3

S.N.	Name of Plant Species	Basal Area (m^2/ha)	Volume (m^3/ha)
1	*Bombax ceiba*	8.1705	92.2590
2	*Castanopsis indica*	3.3871	12.8711
3	*Cedrella toona*	0.5307	2.0696
4	*Eurya acuminata*	0.2572	0.6173
5	*Lyonia ovalifolia*	1.6685	3.8376
6	*Myrica esculenta*	0.6421	2.2875
7	*Rhus wallichii*	0.7160	3.6156
8	*Schima wallichii*	10.7962	62.8878
Total		26.1683	180.4455

In site 4, altogether 14 tree species were recorded. Among these tree species *Bombax ceiba* had the highest Basal area (1.0922m^2/ha) and volume (5.3379m^3/ha). These values were followed by *Schima wallichii* which were 0.5135 m^2/ha and 1.2410 m^3/ha respectively. In this site *Phyllanthus emblica* had lowest basal area and volume, which were 0.0242 m^2/ha and 0.0254 m^3/ha respectively (Table 5.6).

Table 5.6: Basal Area and Wood Volume per Hectare in Site 4

S.N.	Name of Plant Species	Basal Area (m^2/ha)	Volume (m^3/ha)
1	*Acacia catechu*	0.3494	1.6567
2	*Albizia spp.*	0.3834	1.1694
3	*Boeheria rugulosa*	0.1452	0.2251
4	*Bombax ceiba*	1.0922	5.3379
5	*Cedrella toona*	0.0509	0.0534
6	*Engelhardtia spicata*	0.1168	0.2863
7	*Ficus racemosa*	0.1550	0.8988
8	Ghokro*	0.1910	0.3439
9	Kande*	0.1410	0.7118
10	*Myrsine semiserrata*	0.0754	0.3807
11	*Phyllanthus emblica*	0.0242	0.0254
12	*Premma latifolia*	0.0817	0.0858
13	*Rhus wallichii*	0.0302	0.0769
14	*Schima wallichii*	0.5135	1.2410
15	*Terminalia chebula*	0.1149	0.3218
Total		3.4648	12.8149

Note: * indicates local name of the plant species

In site 5, 13 tree species were recorded. Among the tree species *Engelhardtia spicata* had highest basal area (4.7698 m^2/ha) and volume (20.5403m^3/ha). These values were followed by kande, which were found to be 3.3268 m^2/ha and 6.9864m^3/ha. In this site *Lyonia ovalifolia* had lowest basal area and volume, which were 0.0816 m^2/ha and 0.1266m^2/ha respectively (Table 5.7).

Table 5.7: Basal Area and Wood Volume per Hectare in Site 5

S.N.	Name of Plant Species	Basal Area (m^2/ha)	Volume (m^3/Ha)
1	*Albizia spp.*	0.4863	1.4711
2	*Alnus nepalensis*	0.4540	0.8286
3	*Boeheria rugulosa*	0.4890	1.1249
4	*Bombax ceiba*	0.4019	1.4570
5	*Engelhardtia spicata*	4.7698	20.5403
6	*Erythrina stricta*	0.2715	0.7604
7	*Grevillea robusta*	0.1074	0.3331
8	Kande*	3.3268	6.9864
9	*Lyonia ovalifolia*	0.0816	0.1266
10	*Macropanax undulatus*	0.9077	2.4207
11	*Myrica esculenta*	0.6031	1.8245
12	*Sapium insigne*	0.3331	1.3158
13	*Schima wallichii*	0.2798	1.0073
Total		12.5126	40.1967

Note: * indicates local name of the plant species

In site 6, among to tree species, *Bombax ceiba* had the highest basal area and volume which were 3.3768 m^2/ha and 24.1441 m^3/ha respectively. These values were followed by kande. Kande had basal area and volume equal to 2.8444m^2/ha and 9.1305 m^3/ha respectively. In this site *Engelhardtia* had lowest basal area (0.0849 m^2/ha) and *Ficus rcemosa* had lowest volume (0.1379 m^3/ha) (Table5.8).

Table 5.8: Basal Area and Wood Volume per Hectare in Site 6

S.N.	Name of Plant Species	Basal Area (m^2/ha)	Volume (m^3/Ha)
1	*Bombax ceiba*	3.3768	24.1441
2	*Engelhardtia spicata*	0.0849	0.7726
3	*Ficus racemosa*	0.1149	0.1379
4	Ghokro*	0.2716	1.0727
5	Kande*	2.8444	9.1305
6	*Myrica esculenta*	2.2891	6.1518
7	*Myrsine semiserrata*	1.6323	8.2431
8	*Phyllanthus emblica*	0.1583	0.6015
9	*Sapium insigne*	1.2001	5.4005
10	*Schima wallichii*	0.7393	6.5058
Total		12.7117	62.1607

Note: * indicates local name of the plant species

In site 7, among 8 tree species *Engelhardtia spicata* had highest basal area (4.077 m^2/ha) and *Albizia* sp. had highest volume (14.9622 m^3/ha). Basal area followed by *Albizia* spp (2.6134 m^2/ha) and volume by *Engelhardtia spicata* (14.2905 m^3/ha). In this site *Ficus semicordata* had the lowest basal area (0.4906 m^2/ha) and volume (1.3738 m^3/ha) (Table5.9).

Table 5.9: Basal Area and Wood Volume per Hectare in Site 7

S.N.	**Name of Plant Species**	**Basal Area (m^2/ha)**	**Volume (m^3/ha)**
1	*Albizia spp.*	0.9388	8.0116
2	*Bombax ceiba*	2.6134	14.9622
3	*Engelhardtia spicata*	4.0771	14.2905
4	*Ficus semicordata*	0.4906	1.3738
5	Kande*	1.0450	2.7171
6	*Myrica esculenta*	1.1329	2.7001
7	*Persea gamblei*	1.7046	9.2052
8	*Schima wallichii*	1.4367	5.4118
Total		13.4396	58.6724

Note: * indicates local name of the plant species

In site 8, 21 tree species were recorded. Among 21 tree species, *Albizia* spp. had highest basal area and volume which were found to be 2.4689 m^2/ha and 18.5904 m^3/ha respectively. The basal area value was followed by *Engelhardtia spicata* (2.3560 m^2/ha) and volume value of *Bombax ceiba* (17.5124 m^3/ha). In this site the *Ficus lacor* had the lowest basal are (0.1650 m^2/ha) and volume (0.3383 m^3/ha) (Table5.10). This site was found to be more diverse than other sites which indicate that the microclimatic condition of this site was favorable for the existence of various tree species.

Table 5.10: Basal Area and Wood Volume per Hectare in Site 8

S.N.	**Name of Plant Species**	**Basal Area (m^2/ha)**	**Volume (m^3/ha)**
1	*Albizia spp.*	2.4689	18.5904
2	*Artocarpus lakoocha*	1.1039	9.0528
3	*Betula alnoides*	1.8389	13.0569
4	*Boeheria rugulosa*	0.9289	8.6397
5	*Bombax ceiba*	2.0942	17.5124
6	*Bridelia retusa*	0.26	0.9231
7	*Cedrella toona*	0.4828	2.6313

8	*Engelhardtia spicata*	2.356	12.2982
9	*Ficus lacor*	0.165	0.3383
10	*Ficus sarmentosa*	0.2716	0.7061
11	*Ficus semicordata*	0.5389	1.8321
12	*Fraxinus floribunda*	0.5225	2.5081
13	*Garuga pinnata*	1.0516	10.257
14	Kande*	1.4252	5.2018
15	*Myrica esculenta*	0.552	1.6559
16	*Persea gamblei*	0.7593	3.6444
17	*Phyllanthus emblica*	0.284	0.9302
18	*Quercus glauca*	1.2372	11.0093
19	*Sapium insigne*	0.6331	2.6592
20	*Schima wallichii*	1.5025	9.0904
21	*Terminalia chebula*	1.1455	7.3312
Total		21.622	139.8688

Note: * indicates local name of the plant species

In site 9, 11 tree species were recorded. Among 11 tree species, *Schima wallichii* had the highest basal area (13.5797m^2/ha). These values were followed by the *Engelhardtia spicata*. *Engelhardtia spicata* had 2.0546 m^2/ha basal are and 6.5489 m^3/ha volume. Similarly, *Rhus wallichii* had lowest basal area and volume which were 0.1188 m^2/ha and 0.2672 m^3/ha respectively (Table5.11).

Table 5.11: Basal Area and Wood Volume per Hectare in Site 9

S.N.	**Name of Plant Species**	**Basal Area (m^2/ha)**	**Volume (m^3/ha)**
1	*Bombax ceiba*	0.7738	3.5206
2	*Castanopsis indica*	0.8551	2.3087
3	*Elaegnus parvifolia*	0.3166	0.6727
4	*Engelhardtia spicata*	2.0546	6.5489
5	*Ficus semicordata*	0.4751	0.7601
6	*Myrica esculenta*	1.2485	4.0577
7	*Phyllanthus emblica*	0.4117	0.6278
8	*Rhus wallichii*	0.1188	0.2672
9	*Sapium insigne*	0.2168	0.7316
10	*Schima wallichii*	13.5797	114.2052
11	*Terminalia chebula*	0.4171	1.4600
Total		20.4678	135.1605

In site 10, 13 different species were found. Among all species, *Bombax ceiba* had highest basal area (3.9691 m^2/ha). Basal area value was followed by *Engelhardtia spicata* (1.7605 m^2/ha) and volume by *Albizzia* spp. (10.4529 m^3/ha). In this site *Syzygium cumuni* had lowest basal area (0.3109 m^3/ha) (Table5.12).

Table 5.12: Basal Area and Wood Volume per Hectare in Site 10

S.N.	**Name of Plant Species**	**Basal Area (m^2/ha)**	**Volume (m^3/ha)**
1	*Albizia spp.*	1.0401	10.4529
2	*Bombax ceiba*	3.9691	34.3329
3	*Engelhardtia spicata*	1.7605	7.7022
4	*Ficus semicordata*	0.1673	0.4936
5	*Madhuca butraceae*	0.5585	1.7128
6	*Mallotus philippinensis*	0.2186	0.6558
7	*Myrica esculenta*	0.8781	4.3687
8	*Phyllanthus emblica*	0.2434	0.7118
9	*Sapium insigne*	0.7207	5.0809
10	*Schima wallichii*	1.5798	8.7940
11	*Spondias pinata*	0.2658	1.6478
12	*Syzygium cumini*	0.1130	0.3109
13	*Terminalia chebula*	0.8197	3.2584
Total		12.3346	79.5227

5.4 DBH Class Distribution of Trees Species

Table 5.13 indicates the distributions of tree species according to different DBH classes.10-20 cm DBH class predominated in site 1 which was 85% of the DBH class. Similarly, 20-30cm DBH class dominated in site 5 which was 48.27%, 30-40 cm DBH was dominated in site 8 which was 17.94% and >40 cm DBH class was dominated in site 3 which was 30%. From this analysis it indicates that in site 3 trees were matured than other sites and in site 1 most of the plant sp. were in growing stages.

Table 5.13: Tree Density according to DBH Class

Site No.	No. of Plant Species	Tree Density/ha			
		10-20cm DBH	20-30cm DBH	30-40cm DBH	>40cm DBH
1	9	170	30	-	-
2	14	90	60	30	20
3	8	180	20	10	90
4	15	150	40	-	10
5	13	140	140	-	10
6	10	110	60	20	40
7	8	120	60	40	30
8	21	120	180	70	20
9	11	210	90	10	30
10	13	120	120	50	10

5.5 Indices of Diversity, Dominance and Evenness

Evenness, plant species diversity and index of dominance for tree, shrubs and herbs were shown in table 5.14. Index of diversity of tree, shrubs and herbs were calculated as 4.3519, 4.3711 and 5.0848 respectively. Species evenness for tree was 0.80707, for Shrub 0.9193 ad for herb 0.89642. Similarly, index of dominance for trees, shrubs and herbs were calculated as 0.0767, 0.0576 and 0.03804 respectively.

Table 5.14: Indices of Diversity, Dominance and evenness of Trees, Shrubs and Herbs

Habitat	Diversity index Value (H)	Species evenness Value (J)	Dominance index Value (Cd)
Tree	4.3519	0.8070	0.0767
Shrub	4.3711	0.9193	0.0576
Herb	5.0848	0.8964	0.0380

5.6 Analysis for Shrubs Species

From the table *Innula cappa* had the highest value of density and relative density 420pl/Ha and 11.08% respectively. These values were followed by *Hypericum chisia* which were 385 Pl/ha and 10.16% respectively. Similarly *Maclura cochinhinensis* had lowest density and relative density which were 10 Pl/ha and 0.26% respectively. Highest value of density and relative density indicates the numerical strength of plant species in the community. The highest value of frequency and relative frequency were observed for *Mimosa rubicaulis, Mussaenda treuleri, Woodfordia fruticosa, and Innula cappa* each with the frequency of 95.00% and 6.23%

relative frequency. The *Maclura cochinhinensis* had the lowest frequency (10%) and relative frequency (0.66%). The lowest value of frequency were due to unfavorable microclimate i.e. soil, nutrients, water etc.

The highest coverage among shrub species was 62.5% for each *Mimmosa rubicaulis Hypericum chisia, Innula cappa, Butea minor* and *Colebrookia oppositifolia* and was followed by *Mussaenda treuleri, Woodfordia fruticosa, Osynis wightilna, Rubus ellipticus* each with 37.5%. The respective relative coverage of these species was 8.82% and 5.29% respectively. Similarly, the lowest coverage was estimated for *Scutellaria discolor* and *Maclura cochinhinensis* each with the value of 3 and the relative coverage of these species was 0.42%.

Among 27 shrub species, *Inula cappa* had the highest IVI value (26.19%) and was followed by *Hyperiucum Chisia* (24.94%), *Mimmosa rubicaulis* (22.24%) and *Colebrookia oppositifolia* (20.48%). Similarly, the lowest IVI among the shrub species was calculated for *Macular cochinhinensis* (1.35%) and was followed by *Scutellaria discolor* (1.94%) ad *Leea asiatica* (4.10%).

The density, RD, frequency, RF, coverage RC and IVI for shrub species were analyzed and tabulated in the following table 5.15.

Table 5.15 Analysis of Shrubs

Total No. of Quatrates 20									
Size of the Quadrates (3m X3m)									
S.N.	**Botanical name**	**Total No.Of Individuals**	**Density (P/Ha)**	**Frequency (%)**	**Coverage (%)**	**RD (%)**	**RF (%)**	**RC (%)**	**IVI (%)**
1	*Adhatoda vasica*	15	75	20	15	1.98	1.32	2.12	5.42
2	*Antidesma acidum*	15	75	30	15	1.98	1.99	2.12	6.08
3	*Arundo donax*	29	145	80	15	3.83	5.30	2.12	11.24
4	*Bambusa* spp.	24	120	60	15	3.17	3.97	2.12	9.26
5	*Buddleja asiatica*	22	110	45	15	2.90	2.98	2.12	8.00
6	*Butea minor*	49	245	75	62.5	6.46	4.97	8.82	20.25
7	*Cinnamomum glaucescens*	7	35	25	15	0.92	1.66	2.12	4.70
8	*Colebrookio oppositifolia*	57	285	70	62.5	7.52	4.64	8.82	20.98
9	*Coriaria nepalensis*	23	115	45	15	3.03	2.98	2.12	8.13
10	*Desmodium oojeinense*	6	30	25	15	0.79	1.66	2.12	4.56
11	*Hyperiucum chisia*	77	385	90	62.5	10.6	5.96	8.82	24.94
12	*Inula cappa*	84	420	95	62.5	11.8	6.29	8.82	26.19
13	*Jatropha curcas*	28	140	65	15	3.69	4.30	2.12	10.12
14	*Leea asiatica*	5	25	20	15	0.66	1.32	2.12	4.10
15	*Maclura cochinhinensis*	2	10	10	3	0.26	0.66	0.42	1.35
16	*Maesa chisia*	13	65	60	15	1.72	3.97	2.12	7.81
17	*Mimmosa rubicaulis*	54	270	95	62.5	7.12	6.29	8.82	22.24
18	*Mussaenda treuleri*	39	195	95	37.5	5.15	6.29	5.29	16.73
19	*Nyctanthes arbo-tristis*	24	120	50	15	3.17	3.31	2.12	8.59
20	*Osbeckia nepalensis*	27	135	45	15	3.56	2.98	2.12	8.66
21	*Osyris wightiana*	36	180	90	37.5	4.75	5.96	5.29	16.00
22	*Pyrecantha crenulata*	12	60	50	15	1.58	3.31	2.12	7.01
23	*Rubus ellipticus*	33	165	80	37.5	4.35	5.30	5.29	14.94
24	*Sambuscus hookeri*	21	105	40	15	2.77	2.65	2.12	7.54
25	*Scutellaria discolor*	4	20	15	3	0.53	0.99	0.42	1.94
26	*Vitex negundo*	11	55	40	15	1.45	2.65	2.12	6.22
27	*Woodfordia fruticosa*	41	205	95	37.5	5.41	6.29	5.29	16.99
Total			3790			100	100	100	300.0

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5.7 Analysis of Herb Species

From the Table 5.16 the density of herbs ranged from 0.34 pl/m^2 to 22.18 pl/m^2. The *Artemisia vulgaris* had the highest density (22.18 Pl/m^2) and relative density (8.29%). The values were followed by *Cynodon dactylon* which were 16.18 pl/m^2 and 6.05% respectively. Similarly, *Cirsium* spp. had lowest density and relative density which were 0.34 Pl/m^2 and 0.13% respectively. The highest value of *Artemisia vulgaris* indicates the highest strength in the community.

The highest value of frequency (94%) and relative frequency (3.32%) were observed for *Artemisia vulgaris* and *Imperata cylindrica*. While *Cirsium* had the lowest frequency (10%) and relative frequency (0.35%).

The highest coverage among the herb species was 37.5% for each *Ageratum conyzoides, Artemisia vulgaris, Artharakson lancifolia, Cynodon dactylon, Eulaliopsis binata Eupatorium adenophorum, Imperata cylindrica, Thysnolacna maxima* and *Typha* spp. And the relative coverage of these species was 6.71% similarly, *Cirsium* spp., *Hedychium coronanium, Xanthium strumarian, Zizyphus* spp and Jaki had lowest coverage (0.5%) and the relative coverage of these species was 0.09%.

Among 51 herb species *Artemisia vulgaris* had the highest IVI value (18.32 %) and was followed by *Cynodon dactylon* (15.73%), *Imperata cylindrica* (15.40%) and *Eupatorium adinophorum* (15.39%). Similarly, the lowest IVI among the herb species was calculated for *Cirsim* spp. (0.57%) and was followed by *Xanthium stromarian* (0.92%) and Jaki (1.05%)

Table 5.16: Analysis of Herbs

S.N.	Botanical Name	Total no. of individual	Density P /m2	Frequency (%)	Coverage (%)	RD (%)	RF (%)	RC (%)	IVI (%)
1	*Achyranthes bidentata*	124	2.48	60	3	0.93	2.12	0.54	3.59
2	*Aconogonum molle*	73	1.46	24	3	0.55	0.85	0.54	1.93
3	*Ageratum conyzoides*	680	13.60	90	37.5	5.08	3.18	6.71	14.97
4	*Artemisia vulgaris*	1109	22.18	94	37.5	8.29	3.32	6.71	18.32
5	*Asparagus* spp.	60	1.20	34	3	0.45	1.20	0.54	2.19
6	*Barleria cristata*	29	0.58	72	3	0.22	2.55	0.54	3.30
7	*Bidens pilosa*	172	3.44	68	3	1.29	2.40	0.54	4.23
8	*Bistorta capitata*	77	1.54	32	3	0.58	1.13	0.54	2.24
9	*Boennighausenia albifora*	197	3.94	58	3	1.47	2.05	0.54	4.06
10	*Cannabis sativa*	289	5.78	66	3	2.16	2.33	0.54	5.03
11	*Carassocephalum crepidioides*	92	1.84	46	3	0.69	1.63	0.54	2.85
12	*Celtis australis*	306	6.12	70	15	2.29	2.48	2.68	7.45
13	*Centalla asiatica*	331	6.62	80	15	2.47	2.83	2.68	7.99
14	*Chrysopogon serrulatus*	78	1.56	40	3	0.58	1.41	0.54	2.53
15	*Cirsium* spp.	17	0.34	10	0.5	0.13	0.35	0.09	0.57
16	*Arthrakson lancifolia*	617	12.34	70	37.5	4.61	2.48	6.71	13.80
17	*Cperus* spp.	407	8.14	74	15	3.04	2.62	2.68	8.34
18	*Cynodon dactylon*	809	16.18	84	37.5	6.05	2.97	6.71	15.73
19	*Dactyloctenium aegypticum*	88	1.76	42	3	0.66	1.49	0.54	2.68
20	*Desmodium* spp.	124	2.48	44	3	0.93	1.56	0.54	3.02
21	*Dichrocephala chrysanthemifolia*	150	3.00	38	3	1.12	1.34	0.54	3.00
22	*Digitaria adscendens*	360	7.20	72	15	2.69	2.55	2.68	7.92
23	*Drepanostachyum falcatum*	190	3.80	72	3	1.42	2.55	0.54	4.50
24	*Drymaria diandra*	124	2.48	44	3	0.93	1.56	0.54	3.02
25	*Duchesnea indica*	107	2.14	50	3	0.80	1.77	0.54	3.10
26	*Eclipta prostrata*	55	1.10	30	3	0.41	1.06	0.54	2.01
27	*Elastostema rupestre*	222	4.44	50	3	1.66	1.77	0.54	3.96
28	*Elusine indica*	105	2.10	52	3	0.79	1.84	0.54	3.16
29	*Eulaliopsis binata*	717	14.34	62	37.5	5.36	2.19	6.71	14.26
30	*Eupatorium adenophorum*	792	15.84	78	37.5	5.92	2.76	6.71	15.39
31	*Euphorbia hirta*	111	2.22	60	3	0.83	2.12	0.54	3.49
32	*Galinsoga parvifora*	206	4.12	62	3	1.54	2.19	0.54	4.27
33	*Galium* spp.	131	2.62	48	3	0.98	1.70	0.54	3.21
34	*Girardinia diversifolia*	322	6.44	84	15	2.41	2.97	2.68	8.06
35	*Hedychium coronarium*	40	0.80	28	0.5	0.30	0.99	0.09	1.38
36	*Heteropogon centortum*	109	2.18	52	3	0.81	1.84	0.54	3.19
37	*Imparata cylindrica*	718	14.36	94	37.5	5.37	3.32	6.71	15.40
38	*Oreocnide frutescens*	337	6.74	66	15	2.52	2.33	2.68	7.54
39	*Oxalis corniculata*	314	6.28	78	15	2.35	2.76	2.68	7.79
40	*Phylllanthus urinaria*	64	1.28	36	3	0.48	1.27	0.54	2.29
41	*Polygonum barbata*	72	1.44	38	3	0.54	1.34	0.54	2.42
42	*Sacchharum apontaneum*	371	7.42	44	15	2.77	1.56	2.68	7.01
43	*Setaria pumia*	118	2.36	42	3	0.88	1.49	0.54	2.90
44	*Solanum aculeatissmum*	146	2.92	70	3	1.09	2.48	0.54	4.10
45	*Thallictrum foliolosum*	56	1.12	34	3	0.42	1.20	0.54	2.16
46	*Thysanolaena maxima*	698	13.96	74	37.5	5.22	2.62	6.71	14.54
47	*Typha* spp.	584	11.68	64	37.5	4.37	2.26	6.71	13.34
48	*Urtica dica dioica*	366	7.32	76	15	2.74	2.69	2.68	8.11
49	*Xanthium strumarian*	26	0.52	18	0.5	0.19	0.64	0.09	0.92
50	*Zizyphus* spp.	42	0.84	36	0.5	0.31	1.27	0.09	1.68
51	Jaki*	43	0.86	18	0.5	0.32	0.64	0.09	1.05
Total			267.50			100.00	100.00	100.00	300.00

5.8 Soil Analysis

In this study different soil parameters (physical and chemical) were analyzed (Table5.17) showed the different soil characteristics. From the analysis texture of the soil was found to be loamy sand. The percentage of sand ranged from 68.39% to 83.87%. Similarly, percentage of clay and silt ranged from 1.93%-10.97% and 12.90%-27.10% respectively. The soil of the project area was slightly acidic in nature and pH ranged from 5.7-6.6.The WHC varied from 36%-50%, conductivity from 18.00 µs/cm-98 µs/cm, chloride from 4.26 ppm to 17.09ppm, Nitrogen from 0.14% to 0.47%, OM from 6.56%-11.85% and phosphorus from 0.12%-0.15% (Table5.17).

Table5.17: Different soil parameters in the project area.

Sites	pH	Conductivity (µs/cm)	Cl (ppm)	OM (%)	Nitrogen (%)	Phosphorus (%)	WHC (%)	Soil Texture			
								Sand (%)	Silt (%)	Clay (%)	Class
A	6.2	43.0	9.94	8.07	0.196	0.12	37	83.87	6.45	9.68	Loamy Sand
B	5.9	31.0	5.68	11.35	0.392	0.13	49	77.42	20.65	1.93	"
C	6.6	98.0	4.26	9.58	0.252	0.15	39	78.71	14.84	6.45	"
D	6.1	50.0	17.04	11.85	0.476	0.14	50	76.13	12.90	10.97	"
E	6.3	18.0	12.78	6.56	0.140	0.12	36	68.39	24.52	7.09	"
F	5.7	44.0	7.10	10.34	0.322	0.15	44	70.97	27.10	1.93	"

Note: A: Near intake, B: Near Power House (Left Bank of P.H.), C: Near power House (Right bank of P.H.), D: Access road near Power house, E: Access road near Thulo bensi, F: Access road near Dovan chaur

5.9 Result of Questionnaire Survey

5.9.1 Information about the ethno-botanical Use of Plant in the Project Area

Local people depend on forest resources for fodder, fuel wood, timber and non-timber forest products. A few tree species such as *Engelhardtia spicata* and *Schima wallichii* are used for timber. However, *Artocarpus lahoocha*, *Bridelia retus*, *Castanopsis indica*, and *Ficus semicordata* were mainly used as fodder plants. Fruits of *Artocarpus lahoocha*, *Myrica* *esculenta* and *Rubus ellipticus* are edible and consumed by local people. Stems of *Boehmeria rugulosa* are used for making wooden vessels known as “Theki” while brooms are made from the inflorescence of *Thysanolaena maxima* (Table 5.18).

According to the local informants, residents prefer to receive treatment from modern (allopathic) medicine as opposed to tradition herbal (ayurvedic) medicine. This is mainly due to the facilities available at Bahundanda’s healthpost. Commonly used local medicinal values are presented below in table 5.18.

Table 5.18: Information about the ethan botanical Use of Plant in the Project Area

S.N.	Botanical Name	Local Name	Growth form	Parts used	Uses
1	*Adhatoda vasica*	Asuro	Shrub	Leaves,root	Cough ,asthma, insecticide
2	*Artemisia indica*	Titepati	Herb	Root	Antiseptic
3	*Artocarpus lakoocha*	Badahar	Tree	Fruits, leaves	Fruits edible ,leaves fodder
4	*Arundo donax*	Nigalo	Herb	Stem, leaves	Making basket ,fodder
5	*Bambusa* spp.	Bans	Herb	Stem, leaves ,young shoots	Making basket,fodder,young shoot edible
6	*Boehmeria rugulosa*	Daar	Tree	Stem	Making wooden pots(Theki)
7	*Bombax ceiba*	Simal	Tree	Root, flower	Tonic,snakebite
8	*Bridelia retusa*	Gayo	Tree	Leaves	Fodder
9	*Cannnabis sativa*	Bhang	Herb	Entire plant	Stomachic tonic,narcotic
10	*Castanopsis indica*	Katus	Tree	Seeds ,leaves	Seeds edible,fodder
11	*Centella asiatica*	Ghodtapre	Herb	Leaf	Improving memory
12	*Cyathaea spinulosa*	Kukh unyu	Tree	Young leaves	Edible
13	*Dendrocalamus* spp.	Bans	Herb	Stem, leaves ,young shoots	Making basket,fodder,young shoot edible
14	*Engelhardtia spicata*	Mauwa	Tree	Stem	Timber
15	*Eulaliopsis binata*	Babio	Herb	Leaves	Making brooms
16	*Ficus hispida*	Bello	Tree	Leaves	Fodder
17	*Ficus lacor*	Kabro	Tree	Bark	Gastric, ulcers
18	*Ficus semecordata*	Khaniya	Tree	Leaves	Fodder
19	*Jatropha curcas*	Sajiban	Shrub	Entire plant,stem	Fencing,tooth brush
20	*Madhuca butyraceae*	Chiuri	Tree	Fruits	Edible
21	*Myrica esculenta*	Kafal	Tree	Fruits	Edible
22	*Oxalis corniculata*	Chariamilo	Herb	Leaf,fruit	Stomachic antiscorbutic
23	*Phyllanthus emblica*	Amala	Tree	Fruit	Diarrhoea,dysentry
24	*Premna latifolia*	Ginderi	Tree	Leaves	Fodder
25	*Rubus ellipticus*	Ainselu	Shrub	Fruits	Edible
26	*Schima wallichii*	Chilaune	Tree	Stem	Timber
27	*Thysanolaena maxima*	Amliso	Shrub	Inflorescence, leaves	Broom, forage
28	*Urtica dioica*	Sishnu	Herb	Root	Anthelmintic,Jundice
29	*Vitex negundo*	Simali	Shrub	Entire plant	Fencing
30	*Woodfordia fruticosa*	Dhanero	Shrub	Root,flower	Dysentry

5.9.2 Energy Resources Used by Respondents in the Study Area:

Energy resources used by respondents in the study areais presented in table 5.19 below

Table 5.19: Energy Resources Used by Respondents in the Study Area

Sources of Energy	Source	Cost	% of respondent
Firewood	Forest	100 Rs/load	100%
Kerosene	Market	70 Rs/ R	95%
Batteries	Market	100Rs/Pack of 2	75%
Crop residues	AG land	-	35%
Solar cell	Sun	-	15%
Electricity	Water	-	75%
Dung	Cattle	-	30%
Biogas	Cattle	-	5%
L.P. Gas	Market	1000 Rs/Cylinder	35%

Source: Field survey, July, 2007.

5.9.3 Response of Respondents towards NHP Proposed Activities

Response of respondents towards NHP proposed activities is presented in table5.20

Table 5.20: Response of Respondents towards NHP Proposed Activities

Issues	Response	Percentage of respondents
Information about NHP	Yes	98%
	No	2%
Benefits anticipated:	Kerosene substitute	75%
	Employment	40%
	Firewood substitute	45%
Disadvantage anticipated	Unemployment	35%
	Inflation	20%
	Loss of property	40%
	Land slide	20%
	Negative impact on forest Resources and wildlife habitat	60%

5.9.4 Rare and Endangered Flora Found in Project Area

A number of rare and endangered species of vegetation were found in the study area which are listed in table 5.21

Table: 5.21 List of Rare and Endangered Flora Found in Project Area

S.N.	Botanical Name	Local Name	Protection Category		
			IUCN	CITES	GoN
1	*Accacia catechu* (L.F.) Willd	Khayar	√		√
2	*Bombax ceiba* L.	Simal			√
3	*Cythea spinulosa* Wall. ex Hook.	Rukh unue		√	
4	*Terminaalia chebula* Retz.	Harro			√

CHAPTER-VI

DISCUSSION

The present research had been carried out to assess the baseline information about the surrounding vegetation and edaphic factors in Nyadi Hydro-electric project. The presence of large number of tree, shrub, and herb species in the project area represented the high richness of floral diversity.42 species of trees, 27 species of shrubs and 52 species of herbs were recorded in the project area. Soil is an important factor that determines the ground vegetation. Variation in surface soil characteristic leads to changes in vegetation distribution. Shrestha (1979) showed that differences in vegetation distribution were attributable to the variation in edaphic factors. Forest soil infuences the composition of the forest stand and ground cover, tree growth, vigor of natural reproduction and other silviculturally important factors (Bhatnagar 1965).

6.1 Vegetation Status

The present study is mainly related to the documentation of vegetation status of the Nyadi hydroelectric projects. It deals with the study of trees, shrubs and herbs of surrounding areas of project. 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 within a 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 edaphic factors. These factors in general determine the distribution pattern of plants in a community (Brooks 1969). More frequent species are more important than less frequent or rare ones. So, the common species have greater effect on distribution of the species.

In this study the average density of trees per 100 m^2 sample plot was less (27 trees/100m^2) than as compated to average density (43.16 trees/100m^2) recorded in EIA report of Langtang hydroelectric project. Similarly the average density of the project area (270 trees/ha) was found to be higher than the findings of Pandey (2001) in KG'A' HEP (145.29 trees/ha), 159.5 trees/ha as recorded in EIA report of Upper Tamakoshi hydropower project. The highest tree density was found in site 8 (access road near Thulo bensi) (390 Pl/ha) and lowest in site 1 (near intake), 2 (near Naije village and site 4 near power house) each with 200 Pl/ha. The value was close to the value 226.43-235.39 Pl/ha as reported by Paudel (2000) in community and government managed forest of Udayapur district and 318.45 Pl/ha, as reported by Gewali (1999) in Biruwa community forest of Makawnapur district. The total tree density (2700 Pl/ha) in the study area was higher than other reported value such as 1124.92-2189.28 pl/ha as reported by Duwadee (2000) in Arun River Basin, 1949.95-2482.60 pl/ha as reported by Nepal (2001) in Ghandruk, 2546.17-2579.95 pl/ha as reported by Gautam (2002) in Palpa and 1092-1153 as reported by Marasini (2003) in Rupendehi District.

The number of tree species (42sp) found in the project area was less than findings of EIA reported of upper Tamakoshi hydropower (2005) (98 sp). This value was also lower than the findings of EIA study of Solukhola small hydroelectric project (2006) (143 sp), findings of EIA reported of Middle Marsyangdi Hydropower (2001) (57sp). On the other hand number of shrubs and herbs (79sp) was higher than the value recorded by EIA of Middle Marsyangdi hydropower (72sp).

The total density of shrub was found to be 3790pl/ha. The present value was higher than the value 977-2466pl/ha as reported by Gewali, (1999) in Kulekhani watershed, 2756.99-3132.07 pl/ha as reported by Paudel (2000) in community and government managed forest of Udayapur district, 973.43-1458.30 pl/ha as reported by Marasini (2003) in Rupendehi and 490-1730 pl/ha as reported by Singh and Singh (1989) in Himalayan region.

Various factors like soil, altitude, vegetation type and anthropogenic activities influence the plant density. In the present study, the lower density of tree species at site 1, 2 and 4 was due to intense human interference. Grazing, lopping and collection of firewood were more common in these sites. This may be the reason that the total tree density was lower in these sites in comparison to other sites. Higher density in site 8 was due to the areas lies in the community forest.

The basal area is an indicator of the natural fertility of the site (Bruening 1968). The total average basal area of tree was 13.81 m^2/ha. The value was higher than the findings of Pandey (2001) in KG'A' HEP 7.73 (m^2/ha) and higher than the value range from 34.85-50.49 m^2/ha as reported by Paudel (2000) in community and government managed forest of Udayapur, and 34.20-36.14 m^2/ha by Marasini (2003) in Churia forest of Rupendehi district. The highest basal area attained in the site 3 (36.16 m^2/ha) was mainly due to the greater number of trees and thick tree trunk.

The total average volume of tree was 82.6555 m^3/ha. This value was less than the value 130.075m^3/ha as reported in EIA report of Langtang Khola hydro-electric project.

Important value index (IVI) shows clear picture of the forest as well as of an individual species. The IVI analysis of present study revealed that *Schima Wallichii* (31.05%), *Engelhardtia spicata* (28.82%) and *Bombax ceiba* (27.89%)were the most importance and most successful plant species in that particular environment. It 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). While EIA report of Khudi HEP revealed that most of the project area dominated by the *Alnus nepalensis*, *Albizzia lebbek*, and *Cedrella toona*. This report also reported that *Bombax ceiba, Schima wallichii* were rarely existing. The IVI value of shrub was highest for *Inula cappa* (26.19%) followed by *Hyperiucum Chisia* (24.94%) and *Mimosa rubicaulis* (22.24%). Similarly, in herbs, *Artemisia vulgaris* (18.32%), followed *Cynodon dactylon* (15.73%), and *Imperata cylindrica* (15.40%) were the most important species indicated successfully found in that type of environment.

Variability of natural community is well known. Diversity is applied to represent this variability (Pielou 1975). Species diversity is a function of the 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). In present study the diversity index for trees, shrubs and herbs were found to be 4.3519, 4.3711 and 5.0848 respectively. Values of Shannon diversity index for real communities are found between 1.5 to 3.5 (Stilling, 2004). Taking this into consideration, we can say that species diversity values of trees, shrubs and herbs were high .For any information-statistic index, the maximum diversity of a community is found when all the species equally aboundant (Stilling, 2004). Species diversity tends to be low in physically controlled ecosystem (i.e. subjected to physiochemical limiting factors) and high in biologically controlled ecosystem (Odum, 1971). The present reported value of the species diversity index for tree was within the range of 3.02 to 8.10 as reported by Paudel (2000) in community and government managed forest of Udayapur district and in Churia forest in Rupendehi (Marasini, 2003) .The value was lower than the value reported by Nepal (2001) in Ghandruk but this value was higher than value 1.3-1.66 as reported by Gewali (1999) in Biruwa community forest. In this study species diversity index found to be higher for herbs it was mainly due to the greater number of herb species than tree and shrub.

The higher species diversity is an indication of maturity in the ecosystem (Marglef 1963, Odum 1969) and low species diversity is a result of incorporation of same species through competition. Index of dominance for trees, shrubs, herbs species was 0.0767, 0.0576, and 0.0380 respectively. Dominance of the plant species dependent on the ground coverage of the plant. In tree due to large girth and height the dominance value found to be higher than shrub and herb Evenness of species is expressed as relationship of species to each other. In present study the species evenness value for trees, shrubs, and herbs was 0.80707, 0.9193and 0.89642 respectively. From these values of evenness it can be estimated that shrub species were evenly distributed than tree and herb because the evenness value for shrub species found to be highest.

6.2 Analysis of Soil

Living organisms, both microscopic and macroscopic help to alter the parent material and make it into soil. Vegetation, no doubt is one of the ovious factors among them. Although the forest growth is under the influence of climate, but in 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 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 forest. Therefore, a study has been done to determine the nutrient contents in the forest of Nyadi hydropower project area. The physico-chemical characteristics of 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 of soil organic matter (OM), which influences physico-chemical characteristics of soil such as pH, 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 edaphic variations (Bhatta, 1981).

Soil texture of the study area was found to be loamy sandy type. The texture is the important factor for determining the WHC. The soil sample with higher amount of sand and silt particles was the lower WHC but with higher amount of clay favours higher WHC.The WHC value is also higher in regenerating areas due to high litter content. The water holding capacity of the soil is an important factor for the good regeneration of trees and the saplings. The water holding capacity ranged from 36% -50%.

The pH of the soil revealed that the whole study area posses slightly acidic soil. In the present study pH value ranged from 5.7-6.6 .The estimated value was similar to that as proposed by Howell (1987) 5.5 -6.06 for Mountain forest soil, 4.4-5.8 as reported by Juwa (1989) in Nagarkot Hill. According to Singh and Singh (1989) pH range of 4.5-5.5 is good for the sapling growth and the value of present was higher than this range.

Organic matter (OM) is the chief source of minerals return to soil and is contributed by dead bodies of plants and animals as well as micro-and macro-organisms living in the soil. The organic matter ranged from 6.56%-11.85%. According to Suoheimo (1995a) the value of 1.7-2.33% of organic matter is an indicator of a low fertility status of the soil. Organic matter is higher in poor regenerating area (Bhatnagar, 1965). Soil under the dense tree canopy used to be significantly higher in organic matter and nitrogen (Isichei and Monghalu, 1992). The present value was higher than the value 2.5% as reported by Shrestha (1992) in Terai forest, 1.8-4% by Shrestha (1996) in Riyale, 0.56-0.75 % by Pokharel (2002) in Gokarna forestland, 1.33-2.45% by Marasini (2003) in Churia forest in Rupendehi district. However, the present value was lower than the value 18% as reported by Baniya (1984) in Southwest Kathmandu Valley (Chandragiri).

The Nitrogen content in the present study was ranged from 0.140 to 0.476%. This value was similar with the value 0.18- 0.28 % as reported by Juwa (1989) in Nagarkot, and higher than the value0.04-0.09% as reported by Shrestha (1997) in Chitrepani (0.08-0.19 % as reported by Gewali (1999) in Kulekhani, 0.016-0.028 % by Pokharel (2002) in Gorkarna forest and 0.052-0.153% by Marasini (2003) in Churia forest.

6.3 Environmental Impacts of the Hydropower Generation

Environmental impacts have been identified for a number of issues based on observation, field study and information obtained from the local people. The impacts on the vegetation have been quantified to the possible extend and few impacts have been identified based on the value judgment as well as interviews and use of the questionnaires.

Project infrastructure development may be considered to have direct impact on the physical environment and on local flora and fauna. A number of positive impacts, however, may be linked to the improvement of the local economy and socioeconomic condition of the people. The main beneficial impacts were the increased employment, improvement literacy rate, rural electrification, road access to market and health care. Similarly, increased land value, improved entrepreneurship and small business, increased saving etc were other advantages results. The Nyadi Hydro-electric project is medium size and may give some negative impacts too. Change in land use pattern was of significant impact and if might cause long-term impact in future. The ground coverage was cleared in some area due to infrastructure development. Some of other impacts were reduction in land holding capacity; lack of proper compensation to those with undocumented land rights. Reduction in livestock and public grazing areas is also an impact of project. Some negative impacts are related to operational stage also. During the construction phase the felling of the trees and waste disposal have been the direct impacts to the vegetation resources and biotic environment. Loss of vegetation caused a direct impact on wildlife too. Indirect impacts could result because of the excessive use of natural resources by the immigrants and workforce in terms of firewood, communicable disease, poor sanitation practices etc. The recognizable impacts associated with the construction of dam, access road, powerhouse were the vegetation clearance, removal of wood (timber, firewood etc) and loss of habitat of wildlife and plants.

6.4 Discussion on Findings of Questionnaire Survey

In the rural agro-economy forest plays a pivotal role. Forest is the prime source of fuelwood, fodder, timber, medicinal and even agricultural manure. Many of the rural households are even dependent for food and other vegetables during critical periods of the year. The project area is rich in medicinal and wild edible plants. All respondents (100%) used *Schima wallichii* as a fuelwood. Besides this people used *Artemisia vulgaris, Rubus ellipticus, and Phyllanthus emblica* as a medicinal plants, *Artocarpus lakoocha, Ficus semintosa, Ficus semicordata* for fodder. Local people use the different trees and shrubs to meet the household demand for firewood, timber species are used to construct buildings. Local people prefer *Albizia* spp., *Castanopsis indica, Schima wallichii* and *Bombax ceiba* for timber purposes. *Macaranga indica, Schima wallichii, Castanopsis indica* and *Sapium insigne* are the major tree species used for firewood. The major fodder species are Bans, Badahar, and Kutmiro. Due to the construction activities of the project it causes the irreversible impact on bio-diversity as well as landscape which is directly related to the livelihood of the people in the periphery of the project area. Firewood and kerosene are the main energy sources used throughtout the study area. All households in the key villages reported using firewwd as an energy soruce while 95% use kerosene. Firewood is obtained from local forests whgeereas kerosene is imported into the area from Besisahar and most be purchased. From the questionnaire survey it was found that some of the respondents used cow dung cakes (30%), Solar cell (15%), Batteries (75%) as well as biogas (5%) as substitute of fuels. It was also found that most of the respondents anticipated that this renewable energy works for the substitute of kerosene, firewood and on the other hand it enhances the socio-economic status as well as living standard of the surrounding people.

CHAPTER –VII

CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

Hydropower, which is the potential source of energy in Nepal and can be taken as only the major renewable source of energy. The hydropower not only provides the energy source but also can play the major role for the overall economic growth of the nation. Sustainable development of hydropower project hings on how efficiently social and environmental concerns have been integrated into the development project. For the sustainability of the project, it is necessary to address impacts of the project on the socio-economic and bio-physical environment.

The present study reveals the vegetation pattern and composition along with edaphic properties of the Nyadi Hydro-electric project. The ground vegetation will be lost considerably in some areas (Intake, access road, Power house area). Similarly, the changes in landuse pattern will also another potential impact by construction activities of the project. The recognized impacts might be vegetation clearance, removal of wood, threating of endangered and rare species. On the other hand impacts will be also observed indirectly through population pressure. In the project areas plant species like *Schima walichii, Bombax ceiba, and Engelhardtia spicata* were found to be dominant. Similarly, *Innula cappa, Hypericum chisia, Mimmosa rubicaulis, Coelobrookia oppositifolia* and *Woodfordia spicata* were found to be dominant shrub and *Artimisia vulgaris, Cynodon dactylon, Imperata cylindrica* and *Eupatorium adenophorum* were found as dominant herb species in the project areas. So these are more affected by the project activities.

The status of forest in the project area and its vicinity was found relatively poor. The area was found to be rich in biodiversity. About 42 tree species, 27 shrubs and 51 herbs were recorded in the project area and its vicinity. The project site and vicinity area consist some plants that are under different protection categories such as one endangered tree species (*Cyahtea spinulosa)* and three protected plant species like *Acacia catechu*, *Bombax ceiba*, and *Terminalia chebula*. In this study it was also found that, most of the people dependent on the forest resources for their livelihood purposes. Hence, this tremendous pressure on the forest resources must be controlled and it is possible only adopting proper alternative measures. From this study, it can be concluded that the impact on vegetation will be higher along the access road and vicinity of powerhouse area. The habitat loss and illegal felling of trees by the laboures will be the main causative agents and would be controlled by giving special attention to the contractor.

7.2 Recommendations

Every development project has its own pros and cons. Beneficial impacts need to be entertained and adverse impacts need to be mitigated. For the proper management of forest area and reduction of the potential impacts due to loss of vegetation from the various activities of the construction workforce and contractors following are some of the recommendations:

1. Purchases and use of local timbers, firewood from the Nyadi Hydro-electric project ROI should be prohibited.
2. Establish kerosene or LPG deposits in the construction and labour camps for the substitution of firewood during construction phase of the project.
3. Illegal felling of trees and encroachment of community forests areas should be prohibited.
4. Rehabilitation and afforestation of the areas not occupied by project structure after the completion of construction activities should be done.
5. Emphasize should be given on the conservation of endangered, protected and threatened plant species by planting sapling in different areas recommended by forest act has to be initiated practically.
6. Project should support, plan and manage programme to community forest and compensatory plantation.

7. Encourage the local people for the establishment of bio-gas plant.
8. Bio-engineering works should be adopted by sowing or planting grasses together with fast growing and deep rooted thorny, shrubby and weedy plant species such as *Arundinaria* spp., *Imperata cylindrica, Sacchharum spontaneum, Thysanolaena maxima, Eulaliopsis binata, Woodfordia fruticosa, Vitex negundo* etc.
9. Encourage the local people to plant useful plants including a variety of medicinal plants in bare, open meadows and shady moist places. They should also be encouraged to plant fodder, timber and firewood species so as to reduce the pressure on forests and consequently contributed for the conservation of bio-diversity.
10. Local people should be properly educated concerning rare, threatened and endangered plants as to why such conservation is necessary.

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Annex-I

Photo Plates Of Field Observation

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Disscussion With Co- Supervisor in field

Reasearcher taking interview with local resident

Sampling Site near Power House

Sampling Site in access road

Researcher taking DBH of Tree

Annex-II

Questionnaire used for the field survey

Dear Respondent,

This questionnaire has been developed only for fulfillment of the master's degree dissertation in Environmental Science at T.U.I am heartly appealing you to answer the following questions. All your responses will remain confidential.

1. General information

Questionnaire No…………

Location………………V.D.C……….. Date…/…. /…Ward No…

Name of Household Head……………………Occupation………Sex…

Education ………….. Ethnicity. Land use ……………………

Name of Interviewee…………………………………………………

2. Write the Name of Plant species used by local people residing the project area.

S.N.	Local Name	Used Part	Used for

3. Why are the plants being collected?

a. Domestic use b. Commercial use

4. If the commercial use, answer the following:-

S.N.	Local Name	Plant Part	Plant production	Quantity export (Kg)	Amounts (Rs.)

5. Are there any industries based on non-timber forest products? Yes /No. If Yes, Name them. ………..…If closed why……………………..

6. Write the name of sensitive forest areas along the access road and project area if any ……………………………………………………………..

7. What are the types of energy used?

Types of Energy used	Source	Cost	Quantity Used

8. Write the name of the plant, which are rarely found in the project area.

S.N.	Local Name	Increase	Decrease	Extent	Reason

9. Types of the forest around project area.

a. Government b. Private c. Community

10. Do you know the meaning of the endangered species?

………………………………………………………………………………

11. Why forest is going to disappeared day by day?

………………………………………...

12. Why we should protect our forest?

………………………………………………………………………………

13. What is your opinion about the conservation of forest area?

…………………………………………………………………………........

14. What are the advantage and disadvantages due to this hydropower project?

Advantages: ……………………………………………………………

Disadvantage: ……………………………………………………………

15. In your opinion what are the suggestions to protect or minimize the impact of project on forest area?

………………………………………………………………………………

………….……………………………………………………………………

………………………….……………………………………………………

Thank you

Annex-III

List of Plant Species Recorded In the Project Area

S.N.	Botanical Name	Local Name	Family	Life Form	Local Uses
1	*Acacia catech* (L.f.) Willd.	Khayar	Leguminaceae	Tree	Timber, Firewood
2	*Achyranthes bidentata* Blume	Datti ban	Achyrantaceae	Herb	Medicine
3	*Aconogonum molle* (D.Don) Hara	Thotne	Polygonaceae	Herb	Fodder
4	*Adhatoda vasica* Nees	Asuro	Acanthaceae	Shrub	Medicine
5	*Ageratum conyzoides* L.	Gandhe ghans	Compositae	Herb	Medicine
6	*Albizia spp.*	Sirish	Mimosaceae	Tree	Fodder, Firewood
7	*Alnus nepalensis* D.Don.	Utis	Betulaceae	Tree	Fodder, Firewood
8	*Antidesma acidum*	Arjal	Euphorbiaceae	Shrub	Fodder, Firewood
9	*Artemisia vulgaris* L.	Titepati	Compositae	Herb	Medicine
10	*Arthrakson lancifolius*	Bhuighans	Poaceae	Herb	Fodder
11	*Artocarpus lakoocha* Wall.	Badahar	Moraceae	Tree	Fodder, Firewood
12	*Arundo donax*	Nigalo	Poaceae	Shrub	Making basket, fodder
13	*Asparagus spp.*	Kurilo	Liliaceae	Herb	Medicine
14	*Bambusa spp.*	Bans	Poaceae	Shrub	Making basket, fodder, young shoot edible
15	*Barleria cristata* L.	Bhende kuro	Acantheaceae	Herb	Medicine
16	*Betula alnoides* Buch.-Ham. Ex D. Don	Saur	Brtulaceae	Tree	Timber, Fodder, Firewood
17	*Bidens pilosa* L.	Kable kuro	Compositae	Herb	Medicine
18	*Bistorta capitata* (D.Don) Greene	Ratamilo	Polygonaceae	Herb	Medicine
19	*Boeheria rugulosa*	Daar	Urticaceae	Tree	Making wooden pots
20	*Boennighausenia albifora* (Hook.) Rechenb.ex Meissn.	Hirimiri	Rutaceae	Herb	Fodder
21	*Bombax ceiba* L.	Simal	Bombacaceae	Tree	Timber, Fodder, Firewood
22	*Bridelia retusa* (L.) Spreng.	Gayo	Euphorbiaceae	Tree	Fodder, Firewood
23	*Buddleja asiatica* Lour.	Bhimsenpati	Loganiaceae	Shrub	Firewood
24	*Butea minor* Buch.-Ham. Ex Baker	Bhujetro	Papilionaceae	Shrub	Medicine
25	*Cannabis sativa* L.	Bhang	Cannabaceae	Herb	Medicine
26	*Carassocephalum crepidioides* (Benth.) S. Moore	-	-	Herb	Fodder
27	*Castanopsis indica* (Roxb.) A.DC.	Katus	Fagaceae	Tree	Fodder, Firewood
28	*Cedrella toona*	Tooni	Meliaceae	Tree	Fodder, Firewood
29	*Celtis australis* Linn.	Khari	Ulmaceae	Herb	Fodder, Thatching
30	*Centalla asiatica* (L.) Urban.	Ghodtapre	Umbeliferaceae	Herb	Medicine
31	*Chrysopogon serrulatus*	Salimo	Poaceae	Herb	Fodder
32	*Cinnamomum*	Mala gedi	Lauraceae	Shrub	Medicine

	glaucescens (Nees) Nand. Mazz.				
33	*Cirsium* spp.	Thakal	Compositae	Herb	Fodder
34	*Colebrookio oppositifolia* Sm.	Dhursel	Labiateae	Shrub	Firewood
35	*Coriaria nepalensis* Wall.	Machhino	Coriariaceae	Shrub	Fodder, Firewood
36	*Cperus* spp.	Mothe	Cyperaceae	Herb	Fodder
37	*Cyatheae spinulosa* Wall.ex Hook.	Tree fern	Cyathaeaceae	Tree	Young leaves edible
38	*Cynodon dactylon* (L.) Pers	Dubo	Poaceae	Herb	Fodder
39	*Dactyloctenium aegypticum*	-	Poaceae	Herb	Fodder
40	*Desmodium oojeinense* (Roxb.) Ohashi	Sadan	Leguminosae	Shrub	Fodder, Firewood
41	*Desmodium spp.*	-	Poaceae	Herb	Fodder
42	*Dichrocephala chrysanthemifolia* DC.	Chhinke ghans	Compositae	Herb	Midicine
43	*Digitaria adscendens*	Banso	Poaceae	Herb	Fodder
44	*Drepanostachyum falcatum*(Munro) Keng f.	Phurke ghans	Poaceae	Herb	Fodder
45	*Drymaria diandra* Blume	Abhijalo	Caryophyllaceae	Herb	Medicine
46	*Duchesnea indica* (Andr.) Focke	Sarpe kafal	Rosaceae	Herb	Medicine
47	*Eclipta prostrata* (L.) L.	Bhiringiraj	Compositae	Herb	Medicine
48	*Elaegnus parvifolia*	Goyali	Elaegnaceae	Tree	Fodder, Firewood
49	*Elastostema rupestre*	Likhe ghans	Urticaceae	Herb	Fodder
50	*Elusine indica* Gaertn.	Kode Ghans	Poaceae	Herb	Fodder
51	*Engelhardtia spicata* Lsch.ex Bl.	Mauwa	Juglandaceae	Tree	Timber, Fodder, Firewood
52	*Erythrina stricta*	Phaledo	Eriaceae	Tree	Fodder, Firewood
53	*Eulaliopsis binata* (Retz.) C. E. Hubbard	Babiyo	Poaceae	Herb	Fodder, Thatching
54	*Eupatorium adenophorum* Spreng.	Banmara	Compositae	Herb	Fencing
55	*Euphorbia hirta* L.	Dudhe jhar	Euphorbiaceae	Herb	Medicine
56	*Eurya acuminate* DC.	Jhayanu	Theaceae	Tree	Fodder, Firewood
57	*Ficus lacor* Buch.-Ham.	Kavro	Moraceae	Tree	Fodder, Firewood
58	*Ficus racemosa* L.	Timala	Moraceae	Tree	Fodder, Firewood
59	*Ficus sarmentosa* Buch.-Ham.ex Sm.	Bello	Moraceae	Tree	Fodder, Firewood
60	*Ficus semicordata* Buch.-Ham.ex Sm.	Khaniyo	Moraceae	Tree	Fodder, Firewood
61	*Fraxinus floribunda* Wall.	Lakuri	Oleaceae	Tree	Fodder, Firewood
62	*Galinsoga parviflora* Cav.	Chitlang ghans	Compositae	Herb	Fodder
63	*Galium* spp.	-	Rubiaceae	Herb	Medicine
64	*Garuga pinnata*	Dabdabe	Burseraceae	Tree	Fodder, Firewood
65	*Girardinia diversifolia* (Link) Fris	lato Sisanu	Urticaceae	Herb	Medicine
66	*Grevillea robusta* A.	Kayio	Proteaceae	Tree	Firewood

	Cunn. Ex R. Br.				
67	*Hedychium coronarium*	Sirra	Zingiberaceae	Herb	Fodder
68	*Heteropogon centortun* (L.) Beauvois	Arthunge	Poaceae	Herb	Medicine
69	*Hyperiucum chisia*	Khareto	Hypericaceae	Shrub	Firewood
70	*Imparata cylindrica* (L.) Beauv	Siru	Poaceae	Herb	Fodder, Thatching
71	*Inula cappa*	Gai tihare	Compositae	Shrub	Firewood
72	*Jatropha curcas* L.	Sajiwani	Euphorbiaceae	Shrub	Fencing, tooth brush
73	*Leea asiatica*	Golauri	Leeaceae	Shrub	Fodder, Firewood
74	*Litsea monopetala* (Roxb.) Pers.	Kutmiro	Lauraceae	Tree	Fodder, Firewood
75	*Lyonia ovalifolia* (Wall.) Drude	Angeri	Eriaceae	Tree	Fire wood
76	*Macaranga indica* Wight.	Malath	Euphorbiaceae	Tree	Fodder, Firewood
77	*Maclura cochinhinensis*	Damaru	Moraceae	Shrub	Fodder, Firewood
78	*Macropanax undulatus* (Wall.ex G.Don) Seem	Chichinde	Arallaceae	Tree	Fodder, Firewood
79	*Madhuca butraceae*	Chiuri	Spotaceae	Tree	Edible Fruits
80	*Maesa chisia* Buch.-Ham. ex D. Don	Dhubeni	Myrsinaceae	Shrub	Firewood
81	*Mallotus philippinensis* (Lam) Muell. - Arg.	Sindure	Euphorbiaceae	Tree	Fodder, Firewood
82	*Mimosa rubicaulis*	Areli	Mimosaceae	Shrub	Firewood
83	*Mussaenda treuleri*	Bilaune	Rubiaceae	Shrub	Fodder, Firewood
84	*Myrica esculenta* Buch.-Ham. ex D. don	Kafal	Mricaceae	Tree	Edible fruits, Firewood
85	*Myrsine semiserrata* Wall.	Kalikath	Myrisinaceae	Tree	Fodder, Firewood
86	*Nyctanthes arbo-tristis* L.	Rutilo	Oleaceae	Shrub	Fodder, Firewood
87	*Oreocnide frutescens* (Thunb.) Miq.	Chiple ghans	Urticaceae	Herb	Fodder
88	*Osbeckia nepalensis* Hook.	Angeri	Melatomataceae	Shrub	Firewood
89	*Osyris wightiana* Wall.	Chewang	Santalaceae	Shrub	Medicine
90	*Oxalis corniculata* L.	Chariamilo	Oxalidaceae	Herb	Medicine
91	*Persea gamblei*	Kathe kaulo	Lauraceae	Tree	Fodder, Firewood
92	*Phyllanthus emblica* L.	Amala	Euphorbiaceae	Tree	Medicine, Edible Fruits
93	*Phylllanthus urinaria* L.	Bhuiamala	Euphorbiaceae	Herb	Medicine
94	*Polygonum barbata* (L.) Hara	Nali ghans	Polygonaceae	Herb	Medicine
95	*Premma latifolia*	Golaunri	Verbanaceae	Tree	Fodder, Firewood
96	*Pyrecantha crenulata*	Ghangaru	Rosaceae	Shrub	Firewood
97	*Quercus glauca* Thunb.	Phalant	Fagaceae	Tree	Timber, Fodder, Firewood
98	*Rhus wallichii* Hook. F.	Bhalayo	Anacardiaceae	Tree	Fodder, Firewood
99	*Rubus ellipticus* Smith	Anselu	Rosaceae	Shrub	Medicine
100	*Sacchharum*	Kans	Poaceae	Herb	Thatching

	spontaneum L.				
101	*Sambuscus hookeri* Rehder	Galeni	Caprifolioceae	Shrub	Fodder, Firewood
102	*Sapium insigne* (Royle) Benth. Ex Hook. F.	Khirro	Euphorbiaceae	Tree	Fodder, Firewood
103	*Schima wallichii* (DC.) Korth.	Chilaune	Theaceae	Tree	Timber, Fodder, Firewood
104	*Scutellaria discolor* Colebr.	Rato pate	Labiateae	Shrub	Fodder, Firewood
105	*Setaria pumia*	Kutkute	Poaceae	Herb	Fodder
106	*Solanum aculeatissmum* Jacq.	Kantkari	Solanaceae	Herb	Medicine
107	*Spondias piñata*	Amaro	Anacardiaceae	Tree	Fodder, firewood
108	*Syzygium cumini* (L.) Skeels	Jamuna	Martaceae	Tree	Edible fruits, Firewood
109	*Terminalia chebula* Retz.	Harro	Combretaceae	Tree	Medicine, Firewood
110	*Thallictrum foliolosum* DC.	Dampate	Rannunculaceae	Herb	Medicine
111	*Thysanolaena maxima* (Roxb.)O.Kuntze	Amliso	Poaceae	Herb	Broom
112	*Typha* spp.	Khar	Typhaceae	Herb	Thatching
113	*Urtica dioica* L.	Sisnu	Urticaceae	Herb	Medicine
114	*Vitex negundo* L.	Simali	Verbenaceae	Shrub	Fencing
115	*Woodfordia fruticosa* (L.) Kurz	Dhayaro	Lythraceae	Shrub	Firewood
116	*Xanthium strumarian* L.	Kuru	Compositae	Herb	Medicine
117	*Zizyphus* spp.	Bayar	Rhamnaceae	Herb	Fencing
118	-	Ghokro	-	Tree	Fodder, Firewood
119	-	Kande	-	Tree	Fodder, Firewood
120	-	Jaki	-	Herb	Medicine

Annex-IV

Summary Impact Matrix of the NHP on the Forest Resources

Impacts	Impact Prediction			Mitigation (s)	Responsibility	Initiation of Impact
	Magnitude	Extent	Duration			
Loss of vegetation from the clearance of quarry site, surge tank site, spoil disposal site	L	SS	ST	Spoil deposit in gullies and denuded slopes	Contractor, DFO	Construction
Loss of Biodiversity and genetic diversity from the clearance of vegetation	L	SS	MT	Formation of user groups maintaining community forestry	LEDCO, Local user goup, LOcal VDCs, CFDP	Construction
Loss of economically important species	L	SS	ST	Plantation in private / public land	Local VDCs, Contractor and CFDP	Construction
Loss of grazing land	L	SS	ST	Pasture improvement in adjacent areas	Contractor	Construction
Soil erosion and landslide	L	SS	ST	Creation of retention wall and plantation of grasses and trees over spoil deposits	Contractor	Construction/ Operation

Note: L= Low, SS =Site Specific, ST=Short-term (<10Yrs.), MT=Medium-term (>10Yrs.)